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► **To cite this version:**

Juliette Blevins, Ander Egurtzegi. Refining explanation in Evolutionary Phonology: macro-typologies and targeted typologies in action. *Linguistic Typology*, 2023, 27 (2), pp.289-311. 10.1515/lingty-2021-0036 . hal-03930876v3

HAL Id: hal-03930876

<https://hal.science/hal-03930876v3>

Submitted on 10 Jan 2024

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Refining explanation in Evolutionary Phonology: macro-typologies and targeted typologies in action

<https://doi.org/10.1515/lingty-2021-0036>

Received June 9, 2022; accepted November 7, 2022; published online December 26, 2022

Abstract: In this paper, we highlight the role of typology in providing an empirical basis for explanation within Evolutionary Phonology with a focus on rare sound patterns and extra-phonetic explanation. Broad typological surveys of sound patterns or macro-typologies that include phonetic detail may, at once, support universal tendencies and document rare sound patterns, offering arguments for theories in which universal tendencies based on phonetic explanation are emergent properties of markedness-free grammars. However, in order to explain rarity and explore extra-phonetic factors, targeted typologies, narrowed by specific structural properties or contact histories, may be necessary. In this study, the complementary roles of broad and targeted typologies are illustrated through recent case studies of three basic components of phonological systems—sound inventories, alternations, and phonotactics—, with a focus on non-phonetic explanations that have enhanced the predictive power of the Evolutionary framework.

Keywords: aspirate nasalization; epenthesis; explanation; final voicing; macro-typology; phonological typology; rare sound patterns; targeted typology

1 Typology as the empirical basis for explanation in Evolutionary Phonology

Evolutionary Phonology (Blevins 2004a, 2006a, 2015, 2017b) defines concrete problems in the domain of sound patterns and sound change that cry out for scientific explanation. The most general problems concern non-random distributions of sounds in the world's languages which are referred to here generally as *sound patterns*. Subtheories within Evolutionary Phonology are formulated to

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explain why certain sound patterns have the typological distributions they do, and the language-internal and cross-linguistic features they do. Leading research questions are summarized in (1).

- (1) Leading research questions in Evolutionary Phonology
- Why are certain sound patterns extremely common, while others are rare?
 - What factors play a role in determining similar sound patterns across languages?
 - What explains the striking identity between recurrent context-dependent instances of sound change, recurrent alternation types, and static distributional asymmetries across the world's languages?

Within this framework a great deal of progress has been made by isolating recurrent sound patterns and formulating subtheories to account for cross-linguistic asymmetries or skewings whose frequency and distribution demand explanation. Sound patterns with well-grounded phonetic explanations include: metathesis (Blevins and Garrett 1998, 2004); final obstruent devoicing and other laryngeal neutralizations (Blevins 2004a, 2006a, 2006b); consonant epenthesis (Blevins 2008); vowel syncope (Blevins 2009); and the evolution and distribution of voiceless sonorants (Blevins 2018). Sound patterns with significant non-phonetic structural, information-theoretic, or lexical components include: compensatory lengthening (Kavitskaya 2002); final consonant loss (Blevins 2004b); unexpected consonant loss in reduplication (Blevins 2005a); vowel syncope (Blevins 2009); antigemination (Blevins 2005b); *t > k and *kl > tl sound changes (Blevins and Grawunder 2009); inhibited sound change (Blevins and Wedel 2009); cluster-splitting epenthesis (Blevins 2017a) and a range of other patterns associated with language contact (Blevins 2017c). This progress has allowed the majority of cross-linguistic tendencies in sound patterns to be explained, not in terms of absolute universals or properties of Universal Grammar in the pre-generative, generative or OT sense (Chomsky and Halle 1968; Jakobson 1962; Prince and Smolensky 1993), but as statistical tendencies arising from a wide range of grammar-external causal factors (Blevins 2004a, 2010; Bybee 2001; Evans and Levinson 2009; Greenberg 1965/1978; Ohala 1979, 1983), including phonetic (“channel”) bias (Sóskuthy 2013).

Since explanations for common and rare sound patterns can be attributed to direct genetic inheritance,¹ convergent (typically phonetically-based) evolution,

¹ The role of phylogenetic inheritance as a source of cross-linguistic similarity in Evolutionary Phonology is explicit (Blevins 2004a: 47–48, 209–211), and central to many recent case studies, including a typology of $\theta > f$ and $f > \theta$ sound changes (Blevins 2019), and an exploration of Proto Austronesian *q, both based on general phylogeny-internal stability within the Austronesian language family (aust1307) of 1,000+ languages (Blevins 2021).

synchronic constraints on form and function (including phonological or other linguistic universals), or chance (Blevins 2004a: 47–52), diachronic and synchronic typological studies are central empirical components of work in Evolutionary Phonology. However, phonological macro-typologies, like most of those in Tables 1 and 2, have several weaknesses, as outlined in (2).

- (2) Some weaknesses of macro-typologies
- a. Without phonetic detail, explanations cannot be assessed.²
 - b. With use of language sampling, rare sound patterns can be missed, and more common patterns underrepresented.
 - c. With limited phonological properties encoded, extra-phonetic structural factors cannot be properly evaluated.
 - d. Sound change databases, to the extent that they exist, are not paired with input/output languages or proto-languages, also limiting the assessment of extra-phonetic structural factors.

As an example of (2a), consider the question of whether true voicing (vs. VOT contrasts) may have an areal component. One might think that Chapter 4 of WALS, “Voicing in plosives and fricatives” (Maddieson 2013a), would allow one to assess the geographic distribution of true contrastive obstruent voicing in the world’s languages, since “voicing” is used to describe a state in which “the vocal folds vibrate to produce regular voicing” (Maddieson 2013a). However, English (stan1293), German (stan1295) and Norwegian (norw1258), whose phonetics are well studied, are all classified as languages having a voicing contrast for stops, despite the fact that the phonetic contrast in standard varieties of these languages is of aspiration, —zero to short lag VOT versus long-lag VOT stops (Jansen 2004: 41–42). As an example of (2b) where a rare pattern is omitted, consider an assessment of the distribution of ternary rhythms cross-linguistically. Chapter 17 in WALS, “Rhythm types” (Goedemans and van der Hulst 2013) might be a good starting point. But, of the handful of languages described with ternary rhythms—Cayuvava (cayu1262) (Levin 1988), Chugach Alutiiq (chug1254) (Rice 1992), and Kiribati (gilb1244) (Blevins and Harrison 1999)—, none are included in this language sample (despite the fact that three Yup’ik languages, including Central Alaskan Yup’ik [cent2127], closely related to Alutiiq, are included). On the flip side of (2b), Chapter 19 “Presence of uncommon consonants” (Maddieson 2013b), promises to offer data allowing one to quantify the occurrence and

² A reviewer states that “The field already acknowledges that a descriptively rich, phonetically rich typology is important for any kind of theory development.” This may be so, but none of the typological databases listed in Table 1 are phonetically rich.

Table 1: Some phonological databases for macro-typology (full references are provided for most recent versions only, unless the work is cited in the text).

Database	# of languages/sample type	Phonological data	Reference
UPSID	451/balanced	inventories	Maddieson (1984)
WALS (The World Atlas of Language Structures)	(see Table 2) balanced	(see Table 2)	Maddieson and Precoda (1990)
WALS online			Dryer and Haspelmath (2013)
Regular sound change	294 (languages & dialects)	consonantal sound changes	Kümmel (2007)
UniDia	302	10,349 sound changes	Hamed and Flavier (2009)
ST2 (StressTyp2)	750+	stress and accent	van der Hulst and Goedemans (2009)
World Phonotactics Database	2,300+	phonotactics (2,300) inventories (1,400)	Goedemans et al. (2015)
LAPSYD (Lyon-Albuquerque Phonological Systems Database)	654	inventories syllable structure stress and tone	Donohue et al. (2013)
SAPhon v2.1.0 (South American Phonological Inventory Database)	367/South American	inventories	Maddieson et al. (2013)
BDPROTO	206/ancient & reconstructed	inventories	Maddieson et al. (2014–2016)
PBase	629	inventories, patterns/alternations	Michael et al. (2015)
PHOIBLE 2.0	2,584	inventories (3,020)	Marsico et al. (2018)
			Moran et al. (2020)
			Mielke (2019)
			Moran and McCloy (2019)

Table 2: WALS online phonological databases for macro-typology (for full bibliographical references of all chapters, see Dryer and Haspelmath 2013).

WALS chapter	# of languages	Phonological data	Author(s)
Introduction	100	All features listed below	Comrie et al.
1 Consonant inventories	563	C-inventory size (S, mS, A, mL, L)	Maddieson
2 Vowel quality inventories	564	V-inventory size (S, A, L)	Maddieson
3 Consonant-vowel ratio	564	C-V ratio (L, mL, A, mH, H)	Maddieson
4 Voicing in plosives and fricatives	567	Voicing contrast (no; plosives; fricatives; both)	Maddieson
5 Voicing and gaps in plosive systems	567	/p t k b d g/: no /p/: no /g/: no /p.g/: other	Maddieson
6 Uvular consonants	567	Uvulars (no; stops; continuants; both)	Maddieson
7 Glottalized consonants	567	Glottalized Cs (no; ejectives; implosives; resonants; combos)	Maddieson
8 Lateral consonants	567	None; /l/: other lateral sonorant; lateral obstruent; combos)	Maddieson
9 The velar nasal	469	No /ŋ/: /ŋ/ & initial; /ŋ/ non-initial	Anderson
10 Vowel nasalization	244	Contrastive vowel nasalization? Yes/no; +/- vowel length; +/- nasal spread	Hajek
11 Front rounded vowels	40 (W. Africa)	None; high; mid; both	Maddieson
12 Syllable structure	562	Simple; mod. complex; complex	Maddieson
13 Tone	486	None; simple; complex	Maddieson
14 Fixed stress locations	527	None; 1st; 2nd; 3rd; antepenult; penult; last	Goedemans and van der Hulst
15 Weight-sensitive stress	502	Bounded (L-edge/left; R-edge/right), unbounded; combined; unpredictable; fixed stress (none)	Goedemans and van der Hulst
16 Weight factors in weight-sensitive stress systems	500	None; VV; VC; VVC; other; lexical; combos	Goedemans and van der Hulst
17 Rhythm types	323	Trochaic; iambic; dual; unclear; none	Goedemans and van der Hulst
18 Absence of common consonants	567	All present; no bilabials; no fricatives; no nasals; no bilabials or nasals/fricatives	Maddieson
19 Presence of uncommon consonants	567	None; clicks; labial-velars; pharyngeals; 'TH'; combos	Maddieson

distribution of rare consonants, including dental or alveolar non-sibilant ‘TH’ fricatives like /ð, θ/. As pointed out by Ives Goddard (pers. comm. 4/27/2011) in the comments section, the 567 language sample omits most native languages of North America that have TH-sounds (including ten Northern Athabaskan [atha1247] and seven Algonquian [algo1257] languages), making them seem rarer than they are, at least in North America. Another weakness of most macro-typologies is their encoding of limited types of phonological information (2c): for example, PHOIBLE 2.0 (Moran and McCloy 2019), the largest current segment-inventory database, includes 3,020 segment inventories from 2,584 distinct languages, but no phonotactic information.³ In order to address typological questions relating, for example, to the origin, stability, segmental implications and phonetic properties of complex syllable types, a targeted database, like that constructed by Easterday (2019), is necessary. Finally, (2d) highlights a difficult issue for those interested in relationships between sound patterns and sound change: determining correlations between, for example, a sound change of final consonant loss formalized as $C > \emptyset/V_ \#$ and an output state of uniform (C)V syllable structure is not possible with any phonological database currently available.⁴ From the perspective of Evolutionary Phonology, then, the majority of macro-typologies compile data which, on their own, cannot answer the research questions in (1).⁵ As a consequence, information gleaned from these databases is typically combined with targeted typologies. For example, Blevins’ (2004b) attempt to explain the distribution, rarity and non-phonetic factors in $C > \emptyset/V_ \#$ sound changes included a targeted sample of languages argued to have undergone this sound change, in order to see what, if any, structural features they had in common.

In contrast to large macro-typological databases which may be all-inclusive, or carefully sampled to eliminate areal or genetic bias, targeted typologies involve

³ Gordon (2016) bases assessment of cross-linguistic frequencies on the basis of the WALS 100 (see Table 2), slightly altered to 97 languages by taking away the bias introduced by English, French (stan1290), and Modern Hebrew (hebr1245). Some syllable analyses are based on this, but when more nuanced analyses are required, The World Phonotactic Database is used (Gordon 2016: 86–87.)

⁴ A Database of Regular Sound Change, meant to fill this gap, was conceived of by the first author, and together with David Kamholz, designed and implemented as a prototype with a web interface at the Max Planck Institute for Evolutionary Anthropology, 2005–2007. Unfortunately, this project was discontinued. Databases of regular sound change without synchronic output phonologies include Kümmel (2007) and Hamed and Flavier (2009).

⁵ This is not to say that such databases cannot be useful for other purposes. A number of studies of potential genetic and environmental factors shaping sound inventories have made use of them. For example, Everett et al. (2016) examine the geographic distribution of lexical tone in a combined database of over 3,700 languages, using both WALS online and the World Phonotactics Database, arguing that the presence and/or complexity of tone is inversely correlated with aridness of climate. See Donohue (2016) for technical problems, and a general critique of studies invoking physical geographical causes for linguistic features.

databases selected for precise phonological and other features that are of interest, and may be very small or very large.⁶ Recent uses of targeted typologies are instructive. In attempting to determine the phonetic laryngeal properties of oral stops in languages with no laryngeal contrasts, Kakadelis (2018) created an acoustic database of three areally and genetically diverse languages: Bardi (bard1255), a Nyunyulan language of Australia; Arapaho (arap1274), an Algonquian language now spoken in Wyoming and Oklahoma; and Sierra Norte de Puebla Nahuatl (high1278), a Uto-Aztecan language of central Mexico. These languages shared several important properties: they all had a single laryngeal series of oral stops, with stops occurring intervocally and initially; many hours of high quality recordings existed for acoustic analysis; phonological descriptions suggested distinct realizations of stops across the three languages;⁷ linguists who had done fieldwork on these languages were accessible and interested in the project; and the languages were (generally) not written, so there would be no influence of orthography on speech. A larger targeted typology is the language sample used by Easterday (2019) to investigate highly complex syllable structures. This language sample includes 100 languages, distributed across four categories of syllable types, from simple to highly complex. Central considerations were: that the sample size be big enough to yield meaningful quantitative analysis; that the sample size be small enough to allow for detailed phonological and phonetic analysis of languages with highly complex syllable structure; that the proportional representation of the four syllable types be approximately equal; and that areal and genealogical bias be avoided by balanced sampling. And an even larger targeted typology is the 1,000+ language sample in the Austronesian Comparative Dictionary (Blust and Trussel 2010), supplemented by grammatical material, that was used to explore the question of structural factors that could play a role in the shift of *q from uvular to non-uvular in all but a handful of languages (Blevins 2021). In each of these cases, it is the nature of the research question that targets a specific phonological characteristic or set of characteristics, and determines other aspects of the language sample.

6 There is a rich history of targeted typologies (or more informal cross-linguistic language surveys) in modern phonology, from the early vowel and neutralization collections of Trubetzkoy (1929, 1939), to the stress patterns of Hyman (1977) and Hayes (1980, 1995), and from the panchronic notes of Haudricourt (1940) to the perception experiments relating synchronic and diachronic velar palatalizations in Guion (1998). See Hyman (2007) and Gordon (2016: 1–42) for further discussion of the history of typology in phonology. Our focus here is on the importance of targeted typologies in developing theories which answer the questions in (1), and which have increased and/or provided further support for the predictive power of the Evolutionary framework.

7 And, in the case of Bardi, it was possible that Kakadelis' findings might extend to other Australian languages described as having no voicing contrast, but a single series of oral stops that are phonetically voiced.

Section 2 of this paper reviews three recently documented rare sound patterns that have direct implications for the role of macro- versus targeted typologies in our understanding of linguistic universals as extra-grammatical universal tendencies that allow for clear exceptions. We have chosen these three sound patterns for several reasons: first, they are relatively recent discoveries whose implications have yet to be fully appreciated in the context of phonological typology and linguistic typology more generally; second, they are all supported by phonetic documentation, and highlight the importance of phonetic information in phonological databases; third, in order to explain each sound pattern, a targeted typology is necessary; fourth, these studies cover three of the general types of sound patterns found in spoken languages: segmental contrasts; segmental alternations; and general phonotactics. One additional aspect of the case studies under review is worth highlighting, and that is the importance of dialect diversity in typology. An entry in a typological database for one dialect of a language is just that; nothing should be assumed about other dialects. The fact that Standard American English and Standard German have word-initial *kl-* and *gl-* clusters but lack *tl-* and *dl-* clusters has incorrectly led earlier researchers to assume that all varieties of English and all varieties of German show this pattern. A tendency to avoid clusters of coronal obstruent + liquid was assumed, and some even suggested a constraint against these clusters as part of Universal Grammar. However, as detailed by Blevins and Grawunder (2009), independently, in varieties of English and German (among other languages) **kl-*, **gl-* > *tl-*, *dl-* occurred. As a result, there are varieties of both languages where our descriptions must be reversed: these varieties have initial *tl-* and *dl-* clusters, but initial *kl-* and *gl-* clusters are absent. A tendency to avoid *tl-*, *dl-* must be recognized as just that, and the same initial clusters must be not only allowed, but preferred, in the grammars of these innovating dialects.

Section 3 offers summary remarks regarding targeted typologies and the increased predictive power of Evolutionary Phonology.

2 Typology in action: rare sound patterns and their implications

2.1 A contrast between /h/ and /ħ/ in Zuberoan Basque

Phonological theory in the 20th century prides itself on a distinctive feature system that serves multiple functions. Most centrally, distinctive features distinguish contrastive sounds from each other, and as part of Universal Grammar, define all possible phonological contrasts in spoken languages (A secondary role is their

function in defining natural classes). However, typological studies show that some predicted phonological contrasts appear to be extremely rare or non-existent. For example, there is no known language that distinguishes between a voiceless lateral approximant /l̥/ and a voiceless lateral fricative /ɬ/ (Ladefoged 1971: 53; Maddieson and Emmorey 1984), though this contrast involves at least two and possibly three feature differences: while both sounds are arguably [+lateral, –voiced, +consonantal], /l̥/ is [+sonorant, +spread glottis, –strident], while /ɬ/ is [–sonorant, +strident] with [+spread glottis] or [–spread glottis] possibilities, like other fricatives. Distinctive feature theory predicts that the two sounds should contrast in some language, and a typological study of the phonetics and phonology of both types of sounds confirms that they do indeed differ in acoustic characteristics, and in their phonological behavior (Maddieson and Emmorey 1984). What implications, then, are we to draw from the apparent absence of a /l̥/ versus /ɬ/ contrast in some phonological system?

One possibility is that the sample size of described languages is too small. If the probability of a language with a /l̥/ versus /ɬ/ contrast is on the order of 1/10,000 or less, then we could attribute non-attestation to the rarity of the contrast, and seek an explanation for its low probability. Within Evolutionary Phonology, this is the general strategy, since the attempt is to explain the non-attestation, independent of distinctive feature theory. Under this approach, one might first observe the rarity of /l̥/ as a contrastive segment (2% of the 2,584 languages in PHOIBLE; Blevins 2018), the low frequency of /ɬ/ (5% of the 2,584 languages in PHOIBLE) and then consider the simple combined probability of /l̥/ and /ɬ/ based on their individual cross-linguistic frequencies ($0.02 \times 0.05 = 0.001$). One might also consider the fact that allophonic variation of each of these segments could result in neutralization of phonetic features which, in general, might distinguish them; this kind of variation is supported by at least one acoustic study of voiceless laterals in Estonian Swedish (esto1259, Asu et al. 2015). Another possibility is to question the value of distinctive feature theory as an explanatory model. Mielke (2008) does just this: while open to distinctive features as learned, language-specific aspects of phonological grammars, Mielke questions their status as innate, universal entities that define contrasts and natural classes.⁸

With this as background, let us consider another phonological contrast that is extremely rare: the contrast between /h/, a voiceless aspirate, and /h̥/, the same

⁸ Note that in order to do this, Mielke (2008) needed to create an enriched database that encoded not only a representative sample of the contrastive sound inventories of the world's languages, but the phonological rules and constraints that these sounds take part in. As such, Mielke's PBase stands out as one of the only phonological databases where potential implicational relations between alternations/distributional constraints and sound inventories can be assessed.

segment with distinctive nasalization. First, we examine the macro-typology. In this case, the rarity of the contrast is not due to the combined rarity of each segment type: though very few languages have / \tilde{h} / as the only aspirate, /h/ is a common segment type in the world's languages, occurring in more than 88% of the languages (279/317) in the UPSID database (Maddieson 1984) and in 56% of the phonological inventories (1,703/3,020) in the PHOIBLE database. Two South American languages are described as having only a single aspirate / \tilde{h} / that is voiceless and nasalized: Madí (jama1261, Vogel 2003) as spoken in Amazonas, Brazil; and Yiné (Piro, yine1238) as spoken in Peru (Urquía Sebastián and Marlett 2008). In both languages, / \tilde{h} / gives rise to nasalization on adjacent vowels. This fact about ambient nasalization of vowels adjacent to phonemic / \tilde{h} / is important, as earlier researchers have suggested that contrastively nasalized glottal segments like / \tilde{h} / and / $\tilde{ʔ}$ / are not possible, in line with the shaded cell in the IPA chart where the “Nasal” row and the “Glottal” column meet. The impossibility of a segment like / \tilde{h} / is associated with an aerodynamic definition of the distinctive feature [+/-nasal], defining [+nasal] segments in terms of measurable nasal airflow. However, a less problematic definition is articulatory: [+nasal] segments are produced with the velopharyngeal port open, while [-nasal] sounds are produced with the velopharyngeal port closed (Walker and Pullum 1999: 767). Since spreading of the vocal folds for /h/ can occur with the velopharyngeal port open or closed, it is possible to produce / \tilde{h} / or /h/, and, in principle, these sounds could contrast in some language.

We turn now to a targeted typology of languages with this reported contrast. To date, such a contrast has been proposed for only a handful of languages, including: Kwangali (kwan1273) and ThiMbukushu (mbuk1240), two Southern Bantu languages of northern Namibia (Ladefoged and Maddieson 1996: 132–133); Seimat, an Oceanic language of the Admiralty Islands (seim1238, Blust 1998, 2013: 661–662); and the easternmost varieties of Basque (basq1248), of the Pyrenees Spain-France border region (Camino 2016; Egurtzegi 2018; Hualde 1993). In Kwangali and ThiMbukushi, the segment analyzed as / \tilde{h} / is phonologically part of the “pre-nasalized” series, which includes the pre-nasalized stops and pre-nasalized fricatives / $^m p^h$, $^n t^h$, $^n k^h$, $^m b$, $^n d$, $^n g$, $^m f$, $^n s$, $^m v$, $^n z$ /. As a consequence, though Ladefoged and Maddieson (1996) present evidence for a phonetic contrast between [h] and [h̃], at the phonological level, we can't be sure that [h̃] is a realization of / \tilde{h} / as opposed to /Nh/, where N is a nasal consonant unspecified for place of articulation. The situation with Seimat is ambiguous in different ways. First, though Blust (1998, 2013) analyzes vowel nasalization in Seimat as a consequence of historical * \tilde{h} < *r, in contrast to h < *p which does not trigger nasalization of a following vowel, the limited distribution of nasality in the language could be seen as lexicalized, and hence, a property of vowels. Further, no phonetic evidence has demonstrated nasal airflow or an open velopharyngeal port simultaneous with the proposed / \tilde{h} / in Seimat. While we agree with Walker and

Pullum (1999) that /h/ versus /h̃/ contrasts are possible, at present, the strongest evidence for this contrast appears to be in eastern dialects of Basque, as summarized here.

In eastern varieties of Basque, in particular, Zuberoan (basq1250, Hualde 1993) and the Mixean variety of Low Navarrese (east1470, Camino 2016) there is a synchronic contrast between /h/ and nasalized /h̃/ as in *ehe* ‘wash water’ versus *ēhe* [ẽhẽ] ‘no’. Oral /h/ in morpheme-internal intervocalic position is the regular reflex of *h, a segment reconstructed to the earliest stages of the language (Michelena 1977/2011). In contrast, nasalized /h̃/ continues intervocalic *n, with lenition of *VnV > Vh̃V occurring roughly at the time of contact with Late Latin (late1252) and/or early (Western-) Romance (west2813, Egurtzegi 2018). This cross-linguistically rare contrast between oral and nasalized aspirates has been lost in almost all Basque varieties: most eastern varieties, with the exception of Zuberoan and the Mixean variety of Low Navarrese, have merged /h/ and /h̃/ to /h/, while central and western Basque dialects have lost aspiration altogether. A subsequent development in these varieties is a sound change taking *h* > *h̃* /NV_ (N a nasal consonant) as in the emphatic 1st person pronoun *niñaur* ‘me myself’, from *ni* ‘me’ + *haur* ‘this’ (the latter with an etymologically oral /h/), by means of a nasal spreading or harmony similar to that described in Arabela (arab1268) or Aguaruna (agua1253) (Walker and Pullum 1999: 769). Egurtzegi (2018) argues that the output of this process is a phonological segment /h̃/, and not simply a nasalized allophone of /h/ due to surrounding nasalized vowels. The argument is based on a subsequent analogical change: from the emphatic pronoun *niñaur* ‘me, myself’ /h̃/ is extended to the rest of the paradigm of emphatic pronouns: *iñaur* ‘you yourself’, *ziñaur*, ‘you yourself (formal)’, *giñaur* ‘we ourselves’, etc. In addition to the phonological evidence, a recent phonetic study presents acoustic evidence for this opposition in the Mixean variety (Egurtzegi and Carignan 2020). On average, the nasalized glottal approximant /h̃/ is less nasalized than a vowel adjacent to a nasalized consonant, but significantly more nasalized than an oral /h/ or an oral vowel.

From an articulatory point of view, a contrast between oral and nasalized glottal approximants should be possible in human language (Walker and Pullum 1999). From a targeted typology, we conclude that the strongest case to date for a phonological contrast between /h/ and /h̃/ are eastern dialects of Basque. A central question for typologically oriented approaches intent on *explaining* sound pattern distribution, like Evolutionary Phonology, is why this contrast should be so rare. In this case, the answer may lie in the realm of perception, not production. Acoustically, nasalization and glottalization produce very similar effects (Ohala 1975). This acoustic similarity can produce a perceptual ambiguity that has been argued to be the seed of the process known as rhinoglottophilia (Matisoff 1975), whereby a glottal segment becomes nasalized or vice versa (Igartua 2015; Johnson 2019; Klatt and

Klatt 1990; Ohala 1980, 1987). Given the spontaneous percept of nasalization in [h], and the potential interpretation of [h̃] as heavily aspirated (but not nasalized), a contrast of /h/ versus /h̃/ is expected to be perceptually weak, unless it is buttressed by nasal harmony spread from /h̃/ to adjacent vowels. It is not surprising then that the Basque dialects that maintain the /h/ versus /h̃/ contrast also show vowel nasalization in neighboring vowels, and that Seimat shows historical evidence of the same process.

It is worth emphasizing that the explanation for the rarity of /h/ versus /h̃/ contrasts in spoken languages does not turn on the markedness of [h̃]: /h/ is often nasalized in the context of nasalized vowels and nasal consonants, and nasalized allophones of /h/ are reported for Akan (akan1250), Igbo (nucl1417), Mazateco (maza1295), Mundurucu (mund1330) and Sundanese (sund1252), among other languages (Moran and McCloy 2019). In this case, the rarity of the contrast turns on intrinsic phonetic facts about the perception of aspiration and nasalization; it is not predicted by phonological feature theory, nor by theories of phonological markedness. Even universalist approaches which attempt to build in phonetic measures of perceptual saliency and perceptual distance (e.g. Flemming 2017; Steriade 2009) are likely to fail for reasons that have only become clear in the last decade or so. Voiceless vowels, whose perceptual salience approaches zero, have been documented phonetically and phonologically, and have been shown to persist across generations (Blevins 2018; Gick et al. 2012): in this case, universalist proposals based on perceptual saliency predict vowel loss, in contrast to the language-specific account which invokes structure-preserving aspects of phonotactics (Blevins 2018). Another problem for universalist accounts are phonological segmental contrasts whose proposed perceptual distance is extremely small or close to zero, like the /h/ versus /h̃/ contrasts described above, or parallel /ʔ/ versus /ʔ̃/ contrasts. These cannot be assessed in isolation, since, typically, the nasalized member of each pair occurs in a multi-segmental nasal domain which includes high-sonority nasalized vowels: again, universalist phonetic proposals predict absence of segmental contrast, while language-specific holistic phonetic explanation is able to understand the contrast in terms of a long-domain feature of nasality. In addition, recent phonetic work on spontaneous nasalization in Thai (thai1261) shows significant articulatory differences between onset /h/ and onset /ʔ/ in stressed syllables, suggesting that, at least in this language, /h/ may be underspecified for velopharyngeal opening, while /ʔ/ is specified for the same phonetic feature (Johnson 2019). These apparent language-specific phonetic settings pose further challenges for universalist approaches.

The Evolutionary framework, making use of macro- and targeted typologies, is able to both discredit frequency and markedness based accounts, and to provide empirical support for a perceptual explanation for rare /h/ versus /h̃/ contrasts. Since,

to our knowledge, the facts of Zuberoan Basque are not entered in any phonological database, a targeted typology is critical to the success of this study.

2.2 Final obstruent voicing in Lakota

Final obstruent devoicing is a common sound pattern in the world's languages and constitutes a clear case of parallel phonological evolution, occurring independently in a wide range of unrelated languages, as famously observed by Trubetzkoy (1939) and supported by several typological studies in more recent decades (Blevins 2004a, 2006a, 2006b; Iverson and Salmons 2011; Wetzels and Mascaró 2001), all, to a great extent, targeted in assembling languages with word-final laryngeal neutralizations. In some languages, like Czech (czec1258, Šimáčková et al. 2012), this sound pattern takes the form of synchronic alternations, where a voiced series of stops like /b/, /d/, /g/ is produced as a voiceless series [p], [t], [k] in final position. In other languages, like Basque (Egurtzegi 2013), the sound pattern takes the form of a static distributional constraint: word-finally, all obstruents are voiceless, but elsewhere, there is a voicing contrast in obstruents.

The sound pattern of final obstruent devoicing has played an important role in modern phonological theory, crystallizing universal markedness accounts, in contrast to approaches grounded in phonetic explanations for universal tendencies. Within markedness accounts inspired by Trubetzkoy (1939) (e.g. Wetzels and Mascaró 2001) and formalized in Optimality Theory (e.g. Kager 1999; Kiparsky 2006; Lombardi 1999), final obstruent devoicing is understood as a consequence of universal phonological markedness constraints. Voiced obstruents are marked, voiceless obstruents are unmarked, and final devoicing, as neutralization, shows a predicted shift to the unmarked. In Optimality terms, a markedness constraint prohibiting voicing in obstruents typically combines with positional markedness or faithfulness constraints. As components of Universal Grammar, these markedness constraints suggest that obstruent voicing will be generally disfavored, and particularly disfavored in final (or noninitial) position. The same markedness accounts make explicit predictions that final obstruent *voicing* should not exist (Kiparsky 2006, 2008): /p/, /t/, /k/ regularly pronounced as [b], [d], and [g] in phrase- word- or syllable-final position is ruled out, since, under this family of analyses, the voiced obstruents are marked in contrast to their voiceless counterparts.

Phonetic-historical approaches to final obstruent devoicing, like Evolutionary Phonology (Blevins 2004a, 2006a, 2006b, 2015) view this sound pattern as a strong tendency determined by a range of natural phonetic processes. Within this approach, final obstruent devoicing is cross-linguistically common because of the way we speak and the way we perceive speech. Natural reduction of pulmonic airflow at the ends of

phrases, phrase-final laryngeal gestures, phrase-final lengthening, and final consonant non-release, along with perception and phonologization of these articulatory routines, can all give rise to voicelessness, or the perception of voicelessness, in final obstruents (Blevins 2004a, 2006a) and are supported by other sound patterns that may result in final laryngeal epenthesis (Blevins 2008), or, are less amenable to phonologization, like final vowel-devoicing, and devoicing of final sonorant consonants (Blevins 2018). A central distinguishing feature of Evolutionary Phonology in contrast to the markedness approaches outlined above is that nothing prohibits sound patterns of final obstruent *voicing* in synchronic grammars. Final obstruent voicing is predicted to be rare, due to the phonetic factors just mentioned that yield final devoicing. But phonetic and non-phonetic pathways to final obstruent voicing are conceivable, and for this reason, some effort has been put towards examining any sound pattern that might instantiate it. This has resulted in a targeted typology of potential cases of final voicing (Blevins 2006a, 2006b; Yu 2004), which has crystallized into a typology of one.

The case-study of note is Blevins et al.'s (2020) phonetic and phonological investigation of final obstruent voicing in Lakota, a Siouan language (lako1247), currently spoken by approximately 2,000 people, mainly in North and South Dakota. Recordings from Lakota speakers were used to confirm the distribution of obstruent voicing that has been described in earlier published literature. In Lakota, word-final and syllable-final oral stops /p/ and /k/ become voiced [b] and [g], respectively, while /t/ and the affricate /č/ are both pronounced as [l] (a voiced lateral approximant) syllable-finally. The Lakota sounds transcribed as [b] and [g] in the coda have acoustic properties typical of voiced oral stops: they are usually voiced, and they have the closure duration, burst properties, and low energy values of oral stops.

If Lakota represents the predicted possibility of word-final obstruent voicing within emergentist approaches, why is final obstruent voicing so rare cross-linguistically? Recall that within Evolutionary Phonology, where nothing prohibits sound patterns of final obstruent voicing, these patterns are expected to be rare, due to the articulatory and perceptual factors that yield final devoicing patterns cross-linguistically (Blevins 2006a, 2006b). Indeed, in line with general devoicing tendencies, significant evidence of phrase-final and pre-obstruent devoicing was observed in Lakota too (Blevins et al. 2020: 297, 306, 310–311, 316). Only by looking at tokens in non-phrase final position was it possible to see clear evidence of final obstruent voicing, since, elsewhere, coda voicing was sometimes obscured by gradient phrase-final devoicing. Our working hypothesis is that this same cluster of devoicing tendencies makes some final obstruent voicing patterns difficult to quantify, since their effects may be easily masked, in line with recent findings of Beguš (2020). However, while Lakota is included in some large databases, details

central to this case study are either inaccurate or absent. WALS does not acknowledge a voicing contrast in /p/ versus /b/, a contrast we were able to confirm. And even in Beguš' (2020) novel and promising method for predicting the probability of natural and unnatural sound change (and hence, natural and unnatural sound patterns), including final devoicing versus final voicing, Lakota is omitted from the targeted database of sound changes.⁹ Our targeted typology of one, then, seems justified.

2.3 The role of contact in rare sound patterns

A final area where targeted typologies have advanced explanation in Evolutionary Phonology is in the study of contact-induced change. The study of areal sound patterns with geographically-targeted typologies has yielded a sub-theory of contact-induced change which emphasizes the role of the perceptual magnet effect (Kuhl 1991, 2000) in triggering apparent regular sound changes whose occurrence outside of specific types of contact is negligible (Blevins 2017c). Well known cases of contact-induced regular sound change include the spread of retroflexion from Dravidian (drav1251) to Sanskrit (sans1269, Emeneau 1956; Hamp 1996), however, until targeted typologies could be compared, no generalizations were possible. Now, with more careful studies, from the evolution of pharyngeals in the inherited vocabulary of Kurdish (kurd1259, Barry 2019) to the areal distribution and viral spread of front rounded vowels across Western Europe (Blevins 2017c; Egurtzegi 2017; Maddieson 2013c; Shavitz 2020), there is growing evidence that some sound changes, whether context-sensitive or context-free, giving rise to a new output segment *X* are much more likely to occur when *X* is present in a contact language.

Phonotactics, as opposed to individual phones, offer a different kind of contact template, but one where explanation of patterns has also advanced. An extreme example of this is examined in Blevins (2017a, 2020), with a targeted typology of languages that have a regular sound change of cluster-splitting epenthesis of #TRV >> #TVRV, *T* an oral stop, and *R* a sonorant consonant. While this phonological process is well known from studies of loan word phonology (Fleischhacker 2001, 2005) where it is typically attributed to the effects of Universal Grammar in the absence of complex onsets in the target language, cluster-splitting epenthesis as *regular sound change*

⁹ See Beguš (2020: 530, fn.12), where Blevins et al. (2020) is said to have “limited data on alternations and no data on productivity”. This is disconcerting since we emphasize that the synchronic alternations formalized in (5) and exemplified in Table 11 (pp. 306–307) of that work, “are regular and, as far as we can tell, productive” occurring both in new compounds, as well as in words that have undergone (optional, post-lexical, fast-speech) loss of final unstressed vowels (p. 308). In contrast, the final voicing pattern in Lezgian (Yu 2004) is limited to certain monosyllabic nouns.

does not occur outside of specific types of language contact. In a targeted survey of regular sound change for proto-languages with initial *CR clusters, only three instances of this regular sound change were observed. Of the ~400+ Indo-European languages (indo1319), inherited *TR clusters were regularly split by epenthesis only in Persian (sout3157) and Western Armenian (homs1234), and a similar change was found in Siouan for Hooc̣ak (aka Winnebago, hoch1243), attributable to intense historical contact with Central Algonquian languages (cree1271). In all three cases, language contact appears to have played a catalytic role: native adult speakers of a first language lacking complex onsets had intense and rapid contact with a second language containing complex onsets. If cluster-splitting epenthesis was a consequence of Universal Grammar, the contact-induced distribution of this sound change would be unexplained, and the stability of initial #TR clusters in Indo-European for over 5,000 years would also be unexpected. In contrast, viewing simple C-onsets as a learned property of a language-specific grammar, with perceptual (Dupoux et al. 1999, 2011) and articulatory (Tilsen 2016) implications, one is able to explain the rarity of this sound pattern: perceptual illusions (of vowels after consonant release) constitute the cognitive catalyst for phonological change when native adult speakers are driven to acquire a new language with complex onsets quickly, with little time for familiarization with the foreign grammar (Blevins 2017a, 2020). On the basis of this typological study, Evolutionary Phonology predicts that wherever *#TRV > *#TVRV appears to have occurred, it will be the case that a language with initial clusters has been acquired by speakers of a language without those initial clusters.

3 Summary remarks

Our understanding of universal tendencies in phonology is informed by extensive typological surveys revealing both common and rare sound patterns. The case studies reviewed here underscore the importance of dialect diversity, phonetic documentation, and careful studies of language contact in phonological typology, in particular in the discovery of rare patterns. Without diverse dialect representation and phonetic documentation in phonological databases, it is unlikely that rare sound patterns like Zuberoan Basque / \tilde{h} / versus /h/, or Lakota final obstruent voicing, would be recognized at all. And without detailed histories of language contact to complement phonological typologies, the observation that certain sound changes are rare, or occur *only* when contact is involved, could not be formulated.

All of the rare features identified here have important implications for conceptions of phonological universals, whether formulated as violable constraints

(Prince and Smolensky 1993), weak analytic biases (Moreton 2008), or emergent properties of grammar (Blevins 2004a, 2006a, 2015). In the realm of segmental contrasts, the existence of perceptually non-salient categories like / \tilde{h} / versus /h/ suggests two further avenues of research: associated sound patterns that allow the contrast to be more perceptually salient (like the nasal spread referred to above), and more global issues of functional load that might play a role in contrast maintenance and contrast enhancement (Blevins and Wedel 2009). Where alternations are concerned, the targeted typology of one language, Lakota, is in line with the findings of Beguš (2020), that the typological difference between common (natural) final obstruent devoicing and rare (unnatural) final obstruent voicing is due to the fact that common sound patterns, for the most part, reflect sound changes that are phonetically motivated (“channel bias”). Lakota final voicing also suggests important avenues for further research: does Lakota (and possibly other related languages) represent a fleeting natural stage of grammar, prior to the obliteration of final voicing by the phonetic forces involved in final devoicing, or have similar cases been overlooked due to the absence of phonetic records? Finally, the study of initial cluster-splitting epenthesis as regular sound change summarized in Section 2.3 offers a vast new area where phonological typology can inform historical phonology. If enough sound changes of this type can be identified, they can be used to formulate hypotheses about language contact, where other types of evidence may be absent, or to further support prehistoric models of population contact based on genetic and/or archeological evidence.

Whether at the macro level or in targeted databases, phonological typology continues to play a central role in explanation within Evolutionary Phonology. The strongest prediction of the model—that phonetically based sound change is the source of the majority of common recurrent sound patterns in the world’s languages—, continues to be affirmed by synchronic, diachronic, and panchronic studies of the kind summarized here, and by recent studies of sound change that explore potential mismatches between predicted and observed typologies (Beguš 2020). At the same time, outside of phonetic explanation, structural and functional factors involved in sound change have been demonstrated, allowing one to make many new predictions regarding sound patterns and sound change: consistent (C)V syllable structure will have an inhibitory effect on syncopating sound change (Blevins 2009, 2018); initial cluster-splitting epenthesis implies language contact (Blevins 2017a, 2020); and uvular versus velar contrasts in oral stops are likely to weaken if certain expansions of the vowel system take place (Blevins 2021). Overall, it is hoped that this summary will inspire researchers in both typology and phonology to combine insights from macro and targeted typologies as they explore further implications of this and other explanatory models.

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