Part III Basic Tendencies and Types of Change

Evolutionary Phonology: A holistic approach to sound change typology

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1. Evolutionary phonology and sound change typology.

A central goal of Evolutionary Phonology (Blevins 2004a, 2006a, 2008a, 2009a, 2009b, 2010) is to explain why certain sound patterns have the properties and typological distributions they do. Why are sound patterns involving, for example, final obstruent devoicing, extremely common cross-linguistically, while final obstruent voicing is rare? Why is laryngeal epenthesis common but sibilant epenthesis rare? Though these kinds of questions relate directly to aspects of synchronic sound patterns, comprehensive answers to them typically refer to properties of sound change typology. Common sound patterns often reflect common instances of sound change. Since the most common instances of sound change appear to be those with clear and robust phonetic conditioning, there is a direct link in this model between phonetically motivated sound change and common sound patterns. In contrast, rare sound patterns may reflect rare types of sound change, rare historical sequences of change, lack a source in phonetically motivated sound change, reflect language-specific analogical change, or, for other reasons, be the endpoint of a highly unlikely evolutionary pathway.[1]

Sound change typology is a somewhat new area of study, to the extent that clear explanations are sought for properties of sound change (target, structural change, environment), typological distributions of sound change (common, rare, areal properties, structural associations), and asymmetries in certain types of change (e.g. velar palatalization vs. palatal velarization, final obstruent devoicing vs. final obstruent voicing). For common patterns of obstruent devoicing and laryngeal epenthesis, we now have a relatively good grasp of the phonetic origins of both of these processes. Phrase-final obstruent devoicing can have its source in aerodynamic, articulatory and perceptual properties of the speech stream, while the opposite process of voicing an obstruent in this position has no known phonetic source (Blevins 2006a, 2006b). Phonetic origins for epenthetic laryngeals have also been studied. Laryngeal epenthesis appears to have its origins in laryngeal articulations that mark phrase-boundaries in many languages, most notably constriction or spreading of the vocal folds (Blevins 2008a). In contrast, synchronic patterns of sibilant epenthesis do not have direct phonetic sources and are rarer: either a phonetically natural epenthetic glide subsequently undergoes strengthening to a sibilant; a historical process of sibilant lenition and loss is reanalyzed as an inverted rule of sibilant insertion (Blevins 2008a). The prevalence of velar palatalization over

[1] Assessment of what is common and what is rare is based more and more on attempts to collect sound patterns and instances of sound change into cross-linguistic databases that may overcome genetic or areal biases. See Gilman (2012a) for a recent overview of databases of this kind, and Gilman (2012b) on how one can use such databases effectively in applying the comparative method.

palatal (or coronal) velarization appears to be related to perceptual biases (Guion 1998), and supports the general view that perception and misperception play important roles in common types of sound change (Ohala 1981, 1993).

Phonetic explanations for sound patterns not only allow identification of sound patterns with common natural bases in contrast to those lacking the same, but also offer new insights into properties of the sound patterns themselves: final devoicing is more common than initial devoicing because it can be associated with natural decay of intra-oral air pressure and phrase-final lengthening. In contrast, initial and final laryngeal epenthesis are both common due to association of both initial and final phrase boundaries with language-specific laryngeal landmarks. Phonetic explanations for both of these patterns also allow one to better understand the pathway of phonologization (Hyman 1977), the life-cycle of sounds, from variable phonetic patterns, to statistical regularities, to identifiable sound patterns associated with the phonology of a particular language. Both final-devoicing and laryngeal epenthesis appear to begin as variable phrase-boundary phenomena, with phonologization resulting in regularization of the pattern at phrase boundaries, then smaller phrase or word boundaries, and only later to foot and/or syllable boundaries (Blevins 2006a; Blevins 2008a; Mielke to appear).

As more sound changes have received plausible phonetic explanations grounded in theories of speech production, speech perception, and acoustic and aerodynamic properties of speech,[2] it has become possible to ask a range of new questions about sound change typology. Given that a particular sound change is understood to be phonetically natural, grounded in articulatory, perceptual or aerodynamic properties of speech, can we identify independent phonetic and non-phonetic factors that can encourage or inhibit the particular change? Are there phonetically natural sound changes that require specific structural phonological preconditions? Are there other structural conditions that can give rise to phonetically unnatural but regular instances of sound change? Are there lexical conditions that can inhibit regular sound change? In this chapter, I briefly summarize recent work on these topics. The general view put forth is that the original Neogrammarian dichotomy between phonetic law and analogy needs to be expanded and elaborated. Phonetic laws may be phonetically natural only in the context of particular phonological systems. Analogy may be word-based, but other types of analogical change must be recognized as well, including those that are based on structural properties of sound patterns (see Fertig, this volume). Further, where relationships between word-forms can form the basis of analogical change, they can also be the nexus of inhibited sound change.

This holistic approach to sound change can be viewed as a natural extension of the integration of analogy and exemplar-based modeling into Neogrammarian theories of sound change.[3] As summarized and elaborated on by Karsten (1894:312) [4]:

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[2] See, for example, Kümmel (this volume) on the Glottalic Theory. A more comprehensive phonetic grounding of laryngeal features, especially voice and breathy voice, and their role in sound change is presented in Miller (2012). Not only sound patterns and sound change but distinctive features themselves are shown to be emergent properties of recurrent sound change (Mielke 2008, to appear).

[3] On exemplar modeling, see chapters by Bybee, Phillips, and Yu in this volume, as well as Morley (to appear a,b) for specific proposals concerning regular sound change.

> The mechanical dissection of individual words could no longer be applied to languages which had inherited these words as ready-made units, but each single word-form *must be judged as a whole* in connection with and in the light of related forms…

Within this framework, sounds and words are not considered in isolation but form constellations of sounds and words within an exemplar-based model of grammatical knowledge (Goldinger 1996, Johnson 1997, Pierrehumbert 2001, Gahl and Yu 2006, Wedel 2006). Relationships between exemplars and structural generalizations gleaned from them form the basis of positive and negative forces conditioning sound change.

Three properties of this model are strikingly modern. First, linguistic representations are assumed to contain a great deal of phonetic detail (cf. Pierrehumbert 2002; Jannedy and Hay 2006; Baayen 2007). Second, speakers are thought to store generalizations involving this phonetic detail at multiple intersecting levels, for example word, syllable and segment (cf. Bybee 2002, Pierrehumbert 2003). And third, speakers' mental representations are thought to include a record of previously encountered detail, with this detail influencing subsequent categorization and production (cf. Pierrehumbert 2001, 2006; Wedel 2007; Blevins and Wedel 2009). This last point results in a grammar which is neither purely synchronic nor diachronic: grammars are constantly changing systems, shifting ever so slightly each time a new linguistic experience of hearing or speaking takes place, and changing in a myriad of ways as memories themselves wax and wane.

This last property is the focus of a lengthy discussion in Karsten's 1894 paper. In recognizing the degree of variation in the signal he questions how categorization occurs, suggesting a merger of exemplars:

> … it is of extreme importance in speech… how can repetition take place in such a way that the new impression fits into, and renews or strengthens the memory picture of a previous impression, when in reality, considering the incessant change of subject and object, no two impressions can ever be perfectly equal? They can indeed only be more or less similar to each other, but they are nevertheless connected in our mind and for this reason: similarity means, of course, partial equality, equality of parts, and the apperception of equal impressions into the same memory-picture naturally involves the merging into one another of the corresponding equal parts of two similar impressions. (Karsten 1894:318)

[4] Karsten was a student of Hermann Paul. For an overview of Paul's (1880, 1920) exemplar-based approach to memories and their role in sound change, see Garrett and Johnson (to appear), and for a general history of historical phonology, see Murray (this volume). I focus here on Karsten because he explored listener-based innovation, and seemed to have a clear notion of misperception or altered perception and its role in sound change. He, then, is an exception to Garrett and Johnson's (to appear:6) observation that "…in emphasizing the articulatory basis of sound change, neither the neogrammarians nor their successors explored the possible details of listener-based innovation". Another linguist with early emphasis on the role of listeners in sound change is Kruszewski (e.g. 1881), whose contributions to this area are detailed in Silverman (2012).

His conclusion is that this merger of auditory representations results in shifts or movements, analogous to those posited in modern exemplar models when blended memory traces give rise to what has been termed an aggregate response (e.g. Goldinger 1996, Pierrehumbert 2002).

> It appears that is it not the spoken word that changes, but the acoustic picture in our mind through its transmission from one individual to the other. Treating now first the especially so-called phonetic changes, it is clear that the very act of speaking involves the possibility and the necessity of change…We at once understand that there must be an infinite number of speech varieties in existence all the time…All these speech varieties are constantly influencing each other. Even a pronunciation noticeably different from our own and one which we subconsciously feel to be less perfect will affect our own speech as long as the sound pictures heard promptly call up and join the memory-pictures in our mind, and the result must be a new, composite sound-picture, a compromise between the old and the new. (Karsten 1894: 325)

Within Evolutionary Phonology also, sound change is a feature of grammars. A synchronic grammar is a useful idealization, but there is no true static grammar.[5] Linguistic experience at every turn alters the memories of an individual, and can thereby minutely alter the grammar. The importance of exemplar-based modeling in understanding sound change typology has only recently begun to be appreciated, and I will highlight its role in the discussion that follows.

The central goal of Evolutionary Phonology is to understand sound patterns, to the extent possible, in terms of their evolutionary history. This requires a clear understanding of the fundamental nature of sound change, and it is this understanding of sound change, and its holistic nature, which is the focus of the remainder of this chapter.

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[5] It is worth clarifying this statement, as some criticisms of Evolutionary Phonology and related approaches claim that these models have no role for synchronic grammars. This is not true. Synchronic generalizations can be useful and meaningful in accounting for observed productivity in sound patterns, from observed nonce-words and loan-phonology, to a range of behaviors exhibited under experimental conditions. However, any formalization of synchronic generalizations of this kind within Evolutionary Phonology (or other models accepting exemplar-based generalization) acknowledges that these generalizations: (i) may differ across speakers; (ii) may differ across periods of a single life-span of an individual; and (iii) may be formulated in terms of learned or emergent phonological categories as opposed to innate or universally specified ones.

In this way, Evolutionary Phonology differs significantly from generative rule-based approaches and Optimality Theory where rules and their sub-parts, or constraints and their evaluation, are posited as universally specified components of phonological grammars, and claimed to be uniform across speakers of the same language. See Dresher and Holt (this volume) for more on these alternative approaches to sound change.

At the same time, Evolutionary Phonology differs centrally from other usage-based models (e.g. Bybee 2001) by acknowledging highly specific synchronic generalizations (constraints on distribution of laryngeal features, anti-gemination, the nature of *TL gaps, etc.) and attempts to understand the extent to which these can be explained by a confluence of external and language-specific factors.

2. The phonetic basis of sound change.

The phonetic basis of sound change in Neogrammarian models was limited, for the most part, to variable articulation. Evolutionary Phonology follows Karsten (1894), and the extensive research program of John J. Ohala in the 20th century in integrating all aspects of phonetic science into a more comprehensive model of sound change and sound change typology. A sound change may have origins in articulatory variation, aspects of speech aerodynamics, perceptual properties of speech, or some combination of these. For example, both articulatory variation in the production of coda nasal consonants and the percepts associated with this variation give rise to common sound change taking VN. sequences to nasalized vowels (Beddor 2009). In contrast, the context-free devoicing of voiced obstruents does not seem to be grounded in articulatory variation, but follows, primarily, from the aerodynamics of voicing (Ohala 1997).[6] Other sound changes, like the shift of θ > f, appear to be based, not in articulatory variation or aerodynamics, but in the acoustic/perceptual similarity of the two sounds (Blevins 2004a:134-35; Blevins 2006c:11-12).[7] Within each of these broad categories, finer explanatory models exist. For example, in the articulatory domain, Lindblom (1990) has elaborated the H&H model where articulatory compression and expansion are modeled, giving rise to numerous types of reduction/lenition and strengthening/fortition respectively. And Articulatory Phonology is refining models of articulatory timing and overlap which can explain many cases of apparent segment deletion and insertion in terms of gestural overlap and non-overlap respectively (e.g. Browman and Goldstein 1992, Byrd 1992, Pouplier and Goldstein 2010).

An additional feature of new approaches to sound change typology are attempts to classify sound changes in terms of their fundamental phonetic catalyst or source. As phonetic science advances, clearer and more precise explanations for a range of phenomena have emerged, expanding the Neogrammarian bipartite scheme of gradual articulatory drift and "other". Within Evolutionary Phonology, a primary three-way classification of sound change distinguishes CHANGE, CHANCE and CHOICE. Of these, the category which includes sound change based on articulatory variation (co-articulation/assimilation, lenition, fortition) is CHOICE. Sound changes with origins in CHOICE differ in several ways from the classical Neogrammarian conception of

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[6] An aerodynamic explanation for context-free devoicing makes predictions regarding the most and least likely stops to passively devoice: [g] is more likely to devoice than [d], which is more likely to devoice than [b]. See Ohala and Riordan (1980), Ohala (1997), and Pape et al. (2003) for further discussion. Though Blust (1996) attributes pandemic irregularity of word-initial velar stop reflexes within Austronesian to perceptual confusions of [k] and [g] due to smaller differences in VOT than stops at other points of articulation, the aerodynamics of voicing may also be involved, and may even be primary.

[7] A reviewer questions whether articulatory difficulty of [θ] may play a role in θ > f sound change. While could be a factor, one must still explain why [θ] shifts to [f] (which is not an articulatory variant of [θ]), as opposed to [s], [t], etc.

For a metric of perceptual similarity in these and other sound changes, see Mielke (2012).

articulatory variability. Variation can be due to compression or expansion along the hyper-to-hypoarticulation continuum, to imprecision, to gestural overlap, or to aerodynamic features of the vocal tract which give rise to variable articulation.[8] It is important to stress that expansion or intensification of articulatory gestures results in fortition or strengthening. While regular sound changes involving strengthening are, overall, less common than weakening, and tend to be associated with strong prosodic positions, they need not be, and require a place in any sound change typology.[9] Consider, for example, the context free shifts of *w > g^w and *j > dz in the history of Chamorro (Blust 2000). The shift from a glide to an obstruent involves articulatory strengthening, and since these are context free, they cannot be attributed to retiming of gestures in the context of a strong prosodic position.[10] In addition to glide-strengthening of this kind, strengthenings that are near mirror-images of common weakening processes are also attested. Common debuccalizations of voiceless fricatives (e.g. s > h, x > h), can be compared with less common context-sensitive strengthening of h to voiceless fricatives, as appears to have occurred in, for example, Singhi, where Pre-Singhi *-i > ih > Singhi /-is/, and Pre-Singhi *-u > -uh > /-ux/, and in the same languages where historical *h yields fricatives. In the same contexts, these final fricatives have be further strengthened to stops, resulting in patterns like Pre-Lom *-i > ih > ic > /-ic/, and *-u > -uh > ux > /-uk/ (Mortensen 2004; cf. Blust 1994).

Under CHANGE, the phonetic signal is misperceived by the listener due to acoustic/perceptual similarities between the utterance and the perceived utterance and biases in the human perceptual system. The existence of this category has been recently called into question by Garrett and Johnson (to appear). For this reason, it is worth listing some of the most convincing cases of perceptual bias in the literature. They include: misperception of palatalized velars as alveopalatals in velar palatalization sound change (Guion 1998)[11]; the misperception of heterorganic intervocalic nasal-stop clusters as

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[8] This classification differs slightly from that presented in Garrett and Johnson (to appear), where variation due to aerodynamic factors is classified separately. Within Evolutionary Phonology, what groups these two types together as CHOICE is the variability of tokens yielding an exemplar space from which speakers "choose" a norm, or, more accurately, calculate an aggregate based on the distribution of these variants. See Morley (to appear a) for a precise model of this procedure.

[9] It is striking how often the prevalence of leniting sound changes leads to models where fortition is simply ruled out. Mowrey and Pagliuca (1995), for example, claim that all temporal changes are due to the compression of gestures, while Bybee (2001:79-81) seems to suggest that temporal and substantive reduction are the main types of articulatory change, but admits that "one might conclude that strengthening does take place under certain conditions" (Bybee p.81).

[10] It is entirely possible that there was an intermediate stage of voiced fricatives. However, the shift from glides to voiced fricatives is also one of articulatory strengthening. Aerodynamic factors disfavoring voiced fricatives are discussed in the context of sound change in Garrett and Johnson (to appear).

[11] The role of coarticulation in velar palatalization is not questioned; but, as in the case of θ > f discussed above, a shift in articulator, in this case from dorsal to coronal, still needs to be explained, and can be through perceptual bias.

homorganic nasal-stop clusters based on the place features of the stop, accounting for common regressive place assimilation sound changes $VN_iT_jV > VN_jT_jV$ (Ohala 1990); the misperception of [t] as [k] in languages with /k/-gaps, accounting for common t > k sound changes in Austronesian (Blevins 2004a: 123-25; Blust 2004); the misperception of [kl] as [tl] in languages with /tl/-gaps, accounting for kl > tl sound changes (Blevins and Grawunder 2009); the tendency for listeners to hear long vowels with final devoicing as short vowels, accounting for common final vowel shortening sound changes (Myers and Hansen, 2007).; and the mishearing of [θ] as [f], or [f] as [θ], which accounts for θ > f and f > θ sound changes in a range of unrelated languages (Blevins 2004a: 134-35; Blevins 2006c:11-12).[12] The mention of gaps as preconditions for sound change in cases of CHANGE is a topic I return to in section 4.

The CHANCE classification includes sounds changes whose origins lie in intrinsic phonological ambiguity of the phonetic signal. These typically involve long-domain features which are reanalyzed in non-historic positions, and include vowel harmony, compensatory lengthening, dissimilation, and metathesis.

In terms of matching phonetic discoveries in all these areas with sound change typology, there are at least two basic complementary approaches. One can start with unexplained sound changes and search the phonetic literature for potential explanations (e.g. Blevins 2004a), or, one can look at phonetic results and attempt to predict types of expected sound changes (Garrett and Johnson, to appear). Both approaches appear to be productive, and in many cases, as expected, the methods converge. While many of the most common sound changes now have well accepted phonetic explanations (see Blevins 2004a, Blevins 2008b, Garrett and Johnson, to appear), there remain recalcitrant cases that are not well understood. In the following section I review some of these.

3. Regular sound change without phonetic motivation?

3.1 Apparent cases? In a controversial paper, Blust (2005) has suggested that regular sound change can occur without phonetic motivation. The changes he discusses are not analogical, and have all the hallmarks of regular phonetically based sound change: they target natural classes, they are regular, and they apply in very specific phonetic or phonological environments. Blust classifies ten regular sound changes in Austronesian in this way. Since the majority of these changes involve unlikely single-step changes in the feature composition of segments (e.g. *b > -k- in Berewan), there is always the possibility of intermediate steps which have been erased from the historic record. However, Blust (2005, 264) remarks: "No amount of speculation about possible intermediate steps is likely to provide a plausible phonetic motivation for more than a few of the changes considered here…". In light of this, he concludes that they defy phonetic explanation, and, quite radically, that they defy linguistic explanation altogether.[13]

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[12] The existence of f > θ sound change is disputed (e.g. Garrett and Johnson to appear), however, there appears to be at least one clear case in Peninsular Spanish, as reported in Fernández (1996:216).

[13] This theme, that regular sound change can be phonetically and linguistically unmotivated, is a recurrent one in Blust's recent work. For example, Blust (2001, 2005, 2007) insists that the syncope of stressed vowels in Mussau is a subcase of a regular

Consider Blust's (2005) claim that the sound change of word-final *-b,-d,-g > -m,-n,-ŋ which occurred independently in two Austronesian languages, Northern Batak and Berawan, has no clear phonetic basis. As pointed out by Blevins (2007), if an intermediate stage of pre- or post-nasalized stops can be justified, then a phonetic explanation would be possible, with a final stage involving retiming or loss of oral airflow. Indeed, variation between voiced stops and pre-nasalized voiced stops is common cross-linguistically. Furthermore, in Mwotlap, an Oceanic language, synchronic variation occurs between word final ^{m}b, ^{n}d, and m,n. In sum, a phonetically natural sequence of changes, *-b/-d/-g > -^{m}b, -^{n}d, -^{ŋ}g > -m/-n/-ŋ or *-b/-d/-g > -b^{m}, -d^{n}, -g^{ŋ} > -m/-n/-ŋ would involve a sequence of changes, each of which is independently evidence by phonetically-based variation or change elsewhere in the world. For a discussion of other cases which lend themselves to reanalysis in terms of intermediate stages or analogical change, see Blevins (2008a, 2008b).

3.2 Real cases? Are there regular sound changes which, to the best of our knowledge, are not the result of analogy, and yet, lack a plausible phonetic explanation? There appear to be very few, though Blust’s (2005) example of Sundanese w/b > c-, -nc- certainly qualifies. This is a one-of-a-kind change and it is context-free, so, it could involve multiple intermediate stages. Are there other recurrent changes that are context-sensitive and smack of phonetic explanation, though none is apparent?

The ultimate answer to this question should have an important bearing on theories of phonological markedness (e.g. de Lacy 2006) and their relationship to language change. If universal phonological markedness principles can play a role in language change, then phonetically unmotivated regular sound change is expected. For example, if there is a true markedness principle which values open syllables over closed ones, we might expect a phonetically unmotivated sound change of unconditioned coda-loss in one or more of the world’s languages. Interestingly, the sound changes which come closest to this hypothetical case appear to have interesting structural preconditions which suggest language-specific, as opposed to universal, conditioning. Before looking at these cases, I briefly review two recurrent sound changes that have neither a clear phonetic explanation, nor explanations grounded in phonological markedness.

One sound change that remains in this category is low vowel dissimilation, a recurrent sound change targeting sequences of low vowels in adjacent syllables. Under this sound change, the first of two low vowels becomes non-low: aCa > eCa, aCa > iCa, aCa > əCa. Blust (1996a,b) details at least five seemingly independent cases of low vowel dissimilation sound change in Oceanic, and the discovery of a parallel alternation in Alamblak, a Sepik Hill language of New Guinea suggests that the change is independent of structural pressures unique to Proto-Oceanic (Blevins 2009c). A phonological markedness principle disfavoring *aCa sequences seems *ad hoc*, and does not explain why the sequence is resolved by vowel raising, nor why it is the first vowel in the

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syncope rule, and therefore, defies phonetic motivation. More recently, Blust (2009) suggests that the Palauan intrusive velar nasal has no plausible historical phonetic or analogical source. See Blevins (2008c) where the Mussau case is reanalyzed as a combination of phonetic unstressed vowel syncope and analogical change, and Blevins and Kaufman (2012) on a historical morphological source for the Palauan velar nasal.

sequence which undergoes a change. As with most markedness accounts, a successful analysis of this change in non-phonetic terms will still leave its typology unexplained: why is this sound change common in Oceanic languages but so rare elsewhere in the world?

Another sound change that appears to remain in this category is the wholesale loss of word-initial consonants in a wide range of Australian languages (Blevins 2001).[14] Though weakening of initial consonants in unstressed syllables with subsequent loss is an expected development, some of these languages show no evidence of a lenition phase, with the full range of oral stops, nasals, liquids and glides seemingly dropping off the edge of the word. Until recently, this sound change was limited to Australian languages, suggesting a structural pressure or phonetic property of initial consonants unique to that area or family. However, in a recent study of the historical phonology of the Sogeram languages of Papua New Guinea, Daniels (2010) reports on a strikingly parallel development in the West Sogeram languages Nend and Atemple where "all word-initial consonants were lost from polysyllabic words" (p.172). While the polysyllabic condition suggests that stressed monosyllables were exempt, and therefore that, as in Australia, initial C-loss was mostly likely associated with stressless syllables, it is still striking that, in West Sogeram voiceless stops, nasals, and the sibilant *s are all lost. At the same time, comparative evidence from other Sogeram languages supports intermediate stages of lenition: in South Central Sogeram, word-initial *p-, *t-, *k- lenited to voiced fricatives. Given that some Australian languages also show evidence of initial lenition as opposed to loss, it seems more likely that what looks like abrupt C-loss in initial unstressed syllables may be the end result of a phonetically natural sequence of changes, with articulatory reduction of the unstressed syllable resulting in lenited consonants, before being lost altogether.

A mirror-image sound change is the regular loss of word-final consonants that has occurred multiple times in the Austronesian family (Blevins 2004b, 2009b). As with the cases just discussed, the phonetically surprising fact about most of these changes is that there is no evidence for intermediate lenition, nor any evidence of a scale of resistance to loss: voiced and voiceless stops, sibilants, and nasals simply fall off the end of the word without a trace. Where they are maintained before suffixes, there is no evidence of lenition.[15] Unlike the two sound changes mentioned above, however, there is a plausible explanation for this change in terms of universal markedness: the loss of a final

[14] Since direct outputs of this change are vowel-initial words and syllables, which, under most theories, are claimed to be marked sound patterns, the sound change has not, as far as I know, been attributed directly to a phonological markedness account. Again, it could be, but the markedness constraint demanding, for example, that words begin with vowels, would appear to be ad hoc, and again, there would be no explanation for the typological distribution of this change: why is it common in Australia languages and rare elsewhere? See directly below for a reevaluation of potential phonetic conditioning factors.

[15] There are a limited number of Southern Melanesian languages where only subclasses of consonants are lost (Lynch 2005). For example, in Northern New Caledonia, only final nasals are lost, while in Aneityum, *k, *q and *R are lost, but nasals and other stops are maintained. Still, in these languages, there is no evidence of gradual loss in the form of lenition.

consonant renders the final syllable open, and can be attributed to a universal preference for open syllables. One central problem with a markedness account is a typological one: if universal markedness is invoked, why is word-final consonant loss relatively common within the Austronesian family, but rare elsewhere in the world's languages?[16]

In this case, I believe a structural phonological account can be proposed, but it is language-specific not universal. As noted in Blevins (2004b), there is a correlation between final consonant loss, which has occurred independently at least 14 times within the Austronesian language family, and the elimination of inherited word-medial codas. In Proto-Austronesian, canonical word templates were disyllable, and many consisted of reduplicated C_1VC_2 C_1VC_2 strings. An innovation at the level of Proto-Central Eastern Malayo-Polynesian was a reduction of all medial consonant clusters to single consonants (Blust 1993), resulting in canonical CVCVC words. It turns out that in every case where abrupt final consonant loss occurred, it resulted in languages which had only open syllables. In other words, in all languages which underwent –C > zero, there were no word-medial codas before the change occurred. The explanation I propose is very simple. In the process of acquiring a language where all non-final syllables are open, there is a strong expectation on the part of the language learner that syllables will be open. It is this expectation or structural analogy that can result in inattention to and subsequent loss of final consonants. Returning to the exemplar-based model introduced at the start, generalizations across sound patterns in the language will result in a dominant CV syllable structure. As new words enter the lexicon in the course of acquisition, this dominant pattern may exert itself in a top-down fashion: where final consonants may be in unstressed syllables and at the end of a phrase, and less prominent than others to begin with, a further structural pressure will lead the listener to assume they are not there at all.[17]

This simple analysis of final C-loss in Central Eastern Malayo-Polynesian languages makes several interesting predictions that can be tested both against new-found typological data and in the laboratory. First, it suggests that in the stage preceding a regular sound change of final consonant loss, there will be no non-final (unambiguous) closed syllables. Second, it suggests that structural priming of the kind necessary to

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[16] Final C-loss is limited to fairly well-defined subgroup within the Austronesian family: it is found only in languages which descend from Proto-Central Eastern Malayo-Polynesian. This means it is not found in any Formosan languages, nor in any Western Malayo-Polynesian languages. The explanation I propose accounts directly for this distribution.

Elsewhere in the world, the only sound change I know of which resembles this one is the Middle Indo-Aryan loss of all final consonants but the final velar nasal (or nasal glide) (Masica 1991:170). However, the retention of the final velar nasal is a significant difference, at least in the context of the explanation I offer below.

Finally, preference for open syllables in early stages of first language acquisition is a clear performance effect (Blevins 2004a: 227-32), that quickly disappears. If this developmental stage did play a role in sound change, we would expect far more languages to show the C-loss pattern.

[17] See Wedel (this volume) for models of feedback loops in the course of language acquisition with these kinds of effects.

induce the change, should be discoverable in properly designed laboratory experiments. Experimental paradigms for testing phonological priming exist, though to date, they have been used primarily to explore the nature of phonemic categories. In cases where phonemic category boundaries are shifted, subjects have been shown to have more inclusive phonemic categories depending on the shifts they are exposed to extend these shifts to new words (see, e.g. Cutler et al. 2005). Could exposure to open-syllable-only words in the laboratory induce listeners to mishear final VC# sequences as V#, where C is a weak but audible consonant, while others, exposed to only closed syllables, hear the final C more consistently? A positive answer to this question would lend support to the language-specific structural account given above, and to the more general thesis that pre-existing phonotactics of a language is important to understanding sound change typology.

In sum there may be cases of regular sound change that cannot be explained in purely phonetic terms. Although there is some indication that word-final consonants are weaker than word-initial consonants in many Austronesian languages, this relative weakness alone is not enough to result in the regular loss of final consonants. On the contrary, the majority of Western Malayo-Polynesian languages retain these consonants with little change. However, if this intrinsic weakness is coupled with word phonotactics where all non-final syllables are open, there seems to be strong tendency for final consonants to be lost. This hypothesis harks back to Karsten's remarks in section 1, that "…each single word-form must be judged as a whole in connection with and in the light of related forms…" (p.2), that "equality of parts, and the apperception of equal impressions into the same memory-picture naturally involves the merging into one another of the corresponding equal parts of two similar impressions" (p.3), and that "a pronunciation …will affect our own speech … and join the memory-pictures in our mind, and the result must be a new, composite sound-picture, a compromise between the old and the new" (p.3).

4. Where phonetic motivation is not enough. Sound change typology then is shaped, to a large degree, by phonetic naturalness. However, we have uncovered at least one area where structural properties of a language might encourage a regular sound change that would otherwise not take place. It may also be the case that natural and expected sound changes with solid phonetic motivation are found only when additional structural conditions are met, or that the same changes can be inhibited by other aspects of grammar. I will briefly discuss several cases that may fall into one of these categories.

4.1 Pre-existing contrast as catalyst. It has long be noted that many sound changes are "structure-preserving" in the sense that they result in segments or structure types that existed at earlier stages of the language (Kiparsky 1995; this volume). However, as many of these sound changes have been more closely studied, it has become clear that, though there is a strong tendency for certain changes to be structure-preserving, the tendency can rarely be stated as an absolute (Blevins 2009b).[18]

[18] Within Evolutionary Phonology, the tendency for certain sound changes to be structure-preserving is strongly associated with CHANCE and CHOICE, where perceptual

One sound change in this category is compensatory lengthening. Kavitskaya (2002) argues that compensatory lengthening sound changes result from phonologization of pre-existing differences in phonetic vowel duration. Phonetic factors leading to longer vowel durations include longer V-C transitions, longer vowels before particular consonants, and open-syllable lengthening. In her survey of 80 languages with historical compensatory lengthening sound changes, 72 or 90% occur in languages with pre-existing long/short vowel contrasts, while only 8 or 10% are found in languages without a pre-existing vowel length contrast. In other words, in this case, the pre-existence of a vowel length contrast makes it more likely that a compensatory lengthening sound change will occur.

Another sound change that appears to occur more often when there is a pre-existing contrast is the perceptually based context-free shift of θ > f. Though most cases of θ > f known from the literature occur in languages with pre-existing /f/, at least one instance of this sound change has been identified for a language with no historical labiodentals. Northern Athabaskan is reconstructed with *θ and *ð, but with no labiodentals or labial obstruents. In the Dene Tha dialect of South Slave these interdentals persist, but Tulita-Slavey has undergone *θ, *ð > f (Blevins 2011).

Within the exemplar-based model adopted here, the significance of pre-existing contrasts and its role in sound change is expected. In the process of acquiring a language with a clear contrast between long and short vowels, the language learner will begin to form long vowel and short vowel categories as clouds of exemplars cluster resolve themselves. As new words are heard and stored, a word with a vowel whose length is somewhat ambiguous between long and short will be more likely to be categorized as long, for the simple reason that *there is a long vowel category*. In languages where a pre-existing vowel length contrast is absent, the same slightly longer vowel will have no long vowel category to go into. A hypothesis regarding the small percentage of languages that show compensatory lengthening, but lack earlier vowel length contrasts, is that the contrast which evolved was a large and very noticeable one, perhaps combined with other prosodic cues.

4.2 Pre-existing gap as catalyst. Are there phonetically natural sound changes that occur only when a particular contrast is missing in a language? Gap-filling sound changes are commonly noted, but, as far as I am aware, there is no literature on sound changes that require a gap as a precondition, or that are strongly associated with a gap.

Two sound changes of this type have already been noted in passing. One is the misperception of [t] as [k] in languages with /k/-gaps, accounting for common t > k sound changes in Austronesian (Blevins 2004a: 123-25; Blust 2004). The other is the misperception of [kl] as [tl] in languages with /tl/-gaps, accounting for kl- > tl- sound changes (Blevins and Grawunder 2009). In both cases, all languages with regular t > k and regular kl- > tl- show pre-existing /k/ and /tl-/ gaps respectively. In this situation, it appears that the existence of a contrast will inhibit misperception. For the cluster case, the hypothesis is that tl gaps are structure factors which greatly increase the probability of a kl > tl sound change. Evidence in favor of this position can be found in the experimental

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biases are non-primary. In CHANGE, where perceptual bias is primary, this bias can override the ambient effects of pre-existing structures on interpretation of phonetic input.

phonetics literature and from broader cross-linguistic typological surveys of kl > tl changes, as reported in Blevins and Grawunder (2009).

4.3 Pre-existing structure as catalyst. Are there phonetically natural sound changes that occur only when a particular structure is present in a language? Structure-preserving sound changes are commonly noted, but, as far as I am aware, there is not a large literature on sound changes that require a particular phonotactic as a precondition, or that are strongly associated with a pre-existing foot type or syllable type.

One phonetically natural sound change that may fall into this class is unstressed medial vowel syncope: $VC^{V}CV$ > VC.CV (where superscript 'V' is a short unstressed vowel). In a typological survey of languages that have undergone this change, Blevins (2009b) observes that in all cases, the unambiguous closed syllables existed prior to the change. As with final C-loss, the analysis of structural factors depends critically on the effect that incoming exemplars have on previously stored auditory representations. If words with closed syllables have been stored again and again, a listener or language learner will be more likely to interpret an incoming $VC^{V}CV$ string as VC.CV. If only open syllables have been encountered, the medial vowel is more likely to be maintained, and in fact, may even be "heard" when not present.[19]

As with final C-loss, the holistic approach suggested here shows that phonetic naturalness is just one factor determining sound change typology. A sound change like final C-loss may not have clear or strong phonetic conditioning, and may be a primary consequence of structural factors. On the other hand, unstressed vowel syncope, whose phonetic conditioning is strong and clear, may still require additional structural conditions to shift from an aspect of phonetic variability to a regular sound change.

4.4 Predictability as catalyst for lenition/loss. There is growing evidence that in positions where a particular sound or word has a high predictability of occurrence, phonetic reduction is more likely and more extreme than elsewhere (Lindblom 1990; Moon and Lindblom 1994; Bard et al. 2000; Jurafsky et al. 2001; Bell et al. 2003, Scarborough 2006). Lindblom's research program explores the hypothesis that hypoarticulation correlates with the degree to which speakers or listeners can supplement acoustic information with information from other sources, like knowledge of the world or textual knowledge. Jurafsky and colleagues focus more specifically on transitional probabilities drawn from large corpora, and demonstrates that knowledge of such probabilities plays a role in speech production and processing. When the results of these research programs are pooled, a clear picture emerges: articulatory reduction of words is, in part, a function of contextual predictability and recoverability. The more predictable or recoverable a string is, independent of acoustic information, the more likely the word is to be produced in a phonetically reduced form.

In most domains, predictability is lexically specific, and the reduction expected by models like those mentioned above is also lexically specific. But there is at least one domain where predictability is grammatically determined, and that is where reduplication

[19] I refer here to the fact that in fast speech, there is data showing vowel loss in languages like Fijian, despite the fact that the language has maintained a basic CV syllable structure for thousands of years. See Blevins (2009b) for further discussion.

is involved. In regular reduplicated forms, phonological material is predictable from the base. As a consequence, higher rates of reduction are expected in the reduplicated portion of the stem than elsewhere in the word. Can such reduction result in regular sound change? Is there typological support for exclusive associations between leniting sound change and reduplicative morphology? The answer appears to be yes.

One well-studied instance of this is found in the history of Hausa (Newman 2004). Preceding (and bleeding) Klingenheben's Law, three sound changes took place between the coda consonant of a CVC- replicative prefix and the following stem-initial consonant: velar and labial (grave) obstruents assimilate totally to the following consonant; coronal obstruents lenite to liquids; and /m/ assimilates in place to a following consonant. The question is why all of these leniting sound changes should occur only at the reduplicative boundary and not elsewhere in the word. The answer requires a holistic approach to sound change typology: since reduplicative prefixes are predictable CVC-strings, phonetic reduction is expected to be more likely and more extreme than elsewhere.

Other well-studied cases involving regular segment loss restricted to reduplicative substrings are found in Oceanic (Blevins 2005). In Bugotu, a South-East Solomonic language, synchronic reduplication of CVCV stems is CVV-, with the medial consonant absent. A more interesting case is the regular historical shift of *CRV > CV in Kokota, another language of the Solomons. In general, the loss of R, a sonorant, in CRV onsets is uncommon cross-linguistically. However, where reduplication is involved, it is found in widely distant unrelated languages: in Kokota; in Klamath-Modoc of south-central Oregon; and in a range of Indo-European languages (e.g. Old Irish, Gothic, Attic Greek, and Sanskrit). From a typological perspective, we must ask why the regular sound change *CRV- > CV-, which may look like a phonetically natural process of sonorant lenition, is strongly associated with reduplicative strings.[20] The answer is one grounded in a holistic view of sound patterns: where segmental information is predictable, as in reduplicative affixes, regular leniting sound changes are expected, and unpronounced segments may be interpolated by the hearer, based on their knowledge of the base form. Informal elicitation sessions with Kokota speakers support this view: though CV-reduplicated prefixes were spoken, elders seemed to hear CRV-, and repeated the words with the full copy sequence. While reference to prosodic domains may go some way towards explaining sound changes which are limited to reduplicative prefixes, they cannot account for the skewed distribution of CRV- > CV- sound changes in the world's languages.

4.5 Lexical competition as an inhibitor. In section 4.3 an inhibiting factor for syncope was hinted at: if a language has only …CVCV… syllable structure, it will be less likely to undergo $VC^{V}CV$ > VC.CV medial syncope than a language with pre-existing closed syllables. Are there other non-local features of grammars that can inhibit a phonetically natural sound change?

[20] I say "may look like a natural process", although in some cases, e.g. Kokota *knusu* 'break', *ku-knusu* 'a broken piece of something', the loss of the nasal stop does not smack of naturalness.

One non-local feature that may play a role in neutralizing sound changes is the extent to which words "compete" against each other in running speech. It has often been noted that phonological contrasts with a light functional load are more likely to be neutralized than others. However, functional loads are relative to context. Is it possible that a natural phonetically motivated sound change can apply everywhere except where it is the primary realization of a lexical contrast between two words that engage in a high level of lexical competition?

A recent investigation of this question by Blevins and Wedel (2009) suggests that lexical competition can inhibit regular sound change. The two examples put forth involve neutralization of a short vs. long vowel contrast in Banoni, and Oceanic language, and syncope in Dakelh, an Athabaskan language. While exceptions to regular sound change are well known in the literature, the locus of exceptionality within paradigms in both of these languages is striking, and requires explanation. The explanation based on lexical competition not only accounts for this locus, but also predicts that in the same contexts of lexical competition, extreme phonetic contrasts may emerge and be maintained. Simulations of lexical competition support the analysis: where similar tokens compete fiercely, categories maintain a healthy distance. Where the level of competition is low, mergers occur. And, where competition is high, aggregates are more likely to shift towards extreme exemplars than to move towards the center.

5. Concluding remarks. Our understanding of sound change typology has increased exponentially over the past century, primarily as a result of advances in phonetic science. The majority of regular sound changes are grounded in articulatory, aerodynamic, and perceptual aspects of speech, and technical advances in description and experimentation in these areas continue to deepen our understanding of both the physical underpinnings and cognitive extensions of these components.

At the same time, our understanding of the holistic nature of grammar continues to grow. Exemplar models are easy ways of capturing this holistic nature, since memory traces, independent of their level of decay, are wholes, not parts of wholes. In the study of sound change typology, there is much that remains to be explained. However, by beginning to associate phonetically based regular sound change with structural, morphological and lexical conditions that inhibit or facilitate change, we are closer to predicting the probability that, from some given pool of variants, sound change will or will not proceed in a given direction. This seems like progress.

References

Baayen, R. Harald. 2007. Storage and computation in the mental lexicon. In G. Jarema and G. Libben (Eds.), *The Mental Lexicon: Core Perspectives*. New York: Elsevier. 81-104.

Bard, E. G., A. H. Anderson, C. Sotillo, M. P. Aylett, G. Doherty-Sneddon, and A. Newlands. 2000. Controlling the intelligibility of referring expressions in dialogue. *Journal of Memory and Language* 42:1-22.

Beddor, Patrice S. 2009. A coarticulatory path to sound change. *Language*. 785-821.

Bell, Alan, Daniel Jurafsky, Eric Folser-Lussier, Cynthia Girand, Michelle Gregory, and Daniel Gildea. 2003. Effect of disfluencies, predictability, and utterance position on

word form variation in English conversation. *Journal of the Acoustic Society of America* 113:1001-1024.
Blevins, Juliette. 2001. Where have all the onsets gone? Initial Consonant Loss in Australian Aboriginal Languages. In Jane Simpson, David Nash, Mary Laughren, Peter Austin, and Barry Alpher (eds.) *Forty years on: Ken Hale and Australian languages* Pacific Linguistics 512. Canberra: The Australian National University. 481-492.
Blevins, Juliette. 2004a. *Evolutionary phonology: The emergence of sound patterns*. Cambridge: Cambridge University Press.
Blevins, Juliette. 2004b. The mystery of Austronesian final consonant loss. *Oceanic Linguistics* 43: 179-184.
Blevins, Juliette 2005. The role of phonological predictability in sound change: Privileged reduction in Oceanic reduplicated substrings. *Oceanic Linguistics* 44:455-464.
Blevins, Juliette. 2006a. A theoretical synopsis of Evolutionary Phonology. *Theoretical Linguistics* 32:117-65.
Blevins, Juliette. 2006b. Reply to commentaries. *Theoretical Linguistics* 32:245-56.
Blevins, Juliette. 2006c. New perspectives on English sound patterns: 'Natural' and 'Unnatural' in Evolutionary Phonology. *Journal of English Linguistics* 34:6-25.
Blevins, Juliette. 2007. The importance of typology in explaining recurrent sound patterns. *Linguistic Typology* 11:107-113.
Blevins, Juliette. 2008a. Consonant epenthesis: natural and unnatural histories. In Jeff Good (ed.), *Language universals and language change*. Oxford: Oxford University Press. 79-107.
Blevins, Juliette. 2008b. Natural and unnatural sound patterns: A pocket field guide. In Klaas Willems and Ludovic De Cuypere (eds.), *Naturalness and Iconicity in Language*. Amsterdam: John Benjamins. 121-48.
Blevins, Juliette. 2008c. Phonetic explanation without compromise: The evolution of Mussau syncope. *Diachronica* 25: 1-19.
Blevins, Juliette. 2009a. Phonetic explanations for recurrent sound patterns: Diachronic or Synchronic? In C. Cairns and E. Raimy (eds.), *Contemporary Views on Architecture and Representations in Phonology*. Cambridge, MA: MIT Press. 325-36.
Blevins, Juliette. 2009b. Structure-preserving sound change: A look at unstressed vowel syncope in Austronesian. In Alexander Adelaar and Andrew Pawley (eds.), Austronesian historical linguistics and culture history: a festschrift for Bob Blust. Canberra: Pacific Linguistics. 33-49.
Blevins, J. 2009c. Low vowel dissimilation outside Oceanic: The case of Alamblak. *Oceanic Linguistics* 48:2: 477-83.
Blevins, Juliette. 2010. Phonetically-based sound patterns: Typological tendencies or. phonological universals? In C. Fougeron, B. Kühnert, M. D'Imperio, and N. Vallée (eds.), *Papers in Laboratory Phonology X: Variation, phonetic detail and phonological modeling*. Berlin: Mouton de Gruyter. 201-224.
Blevins, Juliette. 2011. Perceptual similarity and sound change typology: Notes on θ > f and f > θ. Manuscript, CUNY.

Blevins, Juliette and Andrew Garrett. 2004. The evolution of metathesis. In Bruce Hayes, Robert Kirchner, and Donca Steriade (eds.). *Phonetically based phonology*. Cambridge University Press. 117-56.

Blevins, Juliette and Sven Grawunder. 2009. *Kl > Tl sound change in Germanic and elsewhere: Descriptions, explanations, and implications. *Linguistic Typology* 13: 267-303.

Blevins, Juliette and Daniel Kaufman. 2012. Origins of Palauan intrusive velar nasals. *Oceanic Linguistics* 51: 18-32

Blevins, Juliette and John Lynch. 2009. Morphological conditions on regular sound change? A reanalysis of *l-loss in Paamese and Southeast Ambrym. *Oceanic Linguistics* 48: 111-29.

Blevins, Juliette and Andrew Pawley. 2010. Typological implications of Kalam predictable vowels. *Phonology* 27.1:1-44.

Blevins, Juliette and Andrew Wedel. 2009. Inhibited sound change: An evolutionary approach to lexical competition. *Diachronica* 26.2: 143-83.

Blust, Robert. 1993. Central and Central-Eastern Malayo-Polynesian. *Oceanic Linguistics* 32:241-293.

Blust, Robert. 1994. Obstruent epenthesis and the unity of phonological features. *Lingua* 93:111–139.

Blust, Robert. 1996. The neogrammarian hypothesis and pandemic irregularity. In Mark Durie and Malcolm Ross (eds.), *The comparative method reviewed: Regularity and irregularity in language change*. Oxford: Oxford University Press. 135-56.

Blust, Robert. 2000. Chamorro historical phonology. *Oceanic Linguistics* 39: 83-122.

Blust, Robert. 2001. Some remarks on stress, syncope, and gemination in Mussau. *Oceanic Linguistics* 40: 143-50.

Blust, Robert. 2004. *t to k: An Austronesian sound change revisited. *Oceanic Linguistics* 43: 365-411.

Blust, Robert. 2005. Must sound change be linguistically motivated? *Diachronica* 22: 219–269.

Blust, Robert. 2007. Disyllabic attractors and antigemination in Austronesian sound change. *Phonology* 24: 1-36.

Browman, C.P. and Goldstein, L. 1992. Articulatory phonology: an overview. *Phonetica* 49: 155-180.

Bybee, Joan. 2001. *Phonology and language use*. Cambridge: Cambridge University Press.

Bybee, Joan. 2002. Word frequency and context of use in the lexical diffusion of phonetically conditioned sound change. *Language Variation and Change* 14: 261-290.

Byrd, D. 1992. Perception of assimilation in consonant clusters: A gestural model. *Phonetica* 49:1-24.

Cutler, Anne, J.M. McQueen, J.M. and D. Norris. 2005. The lexical utility of phoneme-category plasticity. *Proceedings of the ISCA Workshop on Plasticity in Speech Perception*:103-107. London

Daniels, Don R. 2010. A preliminary phonological history of the Sogeram languages of Papua New Guinea. *Oceanic Linguistics* 49: 163-93.

de Lacy, Paul. 2006. *Markedness: Reduction and preservation in phonology*. Cambridge: Cambridge University Press.

Fernández, Francisco Moreno. 1996. Castilla la Nueva. In M. Alvar (ed.), *Manual de dialectología hispánica: El español de España*. Barcelona: Ariel Lingüística. 213-232.
Gahl, Susanne and Alan Yu. 2006. Introduction to the special issue on exemplar-based models in linguistics. *The Linguistic Review* 23: 213-16.
Garrett, Andrew and Juliette Blevins. 2009. Analogical morphophonology. In Sharon Inkelas and Kristin Hanson (eds.). *The Nature of the Word: Essays in Honor of Paul Kiparsky*. MIT Press. 527-46.
Garrett, Andrew and Keith Johnson. To appear. Phonetic bias in sound change. In Alan C. L. Yu (ed.) *Origins of sound change: Approaches to phonologization*. Oxford: The Oxford University Press
Gilman, Sophia. 2012a. Comparative Method Algorithm. *Cambridge Occasional Papers in Linguistics* (COPIL). Cambridge: University of Cambridge.
Gilman, Sophia. 2012b. Operationalizing the intuitive aspects of the comparative method. Ms., Yale University.
Goldinger, Stephen D. 1996. Words and voices, Episodic traces in spoken word identification and recognition memory. *Journal of Experimental Psychology, Learning Memory and Cognition* 22: 1166-1182.
Guion, Susan G. 1998. The role of perception in the sound change of velar palatalization. *Phonetica* 55:18-52.
Hyman, Larry. 1977. Phonologization. In Alphonse Juilland (ed.), *Linguistic studies presented to Joseph H. Greenberg*. Saratoga, CA: Anna Libri. 407-418.
Jannedy, Stefanie and Jennifer Hay. 2006. Modelling sociophonetic variation. *Journal of Phonetics* 34:405-08.
Johnson, Keith. 1997. The auditory/perceptual basis for speech segmentation. *Ohio State University Working Papers in Linguistics* 50:101-113.
Jurafsky, D., A. Bell, M. Gregory, and W. D. Raymond. 2001. Probabilistic relations between words: Evidence from reduction in lexical production. In J. Bybee and P. Hopper (eds.) *Frequency and the emergence of linguistic structure.* Amsterdam: John Benjamins.
Karsten, Gustaf E. 1894. The psychological basis of phonetic law and analogy. *PMLA* Vol.9, No.2:312-41.
Kavitskaya, Darya. 2002. *Compensatory lengthening: phonetics, phonology, diachrony*. New York: Garland.
Kiparsky, Paul. 1995. "The Phonological Basis of Sound Change". In John Goldsmith (ed.) *Handbook of Phonological Theory*. Oxford: Blackwell.
Kruszewski, Mikołaj. 1881. On sound alternation, originally *Über die Lautabwechslung*. Reprinted 1995, *Writings in general linguistics,* ed. by E.F. Konrad Koerner, 7–35. (= Amsterdam Classics in Linguistics 11.) Amsterdam: John Benjamins.
Lindblom, Björn. 1990. Explaining phonetic variation: A sketch of H and H theory. In W. J. Hardcastle and A. marchal (eds.), *Speech Production and Speech Modelling.* Dordrecht: Kluwer. 403-39.
Mielke, Jeff. 2008. *The emergence of distinctive features*. Oxford: Oxford University Press.
Mielke, Jeff. 2012. A phonetically-based metric of sound similarity. *Lingua* 122: 145-163.
Mielke, Jeff. To appear. Phonologization and the typology of feature behavior. In Alan

Yu, eds., *Origins of sound change: Approaches to phonologization*. Oxford: Oxford University Press.
Miller, Brett. 2012. *Feature Patterns: Their source and status in grammar and reconstruction.* PhD dissertation. University of Cambridge.
Moon, Seung-Jae and Björn Lindblom. 1994. Interaction between duration, context, and speaking style in English stressed vowels. *The Journal of the Acoustical Society of America* 96:40-55.
Morley, Rebecca. To appear a. Implications of an Exemplar-Theoretic Model of Phoneme Genesis: A Velar Palatalization Case Study. *Language and Speech.* In press.
Morley, Rebecca. To appear b. The Emergence of Epenthesis: An Incremental Model of Grammar Change. *Language Dynamics and Change.* In press.
Mortensen, David. 2004 "The emergence of dorsal stops after high vowels in Huishu." Proceedings of the Thirtieth Annual Meeting of the Berkeley Linguistics Society (BLS 30): 292-303.
Mowrey, Richard and William Pagliuca. 1995. The reductive character of articulatory evolution. *Rivista de Linguistica* 7:37-124.
Myers, Scott. 2010. Final devoicing: Production and perception studies. Manuscript, University of Texas at Austin.
Myers, Scott and Benjamin B. Hansen. 2007. The origin of vowel length neutralization in final position: Evidence from Finnish speakers. *Natural Language and Linguistic Theory* 25:157-93.
Newman, Paul. 2004. *Klingenheben's Law in Hausa*. (Chadic Linguistics 2). Cologne: Rüdiger Köppe Verlag.
Ohala, John J. 1981. The listener as a source of sound change. In *Papers from the Parasession on Language and Behavior*. Carrie S. Masek, Robert A. Hendrick, and Mary Frances Miller (eds.), 178-203. Chicago: Chicago Linguistic Society.
Ohala, John J. 1990. The phonetics and phonology of aspects of assimilation. . In J. Kingston and M. Beckman eds., *Papers in Laboratory Phonology I*. Cambridge University Press, Cambridge. 258-75.
Ohala, John J. 1993. The phonetics of sound change. In *Historical linguistics: Problems and perspectives*. Charles Jones (ed.), 237-278. London: Longman.
Ohala, John J. 1997. Aerodynamics of phonology. *Proceedings of the Seoul International Conference on Linguistics*. Seoul: Linguistic Society of Korea. 92-97.
Ohala, John J. and C. Riordan. 1980. Passive vocal tract enlargement during voiced speech. *Report of the Phonological Laboratory. UC Berkeley 5*.
Pape, Daniel, Christine Mooshammer, Phil Hoole and Susanne Fuchs. 2003. Devoicing of word-initial stops: A consequence of the following vowel? *Proceedings of the 6th International Seminar on Speech Production, Sydney, December 7-10, 2003*. 207-12.
Paul, Hermann. 1880. *Principien der Sprachgeschichte*. 1st edition. Max Niemeyer.
Paul, Hermann. 1920. *Prinzipien der Sprachgeschichte*. 5th edition. Halle: Niemeyer.
Pierrehumbert, Janet. 2001. Exemplar dynamics, word frequency, lenition, and contrast. In Joan Bybee and Paul Hopper (eds.), *Frequency effects and the emergence of linguistic structure*. Amsterdam: John Benjamins. 137-157.
Pierrehumbert, Janet. 2002. Word-specific phonetics. In Carlos Gussenhoven, Tanya Rietvelt and Natasha Warner (eds.), *Laboratory Phonology* VII, Berlin/New York: Mouton de Gruyter. 101-139.

Pierrehumbert, Janet. 2003. Probabilistic phonology: Discrimination and robustness. In Bod, R., Hay, J., and Jannedy, S. (eds.). *Probabilistic Linguistics*. Cambridge, MA: The MIT Press. 177-228.

Pierrehumbert, Janet. 2006. The next toolkit. *Journal of Phonetics* 34: 516-30.

Pouplier, M. and L. Goldstein. 2010. Intention in Articulation: Articulatory timing of coproduced gestures and its implications for models of speech production. *Language and Cognitive Processes* 25:616-649.

Scarborough, Rebecca. 2010. Lexical and contextual predictability: Confluent effects on the production of vowels. In Cécile Fougeron, Barbara Kuehnert, Mariapaola Imperio, and Nathalie Vallee (eds.), *Laboratory Phonology 10*. Berlin: de Gruyter.

Silverman, Daniel. 2012. "Mikołaj Kruszewski: Theory and Vision". *Language and Linguistics Compass.* Part 1, 6/6.330–342, 10.1002/lnc3.336; Part 2, 6/5.296–309, 10.1002/lnc3.335.

Wedel, Andy. 2006. Exemplar models, evolution and language change. *The Linguistic Review 23:247-74.*

Wedel, Andy. 2007. Feedback and regularity in the lexicon. *Phonology* 24: 147-85.