Alan C. L. Yu (ed.). Origins of Sound Change: Approaches to Phonologization.
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Most chapters of this edited volume originate from presentations at a workshop on phonologization (University of Chicago, 2008), with a few later additions. The aim of the workshop was to stimulate interdisciplinary cooperation among researchers looking for an explanation for the origins of sound change. This is reflected in the structure of the book, which is divided into four parts: "What is phonologization?", "Phonetic considerations", "Phonological and morphological considerations", and "Social and computational dynamics".

Part I. ("What is phonologization?") contains two papers. In "Enlarging the scope of phonologization", Larry M. Hyman provides important background to the rest of the papers in the volume, by developing further his original definition of phonologization as "what begins as an intrinsic byproduct of something, predicted by universal phonetic principles, ends up unpredictable, and hence, extrinsic" (Hyman 1976, 408). As the boundary between phonetics and phonology is itself not easily defined, perhaps the notion of contrast can be of help. For example, during transphonologization, one contrast (e.g. that of consonant voicing) is replaced by another (e.g. tones on vowels). However, not all cases of phonologization involve replacement of contrasts. The next question considered is whether phonologization is only triggered by contrastive features. This is disproved by the behavior of non-contrastively voiced prenasalized stops which cause depressor effects in some languages, but not in others, and by ATR-harmony in Punu, where mid vowels are tensed by a non-contrastive feature of following high vowels. Hyman also identifies three other sources of phonology, in addition to phonetics: frequency distributions, analogical processes, and borrowing. Finally, the rise-and-fall 'life cycle' of phonology is discussed, phonologization is compared to syntacticization, and it is included as a subtype of grammaticalization: 'the processes by which grammar comes into being' (p. 26). The question still remains why phonologization (grammaticalization) happens at all. And Hyman claims that not all properties of grammar can be derived from substance.

In "The role of entropy and surprisal in phonologization and language change", Elizabeth Hume and Frédéric Mailhot approach phonologization from the perspective of information theory. Entropy is a probabilistic measure of the amount of uncertainty regarding the outcome of a linguistic event. The surprisal (or information content) associated with linguistic elements is the negative logarithm of their probability. These concepts are relevant for phonologization, first, because a key component of learning is attentional focus, which in turn is drawn to higher surprisal elements, and second, because they can predict likely targets and results of change. (Near) certain/impossible outcomes have a small entropic contribution, and are thus less important for successful communication. Therefore, elements with extreme degrees of surprisal are unstable and expected to change. High surprisal elements are predicted to change in structure preserving ways to similar elements with lower surprisal, while low surprisal elements are typically subject to reduction, potentially producing new

patterns. Degree of surprisal is dependent on frequency of occurrence, perceptual distinctiveness, articulatory complexity etc. Surprisal is the state of inverse expectedness, which has been shown to have biological roots. Expectation creates bias, especially in contexts of ambiguity, which in turn pushes the given sequences away from the surprisal extremes.

Part II. ("Phonetic considerations"), comprising four chapters, starts with a paper by Andrew Garrett and Keith Johnson on "Phonetic bias in sound change". They study the typology and actuation of sound change, and examine the three elements of phonologization: structured variation, constrained selection, and innovation. They review two previously proposed typologies. The traditional one divides sound changes into articulatorily-grounded and other types of changes. The more recent typology is listener-oriented: Ohala (1993) distinguishes between hypocorrection (resulting in phonologization of coarticulatory patterns), hypercorrection (resulting in dissimilation), and confusion of acoustically similar sounds; while Blevins (2004) introduces the terms choice, chance, and change (which roughly correspond to Ohala's categories). Garrett and Johnson then present their own typology which is grounded in biases emerging from speech production and perception. It is these biases that make variation and change non-random and directional. The bias factors include (a) motor planning (blending or inhibition), (b) aerodynamic constraints (on voicing and frication), (c) gestural mechanics (overlap and blend), and (d) perceptual parsing (asymmetric misperception and perceptual hypercorrection). Sound changes originating in these biases are discussed: (a) consonant harmony and long-distance displacement (nonlocal metathesis), (b) final obstruent devoicing and voiced fricatives becoming glides, (c) vowel nasalization, cluster simplification, stop debuccalization; and coronal or velar palatalization, precoronal vowel fronting, and vowel coalescence, (d) velar palatalization, unconditioned [θ] > [f] change, and obstruent + [w] > labial obstruent shift (although the origin of the changes in (d) is controversial). Finally, nonlocal dissimilation is examined, which might originate from either (a) or (d). Biases in speech production and perception thus initiate sound change by leading to structured variation. The next step in the process of phonologization is administered by system-dependent factors, such as enhancement (articulatory or auditory), selectional biases, and lexical and morphological effects. The final question to consider is that of actuation: why a particular change actually happens in one particular place and point in time, and not in some other. For this, two types of individuals are required: innovators and early adopters. Garrett and Johnson explain their difference from all other speakers by differences in their sociolinguistic awareness. They present some simulations in an exemplar-based model, which can explicitly capture the relationship between phonetically biased variation and sound change. They posit word-sized exemplars for speech perception and smaller exemplars for speech production, and they assume a difference between a special speech mode of segment perception and a more usual language mode of word perception (which ensures that sound change is generally resisted). The link between bias factors and sound change is provided by imitation, which causes phonetic accommodation. The simulations show that actuation of a sound change depends on whether the bias variants are included in the cloud of exemplars that the speakers' production is based on. This in turn depends on whether speakers in the group want to identify with other members of the group, for which production of bias variants might

be utilized.

In "From long to short and from short to long: Perceptual motivations for changes in vocalic length", Heike Lehnert-LeHouillier aims at explaining the asymmetry between bidirectional and unidirectional sound changes, involving vowel length and tone or vowel height, based on differences between the perception of f_0 vs. spectral cues. She argues that intrinsically associated cues (impacting listeners of all languages) are preferably not separated, resulting in unidirectional changes (i.e. a vowel length contrast can develop into a height contrast, but not vice versa). Conversely, extrinsically associated cues (only impacting listeners of languages where the cue systematically cooccurs with vowel duration) allow for changes in either direction (i.e. from a length contrast to a tonal contrast, or vice versa). Examples of each type of attested change are discussed, except for the "extremely rare" cases of height > length contrast changes, where at least a few references would be welcome. (Incidentally, should such changes not involve high vowels lengthening and mid vowels raising, contrary to what is shown in (5) (p. 103)?) After this, a perception experiment is presented, which was conducted in four languages to test the hypothesized difference between the impact of f_0 and spectral cues on the perception of vowel duration. Spectral cues are found to influence length perception in all languages, whereas f_0 only has an effect in languages where a falling f_0 is restricted to occur only on long vowels.

In the paper entitled "Inhibitory mechanisms in speech planning maintain and maximize contrast", Sam Tilsen examines vowel-to-vowel coarticulation, which might phonologize into vowel harmony through hypocorrection (captured successfully by exemplar theories), unless checked by opposing forces striving for maximal perceptual distinctiveness of contrasts (modeled by dispersion theories). Tilsen discusses experimental work on speech motor planning (primed vowel/tone-shadowing tasks), showing dissimilation between vowels/tones caused by inhibitory interactions between articulatory targets planned simultaneously. Intergestural inhibition is thus "a real-time, utterance-anchored mechanism for maintaining and maximizing contrast" (p. 126), complementing in this way dispersion theories which cannot account for what exactly happens at the level of the speaker.

"Developmental perspectives on phonological typology and sound change", by Chandan Narayan, considers the potential role of infant speech perception and caregiver speech production in shaping the typology of phonological inventories and in phonologization. Although children's production errors cannot generally be mapped on typical sound changes, a relationship can be revealed between the age of successful production of a sound and its typological frequency across languages of the world. This suggests that sounds which are found more difficult to articulate by children are rarer in phonological systems. As far as perception is concerned, two types of contrasts exist: some are initially easy to discriminate for the child (and subsequently non-native discrimination declines); whereas others are initially poorly discriminated, and discrimination is then enhanced with experience. Narayan demonstrates via a series of case studies that the difference between the two types is connected to acoustic salience and typological frequency of the contrast. The case studies deal with nasal place of articulation, voice onset time (VOT), and the contrasts /f/–/θ/, /s/–/z/, /l/–/ɹ/, and /d/–/ð/. Finally, Narayan examines infant-directed speech (IDS) which in early infancy is characterized by exaggerated prosodic features, and

less acoustic clarity at the segmental level, before infants produce their first word. A corpus study on voicing in English IDS and ADS (adult-directed speech) is reported, which has shown more overlap between voiced and voiceless stops along VOT in IDS than in ADS. In addition, where VOT is most ambiguous in the signal, f_0 becomes a better cue to voicing, providing a potential source for tonogenesis.

Part III. ("Phonological and morphological considerations") contains three chapters, the first of which is entitled "Lexical sensitivity to phonetic and phonological pressures", by Abby Kaplan. She addresses the question whether patterns of lexical frequency are controlled by phonological markedness or by phonetic pressures, via two corpus studies of underphonologization in seven languages. The first considers the effect of coronal consonants on adjacent vowels: fronting is attested both as a gradient and as a categorical change (although it is gradient in all languages investigated here); whereas dissimilatory backing, resulting from perceptual overcompensation, is never found to be phonologized. Consistently with this, coronals generally occur next to front vowels in the corpora, while non-coronals next to back ones. The second study compares height–height interactions between vowels, phonologizable into vowel harmony in other languages, with the raising effect of voiced obstruents on a preceding vowel, which is underphonologized. Again, lexical frequency patterns match the phonologizable interaction but not the underphonologized one. On the basis of this, Kaplan claims that there is no direct connection between phonetics and the lexicon, influence must be mediated by phonological markedness instead.

In "Phonologization and the typology of feature behavior", Jeff Mielke distinguishes innate feature theories from emergent feature theories. He counts and categorizes phonologically active classes in P-base (a database of sound patterns from 549 languages) in terms of SPE-type features and according to their behavior as taking part in spreading, dissimilation, partitioning (defining targets/triggers of a process), or other processes. The most frequently used features turn out to be [voice] and [high], followed by [back], [nasal], [continuant], and [sonorant]. The majority of spreading processes involve [+voice], [+nas], [+back], and [+cont]. Other features are mainly used for partitioning (notably [–son], [–voc], and [+cons]). Dissimilation is much rarer than assimilation, and it mostly affects [–son] and [+cons]. Mielke argues that feature values are likely to spread if their phonetic correlates show coarticulatory effects, whereas feature values primarily used for partitioning show no such effects and, in addition, they have been difficult to define phonetically. I find it unfortunate, though, that he criticizes representational feature theories in general on the basis of the outdated and unrestrictive system of SPE, while the same points could not be leveled against a more recent and more restrictive approach such as, for example, Element Theory (e.g. Backley 2011).

In "Rapid learning of morphologically conditioned phonetics: Vowel nasalization across a boundary", Rebecca Morley investigates the emergence of derived environment effects (i.e. when a process is restricted to apply only across a morpheme boundary) in an Evolutionary Phonology framework. An artificial grammar learning experiment was conducted concerning nasalization of pre-nasal vowels, a non-contrastive property in English (the native language of the participants). Listeners were able to learn the morphological association with the sub-phonemic cues in both conditions (across boundary only vs. within morpheme only), supporting a phonetic

origin for processes with this type of domain restrictions. Finally, Morley conjectures that all sound changes arise across a boundary, although it is unclear how this would follow from her results or why it would be advantageous.

Part IV. ("Social and computational dynamics"), comprising four chapters, begins with "Individual differences in socio-cognitive processing and the actuation of sound change", by Alan C. L. Yu, taking up the question of actuation again. Innovators and early adopters are proposed to differ from other speakers in their cognitive processing style. In particular, so-called autistic traits are significantly associated with perceptual compensation for vocalic coarticulation in speech, as well as with personality traits, such as drives to empathize or systematize. A sibilant perception experiment is reported, where minimal compensators (i.e. those less influenced by vocalic context) are found to exhibit imbalanced empathy and systematizing traits. Such minimal compensators are in turn argued to have a personality and social profile that facilitate the propagation of linguistic innovation.

In "The role of probabilistic enhancement in phonologization", James Kirby poses two questions: out of the multiple phonetic cues capable of signaling any phonological contrast, why only certain cues are phonologized, and why phonologization of one cue often results in dephonologization of another (i.e. in transphonologization). Kirby proposes that phonologization emerges as a consequence of adaptive enhancement in speech, in compensation for reduction in contrast precision. The probability of a given cue's enhancement depends on its informativeness, or statistical reliability. Phonetic categories are modeled as finite mixtures in agent-based computational simulations, with a speaker and a listener as agents. Each iteration proceeds through four steps: production, enhancement, bias, and categorization. The ongoing tonogenesis in Seoul Korean conditioned by obstruent voicing is explored. Five cues relevant for the stop contrast are examined: VOT, f_0 and length of the following vowel, spectral tilt, and burst amplitude. A covert f_0 contrast was already present in the Seoul Korean of the 1960s. The model predicts enhancement of this contrast (as opposed to any other) without explicitly targeting it, as precision of the VOT contrast is progressively reduced due to a systemic production bias. A model employing both bias and adaptive enhancement can thus predict (trans)phonologization, if a covert contrast is already present and the primary cues are reduced.

In "Modeling the emergence of vowel harmony through iterated learning", Frédéric Mailhot investigates the diachronic development of lexical harmony from vowel-to-vowel coarticulation interacting with a biased transmission-acquisition feedback loop. He presents simulations in an iterated learning model, containing one adult and one learner per generation. The results show an increase in the amount of harmonic lexical items over time. In addition to the states of lack of harmony and complete harmony, two stable intermediate levels of harmony are found. This is explained by differential resistance to coarticulation by different vowels (especially by the stability of high front vowels).

In the last chapter of the book, "Variation and change in English noun/verb pair stress: Data and dynamical systems models", Morgan Sonderegger and Partha Niyogi examine the actuation problem both from a historical linguistic and from a computational perspective. They consider stress shift in disyllabic noun-verb pairs in English between 1700–2007 (based on data from many dictionaries), where the large

majority of the pairs are found to be stable, posing the question of why the minority does change. The most frequent change occurs in the direction of N=1 (initial), V=2 (final); both members never change simultaneously; and the pattern N=2, V=1 is not observed to occur at any given time. Short-term variation often occurs near endpoints; long-term variation occurs, but rarely in both forms at the same time. Beside the population-level variation evidenced by dictionaries, individual-level variation is also found, in data collected from radio programs (although it is unclear why an American network is chosen, when dictionary data has been restricted to British sources). Sonderegger and Niyogi investigate the relevance of asymmetric transmission errors, (changes in) frequency, and analogy/coupling for the diachronic dynamics of stress observed in N/V pairs. Then they test three dynamical systems models of learning by individuals whether these show a bifurcation, which corresponds to one aspect of the observed dynamics at the population level: a sudden change after a long period of stability as a system parameter passes a critical value. Mistransmission does not lead to bifurcations, whereas discarding does, and a combined model shows bifurcation-like behavior. These findings show that different causes proposed for individual-level changes lead to different results at the population level, and therefore theories of language change may be evaluated along the above lines.

In summary, in line with the original intention of the workshop, chapters in this volume approach phonologization from perspectives as diverse as phonetics, phonology, information theory, language acquisition, cognitive psychology, sociolinguistics, and computational linguistics, providing a comprehensive overview of the topic. While each chapter can be read separately, many of them are connected on various levels, without becoming repetitive. The collection presents fascinating insights and raises intriguing further questions. And although we still do not have an answer to the question why sound change occurs when and where it does, we do know much more about how it happens. This book will be of interest not only to a readership in historical linguistics or phonology, but also to researchers and students in other disciplines interested in sound change.

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