

The initiation and incrementation of sound change: community-oriented momentum-sensitive learning

Ricardo Bermúdez-Otero
University of Manchester

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Abstract

Particular historical events are not amenable to deductive explanation, but the general macroscopic facts of sound change are. At present, widely accepted explanations of such facts posit causes that are either invariant (physical law, the architecture of grammar) or involve broad demographic variables (age, gender, class). Recent research, however, draws attention to differences between individual speakers that are claimed to affect their likelihood of behaving as innovators or propagators of change.

One line of argument appeals to the existence of acoustically covert individual differences in articulation to explain the fact that, although the biases that drive innovation are permanently active, sound change is sporadic. This proposal lacks generality and fails to account for localized bifurcations, in which change takes off in one location but not in another. A more general solution is provided by the hypothesis that learners are community-oriented, i.e. rejecting individual idiosyncrasies, and momentum-based, i.e. sensitive to differences in the use of linguistic variables across age-groups.

Another line of argument suggests that the indexing of individual stances through the use of socially meaningful variants is key to the incrementation and propagation of change. This claim encounters difficulties over the granularity and predominantly oppositional character of social meaning. Instead, phenomena like class stratification, curvilinear propagation, and even change reversals submit to predominantly mechanical explanations driven by density of communication.

Thus, the available evidence is consistent with the hypothesis that most general macroscopic facts about sound change can be adequately explained by models that abstract away from individual differences.

Keywords

Actuation, community-oriented learner, density of communication, intergenerational incrementation, individual differences, momentum-based learner.

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1. Introduction

τῆς γὰρ ἀθρόας ἐπιβολῆς πυκνὸν δεόμεθα,
τῆς δὲ κατὰ μέρος οὐχ ὁμοίως.

Epicurus, *Ad Herodotum*, 35.9-10

Though we have much to learn from micro-analysis,
we have more to learn from our efforts to grasp the
larger pattern.

Labov (2014a: 28)

The actuation problem, as originally posed by Weinreich et al. (1968: 102), remains unsolved: deductive-nomological explanations of particular instances of sound change lie beyond our reach, probably forever (Lass 1980). But historical linguists have a better record of accounting for general facts about implementation, innovation, and propagation. The observation that some sound changes are implemented in neogrammarian fashion, for example, has long been understood to reflect the double articulation of language: phonological representations consist of recurring discrete categories whose realization in continuous phonetic space is assigned by rule (Paul 1886: 62; Bloomfield 1933: 364-365). Similarly, Ohala's (1981, 1989) notions of perceptual hypo- and hyper-correction provide an account of innovation that avoids teleology and succeeds in making falsifiable predictions about the relative frequency with which different types of sound change are attested in the history of the languages of the world. In turn, decades of sociolinguistic research have demonstrated that the propagation of change through a speech community involves orderly shifts in the frequency of competing variants along demographic dimensions such as age, gender, and class (Labov 2001). Remarkably, all of these explanatory models abstract away from differences between individual speakers, focusing instead either on invariant factors (e.g. physical law, the architecture of mental grammars) or on broad demographic categories. Recent years, however, have witnessed a rapid accumulation of evidence for linguistically relevant differences between individuals, encouraging a growing interest in the possibility that incorporating individual variation into our models may lead to better explanations of sound change.

1.1. Individual differences

An initial challenge to the customary focus on broad demographic groups at the expense of individual differences comes from instances of phonetic and phonological variation that fail to correlate with traditional dialectal or sociolectal distinctions. Ellis & Hardcastle (2002), for example, found major differences in the articulatory realization of /n#k/ clusters across speakers of British English, which Bermúdez-Otero & Trousdale (2012: 694-696) interpreted as reflecting a diachronic progression from gradient phonetic to categorical phonological sandhi; however, dialect background appears to be a poor predictor of the sandhi strategies adopted by Ellis and Hardcastle's informants. More strikingly, Mielke et al.'s (2016) ultrasound study of American English /ɹ/ documents a wide range of allophonic patterns, often highly complex and speaker-specific, which may reflect both individual acquisition trajectories and individual articulatory motivations.

In parallel, psycholinguistic research has demonstrated that individual speakers display consistent and stable differences from one another in their language processing styles. These

differences often concern important aspects of speech perception: e.g. the amount of gradience exhibited in phonemic categorization tasks (Kong & Edwards 2016); the individual's susceptibility to the Ganong effect, which biases categorization towards known words (Stewart & Ota 2008); relatedly, the extent to which listeners rely on top-down lexical information when parsing acoustically degraded speech (Ishida et al. 2016); and, most notably, how much individuals compensate for coarticulatory effects in speech perception (Yu 2010, 2013). The chapters in Fuchs et al. (2015) provide further examples. Such individual differences in speech processing styles have been hypothesized to correlate with differences in more general subpersonal cognitive characteristics: e.g. executive function capacity (Miyake et al. 2000), declarative vs procedural learning abilities (Ullman 2004), and autistic traits as measured by the Autism-Spectrum Quotient (AQ; Baron-Cohen et al. 2001). Kong & Edwards (2016) found no correlation between gradience in phonemic categorization and measures of executive function capacity. In contrast, Lee & Tomblin (2015) report that individuals with poor language abilities (including those with a history of language impairment) do tend to perform worse than individuals with typical language skills in tasks assessing different forms of procedural learning. AQ scores have proved to be particularly good predictors of individual differences in auditory speech processing, in line with the general observation that young adults suffering from Autism Spectrum Disorder exhibit increased auditory perceptual capacity when compared with neurotypical controls (Remington & Fairnie 2017): low AQ scores correlate with lesser sensitivity to implicit prosodic boundaries in syntactic parsing (Jun & Bishop 2015), greater susceptibility to the Ganong effect (Stewart & Ota 2008), and less perceptual compensation for coarticulation, particularly among women (Yu 2010, 2013).

Crucially, it has been suggested that such individual traits may affect the likelihood of a speaker's behaving as an initiator or propagator of sound change. Particular attention has been devoted to the fact that listeners differ in how much they will compensate for coarticulatory influences: Yu (2010), for example, found that low-AQ women are relatively more likely to interpret low-frequency noise in a sibilant at face value as realizing /j/, rather than as reflecting the coarticulatory influence of an immediately following /u/ on /s/. Since Ohala's (1981, 1989) widely accepted account of phonetic innovation posits perceptual hypocorrection as a key mechanism in the initiation of change, it is therefore tempting to regard low-AQ women as having a greater chance of starting sound changes. The appeal of this hypothesis increases in view of the fact that, by virtue of their low AQ, the same individuals exhibit social profiles that may be supposed to increase the likelihood of their behaving as propagation hubs: they tend to be more extraverted and agreeable, and to have more social contacts and close friends (Yu 2013). Stevens & Harrington (2014) provide further discussion of this literature.

A different strand of research, conducted mainly by sociolinguists, ethnographers, and anthropologists, calls for greater attention to individual differences involving personal identity and agency. This work draws on numerous empirical studies showing an effect of speaker attitudes on variant use in the course of sound change. Attitudes to local traditional life-styles feature in a particularly large number of reports: Labov's (1963) foundational study of Martha's Vineyard notes a divergence between speakers committed to local ways of life centred on traditional occupations such as fishing and speakers oriented towards the new economy driven by tourism from the mainland; Zhang's

(2005) work on mid-ranking professionals in Beijing opposes those employed in the Chinese state sector (“state managers”) to those working for multinational firms (“yuppies”); and Roberts’s (2016) paper on Vermont highlights the effects of the speaker’s degree of identification with the traditional lifestyle of rural “uphill” areas. Attitudes to education among adolescents are also often cited as a factor: e.g. in Eckert’s (1989, 2000) ethnographic account of “jocks” and “burnouts” in a Detroit high school, and in Wagner’s (2012) work on female teenagers at a parochial school in Philadelphia.

This and other evidence indicates that there is more to propagation than Bloomfield’s (1933: 46ff) principle of density of communication: the way in which sound change spreads is not always exhaustively explained by relative frequencies of interpersonal contact alone as determined by demographic factors like age, gender, and class. Some scholars take their conclusions further and argue that it is necessary to regard individual speakers as indexing their stances through their use of socially meaningful variables, creating personal styles in the process (Kiesling 2009). Ultimately, third-wave sociolinguistics attributes a crucial role to individual identity and agency in the propagation of change: speakers are portrayed as “stylistic agents, tailoring linguistic styles in ongoing and lifelong projects of self-construction and differentiation” (Eckert 2012: 97-98).

1.2. Preview of the argument

Despite the evidence surveyed in §1.1, individual differences are ignored in virtually all the explanatory accounts of sound change that enjoy some currency today. The article’s opening paragraph gave three examples: the modular explanation of the existence of neogrammarian change, Ohala’s theory of phonetic innovation, and Labov’s account of propagation. These models resemble one another in methodologically significant ways. First, none seeks to explain phenomena occurring in a particular location at a particular time; rather, all of them set out principles from which one can deduce general statements about sound change. Secondly, each account addresses itself to a specific facet of the problem: e.g. how change is implemented on the phonetic and lexical dimensions, how innovations first appear, how they propagate. In this sense, all these models presuppose a certain division of labour in the explanation of sound change. Thirdly, the three theories concern themselves with macroscopic facts: i.e. they seek to explain generalizations about phenomena that can be observed either crosslinguistically with the tools of the typologist, or in the history of whole languages with the tools of philology, or at the level of the speech community with the tools of classical variationist sociolinguistics. In turn, the proposed explanations depend on claims about a wide range of domains, including physical law, physiology, cognition, and the structure of human societies. Crucially, however, none of these accounts appeals to differences among individual speakers beyond those defined by broad demographic categories such as age, gender, and class. In this sense, the proposed mechanisms are always infra- or supra-individual.

Is it time, therefore, to break this pattern and incorporate individual variation into our explanations of sound change? In answer to this question, this paper counsels caution: I examine two theories that portray individual differences as crucial to explaining basic facts of sound change, and in both cases I find that they are insufficiently general, accounting just for small-scale effects

superimposed on larger macroscopic patterns that turn out to be driven by infra- and supra-individual mechanisms.

In §2 I consider Baker et al.'s (2011) claim that acoustically covert individual variation in articulation explains the fact that, although the phonetic biases that drive innovation apply permanently, change from gradient to categorical sound patterns occurs only sporadically. I argue that the explanatory challenge is actually much tougher. First, change is not only sporadic but also localized: although known biases may be held in the same balance across a certain geographical space, change is frequently confined to a subregion of that space. Secondly, sporadic and localized bifurcations characterize change in all components of grammar, also including morphophonology and syntax. We therefore need a more general account of the initiation and incrementation of language change. To this end, I assume, first, that learners are community-oriented, rejecting individual deviations from the collective norm (Labov 2014a, 2014b). During acquisition, moreover, learners build mental representations of differences in variable use across age-groups: in the course of change, adolescents are consequently driven to increase their use of the new variant by their internalized knowledge of the variable's momentum in apparent time (Labov 2001, 2010; Mitchener 2011). Crucially, community-oriented momentum-based learning predicts sporadic localized bifurcations: learners reject an innovation if it is isolated or randomly scattered, but they adopt it and actively increment it if it accidentally displays an inverse correlation with age. The model further predicts that diachronic trajectories will be typically monotonic: change is both "self-actuating" and "self-reinforcing" (Stadler et al. 2016: 184, 188).

In §3 I examine the claim that the social meanings of linguistic variables drive the incrementation and propagation of change through the stylistic agency of speakers (Eckert 2000, 2008, 2012). This hypothesis is inconsistent with data from the Northern Cities Shift (Labov 2007) and from Velar Nasal Plus (Bailey 2018), whose social evaluation is respectively too fine-grained and too coarse to explain the advance of ongoing change. An account driven by social meaning further predicts that interspeaker variation will increase as sound change gathers momentum, but Fruehwald's (2017b) statistical analysis of /aɪ/- and /eɪ/-raising in 20th-century Philadelphia falsifies this prediction. I argue, instead, that the mechanical effects of density of communication must play the primary role in the rise of class stratification, both temporally and causally: this is confirmed by Baranowski's (2017) study of GOOSE and GOAT in Manchester, where status outperforms attitudes as a predictor of variation. The same approach extends to cases of curvilinear propagation, in which a change from below spreads out from intermediate-status groups (Labov 1972, 2001): dynamical systems modelling suggests that this pattern arises spontaneously in any social network clusterized by class, even when social evaluation is completely absent (Kauhanen 2017). Indeed, mechanical explanations are possible even for instances of change reversal: as we saw above, momentum-driven incrementation is self-sustaining, but it can be disrupted by population changes or shifts in patterns of community segregation (cf. Hall-Lew 2017). In sum, the stylistic agency of individual speakers, engaged in expressing their personal stances through the use of socially meaningful variants, is undeniable but produces small-scale effects; macroscopic patterns of propagation often submit to mechanical explanations driven by supra-individual demographic factors.

In §4 I pursue the implications of these results. I note that research into individual differences may illuminate many important questions about sound change, even if, as shown in this article, it is appropriate

to abstract away from individual variation when explaining macroscopic facts such as localized bifurcation, monotonic incrementation, the adolescent peak, class stratification, and curvilinear propagation. This outcome, however, reminds us of the indispensable role of abstraction in the study of sound change: increasing the number of microscopic variables in a model of a macroscopic phenomenon constitutes progress only insofar as those variables do actually cause macroscopic effects.

2. The problem of sporadic localized change

2.1. Permanent biases, but sporadic and localized change

Subpersonal linguistic differences between individual speakers have been portrayed as holding the key to the problem posed by the sporadic incidence of sound change (Baker et al. 2011). This challenge is best understood by reference to Ohala's (1981, 1989) theory of innovation. According to the latter, speech perception requires the listener to correct for the noise (in the information-theoretic sense) introduced by phonetic biases; from time to time, correction errors occur, and those errors that are retained in the listener's own production constitute innovations. Yet phonetic biases grounded in physical law and in universal physiological and cognitive traits apply permanently: accordingly, if the errors they cause accumulated over time, sound change would become inevitable in the long run. We know, however, that change is in fact sporadic: at any point, most of the properties of a language are either invariant or subject to stable variation (Stadler et al. 2016: 172). Theoretical adjustments that reduce the overall probability of innovation mitigate but do not solve this problem: as soon as error is permitted to accumulate, change becomes inexorable in the long run; lowering the frequency of innovation merely delays the inevitable (Baker et al. 2011: 363-364).

In the terminology of dynamical systems theory, allowing error to accumulate has the effect that even very gentle biases create attractors in linguistic phase space: for example, a slight bias against a property will sooner or later drive all languages into regions of phase space in which that property is absent. More complex dynamics, however, give rise to attractors that are not fixed points: notably, Boersma (1998: ch. 17) shows how interacting biases can keep languages moving eternally in closed cycles. Developing this line of reasoning, many linguists (e.g. Sóskuthy 2015) have sought the explanation for the sporadic incidence of sound change in competing-motivations models (Croft 2000: 81-82): in such models, one bias may be held in check by another, and the complex interactions of multiple biases give rise to the variety of linguistic systems that we actually observe.

Competing-motivations models play an indispensable role in the explanation of typological facts, but they fall short of solving the problem of sporadic change because they fail to account for the prevalence of localized bifurcations. In the current context, a bifurcation is said to occur when a variable ceases to be stable and starts to undergo incremental change (e.g. Kirby & Sonderegger 2015; see §2.3 for a detailed description of incrementation). The bifurcation is localized if the change is confined to a subregion of the geographical space in which the affected linguistic variety is spoken. Localized bifurcation is commonplace in sound change: notably, it produces the characteristic branching pattern encoded in phylogenetic trees (see Figure 1 for an example).

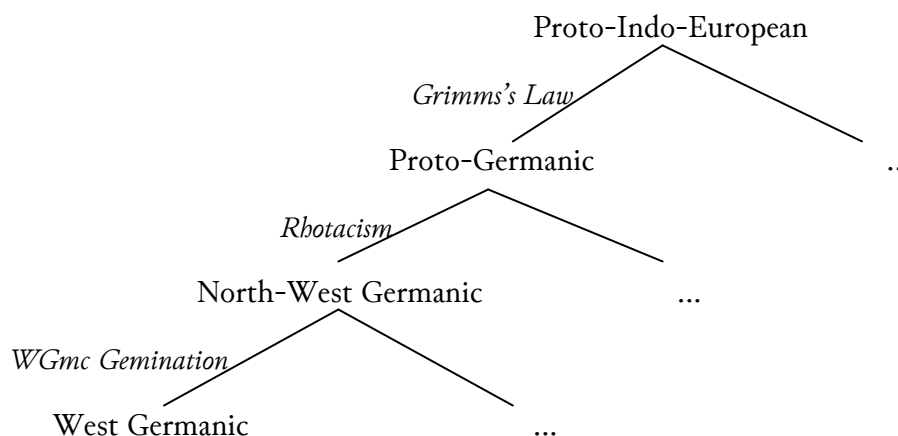


Figure 1: Evolutionary branching by localized bifurcation in Germanic (after Lass 1994).

Any explicit competing-motivations model encounters a problem whenever variation in respect of the biasing factors included in the model is uniform across a geographical space and yet change occurs within a limited subregion of that space. Appeals to undetectable variation or to biases yet to be identified is of course possible, but, when repeated, reduces the overall programme to unfalsifiability. Alternatively, the model may assume a measure of stochasticity and allow one subregion to surge ahead, while the other is predicted to follow suit with a high probability. This sort of parallel evolution—a special case of Sapir’s (1921: ch. 7) drift—does occur (e.g. Lass 1997: 120-121), but evolutionary divergence is even more common.

Recognition of the challenge posed by sporadic localized bifurcation is very old: as Bloomfield (1933: 386) put it, “No permanent factor [...] can account for specific changes which occur at one time and place and not at another.”¹

2.2. Covert articulatory variation

Baker et al. (2011) propose an account of English /s/-retraction driven by acoustically covert individual differences in articulation, and they suggest that this account instantiates a general solution to the problem of sporadic sound change. Here, /s/-retraction denotes an [ʃ]-like realization of /s/ in the vicinity of a following /ɹ/. Word-initial /stɹ/-clusters provide the most favourable environment: e.g. [ʃ]treet. The change has been independently observed in many varieties of present-day English: see Baker et al. (2011: 348) for references.

Drawing on observations by Mielke et al. (2010), Baker et al. (2011) note that the coarticulatory influence of /ɹ/ upon a preceding /s/ depends in part on the speaker’s /ɹ/-production

¹ The similarity between Bloomfield’s statement and Weinreich et al.’s (1968: 102) formulation of the actuation problem is obvious. Nonetheless, following Lass (1980), I reserve the term *actuation problem* for the demand to produce deductive-nomological explanations of particular changes. Obviously, one can deduce from first principles the sporadic occurrence of localized bifurcations (a general fact) without predicting particular events.

strategy. English exhibits wide individual differences in /ɹ/-articulation; these differences are covert in that it is virtually impossible to detect them acoustically (Delattre & Freeman 1968). In general, the phoneme has two discrete allophones: one bunched, the other retroflex. These two allophones appear in a wide variety of distributional patterns, often highly complex and speaker-specific (Mielke et al 2016). In addition, there is continuous articulatory variation within each allophonic category: in particular, a speaker's lingual configuration for bunched [ɹ] may be more or less similar to his or her tongue shape for /s/ (Mielke et al. 2010). Crucially, Mielke et al. (2010) report that, among speakers exhibiting merely gradient /s/-retraction, the coarticulatory influence of /ɹ/ upon the preceding /s/ in an initial /stɹ/-cluster is positively correlated with the similarity between the individual's /ɹ/- and /s/-postures: in other words, /s/ sounds relatively [ʃ]-like in /stɹ/-clusters when the speaker's tongue shape for bunched [ɹ] is relatively similar to his or her /s/-posture.

Given this, Baker et al. (2011) propose an actuation mechanism for the change from gradient to categorical /s/-retraction, which corresponds to the stabilization phase in the life cycle of the pattern: see Figure 2 and Bermúdez-Otero (2007: 504-506; 2015: 383, 386-388). The hypothesis is that the potential for stabilization arises in relatively rare encounters between two types of interlocutor: a speaker exhibiting a high degree of gradient /s/-retraction by virtue of having relatively similar /s/- and /ɹ/-postures, and a listener displaying a low degree of gradient /s/-retraction in consequence of having relatively different /s/- and /ɹ/-articulations. In such circumstances, Baker et al. suggest, the listener will perceive the speaker's pronunciation of /s/ in /stɹ/-clusters as retracted, but will not have access to the coarticulatory cause of this retraction: in the listener's own speech, /ɹ/ exerts less coarticulatory influence upon /s/, and the acoustic signal provides no clue to the fact that the speaker articulates /ɹ/ with a different tongue shape. As a result, the listener may end up misparsing gradiently retracted tokens of /s/ as categorically retracted, i.e. as realizing [ʃ] in the surface phonological representation.

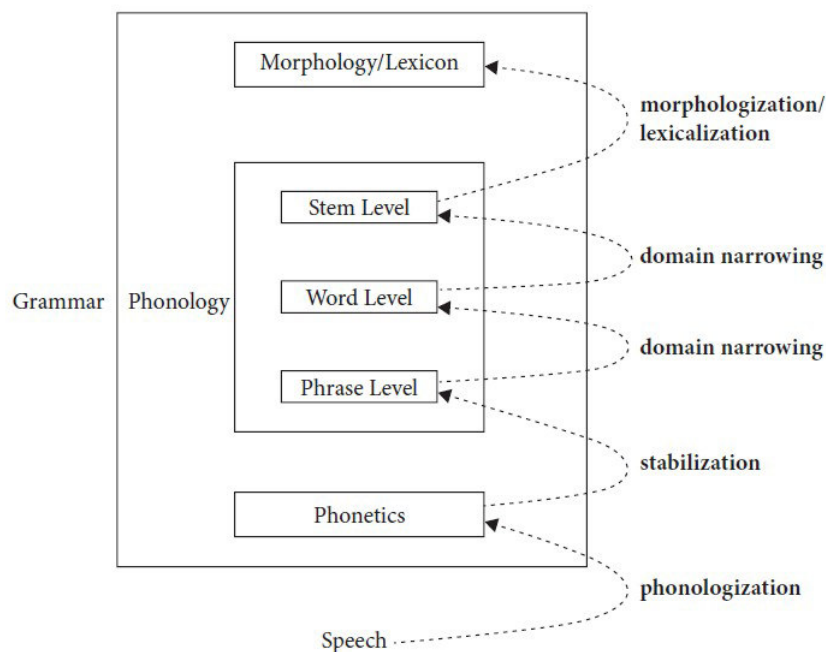


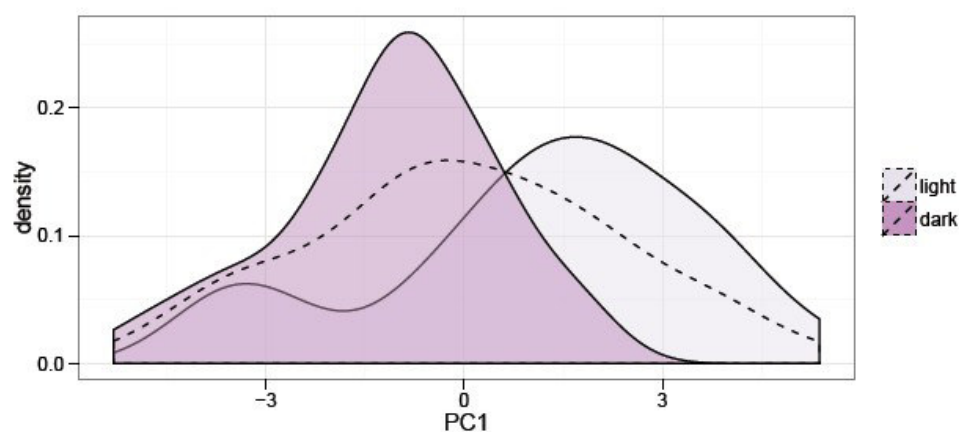
Figure 2: The life cycle of phonological processes (Bermúdez-Otero & Trousdale 2012: 700).

As Baker et al. emphasize, their proposal predicts that, in general, stabilization will occur infrequently. Listeners are ordinarily very good at compensating for coarticulatory effects (e.g. Mann 1980, Mann & Repp 1980). Baker et al.'s account of English /s/-retraction names conditions under which the probability of compensation failure may be expected to increase, but these conditions are met only rarely. On this basis, Baker et al. suggest that covert individual differences in articulation may hold the key to the sporadic incidence of sound change.

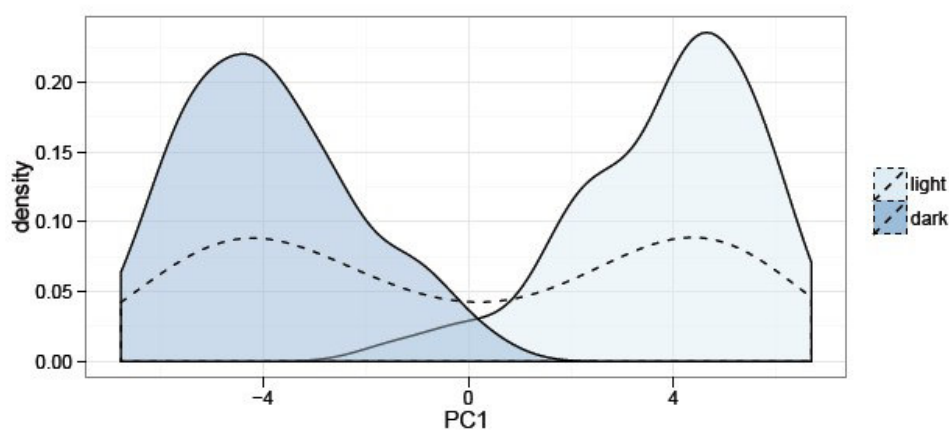
Several considerations indicate, however, that Baker et al.'s proposal is insufficiently general. First, sporadic incidence is a hallmark of *all* types of language change. Even if we limit our discussion to phonetic and phonological change, sporadic localized bifurcation characterizes all stages in the life cycle of sound patterns, not just stabilization (Figure 2). For example, Turton (2014) and Ramsammy (2015) describe several cases of dialectal variation involving a categorical phonological process whose morphosyntactic domain has undergone narrowing in one location but not another.

There are, moreover, many documented instances of stabilization in which all the known coarticulatory triggers are acoustically overt. For example, Turton (2014, 2017) investigated categoricity and gradience in /l/-darkening across a range of English dialects. Each facet in Figure 3 provides data from one representative speaker: the upper facet illustrates Manchester working-class speech; the lower facet, conservative RP. Within each facet, the light-grey density consists of tokens of /l/ that are in the onset at the word-level, whereas the dark-grey density reflects /l/ in the coda at the word level; the dashed line depicts the overall distribution. Turton performed principal component analysis on the ultrasound splines, and darkness in Figure 3 is represented on the x-axis in terms of the loading of the first principal component: higher values indicate lighter /l/s. Manchester working-class speech turns out to exhibit a monocategorical pattern with gradient /l/-darkening,

reflected in an overall unimodal distribution; in contrast, /l/-darkening has undergone stabilization in conservative RP, which displays two discrete allophones, forming a strongly bimodal distribution (see Turton 2017: 24 for further diagnostics). Turton's analysis thus demonstrates that the stabilization of English /l/-darkening involves localized bifurcation: stabilization has taken place in RP, but not in Manchester working-class speech. Yet, to date, the continuous phonetic factors known to exert a gradient effect upon /l/-darkness are all acoustically overt: the main ones are surrounding vowel quality and rhyme duration (Sproat & Fujimura 1993). It thus appears that English /l/-darkening offers a case of localized stabilization unmediated by covert articulatory variation.



a. Manchester working class: monocategorical.



b. Conservative RP: bicategorical.

Figure 3: Localized stabilization of English /l/-darkening (Turton 2014: 143, 167).

Finally, localized bifurcation raises a further problem. Baker et al (2011: 348) observe that /s/-retraction exhibits a wide dialectal distribution in present-day English. Nonetheless, the change remains localized in that it has failed to reach certain regions, such as the English counties of Northumberland, Tyne and Wear, County Durham, and Yorkshire (Glain 2014: 23). If North East England were to remain impervious to /s/-retraction forever, this would be no more surprising than the fact that the North West and the West Midlands retain nonprevocalic [ŋg], even though the

varieties ancestral to RP had already lost it by the 18th century and it is today absent from the rest of the English-speaking world (see §3.2 for discussion and references). Such a scenario, however, would be hard to understand under Baker et al.'s proposal: the latter predicts that, if covert variation in /ɹ/-articulation is spread uniformly across the English-speaking world, then all locations will be equally likely to witness the stabilization of /s/-retraction; however sporadic its incidence, no region should be able to resist it in the long run. Admittedly, the geographical distribution of individual variation in /ɹ/-realization patterns remains unknown. Nonetheless, the question highlights a broader challenge for any approach to the initiation of sound change that relies crucially on individual differences: if those differences are distributed uniformly in geographical space, the approach will not explain localized bifurcation.

In sum, models driven by individual differences do not solve the problem posed by the sporadic and localized incidence of change. As we have seen, a sufficiently general account of this phenomenon should be applicable to a broad range of linguistic changes. In §2.3 I set out two further desiderata: the right theory must be consistent with the fact that change normally advances by intergenerational incrementation, and that trajectories of change are commonly monotonic and often S-shaped. In §2.4 I show how all these requirements are met by community-oriented momentum-based learning.

2.3. Desiderata for a general mechanism of initiation and incrementation

As we saw in §2.1, a model of initiation must predict the sporadic and localized incidence of change. In addition, it must of course do so without rendering change equiprobable in all circumstances; during our discussion of competing-motivations models, for example, we saw that Sapirian drift does exist. To take an illustration from syntax, the probability of word-order change from OV to VO receives a boost in languages that have prepositions: such a development has taken place independently in several branches of Indo-European, including Baltic, Germanic, and Romance. However, even very strong drifts are resistible, and indeed Persian holds out as a prepositional OV language (Hawkins 1990: 121, based on Friedrich 1975).

Our model must also predict that, once initiated, change advances by intergenerational incrementation: while the change is ongoing, each successive generation of speakers uses the innovative variant more than the preceding generation (Labov 1994: 83-84, 112; 2001: ch. 14). Thanks to work in Labovian sociolinguistics, the empirical facts of incrementation are known in considerable detail. In general, preadolescent children are conservative: they use the innovative variant less than contemporary teenagers and younger adults. During adolescence, however, speakers rapidly increase their use of the innovative variant, so that, around the age of 17, they reach a level exceeding that of all contemporary age-groups: this is known as the adolescent peak (Labov 2001: ch. 14, Tagliamonte & D'Arcy 2009). After adolescence, the speaker's mean use of the variable remains largely stable.

In consequence, apparent-time studies of ongoing sound change typically find the pattern illustrated in Figure 4, which plots the degree of /ou/-fronting by age-group in Charleston, South Carolina, at the end of the 20th century (Baranowski 2007). Among adults, /ou/-fronting is inversely

correlated with age: each age-group exhibits the amount of fronting that they reached by late adolescence, which was higher than that of the immediately preceding cohort. Preadolescent children are conservative, producing realizations of /ou/ within the adult range. In contrast, adolescents have the highest level of fronting, giving rise to the expected peak.

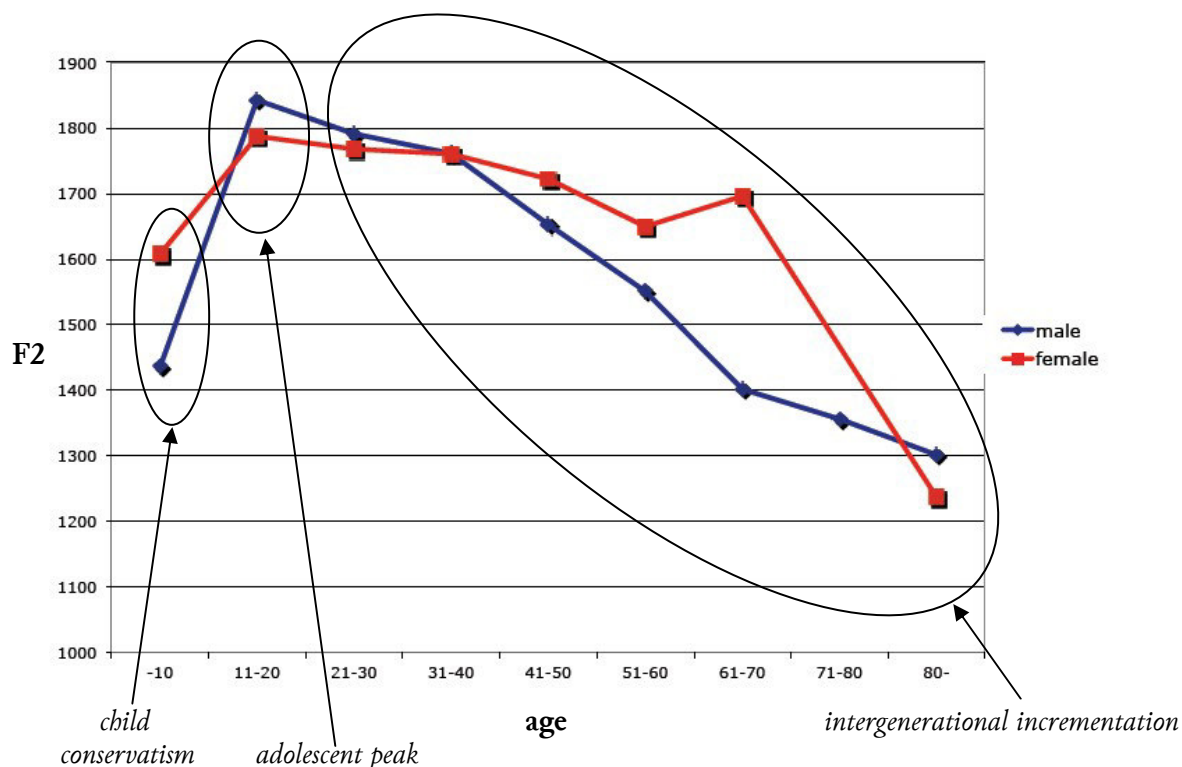


Figure 4: /ou/-fronting in Charleston
(courtesy of Maciej Baranowski; data from 100 speakers).

Several quantitative correlations confirm that the adolescent peak is intimately bound with the mechanism of intergenerational incrementation (Labov 2001: ch. 14, Tagliamonte & D’Arcy 2009). First, the prominence of the adolescent peak at a given point in real time t is directly proportional to the speed (instantaneous velocity) of the change at t . In changes following a logistic trajectory, therefore, the adolescent peak is sharpest at the mid point, when incrementation is fastest. Near floor or ceiling, in contrast, velocity is lower, and so apparent-time curves look flatter. Similarly, if change a advances faster than change b , then a will show a more prominent adolescent peak.²

This account of intergenerational incrementation is not invalidated by the observation that some individuals exhibit life-span changes, i.e. shifts in variable use after adolescence (e.g. Sankoff & Blondeau 2007, Wagner & Sankoff 2011; see also §4.2 below). Indeed, the decline of linguistic plasticity after adolescence is not absolute and affects some parts of the grammar less severely than others: in particular, adults appear to perform gradient phonetic adjustments (Harrington 2006) more

² The interaction of the adolescent peak with gender is a complex issue. Current evidence suggests that adolescent peaks are present in both genders, whether the change is led by females or by males (Holmes-Elliott 2016).

easily than they learn new categories (Nahkola & Saanilahti 2004) or large-scale patterns such as chain-shifts (Labov 2007). Nonetheless, the empirical record confirms that generational change is the main mechanism of incrementation: in a study of five variables using data from the Philadelphia Neighborhood Corpus (PNC), for example, Fruehwald (2017a) found relatively weak evidence for effects of life-span change, while generational effects proved extremely robust.

Finally, our account of incrementation must explain the fact that the progress of sound change is typically monotonic, although change reversals do occur (see §3.5). In addition, it is generally agreed that the model must be able to produce sigmoid (S-shaped) curves, though a number of studies have observed largely linear trajectories of change (e.g. Labov et al. 2013).

2.4. Community-oriented momentum-based learning

I now proceed to show how the desiderata listed in the previous section are met by a model of initiation and incrementation based on the hypothesis that learners are community-oriented (i.e. rejecting individual idiosyncrasies) and momentum-based (i.e. sensitive to differences in the use of linguistic variables across age-groups).

This model implements the key insight of Janda & Joseph's (2003) "big bang" theory: the mechanism that brings new variants into being is not the same as the mechanism that initiates and sustains the incrementation of their use. In particular, I assume that new sound patterns are created by phonologization through Ohalian correction failure; later developments in the life cycle of those patterns (Figure 2) involve input restructuring (Bermúdez-Otero 2015: 382-388). However, whilst correction failure and input restructuring create new variants, they are not responsible for incrementing their level of use; as we shall see presently, that task is performed by momentum-based learning. This division of labour explains why error fails to accumulate inexorably under the effect of the permanent biases that cause innovation (cf. §2.1).

I follow Labov (2014a, 2014b) in assuming that language acquisition is community-oriented. This means that learners seek to internalize the collective norm as reflected in their experience of language use in the community. Accordingly, learners reject variants that they perceive as individually idiosyncratic. The most dramatic example of this ruthless suppression of individual deviation is found in children's rejection of features of parental speech that fail to match the local dialect. Labov provides a long list of instances of this phenomenon: for example, children in new towns like King of Prussia just outside Philadelphia (Payne 1976) and Milton Keynes in England (Williams & Kerswill 1999) abandon their parents' diverse dialects and converge upon the local norm; similarly, Labov (2006) found no significant differences in variable use between second-generation and third-generation New Yorkers on the Lower East Side, even though the former had non-native parents.

Community-oriented learning is consistent with the fact that preadolescent children are conservative in their use of variables (Figure 4). This reflects the fact that, early in life, their linguistic experience is limited and dominated by the speech of their immediate caregivers. In later childhood and adolescence, however, learners gain much wider exposure to the speech community: in urban areas of developed countries, in particular, this is often facilitated by attendance at large schools. This wider

socialization into the community enables learners to build more detailed mental representations of the community norm.

A second assumption of the model is that the learner's mental representation of the community norm comes to include an age vector: in other words, children and adolescents internalize knowledge of the differences in variable use between age-groups in their community (Labov 2001: ch. 14; 2010: 195-195, 344, 369). Crucially, adolescents retain sufficient linguistic plasticity to enforce this age vector in their own speech. To understand this, consider children socialized into a speech community undergoing sound change. As their social experience widens, those children find that their own use of the relevant variant matches that of adults but falls below that of adolescents (see Figure 4 again). As they grow, therefore, the children increment their use of the variant in the direction of the older cohort of adolescents. When the members of that older cohort reach adulthood, they undergo a decline in linguistic plasticity, and so their use of the variant levels out. The adolescents in the younger cohort, however, remain plastic and so are able to sustain incrementation. Indeed, their mental representations of the age vector require them to do so: the older cohort are now adults, and the adolescents' internalized knowledge of the community norm demands that they should use the variant at a higher rate than adults. The result is that, by age 17, the younger cohort reach a peak beyond that of the older cohort, only then to see their own linguistic plasticity decline.³

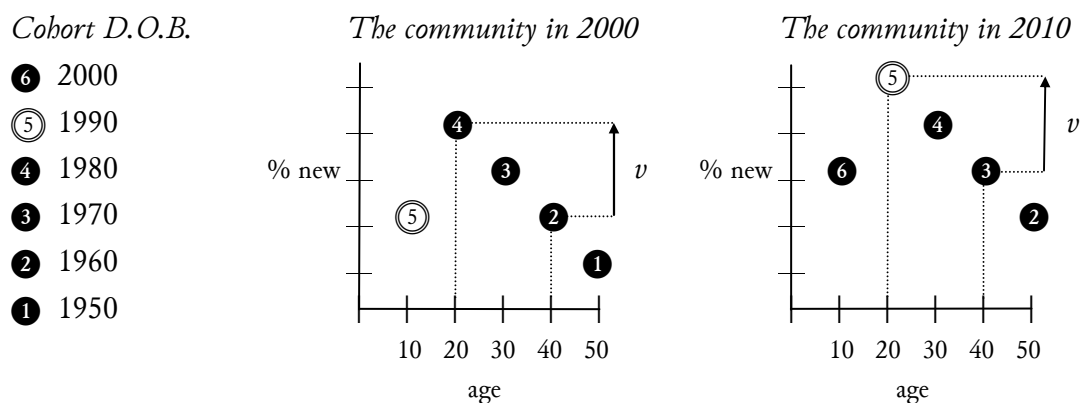


Figure 5: Cohort ⑤ enforces the age vector during adolescence, causing incrementation.

Figure 5 provides a schematic representation of the age vector in action. Successive cohorts are identified by numbered circles; their dates of birth are shown on the left-hand side column. The diagrams in the middle and on the right-hand side provide snapshots of the community at two points in real time separated by a ten-year interval. In the year 2000, the children of cohort ⑤ are ten years old: they internalize an age vector v , encoding the community pattern whereby late adolescents (cohort ④) use the new variant more than adults (cohorts ③ and ②). By 2010, the members of cohort ⑤ are twenty

³ A decline in linguistic plasticity during adulthood is also crucial for Baxter & Croft (2016), but their account of the adolescent peak is otherwise very different. Baxter and Croft assume that incrementation is driven by the “differential social valuation of variants by speakers” (2016: 133). The precise nature of this valuation is not specified, but various forms of social meaning would fit the bill: see Blythe & Croft (2012: 272-273); cf. §3 below. In this sense, Baxter and Croft interpret the adolescent peak as an *effect* of the incrementation mechanism, whereas, in an account driven by the age vector, the adolescent peak is the *cause* of incrementation.

years old: the use of the new variant by cohort ④ has not changed in adulthood, whereas cohort ⑤ have performed incrementation during adolescence, so that their distance from older adults (cohorts ④ and ③) complies with v .

This account of the incrementation of sound change belongs in the general class of momentum-based selection models. The term *momentum* is due to Gureckis & Goldstone (2009), who use a model of this type to explain the historical evolution of parental choices for children's first names (see also Lieberman 2000, discussed in Labov 2010: 194-195). Mitchener (2011) and Stadler et al. (2016) conduct mathematical and computational explorations of momentum-based selection in language change: Mitchener's model is driven by apparent-time momentum, like the account proposed here, whereas Stadler et al.'s model relies on real-time input, but both produce qualitatively similar dynamics. Stadler (2016) provides further discussion, assessing the evidence for speakers' knowledge of the momentum of sociolinguistic variables. One of Stadler et al.'s (2016) most important results is that momentum-based learning produces monotonic incrementation and S-shaped curves reliably. The emergence of sigmoid trajectories is due to the fact that a variable's momentum, reflected in the size of the age vector acquired by the learner, does not remain the same as the change advances in real time: in consequence, incrementation need not be linear. Indeed, Stadler et al. (2016) demonstrate that momentum-based learning gives rise to S-shaped changes under a very broad range of conditions: their model includes a parameter b which modulates the effects of the variable's momentum on the learner's acquired level of use; when $b \geq 1$, sigmoid trajectories occur systematically.

The most appealing property of community-oriented momentum-based learning is that it predicts the existence of sporadic localized bifurcation. Recall that the factors that drive innovation are permanently active (§2.1). In consequence, individual innovations occur continually at a basic rate determined by the strength of the relevant biases and their interactions. Community-oriented learners, however, reject individual idiosyncrasies. As a result, the vast majority of innovations fail to undergo incrementation and to propagate: a learner will reject an innovation, even if it is carried by more than one individual in his or her social circle, as long as it is perceived as a randomly scattered deviation from the community norm. Incrementation begins only if the learner's encounters with individuals carrying the innovation are accidentally skewed by age in the right direction: if this accidental skew is sufficiently strong, the learner sets up an age vector and incrementation begins. As Mitchener (2011: 395) puts it, "the mechanism of these spontaneous changes is that[,] every so often, children pick up on an accidental correlation between age and speech." Similarly, Stadler et al. (2016: 188) describe change as "self-actuating" in a momentum-based model.

Indeed, an account combining community orientation and sensitivity to momentum is eminently well-suited to generating sporadic localized bifurcations: isolated and randomly distributed innovations are actively repressed; innovations that accidentally cluster in a pattern inversely correlated with age are not only adopted but also actively incremented by the learner. It should be noted, moreover, that the role of accidental age-skewed distributions in this account of initiation does not render all changes equiprobable; on the contrary, the probability of random fluctuations creating such a skew in the linguistic experience of a group of learners is very much dependent on the basic rate of innovation (see the discussion of "symmetric selection of asymmetric innovation" in Stadler 2016: ch. 6). Thus, community-oriented momentum-based learning preserves the results of Ohala's theory of

innovation concerning the relative crosslinguistic frequencies of different types of sound change, and it has no difficulty incorporating the insights of competing-motivations models concerning phonological typology (cf. §2.1, §2.3).

2.5. Possible roles for subpersonal individual differences

I have argued that community-oriented momentum-based learning is the mechanism that drives localized bifurcations and intergenerational incrementation in sound change. This means that subpersonal individual differences do not hold the key to the problem of sporadic and localized change, but does not imply that they have no effect on how phonological innovations start and spread. On the contrary, the scenario proposed here is compatible with a broad range of hypotheses asserting that subpersonal individual differences play a modulating role in processes of initiation and propagation.

In one set of scenarios, for example, the prevalence of a certain individual trait within human populations may be one of the causal factors that set the basic rate of a certain type of innovation and so contribute to determining the crosslinguistic frequency of a certain type of sound change. In this way, the distribution of the relevant individual trait may come to affect the likelihood of languages' acquiring or losing a particular phonological property: i.e. it may affect the ingress or egress probability of that property (Kauhanen et al. 2018, formalizing ideas in Greenberg 1978, 1995). For example, the presence of clicks in the phonemic inventory of a language is a canonical example of a feature with low ingress and low egress probabilities: phonemic clicks are innovated rarely, but, once present, they are highly stable (Greenberg 1995: 152). According to Dediu et al. (2017), the ingress probability of phonemic clicks may be partly conditioned by inter-individual variation in alveolar ridge prominence. If that is the case, alveolar ridge prominence presumably works its effects by modulating the likelihood of individuals' initiating or participating in the change, whilst the emergence of an age vector remains crucial for localized bifurcation and incrementation to take place.

Another possibility is that, although anyone can behave as an initiator or propagator of change, some individuals are more likely to perform those roles than others, either because their perceptual styles make them more likely to hypocorrect (§2.1), or because their social skills increase their relative density of communication (§3): see again the description of Yu's (2010, 2013) proposals in §1.1. So far, empirical work on the leaders of ongoing sound changes has failed to provide clear support for this hypothesis. According to research cited by Tamminga (2016b), for example, which speakers lead one particular change in a community is a poor predictor of which speakers will lead another change taking place at the same time in the same community. Tamminga's (2016b) own study of Philadelphia suggests that covariation does not improve if sociolinguistic variables are sorted into different types (e.g. advancing vs retreating changes). Further, Tamminga (2016a) shows that leadership in preconsonantal /eɪ/-raising in Philadelphia does not meaningfully correlate with personality traits such as empathy, nonconformity, or susceptibility to linguistic convergence in shadowing experiments.

The situation described by Tamminga could come about in either of two ways. It could be that different people lead different changes because each change is associated with its own highly specific indexical field (Eckert 2008), so that leadership depends on individual identity and agency. Or

it could be that leadership in specific sound changes depends not so much on individual speaker characteristics as on the topology of the social network: more specifically, on how a speaker is positioned in the network, and on what region of the network the change irradiates from. The choice between these two alternatives is explored in the next section, which provides evidence in favour of the second scenario.

3. Macroscopic patterns of propagation

3.1. Density of communication vs social meaning

As we saw in §1.1, individual speakers' personal attitudes may affect their use of linguistic variants: see Eckert & Labov (2017: 5-14) for a review of the evidence from production. At the same time, some linguistic variables acquire social meaning, which can be detected in perceptual studies, notably by means of the matched guise technique (Lambert et al. 1960): see e.g. Campbell-Kibler (2006). I take these to be established empirical facts. But how far do their consequences reach? In particular, to what extent should we incorporate social indexicality into models seeking to explain general macroscopic facts about the propagation of sound change?

Views on this question vary widely. Some scholars are relatively circumspect: for example, Roberts (2016) observes that, among young speakers, life plans can affect linguistic usage even before they are put into practice, and on this basis she concludes that individual variation has an irreducible attitudinal component that cannot be explained mechanically in terms of interpersonal contact; these attitudinal factors, she implies, can have macroscopic effects, but she does not state how large or how pervasive. In contrast, Labov's (2002: 281) review of Eckert (2000) highlights the existence of much bolder claims, according to which social meaning is crucial both to intergenerational incrementation and to the orderly propagation of innovations across urban areas. In this view, changes would not be observed to spread as they do at the community level were it not for the stylistic agency of individual speakers expressing their stances through variable use.

In this section I raise a number of objections to these stronger claims. First, I will argue that the limited granularity of sociolinguistic evaluation and the predominantly oppositional nature of social meaning cast doubt on the hypothesis that indexicality drives the intergenerational incrementation of ordinary sound changes advancing monotonically to completion (§3.2). Then I will present evidence that macroscopic patterns of propagation, including class stratification (§3.3), curvilinear propagation (§3.4), and even change reversals (§3.5), can often be adequately explained mechanically in accordance with Bloomfield's (1933: 46ff) principle of density of communication (Labov 2001: 19-20; Trudgill 2008, 2014). The overall picture is one where individual identity and agency produce small-scale effects, whilst community-level distributions are often largely determined by supra-individual demographic factors.

3.2. General considerations about social meaning: granularity, oppositionality

The first problem we encounter is methodological. Assuming that we can somehow control for automatic accommodation, we can estimate the relative effect of style on production by comparing an individual's usage across different social settings (e.g. Eckert & Labov 2017: 5-10). It is far more difficult, however, to determine the extent to which an individual's (or a social group's) overall mean level of use of a variant depends on the social meaning of the latter. This is in part because an individual's position in the community's spectrum of variation will reflect the combined effects of both attitudes and exposure, but the two are hard to disentangle, as people with different attitudes socialize in different ways, and vice versa (Pierrehumbert 2016: §3.3): a high-schooler's stance in respect of higher education, for example, will affect his or her stylistic practice, but also the composition of his or her social network (cf. the discussion of Roberts 2016 in §3.1). In consequence, it should not come as a surprise that, in statistical analyses of variation at the community level, attitudinal variables can exhibit a strong linear relationship with demographic variables like class (Baranowski 2017: 328-329). This collinearity is further explored in §3.3 below, which also discusses the case of sociolinguistically exceptional individuals (Eckert & Labov 2017: 12-14).

The second problem is both methodological and substantive. It arises over the fact that, as noted in §3.1, social meaning can be detected directly in perception (e.g. by means of matched guise experiments) and indirectly in production (e.g. by analyses of style-shifting). It turns out, however, that these two procedures do not necessarily converge on the same result. Notably, Haddican et al. (2013) relied on production data to infer the indexical values associated with the fronting and diphthongization of /u:/ and /o:/ in York, but Lawrence (2017) found a poor match between these indexical values and the social meaning that York listeners assigned to the variables in a perceptual task. One possible account of this mismatch (Hall-Lew 2017) is that it reflects the personal stylistic agency of the participants in Lawrence's experiment: the hallmark of indexical value would be its "mutability" because individuals are constantly "reinterpreting variables [...] in a continual process of bricolage" (Eckert 2012: 94). Adopting this account, however, is tantamount to conceding the argument of this section: if personal stylistic agency causes social evaluation to diverge from community-level production patterns, it can hardly be the main cause of those patterns.

Indeed, the social evaluation of variants is often either too fine-grained or too coarse to serve as the engine of propagation of ongoing change. For example, Labov (2002: 281-283) and Eckert & Labov (2017: 22-23) cite the case of the Northern Cities Shift, a large-scale pattern that involves a set of five vowel phonemes rotating in phonetic space. Observations of speakers' stylistic practice indicate that social meaning attaches to the realizations of single phonemes or, at most, of pairs of adjacent phonemes. This is consistent with the fact that, in areas where the shift is propagated mainly by contact between adult speakers, such as the St. Louis corridor, the pattern spreads only in a fragmentary fashion (Labov 2007: §4). In the Inland North, however, where the shift advances by intergenerational incrementation in the course of language acquisition (§2.3), the integrity of the pattern is highly preserved (Labov 2007: 372, 375, 378). This would come as a surprise if

intergenerational incrementation itself were propelled by indexicality, rather than by momentum-based learning (§2.4).

Just as the granularity of social meaning is too fine to drive the incrementation of the Northern Cities Shift in the Inland North, it is too coarse to account for ongoing shifts in the use of Velar Nasal Plus in North West England. This phenomenon consists of the conservative realization of etymological *ŋg* as [ŋg] rather than [ŋ] in positions where it is not followed by a vowel belonging to the same stem-level domain, so that *si*[ŋg]-*er* rhymes with *fi*[ŋg]*er* (Bermúdez-Otero 2011: 2020–2025; Bermúdez-Otero & Trousdale 2012: 697–699). In a recent matched-guise experiment, Bailey (2018) found that Velar Nasal Plus is becoming available to carry social meaning: older speakers exhibit identical responses to [ŋg] and [ŋ] guises, but younger speakers show an incipient evaluative distinction. At the same time, sociolinguistic interviews show an increase in the use of [ŋg] in apparent time (Bailey submitted). It transpires, however, that the ongoing incrementation of Velar Nasal Plus is not driven by its incipient indexicality: natural and laboratory data reveal that this incrementation is strictly confined to prepausal position (Bailey submitted), whereas social evaluation attaches to the [ŋg] variant in all contexts, including those in which the variable remains stable (Bailey 2018).

Finally, sociolinguistic and ethnographic studies of the social meaning of linguistic variants often highlight their oppositional value: as we saw in §1.1, the inhabitants of Martha’s Vineyard use centralized diphthongs to signal a commitment to the island’s traditional way of life and a rejection of the influence of newcomers from the mainland (Labov 1963), and the replacement of neutral tones with full tones by Beijing yuppies indexes their positive stance towards the cosmopolitan culture of Hong Kong in contrast with the perceived insularity of state managers (Zhang 2005). Thus, Eckert (2012: 98) emphasizes how the personal stylistic agency of speakers manifests itself in “lifelong projects of self-construction and *differentiation*” (emphasis mine). However, the predominantly oppositional character of social meaning suggests that indexicality cannot be the primary driver of propagation in the case of ordinary sound changes undergoing monotonic incrementation to completion, for in such situations the lagging groups end up converging with the leading groups.⁴ If oppositional indexicality drove propagation, one would at least have to ask why we do not see more cases of arrested incrementation ushering in stable linguistic polarization.

Let us suppose that this problem can be circumvented by positing an additional mechanism that depolarizes the social evaluation of the variable and brings the lagging groups up to the level of use of the leading groups. Such a scenario still predicts that interspeaker variation will increase in magnitude during the initial phase of the change, as propagation gathers momentum under the effect of oppositional indexicality. This prediction, however, is in direct conflict with the empirical evidence currently available. The relevant information is not abundant: as Fruehwald (2017b) notes, many studies of ongoing sound change follow the variable’s central tendency over time, but few track the evolution of its dispersion. Using data from the PNC, however, Fruehwald (2017b) monitored intra-

⁴ Blythe and Croft (2012) argue that changes will not normally follow S-shaped trajectories unless variants are subject to differential social valuation (see note 3 above). As we saw in §2.4, however, momentum-based learning suffices to generate S-curves reliably (Stadler et al. 2016). See also Kauhanen (2017) for germane discussion.

and inter-speaker variance during the incrementation of prefortis /aɪ/-raising and preconsonantal /eɪ/-raising in Philadelphia from the late 19th to the late 20th century. Crucially, he found that, for both variables, intra- and inter-speaker variance remained stable during this period: see the schematic representation in Figure 6. This observation rules out oppositional indexicality as the main engine of incrementation of sound change.

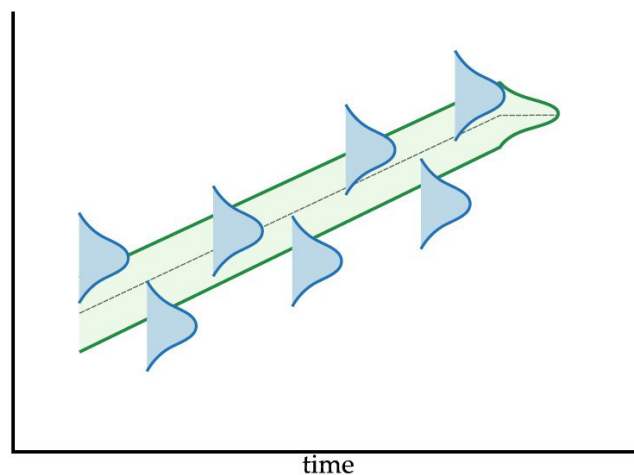


Figure 6: Intra-speaker variance (blue Gaussians) and inter-speaker variance (green Gaussian) remain stable during the incrementation of sound change; the dashed line represents the variable's central tendency at the community level (Fruehwald 2017b).

The situation may be illuminated by an analogy, somewhat similar to a comparison proposed by Labov (2002: 283). An ordinary sound change undergoing monotonic incrementation to completion may be likened to a large swell wave coursing through the open sea: its origin, amplification, and propagation from a distant fetch of ocean are like the initiation and incrementation of sound change driven by community-oriented momentum-based learning. In contrast, the short-wave roughness on the surface of the swell is caused by local winds; this is like the effect of personal identity and agency on the ongoing change. Both phenomena are real, interesting, and important,⁵ but they operate at measurably different scales and are to a significant extent causally independent from each other.

Pursuing these arguments, the following sections provide empirical evidence of macroscopic patterns of propagation that are best explained mechanically by the principle of density of communication, rather than in terms of social meaning.

⁵ Sea waves of every length, from tides through swell down to capillary waves, as well as their interactions with one another and with atmospheric activity, are all flourishing fields of research in fluid dynamics, oceanography, meteorology, and related disciplines.

3.3. Class stratification

One of the most salient phenomena in the propagation of sound change is stratification by class: since Labov's seminal study of New York City in the early 1960s, this observation has been replicated time after time (Labov 2006: 397). But what causes class stratification: density of communication or social meaning? A number of conceptual arguments suggest that the role of density of communication is primary and dominant.

At the birth of a variable, sociolinguistic differentiation must precede sociolinguistic evaluation both temporally and causally. If a variant were distributed uniformly across the speech community, it would have no indexical value and so could not acquire social meaning. Differences in the social distribution of variants must thus arise first by mechanical means (Labov 2006: 397). This is easily explained on a background of neutral propagation by probability matching (Labov 1994: 580-583; see also Kauhanen 2017: §2). As proposed in §2.4, the locus of initiation, where incrementation begins, consists of a small set of learners who acquire an age vector upon exposure to an accidental pattern of age-skewed variation. Subsequently, other speakers in the larger community become exposed to the change in inverse proportion to their status distance from the locus of initiation, simply because average density of interaction decreases with distance on the status scale. This mechanical effect endows the innovative variant with first-order indexicality (Eckert 2008: 463, after Silverstein 2003), which can come to be cognitively represented in the minds of some members of the community. Once we have reached this stage, further developments become possible: knowledge of the variable's value as a first-order index may lead some speakers to endow it with additional social meanings, and those speaker's productions may accordingly start to display attitudinal effects.

Moreover, it seems reasonable to expect that, in a large proportion of cases, those attitudinal effects may at most amplify, but will not qualitatively alter, the pattern of class stratification created mechanically by density of contact. This is because attitudinal variables often exhibit strong linear relationships with status. This appears to be true, in particular, of the two important types mentioned in §1.1: attitudes to local traditional life-styles and attitudes to education. In Eckert's (1989, 2000) study of Belten High, for example, jocks, characterized by their educational aspirations and cooperative relations with teachers, came mostly from the upper half of the local socioeconomic hierarchy, whilst burnouts came mostly from the lower half (Eckert 2012: 92).

In sum, class stratification is one of the most salient facts about the propagation of sound change. The arguments we have considered so far suggest that it emerges mechanically from the impact of socioeconomic distance on density of communication; the effects of personal identity and agency are causally secondary and smaller in scale.

Baranowski's (2017) study of GOOSE- and GOAT-fronting in Manchester provides strong empirical support for this conclusion. Unlike the majority of English dialects, Manchester shows advanced fronting of /u:/ before coda /l/, as in *school* and *pool*. The variable is stable in apparent time and exhibits strong stratification by class: the speakers' degree of /u:/-fronting before /l/ correlates inversely with their socioeconomic status (Figure 7).

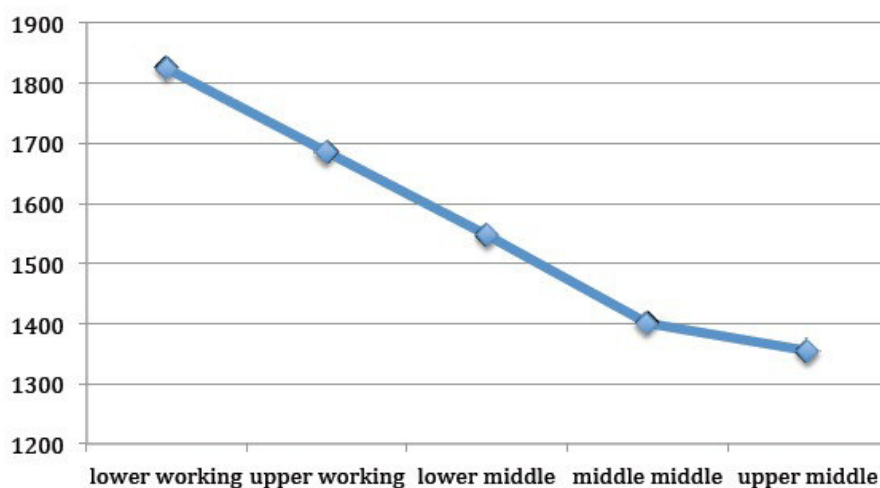


Figure 7: Class stratification of pre-/l/ /u:/-fronting in Manchester. The y-axis indicates F2 in Hz. (Courtesy of Maciej Baranowski.)

Unusually, Baranowski’s study directly compared the effects of socioeconomic status and those of attitudes to Manchester. Status was operationalized in terms of occupation (Baranowski 2017: 303). Attitudes to Manchester were operationalized in terms of the responses to questions such as “how Mancunian do you feel?” (Baranowski 2017: 326). As expected, attitudinal scores displayed a fairly large correlation with status, but not so strong as to prevent both variables from being entered into the same mixed-effects linear regression (Baranowski 2017: 328, 330–331). Baranowski ran three regressions with the F2 of GOOSE before /l/ as the the dependent variable: the first included status as a predictor, but not attitudes; the second included attitudes, but not status; and the third included both. The first model outperformed the second according to both the Akaike information criterion (AIC) and the Bayesian information criterion (BIC). Crucially, the third, more complex, model did not emerge as a clear winner over the first: it was favoured by AIC but not BIC. In this light, “we cannot confidently conclude that adding attitudes to social class improves the explanation of the variation” (Baranowski 2017: 331). In the case of GOAT-fronting, which also displayed strong class stratification, the results were even clearer: an ANOVA comparison showed that a model including both class and attitudes was not significantly different from one with class alone.

As Baranowski (2017: endnote 13) acknowledges, a critic might object that a different selection or operationalization of attitudinal variables might have resulted in a bigger effect of attitudes. Note, however, that this argument cuts both ways: the operational definition of class is itself not trivial, and so, had the effect of attitudes proved significant, an opponent might just as well have objected that this effect could disappear in a study using a better operationalization of class. All one can conclude from such prudential considerations, well motivated though they are, is that it would be highly desirable for many more studies like Baranowski’s to be conducted until the overall picture emerges clearly by simple preponderance of evidence.

In the meantime, it is useful and enlightening to pursue the implications of the hypothesis that many, perhaps most, sociolinguistic variables behave like GOOSE and GOAT in Manchester. This scenario invites us to consider in greater depth the following question: why is there such a strong

correlation between status and attitudes, and why does status outperform attitudes as a predictor of variation? The conceptual considerations explored at the beginning of this section suggest a plausible answer. First, status exerts a causal effect upon attitudes: for example, parental occupation and income partially determine the chances of an American student becoming a jock or a burnout. In consequence, status shapes linguistic variation both primarily through the mechanical effects of interpersonal contact and secondarily through its effect on attitudes. Figure 8 represents a subset of the relevant causal relations.⁶

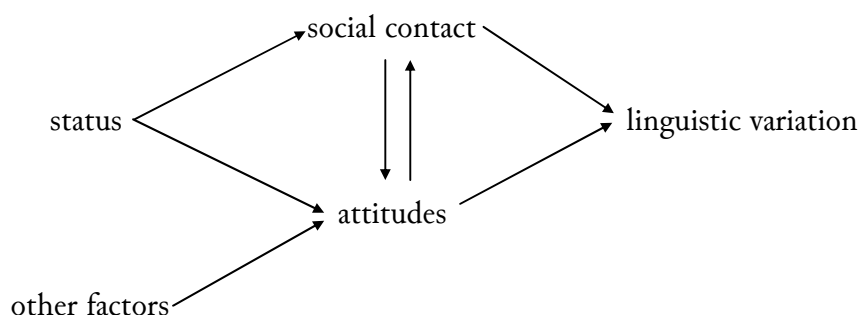


Figure 8: Status and attitudes in the chain of causation of linguistic variation.

This depiction of the causal chain is fully compatible with the existence of sociolinguistically exceptional individuals and with the possibility that many of them owe their exceptionality to their personal stylistic agency (Eckert & Labov 2017: 12–14). Those exceptional speakers may be expected to exert a limited influence on the community pattern anyway. First, a few special cases contribute far less to the average than the mass of the ordinary. Secondly, and more importantly, the community-oriented learner, like a statistician suspicious of outliers, actively rejects individual idiosyncrasies (Labov 2014a, 2014b, and see again §2.4 above).

3.4. The curvilinear pattern

A special case of class stratification is the curvilinear pattern (Labov 1972: 294–295; 2001: 31–33, 171–172), in which an ongoing sound change is led by the social classes that occupy the interior of the socioeconomic hierarchy, whilst the lowest- and highest-status groups lag behind. Figure 9 illustrates this phenomenon with data from the *cot-caught* merger in Charleston (Baranowski 2013): the loss of the contrast is led by the lower and middle segments of the middle class (LM and MM), whilst the working (WC), upper-middle (UM), and upper (UC) classes are relatively conservative, exhibiting higher distinction scores.

⁶ Note that Figure 8 represents interpersonal contact and attitudes as mutually dependent. This is because, as we saw in §3.2, people with different attitudes socialize in different ways and, in turn, socialization patterns shape attitudes.

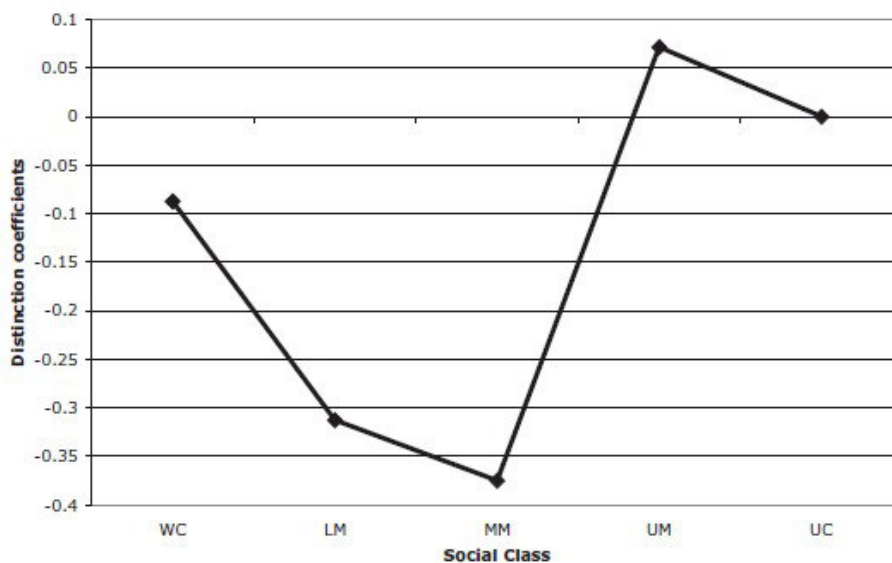


Figure 9: Curvilinear pattern of the *cot-caught* merger in Charleston.
(Courtesy of Maciej Baranowski.)

The curvilinear pattern is very commonly observed in sound changes fulfilling two requirements: first, they operate below the level of social awareness; secondly, they are in progress, advancing rapidly by intergenerational incrementation. The *cot-caught* merger in Charleston fits this description exactly. It does not elicit overt comments (Baranowski 2013: 288, 291), and it displays the expected distribution in apparent time: distinction scores rise smoothly with age among speakers up to 50, and older speakers retain the contrast (Baranowski 2013: 275). In this respect, the *cot-caught* merger stands in stark contrast with a similar ongoing change in Charleston: the *pin-pen* merger. The latter also shows vigorous incrementation in apparent time, but it operates above the level of social awareness, prompting overt remarks from speakers (Baranowski 2013: 287). Significantly, the *pin-pen* merger fails to conform to the curvilinear pattern, instead displaying an inverse monotonic correlation with socioeconomic status (Baranowski 2013: 282-283, 291).

Why should it be the case that sound changes are likely to follow the curvilinear pattern while they are in progress if they operate from below? Labov (2001) contemplates two possibilities. One is purely mechanical: the curvilinear pattern is created by density of communication (Labov 2001: 191-192). The other involves covert social meaning: changes are led by members of the interior status groups because these are in the best position to “display the symbols of nonconformity in a larger pattern of upward social mobility” (Labov 2001: 516-517). A strong argument favours the first of these two answers: changes from below tend to exhibit curvilinear propagation because this is the pattern most likely to arise mechanically from the topology and dynamics of the social network.

Support for this assertion may be found in Kauhanen’s (2017) mathematical and computational exploration of neutral change, i.e. change propagated by probability matching in the absence of social evaluation. Kauhanen demonstrates that neutral change exhibiting realistic patterns of propagation (§2.3) occurs spontaneously in a network if the latter satisfies two properties, one topological, the other dynamic. First, the network must be strongly clustered: some nodes occupy a relatively central

position by virtue of having a large number of connections; other nodes have fewer connections and so count as more peripheral. Secondly, the network must undergo rewiring: periodically, some nodes are removed, and others are created. Crucially, neutral change in such a network will typically irradiate from the centre: over time, propagation is easy from the centre to the periphery, but hard in the opposite direction (Kauhanen 2017: 349–351).

Admittedly, Kauhanen conceives of the nodes in his model as individual speakers, but extrapolating his results to a coarser level of granularity leads to an interesting scenario. If nodes consist of groups of speakers of similar socioeconomic status, then middle-status nodes are more likely than high- or low-status nodes to occupy central positions in the network (in the technical sense). This is because, with density of communication falling in direct proportion to status distance, only intermediate-status nodes are likely to have strong connections with other nodes throughout the social scale. Accordingly, propagation is more likely to be successful precisely for those innovations that originate in the intermediate-status groups. If this extrapolation is correct, the curvilinear pattern is the hallmark of mechanical propagation in a social network clusterized by class.

3.5. Change reversal

I have argued that many macroscopic patterns of propagation submit to largely mechanical explanations. In such cases, attitudinal variables may have significant small-scale effects, but the large-scale evolution of the community depends mainly on supra-individual topological properties of the social network, notably density of communication as determined by demographic variables such as class. As highlighted in Hall-Lew (2017), however, the acid test for this approach to propagation lies in accounting for scenarios of change reversal, in which the use of a variant starts to decline after a period of consistent growth. Labov et al.'s (2013) survey of twentieth-century Philadelphia highlights two cases: /au/-raising and /ou/-fronting, both led by women in the first half of the century, went into reversal in the second half.

Change reversal is problematic because, according to the model of momentum-based learning outlined in §2.4 above, intergenerational incrementation, once initiated, is self-sustaining. Crucially, however, the model also predicts that incrementation may cease and even go into reverse if, for any reason, a new cohort of adolescents comes to be exposed to a community pattern in which the use of the innovative variant by adults no longer decreases monotonically with speaker age. Such a situation can be brought about by population changes (e.g. migration) or changes in network topology (e.g. shifts in class segregation). In a simple scenario, for example, the arrival of a large contingent of young immigrants of working age lacking the local variant may invert the age vector acquired by the current adolescent cohort.

What role, if any, population or network topology changes may have had in the reversal of /au/-raising and /ou/-fronting in Philadelphia is at present unclear (Labov et al. 2013: 51–52, 59–60). However, an instance of reversal in which population change was demonstrably decisive, in combination with network topology, is the retreat from the Southern Vowel Shift in Raleigh, North Carolina. In this case, the reversal was triggered by an influx of white-collar workers from the North

and was crucially facilitated by social segregation by status, as affluent local residents and their children interacted more frequently with affluent Northern immigrants than with the local working-class population (Dodsworth & Kohn 2012). This confirms that, as Hall-Lew (2017) argues, the reversal of sound change is impossible in the absence of social change. It is, however, quite feasible for the relevant social change to operate mechanically, while attitudinal variables add small-scale effects.

4. General discussion

4.1. Idealization and the explanation of sound change

As we have seen, the debate on the role of individual differences in sound change bears on major issues of substance, such as the triggers of localized bifurcations (§2.1, §2.4), the forces driving S-curves (§2.3, §2.4), the causes of class stratification (§3.3) and curvilinear propagation (§3.4), and the factors that govern the ingress and egress probabilities of typological properties (§2.5). There is also, however, an important methodological question at stake: namely, the proper use of abstraction and idealization in historical linguistics.

Since the 1960s, Labovian sociolinguistics has significantly improved our understanding of sound change. This progress has been achieved largely by dispensing with idealizations that—however well-motivated and productive in the pursuit of different research questions—concealed the mechanisms whereby innovations are implemented, incremented, and propagated. Chomsky’s (1965: 3) ideal speaker-hearer, for example, is a useful tool in research whose main goal is to ascertain the generative capacity of the human faculty for language and to solve Plato’s Problem. One must give it up, however, if one’s goal is to understand how sound change is implemented: the fundamental question of lexical regularity vs diffusion, for example, could not be put on a firm empirical footing until the arrival of quantitative variationist sociolinguistics (Labov 1981). Similarly, Andersen’s (1973: 767) Z-model of change (Figure 10) is a reasonable and helpful idealization if one’s purpose is to develop a model of reanalysis as a mechanism of innovation. The Z-model, however, treats the child’s input as if it were produced by a single generation of adult speakers, and so it excludes the possibility of acquiring an age vector. It thus sets aside facts that are crucial to understanding incrementation—at least if the proposal of momentum-based learning outlined in §2.4 above is broadly correct.

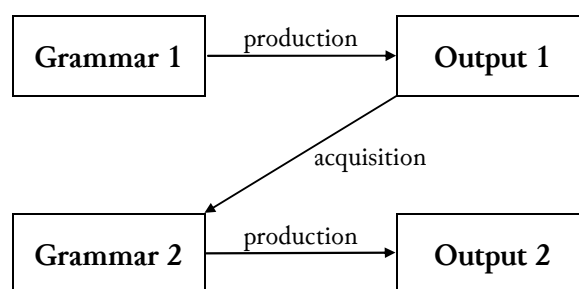


Figure 10: The Z-model of innovation (adapted from Andersen 1973: 767).

In this light, it may seem reasonable to expect that, every time we roll back abstraction and idealization in the study of sound change, we will receive an immediate pay-off in the form of models of greater explanatory power and that, accordingly, greater attention to individual differences between speakers can only lead to deeper and better explanations of the macroscopic facts of change.

An example from physics, however, suggests that this expectation is not well-founded. The macroscopic behaviour of gases is described in terms of properties such as temperature, pressure, volume, and amount of substance. Under certain conditions (chiefly high temperature and low pressure), the relations between these variables are excellently approximated by the ideal gas law, which is in turn derived from the microscopic behaviour of molecules by the kinetic theory of gases. Crucially, the latter shows that the temperature of a gas depends on the speed distribution of its molecules, but not on their positions or directions of travel. Modern versions of the theory, moreover, explain the circumstances under which factors like molecular size cease to be negligible. Historically, the discovery of the gas laws predates their derivation from the kinetic theory, whose initial assumptions were in turn only relaxed in later formulations.

This analogy suggests a number of methodological lessons that are directly relevant to the study of sound change (see also Kauhanen 2018). Choosing the right idealization is often crucial to making progress towards solving a scientific problem. In particular, successful accounts of macroscopic facts typically ignore much of the available information about the corresponding micro-states, precisely because a key measure of their explanatory success is the extent to which they incorporate only causally efficient factors. By the same token, our macroscopic models improve by the addition of microscopic variables only insofar as we can correctly track the effects of those variables. As we saw in §2 and §3, it is possible to overestimate the effects of individual differences on sound change.

4.2. Reasons to study individual differences

Even if most general macroscopic facts about sound change turn out to call for explanations that abstract away from individual differences, research into the latter is likely to illuminate a broad range of important questions. As we saw in §1.2, for example, widely accepted theories of sound change often assume that key physiological and cognitive traits are uniformly distributed among human beings; if variation in respect of those traits exceeded certain bounds, the theories would break down. For this reason, the study of individual differences provides a vital empirical check on the assumptions of models of change.

The limited role for individual differences in the explanation of sound change that I have proposed in this article is also consistent with scenarios where individual variation has a modulating effect on how innovations start and spread. As we have seen, it is entirely possible that variation in certain anatomical and cognitive traits across human populations may affect the crosslinguistic frequency of some types of sound change, thereby playing a role in determining the ingress and egress probabilities of particular typological features (§2.5). Similarly, more research is needed before we can conclusively decide whether individuals with certain cognitive styles and personality traits are more likely to be numbered among the leaders of change in progress (§2.5). And, even if covert articulatory

variation does not provide a general explanation for the sporadic and localized incidence of sound change, it nonetheless remains a plausible hypothesis about the mechanism of stabilization in the life cycle of some sound patterns: again, the question deserves to be pursued (§2.2).

Going further, research into individual differences may hold the key to certain phenomena that remain poorly understood at present, such as life-span change (cf. §2.3). Whenever a speaker's observable linguistic behaviour shifts in adulthood, we may ask whether this reflects a change in grammar, in attitudes, or in the physiological and cognitive mechanisms of speech, corresponding to Tamminga et al.'s (2016) categories of *i*-, *s*-, and *p*-conditioning. In cases where an adult's performance shifts away from the community norm, the cause is probably socio- or psycholinguistic. For example, MacKenzie (2017) reports that, between his thirties and his eighties, the broadcaster Sir Richard Attenborough increased his use of tapped /r/ in word-final prevocalic position, in opposition to the general pattern in British English. Since the change was confined to frequently uttered collocations, MacKenzie suggests that it does not reflect an update to Attenborough's /r/-tapping rule, but rather the accumulated effect of life-time experience on the structure of the stored representations of the relevant linguistic chunks. A similar process is probably at work in the more general pattern of age-grading that Guy & Boyd (1990) observed in the application of /t,d/-deletion to irregular weak verbs like *kept* and *told*.

In sum, there is no shortage of good reasons to study individual differences. This does not entail, however, that individual variation should be incorporated into theoretical models seeking to explain such macroscopic properties of sound change as the occurrence of localized bifurcations, the adolescent peak, monotonic incrementation, class stratification, curvilinear propagation, or even the existence of change reversals. In this respect, the study of sound change is not different from any other domain of scientific enquiry: for each explanatory task there is an optimal level of abstraction.

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Competing interests

The author has no competing interests to declare.

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