Saltation and the P-map*

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Abstract

We define a *saltatory* phonological alternation as one in which sound A is converted to C, leaping over a phonetically intermediate sound B. For example, in Campidanian Sardinian, intervocalic [p] is realized as [β] — leaping over [b], which does not alternate. Based on experimental evidence, we argue that saltatory alternation is a marked phenomenon, in the sense that a UG bias causes language learners to disprefer it. However, despite its marked status, saltation does arise from time to time in the world's phonologies; we survey the diachronic origins of saltation and suggest that it is never introduced as a sound change, but arises only incidentally from a variety of historical accidents. Lastly, we propose a new approach to the formal analysis of saltation, based on Zuraw's (2007, 2013) idea of *MAP constraints and Steriade's (2001, 2008) notion of the P-map. Under our proposal, saltation is predicted to be disfavored, since by definition it is not P-map-compliant. We argue that this approach can account for the psycholinguistic evidence for learning bias and is more restrictive than previous proposals.

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Supplemental materials for this article are posted at http://www.linguistics.ucla.edu/people/hayes/Saltation/.

1. Introduction

We define **saltation** as a property of phonological alternations:

(1) *Defn.: saltation*

- Let A, B, and C be phonological segments.
- Suppose that for every feature for which A and C have the same value, B likewise has that value; but that B differs from both A and C.
- If in some context A alternates with C, but B remains invariant, then the alternation A ~ C is a *saltation*.[1]

Here is an example of saltation, taken from the work of Bolognesi (1998). In the Sestu Campidanian dialect of Sardinian, the voiceless stops /p, t, k/, when occurring in intervocalic[2] position, are lenited to [β ð ɣ]. The following examples illustrate the phenomenon:

(2) *Intervocalic lenition of* /p t k/ *in Campidanian* (Bolognesi 1998, pp. 30-31)

a.	belːu [p]iʃːi	→	belːu [β]iʃːi	'nice fish'
b.	sːu [t]rintaduzu	→	sːu [ð]rintaduzu	'the thirty-two'
c.	dɛ [k]uatːru	→	dɛ [ɣ]uatːru	'of four...'

(3) *Retention of intervocalic* /b, d, g/ (pp. 36-39)

a.	sːu [b]inu	→	sːu [b]ĩu	'the wine'
b.	donːja [d]ominiku	→	donːja [d]ominiɣu	'every Sunday'
c.	dɛ [g]ɔma	→	dɛ [g]ɔma	'of rubber'

Bolognesi attests to the productivity of the pattern with examples of application to borrowed or recently-introduced words: sːa [p]olonia → sːa [β]olonia '(the) Poland', sːu [t]asːi → sːu [ð]asːi. 'the taxi', sːu [k]omputːɛ → sːu [ɣ]omputːɛ 'the computer' (pp. 32-33, 463). He further notes (p. 36) that the output pattern is maintained consistently: 'Speakers not only do not spirantize voiced stops, but judge this ... as entirely ungrammatical, instead. For them a phrase such as, for example, *saːβɔtːa* could only be the output of underlying *sːa pɔrta* ('the door'), and never of *sːa bɔrta* ('the time'). They claim the second interpretation to be wrong.'

We adopt the term 'saltation' from Minkova (1993) and Lass (1997), who use it in the context of historical sound change; we discuss their claims about diachrony below. 'Saltation'

[1] We define saltation here on the basis of features for the sake of explicitness. This is not to say that features are the only way, or even the best way, to define this relationship. For instance, perceptual similarity may be an important dimension (White 2013); we return to this in §4. Other relevant dimensions may include articulatory properties as well as abstract structure such as moras or feet. Our main arguments do not rest on knowing precisely which of these dimensions are necessary or sufficient for a definition of saltation.

[2] More precisely, postvocalic onset position; see (2b). The voiceless affricate /tʃ/ also spirantizes (to [ʒ]), but with lexical exceptions (Bolognesi, p. 32); we omit analysis of this segment here.

derives from the Latin word for 'leaping'.[3] As shown in (4), underlying /p/ can be seen as leaping over intervening /b/ in arriving at [β]:

(4) *The path of saltation in Campidanian*

$$\begin{array}{ccc} \text{p} & \text{b} & \beta \\ \begin{bmatrix}-\text{voice}\\-\text{continuant}\end{bmatrix} & \begin{bmatrix}+\text{voice}\\-\text{continuant}\end{bmatrix} & \begin{bmatrix}+\text{voice}\\+\text{continuant}\end{bmatrix} \end{array}$$

Intuitively, we can think of saltation as a case in which a non-alternating sound B is phonetically "intermediate" between two alternating sounds, A and C. Although the diagram in (4) represents this relationship in a linear fashion for illustration, we are not claiming that this intermediate status must be defined on a single phonetic dimension. Indeed, by referencing phonological features, our formal definition of saltation in (1) explicitly allows the intermediate sound B to be defined in terms of multiple dimensions. The Campidanian case is an example of this, as seen in (4): voiced stops are intermediate between voiceless stops and voiced fricatives on the basis of two dimensions, voicing and continuancy.

The concept of saltatory alternation has been discussed before (Lubowicz 2002, Ito & Mester 2003, McCarthy 2003) under the label 'derived environment effects'. We prefer the term 'saltation' because it is theoretically neutral; it describes the data pattern rather than a proposed mode of analysis.[4]

We think that saltatory alternation is a marked phenomenon, in the pretheoretical sense; specifically, we suggest that a UG bias causes language learners to disprefer saltation as a hypothesis. Our support for this claim comes from experimental evidence reported in White (2013, 2014) and White & Sundara (2014).

If we are correct in claiming that saltation is marked, we must ask why it should exist at all. The answer, we claim, is that diachronically, saltation arises through a variety of accidents, involving borrowing, telescoping, and similar factors.[5] Thus it forms a classic case study for the interaction of synchrony and diachrony in phonology, a topic explored in Kenstowicz & Kisserberth 1977 and much subsequent work.

The remaining topic we address is finding an appropriate theoretical account of saltatory alternations. We suggest that current accounts overgenerate in serious ways, and propose an alternative based on the *Map constraints of Zuraw (2007, 2013), which in turn is an

[3] OED *saltate*: 'f. L. *saltāt-*, ppl. stem of *saltāre* to dance, frequent. of *salīre* to leap'.

[4] Specifically, Lubowicz and McCarthy's analyses relate saltation to the 'derived environment rules' discovered by Kiparsky (1973); our account makes no such connection.

[5] In this respect saltation may be similar to the notion of *exchange rule*, a sort of "mutual saltation" discussed in Anderson and Brown (1973) and related literature.

implementation of Steriade's (2001, 2008) P-map principle. Our account both avoids overgeneration and provides the basis of a learning bias to explain the experimental findings.

The article is organized as follows. Sections 2 and 3 treat diachrony, arguing for the essentially accidental origin of saltatory alternations. Section 4 summarizes the experimental evidence for a UG bias against saltation. In sections 5-6 we turn to theory, proposing an account that provides the appropriate UG bias, without leading to gross overgeneration in other domains. Sections 7 and 8 address residual issues and conclude.

2. Theoretical background: the classical theory of phonological change

We situate our discussion of the diachronic aspects of saltation in the context of what we will call the "classical" theory of phonological change. This approach dates from the 19th century (Anderson 1985), with continuation in more recent times in work such as Bach & Harms (1972), Hyman (1975), Anderson (1981), Labov (1994), and Blevins (2004). The literature is vast and we will only give a brief overview.

The key problem is: if the structure of phonological systems is guided, as many scholars believe, by language-independent principles of markedness, how is it that phonological systems can attain unnatural states? Such cases seem to arise especially often for patterns of alternation; we offer some cases below from the literature.

(5) *Some plausibly-unnatural phonological alternations*

a. Odawa palatalization: n → ʃ in front contexts (Kaye 1978, Buckley 2000)
b. Open syllable shortening and closed syllable lengthening in Menomini (Hayes 1995: 218-221; Buckley 2000)
c. Epenthesis of unexpected consonants such as [ɹ] (Vaux 2002)

In the classical model the origin of such unnatural alternations lies in a bifurcation of the sound system into phonetic processes and phonological processes.[6] The phonetic processes constitute the primary engine driving diachronic change. Such processes are normally subphonemic and involve continuous variation along phonetic continua (such as height, rounding, etc.). Synchronically, they create free variation and often reflect stylistic preferences. Phonetic change is seen as natural, involving for instance the lengthening of stressed vowels, lenition of intervocalic consonants, palatalization before front vowels, and so on. Gradient phonetic effects may act as precursors to phonological processes; for instance, /VpV/ may be pronounced more and more similar to [VbV] over time due to the voicing present in adjacent vowels, which may itself lead to a phonologized process of intervocalic stop voicing (e.g., Hyman 1975: 172-173, Blevins 2004, Moreton 2008).

[6] Other versions of the classical approach adopt different distinctions, e.g. the 19th century distinction of sound change vs. analogy; Baudouin de Courtenay's "neophonetic" vs. "paleophonetic" alternations (Anderson 1985: 73), the "processes" vs. "rules" of Natural Phonology (Stampe 1973), or the postlexical-lexical distinction made in Mohanan's (1982) version of Lexical Phonology.

The essential premise of the classical approach is that (at least to some degree) phonetic processes are *indifferent to the consequences incurred by the higher-level phonological system*; for explicit defense of this idea see Labov (1994). As a result, phonetic change, particularly as it accumulates over time, can end up creating patterns that are unnatural when construed in synchronic terms.[7] The phenomenon is sometimes referred to under the rubric of "telescoping" (Wang 1968, Hyman 1975, Kenstowicz & Kisseberth 1977). To give one example, the gradual changes (Jespersen 1909: 232–233; Dobson 1968: 659–662) that led to the modern pronunciation of Middle English long [iː] as [aɪ] led to the phonetically extreme alternation of [aɪ] ~ [ɪ] in Modern English Trisyllabic Shortening alternations such as such as *divine* ~ *divinity*. In another case, Kenstowicz and Kisseberth describe how Ukrainian acquired the alternation o → i in the environment / ___C#: roughly, final oC-ɪ# and oC-ʊ# evolved to oːC# (apocope with compensatory lengthening), then yːC# (fronting and raising), then iC# (Unrounding, loss of phonemic length); while other forms in the paradigm of oC-V# stayed unchanged. All the processes that were telescoped were natural, but the end result hardly so.

The telescoping of phonetic changes represents a common way that languages acquire unnatural phonological patterns. However, the new generations that get exposed to the pattern in childhood are not always passive replicators, but sometimes engage in *restructuring*, i.e. imperfect phonological learning that creates a novel pattern (see, e.g. Kiparsky 1965, Kenstowicz & Kisseberth 1977: 65–77). One classical case of this kind is rule inversion (Kiparsky 1965: 1–11, Vennemann 1972a), of which a famous example has occurred in most non-rhotic dialects of English: what was originally a deletion alternation (*sore* [sɔː] ~ *sore as* [sɔːɹ æz] was restructured as epenthesis, and thus extended to ahistorical cases like *saw* [sɔː] ~ *saw it* [sɔːɹ ɪt]. The recutting of formerly stem-final consonants as epenthetic consonants — the inversion of the historical deletion process — is indeed suggested by Vaux (2002) as a common source of "unnatural" forms of epenthesis. Rule inversion is not the only kind of restructuring; other cases include those treated by Kiparsky (1965, 1982) as rule reordering, as well as paradigm leveling, which can be sporadic (e.g. English *fungi* [ˈfʌŋgaɪ] for historical [ˈfʌŋdʒaɪ]), or occasionally across-the-board, with massive changes across the entire vocabulary (see Bowers's (2012) account of such a change in Odawa).

In sum: the classical theory explains the great variety of natural and unnatural phenomena through a dual bifurcation. At the synchronic level, the essential bifurcation is that of phonetic vs. phonological patterning, with a degree of independence of the former from the latter; this is the seed for the long-term creation of unnatural patterns. Diachronically, the bifurcation is between the cumulative effects of phonetic change on the one hand, and grammar change on the other.

[7] We do not advocate a Neogrammarian conception of sound change as fully blind to linguistic structure (a view appropriately criticized in Kiparsky (1965) and later work); for our purposes it need only be true that phonetic change is "blind enough" to create synchronic conundrums as changes accumulate.

3. The historical origin of saltation

How does saltation fit into the classical theory? The first point is that it is unlikely that a saltatory alternation could arise in the simplest possible way, namely as emergence of a single sound change into the phonological system. The reason is straightforward: if (using the A - B - C format of (1)), sound A gradually drifted in the direction of C, it would trigger a neutralization with intervening B. This point is asserted by Minkova (1993), Labov (1994), and Lass (1997), all of whom who suggest that single sound changes are never saltatory.

If saltation cannot arise from a single unidirectional sound change, then how do saltatory patterns come to be? By studying the cases we could locate, we have arrived at a simple taxonomy of the origins of saltation, given in (6).

(6) *Origins of saltation: a taxonomy*

a. *Interposition by borrowing*

A becomes C in some context;[8] B is later interposed when acquired as a new phoneme in loanwords.

b. *Interposition by grammar change*

A becomes C in some context; B is later interposed as a result of grammar change.

c. *Flanking*

A was originally something else (A′) that became C in the alternation context; then A′ changes to A in the non-alternation context; A and C now flank B, forming a saltation.

We elaborate these three cases below with examples.

3.1 Interposition by borrowing

A case of this type is described by Ito & Mester (2003) for Standard German: /g/, occurring in final position following atonic [ɪ], surfaces as [ç] (the allophone of /x/ found after front vowels), as in /ˈkøːnɪg/ → [ˈkøːnɪç] ‘king’ (cf. [ˈkøːnɪgə] ‘kings’). Yet underlying /k/ in this position is invariant: [ˈplastɪk] ‘plastic’. The sounds [g] and [ç] differ in voicing, continuancy, and place of articulation; [k] differs from [g] in voicing and from [ç] in continuancy and place; hence by our definition (1) the alternation is saltatory.

Inspection of the cases with [k] after atonic [ɪ] shows that they are cosmopolitan words; Ito & Mester give examples like *Plasti*[k] ‘plastic’, *Derri*[k] ‘name of television detective’ and *Bati*[k]; patently late loan words in German.[9] The likely reason that /k/ had previously been

[8] N.B. the change from A to C, both here and in (6b), should not be construed as a leap; rather we assume that it represents the telescoped result of what may have been a whole series of minor changes.

[9] With help from Prof. Armin Mester we have verified this generalization using the Leipzig Online Dictionary, http://wortschatz.uni-leipzig.de.

missing finally after stressless /ɪ/ was because earlier, historical *k* had been converted to *x* by the Second German Consonant Shift; see e.g. Salmons (2012: 116).

Interposition by borrowing also characterizes two other saltations reported by Lubowicz (2002). In Slovak (Rubach 1993), the sounds [e o] alternate in a variety of contexts with the diphthongs [ie uo], thus saltating over [eː oː]. ([eː oː] share their vowel quality with [e o] and their status as heavy nuclei with [ie uo].) The long mid vowels are originally almost entirely from loanwords of the usual pan-European character such as [majoneːz] 'mayonnaise' (Rubach 1993: 177). Lubowicz reports a similar case in Polish: here, underlying /g/ surfaces as [ʒ] before front vowels, skipping over intermediate [ʤ];[10] thus /va[g]+i+ć/ → va[ʒ]+ɨ+ć 'to weigh', but brɨ[ʤ] + ĭk + ɨ → brɨ[ʤ] + ek, not *brɨ[ʒ]+ek 'bridge (game; dim.)'. The forms with invariant [dʒ] are evidently pan-European loans like the word for 'bridge' (see Lubowicz 2002: 245, Rubach 1984: §5.3). We see these cases as showing that, at least in some instances, the pressure to be faithful to a foreign-language source can override whatever system-internal pressure there may be (see §4 below) to avoid saltation within the synchronic system.

3.2 Interposition by grammar change

We argue that Campidanian (§1) likewise is a case where B was interposed between a pre-existing alternation of the form A → C. But the mechanism is more interesting: it arose from grammar change. In our proposal, the Campidanian pattern originated as an ordinary lenition chain, shown schematically in (7):

(7) $\left\{\begin{matrix} \text{p} & \rightarrow & \text{b} & \rightarrow & \beta \\ \text{b} & \rightarrow & \beta & \rightarrow & \varnothing \end{matrix}\right\}$ / V ___ V

That is to say, historical *p* and *b* (and similarly for *t*, *d*; *k*, *g*) weakened intervocalically, while remaining distinct, along the same lenition path. *b*, being in the lead, was the first to reach the extreme of full deletion. This was a radical step, in that it created extensive neutralization (all three voiced stops) in a sensitive place, i.e. stem-initial position (cf. Beckman 1997, 1998; Casali 1997; Becker et al. 2012).[11] We conjecture that when this merger became phonetically complete, the language reached a crisis stage, resolved when a new generation of children refused to accept the extreme alternation and 'fixed' the language by restoring the isolation allomorphs post-vocalically. Our scenario is summarized in (8):

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[10] [g] and [ʒ] differ in continuancy, stridency, and place of articulation; [ʤ] differs from [g] in stridency and place and from [ʒ] in continuancy.

[11] In principle, there would have been merger with the historically vowel-initial words as well. However, as Bolognesi notes (p. 216), the historically vowel-initial words trigger hiatus resolution processes when a vowel-final word precedes them, whereas the words derived from initial /b d g/ — like the *h*-aspiré words of French — typically do not.

(8)	*'nice fish'*	*'the wine'*	
a.	bɛlːu [p]iʃːi	sːu [b]ĩu	initial stage
b.	bɛlːu [b]iʃːi	sːu [β]ĩu	early lenition
c.	bɛlːu [β]iʃːi	sːu [∅]ĩu	crisis stage — massive stem-initial neutralization
d.	bɛlːu [β]iʃːi	sːu [b]ĩu	post-crisis stage — restructuring

In defending our scenario, we must address primarily *whether* the conjectured events happened; we will also speculate on *why* they happened.

Concerning the factual accuracy of the scenario, we first note that (as Bolognesi points out (p. 36, citing Virdis)), there are neighboring dialects of Sardinian where the hypothesized stage (8b) is still attested; that is, voiced stops are still realized as voiced fricatives intervocalically. This increases the plausibility that Campidanian also went through such a stage.

Second, historical evidence indicates that the voiced stops that were intervocalic *within morphemes* in Campidanian disappeared entirely (Bolognesi, p. 212). The following examples illustrate this.

(9) *Invariant loss of intervocalic /b, d, g/ in Campidanian*

a. [teula]	'shingle'	Latin TEGULA 'tile'	p. 189
b. [kɔa]	'tail'	Latin CAUDA	p. 24
c. [nuu]	'knot'	Latin NŌDUS	p. 24
d. [taula]	'board'	Latin TABULA	p. 31

This makes sense under our account, since a medial voiced stop would not have any other allomorph from which the underlying form could be recovered. In historical linguistics, such relic monomorphemic forms constitute a classical diagnostic for the scenario of sound change followed by grammar change; for examples see Kiparsky (1968: 176–179), King (1969: 46–48), Vennemann (1972b), and Bynon (1977: 144).

Third, Bolognesi notes the existence of particular words beginning with voiced stops that, even in contemporary Campidanian, alternate optionally with zero, as in (10).

(10) a.	[bakːa]	[sːa bakːa] ~ [sːa akːa]	'cow/the cow'	(p. 37)
b.	[dɔmu]	[sːa dɔmu] ~ [sːa ɔmu]	'house/the house'	
c.	[gatːu]	[sːu gatːu] ~ [sːu atːu]	'cat/the cat'	

Such alternation is allowed only in 'a restricted number of lexical items' (p. 190), forming a 'closed class' (p. 215). Other words do not allow alternation at all:

(11) a.	[barːĩa]	[sːa barːĩa], *[sːa arːĩa]	'the drill'	(p. 37)
b.	[dɔtːori]	[sːu dɔtːori], *[sːu ɔtːori]	'the doctor'	
c.	[gauɲdʒu]	[sːu gauɲdʒu], *[sːu auɲdʒu]	'the food that can be put on bread'	

An examination of the data throughout Bolognesi's work suggests the following generalization: alternators tend to be words of the core vocabulary, whereas non-alternators are more sophisticated vocabulary.[12] We suggest that the alternating forms are relics, dating from the time when intervocalic deletion of voiced stops applied across the board; in this respect they resemble English *kept*, a relic dating from when pre-cluster shortening was applicable across the board in English. As with relic forms elsewhere in historical phonology, they skew toward the core vocabulary, since it is in core vocabulary that relic forms tend to be retained over time (Bynon 1977: 42–43, Bybee 1985: 119–120).

A further remarkable property of the relic alternating forms is that their ∅-initial allomorphs are employed in *careful*, not fluent, speech (Bolognesi 1998: 36–37); this may reflect the demands of lexical retrieval for listed forms.[13]

Thus, if the arguments just given are correct, Campidanian saltation was never a sound change; rather, it involved interpolation of the voiced stops in the intermediate position by grammar change. We return to the formal analysis of Campidanian below (§6), as well as the question of why the grammar change took place as it did (§7).

A second instance of saltation through grammar change is offered by Ito & Mester (1997). In the *rendaku* (compound voicing) alternations of Conservative Tokyo Japanese, basic /k/ saltates over /g/ in becoming [ŋ], as in /ori + kami/ → [oriŋami] 'folding paper'. That the alternation is saltatory is shown by forms like /niwa + geta/ → [niwageta] 'garden clogs'.[14] The historical evolution of this pattern is plausibly as follows: (a) *k* was originally voiced by rendaku to *g*, in parallel with other obstruents; (b) *g* then further evolved to [ŋ] intervocalically in the Conservative Tokyo dialect; (c) lastly, *g* was optionally restored in paradigms (grammar change). As Ito and Mester suggest, this could have arisen through promotion of an output-to-output correspondence constraint (Benua 1997) requiring an exact match to [g] in the base form, as in [niwageta]. No base form with [g] is available for [oriŋami], which accounts for its invariant [ŋ].

3.3 Flanking

Ito & Mester (2003) report a saltation in certain Northern varieties of German in which the surface form of underlying /g/ in final position is not the expected [k] (via the well-known process of Final Devoicing) but rather [x], as in [fraːx] 'asked-1 sg.' (cf. [fraːgən] '1 pl.'). Since there are also non-alternating forms with [k] (e.g. [dɪk] 'fat'; inflected [dɪk-ə], this is saltation of /g/ to [x] over [k].

[12] E.g., alternating forms have glosses like 'of', 'want', 'road', 'house'. Non-alternating forms have glosses like 'doctor', 'drill', 'rubber', 'chicory'.

[13] An issue we will not treat in detail is how the irregular forms of (10) should be analyzed in a formal grammar. They do not seem fundamentally different from any other forms of lexical allomorphy, and appropriate theoretical apparatus has been proposed in the literature; see e.g. Mascaró (2004) and John McCarthy's (2004) appended commentary for further references. Following this tradition, we suggest that words of the class in (10) have dual lexically listed allomorphs, such as (for 'cow') {/bakːa/, /akːa/}, and that the appropriate allomorph is selected (sometimes in free variation) by the constraint system.

[14] The latter form may also be pronounced [niwaŋeta]; hence the alternation is not *invariably* saltatory.

A plausible origin for this case is described by Robinson (2001), relying on earlier work by Zhirmunskii (1962) and Pilch (1966): it appears to be not a consequence of sound change but of hypercorrection. In vernacular varieties of North German, earlier [g] evolved into the spirant [ɣ][15] whenever it followed a vowel; including intervocalically (Zhirmunskii 1962). For these vernacular varieties, sample paradigms would have evolved as in (12).

(12) *North German saltation, phase I: the vernacular dialects*

fragen ~ frag	*dicke ~ dick*	*machen ~ mach*[16]	
g ~ g	k ~ k	x ~ x	pre-North German
ɣ ~ ɣ	k ~ k	x ~ x	Spirantization of /g/ after vowels
ɣ ~ x	k ~ k	x ~ x	Final Devoicing

According to Pilch (1966), North German varieties are subject to normative influences; he mentions the social ‘pressures of educated society’. This influence has given rise to a variety that Pilch calls ‘refined’ (*vornehm*) North German, exemplified by the paradigms in (13).

(13) *North German saltation, phase II: refined varieties*

fragen ~ frag	*dicke ~ dick*	*machen ~ mach*
g ~ x	*k ~ k*	*x ~ x*

As can be seen, in Pilch’s Refined North German — which is in fact the variety Ito and Mester describe[17] — [ɣ] is replaced (either optionally or obligatorily) by the normative form [g]; thus *fra*[g]*en* instead of *fra*[ɣ]*en*. Less often, Pilch notes, Refined speakers also southernize forms like *fra*[x] to *fra*[k]. Yet it would seem easier (a surface, perhaps postlexical operation) to cleanse one’s speech of all [ɣ]’s by replacing them with [g] than to ‘fix’ only the [x]’s that derive from /g/ with [k]. When a speaker makes the easy repair but not the hard one, the resulting pattern is the saltation seen in (13).

The realism of this scenario is further increased by the existence of speakers (Armin Mester, personal communication) who produce the Refined North German variants in careful, public contexts, but the vernacular forms in casual contexts with family and friends.

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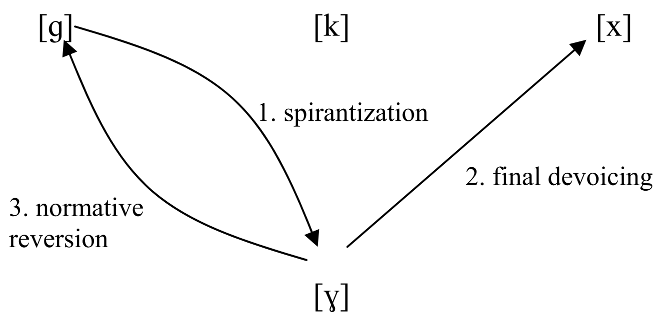
[15] Or its partner [ʝ] in the environment after front vowels (Robinson 2001: 91); velar examples are used here for simplicity.

[16] These forms are schematic and not guaranteed to match actual dialect data. Glosses: ‘ask-imperative/infinitive’; ‘fat-adjectival inflection/plain form’; ‘do-imper./infin’.

[17] We will not venture to reconcile Pilch’s calling the same variety ‘Refined’ that Ito/Mester call ‘Colloquial’; perhaps standards of refinement have risen during the four decades separating these works.

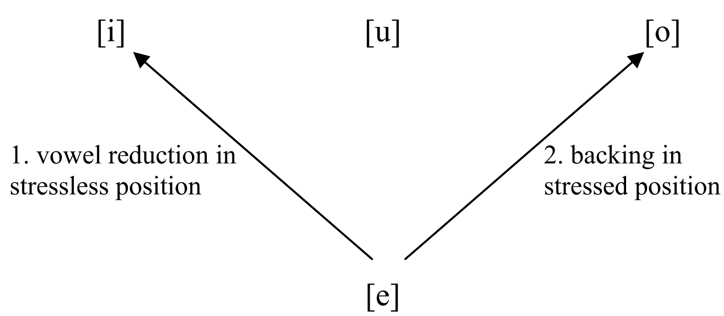
From the diachronic perspective, it can be seen that Refined North German acquired a saltatory alternation through a sort of flanking maneuver, as seen in (14): on one flank, historical *g* evolved into [ɣ], thence (in final position only) into [x]. This in itself did not produce saltation; however, a reverse change, the normatively-driven shift of [ɣ] back to [g], moved the alternating pair [g] ~ [x] into a saltatory arrangement with respect to [k]. As with previous cases, saltation was not a direct historical innovation.

(14) *Formation of North German saltation though flanking*



Crosswhite (2000) offers another case of saltation from Russian that likewise can be considered as a case of flanking. Here, phonemic stressless /o/ is reduced to [i] when following a palatalized consonant (and not immediately pre-tonic), with phonemic stressless /u/ remaining as [u] in the same environment. Since [u] is high like [i] and back and rounded like [o], this is saltation. Crosswhite gives the diachronic background: ‘This unusual pattern of /o/ > [i] but /u/ > [u] derives historically from the fact that *stressed* /e/ became [o] when preceded by a palatalized consonant but not followed by one: C^{j}éC > C^{j}óC’. In our terms, this is saltation by diachronic flanking, as shown in (15).

(15) *Formation of Russian saltatory vowel reduction though flanking*



Crosswhite also presents evidence that the Russian saltation pattern is no longer productive (at least in certain dialects): it fails to apply to real words newly introduced into Russian, it was emphatically rejected by native speakers in a nonce-word test conducted by Crosswhite, and it gives rise to regularizing shifts in the pronunciation of existing words. This fact will be relevant below when we consider the synchronic analysis of saltation.

To sum up our historical survey: the data so far given seem compatible with the view that saltation is never the result of a single sound change but is always the result of secondary factors such as borrowing, telescoping, or restructuring.

3.4 Further saltatory alternations

We cover four further cases; with these examples, we have listed all instances of saltatory alternation of which we are aware.

3.4.1 Manga Kanuri

The Manga dialect of Kanuri (Schuh 2003, 2005; Jarrett 2007) constitutes the biggest puzzle for our view that saltation cannot arise directly from sound change. In this language, basic /t/ surfaces as [ð] when between two sonorants, saltating over [d], which is invariant in this position. Historically at least, [ð] was an allophone (noncontrastive variant) of /t/, much as in Campidanian. There are also alternations that persist today, as with the nominalizer prefix /kə̀n-/; compare [tà] 'catch (verb)' ~ [kə̀nðâ] 'catch (noun)'; [dóndì] 'sick' ~ [kə̀ndóndì] 'sickness'.

Similarly to the Russian example just given, the Manga Kanuri pattern seems to be breaking down: intervocalic [t] is now phonologically legal in the language and thus contrasts with /ð/; this is attested by about 24 stems with intervocalic [t] in the dictionary of Jarrett (2007), occurring both in European loans and otherwise.

Concerning the history of saltation in Manga Kanuri, we note a particularity of this dialect, namely that the region in which it is spoken was not originally Kanuri-speaking: historically, Kanuri spread westward into areas populated by speakers of Chadic languages, of which Bade and Ngizim still survive as near-islands, now separated from one another by a Kanuri-speaking area (Schuh 2003, 2005; Hutchinson 1981: 4). Both Bade and Ngizim include implosive [ɗ] in their phoneme inventories, making it reasonable to suppose that this was true of the now-extinct Chadic varieties that were displaced by Kanuri. Our conjecture is that the Chadic speakers who first adopted Kanuri rendered Kanuri [d] with their own implosive [ɗ].[18] If this [ɗ] was still in place when *t* lenited to [ð] between sonorants; then it was not on the direct path between [t] and [ð] (neither of which are implosive) and the change was therefore not saltatory. Ultimately, the hypothesized Chadic-influenced variety of Kanuri lost [ɗ], shifting it to [d] in conformity with other Kanuri dialects. Thus [d] was interposed between [t] and [ð] (cf. §3.1, §3.2 above), creating the saltation. This account of Manga Kanuri saltation is speculative and the matter deserves further attention.

3.4.2 Suma

Discussing the tonal phonology of Suma, Bradshaw (1995, 1998, 1999) indicates that in the associative construction of this language, a final low tone becomes high when it is preceded by a high tone, resulting in an alternation between a HL pattern and a HH pattern. Bradshaw states

[18] For an instance where implosives have been employed in loan adaptation of foreign words with voiced stops, see Smith and Haabo (2007) on Saramaccan.

that 'nouns with final H or M tones do not alternate' (1998: 117); however, no examples of this type are given; nor are the possible historical origins of the claimed saltation discussed.

3.4.3 Makassarese

McCarthy (2003) offers what may be an additional example of saltation from Makassarese (Aronoff *et al.* 1987), namely /{r,l,s}#/ → [{r,l,s}Vʔ#], with a form of glottal epenthesis that is not found for simple underlying final vowels (i.e. /V#/ → [V#]). This would be an interesting case of saltation because it involves segment sequences, not individual segments, and thus falls outside the scope of the definition in (1). The case for saltation here is not ironclad, however, because the contexts of the two changes are different: given the Makassarese stress pattern, stable final V is always directly posttonic, whereas derived final Vʔ occurs only when there is antepenultimate stress. Inkelas (1999: 145) and Anttila (2012: 87) have suggested constraints that forbid heavy syllables in clash; if present in Makassarese, such constraints could independently block the appearance of [ʔ] for underlying final V; i.e. [ˈCVCVʔ] from /CVCV/ would be clashing, [ˈCVCVCVʔ] from /CVCVC/ would not.

3.4.4 Campidanian II

Campidanian also saltates voiced geminates /bː dː gː/ to [β ð ɣ] crossing over [b d g]; this saltation is discussed in §6.4 below.

3.5 Local summary

As summarized in §2, the classical framework of phonological change provides a plausible account of the origin of unnatural phonological alternations via telescoping and restructuring. We have supported the view, expressed by Lass, Minkova, and Labov, that there is no need to appeal to saltatory sound changes to explain the existence of synchronic saltatory alternations. Indeed, saltatory alternations appear to constitute a classic illustration of the variegated ways in which telescoping and restructuring can give rise to surprising synchronic patterns, just as the classical theory (§2) maintains.

4. Evidence for a learning bias against saltation

We turn now to synchrony, asserting that saltation is a marked phenomenon, disfavored as a hypothesis by language learners. In making this claim, we cannot rely on a traditional source of evidence in phonology, namely the rarity of a phenomenon across languages. Should saltation be rare (we suspect it is, but our data do not suffice to prove it), we already have an explanation, namely that it requires exceptional diachronic circumstances to come into being. Instead, the evidence must come from direct observation of language learners. For instance, we might expect that children learning Campidanian would have difficulty, making errors such as converting /b/ to [β] in intervocalic position.[19] Sadly, it would be difficult to verify this point, since it appears that very few if any young children are still learning this language (Bolognesi 1998: Chap. 1).

[19] Bolognesi (1998: 36) reports that Campidanian-speaking adults make this error — but only rarely.

A more feasible research path is to test the acquisition of saltatory patterns in artificial language learning experiments. Recent work in this area has yielded results that suggest that saltation is indeed difficult to learn. White (2013, 2014) exposed adult English-speaking participants to an artificial language containing phonological alternations comparable to those seen in Campidanian: voiceless stops ([p t]) changed to voiced fricatives ([v ð]) intervocalically, but voiced stops ([b d]) did not alternate. Despite their training, participants frequently spirantized voiced stops in error when tested on novel forms. Control conditions indicated that the errors were due to an anti-saltation effect and not merely to other factors such as rule overgeneralization or product-oriented learning.

Indeed, the same pattern emerges in experiments on infants. White & Sundara (2014) exposed 12-month-old infants to potentially saltatory alternations (e.g. [p ~ v]) in an artificial language; infants who learned the [p ~ v] alternation generalized to [b ~ v], but not *vice versa*. Further, Sundara et al. (2013, submitted) showed that American English-learning infants acquire the [d ~ ɾ] alternation (*pad ~ padding*), but not the [t ~ ɾ] alternation (*pat ~ patting*), by 12 months of age. Sundara et al.'s corpus search revealed that there is greater statistical evidence for the [t ~ ɾ] alternation in infants' language input, suggesting that the earlier acquisition of the [d ~ ɾ] alternation is due to a learning bias. These results are consistent with our proposal that saltation is dispreferred: if infants had instead learned the [t ~ ɾ] alternation before the [d ~ ɾ] alternation, this would be a saltation because [d] is intermediate between [t] and [ɾ] by our definition in (1).

In some instances, data from language change also suggest that saltation may be dispreferred during learning: as already mentioned (§3.3), Crosswhite (2000) documented ongoing synchronic breakdown of the Russian [o] - [u] - [i] saltation, and in Manga Kanuri (§3.4.1) the formerly allophonic relationship of [t] and [ð] has broken down with the admission of new forms with intervocalic [t]. Yet we cannot always expect to see such traces: it may well be that adult speakers of languages with saltation are often exposed to such extensive data that they do learn their language successfully; in particular we noted above (§1) Bolognesi's argument that Campidanian saltation is productive.

A striking case of acquisition error may be evident in the spirantization pattern of Logudorese, a Sardinian dialect related to Campidanian (Ladd & Scobbie 2003). Here, the same kind of relic forms noted in §3.2 above for Campidanian ([ˈbakːa] 'cow' ~ [sa ˈakːa] 'the cow') demonstrate that in this dialect voiced stops originally lenited to zero intervocalically, just as they did in Campidanian. But the innovating (and probably productive) pattern in contemporary Logudorese is to lenite underlying intervocalic /b d ɡ/ to [β ð ɣ], neutralizing them with underlying /p t k/; thus [duˈtɔːɾɛ] 'doctor' ~ [su ðuˈtɔːɾɛ] "the doctor", matching /t/ in [ˈtɛra] 'land' ~ [sa ˈðɛra] 'the land'.[20] It is tempting to suppose Logudorese ancestrally had the same pattern as Campidanian, and evolved into its current state by precisely the kind of acquisition error committed by White's experimental subjects.

[20] Our transcriptions give [β ð ɣ] but these are actually in free variation with [b d ɡ], perhaps indicating that historical /p t k/ did not lenite as far in Logudorese as they did in Campidanian. The essential point is that unlike in Campidanian, Logudorese /p t k/ and /b d ɡ/ are neutralized intervocalically, eliminating the saltation.

In sum, evidence from recent experimental work with adults and infants as well as historical change suggests that saltatory patterns are difficult to learn or otherwise dispreferred by learners.

5. Synchronic theories of saltation: earlier accounts

We turn now to theoretical approaches to the synchronic analysis of saltation. The discussion above offers possible criteria of adequacy for such analyses. Whatever theory we adopt should include some element to which we can attach the imputation of difficulty in learning, in order to be able to explain the experimental and language-change evidence just adduced. More straightforwardly, the theory should predict that saltation is at least *possible*; since it appears that on occasion, when historical change dishes up a saltatory pattern, language learners have been able to maintain it productively for some period of time.

We will also invoke one further criterion of adequacy, namely restrictiveness. In general, phonologists have sensibly preferred theories that do not allow the generation of bizarre patterns unattested in the world's languages; and we will invoke this form of argument in assessing the theories reviewed below.

5.1 Why saltation cannot be derived in classical Optimality Theory

We begin by repeating the arguments of Lubowicz (2002) and Ito & Mester (2003) that saltation cannot be derived in 'classical' Optimality Theory. By the latter we mean Prince & Smolensky (1993) as modified by the Correspondence Theory of McCarthy & Prince (1995).

Consider first Campidanian. When /p t k/ shift to [β ð ɣ] in intervocalic position, they become voiced; in standard OT this will follow if a Markedness constraint banning intervocalic voiceless sounds (*V[−voice]V) outranks the opposing Faithfulness constraint for voicing, IDENT(voice). In addition, when shifting to [β ð ɣ], /p t k/ become [+continuant]. This will follow if a Markedness constraint banning intervocalic stops (*V[−cont]V) outranks the opposing Faithfulness constraint for continuancy, IDENT(continuant). As shown in (16), a grammar that respects these rankings will generate (to cover just the bilabial case) [aβa] from underlying /apa/:[21]

(16)

/apa/	*V[−voice]V	* V[−cont]V	IDENT(voice)	IDENT(cont)
☞ aβa			*	*
aba		*!	*	
aɸa	*!			*
apa	*!	*		

However, since V[−cont]V outranks IDENT(continuant), then /aba/ will likewise surface as [aβa], which is incorrect:

[21] To save space we use schematic underlying forms with the vowel /a/ only; these are meant to represent actual data such as those presented above in §1.

(17)

/aba/	*V[−voice]V	* V[−cont]V	IDENT(voice)	IDENT(cont)
☞ *aβa				*
aba		*!		
aɸa	*!		*	*
apa	*!	*	*	

Thus, there is a ranking contradiction: V[−cont]V must outrank IDENT(continuant) in order to let /p/ go all the way to [β], but IDENT(continuant) must outrank V[−cont]V in order to keep intervocalic /b/ unaltered.

Now consider the general case, /A/ → [C] with intermediate unchanging B. The rankings that send A to C will also wrongly send B to C, for given our definition of saltation in (1), the Faithfulness violations incurred in changing B to C are a subset of those incurred in changing A to C. Thus, the Faithfulness constraints cannot prevent B from changing to C. Moreover, the same end cannot be achieved by assigning a sufficiently low ranking to the Markedness constraints that favor changing B to C; under this strategy, A would wrongly change to B rather than C. Such considerations suggest that analyzing saltation is, in general, beyond the scope of classical OT.

5.2 The constraint-conjunction approach

If classical OT cannot treat saltation, what can? Lubowicz (1998, 2002) proposed to employ *local constraint conjunction*, in the sense of Smolensky (1995).[22] This solution was carried over by Crosswhite (2000) for Russian and by Ito & Mester (2003) for German. The crucial idea is to conjoin a markedness constraint with a faithfulness constraint, which for Campidanian would work as in (18).

(18) *A conjoined constraint for Campidanian*

*IDENT(voice) & *V[–continuant]V

This constraint says that a segment should not be simultaneously unfaithful (with regard to IDENT(voice)) and marked (with regard to *V[–continuant]V]). Intuitively this can be expressed as the prescription, 'do not be an intervocalic stop if you already violate faithfulness to [voice].' Under this setup, intervocalic /p/ cannot surface as [b], though voicing-faithful /b/ is allowed to do so. In (19) are tableaux illustrating this point.

[22] Specifically, we mean constraints that penalize candidates that are simultaneously "bad in two respects"; for the alternative of penalizing candidates that are bad in *either* of two respects, see Crowhurst and Hewitt (1997), Downing (1998), and Crowhurst (2011).

(19) *Saltation with conjoined constraints*

a. Conjoined constraint forces /p/ *to become* [β]

/apa/	ID(vce) & *V[−cont]V	*V[−vce]V	ID(voice)	ID(cont)	*V[–cont]V
☞ aβa			*	*	
*apa		*!			*
*aba	*!		*		*

b. /b/ *is stable*

/aba/	ID(vce) & *V[−cont]V	*V[−vce]V	ID(voice)	ID(cont)	*V[–cont]V
☞ aba					*
*aβa				*!	

However, as Ito & Mester (1998) originally pointed out, the cost of this solution for phonological theory as a whole is extremely high: it leads to a broad license for marked entities to be favored over unmarked ones, contrary to typology. We demonstrate this here with our own example, constructing a hypothetical language whose phonology is highly implausible.

We assume some garden variety constraints: (a) a Markedness constraint, *[−sonorant, +voice], banning voiced obstruents (e.g., Lombardi 1999); (b) an opposed Faithfulness constraint, IDENT(voice); (c) a Markedness constraint banning triple consonant clusters *CCC;[23] (d) an opposing Faithfulness constraint, MAX(C). We assume that our language in the normal case forbids voiced obstruents (as in Hawaiian and other languages), hence employs the ranking *[−sonorant, +voice] >> IDENT(voice). We also assume that our language permits triple clusters, so that MAX(C) >> *CCC. Now we conjoin Markedness and Faithfulness constraints to create IDENT(voice) & *CCC, and rank the resulting constraint above *[−sonorant, +voice]. The result is that in our hypothetical language, voiced obstruents are allowed, but only when they occur as part of a triple cluster. The tableaux demonstrating this are given in (20).

[23] This could be replaced by syllable-based constraints; the point of our example would not change.

(20) *Deriving voiced obstruents only in triple clusters with a Lubowiczian conjoined constraint*

a. *Voiced obstruents disallowed in simple cases*

/ba/	IDENT(voice) & *CCC	MAX(C)	*[–son, +voice]	*CCC	IDENT(voice)
☞ pa					*
*ba			*!		

b. *Voiced obstruents allowed in triple clusters*

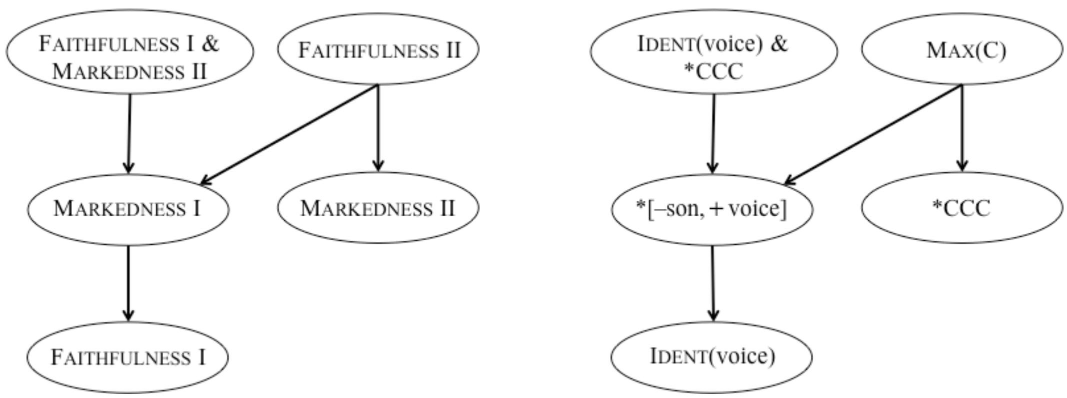
/apdka/	IDENT(voice) & *CCC	MAX(C)	*[–son, +voice]	*CCC	IDENT(voice)
☞ apdka			*	*	
*apka		*!			
*aptka	*!			*	*

We certainly know of no language that permits voiced obstruents only in triple clusters and do not expect to encounter one. At the very least, it is grossly counterintuitive to think that appearance in a highly marked configuration (CCC) would permit the appearance of segments otherwise illegal.

The example can be generalized as follows. Assume two Markedness constraints, MARKEDNESS I and MARKEDNESS II, which are independent and can be violated in the same location. In general, violations of MARKEDNESS I are not allowed because MARKEDNESS I dominates the opposing faithfulness constraint, FAITHFULNESS I. Moreover, FAITHFULNESS II ranks above both MARKEDNESS I and MARKEDNESS II, meaning that violations of these Markedness constraints cannot be resolved by violating FAITHFULNESS II. Finally, a conjoined constraint, FAITHFULNESS I & MARKEDNESS II, dominates MARKEDNESS I. The result will be a language in which MARKEDNESS I can be violated only when MARKEDNESS II is also violated. For comparison, the rankings for both the general scheme and its specific instantiation above are given as Hasse diagrams in (21).

(21) *A problematic constraint ranking*

General scheme *Specific example from (18)*



The general scheme can be cashed out as a panoply of bad typological predictions, for instance, the existence of languages in which nasalized low vowels are confined to stressless syllables; front rounded vowels occur only in hiatus, contour tones are limited to creaky vowels, and so on. It is patently the case in phonology that adding a marked context does not make it easier to violate a markedness constraint; often it makes it harder (which is why conjoined Markedness constraints often make sense; Ito & Mester 2003). For this reason, we feel that it would be sensible to ban Markedness-Faithfulness conjunctions from phonological theory entirely; this was proposed by Ito & Mester (1998: 13) under the title 'Restriction on Conjoinability'.[24]

5.3 The Comparative Markedness approach

Another earlier approach to saltation was provided by McCarthy (2003), who included saltation among the phenomena to be treated in his proposed theory of Comparative Markedness. Under this approach, each Markedness constraint, M, is replaced with two constraints, $_{O}$M and $_{N}$M. $_{O}$M only assesses markedness violations that are 'old', meaning that the violations are present in the fully faithful candidate.[25] $_{N}$M only assesses markedness violations that are 'new', meaning that the violations are *not* present in the fully faithful candidate. $_{O}$M and $_{N}$M may be freely ranked within the constraint hierarchy. It is easy to see that this scheme could give rise to

[24] It is evident from the discussion earlier that Ito and Mester changed their views after writing their 1998 ms., apparently motivated by the need to analyze saltation. We think they were right the first time, and offer an alternative account of saltation below.

One further note on Markedness-Faithfulness conjunction: Baković (2000) suggests it as a solution to the well-known 'majority rules' problem in harmony and assimilation (Lombardi 1999). In light of the argument summarized in this section we are reluctant to accept his solution, since purely Faithfulness-based solutions also exist (e.g., Lombardi's). In addition, the empirical generalization that 'majority rules' phenomena are never found may actually be false; see Bowler (in preparation).

[25] Typically, a markedness violation that is present in the fully faithful candidate will also be present in the underlying form. McCarthy bases the comparison on the fully faithful candidate rather than the underlying form to avoid potential complications from structures that may not be present underlyingly (e.g. syllable structure; see McCarthy 2003).

saltation: in cases where A saltates over B to C, high-ranked *$_{N}$B forces underlying /A/ to surface as [C]; whereas low-ranked *$_{O}$B permits underlying /B/ to remain in place.

Applied to Campidanian, this would work as in (22). First, the Markedness constraints $_{N}$*V[–voice]V and $_{O}$*V[–voice]V are both undominated, forcing all intervocalic obstruents to be voiced. In addition, assume the markedness constraints $_{N}$*VDV and $_{O}$*VDV, which ban 'new' and 'old' intervocalic voiced stops. $_{N}$*VDV is undominated, so newly derived voiced stops are not allowed intervocalically; as a result, underlying /apa/ becomes [aβa] rather than *[aba] (see 22a). Crucially, $_{O}$*VDV is ranked below IDENT(cont), so that the 'old' intervocalic voiced stop found in underlying /aba/ is protected from spirantization, as seen in (22b).

(22) *A Comparative Markedness analysis of saltation in Campidanian*

a. /apa/ surfaces as [*aβa*], *not* *[*aba*], *due to undominated* $_{N}$**VDV*

/apa/	$_{N}$*VDV	$_{N}$* V[−voice]V	$_{O}$* V[−voice]V	ID(cont)	$_{O}$*VDV	ID(voice)
☞ aβa				*		*
apa			*!			
aɸa			*!	*		
aba	*!					*

b. /aba/ surfaces as [*aba*] *because* $_{O}$**VDV is ranked below IDENT(cont)*

/aba/	$_{N}$*VDV	$_{N}$* V[−voice]V	$_{O}$* V[−voice]V	ID(cont)	$_{O}$*VDV	ID(voice)
☞ aba					*	
aβa				*!		
apa		*!				*
aɸa		*!		*		*

Comparative Markedness has a clear formal connection with the constraint conjunction approach (see Lubowicz 2003). The crucial similarity is the ability of Markedness constraints to assess violations only in cases where a candidate is also unfaithful. In constraint conjunction, this is accomplished by conjoining Markedness constraints to Faithfulness constraints. In Comparative Markedness, the same effect is accomplished by allowing $_{N}$M constraints to assess only those Markedness violations that are not present in the fully faithful candidate. In each case, Markedness constraints are given access to Faithfulness, blurring somewhat the traditional distinction between Markedness and Faithfulness.

Assessing the Comparative Markedness approach in general terms is a major undertaking, as it has many ramifications (see, notably, McCarthy 2003 and the commentary papers in the same volume of *Theoretical Linguistics*, as well as Hall 2006). Here, we point out only that the same kind of "phonotactic monsters" (e.g., voicing contrasts only between obstruents) that were discussed above for the conjoined-constraint approach may also arise in Comparative Markedness. We demonstrate this with another hypothetical language.

Once again, we assume several garden variety constraints: (a) Markedness constraints, $_{O}$*[–son,+voice] and $_{N}$*[–son,+voice], banning 'old' and 'new' voiced obstruents; (b) Markedness constraints, $_{O}$AGREE and $_{N}$AGREE, which are violated whenever adjacent obstruents disagree in voicing, (c) Markedness constraints, $_{O}$*p and $_{N}$*p, specifically banning [p] (e.g., as in Arabic and many similar languages with "[p]-gaps" in their stop inventories; see Maddieson 1984: 35), and (d) the Faithfulness constraint IDENT(voice). Consider the ranking of these constraints given in (23).

(23) *A phonotactically-problematic ranking*

$_{O}$*p, $_{O}$AGREE >> $_{N}$*[–son,+voice] >> $_{N}$*p >> $_{O}$*[–son,+voice] >> $_{N}$AGREE, IDENT(voice)

In this hypothetical language, there is no contrast between voiced and voiceless obstruents in general, as seen in (24). Underlying nonlabial voiced stops surface as voiceless because $_{O}$*[–son,+voice] >> IDENT(voice); underlying /b/ and /p/, however, surface as [b] because $_{O}$*p >> $_{N}$*[–son,+voice] (i.e., it is better to avoid an old [p] even if you get a new voiced obstruent), and $_{N}$*p >> $_{O}$*[–son,+voice] (i.e., it is better to avoid becoming a new [p] even if that means you must remain an old voiced obstruent).

(24) *No contrast between voiced and voiceless obstruents generally*

a. /ta/ and /da/ both surface as [ta]

/ta/	$_{O}$*p	$_{O}$AGREE	$_{N}$*[–son,+voice]	$_{N}$*p	$_{O}$*[–son,+voice]	$_{N}$AGREE	ID(voice)
☞ ta							
da			*!				*

/da/	$_{O}$*p	$_{O}$AGREE	$_{N}$*[–son,+voice]	$_{N}$*p	$_{O}$*[–son,+voice]	$_{N}$AGREE	ID(voice)
☞ ta							*
da					*!		

b. /pa/ and /ba/ both surface as [ba]

/pa/	$_{O}$*p	$_{O}$AGREE	$_{N}$*[–son,+voice]	$_{N}$*p	$_{O}$*[–son,+voice]	$_{N}$AGREE	ID(voice)
pa	*!						
☞ ba			*				*

/ba/	$_{O}$*p	$_{O}$AGREE	$_{N}$*[–son,+voice]	$_{N}$*p	$_{O}$*[–son,+voice]	$_{N}$AGREE	ID(voice)
pa				*!			*
☞ ba					*		

However, the contrast between /p/ and /b/ is maintained when the sounds are surrounded by two voiceless obstruents, as seen in (25). Moreover, the contrast is maintained by alpha switching: /atbka/ surfaces as [atpka] whereas /atpka/ surfaces as [atbka].

(25) *Contrast between /p/ and /b/ maintained between two voiceless consonants*[26]

a. /atbka/ surfaces as [*atpka*]

/atbka/	$_{O}$*p	$_{O}$AGREE	$_{N}$*[–son,+voice]	$_{N}$*p	$_{O}$*[–son,+voice]	$_{N}$AGREE	ID(voice)
☞ atpka				*			*
atbka		*!*			*		
adbga			*!*		*		**
adpga		*!*	**	*			***

b. /atpka/ surfaces as [*atbka*]

/atpka/	$_{O}$*p	$_{O}$AGREE	$_{N}$*[–son,+voice]	$_{N}$*p	$_{O}$*[–son,+voice]	$_{N}$AGREE	ID(voice)
atpka	*!						
☞ atbka			*			**	*
adbga			**!*				***
adpga	*!		**			**	**

The reasoning is as follows. Because $_{O}$AGREE is undominated, the two AGREE violations in underlying /atbka/ must be resolved, which rules out candidates [atbka] and [adpga].[27] $_{N}$*[–son,+voice] >> $_{N}$*p, so the candidate with two new voiced obstruents, [adbga], loses to the candidate with a new [p]. Thus, /atbka/ surfaces as [atpka] (see 25a). For input /atpka/, undominated $_{O}$*p rules out candidates [atpka] and [adpga] because the underlying /p/ cannot be maintained. Moreover, $_{N}$*[–son,+voice] >> $_{N}$AGREE, so [atbka] wins over [adbga]; even though the winner introduces two AGREE violations that were not present underlyingly, this is preferable to introducing three new voiced obstruents (see 25b). The result is that the underlying contrast between /p/ is /b/ is maintained in this context, flipping the value of the feature [voice].

A look at the factorial typology suggests that this scenario is not an isolated one. We computed the factorial typology of this constraint set using OTSoft 2.3.3 (Hayes, Tesar & Zuraw 2013). Of the 5040 possible rankings of the constraints, there were 45 unique patterns of winners based on the inputs listed above. Of these 45 patterns, 5 contained a contrast between /p/ and /b/ only in / C_C contexts.

[26] For reasons of space, we have removed the four candidates that have only a single AGREE violation ([atpga], [atbga], [adpka], [adbka]) because they do not affect the outcome.

[27] Assessing violations of $_{O}$AGREE and $_{N}$AGREE raises questions about what counts as an 'old' violation under the Comparative Markedness theory. In particular, do the two AGREE violations present in candidate [adpga], given input /atbka/, count as violations of $_{O}$AGREE or $_{N}$AGREE? Here, we have assumed that they count as violations of $_{O}$AGREE despite the change in sign. To be thorough, we have also explored grammars in which such cases are considered violations of $_{N}$AGREE. We find comparable examples of contrast-only-between-obstruents under this interpretation as well.

Again, we judge that the type of phonological behavior represented in this hypothetical grammar is unlikely to be encountered in any natural language. As with the conjunction of Markedness and Faithfulness constraints, the fact that such patterns are readily derived with Comparative Markedness raises questions about whether the potential cost of the theory is too high.[28] As with Markedness-Faithfulness conjunction, it is conceivable the absence of "monster" phonotactic patterns has a purely diachronic explanation, but all else being equal it seems best to have a phonological theory that doesn't generate them.

Below we present an alternative analysis of saltation that does not make such typological predictions.

6. The analysis of saltation using P-map theory

*6.1 Framework: *MAP( ) cum P-map*

Zuraw (2007, 2013) has proposed to augment the theory of faithfulness beyond the simple constraint types of McCarthy & Prince (1995). In her approach, a constraint of the form ***MAP(*x*, *y*)** assesses a violation to a candidate if a segment belonging to natural class *x* in the input is mapped to a corresponding segment in natural class *y* in the output.[29] An aspect of Zuraw's theory that will be essential here is that unlike in classical correspondence theory with IDENT( ) constraints, *MAP constraints can be **non-minimal**; specifically, they do not require that the corresponding segments *x* and *y* differ in just one feature. Thus, for instance, one could assume a *MAP constraint that penalizes input-output pairs like /p/ ~ [β], which differ in both voicing and continuancy.

The theory is thus made more powerful; in compensation, it is constrained in substantive terms. Zuraw suggests that the natural rankings of *MAP constraints are largely determined by phonetics. Specifically, Zuraw adopts from Steriade (2001, 2008) the principle of the **P-map**, or perceptual map, which encodes the perceptual distance between all segment pairs in all contexts. In this approach, the *MAP constraints are assigned a default ranking as follows: *MAP constraints banning changes that cover a larger perceptual distance are assigned a default ranking higher than constraints banning smaller changes. This ranking preference is taken to be a learning bias in UG; however, given sufficient evidence in the ambient language, it is possible for learners to subvert the default rankings (Zuraw 2007: 297). As we will see (§6.5), this learning bias is crucial in explaining the experimental data on saltation mentioned above in §4.

The basic prediction of the *MAP-cum-P-map proposal — that phonetically-salient alternation is disfavored related to less-salient alternation — is supported by a wide variety of evidence. Zuraw uses it to explain the preferred locations for infixes in initial clusters of Tagalog: they occur where the phonetic change induced in the stem is least salient. Similarly,

[28] Blumenfeld (2003) suggests a modified version of Comparative Markedness that does not generate the pathological case described here, and thus is a promising remedy to the problem we have pointed out.

[29] Two further details: (1) Zuraw permits *MAP( ) constraints to include contexts; for present purposes context-free *MAP constraints will suffice. (2) Since the candidates must be assessed for their phonetic properties, it is assumed (Zuraw 2013) that the relevant type of correspondence is output-output (Benua 1997 *et seq.*), not input-output as in classical OT; this approach seems feasible for all the cases we have seen.

Fleischhacker (2001, 2005) and Shademan (2002) give evidence that in epenthesis alternations, it is preferred to place the epenthetic vowel in the location that changes the stem least saliently. Wilson (2006) discusses the direction of generalization taken by participants in an artificial language study — suggesting that they generalize it to novel cases with less phonetically salient alternation, but not to novel cases where alternation is more salient. Similar experiments, showing that people have difficulty in learning arbitrary phonological alternations that are phonetically extreme, have been carried out by Skoruppa et al. (2011) and by Stove et al. (2013). Lofstedt (2010) shows that in Swedish vowel length alternations, paradigm gaps have arisen in precisely those cases where the distance between long-short vowel pairs is phonetically greatest, owing to concomitant differences of vowel quality. In language acquisition, children are observed to innovate non-adult-like forms that diminish degree of alternation in the paradigm (Hayes 2004, citing Kazazis 1969, Bernhardt & Stemberger 1998). Lastly, there is evidence that in historical change, phonologies are sometimes restructured by a new generation of learners in a ways that reduce the phonetic distance of an alternation (Kiparsky 1982).

6.2 Basics of the proposed analysis

Consider now how the *MAP-cum-P-map approach would be applied to the problem of saltation. The idea is that, given sufficient data to override a learning bias, the system permits rankings that make it possible to analyze saltation. In particular, a *MAP constraint banning correspondence at a greater phonetic distance could be exceptionally ranked below a *MAP constraint banning correspondence as a lesser, subset distance. For Campidanian, the required unnatural ranking is *MAP(b, β) >> *MAP(p, β).[30] Intuitively, this ranking means that it is less bad for voiceless stops to alternate with voiced fricatives than it is for voiced stops to do so, despite the phonetic distances involved. This is what permits /p/ to spirantize but not /b/. The crucial tableaux are given in (26).

(26) *Deriving Campidanian as a marked option with* *MAP( )

a. /p/ *becomes* [β] *intervocalically*

/apa/	*MAP(b, β)	*V[−cont]V	*MAP(p, β)	*MAP(p, b)
☞ aβa			*	
*apa		*!		
*aba		*!		*

b. /b/ *is stable*

/aba/	*MAP(b, β)	*V[−cont]V	*MAP(p, β)	*MAP(p, b)
☞ aba		*		
*aβa	*!			

[30] In our constraint names we use bilabial phonetic symbols like [p] as shorthand for natural classes; '[p]' denotes [−sonorant, −continuant, −voice], '[b]' denotes [−sonorant, −continuant, +voice], and '[β]' denotes [−sonorant, +continuant, +voice].

It is clear from the tableaux that for the analysis to work we must have *MAP(b, β) >> *V[−continuant]V (to block spirantization of /b/) and also *V[−continuant]V >> *MAP(p, β) (so that /p/ will spirantize). By transitivity, this yields *MAP(b, β) >> *MAP(p, β), in violation of the P-map. Thus, although Campidanian is a possible phonology, it is claimed to be harder for language learners, since it requires a ranking that is not P-map-compliant.

6.3 The analysis done more carefully

To make sure our analysis works, we redid it with additional candidates and constraints. In addition to the core cases /apa/ → [aβa] and /aba/ → [aba], we must make sure that (a) /p/ and /b/ are stable when not intervocalic: /pa/ → [pa], /ba/ → [ba]; (b) [β] will not surface except when derived by spirantization from /p/. For the latter, we follow the principle of the Rich Base (Prince & Smolensky 1993: §9.3), requiring that illegal forms surface as something legal. In particular, hypothetical /βa/ must surface as some legal form, which (as it turns out) our analysis predicts to be [pa], and /aβa/ must likewise surface as something legal, which (as it turns out) our analysis predicts to be [aβa].

As candidates we included all three possible output consonants ([p b β]) for all of our input forms, which cover all three consonants in both initial and intervocalic environments. We also assumed for present purposes that the *MAP constraints are symmetrical, so that /pa/ → [ba] and /ba/ → [pa] are equally penalized by *MAP(p, b).

We executed the analysis using OTSoft 2.3.3 (Hayes, Tesar & Zuraw 2013), which ranked the constraints using Recursive Constraint Demotion (Tesar & Smolensky 1995), suitably constrained to respect the a priori ranking *MAP(p, β) >> *MAP(p, b).[31] The resulting tableaux are given in (27).

(27) *Full tableau set for the Campidanian *MAP( ) analysis*

a. *Lenition of intervocalic* /p/

/apa/	*V[−voice]V	*MAP(b, β)	*V[−cont]V	*β	* MAP(p, β)	* MAP(p, b)	*b
☞ aβa				*	*		
aba			*!			*	*
apa	*!		*				

b. *Intervocalic* /b/ *is stable*

/aba/	*V[−voice]V	*MAP(b, β)	*V[−cont]V	*β	* MAP(p, β)	* MAP(p, b)	*b
☞ aba			*				*
aβa		*!		*			
apa	*!		*			*	

[31] As Norval Smith has pointed out to us, the analysis will work even if *MAP(p, β) is outright removed; we include it under the assumption that when children encounter a real alternation in a language they set up a *MAP constraint to cover it.

c. *Initial* /p/ is *stable*

/pa/	*V[−voice]V	*MAP(b, β)	*V[−cont]V	*β	* MAP(p, β)	* MAP(p, b)	*b
☞ pa							
ba						*!	*
βa				*!	*		

d. *Initial* /b/ *is stable*

/ba/	*V[−voice]V	*MAP(b, β)	*V[−cont]V	*β	* MAP(p, β)	* MAP(p, b)	*b
☞ ba							*
pa						*!	
βa		*!		*			

e. *Rich base* '/β/' *indistinguishable from* /p/ *when initial*

/βa/	*V[−voice]V	*MAP(b, β)	*V[−cont]V	*β	* MAP(p, β)	* MAP(p, b)	*b
☞ pa					*		
βa				*!			
ba		*!					*

f. *Rich base* '/β/' *indistinguishable from* /p/ *when intervocalic*

/aβa/	*V[−voice]V	*MAP(b, β)	*V[−cont]V	*β	* MAP(p, β)	* MAP(p, b)	*b
☞ aβa				*			
aba		*!	*				*
apa	*!		*		*		

For rigor's sake we determined the ranking argumentation not by hand but by using the Fusional Reduction Algorithm of Brasoveanu & Prince (2011), as implemented in OTSoft. Applied to the winner-loser pairs contained in the tableaux, the Fusional Reduction Algorithm yielded a simple pattern consisting of one strictly ranked chain of length six, plus one unranked constraint.

(28) *Rankings for the Campidanian *MAP analysis*

a. *Main chain of rankings*

*MAP(b, β) >> *V[−cont]V >> *β >> * MAP(p, β) >> * MAP(p, b) >> *b

b. *No ranking required*

*V[−voice]V

Intuitively, the ranking arguments are as follows. *MAP(b, β) must dominate *V[−cont]V in order to avoid spirantization in (27b) /aba/. *V[−cont]V must dominate *β, because although [β] is generally avoided in the language, it is tolerated in order to avoid a spirantization violation

((27a)). *β must dominate *MAP(p, β) (equivalent to *MAP(β, p), under our assumption of symmetry), because in our analysis the Rich Base candidate /βa/ surfaces as [pa] ((27e)). *MAP(p, β) must dominate *MAP(p, b) under the theoretical assumption that language learners adopt P-map-compliant rankings whenever evidence to the contrary is not present. *MAP(p, b) dominates *b, the normal ranking in languages such as Campidanian where voicing in obstruents is phonemic; see (27d). The constraint *V[−voice]V, though it *can* be placed top of the rankings (it is unviolated in winners), actually could be ranked anywhere at all; indeed, for the data given, the analysis works when *V[−voice]V is removed from the constraint set.[32]

The analysis succeeds in ruling out any unattested patterns of alternation. If any forms are assigned underlying /β/, they will surface with [β] intervocalically and [p] elsewhere — thus, exactly like underlying /p/. If Campidanian learners capriciously chose an underlying form with /β/, it would be undetectable in their speech, which is what we want. Appropriate rankings of the *MAP( ) constraints involving voiceless fricatives could likewise render any underlying /ɸ/ harmless.

For other cases of saltation, similar analyses can easily be constructed. The common theme is the non-default ranking of a *MAP( ) constraint that bans a long 'phonetic path' of alternation below a *MAP( ) constraint that bans a subset of this path.

6.4 A second saltation in Campidanian

For completeness, we mention that Campidanian possesses a second saltatory alternation. The voiced geminate stops [bː dː gː], which are themselves normally derived from underlying clusters, are in a state of free variation: sometimes they are realized as such, but more often they are lenited to [β ð ɣ], thus merging with underlying /p t k/ (Bolognesi 1998: 48). Since (as before) singleton [b d g] do not lenite, this is another saltation: [bː] - [b] - [β]. The diachronic origin of this saltation is the same as before; namely the restoration of [b] in intervocalic position by grammar change.[33]

We have found that it is not hard to model this saltation with the same basic devices used above; the essential aspect of the analysis is a non-P-map compliant ranking, *MAP(b, β) >> *MAP(bː, β). Full tableaux and Hasse diagrams may be obtained from the article web site.

As a reviewer for *Phonology* points out, our *MAP approach makes predictions across phonological processes: the aberrantly high ranking of *MAP(b, β) is the cause of both

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[32] It is needed in the phonology as a whole to account for cases like /asa/ → [aza]; Bolognesi 1998: 149.

[33] Smith et al. (1991) suggest that geminate lenition is determined by stress, but note "exceptions … which we cannot explain;" our own impression is that such exceptions are fairly numerous. The hypothesis of free variation is supported by Bolognesi (1998: 497), where the underlying sequence /pɔtia**t b**i/ 'can see' is realized in the same discourse first as [poðia **β**iɾi] then as [poðia **bː**iɾi] (the [ɾi] syllable is epenthetic; Bolognesi, p. 448).

Smith et al. also take the view that Campidanian "geminates" are not actually long phonetically. Bolognesi (1998) is uncertain on this point, though he does transcribe surface distinctions between, e.g., [b] and [bː]. Plainly, phonetic study would be useful.

Campidanian saltations. Such predictions are not made by theoretical alternatives such as "crazy rules" (in rule-based phonology) or "Anticorrespondence" constraints (Hayes 1999).

6.5 Accounting for experimental results on learning bias with computational modeling

We briefly discuss here how the analysis we have presented can be adapted to explain the experimental results described above (§4). Recall that when experimental participants are exposed to alternations like [p] ~ [v], they tend to generalize the pattern to [b] ~ [v], despite the presence of nonalternating [b] in the training data. We show how this can be accounted for using the P-map framework assumed above; the discussion below briefly summarizes White (2013: Chap. 4).

In order to model the P-map-based learning bias, White shifted from the classical OT model used above to the closely related framework of maximum entropy grammar (Goldwater & Johnson 2003). White employed essentially the constraints assumed above in our Campidanian analysis, namely *V[−voice]V, *V[−cont]V, and all relevant *MAP constraints. As a first step, he established a phonetically realistic and quantitatively explicit P-map, using confusion matrices from earlier perception experiments (Wang & Bilger 1973). The P-map was then used as the basis for establishing Gaussian priors (i.e. preferred values) on the weights of the *MAP constraints. As a result, the learning model had an *a priori* expectation that *MAP constraints would be weighted more highly if they penalized correspondences spanning large phonetic distances. In implementing the P-map bias by way of the prior, White followed the general approach pioneered by Wilson (2006), though White's implementation differed from Wilson's in various ways.

The model was then used to conduct a learning simulation of the artificial language experiments described above in §4. The training data for the model were identical to the set of forms that the participants received in the experiments. When the learned grammar was tested on the same data used for the test items with human participants, it achieved a close approximation of human performance. In particular, when trained on alternations like [p] ~ [v], the model also generalized to [b] ~ [v], even when cases of non-alternating [b] were presented during training.

If these experimental and modeling results can be extrapolated to real languages, then they offer the possibility of explaining the cases of historical change (§4) in which saltatory systems broke down, the idea being that this occurred because saltation was difficult for new generations of language learners to acquire. Going further, if, as we suspect, saltatory alternations are rare, learning bias could be taken as a contributing explanation for their rarity. This idea must be regarded as quite speculative, for three reasons: we don't know for sure whether saltation is rare, we have only given limited evidence that it is unstable, and the rarity of saltation is already expected on diachronic grounds if, as we argued (§3), it cannot be produced by sound change. Thus saltation is a classic instance of Moreton's dilemma (2008): it is very often the case that we cannot confidently attribute a typological pattern to channel bias (i.e. diachronic explanation) or analytic bias (the factor demonstrated in White's experiments). In sum, we think far more evidence must be gathered if we are to make any sort of confident assertion that White's results bear on phonological typology.

6.6 Can the P-map approach overgenerate?

In §5.2, we argued that the conjoined constraint approach—specifically, the conjunction of markedness and faithfulness constraints—should be avoided in phonological theory due to the bad typological predictions about phonotactics that arise when such conjunctions are allowed. In §5.3 we suggested that similar bad predictions emerge from the theory of Comparative Markedness, though as yet we have no systematic understanding of the basis from which they arise. The *MAP approach that we propose here also allows marked patterns to arise in synchronic phonology; indeed, saltation, as we have argued, is one of them. However, we hold that the *MAP-cum-P-map approach is more principled in the types of marked patterns that it allows.

Let us return to our earlier example in which theories wrongly predict the existence of languages that contrast /p/ and /b/ only when flanked by obstruents; as we showed, both constraint conjunction and Comparative Markedness can derive this pattern. Moreover, the relevant analyses employ only garden variety phonological constraints. In the constraint conjunction theory, it sufficed to conjoin IDENT(voice) with a constraint banning consonant clusters. For Comparative Markedness, the relevant constraints were "old" and "new" versions of AGREE(voice), *[−son,_voice], and *p, all of which have strong typological support. Therefore, the problems seem to reside in the core mechanisms used in these theories, rather than in the particular constraints being employed.

Could the *MAP-cum-P-map approach generate comparable phonotactic "monsters"? We judge that, suitably constrained, it will not. There are two circumstances under which the approach could generate a monster. First, and trivially, CON could include constraints that ban configurations that we recognize as phonotactically good rather than bad. An example would be a ban on non-branching onsets, so that /pa/ surfaces (say) as [pra]. This bad possibility is shared by all theories, and it seems reasonable for any theory to assume a CON component that does not include such pathological markedness constraints.

The special properties of the *MAP-cum-P-map approach reside not in its Markedness constraints but its Faithfulness constraints and especially the possibility of their being ranked in ways that go against the P-map. Monsters could arise if a *MAP constraint somehow permitted a repair to occur only in a marked context, as with, say *MAP(p, b) / [−son] ___ [−son], forbidding changes in voicing for /p/ or /b/ flanked by obstruents. With a constraint of this sort, we could derive a pattern where obstruents contrast in voicing only when flanked by other obstruents by ranking the *MAP constraints in the anti-P-map fashion: MAP(p, b) / [−son] ___ [−son] >> *p >> *MAP(p, b) / #___V. This would permit /atpka/ and /atbka/ to surface faithfully but would force /pa/ to be repaired as [ba], neutralizing it with /ba/ and creating a monster similar to what we saw in §5.3.

The monster will arise only if we permit the theory to include Faithfulness constraints that militate against alternation in marked contexts, such as / [−son] ___ [−son]. The appropriateness of contextually limited Faithfulness itself has been questioned (Prince & Tesar 2004: 277–278), but those contextually limited Faithfulness constraints that have been proposed tend to invoke *unmarked* contexts; for instance, Beckman (1998) proposes onset faithfulness, root-initial faithfulness, and stressed-syllable faithfulness, all plausibly unmarked. Thus, assuming that we specify that phonological theory must forbid Faithfulness constraints that specifically invoke marked contexts, we think that the phonotactic overgeneration problem that faces constraint conjunction and Comparative Markedness does not face the P-map approach.

Turning from phonotactics to alternations: it is unquestionably the case that the *MAP-cum-P-map approach can generate pathological alternation types — but we think that these exist, and saltation is just one of them. We think it an advantage of the *MAP-cum-P-map approach that it comes with a more principled way of determining *how* marked one pattern is relative to another, namely a substantive bias based on the P-map.

7. How does grammar change create saltation?

We turn finally to a problem about which we can only speculate. As we argued in §3.2, the saltatory pattern of Campidanian was itself created by grammar change; specifically, the voiced stop ~ ∅ alternations were largely leveled in favor of nonalternating voiced stops. But how did grammar change achieve a configuration that we have just characterized as a marked one? We speculate as follows. First, some principle of neutralization avoidance may have been at play (e.g. following Bolognesi (1998: Chap. 5), Flemming (1995, 2004), and Padgett (2003, 2009)): the reversion of voiced stops keeps the three places of articulation [b d g] from neutralizing with each other, and is "better" than reverting to [β ð ɣ], which would have been neutralized with underlying /p t k/. Second, there is the possibility that grammar change is sometimes "locally improving", in the sense laid out by Kiparsky (1978): the complete reversion of the voiced stop ~ ∅ constituted a huge local improvement with respect to the P-map for these alternations considered alone, though it created a disfavored ranking of the *MAP constraints in the grammar as a whole, creating a less favored grammar at the global level. We consider it a challenge for future work in modeling phonological learning and grammar change to provide formal models that can account for the Campidanian change, as well as the changes that appear to be leveling out saltation in Russian and Manga Kanuri.

8. Conclusion

We offer conclusions in three areas.

Concerning the role of biases in phonological learning, we think the evidence we examined points to a moderate stance, ruling out two extremes. If the P-map bias we posit did not exist, then we could not explain the experimental results described in §4. But if the bias were extreme, saltatory alternations would not exist at all.

Concerning diachrony, our exploration of the origins of saltation supports the view of Minkova (1993) and Lass (1997) that it never arises from sound change but comes from factors like telescoping or restructuring; it is a classic case of "unnatural" phonology.

Concerning restrictiveness in phonological theory, we argued that a learning-bias approach using Zuraw's *MAP-cum-P-map is more promising than conjoined constraints or Comparative Markedness: *MAP-cum-P-map is not only supported as a learning bias by experimental data, but also avoids the problems faced by earlier accounts of generating implausible phonotactic patterns.

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