Faithfulness and underspecification*

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1 Introduction

This work is about two ‘generation problems’ for classic Optimality Theory, *chain shifts* (see e.g. Kirchner 1996) and *saltations* (see e.g. Hayes & White 2015). Chain shifts are exemplified by the following examples from Gran Canarian Spanish (Oftedal, 1985): word-initial voiceless stops alternate with intervocalic voiced stops (1a) and, in turn, word-initial voiced stops alternate with intervocalic voiced fricatives (1b).

(1) A chain shift in Gran Canarian Spanish

a.	[paɾte]	‘part’	[la baɾte]	‘the part’	#p ~ VbV
b.	[baɾaħa]	‘deck of cards’	[la βaɾaħa]	‘the deck of cards’	#b ~ VβV

Saltations are exemplified by examples from Campidanian Sardinian (Bolognesi, 1998), where initial voiceless stops alternate with intervocalic voiced fricatives (2a) and initial voiced stops do not alternate (2b).

(2) A saltation in Campidanian Sardinian

a.	[piʃːi]	‘fish’	[belːu βiʃːi]	‘nice fish’	#p ~ VβV
b.	[bĩu]	‘wine’	[sːu bĩu]	‘the wine’	#b ~ VbV

Traditional analyses of chain shifts and saltations are illustrated in Fig. 1. For chain shifts like the one in Gran Canarian Spanish (Fig. 1, left), the voiceless stop /p/ is assumed to underlie the [p] ~ [b] alternation in (1a) and the voiced stop /b/ is assumed to underlie the [b] ~ [β] alternation in (1b). For saltations like the one in Campidanian Sardinian (Fig. 1, right), the voiceless stop /p/ is assumed to underlie the [p] ~ [β] alternation in (2a) and the voiced stop /b/ is assumed to underlie the [b] ~ [b] non-alternation in (2b).

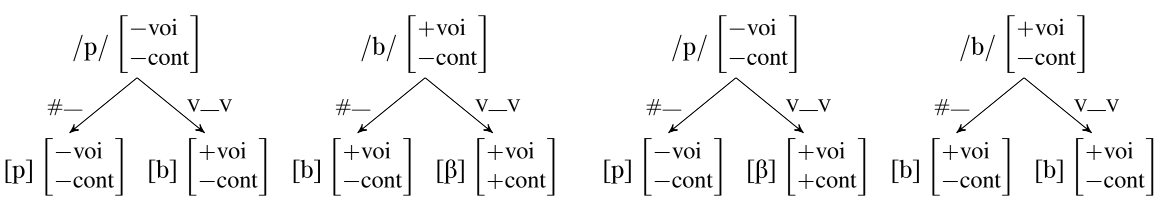

Figure 1: Traditional analyses of chain shifts (left) and saltations (right).

The mapping of intervocalic /p/ to [b] in a traditional chain shift analysis motivates ranking a markedness constraint *V[−voi]V above a faithfulness constraint FAITH-voi, and the mapping of intervocalic /b/ to [β] motivates ranking *V[−cont]V above FAITH-cont. The problem for classic OT is that, given these two rankings, there is nothing to prevent intervocalic /p/ from ‘going all the way’ to [β]. By the same token, the mapping of intervocalic /p/ to [β] in a traditional saltation analysis motivates these same two rankings of markedness over faithfulness, and there is nothing to prevent intervocalic /b/ from also becoming [β].

Viewed more broadly, the problem is that neither of the traditional analyses in Fig. 1 is *output-driven* (Tesar, 2014:13): “A phonological map will be said to be **output-driven** if, for any mapping from an input to an output, any other input that has greater similarity to the output also maps to the same output.” In the case of

*We thank the audiences at AMP 2022 and at two UC San Diego PhonCo meetings where we presented earlier versions of this work, and we are especially grateful to Giorgio Magri and Eric Rosen for very helpful comments on an earlier draft of the paper that significantly improved both the content and the presentation. Any remaining errors, infelicities, and lack of clarity should be drawn, quartered, and divided evenly between the two of us.

Proceedings of *AMP 2022*

chain shifts, the fact that intervocalic /p/ maps to [b], changing [−voi] to [+voi], means that intervocalic /b/ should also map to [b], because /b/ is (quite obviously) more similar to [b] than /p/ is, involving no change at all — but intervocalic /b/ instead maps to [β], changing [−cont] to [+cont]. In the case of saltations, the fact that intervocalic /p/ maps to [β], changing both [−voi] to [+voi] and [−cont] to [+cont], means that intervocalic /b/ should also map to [β], because /b/ is more similar to [β] than /p/ is, involving only the change from [−cont] to [+cont] — but intervocalic /b/ instead maps faithfully to [b].

The issues for OT posed by these traditional analyses of chain shifts and saltations have led to various embellishments of the classic theory, typically in the form of novel constraint types. Among these have been local conjunctions (Smolensky, 2006) of faithfulness constraints with each other (Kirchner, 1996) or of markedness constraints with faithfulness constraints (Łubowicz, 2003), comparative markedness constraints (McCarthy, 2003), and *MAP constraints (Hayes & White 2015, based on Zuraw 2013).[1] In a recent pair of squibs, Reiss (2021a,b) proposes a general solution to the problem of chain shifts and saltations that relies more directly on different assumptions about *representations* than about constraints. Specifically, Reiss assumes that underlying representations may be underspecified, and that a map 'counts' as a chain shift or as a saltation so long as the surface alternants from a uniform underlying representation match the respective observed alternants. In order to distinguish this generalized type of map from the more specific traditional instances shown in Fig. 1, we will refer to any underlying-to-surface map consistent with the surface alternations of a chain shift as a *chain shift map*, and likewise we will refer to any underlying-to-surface map consistent with the surface alternations of a saltation as a *saltation map*.

We report here on three results from our ongoing formal assessment of Reiss's proposed solution. One result concerns Reiss's claim that his solution requires underspecification of *both* of the features involved in the alternation; in our running examples, as made clear in Fig. 1, these features are [voi] and [cont]. We demonstrate that underspecification of one feature alone ([cont], in these examples) is sufficient to generate both the chain shift map and the saltation map; additional underspecification of the other feature ([voi]) is not additionally required. Another result concerns Reiss's claim that his solution requires two types of featural faithfulness constraints; we demonstrate that either one of the two constraint types is in fact sufficient. The third result is our finding that chain shift maps and saltation maps are pathologically yoked together in the full factorial typology predicted by Reiss's system: there are two non-interacting sets of ranking conditions of the relevant constraints yielding a chain shift map, and these are the same two non-interacting sets of ranking conditions that yield a saltation map. Toward the end of the paper we offer some remarks on the output-drivenness of Reiss's proposed system based on Magri's (2018b) extension of this concept to underspecification, and a brief discussion of how chain shift and saltation maps can be disentangled with alternative definitions of featural faithfulness constraints (or pairings thereof).

2 Representations and landscapes

As noted above, we focus here on the features [voi] and [cont], holding values of other features constant across representations. Features are assumed to be binary, with values '+' and '−'; lack of a specified value of a given feature is indicated with '∅'. This results in the nine consonantal representations in Table 1: four of these are fully-specified segments, and five are underspecified to some degree. Note our adoption of the following notation for underspecified representations, avoiding the ambiguities inherent in the traditional use of upper-case alphabetic and other such symbols. Given two IPA symbols *x* and *y*, the notation ⌜*xy*⌟ denotes a representation specified for the feature values that *x* and *y* share in common and unspecified for values of all other features. The first symbol *x* will always be the one with the '−' value(s) of the unspecified feature(s).

	[−cont]	[+cont]	[∅cont]
[−voi]	p	ɸ	⌜pɸ⌟
[+voi]	b	β	⌜bβ⌟
[∅voi]	⌜pb⌟	⌜ɸβ⌟	⌜pβ⌟

Table 1: Fully specified and underspecified representations

Given this as the space of possible underlying representations, Reiss (2021a) shows that a chain shift

[1]See Tesar (2014) and Magri (2016, 2018a) on the precise formal properties that any such constraints must have.

map can be attained within classic OT assuming the underlying-to-surface map on the left in Fig. 2, and Reiss (2021b) shows that a saltation map can be attained assuming the underlying-to-surface map on the right.

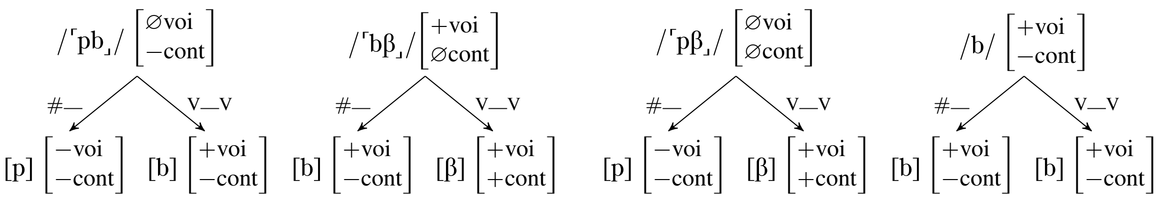

Figure 2: Chain shift maps (left) and saltation maps (right), according to Reiss (2021a,b).

Note how both analyses in Fig. 2 avoid the output-drivenness issue that was noted in §1 for the corresponding traditional analyses in Fig. 1. In the case of the chain shift map (Fig. 2, left), underlying /⌜pb⌟/ is no more or less similar to surface [b] than underlying /⌜bβ⌟/ is — in both cases, a feature value needs to be filled in. This leaves underlying /⌜bβ⌟/ free to map to surface [β] intervocalically. In the case of the saltation map (Fig. 2, right), underlying /⌜pβ⌟/ is no more or less similar to surface [β] than underlying /b/ is — in the former case, two feature values need to be filled in, and in the latter case, one feature needs to be changed from one value to the other. This leaves underlying /b/ free to map to surface [b] intervocalically.

In the present context it is also useful to distinguish three sets of assumptions about the space of potential candidates, which we refer to here as *representational landscapes*. For the purposes of our formal assessment, we can regard these as three distinct ways to define GEN in an OT system (Alber et al., 2016; Alber & Prince, 2021). Each landscape differs primarily in whether underlying and/or surface forms may be underspecified.

(3) Three representational landscapes

a. *Full Specification* (**FS**) ('traditional'; i.e. most OT work)
= both underlying and surface forms are fully specified

b. *Input Underspecification* (**IU**) (e.g. Inkelas 1995)
= underlying forms may be underspecified but surface forms are fully specified

c. *Full Underspecification* (**FU**) (e.g. Ito et al. 1995)
= both underlying and surface forms may be underspecified

Given the space of representational possibilities in Table 1, the sets of underlying and surface forms to be considered derive from the way each landscape is defined in (3), combined with the same basic 2-way positional choice from our running examples: word-initial (#—) and intervocalic (V—V).

The **FS** landscape is the most restrictive of the three. All representations are fully specified, and as such the possible representations in underlying forms is limited to {p, ɸ, b, β}. With each of these occurring in both of the positions #— and V—V, the **FS** landscape consists of eight candidate sets (4 consonants × 2 positions), and each candidate set ('cset') includes the same four fully-specified surface consonants as competing candidates. On the other end of the spectrum, the **FU** landscape is the most inclusive, permitting underspecification at both levels of representation. This landscape includes all nine possibilities in Table 1 in underlying forms, each occurring in both positions #— and V—V. There are thus 18 csets (9 consonants × 2 positions) and each cset also includes all nine possible surface consonants as competing candidates.

Our focus in this paper is on the **IU** landscape, as it is in Reiss (2021a,b). This landscape is intermediate between the other two. With all nine consonantal representations in Table 1 as possible underlying forms, the **IU** landscape consists of 18 csets (9 consonants × 2 contexts), like the **FU** landscape. But each cset in this case includes only the four fully-specified surface consonants {p, ɸ, b, β}, like the **FS** landscape.

3 Constraints

Existing work in OT, particularly since the advent of Correspondence Theory (McCarthy & Prince, 1995, 1999), has developed and defined a multitude of different types of featural faithfulness constraints. Although the points of difference between alternative formulations of featural faithfulness are sometimes at issue for developing a workable explanation for a given phenomenon or pattern, we find that which version of featural faithfulness is ultimately employed is far more often made out of convenience or background preferences, or based on (often implicit) intuitions about simplicity, parsimony, and/or elegance, rather than on the basis of what is strictly necessary to enable the analysis to work as intended. Given that these choices are often tangential to core aspects of various analyses, there has typically been little effort to rigorously interrogate this space of assumptions. This lack of effort is likewise evident in Reiss (2021a,b), despite the fact that the two types of featural faithfulness constraints in (4) are central to the discussion of his solution.[2]

(4) Featural faithfulness constraints

DEP-F : Assign a violation to each insertion of [+F] or [−F], i.e. to each surface segment that is [+F] or [−F] whose underlying correspondent is not specified for the same value of [F].

MAX-F : Assign a violation to each deletion of [+F] or [−F], i.e. to each underlying segment that is [+F] or [−F] whose surface correspondent is not specified for the same value of [F].

Given the possibility of underlying underspecification of a feature [F] in both the **IU** and **FU** landscapes defined in §2, DEP-F penalizes mappings from underlying [+F] or [∅F] to surface [−F] as well as mappings from underlying [−F] or [∅F] to surface [+F]. Symmetrically, the possibility of surface underspecification in the **FU** landscape means that MAX-F penalizes mappings from underlying [+F] to surface [−F] or [∅F] as well as mappings from underlying [−F] to surface [+F] or [∅F]. Reiss assumes the *possibility* of surface underspecification, citing Keating (1988), but explicitly curtails this possibility in his solution by also assuming an undominated SURFACE-SPEC constraint. This effectively restricts the landscape to **IU**, introducing an asymmetry between DEP-F and MAX-F reminiscent of the distinction between *feature-filling* and *feature-changing* rules: MAX-F is violated only by feature-changing mappings, while DEP-F is violated by both feature-changing and feature-filling mappings. This distinction may appear to be significant, but as we'll see in §4 it makes absolutely no contribution to Reiss's solution. The violations assigned by these constraints to the four possible [F]-unfaithful mappings in the **IU** landscape are summarized in Table 2.

F = [voi]	DEP-voi	MAX-voi
a. $/\underset{-}{\text{p}}/ \longrightarrow [\underset{+}{\text{b}}]$	*	*
b. $/\underset{+}{\text{b}}/ \longrightarrow [\underset{-}{\text{p}}]$	*	*
c. $/\underset{\varnothing}{\ulcorner\text{pb}\lrcorner}/ \longrightarrow [\underset{+}{\text{b}}]$	*	
d. $/\underset{\varnothing}{\ulcorner\text{pb}\lrcorner}/ \longrightarrow [\underset{-}{\text{p}}]$	*	

F = [cont]	DEP-cont	MAX-cont
a. $/\underset{-}{\text{b}}/ \longrightarrow [\underset{+}{\beta}]$	*	*
b. $/\underset{+}{\beta}/ \longrightarrow [\underset{-}{\text{b}}]$	*	*
c. $/\underset{\varnothing}{\ulcorner\text{b}\beta\lrcorner}/ \longrightarrow [\underset{+}{\beta}]$	*	
d. $/\underset{\varnothing}{\ulcorner\text{b}\beta\lrcorner}/ \longrightarrow [\underset{-}{\text{b}}]$	*	

Table 2: Unfaithful mapping assessments by DEP-F and MAX-F in the **IU** landscape

These constraints are equivalent to FILL/INSERT-F (= DEP-F) and PARSE-F (= MAX-F) in Kiparsky (1994) and Inkelas (1995). Reiss (2021a,b) also cites Lombardi (2001) and McCarthy (2008) as relevant sources, but the namesake constraints in those works are defined and function differently. This is in large part because the landscape in these latter works is (effectively) **FS**, which neutralizes the intended distinction between the two constraint definitions in (4). In the **FS** landscape context, featural faithfulness constraints with labels like 'DEP-F' penalize only insertion of [+F] (or, if features are monovalent, only insertion of [F]), and those with labels like 'MAX-F' penalize only deletion of [+F] (or deletion of monovalent [F]).

Finally, the markedness constraints involved in both chain shift and saltation maps are given in (5).[3] Note

[2]These constraints are claimed to be *possible* in one squib ("we can adopt the MAX and DEP constraints that treat insertion and deletion of feature values as separate violations of faithfulness"; Reiss 2021a:3) and *crucial* in the other ("[t]he crucial move is to allow the MAX and DEP faithfulness constraints for individual features"; Reiss 2021b:2). In both squibs, however, it is clear that these constraints are considered to be crucial components of the proposed solution.

[3]Curiously, both the labels and aspects of the definitions of some of these constraints differ between Reiss (2021a) and Reiss (2021b). Most significantly, instead of *[+voi] there is STOP-VLESS in Reiss (2021a) and both STOP-VLESS (when defined in the text) and *VOI-STOP (in tableaux) in Reiss (2021b), but in neither case is it necessary for the constraint to be limited to penalizing voiced *stops*. In fact, this limitation predicts ties between optimal word-initial [ɸ] and [β] in a significant subset of the patterns predicted in the full factorial typology, and furthermore needlessly complicates matters by increasing the size of the typology from 25 to 51 predicted patterns. (See also footnote 5 below.)

that Reiss's SURFACE-SPEC markedness constraint is not included here because, as already noted above, the entire function of that constraint is to restrict attention to the **IU** landscape.

(5) Markedness constraints

*V[−voi]V : Assign a violation to each instance of an intervocalic voiceless obstruent. — { *[apa], *[aɸa] }

*[+voi] : Assign a violation to each voiced obstruent. — { *[b], *[β] }

*V[−cont]V : Assign a violation to each instance of an intervocalic stop. — { *[apa], *[aba] }

*[+cont] : Assign a violation to each fricative. — { *[ɸ], *[β] }

Each pair of constraints in (5) should be schematically familiar to anyone acquainted with other specific instances of the general contrast/neutralization typology (McCarthy & Prince 1995, 1999; see also Mai & Baković 2020 and other references therein). The first constraint in each pair is an instance of *specific* (or *positional*) *markedness*, conflicting with the second, *general markedness* constraint in each pair. Each pair conflicts in turn with a pair of DEP-F and MAX-F constraints, where F is the same feature mentioned by both markedness constraints — modulo the fact that MAX-F is not violated by feature-filling mappings. There is no other conflict and thus no interaction between the [voi]-mentioning constraints and the [cont]-mentioning constraints — these are completely separate subsystems within the larger system under assessment.

4 System assessment

To recap: the system underlying Reiss's proposed solution consists of the 18 csets in the **IU** landscape discussed in §2, the two faithfulness constraints in (4), and the four markedness constraints in (5). The factorial typology was calculated using OTWorkplace (Prince et al., 2018), and a total of 25 distinct input-output maps (referred to as 'languages') are predicted. The mappings constituting 14 of these 25 languages are listed in Table 3, and those constituting the remaining 11 languages are listed in Table 4. The header row of each table lists the nine possible underlying consonant representations from Table 1, each centered above its predicted surface manifestations in each of the two relevant positions: word-initial and intervocalic. Each subsequent row represents a distinct language, numbered L.01 to L.14 in Table 3 and L.15 to L.25 in Table 4. A language is a list of 9 pairs of alternating surface symbols [*x*] ∼ [*y*], where [*x*] is the word-initial alternant and [*y*] is the intervocalic alternant of the underlying consonant representation at the top of that column.

	/p/	/b/	/ɸ/	/β/	/⌜pb⌟/	/⌜pɸ⌟/	/⌜bβ⌟/	/⌜ɸβ⌟/	/⌜pβ⌟/
L.01	[p] ∼ [p]	[p] ∼ [p]	[p] ∼ [p]	[p] ∼ [p]	[p] ∼ [p]	[p] ∼ [p]	[p] ∼ [p]	[p] ∼ [p]	[p] ∼ [p]
L.02	[p] ∼ [p]	[p] ∼ [p]	[ɸ] ∼ [ɸ]	[ɸ] ∼ [ɸ]	[p] ∼ [p]	[p] ∼ [p]	[p] ∼ [p]	[ɸ] ∼ [ɸ]	[p] ∼ [p]
L.03	[p] ∼ [p]	[p] ∼ [p]	[ɸ] ∼ [ɸ]	[ɸ] ∼ [ɸ]	[p] ∼ [p]	[p] ∼ [ɸ]	[p] ∼ [ɸ]	[ɸ] ∼ [ɸ]	[p] ∼ [ɸ]
L.04	[p] ∼ [p]	[b] ∼ [b]	[p] ∼ [p]	[b] ∼ [b]	[p] ∼ [p]	[p] ∼ [p]	[b] ∼ [b]	[p] ∼ [p]	[p] ∼ [p]
L.05	[p] ∼ [p]	[b] ∼ [b]	[p] ∼ [p]	[b] ∼ [b]	[p] ∼ [b]	[p] ∼ [p]	[b] ∼ [b]	[p] ∼ [b]	[p] ∼ [b]
L.06	[p] ∼ [p]	[b] ∼ [b]	[ɸ] ∼ [ɸ]	[β] ∼ [β]	[p] ∼ [p]	[p] ∼ [p]	[b] ∼ [b]	[ɸ] ∼ [ɸ]	[p] ∼ [p]
L.07	[p] ∼ [p]	[b] ∼ [b]	[ɸ] ∼ [ɸ]	[β] ∼ [β]	[p] ∼ [p]	[p] ∼ [ɸ]	[b] ∼ [β]	[ɸ] ∼ [ɸ]	[p] ∼ [ɸ]
L.08	[p] ∼ [p]	[b] ∼ [b]	[ɸ] ∼ [ɸ]	[β] ∼ [β]	[p] ∼ [b]	[p] ∼ [p]	[p] ∼ [b]	[ɸ] ∼ [β]	[p] ∼ [b]
L.09	[p] ∼ [p]	[b] ∼ [b]	[ɸ] ∼ [ɸ]	[β] ∼ [β]	[p] ∼ [b]	[p] ∼ [ɸ]	[b] ∼ [β]	[ɸ] ∼ [β]	[p] ∼ [β]
L.10	[p] ∼ [b]	[p] ∼ [b]	[p] ∼ [b]	[p] ∼ [b]	[p] ∼ [b]	[p] ∼ [b]	[p] ∼ [b]	[p] ∼ [b]	[p] ∼ [b]
L.11	[p] ∼ [b]	[p] ∼ [b]	[ɸ] ∼ [β]	[ɸ] ∼ [β]	[p] ∼ [b]	[p] ∼ [b]	[p] ∼ [b]	[ɸ] ∼ [β]	[p] ∼ [b]
L.12	[p] ∼ [b]	[p] ∼ [b]	[ɸ] ∼ [β]	[ɸ] ∼ [β]	[p] ∼ [b]	[p] ∼ [β]	[p] ∼ [β]	[ɸ] ∼ [β]	[p] ∼ [β]
L.13	[p] ∼ [b]	[b] ∼ [b]	[p] ∼ [b]	[b] ∼ [b]	[p] ∼ [b]	[p] ∼ [b]	[b] ∼ [b]	[p] ∼ [b]	[p] ∼ [b]
L.14	[p] ∼ [b]	[b] ∼ [b]	[ɸ] ∼ [β]	[β] ∼ [β]	[p] ∼ [b]	[p] ∼ [b]	[b] ∼ [b]	[ɸ] ∼ [β]	[p] ∼ [b]

Table 3: Languages L.01–L.14 of the factorial typology of the system under assessment

	/p/	/b/	/ɸ/	/β/	/⌜pb⌟/	/⌜pɸ⌟/	/⌜bβ⌟/	/⌜ɸβ⌟/	/⌜pβ⌟/
L.15	[p] ∼ [b]	[b] ∼ [b]	[ɸ] ∼ [β]	[β] ∼ [β]	[p] ∼ [b]	[p] ∼ [β]	[b] ∼ [β]	[ɸ] ∼ [β]	[p] ∼ [β]
L.16	[p] ∼ [β]	[p] ∼ [β]	[p] ∼ [β]	[p] ∼ [β]	[p] ∼ [β]	[p] ∼ [β]	[p] ∼ [β]	[p] ∼ [β]	[p] ∼ [β]
L.17	[p] ∼ [β]	[p] ∼ [β]	[ɸ] ∼ [β]	[ɸ] ∼ [β]	[p] ∼ [β]	[p] ∼ [β]	[p] ∼ [β]	[ɸ] ∼ [β]	[p] ∼ [β]
L.18	[p] ∼ [β]	[b] ∼ [β]	[p] ∼ [β]	[b] ∼ [β]	[p] ∼ [β]	[p] ∼ [β]	[b] ∼ [β]	[p] ∼ [β]	[p] ∼ [β]
L.19	[p] ∼ [β]	[b] ∼ [β]	[ɸ] ∼ [β]	[β] ∼ [β]	[p] ∼ [β]	[p] ∼ [β]	[b] ∼ [β]	[ɸ] ∼ [β]	[p] ∼ [β]
L.20	[p] ∼ [ɸ]	[b] ∼ [β]	[p] ∼ [ɸ]	[b] ∼ [β]	[p] ∼ [β]	[p] ∼ [ɸ]	[b] ∼ [β]	[p] ∼ [β]	[p] ∼ [β]
L.21	[p] ∼ [ɸ]	[b] ∼ [β]	[p] ∼ [ɸ]	[b] ∼ [β]	[p] ∼ [ɸ]	[p] ∼ [ɸ]	[b] ∼ [β]	[p] ∼ [ɸ]	[p] ∼ [ɸ]
L.22	[p] ∼ [ɸ]	[b] ∼ [β]	[ɸ] ∼ [ɸ]	[β] ∼ [β]	[p] ∼ [β]	[p] ∼ [ɸ]	[b] ∼ [β]	[ɸ] ∼ [β]	[p] ∼ [β]
L.23	[p] ∼ [ɸ]	[b] ∼ [β]	[ɸ] ∼ [ɸ]	[β] ∼ [β]	[p] ∼ [ɸ]	[p] ∼ [ɸ]	[b] ∼ [β]	[ɸ] ∼ [ɸ]	[p] ∼ [ɸ]
L.24	[p] ∼ [ɸ]	[p] ∼ [ɸ]	[p] ∼ [ɸ]	[p] ∼ [ɸ]	[p] ∼ [ɸ]	[p] ∼ [ɸ]	[p] ∼ [ɸ]	[p] ∼ [ɸ]	[p] ∼ [ɸ]
L.25	[p] ∼ [ɸ]	[p] ∼ [ɸ]	[ɸ] ∼ [ɸ]	[ɸ] ∼ [ɸ]	[p] ∼ [ɸ]	[p] ∼ [ɸ]	[p] ∼ [ɸ]	[ɸ] ∼ [ɸ]	[p] ∼ [ɸ]

Table 4: Languages L.15–L.25 of the factorial typology of the system under assessment

Languages L.09, L.15, and L.22 are the only languages in the predicted typology that include chain shift and saltation maps. We have thus far considered a chain shift map to specifically consist of the pairs {[p] ∼ [b], [b] ∼ [β]}, as observed in Gran Canarian Spanish (1), and a saltation map to consist of the pairs {[p] ∼ [β], [b] ∼ [b]}, as observed in Campidanian Sardinian (2). Note, however, that [ɸ] is the same ‘distance’ from [p] and [β] as [b] is, feature-value-change-wise, and that [ɸ] could thus in principle take the place of [b] in both cases. And indeed, we also see chain shift maps consisting of the pairs {[p] ∼ [ɸ], [ɸ] ∼ [β]} and saltation maps consisting of the pairs {[p] ∼ [β], [ɸ] ∼ [ɸ]} in these languages.

Let’s begin with a focus on language L.09, shown in Table 5. Solid lines link chain shift map pairs and dashed lines link saltation map pairs; thicker solid or dashed lines indicate maps involving [b] (henceforth ‘[b]-maps’) and thinner solid or dashed lines indicate maps involving [ɸ] (‘[ɸ]-maps’).

/p/	/b/	/ɸ/	/β/	/⌜pb⌟/	/⌜pɸ⌟/	/⌜bβ⌟/	/⌜ɸβ⌟/	/⌜pβ⌟/
[p] ∼ [p]	[b] ∼ [b]	[ɸ] ∼ [ɸ]	[β] ∼ [β]	[p] ∼ [b]	[p] ∼ [ɸ]	[b] ∼ [β]	[ɸ] ∼ [β]	[p] ∼ [β]

Table 5: Focus on the chain shift and saltation maps of language L.09

The chain shift [b]-map (= thicker solid line) is based in the underlying forms /⌜pb⌟/ and /⌜bβ⌟/ and the saltation [b]-map (= thicker dashed line) is based in the underlying forms /⌜pβ⌟/ and /b/. In the chain shift case, [voi] must be unspecified in the [p] ∼ [b] half of the alternation (from underlying /⌜pb⌟/) and [cont] must be unspecified in the [b] ∼ [β] half of the map (from underlying /⌜bβ⌟/). In the saltation case, both [voi] and [cont] must be unspecified in the [p] ∼ [β] half of the alternation (from underlying /⌜pβ⌟/).

The chain shift and saltation [ɸ]-maps (= thinner solid and dashed lines, respectively) are based in the underlying forms /⌜pɸ⌟/ and /⌜ɸβ⌟/ (for the chain shift) and /⌜pβ⌟/ and /ɸ/ (for the saltation). In the chain shift case, [cont] must be unspecified in the [p] ∼ [ɸ] half of the map (from underlying /⌜pɸ⌟/) and [voi] must be unspecified in the [ɸ] ∼ [β] half of the map (from underlying /⌜ɸβ⌟/). The underlying basis of the saltation map, /⌜pβ⌟/, is the same in the case of this [ɸ]-map as it was for the corresponding [b]-map discussed above, and so again both [voi] and [cont] must be unspecified here.

Based only on language L.09, then, one might conclude that both [voi] and [cont] must be unspecified somewhere in each map in order for Reiss’s solution to work, regardless of whether it is a [b]-map or a [ɸ]-map. It turns out that the [b]-maps are separable from the [ɸ]-maps, however. Consider first language L.15 in Table 6, which includes only [b]-maps. This language includes the same [b]-map pairs as does language L.09, but it includes in addition (i) a chain shift [b]-map with /p/ as the underlying basis for [p] ∼ [b] and (ii) a saltation [b]-map with /⌜pɸ⌟/ as the underlying basis for [p] ∼ [β]. The only underspecification that is strictly speaking necessary for the chain shift map is in the underlying basis for [b] ∼ [β], /⌜bβ⌟/, and for the saltation map it is in one of the underlying bases for [p] ∼ [β], /⌜pɸ⌟/. Thus, only underspecification of [cont] is necessary to generate chain shift [b]-maps and saltation [b]-maps.

/p/	/b/	/ɸ/	/β/	/⌜pb⌟/	/⌜pɸ⌟/	/⌜bβ⌟/	/⌜ɸβ⌟/	/⌜pβ⌟/
[p] ∼ [b]	[b] ∼ [b]	[ɸ] ∼ [β]	[β] ∼ [β]	[p] ∼ [b]	[p] ∼ [β]	[b] ∼ [β]	[ɸ] ∼ [β]	[p] ∼ [β]

Table 6: Focus on the chain shift and saltation maps of language L.15

Now consider language L.22 in Table 7, which includes only [ɸ]-maps. This language includes the same [ɸ]-map pairs as does language L.09, but it also includes (i) a chain shift [ɸ]-map with /p/ as the underlying basis for [p] ∼ [ɸ] and (ii) a saltation [ɸ]-map with /⌜pb⌟/ as the underlying basis for [p] ∼ [β]. The only underspecification that is strictly speaking necessary for the chain shift map is in the underlying basis for [ɸ] ∼ [β], /⌜ɸβ⌟/, and for the saltation map it is in one of the underlying bases for [p] ∼ [β], /⌜pb⌟/. Thus, only underspecification of [voi] is necessary to generate these [ɸ]-maps.

/p/	/b/	/ɸ/	/β/	/⌜pb⌟/	/⌜pɸ⌟/	/⌜bβ⌟/	/⌜ɸβ⌟/	/⌜pβ⌟/
[p] ∼ [ɸ]	[b] ∼ [β]	[ɸ] ∼ [ɸ]	[β] ∼ [β]	[p] ∼ [β]	[p] ∼ [ɸ]	[b] ∼ [β]	[ɸ] ∼ [β]	[p] ∼ [β]

Table 7: Focus on the chain shift and saltation maps of language L.22

The sets of ranking conditions responsible for these three languages transparently reflect the conclusions just summarized about the necessity of underspecification of [voi] and [cont]; see Table 8. For language L.09, either of the two ranking conditions in column **A** can be paired with either of the two ranking conditions in column **C**; for language L.15, either of the two ranking conditions in column **B** can be paired with either of the two ranking conditions in column **C**; and for language L.22, either of the two ranking conditions in column **A** can be paired with either of the two ranking conditions in column **D**.[4]

<table>
<tr><th>A</th><th>B</th><th>C</th><th>D</th></tr>
<tr><td>DEP-voi
|
*V[−voi]V
|
*[+voi]</td><td>*V[−voi]V
/ \
DEP-voi MAX-voi
|
*[+voi]</td><td>DEP-cont
|
*V[−cont]V
|
*[+cont]</td><td>*V[−cont]V
/ \
DEP-cont MAX-cont
|
*[+voi]</td></tr>
<tr><td>MAX-voi
|
*V[−voi]V
|
*[+voi]</td><td>*V[−voi]V
/ \
DEP-voi MAX-voi
|
*[+voi]</td><td>MAX-cont
|
*V[−cont]V
|
*[+cont]</td><td>*V[−cont]V
/ \
DEP-cont MAX-cont
|
*[+voi]</td></tr>
</table>

Table 8: Sets of ranking conditions for languages L.09, L.15, and L.22

The ‘either of the two’ remark concerning the relevant columns for each language means that, for each feature F ∈ {[voi], [cont]}, either DEP-F or MAX-F is sufficient; it is not necessary to have both. This is most obvious for the ranking conditions in columns **A** and **C**, where the top condition has DEP-F and the bottom condition has MAX-F. (The other constraint is ‘missing’ in each of these rankings because it needn’t be ranked with respect to any of the other constraints.) But the same is true of the conditions in columns **B** and **D**: the top condition in each column simply asserts that *if* MAX-F is present, it must be ranked below the higher-ranked markedness constraint that it conflicts with, and the bottom condition asserts the same of DEP-F. The fact that either faithfulness constraint can be omitted to obtain the same results was further confirmed by calculating the factorial typology with only one or the other faithfulness constraint for each feature, and the exact same set of 25 languages was generated, each obeying the relevant conditions in Table 8.

[4]The last logical possibility, pairing one ranking from column **B** with one from column **D**, generates language L.19. The mappings in this language all converge on intervocalic [β]: [p] ∼ [β], [b] ∼ [β], [ɸ] ∼ [β], and [β] ∼ [β].

Recall now from Table 2 that DEP-F and MAX-F penalize feature-changing mappings equally, but that they assess feature-filling mappings differently: DEP-F is violated by feature-filling mappings and MAX-F is satisfied by them. These two distinct faithfulness constraints are nevertheless interchangeable in the system under assessment because neither DEP-F nor MAX-F *distinguishes* the two feature-filling mappings *from each other*. Faithfulness to F is thus rendered completely irrelevant when the underlying form is not specified for a value of F: the only two viable candidates in the **IU** landscape tie on both of DEP-F and MAX-F. The higher-ranked of the two relevant markedness constraints thus always prevails instead, regardless of its ranking with respect to faithfulness — and thus regardless of whether faithfulness is DEP-F, MAX-F, or both.

Returning to language L.09 in Table 5, and the rankings in columns **A** and **C**: because either DEP-F or MAX-F is dominant in all of these rankings, and because both constraints penalize feature-changing mappings equally, any combination of the rankings in **A** and **C** ensures that (i) all fully-specified underlying forms surface faithfully, and (ii) all underspecified underlying forms surface as the least-marked fully-specified segment that unifies with that underlying form. So for example, for underlying /⌜pb⌟/, [p] is the least-marked word-initial surface alternant because only *[+voi] is relevant there, and [b] is the least-marked intervocalic surface alternant because *V[−voi]V ≫ *[+voi]. Likewise, for underlying /⌜pβ⌟/, [p] is the least-marked word-initial surface alternant because only *[+voi] and *[+cont] are relevant there, and [β] is the least-marked intervocalic surface alternant because *V[−voi]V ≫ *[+voi] and *V[−cont]V ≫ *[+cont].

Languages L.15 (Table 6) and L.22 (Table 7) differ from language L.09 in that one or the other of columns **B** and **D** substitutes for column **A** or **C**, respectively. This places faithfulness to [voi] (in the case of language L.15) or to [cont] (in the case of language L.22) below the higher-ranked markedness constraint that it conflicts with, effectively granting markedness priority in deciding what value of that feature surfaces intervocalically. In language L.15, where DEP/MAX-voi is ranked below *V[−voi]V (column **B**), underlying /p/ surfaces faithfully as [p] word-initially but unfaithfully as [b] intervocalically, allowing /p/ to enter into a chain shift [b]-map relationship with /⌜bβ⌟/. Similarly, underlying /⌜pɸ⌟/ surfaces as [p] word-initially and as [β] intervocalically, allowing /⌜pɸ⌟/ to enter into a saltation [b]-map relationship with /b/. In language L.22, where DEP/MAX-cont is ranked below *V[−cont]V (column **D**), underlying /p/ surfaces faithfully as [p] word-initially but unfaithfully as [ɸ] intervocalically, allowing /p/ to enter into a chain shift [ɸ]-map relationship with /⌜ɸβ⌟/, and underlying /⌜pb⌟/ surfaces as [p] word-initially and as [β] intervocalically, allowing /⌜pb⌟/ to enter into a saltation [ɸ]-map relationship with /ɸ/.

We are now in a position to appreciate the fact that all three of these languages include *both* chain shift maps and saltation maps, which effectively means that the system under assessment predicts that languages exhibiting one type of map, for some morphemes, will also necessarily exhibit the other type of map, for other morphemes.[5] This is not a concern to Reiss, who presents his solution as a simple affirmative answer to the following question (Reiss 2021a:6, emphasis added here): "If we assume a model that allows binary features and underspecification, as well as MAX-F and DEP-F constraints, *is there a lexicon and a constraint ranking that a learner can posit that will generate the observed pattern*?" In other words, Reiss assumes that a language exhibiting only a chain shift for some morphemes and not also a saltation for other morphemes — or vice-versa — can be successfully described by (i) selecting judiciously from among the members of the set of underlying forms in the header row of Table 3 and (ii) establishing a constraint ranking consistent with the sets of ranking conditions responsible for either language L.09, language L.15, or language L.22.

However, as Prince (2007:23) notes, "a theory is the totality of its consequences." One of the central consequences of any OT analysis involves contending with *Richness of the Base* (Prince & Smolensky, 1993; Smolensky, 1996), and thus answering the question: *how is every possible input that can be defined within the representational assumptions of the analysis dispositioned in the output*? In the narrowly-defined system under assessment, those dispositions are laid bare in Table 3, from which it simply follows that any language including a chain shift map for some morphemes will also include a saltation map for other morphemes and vice-versa. One can of course then ask further whether or not this is the right typological prediction to make, and we assert here that the answer is — quite obviously — *no*. Indeed, the pathological predictions of the factorial typology in Table 3 go well beyond this yoking of chain shift and saltation maps.

For example, restricting our attention just to language L.09 in Table 5, we see that some morphemes are

[5]Both in our conference abstract and in our presentation we claimed that chain shift maps entail saltation maps *but not vice-versa*, an error based on a prior assessment of Reiss's system with STOP-VLESS/*VOI-STOP instead of *[+voi]. Recall the typological complications noted in footnote 3 that Reiss's more limited markedness constraint introduces, and see §5.2 below for some discussion of a different source for the same non-mutual entailment.

predicted to have non-alternating [p], other morphemes are predicted to have word-initial [p] alternating with intervocalic [b] (as part of a chain shift [b]-map), yet other morphemes are predicted to have word-initial [p] alternating with intervocalic [ɸ] (as part of a chain shift [ɸ]-map), and still other morphemes are predicted to have word-initial [p] alternating with intervocalic [β] (as part of two saltation maps, one a [b]-map and the other a [ɸ]-map). Morpheme-specific phonological behavior of this kind is of course attested, and indeed one of Inkelas's (1995) key arguments for seriously considering the **IU** landscape in OT is to account for such behavior (see also Inkelas et al. 1996, 1997). However, there are alternative ways of accounting for morpheme-specific phonology in OT (see e.g. Pater 2010 and Anttila 2002, among many others) as well as for chain shifts and saltations (see the references cited in §1), no combination of which appears to force this kind of negative confrontation with the typological consequences of Richness of the Base.

5 Further remarks on featural faithfulness

5.1 *Learnability.* Magri (2018b:585) observes that in at least some OT analyses assuming underspecification, featural faithfulness constraints regulating *weak featural identity* — only penalizing feature-changing mappings — can be inconsequentially replaced with constraints that instead regulate *strong featural identity*, also penalizing feature-filling mappings. This observation parallels one of our own conclusions, the interchangeability between DEP-F and MAX-F as defined in (4) and deployed in the **IU** landscape; in this context, MAX-F only penalizes feature-changing mappings while DEP-F also penalizes feature-filling mappings. As explained in §4, this is due to the fact that neither DEP-F nor MAX-F distinguishes the two feature-filling mappings from each other, rendering both of these faithfulness constraints equally irrelevant when the underlying form is underspecified for [F] —six of one, half a dozen of the other.

Magri (2018b:588*ff*) goes on to prove that two conditions must be met in order for "the learnability implications uncovered by Tesar (2014) to extend from total features [= full specification] to partial features [= underspecification]." Despite the apparent analytical interchangeability of DEP-F and MAX-F (as shown in §4), and more generally between constraints regulating strong vs. weak featural identity (as shown by Magri), the two conditions in Magri's proof favors one of these constraints over the other.

The first condition of the proof is that a given specified feature value must be more similar to itself than *both* (i) other specified feature values *and* (ii) the lack of a specification — that is, [−F] is more similar to [−F] than either [+F] or [∅F] are, and [+F] is more similar to [+F] than either [−F] or [∅F] are.[6] The second condition of the proof is that featural faithfulness constraints must regulate strong featural identity — that is, they must penalize feature-filling mappings just as they penalize feature-changing ones. These twin conditions suggest that, given the choice in Reiss's system between DEP-F and MAX-F, DEP-F is the better choice because it "improve[s] learning speed and algorithmic efficiency" (Magri, 2018b:593).

5.2 *Beyond DEP-F and MAX-F.* DEP-F and MAX-F as specifically defined in (4) are only two of several conceivable ways to define featural faithfulness constraints in the **IU** landscape, given the parameters along which different featural faithfulness constraints are (or tend to be) defined in the Correspondence Theory literature. We have identified three such parameters, described (albeit in somewhat succinct form) in (6).

(6) Parameters of featural faithfulness

a. **Identity**: *identical* (*id*) vs. *nondistinct* (*nd*)
  – *id* : violated by any change: $\langle + \mapsto -\rangle$, $\langle \varnothing \mapsto +\rangle$, $\langle - \mapsto \varnothing\rangle$, etc.
  – *nd* : violated only by change from one specified value to the other: $\langle + \mapsto -\rangle$ and $\langle - \mapsto +\rangle$

b. **Orientation**: *input* (*i*) vs. *output* (*o*)
  – *i* : violation is determined by a condition on the input (= underlying form)
  – *o* : violation is determined by a condition on the output (= surface form)

c. **Symmetry**: *symmetrical* (*s*) vs. *asymmetrical* (*a*)
  – *s* : violated by deviation from $\{+,-\}$ (viewed from the input if **orientation** = *i*, output if = *o*)
  – *a* : violated by deviation from $\{+\}$ (viewed from the input if **orientation** = *i*, output if = *o*)

[6] Technically it must furthermore be the case that [∅F] is more similar to [∅F] than either [−F] or [+F] are, but this is only relevant in the context of the **FU** landscape where mappings to [∅F] are allowed.

The various combinations of settings of these paramaters make possible five distinct featural faithfulness constraints in the intermediate **IU** landscape of immediate interest, shrinking to three distinctions in the most restrictive **FS** landscape and expanding to eight in the most inclusive **FU** landscape. We plan to report in future work on our continuing in-depth investigation of the full taxonomy of featural faithfulness constraint definitions arising from the various combinations of settings of the parameters in (6) across the three representational landscapes **FS**, **IU**, and **FU**. How five of these constraints distinctly assesses the four basic types of unfaithful mappings in the **IU** landscape is shown in Table 9.[7] The candidates in (a) and (b) are feature-changing, and the candidates in (c) and (d) are their feature-filling counterparts.

F = [voi]	DEP^s-F	MAX^w-F	DEP^s-+F	MAX^s-+F	DEP^w-+F
a. $/\underset{-}{\text{p}}/ \longrightarrow [\underset{+}{\text{b}}]$	*	*	*		*
b. $/\underset{+}{\text{b}}/ \longrightarrow [\underset{-}{\text{p}}]$	*	*		*	
c. $/\ulcorner\underset{\varnothing}{\text{pb}}\lrcorner/ \longrightarrow [\underset{+}{\text{b}}]$	*		*		
d. $/\ulcorner\underset{\varnothing}{\text{pb}}\lrcorner/ \longrightarrow [\underset{-}{\text{p}}]$	*				

Table 9: Unfaithful mapping assessments by faithfulness type in the **IU** landscape

The first two constraints are equivalent to DEP-F and MAX-F in (4) — recall also Table 2, showing the same candidate comparisons for both [voi] and [cont] — but the constraint labels are respectively superscripted with '*s*' and '*w*' here to explicitly indicate that DEP^s-F regulates Magri's (2018b) *strong* featural identity, violated by both the feature-changing (a,b) and feature-filling mappings (c,d), while MAX^w-F regulates *weak* featural identity, violated only by the feature-changing mappings (a,b). The other three constraints are described here in the order shown in Table 9.

(7) The other three **IU** constraints

DEP^s-+F : violated by both feature-changing and feature-filling mappings,
like DEP^s-F, but only when the surface result of unfaithfulness is [+F]

MAX^w-+F : violated only by feature-changing mappings, like MAX^w-F,
but only when the underlying source of unfaithfulness is [+F]

DEP^w-+F : violated when the surface result of unfaithfulness is [+F],
like DEP^s-+F, but only when the mapping is feature-changing

We now briefly sketch how these three constraints compare to DEP^s-F and MAX^w-F with regard to chain shift and saltation maps. First, if we replace DEP^s-F and MAX^w-F with any one of the remaining three constraint types, no chain shift or saltation maps can be generated. However, if we consider systems with both MAX^w-+F and either or both of DEP^s-+F and DEP^w-+F, then some of the languages predicted in the resulting factorial typologies do include these maps. Consider the following high-level summary, where 'System 1' refers to a system with both DEP^s-+F and MAX^w-+F, 'System 2' to one with both DEP^w-+F and MAX^w-+F, and 'System 3' to one with all three of these featural faithfulness constraints. Systems 1 and 2 predict slightly different typologies of 36 distinct languages, and System 3 predicts a more diverse typology of 64 distinct languages. In all three typologies, chain shift maps entail saltation maps but not vice-versa (recall footnote 5). Four of the 36 languages in both Systems 1 and 2 include saltation [b]-maps, and two of these also include chain shift [b]-maps. Four of the 36 languages include saltation [ɸ]-maps, and two of these also include chain shift [ɸ]-maps. Eleven of the 64 languages in System 3 include saltation [b]-maps, and five of these also include chain shift [b]-maps. Twelve of the 64 languages include saltation [ɸ]-maps, and six of these also include chain shift [ɸ]-maps. There is furthermore very little overlap between [b]-maps and [ɸ]-maps in all three systems. Only one language in each of Systems 1 and 2 includes both a saltation [b]-map as well as a saltation [ɸ]-map, and only four languages in System 3 have this same property.

[7] The equivalencies between the constraint names in Table 9 and parameter settings in (6) are: DEP^s-F = $\{$*id, id.o.s*$\}$, MAX^w-F = $\{$*id.i.s, nd, nd.o.s, nd.o.a*$\}$, DEP^s-+F = *id.o.a*, MAX^w-+F = $\{$*id.i.a, nd.i.a*$\}$, and DEP^w-+F = *nd.o.a*.

Our ongoing research aims to answer many questions we have about these systems and variations on them. For example, the different numbers of languages in System 3 with [b]-maps and [ɸ]-maps is unexpected, given the overall symmetry of the system. We are also considering the workings of various sorts of 'hybrid' systems, for instance with one type of featural faithfulness constraint for [voi] and another type for [cont]. Not surprisingly, some such hybrid systems predict only [b]-maps while others predict only [ɸ]-maps. We plan to report on our observations and conclusions about them in future work.

We note in closing here that the three distinct **FS** constraints arising from the various settings of the parameters in (6) correspond directly with prototypical featural faithfulness constraints in the Correspondence Theory literature: (i) constraints named IDENT, symmetrically penalizing both mappings from [+F] to [−F] and mappings from [−F] to [+F]; (ii) constraints named DEP, asymmetrically penalizing only mappings from [−F] to [+F]; and (iii) constraints named MAX, asymmetrically penalizing only mappings from [+F] to [−F]. This satisfying correspondence, as well as that between two of the **IU** constraints and DEP-F and MAX-F, gives us reason to believe that the complete taxonomy of featural faithfulness constraints across landscapes defined by the parameters in (6) is worthy of continued investigation.

6 Summary

Reiss (2021a,b) proposes an interesting, uniform solution for two generation problems for classic OT, chain shifts and saltations. Such generation problems have traditionally been addressed with novel constraint types added to the classic theory. Reiss proposes instead to rely on a change in the representational landscape, from the 'full specification' (**FS**) landscape typical of most OT work to the 'input underspecification' (**IU**) landscape of Inkelas (1995). We find that Reiss's solution is at best a descriptive and explanatory mixed bag. Most substantively, one of the results that we report in §4 is that the complete factorial typology of languages predicted by Reiss's solution — and the complete set of mappings predicted for each of the languages in the typology — is replete with curious and questionable claims about maps expected to coexist, the most significant of which is a pathological codependency between chain shift maps and saltation maps.

Our other two results provide further clarification of what is and what is not crucial to Reiss's solution: only underspecification of one of the two features involved in the chain shift or saltation is needed ([cont] in the case of [b]-maps, [voi] in the case of [ɸ]-maps), and only one or the other of DEP-F and MAX-F is sufficient to generate both chain shift and saltation maps. These clarifications highlight the importance of rigorous formal analysis in proposing solutions to theoretical problems. Factoring out the crucial elements of a solution leads to a deeper understanding of the problems it is intended to solve, and permits more substantive and productive comparison with alternative solutions. We have not fully undertaken such solution comparison here, but plan to do so in our ongoing collaboration on this project.

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