Labov, Sound Change, and Phonological Theory*

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Labov begins his landmark *Principles of Linguistic Change* with a volume on internal factors governing sound change (Labov 1994) that focuses on the CONSTRAINTS PROBLEM (Weinreich, Labov, and Herzog 1968): what changes are possible for a language in a given state? On the basis of typological data on sound changes and his research on ongoing change in English, he puts forward a set of principled constraints and generalizations, which the field will be building on for decades to come. Here I take up each of the four major theoretical themes of the book – the regularity hypothesis, mergers and splits, chain shifts, and functionalism – and explore the significance of Labov's findings for generative phonology, and the ways in which recent developments in phonological theory might help advance Labov's research program.

In a longer essay I would have tried to trace the remarkable trajectory from Labov 1963 through Labov 2007, 2010, 2014 and Labov, Rosenfelder & Fruehwald 2013 – five decades of sustained inquiry into the nature of sound change, of ever increasing methodological innovativeness, empirical insight, and theoretical depth. In the way it it integrates linguistic change with phonetics, phonological theory, and sociolinguistics, resolutely rejecting even the least vestige of any Saussurian gulf between them, as in so many other respects, Labov's work has been and remains well ahead of its time.

1 The regularity hypothesis

1.1 The arguments for regularity

Labov's (1981, 1994, 2014) studies of sound change in progress have provided decisive evidence for neogrammarian across-the-board sound change "as a phonetically driven process that affects all words in a phonologically defined set" (Labov 2010: 285), against the view that all sound changes proceed by lexical diffusion, and that regularity is just the final outcome of some of them (Chen & Wang 1975: 256, Bybee 2002, Phillips 2006, Hay et al. 2015). His *Atlas of North American English* shows largely regular sound change with no significant lexical effects: "The close study of these regular sound changes in progress reveals them to be just as Paul, Leskien, Osthoff, Brugmann, Saussure and Bloomfield describe them." (*ibid.*).

The existence of regular sound change finds compelling support in phonology itself. Every language has a system of phonemes with regularly distributed allophones. At least those sound changes which introduce new types of sounds must be regular in the neogrammarian sense, for

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otherwise there would be no compact and orderly phonemic systems: phonologies would be random collections of thousands of contrastive sounds accrued from irregular changes at various earlier stages. Moreover, if such a sound change could spread on a word-by-word basis, it would immediately create a new phonemic contrast between the words that have already undergone it and those which have not yet undergone it. The contrast would disappear again when the sound change has run its course through the vocabulary, or remain as a phonemic split if the change is interrupted. But that is not what happens. Ongoing sound changes do not show the temporary or permanent phonemic splits envisaged in these scenarios. As has always been understood, new phonemes do not arise by spontaneous fission; they arise when allophonic processes become opaque by an overlay of new sound changes (and of course through borrowing, diglossia, and dialect mixture). The postlexical phonological stratum posited in Lexical Phonology and Stratal OT provides a principled basis for regular sound change and the process of phonologization (Kiparsky 2015, Bermúdez-Otero 2007).

While this argument establishes the regularity of sound changes that alter the phonetic repertoire, it is not applicable to sound changes that produce only well-formed combinations of existing phonemes – call them STRUCTURE-PRESERVING sound changes. Significantly, it is from these that nearly all the evidence against the neogrammarian regularity thesis is cited. It would be odd if they were exempted from neogrammarian regularity, because there is nothing intrinsic about them that would make them susceptible to exceptionality. What is special about sound changes that comply with the structural constraints on the existing lexicon is that they can be lexicalized. This observation can be leveraged into a plausible explanation for their seeming proneness to exceptions. In fact, there are least two distinct well-documented mechanisms available for exactly this type of change that are fully compatible with the regularity hypothesis and offer a more restrictive and explanatory account of the apparent exceptions: early lexicalization of reduced forms, and lexical diffusion.

1.2 Early lexicalization

Even regular sound change can produce what *looks* like lexical diffusion as long as it leaves the phonological repertoire intact. If a sound change results in sounds that already exist in the language and fit into its phonotactics, these sounds can be lexicalized in individual words while the change is still in progress. For example, if you first encounter the expression *mashed potatoes* with the pronunciation *mash' potatoes* due to *-t -t-, -d*-deletion, you might add *mash potatoes* to your vocabulary. This looks superficially like sporadic sound change, or a "precursor" of *-t-, -d*-deletion. But obviously it is nothing of the sort. We know that *-t-, -d*-deletion is actually applicable across the board, and that *mash potatoes* is a lexicalization of a reduced pronunciation of it. An earlier such case would be *ice cream* from *iced cream*. Such lexicalization of reduced outputs takes place one expression at a time because learners acquire lexemes one at a time based on what they happen to hear around them. Therefore this mechanism can cause mergers and deletions to take an apparently irregular course. But this does not mean that the phonetic changes themselves are in any way irregular.

To repeat, though all change involves variation, synchronic variation by itself is not sound change. After a thousand years, a variation pattern does not necessarily look like the sound change that originally caused it. Synchronic variation, governed by frequency, morphological and phonological factors, style, social class, and gender, is compatible with the regularity hypothesis. Lexicalization of morphologically opaque outputs of structure-preserving processes and analogical retention or restoration of morphologically transparent forms are also consistent with it.

What would be problematic for the regularity hypothesis are exceptions to non-structure-preserving sound changes, which alter the realization of a phoneme rather than merging it with another or deleting it. For example, such changes as *u*-fronting or the retraction of *s*- in *str*- would not be candidates for early lexicalization because their outputs are not phonemic.

1.3 Lexical diffusion

If the lexicon is subject to phonological rules or constraints, as Lexical Phonology and Stratal OT claims, then lexical representations of individual items could be regularized to conform to the canonical or preferred distribution of phonemes in a given context. Such redistribution of phonemes in the lexicon on a word-by-word basis is arguably the basic mechanism of lexical diffusion (Labov 1994: 542, Kiparsky 1995). It characteristically eliminates marked values of marginally contrastive features (Bermúdez-Otero 2007).

The spread of DIATONES, verb/noun pairs with final stress on the verb and initial stress on the noun, such as *permít/pérmit, rejéct/réject, dischárge/díscharge, confóund/cónfound*, continues to be cited as a canonical case of lexical diffusion (Phillips 2006: 34, Sonderegger 2010, Sonderegger & Niyogi 2013). Diatones have steadily encroached on verb/noun pairs with fixed stress such as *retúrn, disgúst*, so that about 30% of eligible N/V pairs now alternate. This is obviously not sound change but the analogical spread of a morphological stress rule within the lexicon. The spread of accent retraction in non-derived nouns like *mustache, garage, massage, cocaine*, which does not extend an alternation, but simply regularizes the word's stress pattern, is a *nonproportional* counterpart of the same analogical process, which eliminates arbitrary specifications from the lexicon. For example, after [məˈstæʃ] is replaced by [ˈmʌsˌtæʃ], its exceptional primary stress on the final syllable need no longer be registered in its lexical entry, which simplifies the word's lexical representation. Like the accent retraction in diatones, it removes individual exceptions to the rule that nouns bear main stress on a heavy penult, just as the morphological regularization of *kine* to *cows* removes a lexical exception to the plural rule.

Phillips (2006) argues that the least frequent items join the class of diatones first. Recent studies conclude that phonological shape is much more important than frequency (Hotta 2013, Yang 2015). The more important predictor of stress shift, according to these researchers, is the difference in weight between the two syllables. Yang concludes that "diffusion is lexically gradual but the directionality of change is dictated by the productive rules of the grammar, while the role of lexical frequency appears minimal."

1.4 Micro-conditioning

Labov has found micro-conditioning in special narrowly delimited phonetic environments. A striking instance is the small class of words *great, break, drain* that begin with a stop+liquid cluster, which did not undergo the Tensing that fed the 18th century Second Raising (see (12) below) and instead joined the large class of Middle English /æː/. They are in fact not lexical exceptions, but "part of a recurring process in which allophones most strongly differentiated by coarticulatory effects are re-assigned to the neighboring phonemes" (Labov 2014, see also Labov 1994: 306).

Similarly, Labov (1994: 152, 239) notes six words with lengthened *e* before *r* that exceptionally did not raise to *ī*: the verbs *bear*, *wear*, *swear*, and *tear*, plus the nouns *pear* and *bear*, as opposed to *smear*, *spear*, *weir*, to which we can add *shear* and perhaps *gear*. He proposed that lengthened *e* before *r* did not merge with *ē*, but remained phonologically distinct with respect to the feature [peripheral]. It is worth noting, however, that four of the exceptions are the only strong verbs with a uniform $\bar{e} \sim \bar{o}$ backing pattern in the past tense (*shear* had become weak by this time). Perhaps this templatic strong verb pattern prevailed over the phonological process, as can be observed in many instances throughout the strong verb system (for example, strong verbs don't undergo lexical *æ*-tensing). Of course that still leaves the nouns *pear* and *bear*, but then the phonological solution creates its own exceptions *smear*, *spear*, *weir*, and *shear*. Either way, frequency plays no detectable role.

2 Mergers, splits, and contrast

Labov's discovery of near-mergers challenges some fundamental assumptions of phonology, particularly the concept of phonological contrast that is basic to phonemics. A phoneme is defined as a class of non-contrasting sounds, where contrast is defined in two entirely different ways. American structuralists defined it distributionally. Sounds were held to contrast in a given phonological environment if they are neither in complementary distribution nor in free variation in that environment, i.e. if the occurrence of either of them in a given context neither excludes nor implies the occurrence of the other in that context (Bloch 1953). Functionalist phonologists equated contrast with DISTINCTIVENESS, the potential of distinguishing utterances as revealed by minimal or near-minimal pairs and the commutation test. In Martinet's formulation (1964: 53), the function of "phonic elements of a language" ... "is distinctive or oppositional when they contribute to the identification, at one point of the spoken chain, of one sign as opposed to all the other signs which could have figured at that point if the message has been a different one."

Labov's work shows that these two conceptions of the phoneme do not converge: contrastive distribution and distinctiveness are not the same thing. One reason is that sounds which contrast in the distributional sense are sometimes perceptually indistinguishable or hard to distinguish. In NEAR-MERGERS, speakers produce an instrumentally measurable contrast that they cannot perceive reliably, either in the speech of other such speakers or when their own speech is played back to them. An example is the *source : sauce* opposition in some U.S. dialects (Labov 1994, ch. 12).[1] Phoneticians independently found that contextual neutralization can be incomplete (Port & O'Dell 1985, Port & Crawford 1989, Dinnsen 1985, Piroth & Janker 2004, Kleber & Harrington 2010). For example, some German speakers pronounce underlying voiced and voiceless obstruents differently in word-final position, but not differently enough to enable hearers to distinguish them reliably. Berber speakers consistently articulate initial and final geminate voiceless stops longer than singletons, as in *ttut* 'forget him' : *ttutt* 'forget her' : *tut* 'she hit', even though this articulatory difference has no audible effect (Ridouane 2007). These are non-distinctive contrasts.

Another reason for separating contrastiveness and distinctiveness is that distributionally non-contrastive, redundant features can contribute to signaling phonemic distinctions ("the identification of signs" in Martinet's words) and are in that sense phonologically distinctive, or QUASI-PHONEMIC. English vowels are about half as long before tautosyllabic voiceless consonants as before voiced consonants. The length difference originally due to a coarticulation effect has been

[1]Such near-mergers had been reported in the earlier dialectological literature, though their significance remained unappreciated. For example, DeCamp (1958) notes near-merger of *four* and *for* in what was then old-fashioned San Francisco speech; since then replaced by complete merger.

phonologized and enlarged, and now serves as a salient cue to consonant voicing, especially in final position where voicing is often suppressed. Non-contrastive but distinctive features are precisely the enhancements of lexical feature contrasts mentioned in 3.3 below. They can appear on the contrastive segments themselves or on neighboring segments. They can be more salient than the contrastive features they supplement, and historically more stable, often being precursors of new contrasts that arise by phonologization (Janda 1999, Ladd 2006, Bermúdez-Otero 2007, Scobbie & Stuart-Smith 2008).

Severing the link between the structural notion of contrastiveness and the perceptual notion of distinctiveness leaves us with not just phonemes and allophones, but four categories:

(1) Contrastiveness and distinctiveness

	contrastive	non-contrastive
distinctive	phonemes	quasi-phonemes
non-distinctive	near-mergers	allophones

Formally, the distinction between contrastiveness and distinctiveness can be characterized as follows. Two expressions contrast if and only if they are distinct in underlying (input) representations. Phonological derivations cannot differentiate identical inputs: they can enhance, neutralize, and displace contrasts, or translate prosodic or morphological differences into segmental oppositions, but they cannot create differences from nothing. Distinctiveness, on the other hand, is relativized to a derivational level. What levels are recognized depends on the theory: classical phonemics has two levels of representation, Lexical Phonology and Stratal OT has three: the stem phonology (level 1), the word phonology (level 2), and postlexical phonology. Underlying contrasts at one level can become enhanced at the next level by redundant features that help the hearer identify them, or conversely merge in the next level for greater ease of pronunciation. Theories that allow cyclic application or morphological conditioning allow for the creation of DERIVED feature contrasts which are not present in lexical representations. For example, Belfast dentalization, as in *win̪t̪er* vs. *printer*, is a derived contrast that is conditioned by the word-level boundary and thereby provides a cue to the morphological makeup of the word. Similarly British *holey* [hɒʊ.liː] vs. *holy* [hʌʊ.liː] is a morphologically conditioned derived contrast sensitive to the same boundary.[2] The point is that contrastiveness and distinctiveness are not just functionally distinct but have a different theoretical status in formal phonology.

The dissociation of contrastiveness and distinctiveness not only forces us to rethink the phoneme, but also sheds new light on sound change. Labov notes that near-mergers offer a way out of the problem that contrasts sometimes appear to merge by sound changes and then reappear as full-fledged contrasts at a later historical stage. The intermediate stage, he argues, is one of near-merger. And quasi-phonemic status may be a prerequisite for phonologization. The natural diachronic hypothesis is that all phonemes enter as quasi-phonemes and exit as near-mergers. That is, a segment becomes distinctive, then contrastive, then loses its distinctiveness, and finally merges with another.

[2]Borowsky 1993, Harris 1990, MacMahon 1991, Wells 1982:431, Kiparsky (in press).

3 Chain shifts

3.1 Questions

The non-mergers we call CHAIN SHIFTS are every bit as challenging as mergers, and Labov's brilliant contributions have raised our understanding of them to a new level. Chain shifts are sound changes that shift a sound and move another sound to the vacated position, leaving a new vacated position that may in turn be filled by another sound. Labov's work provides three arguments that such chains are not just fortuitous sequences of events on which we subjectively impose a pattern, like gamblers' streaks, but causally connected (1994: 119).[3] Chain shifts typically move along a single phonetic dimension, such as vowel height, consonant strength, and pitch level, although they may be initiated and terminated by "sideways" shifts. This coherent directionality points to causality rather than chance. In such movements the logically separate steps cause no gross disruption of the symmetry and dispersion of the phonological system at any stage; in the vowel shifts we'll look at they appear to happen together. Finally, Labov establishes that vowel shifts fall into a small number of recurrent types, governed by important cross-linguistic generalizations.

For a phonologist, Labov's chain shift principles offer much to reflect about:

- How can chain shifts along a phonetic scale be reconciled with SPE-type binary features? Do we need multivalued scalar features in phonology?
- How can the connection between length, tenseness, height, and diphthogization in vowel shifts be explained? Does it require Labov's feature [peripheral]? Can that feature be phonetically defined, and what implications would it have for phonological theory and typology?
- How and why are chain shifts initiated? Historical phonologists distinguish pull-chains from push-chains according to whether they are triggered by vacant slots or overcrowding in phonetic space. Can these scenarios be explained by phonological theories of dispersion, contrast, and symmetry?
- How and why do chain shifts progress? Do the steps occur sequentially, or are they single simultaneous transpositions of contrast, as in synchronic phonological treatments of chain shifts?
- How and why do chain shifts terminate? Labov's Exit Principles (p. 280) embody interesting empirical generalizations, such as that vowel raising ends in diphthongization and fronting, but as yet await a unifying formulation.

3.2 Maintaining binarity: [high] and [low]

The centerpiece of Labov's (1994) analysis of historical chain shifts is the English Great Vowel Shift (GVS). In the course of his work, Labov returns to it at increasing levels of abstraction: from

[3] The sceptical position, which I confess to having once harbored myself, is succinctly stated by Mortensen (2004: 7): "There is little reason to believe that the historical processes that give rise to chains... are related at all. Two unrelated sound changes, the second of which coincidentally recreates some structure which had been obliterated by the first, can very easily give rise to scenarios of this sort. Furthermore, such chains do not show obvious progress in any dimension."

its individual steps in their intrinsic “logical order” (p. 150) to representations which compress the sequence into a single vowel chart (p. 234), culminating in a general vowel shift schema of which the GVS is but one instantiation (p. 247). Along the way his characterization of the conditioning feature also moves from concrete to abstract, each time with greater empirical scope: from the measurable property of length to the more complex feature [tense], which stands for a “combination of impressionistic and acoustic features” (Labov 1994:505), and finally to the notion of peripheral and non-peripheral TRACKS on which tense and lax vowels respectively move:

(2) $$[z\ \text{high}] \rightarrow [z + \alpha\ \text{high}]\ /\ \begin{bmatrix} \underline{\qquad} \\ \alpha\text{peri} \\ \beta\text{round} \\ +\text{str} \\ +\text{long} \end{bmatrix} [\beta\text{round}]$$

(2) assumes a four-valued height feature, and applies to a vowel that is stressed, long, and followed by a segment of like rounding to increase its height if it is peripheral and decrease it if it is non-peripheral. A high vowel has the value [3 high]; raising it to [4 high] is interpreted as turning it into a glide; such a glide is then assumed to receive a homorganic vowel before it to satisfy minimum sonority conditions on the syllabic nucleus. The posited development of high vowels on this view is [i:] → [j] → [ij], where the middle phase can be seen as a virtual phase in the derivation. This schema is not meant to model any particular change directly. Rather, specific shifts could be thought of as instantiations of it by fixing the values of z, α, and β parametrically: “By describing the whole process in a single statement, it links the separate elements to the general principles of vowel shifting, and consequently to a single causal connection,” which we may not be able to identify yet (p. 251). The unfolding of this analysis is an inspiring object lesson in how scientific insight is achieved by jointly extending theoretical generalization and empirical coverage.

How essential are multivalued [high] and the the feature [peripheral] to the analysis? Can its substance be captured by strictly binary phonological features such as the ones widely used in phonology since SPE? Let us try the vowel features in (3) (Kiparsky 1974).

(3) Vowel features

		–Back		+Back	
		–Round,	+Round	–Round,	+Round
+Hi, –Lo	+Tense	i	y	ɯ	u
	–Tense	ɪ	ʏ	ɨ	ʊ
–Hi, –Lo	+Tense	e	ø	ɤ	o
	–Tense	ɛ	ø̞	ʌ	o̞
–Hi, +Lo	+Tense	æ	œ	ɐ	ɔ
	–Tense	a	ɶ	ɑ	ɒ

Unlike the SPE features (Chomsky & Halle 1968), (3) differentiates low front [æ] and [a] in terms of tenseness, parallel to mid [e] : [ɛ]. This turns out to work nicely for English.[4]

In terms of the feature system (3), Middle English (ca. 1400) had the vowel system (4):

[4]Note that this system posits two varieties of [ɔ], a lax one that corresponds to [ɛ] and a tense one that corresponds to

(4) The Middle English vowel system

		[–Back –Round] Long	Short	[+Back +Round] Long	Short
+Hi, –Lo	+Tense	ī *bite*		ū *bout*	
	–Tense		ɪ *bit*		ʊ *but*
–Hi, –Lo	+Tense	ē *beet*		ō *boot*	
	–Tense	ɛ̄ *beat*	ɛ *bet*	ɔ̄ *boat*	ɔ *pot*
–Hi, +Lo	–Tense	ā *bate*	a *bat*		

The distinctive features are [Back, High, Low, Tense] and vowel length (one-mora short vowels vs. two-mora long vowels and diphthongs). Long mid vowels had a tense:lax contrast /ɛ̄/:/ē/ and /ɔ̄/:/ō/; otherwise tenseness was dependent on length. Rounding was entirely dependent on backness: all front vowels were unrounded, and all back vowels were rounded. *ā, a* were low front vowels like the [a] of Boston *car, father* and of French *patte* (Dobson 1959: 545, 594).

During the 15th-18th century, English underwent three major vowel shifts:

(5) The three episodes of the vowel shift

	by 1500	by 1650	by 1750
Middle English	1st Raising	Tensing	2nd Raising
ī, ū	→ ɪy, ʊw		
ē, ō	→ ī, ū		
ɛ̄, ɔ̄		→ ē, ō	ē → ī
ā, a		→ ǣ, æ	ǣ → ē

The first of these vowel shifts is the GVS proper, or at any rate its core episode. It affected all and only the tense vowels of Middle English:

(6) a. Tense high vowels were diphthongized to [ɪy] and [ʊw].
b. Tense mid vowels were raised to [ī] and [ē].

The two changes in (6) are formally and featurally distinct, but nevertheless took place simultaneously.[5] What is the unifying motive behind these processes, what drives them, and how do we explain the failure of the mid and high vowels to merge?

[æ]. Like the SPE features, this system treats central vowels as lax back vowels. In order to accommodate the rounded central vowels [ʉ], [ɵ], [ɞ] properly, we should probably decompose the front/back dimension into two features [front] and [back], with central vowels as [–front, –back].

[5]That (6) is the first step in the GVS is convincingly argued for by Labov (1994: 249) and by Dobson (1959: 661, 685), who establishes the chronology, mainly from orthoepic evidence, and cites parallels for the diphthongization in (6a) from modern dialects. The shift begins as early as the 13th century (Minkova 2014: 253), and is completed by the 15th century (Dobson 1959: 651, 681, 659).

3.3 Length and tenseness as enhancements of height

Labov (pp. 221, 261) adopts Sievers' idea that long vowels raise because of articulatory overshoot, and short vowels lower by articulatory undershoot. This plausible idea raises the question how such a purely coarticulatory mechanical effect becomes phonologized, and why it happens in some languages and not in others. One causal factor could be that a pure vowel length distinction would be perceptually confusing in English because of the dramatic allophonic length difference between vowels before voiced and voiceless consonants. Reinforcing phonemic length by tenseness alleviates that perceptual problem by providing a robust additional cue for the length contrast. Tenseness (whether redundant or distinctive) can then in turn become further reinforced by height and diphthongization. As a result, heavy nuclei come to be saliently differentiated from light ones independently of their phonetic length, ensuring the perceptibility and preservation of the phonemic weight independently of length. On this account the English vowel shift originates as an ENHANCEMENT process in the sense of Stevens & Keyser 1989 and Keyser & Stevens 2006, followed by a transphonologization of the redundant feature into a new distinctive feature.

Enlisting contrast enhancement in the explanation of chain shifts helps understand the contrast preservation effect that is their central mystery. It also explains why English and other Germanic languages are prone to tensing, raising, and upgliding diphthongization, and why languages in which vowel length does not depend on the voicing of consonants beyond normal coarticulation, such as Japanese and Finnish, usually do not enhance their contrastive vowel length by such Germanic-type vowel shifting.

3.4 Push-chains, pull-chains, and super-optimality

Armed with the features in (4), we can unify the changes in (6) by using a principle introduced in OT for synchronic chain shifts.[6] It connects chain shifts with other contrast-preservation effects through a constraint that directly prohibit the mapping of distinct inputs into identical outputs (Padgett 2003, Kawahara 2003). The specific version of the anti-merger approach that I adopt, for reasons detailed in Kiparsky (2011, in press), uses a bare-bones form of the SUPER-OPTIMALITY constraint (7a),[7] which dominates the markedness constraints (7b,c,d) and the faithfulness constraints (7e) in a constraint system that generates the Great Vowel Shift.

(7) a. SUPER-OPTIMALITY

Assign a violation to the Input-Output correspondence <I, O> if there is an optimal <I',O> that is more harmonic than <I,O>.

b. $*\begin{bmatrix}\text{+tense}\\ \text{+low}\end{bmatrix}$

c. $*\begin{bmatrix}\text{+tense}\\ \text{-high}\end{bmatrix}$

d. *[+tense]

[6] Unlike all other types of opacity, they appear spontaneously in child language (Applegate 1961, Smith 1973), inviting the conclusion that UG should provide a natural mechanism for chain shifts.

[7] Proposed for semantics and pragmatics by Blutner 2000 and Jäger 2000, 2002 (see Blutner, de Hoop, and Hendriks 2006 for an overview of Bidirectional Optimization). The simplification used here is due to Tania Rojas-Esponda. It is worth noting that it also captures another kind of anti-neutralization effect, the restriction of rules to derived environments.

e. IDENT(F) – an abbreviation for IDENT(high), IDENT(low), IDENT(tense)

Constraints (7b-d) form a stringency hierarchy: each one implies the constraints above it. The set of IDENT constraints (7e) (of which I list only an illustrative subset of the relevant ones) selects, among the output candidates that remain in contention, the featurally most similar to the input.

The constraints in (7) derive the raising and diphthongization of tense vowels as shown in (8).[8] The tableau represents Labov's entire pattern 1 vowel shift. The main phase of the GVS instantiates only the (B) and (C) cases in the tableau. Case (A) is vacuous at this point since there are no tense low vowels in the system yet. Just the front vowels are displayed for clarity, but the constraints are applicable also to the back vowels, which indeed move exactly in parallel to them.

(8)

Vowel Shift	SUPER-OPT	*[+tense +low]	*[+tense -high]	*[+tense]	IDENT(F)
/ǣ/ A1. [ɪy]	*				***
2. [ī]	*			*	**
3. ☞ [ē]			*	*	*
4. [ǣ]		*	*	*	
/ē/ B1. [ɪy]	*				**
2. ☞ [ī]				*	*
3. [ē]			*	*	
4. [ǣ]		*	*	*	*
/ī/ C1. ☞ [ɪy]					*
2. [ī]				*	
3. [ē]			*	*	*
4. [ǣ]		*	*	*	**

In the case of underlying /ǣ/ (set A), (A1) /ǣ/ → [ɪy] violates SUPER-OPTIMALITY because C1 provides a more harmonic optimal source for [ɪy] (in virtue of IDENT(F)). Candidate A2 /ǣ/ → [ī] violates SUPER-OPTIMALITY because B2 provides a more harmonic optimal source for [ī]. Of the two remaining candidates, A3 defeats A4 because it is less marked. In set B, underlying /ē/, B1 /ē/ → [ɪy] violates SUPER-OPTIMALITY because C1 provides a more harmonic optimal source for [ɪy]. B2 wins by markedness as before. In set C, the least marked candidate C1 wins (though C3 succumbs first to Super-optimality).

Super-optimality deals equally well with chain shifts involving consonantal fortition and lenition. For example, Finnish consonant gradation weakens stops in onsets of closed syllables, by degeminating geminates and leniting singletons. In Spanish, palatal onset consonants have undergone a fortition chain shift, which has gone one step further in Argentinian Spanish, evidently a

[8] A brief explanation for readers not familiar with OT: think of the ranked constraints as a set of successive filters that generate the correct output by winnowing out all the wrong ones. Each row in the tableau shows one candidate output. The columns show the constraints, left to right in rank order. Stars mark constraint violations. Start with the leftmost column. If there is one optimal candidate, select it. If there is a tie, discard the losers and repeat on the next column until all but one candidate has been eliminated. Subsequent constraints are then irrelevant. After a candidate has been eliminated, remaining cells in the row are shaded. The optimal, winning candidate in each set is marked by "☞".

case of contrast enhancement (Harris & Kaisse 1999). E.g. *yeti* /jeti/ 'yeti' and *hiato* /iato/ 'hiatus', are respectively pronounced [yeti] and [jato] in Castilian, and [žeti] and [yato] in Argentinian.[9]

(9) Argentinian Spanish onset fortition

/j/	/i/
↓	↓
[y]	[j]
↓	↓
[ž]	[y]

Consonantal chain shifts appear to move along a single strength scale, with fortition in strong positions (onsets, especially of stressed syllables) and lenition in weak positions (codas and medial position). There appears to be no reason to assume distinct "tracks" for consonantal contrast displacement.

3.5 Diphthongs and the "Exit Principles"

The interesting feature of the Super-optimality analysis is that it unifies the two parts of (6) as a single change, and explains Labov's Upper Exit Principle (p. 280).

(10) *Upper Exit Principle*

In chain shifting, one of two high peripheral morae becomes non-peripheral.

The Upper Exit Principle implies that in chain shifts, long high vowels dissimilate in peripherality: [ī] → [ɪy], [ū] → [ʊw] (" peripherality and openness dissimilate", Labov 1994, Ch. 8). Super-optimality predicts this effect as a categorical result of raising of vowels that are already at maximum height, because it is the only way to satisfy (7d). The laxing of the first part of the tense high vowels follows from the very same constraints that drive raising of the tense mid vowels /ē/, /ō/. In the limiting case where the constraint violation of (7d) (the most general markedness constraint in the stringency hierarchy) cannot be repaired by raising, because high tense vowels can raise no further, the violation is repaired by kicking the vowel out of the tense vowel system.

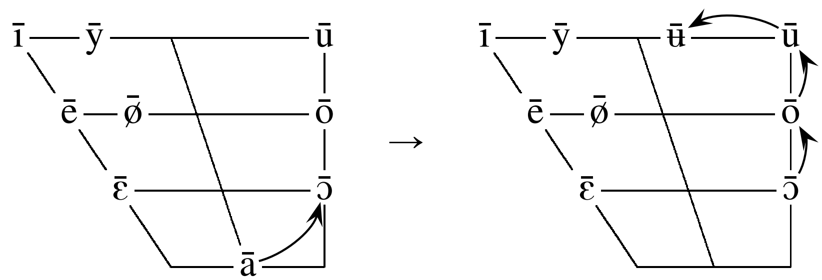
Unlike traditional approaches to sound change, OT relates the distinct "processes" of mid vowel raising and high vowel laxing and diphthongization by the abstract property that they are the optimal outputs that satisfy the constraints (7). Although (7a) was devised for chain shifts in synchronic grammars, it correctly models the historical unity of the GVS as well. If (6a) and (6b) took place concurrently, as the textual record indicates (see fn. 5 above), they constitute neither a pull-chain in which the mid vowels move to occupy the vacant slot created by diphthongization, nor a push-chain in which the high vowels diphthongize to move away from the mid vowels that are encroaching on their space, but a single change. In general, the OT analysis invites the hypothesis that *chain shifts that implement a single constraint or constraint family proceed in lockstep*. This could make sense of the often noted elusiveness of the distinction between push-chains and

[9] [j] = palatal semivowel (glide), [y] = prepalatal lax fricative or approximant, [ž] = postalveolar fricative.

pull-chains (Martinet 1955: 59-62. Chain shifts along a single dimension of phonological feature space would be concurrent, while push-chains and pull-chains would still describe the relation between the sideways movements that create the gaps and crowded spaces and the chain shifts that they trigger, such as the fronting of the low unrounded vowels in the case of the GVS, and their backing and rounding in the case of the Swedish/Norwegian shift (Labov 1994: 131).

Since the proposed explanation of Labov's Upper Exit Principle is purely formal, it holds for chain shifts along any dimension defined by a stringency hierarchy, making predictions about chain shifts in general. Each dimension along which chain shifting takes place implies a range of sideways movements which occur at the end point to bring the shift to a halt. A nice example is what Labov (1994: 129) calls pattern 3 chain shifting, a raising of back vowels which terminates in fronting or unrounding rather than in diphthongization. This raising pattern is driven by narrower versions of constraints (7b-d) that apply only to back rounded vowels. A high back vowel can satisfy them just by becoming fronted. This in fact turns out to be favored exit for Pattern 3 chain shifts, as the proposed approach predicts. An example is the Swedish/Norwegian chain shift of long back vowels, initiated by the rounding of *ā* to ɔ̄ in late Old Scandinavian, and terminated by the centralization of *ū* to ʉ̄ (Labov 1994: 131).[10]

(11) The Swedish/Norwegian chain shift



Commenting on this vowel shift, Haugen (1970: 133) raised the actuation problem: why was the shift restricted to Swedish and Eastern Norwegian, though its putative trigger *ā* > ɔ̄ was pan-Scandinavian? Rising to Haugen's challenge, Eliasson (2010) points out an additional factor specific to Eastern Norwegian and Swedish: prior to the vowel shift, just these dialects had developed a tenth vowel, by a lowering of /ʊ/ to /o̟/, later further lowered and centralized to /ɞ/.[11] All short vowels were then lengthened in open syllables, including two that up to then had no long counterparts, namely the new tenth vowel and /a/ (recall that original /ā/ had become /ɔ̄/). These two new long back vowels /ɞ̄/ and /ā/ overcrowded the space of long back vowels, triggering the vowel shift. On this interpretation, the vowel shift is a push chain in that it is initiated by the two sideways shifts, but nothing indicates that the height shift portion itself is either a push chain or a pull chain; the vowels appear to raise in unison until the movement terminates with another sideways shift.

[10]Other examples of pattern 3 are late classical Greek long vowel chain shift, where the raising of back vowels was terminated by the fronting of *ū* to *ȳ*, French (Haudricourt and Juilland, 1949), and Armenian (Vaux, 1992).

[11]The lowering of /ʊ/ was conditioned by *a* in the following syllable and by geminate *-pp, -kk* in the coda. The vowel appears in some Fenno-Swedish dialects as [ɔ] in monosyllables like *lock*, and elsewhere as [ɷ], and has a wide range of realizations in Sweden (Schalin 2014).

Not all chain shifts find an "exit": some terminate in a merger when they reach the natural end points of their scales. Such shifts do not involve Super-optimality. The chain is halted by ordinary markedness constraints that block it. An example is the Second Raising of English, fed by a tensing process introduced in the mid-17th century:[12]

(12) a. *Tensing*: All long vowels become [+Tense]. (17th c.)

1. [ɛ̄] → [ē] and [ɔ̄] → [ō]
2. [ā] → [ǣ]

b. *Second Raising*: Tense front vowels are raised. (mid-18th c.)

1. [ē] → [ī]
2. [ǣ] → [ē]

(12b) takes the [ē] tensed by (12a) to [ī], and raises ME [ā], which had been low [ǣ] up to 1700, to [ē] (Dobson 602). Second Raising, unlike First Raising, has no effect on vowels that are already [+High]. It is halted by a locally conjoined constraint IDENT(high)&IDENT(low), which is violated by an input/output pair that violates both conjuncts, as in (13):

(13)

Vowel Shift	IDENT(tense)	$*\begin{bmatrix}\text{+tense}\\\text{+low}\end{bmatrix}$	IDENT(high) &IDENT(low)	$*\begin{bmatrix}\text{+tense}\\\text{-high}\end{bmatrix}$	*[+tense]
/ǣ/ A1. [ɪy]	*		*		
2. [ī]			*		*
3. ☞ [ē]				*	*
4. [ǣ]		*		*	*
/ē/ B1. [ɪy]	*				
2. ☞ [ī]					*
3. [ē]				*	*
4. [ǣ]		*		*	*
/ī/ C1. [ɪy]	*				
2. ☞ [ī]					*
3. [ē]				*	*
4. [ǣ]		*	*	*	*

The 16th-17th c. lowering and unrounding of lax vowels [ɔ] → [ɑ], [ʊ] → [ʌ] conforms fully to Labov's vowel shift generalizations. Around the same time, the diphthongs [ɪy], [ʊw], that originated by the First Raising were further dissimilated by lowering the lax vowels, perhaps as part of the general lax vowel lowering pattern (Labov 1994: 123), or due to the general tendency for maximizing the featural distinctness of the components of diphthongs (a classic OCP effect).

[12] For the mid vowels the dating seems certain: "Until about 1650 the more common pronunciation in careful speech, used by those persons who had [æ:] for ME *ā*, was [ɛ:]...", the new pronunciation [e:] replaced it "in careful speech" around 1650 (Dobson 622). The development of ME [ɔ̄] was entirely parallel to that of ME [ɛ̄] (Dobson 671). Short [a] was "... generally used by careful speakers until 1600 and probably still the more usual pronunciation among such speakers until 1650...", with [æ] spreading in the first half of the 17th century and "generally accepted by careful speakers by about 1670" (Dobson 548). [æ] is first reliably attested in John Wallis' Grammar of 1653. Long [ā] was tensed earlier than short [a] , or perhaps at the same time (Dobson 594).

3.6 Peripherality

If we abide by binary features and do not rely on the feature [peripheral], we must find an alternative solution to the "fundamental problem of the Great Vowel shift" (Labov 1994: 234): how was ME *ī (bite)* diphthongized and lowered without merging with ME *ai (bait, maid)*? The above scenario provides such a solution. [ai] was monophthongized to [ǣ] about 1650 in the standard language (p. 778) (earlier in Northern and Eastern dialects, Dobson, p. 594), merging with the vowel of ME [ā] which was tensed to [ǣ] at this time by (12a) and then raised by (12b). Thus it never had a chance to merge with diphthongized /ī/ from the GVS. Analogously, [ɔw] (*blow*) monophtongized to [ɔ̄], merging with the ME *boat* vowel around 1600 in the standard language (p. 805), in time to undergo mid-16th century Tensing, and about the same time [aw] (*law*) was monophthongized to [ɒ̄] (Dobson 786).

Sound changes such as [ɪ] → [e] (e.g. the lengthening of *i* to *ē* in 14th century English, and the merger of Latin short *i* and long *ē* to *e* when length was lost in Romance) reveal a relationships between tense mid vowels and lax high vowels, and between tense low vowels and lax mid vowels. Labov models them as "track-crossing" changes, based on a match in absolute height between [–peripheral] vowels and the [+peripheral] vowels of the next lower height. In a binary feature system without the feature [peripheral], we can use concept of contrast enhancement (in this case, tensing and raising of long vowels and laxing and lowering of low vowels) to do some of its work. This way of modeling the effects subsumes peripherality under a more general mechanism that is applicable to every kind of feature, such as the fortition and lenition of consonants.

The feature system in (3) may provide a new perspective on the nature of "tensed" [æ] in Eastern seaboard dialects (e.g. Philadelphia *glad*, *pass*, *path*), whose phonetic nature remains mysterious (De Decker & Nycz 2012). It may be another instance of track-crossing: [æ] is already a tense vowel, and the change is actually a lengthening; the lengthened tense low vowel sounds much like a drawled lax mid [ɛ] (as in *yeah*), and perhaps "crosses the tracks" into phonemic /ɛ̄/. It then acquires a centralized off-glide, as is typical of non-tense long vowels, with subsequent dissimilatory raising of the nucleus: [ɛ̄] → [ɛə] → [ɪə].

4 Function and Frequency

According to the classic functionalist view, language jointly optimizes effort and information utility. In the final section of his 1994 book, Labov takes up this question and comes to the conclusion that function plays no role in sound change and variation: "Variable morphological constraints are accounted for by mechanical and structural factors rather than functional tendencies to preserve information" (p. 555). In recent years the question has been reopened with new sophisticated statistical techniques. Labov's view has held up in that no compelling evidence for direct functional conditioning of sound change has emerged. But functional factors do seem to impact phonology indirectly, both on the synchronic and diachronic level, in a way that can be modeled by formal phonology and reconciled with the regularity of sound change. An example is the family of anti-neutralization constraints needed for modeling such phonological phenomena as chain shifts and restrictions of processes to derived environments. This suggests a slight friendly amendment to Labov's dictum: functional tendencies to preserve information are encoded in the grammar as mechanical and structural factors.

In a cross-linguistic study of attested diachronic phoneme mergers, Wedel, Jackson, and Kaplan 2013 found that high functional load, as measured by the number of minimal pairs of same-category items, tends to inhibit merger-type sound changes; frequency turned out to be irrelevant. The changes were of the regular neogrammarian type, no lexical splits along functional or frequentistic lines were found.

Cohen-Priva 2012 defines the information utility of a sound, its INFORMATIVITY, as the weighted average of the information it provides across all contexts, and shows that low overall informativity predicts phonetic reduction in a given context more accurately than either frequency or predictability in that context. Lenition and deletion turns out to affect precisely those segments whose informativity does not justify the effort that their articulation demands: they affect even highly informative segments if they are very complex, and even quite unmarked segments if they are uninformative enough. This means that the functional payoff and cost of maintaining a contrast are aggregated over local contexts and then reflected back in overall language use. Such an across-the-board effect implies that phonetic elements are stored as abstract mental representations, to which global informativity values that control usage are attached. These studies thus provide evidence for the class of phonological theories that underpin neogrammarian sound change. In particular, a partially ranked OT constraint system with informativity as faithfulness and articulatory effort as markedness was able to formally model the patterns of phonetic variation that Cohen-Priva observed.

A closely related question is whether sound change can be conditioned by frequency. The ongoing sound changes researched by Labov, mainly vowel shifts, show few if any frequency effects, just as the neogrammarian position implies. Against this view, advocates of lexical diffusion and exemplar theory have made a case for frequency effects. Exemplar theory holds that speakers remember the ways they have heard particular words pronounced, and base their subsequent pronunciations on those accumulated memories. From this perspective Pierrehumbert (2001) argues that frequent words should lead in regular sound change, on the grounds that memories of words that are more often encountered get updated more often, and therefore should be more affected by whatever biases drive change. Sóskuthy (2013) points out that this actually does not follow from exemplar theory, for frequent words should are also be more resistant to biases because their overall memory activation levels are higher. The two effects should cancel out each other, and *no* frequency effect is expected.[13] Ohala's hypercorrection/hypocorrection model, which attributes sound change to misparsing of coarticulatory effects as phonological (as "intended" by the speaker) or vice versa, would on the contrary imply that frequent words should *lag* in sound change, for frequent exposure should decrease the likelihood of the misparsing events that cause sound change. Along the same lines Hay et al. (2015) claim that frequent words should lag in sound change, on the grounds that innovative pronunciations of frequent words are less vulnerable to misperception, hence get more firmly encoded in memory, and become less prone to change. (They claim this specifically for chain shifts, but the same reasoning would seem to apply to any kind of sound change.) Thus there is some unclarity about precisely what frequentistic predictions follow from approaches of this type.

Empirically at least one kind of phonological frequency effect is well-established: reduction and lenition processes affect frequent words more often than rare words. But this does not in any

[13] He however accepts the empirical claim that frequent words change faster, and suggests that this is because they are more autonomous in production. For Bybee 2001 the reason is that they become "automatized" as articulatory targets.

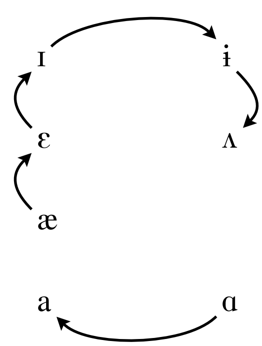
way establish that frequent words lead in sound change. There are two reasons to believe that it is a fact about variation rather than about change. First, the same frequency effects that are observed in ongoing change are observed in stable variation as well. For example, vowel reduction in English is favored in high-frequency lexical items (Fidelholtz 1975), even though vowel reduction is no longer a sound change in progress but a productive synchronic rule of the language. Bell & al. 2003 showed that frequent function words are more likely to be shorter and more reduced in natural speech. Experimental studies reveal the same effect (Pluymaekers, Ernestus, & Baayen 2005). Any such frequency effect in variation is guaranteed to show up in ongoing change as well, since all change involves variation (though not conversely). Thus there is no reason to make the theory of sound change responsible for it. A second argument that the frequency effect arises through variation in speech rather than through sound change is that frequent words do *not* undergo more fortition processes; in fact they are *less* affected by fortition than rare words. This contrary behavior of lenition and fortition is unexpected in theories that locate frequency effects in mechanisms of sound change that rely on misremembering exemplars or on misperception, since neither exemplar clouds nor hypercorrection/hypocorrection formally differentiate between these classes of processes. It does however have a rather natural speaker-based explanation, namely that speakers can afford reduced pronunciations of frequent words because they are more predictable, and resort to clearer pronunciations of rarer words when there is a risk of being misunderstood (Jurafsky et al. 2001). In consequence, high-frequency words will *appear* to lead in historical lenition processes, and they will *appear* to lag behind in historical fortition processes. In reality the variation pattern governed by frequency and other factors remains constant as the change advances across the board (cf. Fruehwald, Gress, & Wallenberg 2013). I believe the empirical study of sound change provides strong evidence for this picture, which is consistent with neogrammarian sound change. A brief review of a standard example will make this clear.

It has been claimed that the syncope of unstressed medial vowels between a consonant and a sonorant is a sound change in English that spreads through the lexicon, frequent words first. According to Bybee (Bybee 2007) the high frequency word *every* has undergone it, the low frequency word *mammary* has not, and the medium frequency word *memory* is in the process of changing. Phillips (2006: 97-98) likewise argues that syncopation depends on word frequency, so that *opera, salary, camera, cabinet, memory, history* tend to syncopate more often than the relatively less frequent *broccoli, gasoline, grocery, buffalo, surgery, chocolate*. Her figures show at best a tenuous correlation to frequency (she does not test for statistical significance). But the more important point is that these data are completely irrelevant, because syncope took place in Old English, and one cannot document the conditions of an Old English sound change with modern English vocabulary. None of the words cited by Bybee and Phillips actually underwent the sound change. *Every* is from OE *ǣfre ylc*, not **ǣfere ylc*, and the others were not yet in the language: *memory* is a 13th c. borrowing from Anglo-Norman, *mammary* is a 17th c. learned borrowing from Latin, and there was no *broccoli, gasoline* or *chocolate* in Old English. The Old English sound change was phonologically conditioned by stress and syllable weight, and conformed perfectly to the regularity hypothesis (Sievers-Brunner 1942: §158-159, Campbell 1983). It left the language with a productive variable synchronic syncope process, which has existed in the grammar, in a modified form, for a millennium down to the present.

Synchronic syncope is a variable rule whose frequency of application depends on a number of factors besides word frequency. The principal phonological inhibitor is the avoidance of stress clash, e.g. *gén'rative* vs. *généràtion*. Phonotactics also appears to play a role: sequences like *-nm-* that involve gestural overlap (Blevins & Garrett 2004) are avoided, as in *enemy, economy* vs. *emery, refectory* (trumping frequency). There is less syncope before word-level suffixes than before stem-level suffixes, e.g. *hindering* vs. *hindrance*. Opaque forms such as *marshal, parchment, poultry, butler, chaplain, apron, dropsy, chimney, remnant, damsel, partner, marshal, captain, laundry* have been entirely reanalyzed in their syncopated form, as have *fancy* and *curtsy* from *fantasy* and *courtesy*, whereas transparently derived words like *cursory, operative, summary, temporal, cidery, buttery, cobblery, clownery, cookery* can retain the trisyllabic underlying form and remain subject to variable syncope indefinitely as long as their morphology stays transparent, because their trisyllabic pronunciation can be acquired ("analogically restored") even by speakers who have only heard them syncopated.

Frequency effects in historical fortition processes are rarely documented, but Hay et al. (2015) have found a small but robust one in the New Zealand vowel shift (3). In this unusual chain shift (Labov 1994: 138), where the short vowels behave like tense vowels, low-frequency words appear to be more raised at all stages, as predicted by the above proposal.

(14) The New Zealand chain shift



Again, if these frequency effects do not arise through mechanisms of sound change but by speakers' deployment of the phonetic resources at their disposal, they should appear at the initial stage of any sound change as well as at all its subsequent stages and after its completion. Moreover they should appear not only in ongoing change but also in stable variation. And in fact there is experimental evidence for fortition and hyperarticulation of low-frequency words independently of any sound change in progress (Zhao & Jurafsky 2009, on Chinese tone realization). Their study also shows that hyperarticulation increases with the level of ambient noise.[14]

Once more, Labov's conception of sound change is fully vindicated.

5 Postscript

While making the final revisions on this essay I received a new study of Philadelphia æ-Tensing by Labov and his collaborators (Labov et al. MS), which yet again pushes the study of variation a major step forward. The leading idea is that speakers choose between different phonological systems, not simply between different variable realizations of a category as assumed in previous

[14]The observation that unfamiliar words tend to be hyperarticulated antedates the experimental literature; recall Hockett's contrast *We have several Thais* vs. *We have several ties*.

work. The new approach presupposes and exploits the insight that sound change is regular and that phonological systems are rule-governed, and has the immediate payoff of providing a sharper probe into social class than has been available so far. It is an impressive example of the seamless integration of sociolinguistics, phonetics, phonology, and change that continues to be a hallmark of Labov's work.

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