Tutorial on Substance-Free Logical Phonology

Rim Dabbous[1], Kyle Gorman[2], and Charles Reiss[1]

[1]Concordia University, Montréal
[2]CUNY Graduate Center, New York

LSA 2025, Philadelphia

1 Introduction

Substance-Free Logical Phonology (henceforth LP) is an austere, formally rigorous theory of phonological computation drawing on:

- the application of ordered rules,
- expressed as simple logical operations over natural classes,
- the postulate that phonological computation is "substance-free", and
- underlying representations employing a form of archiphonemic underspecification.

LP is thus a theory of possible phonological processes and grammars; it also has consequences for our theories of morphophonology and phonological exceptionality.

1.1 What we won't cover

We will **not** discuss:

- phonotactic generalizations (which we conceptualize as ontologically distinct from phonology proper),
- "non-local", long-distance phonological processes (though see Dabbous et al. 2021 for our approach to locality and non-locality),
- phonological—prosodic or tonal—structure above the segment (though we believe that LP can easily be extended to support this), or
- formal results in expressivity or learnability (though we suspect positive results of this sort are very much within reach).

1.2 Why phonology should be logical

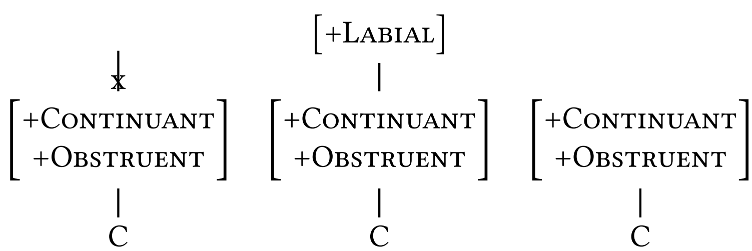
- Phonological rules from the *Sound Pattern of English* (SPE; Chomsky and Halle 1968) era—and much subsequent descriptive work—employ numerous abbreviatory devices such as:
  - “Greek letter” variables to express non-identity with feature coefficients,
  - exchange rules,
  - parentheses to indicate optional expansions,
  - curly braces for disjunctions, etc.
- Logical rigor should allow us to discern which of these are mere metalanguage conventions (cf. McCawley 1974) and which expand the space of possible grammars.
- Anderson (1982) suggests that the following rule should be interpreted as “delete schwa”:

(1) $\varnothing \rightarrow \varnothing$

- But could it not just as well mean “insert schwa” or even “do nothing”?
- Kiparsky (1985) proposes the following representations:

(2) Fricatives:

a. /s/ b. /f/ c. all fricatives



- The question here (e.g., Lees 1961:12–14, Lightner 1971:236, Hayes 1986, Archangeli 1988, Reiss 2003) is how one should refer to underspecified/unmarked members of an class without referring to the whole class; the literature fails to provide an acceptable solution.[1]
- As the examples become phenomenologically more complex—and more challenging for analysts—little enrichment to our theory is needed. Rather, apparent complexity emerges from the combinatorics of our set-theoretic system.
- This reflects Chomsky’s (1982:3) characterization of scientific progress.

> As concepts and principles become simpler, argument and inference tend to become more complex—a consequence that is naturally very much to be welcomed.

[1]As Bonet (1995) notes in a study on clitic selection, this issue also occurs in morphology.

1.3 Why phonology should be substance-free

- Consider the following set of informally-specified rules.

(3) Simple rule I:

  - e → ẽ / __ n
  - Search and copy: "vowel looks at the segment to its immediate right, and if it finds +Nasal it copies it"

(4) Simple rule II:

  - e → i / __ n
  - Search but **do not** copy: "vowel searches to its immediate right, and if it finds +Nasal it becomes +High"

(5) Simple rule III:

  - e → X / __ n
  - Search and change: "vowel searches to its immediate right, and if it finds +Nasal something about it changes."

- There is no need to reify—or even define—notions like assimilation or dissimilation.
- Environments need not provide the features to the target; the rules are computationally arbitrary in this sense.

(6) Substance-Freeness of Structural Changes (Dabbous et al. 2021):

The features added to segments by the application of a rule need not be found in the rule environment.

1.4 Context

LP ties into other important theoretical currents:

- The *diachronic filter*—à la J. Ohala (2003), M. Hale (2003), and Ju. Blevins (2004)—and properties of the LAD explain observed ("Greenbergian") asymmetries/tendencies.
- *Cognitive Phonetics*: a theory of features at the phonology-phonetics interface (Volenec and Reiss 2018, 2019, 2025).
- (Small-*m*) minimalism: we make do without markedness, feature geometry, etc.
- Language as a natural object:

> ...to abstract from the welter of descriptive complexity certain general principles governing computation that would allow the rules of a particular language to be given in very simple forms. (Chomsky 2000:122)

1.5 Outline

- Defining features, segments, and natural classes.
- Decomposing the traditional → operator into:
  - subtraction ($\setminus$) for deleting features,
  - unification ($\sqcup$) for inserting features, and
  - full-segment insertion and deletion via $\mapsto$ and ϵ.
- Applying these tools to propose narrow phonological analyses of "exceptions" and other morpheme-conditioned processes, generalizing classic work by Sharon Inkelas and colleagues.

2 Features, segments and natural classes

2.1 Features

- We assume UG provides $W = \{+, -\}$ and universal, innate, finite feature set $\mathcal{F}$ (Chomsky and Halle 1965, Reiss and Volenec 2022).
- A valued feature is an element of $W \times \mathcal{F} = \{+, -\} \times \{\mathrm{F}_1, \ldots, \mathrm{F}_n\}$; e.g., $+\mathrm{F}_1$ or $-\mathrm{F}_2$.

2.2 Segments

- A feature specification is a set of zero or more valued features.
- Two valued features are *opposing* if they have the same feature but a different coefficients; e.g., +F and −F. A feature specification is *consistent* if it does not contain opposing valued features; e.g., if ς is consistent, then $+\mathrm{F} \in \varsigma \implies -\mathrm{F} \notin \varsigma$, etc.
- Segments are (consistent) feature specifications, linked to an X-slot.
- Feature specifications for segments need not be *complete*: underspecification is permitted.

(7) Segments as sets of features:

$$/\mathrm{i}/ = \left\{\begin{matrix} +\textsc{Syllabic} \\ -\textsc{Back} \\ -\textsc{Round} \\ +\textsc{High} \\ -\textsc{Low} \\ +\mathrm{ATR} \end{matrix}\right\} \qquad /\mathrm{e}/ = \left\{\begin{matrix} +\textsc{Syllabic} \\ -\textsc{Back} \\ -\textsc{Round} \\ -\textsc{High} \\ -\textsc{Low} \\ +\mathrm{ATR} \end{matrix}\right\} \qquad /\mathrm{I}/ = \left\{\begin{matrix} +\textsc{Syllabic} \\ -\textsc{Back} \\ -\textsc{Round} \\ -\textsc{Low} \\ +\mathrm{ATR} \end{matrix}\right\}$$

2.3 Natural classes

- A natural class can consist of a single member: $\bigcap\{\text{i}\}$ = {i}. (Recall that each segment is a set, so {i} is a set of sets.)

(8) Smallest natural class:

Given a language λ and a set of segments S' that is a subset of S (the set of all segments in λ), the smallest natural class containing every member of S' is
$N = \{n : n \in S \text{ and } n \supseteq \bigcap S'\}$.

- Natural classes are *sets of sets of valued features*:

(9) $\left[+\textsc{High}\right] = \left\{x : x \supseteq \left\{+\textsc{High}\right\}\right\}$ = {i, y, ɨ, ʉ, ɯ, u, Y, …}

(10) $\left\{+\textsc{High}\right\}$ = /Y/

(11) **Pop quiz 1:** Is there single rule of Lamba palatalization?:

a. s → ʃ / __ i (e.g., [masa, maʃika] 'to plaster')
b. k → tʃ / __ i (e.g., [fuka, futʃila] 'to creep')

(12) The natural class containing /i, e, I/:

$$\begin{bmatrix} +\textsc{Syllabic} \\ -\textsc{Back} \\ -\textsc{Round} \\ -\textsc{Low} \\ +\text{ATR} \end{bmatrix} = \{\text{i, e, I}\}$$

(13) Singleton natural class:

$$\begin{bmatrix} +\textsc{Syllabic} \\ -\textsc{Back} \\ -\textsc{Round} \\ +\textsc{High} \\ -\textsc{Low} \\ +\text{ATR} \end{bmatrix} = \{\text{i}\}$$

(14) Natural class versus segment:

singleton class $\{i\}$: segment /i/:

$$\begin{bmatrix} +\textsc{Syllabic} \\ -\textsc{Back} \\ -\textsc{Round} \\ +\textsc{High} \\ -\textsc{Low} \\ +\textsc{ATR} \end{bmatrix} = \left\{ \left\{ \begin{matrix} +\textsc{Syllabic} \\ -\textsc{Back} \\ -\textsc{Round} \\ +\textsc{High} \\ -\textsc{Low} \\ +\textsc{ATR} \end{matrix} \right\} \right\} \neq \left\{ \begin{matrix} +\textsc{Syllabic} \\ -\textsc{Back} \\ -\textsc{Round} \\ +\textsc{High} \\ -\textsc{Low} \\ +\textsc{ATR} \end{matrix} \right\}$$

(15) **Pop quiz 2**: Using square brackets, specify the singleton natural class {I}.

- Bale et al. (2020) note that this formalism can refer to the natural class of all segments without resorting to a feature SEGMENT or the class [+SEGMENT].
- Rather this class can be referred to using empty brackets [ ] because it is a theorem of set theory is that every set—and here, every segment—is a superset of the empty set.
- More formally, the empty square brackets are interpreted as follows.

(16) $[\ ] = \{x : x \supseteq \{\ \}\}$

(17) Terminological note:

yes: The vowel /i/ is (specified) +HIGH.
no: The vowel /i/ is (specified) [+HIGH].

- Note then that the traditional notation is not type-consistent:
  - a rule's target and environment are natural classes,
  - but the change is a feature specification.

(18) Extensional formulation:

o, e	→	u, i	/ __	m, n, ŋ
(Target)		(Change)		(Environment)

(19) Traditional formulation:

[−LOW]	→	[+HIGH]	/ __	[+NASAL]
(Target)		(Change)		(Environment)

(20) Revised LP formulation:

[−LOW]	→	{+HIGH}	/ __	[+NASAL]
(Target)		(Change)		(Environment)

3 Deconstructing →

- The → symbol has several different uses including:
  - changing features,
  - inserting features,
  - deleting features,
  - inserting segments, and
  - deleting segments.
- LP deconstructs → into a system of three operators.
- Deconstruction precludes the need for a (diacritic) distinction between feature-filling and feature-changing rules.

3.1 Subtraction

- *Subtraction* (or difference) is denoted by ∖ (`\setminus` in LaTeX)

(21) $x \in X \setminus Y$ iff $x \in X$ and $x \notin Y$.

(22) $\{\mathrm{a,b,c}\} \setminus \{\mathrm{a,b}\} = \{\mathrm{c}\}$

(23) $\{\mathrm{a,b,c}\} \setminus \{\mathrm{b,d}\} = \{\mathrm{a,c}\}$

(24) $\{\mathrm{a,b,c}\} \setminus \{\mathrm{d}\} = \{\mathrm{a,b,c}\}$ (vacuous subtraction)

(25) $\left\{\begin{matrix}+\textsc{High}\\ -\textsc{Round}\\ -\textsc{Back}\end{matrix}\right\} \setminus \left\{\begin{matrix}+\textsc{High}\\ +\textsc{Round}\end{matrix}\right\} = \left\{\begin{matrix}-\textsc{Round}\\ -\textsc{Back}\end{matrix}\right\}$

- To formulate subtraction rules, we assume:
  - the target is a natural class, appearing on the left-hand side of the subtraction,
  - the change is a feature specification, appearing on the right-hand side,
  - an optional environment is specified using natural classes.

(26) $\left[-\textsc{Back}\right] \setminus \left\{-\textsc{High}\right\} \;/\; \_\_ \left[+\textsc{Nasal}\right]$

(27) Terminological note:

a. In LP, rules are total functions whose domain and range are phonological structures (strings, etc.) (see Bale and Reiss 2018).
b. Each rule “applies to” every string at a given point in the derivation so that its output serves as the input to the next rule (or yields the surface representation).
c. **We never say that a rule “does not apply”.**
d. Rather, when input and output are identical we say it *applies vacuously*.

3.2 Unification

- First consider *union*, denoted by ∪.

(28) {a, b, c} ∪ {a, b, d} = {a, b, c, d}

- But union of valued features can give rise to inconsistency.

(29) $\left\{\begin{array}{c} +\textsc{High} \\ \underline{+\textsc{Round}} \\ -\textsc{Back} \end{array}\right\} \cup \left\{\begin{array}{c} +\textsc{High} \\ \underline{-\textsc{Round}} \end{array}\right\} = \left\{\begin{array}{c} +\textsc{High} \\ \underline{+\textsc{Round}} \\ \underline{-\textsc{Round}} \\ -\textsc{Back} \end{array}\right\}$

- We instead use a variant called *unification*, denoted by ⊔ (`\sqcup` in LaTeX).

(30) Unification (to be revised):

If A and B are feature specifications, and the union $A \cup B$ is consistent, then $A \sqcup B = A \cup B$; otherwise it is undefined.

(31) Feature insertion: $\left\{\begin{array}{c} +\textsc{High} \\ -\textsc{Round} \end{array}\right\} \sqcup \left\{-\textsc{Back}\right\} = \left\{\begin{array}{c} +\textsc{High} \\ -\textsc{Round} \\ -\textsc{Back} \end{array}\right\}$

(32) Vacuous application: $\left\{\begin{array}{c} +\textsc{High} \\ -\textsc{Round} \\ -\textsc{Back} \end{array}\right\} \sqcup \left\{-\textsc{Back}\right\} = \left\{\begin{array}{c} +\textsc{High} \\ -\textsc{Round} \\ -\textsc{Back} \end{array}\right\}$

(33) Unification failure: $\left\{\begin{array}{c} +\textsc{High} \\ \underline{-\textsc{Round}} \\ -\textsc{Back} \end{array}\right\} \sqcup \left\{\begin{array}{c} +\textsc{High} \\ \underline{+\textsc{Round}} \end{array}\right\} \rightsquigarrow$ **undefined**

- To preserve the LP notion of rules as total functions, we reinterpret unification failure as vacuous application.

(34) Unification (revised):

If A and B are feature specifications, and their union $A \cup B$ is consistent, then $A \sqcup B = A \cup B$; otherwise, $A \sqcup B = A$.

- In other words, there are two types of vacuous application of unification rules:
  - vacuous unification and
  - unification failure.

- We formulate unification rules similarly to subtraction rules.

(35) $\left[-\textsc{Back}\right] \sqcup \left\{+\textsc{High}\right\}$ / ___ $\left[+\textsc{Nasal}\right]$

3.3 Examples

3.3.1 Russian

Following the suggestions of Poser (1982), Inkelas and Cho (1993), and Siptár and Törkenczy (2000) we model feature-changing processes as subtraction followed by unification.

- As is well-known, Russian exhibits final devoicing.

(36) Russian final devoicing:

	nom.sg.	gen.sg.	
a.	t͡sv^{j}et	t͡sv^{j}eta	'color'
b.	prut	pruda	'pond'

- The LP intuition is that devoicing should be modeled as two-step process: d $\rightsquigarrow$ D $\rightsquigarrow$ t.

(37)

	/t/	/d/	/D/
Voice	–	+	
Sonorant	–	–	–

(38) Part 1 (deletion): $\left[-\text{Sonorant}\right] \setminus \left\{+\text{Voice}\right\}$ / __ %

- Rule (38) maps any word-final segment-set that is a superset of {–Sonorant} to that same segment-set minus {+Voice}.

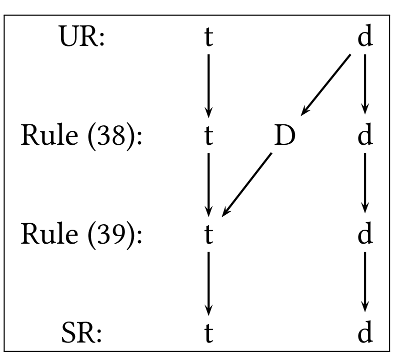
(39) Part 2 (insertion): $\left[-\text{Sonorant}\right] \sqcup \left\{-\text{Voice}\right\}$

(40) Yield of (39):

a.	/t/ $\sqcup$ {–Voice} $\rightsquigarrow$ /t/	(vacuous unification)
b.	/d/ $\sqcup$ {–Voice} $\rightsquigarrow$ /d/	(unification failure)
c.	/D/ $\sqcup$ {–Voice} $\rightsquigarrow$ /t/	(feature filling)

- Thanks to this two-step process and our definition of unification, it is not necessary to distinguish between feature-filling and feature-changing rules.

(41) Russian segment mapping diagram:



3.3.2 Hungarian (Reiss 2021)

- Hungarian exhibits a more complex process of reciprocal voice neturalization.

(42) Hungarian reciprocal voicing (Siptár and Törkenczy 2000:§4.1.1):

	nom.sg.	iness.sg	dat.sg.	abl.sg.	
a.	kalap	kala[b]-ban	kalap-nak	kalap-tól	'hat'
	rés	ré[z]-ben	rés-nek	rés-től	'slit'
	zsák	zsá[g]-ban	zsák-nak	zsak-tól	'bag'
b.	rab	rab-ban	rab-nak	ra[p]-tól	'captive'
	víz	víz-ben	víz-nek	ví[s]-től	'water'
	meleg	meleg-ben	meleg-nek	mele[k]-től	'warmth'
c.	szem	szem-ben	szem-nek	szem-től	'eye'
	őr	őr-ben	őr-nek	őr-től	'guard'

- In this language obstruents take on the voicing of the following obstruent, which might be written as follows in SPE notation.

(43) Reciprocal voice neutralization (traditional notation, to be revised):

$$\left[-\textsc{Sonorant}\right] \rightarrow \left\{\alpha\textsc{Voice}\right\} \;/\; \_\_ \begin{bmatrix}-\textsc{Sonorant}\\ \alpha\textsc{Voice}\end{bmatrix}$$

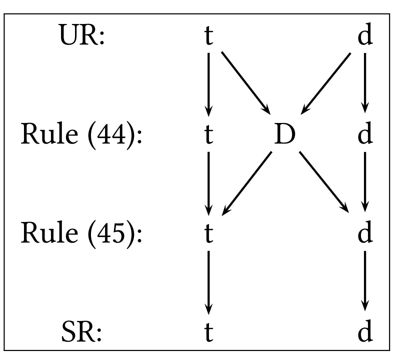
- We now proceed to decompose this into a two-step process.

(44) Part 1 (deletion): $\left[-\textsc{Sonorant}\right] \setminus \left\{\alpha\textsc{Voice}\right\} \;/\; \_\_ \begin{bmatrix}-\textsc{Sonorant}\\ -\alpha\textsc{Voice}\end{bmatrix}$

(45) Part 2 (insertion): $\left[-\textsc{Sonorant}\right] \sqcup \left\{\alpha\textsc{Voice}\right\} \;/\; \_\_ \begin{bmatrix}-\textsc{Sonorant}\\ \alpha\textsc{Voice}\end{bmatrix}$

(46) Critical ordering: (44) $\ll$ (45)

(47) Hungarian segment mapping diagram:



- Note that we were able to use the same two operations for both Russian and Hungarian even though reciprocal voicing "looks" more complex than final devoicing.

3.3.3 Turkish (Bale et al. 2014)

This logic also generalizes to cases involving "ternary" (three-way) contrasts.

- There are three kinds of plosive-final roots in Turkish.

(48) Ternary voicing (Inkelas 1995):

		nom.sg.	acc.sg.	nom.pl.	1sg.poss.	
a.	voiceless:	sana**t**	sana**t**-ɨ	sana**t**-lar	sana**t**-ɨm	'art'
b.	voiced:	ety**d**	ety**d**-y	ety**d**-ler	ety**d**-ym	'etude'
c.	alternating:	kana**t**	kana**d**-ɨ	kana**t**-lar	kana**d**-ɨm	'wing'

- Inkelas proposes final plosives in roots like (48), are underspecified for Voice.

(49)

	/t/	/d/	/D/
Continuant	–	–	–
Voice	–	+	

- She then proposes that the rules which fill in voice specifications are strictly feature-filling.
- LP does not make this distinction, and so it affects /D/ without affecting /t, d/ via vacuity.

(50) Onset voicing: $\left[-\text{Continuant}\right] \sqcup \left\{+\text{Voice}\right\} \;/\; [_{\sigma}\, \_\_$

(51) Yield of (50):

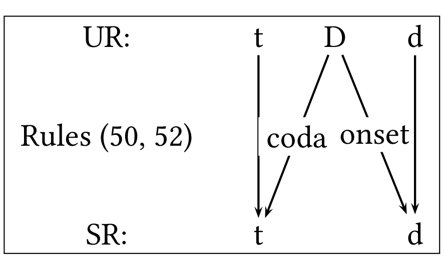
a. /t/ $\sqcup$ {+Voice} $\rightsquigarrow$ /t/ (unification failure)
b. /d/ $\sqcup$ {+Voice} $\rightsquigarrow$ /d/ (vacuous unification)
c. /D/ $\sqcup$ {+Voice} $\rightsquigarrow$ /d/ (feature filling)

- Parallel reasoning applies to Coda devoicing

(52) Coda devoicing: $\left[-\text{Continuant}\right] \sqcup \left\{-\text{Voice}\right\} \;/\; \_\_\,]_{\sigma}$

- Again, only application to /D/ is non-vacuous. Onset /D/ $\rightsquigarrow$ [d], but /t/ is inalterable.

(53) Turkish segment mapping diagram (non-crucial rule ordering ignored here):



3.4 Summary thus far

- Inkelas et al. (1997) argue against treating ternary alternations using cophonologies.
  - Suppose that one of the three patterns in (48)—it's not clear which ought to be—is treated as having a separate cophonology.
  - Then, one could just as well do away with underlying plosive VOICE altogether, and have three separate cophonologies; they take this to be a *reductio ad absurdum.*

- This analysis supports our assumptions of underspecification and binarity, and provides evidence against privativity.
  - Were VOICE privative—as it has often been argued (see citations in Inkelas and Cho 1993:544, fn. 3 and Lombardi 1995)—we could not target /t/ to the exclusion of /d/.
  - And were it privative, underspecification could not help us to express the contrast between /t/ and /D/.

- The Turkish voicing pattern—which might have analyzed using lexical exceptionality or cophonology—can be generated with the same tools as the clearly-phonological patterns in Russian and Hungarian.

- This use of underspecification have been criticized as "opportunististic" (Steriade 1995).
  - But the stipulation that underlying segments are fully specified would be an unmotivated stipulation.
  - And if feature-changing is a two-step deletion-and-insertion process, we must allow partially specified segments in intermediate representations too.
  - We also reject Nevins's (2010:12) "interface requirement", the stipulation that segments be fully specified the surface:
    - Keating (1988) provides phonetic evidence for surface underspecification.
    - Benz and Volenec (2023) use LP subtraction rules to model debuccalization.

- Indeed it is not clear what principle would exclude our analysis of Turkish.

- Progress does not only come from new good ideas, but also rejecting old bad ideas!

3.5 Insertion and deletion of segments

- We require some additional tools to implement the insertion and deletion of full segments.

- Let us assume that segments are not merely sets of features, but also that these sets are linked to X-slots.

(54) X-slot representation of /i/:

$$\begin{array}{c} \text{X} \\ | \\ \begin{Bmatrix} +\textsc{Syllabic} \\ -\textsc{Back} \\ -\textsc{Round} \\ +\textsc{High} \\ -\textsc{Low} \\ +\text{ATR} \end{Bmatrix} \end{array}$$

- We then introduce a new operator, ↦ (`\mapsto` in LaTeX), for transductions over timing slots, and use ϵ to symbolize nullity. We can then define rules for inserting and deleting segments.

(55) Word-final nasal deletion:

$$\begin{array}{c} \text{X} \\ | \\ \begin{bmatrix} +\textsc{Nasal} \end{bmatrix} \end{array} \quad \mapsto \quad \epsilon \quad / \_\_\ \%$$

- The target of this rule is the set of all X-slots associated with a set of features which are a superset of {+Nasal}.
- Segments which are targeted for deletion are commonly assumed to be featurally less specified (e.g., Scholten 1987:56, van Oostendorp 2003:435f., Flemming 2009, Silverman 2011).
- For example, consider two possible representations for a schwa-like vowel.

(56) Strong vs. weak schwa:

a. "strong" b. "weak"

$$\begin{array}{c} \text{X} \\ | \\ \begin{Bmatrix} +\textsc{Syllabic} \\ -\textsc{Back} \\ -\textsc{Round} \\ -\textsc{High} \\ -\textsc{Low} \\ -\text{ATR} \end{Bmatrix} \end{array} \qquad \begin{array}{c} \text{X} \\ | \\ \begin{Bmatrix} +\textsc{Syllabic} \end{Bmatrix} \end{array}$$

- The following rule is an attempt to delete only the weak schwa.

(57) Schwa deletion (to be revised):

$$\begin{array}{c} \text{X} \\ | \\ \left[+\text{S}\textsc{yllabic}\right] \end{array} \quad \mapsto \quad \epsilon$$

- This rule does not just delete (56b), but rather deletes all +Syllabic segments, including strong schwas and any other vowels.
- However, the model can specifically target richly-specified vowels, as in the following example targeting "strong" schwas.

(58) Schwa deletion (revised):

$$\begin{array}{c} \text{X} \\ | \\ \left[\begin{array}{c} +\text{S}\textsc{yllabic} \\ -\text{B}\textsc{ack} \\ -\text{R}\textsc{ound} \\ -\text{H}\textsc{igh} \\ -\text{L}\textsc{ow} \\ -\text{ATR} \end{array}\right] \end{array} \quad \mapsto \quad \epsilon$$

- "Weak" schwa can't be deleted, but it is trivial to insert one.

(59) Weak schwa insertion:

$$\epsilon \quad \mapsto \quad \begin{array}{c} \text{X} \\ | \\ \{+\text{S}\textsc{yllabic}\} \end{array}$$

- **Brackets matter!** (57) targets *all* vowels. Weak schwa deletion is impossible in LP. But insertion of this segment alone is possible (59). Compare the brackets in (57) and (59).
- The traditional idea that segment deletion is accomplished via a gradual loss of features simply cannot be stated in LP: it conflates "nothing" with the empty set. Rather, deletion must target richly-specified segments.
- As it turns out, many apparent cases of weak schwa deletion can be reanalyzed as insertion; see Reiss 2025 for discussion.

4 Underspecification and prespecification

LP, combined with a judicious use of underspecification and prespecification, can model a number of phenomena traditionally classified as *morphophonology*, i.e., involving phonological rules making reference to morphemic/lexical identity.

- Our goal is to show that at least some patterns previously attributed to morphophonology can be expressed using the restrictive LP model of the *narrow phonology*.
- We make the common—but usually implicit—assumption that a narrow phonological analysis is preferable, *ceteris paribus*, to morphophonological alternatives.
- We assume that the child is *epistemically bounded* (in the sense of Fodor 1980:33f.) to prioritize narrow phonological solutions, and resorts to morphophonology (or suppletion) only when they encounter an alternation exceeding the power of the narrow phonology.

4.1 Background

- Sharon Inkelas and colleagues (Inkelas and Cho 1993, Inkelas 1995, Inkelas and Orgun 1995, Inkelas et al. 1997) argue for a form of archiphonemic underspecification from which they derive two conclusions:
  - inalterability is prespecification, and
  - mutability is underspecification.
- We will later add the following slogans, direct corollaries of the LP model:[2]
  - prespecification is catalysis and
  - underspecification is quiescence.

4.2 Inalterability and mutability

- Inkelas and Cho (1993) propose to use prespecification to exempt certain morphemes from phonological processes.
- Inkelas and Cho propose that various forms of prespecified structure—including feature specifications—prevents targets from undergoing feature-filling processes.
- We translate this intuition into LP by using prespecification to create 'negative exceptions'—like a [d] that appears to exceptionally avoid coda devoicing.

[2] Inkelas and colleagues do not use the term "mutability", *catalysis*, or *quiescence*; these are our terms.

4.2.1 Baztan (Gorman and Reiss 2024)

- Hualde (1991) discusses a process called Low Vowel Assimilation (henceforth, LVA) in several dialects of Basque. LVA is attributed to "a rule that raises a low vowel to /e/ after a high vowel, with or without any intervening consonants" (op. cit.:23).

(60) Low Vowel Assimilation (loc. cit.):

/mutil-a/	[multil**e**]	'the boy'
/mendi-a/	[mendi**e**]	'the mountain'
/egun-a/	[eɣun**e**]	'the day'

- We focus on Hualde's account of the Baztan dialect (§2.2), in which LVA affects vowels within words and across certain word boundaries.

(61) Auxiliary verbs with raised vowel after high vowel (op. cit.:29–30.):

a.	torri d**e**	'he has come'	cf. gan d**a**	'he has gone'
b.	gain d**e**	'he will go'	cf. lorriko d**a**	'he will come'
c.	torri g**e**ra	'we have come'	cf. gan g**a**ra	'we have gone'
d.	torri z**e**ra	'you have come'	cf. gan z**a**ra	'you have gone'
e.	in z**e**zu	'do it'	cf. jan z**a**zu	'eat it'

- Hualde claims morphemes in which /a/ are unaffected by LVA belong to different morphological strata from those where it does, but it seems difficult to maintain this position.

(62) Exceptions to LVA (op. cit.:26–30):

  - "Not all derivational suffixes present the same behaviour with respect to Low Vowel Assimilation."
  - "Verbal suffixes generally undergo assimilation."
  - "We need to examine now the application of the rule in conjugated verbal forms. Here, the situation is not uniform... [I]n quite a few conjugated forms the rule fails to apply."
  - "The forms that present the context for Low Vowel Assimilation, but, nevertheless, do not undergo the rule, have just one more irregularity that must be lexically marked."
  - "Certain auxiliary verbs also undergo assimilation... Other forms of the auxiliary, on the other hand, never undergo assimilation, including the other persons of the intransitive present indicative not mentioned above..."
  - "We must conclude that only a few auxiliary forms can behave like clitics and thus undergo Low Vowel Assimilation."

(63) Some auxiliaries that do not undergo LVA:

1sg. *naiz* (e.g., *torri naiz* ‘I have come’), 2sg. informal *aiz*, 2pl. form *zate*

- It is hard to imagine any account which would place (63) in different morphological strata than the auxilaries in (61).
- We instead propose that some morphemes contain underspecified /A/ which is *mutable* via a unification rule (e.g., the singular definite /-A/, the auxiliary /dA/), whereas others (e.g., the auxiliary /naiš/) contain a prespecified /a/ which is *inalterable* with respect to this rule.

(64) Baztan vowel specification (partial):

	/a/	/e/	/A/	/o/
High	–	–	–	–
Low	+	–		–
Back	+	–		+
Round	–	–	–	+

(65) Low Vowel Assimilation: $\begin{bmatrix}-\textsc{High}\\-\textsc{Round}\end{bmatrix} \sqcup \{-\textsc{Low}\}$ / $[+\textsc{High}]$ C_0 ___

(66) Yield of (65):

a.	/a/ ⊔ {–Low} ⇝ /a/	(unification failure)
b.	/e/ ⊔ {–Low} ⇝ /e/	(vacuous unification)
c.	/A/ ⊔ {–Low} ⇝ /e/	(feature filling)
d.	/o/ ⊔ {–Low} ⇝ /o/	(vacuous unification)

- It only *seems* like (65) targets the underspecified segment to the exclusion of others.
- It is necessary to ensure that the “raised” vowel surfaces as –Back, but there are several ways to implement this.

4.2.2 Kashaya

- Buckley (1994) gives the following phonological rules of Kashaya, stated informally.

(67) i → a / m ___

(68) i → u / d ___

(69) V → a / q ___

(70) V → o / q^w ___

- While (67–68) appear to be quite regular, 3 of the 21 *i*-initial suffixes—inchoative *-ibic* and reflexives *-iyic'* and *-ic'*)—do not undergo the expected alternations. For example, [cahno·**dí**ʔ] 'talk to oneself' seems to meet the conditions for (68) but the *i* does not back.
- Similarly, the same three suffixes are apparent exceptions to the otherwise-regular (69–70).
- Buckley proposes that Kashaya has two *i*'s: mutable /I/ and inalterable /i/.[3]

(71) Kashaya vowel specification (op. cit.:24):

	/I/	/i/	/e/	/a/	/o/	/u/
Syllabic	+	+	+	+	+	+
High		+	−	−	−	+
Low		−	−	+	+	+
Back		−	−	+	−	−

- Assuming this specification, we can translate (67–68) into a sequence of unification rules.

(72) $$\left[+\textsc{Syllabic}\right] \sqcup \left\{\begin{matrix}-\textsc{High}\\+\textsc{Low}\\+\textsc{Back}\end{matrix}\right\} / \begin{bmatrix}+\textsc{Labial}\\+\textsc{Nasal}\\-\textsc{Continuant}\\\ldots\end{bmatrix} \text{—}$$

(73) $$\left[+\textsc{Syllabic}\right] \sqcup \left\{\begin{matrix}+\textsc{High}\\-\textsc{Low}\\+\textsc{Back}\end{matrix}\right\} / \begin{bmatrix}+\textsc{Coronal}\\+\textsc{Alveolar}\\+\textsc{Voice}\\\ldots\end{bmatrix} \text{—}$$

(74) $$\left[+\textsc{Syllabic}\right] \sqcup \left\{\begin{matrix}+\textsc{High}\\-\textsc{Low}\\-\textsc{Back}\end{matrix}\right\}$$

(75) Critical ordering: (72–73) ≪ (74)

4.2.3 Spanish (Gorman and Reiss 2024)

- Many Spanish verbs of the third (*-i-*) conjugation have a so-called "raising" alternation between the *e* and *i*, as in *pedí* 'I asked' vs. *pido* 'I ask' or *gemí* 'I wailed' vs. *gimo* 'I wail'; other third conjugation verbs (e.g., like *vivir* 'to live', *sumergir* 'to submerge').
- One could imagine analyzing raising verbs as involving suppletion between *e* and *i* stem allomorphs (e.g., /ped-, pid-/), but Embick (2012:33) notes such an analysis would have to make reference to a complex, disjunctive set of morphosyntactic contexts.[4]

[3]We modify Buckley's notation for consistency; he uses /i/ for mutable *i* and /î/ for inalterable *i*.

[4]Embick also notes that a stem suppletion account for this Spanish case would run counter to his theory of locality conditions on stem suppletion (Embick 2010).

(76) Morphosyntactic contexts for *ped-*/*pid-* (after Embick 2012:33):

a. *ped-*: 1pl./2pl. present indicatives, 1sg./1pl./2sg./2pl. preterites, all imperfectives, all futures, all conditionals
b. *pid-*: 1sg./2sg./3sg./3pl. present indicatives, all present subjunctives, all imperfect subjunctives, 3sg./pl. preterites

- There is no obvious way to treat the difference between (76a) and (76b) in terms of natural classes of morphosyntactic features, so the grammar would necessarily contain:
  - a list with both stem allomorphs,
  - a list of which morphosyntactic contexts select the *i* vs. *e* allomorph.

  He concludes "[a]n analysis that makes reference to morphosyntactic features thus looks very unpromising".

- Embick (2012) instead assumes the alternating vowel is /i/ and proposes the following morphophonological rule to generate /e/ allomorphs (cf. Harris 1969:110f.).

  (77) Lowering (to be revised): $\mathrm{i} \rightarrow \mathrm{e} \,/\, \_\_\, \mathrm{C_0 i}$ (condition: certain roots)

- Embick's proposal is certainly an improvement over a suppletion analysis, because it eliminates the need for the second list expressing the generalizations in (76), but LP allows us to go a step further and replace (77) with a narrow phonological rule.

- Suppose instead that the alternating vowel in underlyingly underspecified for High; let us write this vowel as /I/.

  (78) Spanish vowel specification:

	/I/	/i/	/e/	/a/	/o/	/u/
High		+	−	−	−	+
Low	−	−	−	+	−	−
Back	−	−	−	+	+	+

- Then in lieu of (77), we can give a purely phonological rule for lowering.

  (79) Lowering: $\begin{bmatrix}-\textsc{Back}\\ -\textsc{Low}\end{bmatrix} \sqcup \left\{-\textsc{High}\right\} \,/\, \_\_\, \mathrm{C_0} \begin{bmatrix}-\textsc{Back}\\ +\textsc{High}\end{bmatrix}$

  This rule maps underspecified /I/ to [e] when there is an /i/ in the next syllable, applying vacuously to /i, e/.

  (80) $\left[-\textsc{Low}\right] \sqcup \left\{+\textsc{High}\right\}$

  (81) Critical ordering: (79) ≪ (80)

4.3 A note on markedness

- Inkelas and Cho (S5.3.2) note that some of their analyses require prespecification—or early insertion—of unmarked features, which is inconsistent with the tenets of *radical underspecification* (Kiparsky 1982 et. seq.).

- This is not a problem for LP: it is substance-free and it has no formal notion of markedness.

4.4 Quiescence and catalysis

Inkelas and Cho (55, fn. 26) claim that underspecification cannot handle cases in which "exceptionality takes the form of failure to trigger, rather than failure to undergo, a rule"; they write that cases "remain a problem for us until they can be resolved in a representational fashion".

- LP can handle such cases with ease:

  - Prespecification makes triggers *catalytic*.
  - Underspecification makes "exceptional" non-triggers *quiescent*.

- This is not a novel intuition but it follows directly from the principles of LP.

4.4.1 Barrow Inupiaq

- Barrow Inupiaq has three surface vowels: [i, a, u]. As discussed by Archangeli and Pulleyblank (1994:§2.2.2), Buckley (1994), and Dresher (2009:§7.2.1), among others:

  - "strong" *i*'s are catalytic and trigger palatalization of a following coronal,
  - but "weak" *i*'s (< Eskimo-Aleut **ə*) are quiescent and do not.

(82) Palatalization (Kaplan 1981:§3.22):

a.	iki	'wound'	iki-**ʎ**u	'and a wound'	iki-**ɲ**ik	'wounds'
b.	ini	'place'	ini-**l**u	'and a place'	ini-**n**ik	'places'

- We propose that weak *i* as in *in**i*** is underspecified relative to strong *i* as in *ik**i***, and derive palatalization via a two-step subtraction-and-unification process.

(83)

	strong *i*	weak *i*	a	u
High	+	+	−	+
Back	−		+	+

(84)

	plain coronals	palatal coronals
Anterior	+	−
Coronal	+	+

(85) $\left[+\textsc{Coronal}\right] \setminus \left\{+\textsc{Anterior}\right\}$ / $\begin{bmatrix}+\textsc{High} \\ -\textsc{Back}\end{bmatrix}$ —

(86) $\left[+\textsc{Coronal}\right] \sqcup \left\{-\textsc{Anterior}\right\}$

(87) $\left[+\textsc{High}\right] \sqcup \left\{-\textsc{Back}\right\}$

(88) Critical ordering: (85) ≪ (86–87)

4.4.2 Czech

- Anderson and Browne (1973, henceforth A&B) give an analysis of Czech palatalization which is very similar to our analysis of Barrow Inupiaq.
- The surface front vowels in the "literary" register of Czech are [i, iː, ɛ, ɛː].[5] However, specific instances of these may or may not trigger palatalization of the preceding consonant.

(89) Partial paradigm for *sestřin* 'sister's' (A&B:453):

a.	sestřini	[sɛstr̝i**ɲ**i]	masc.anim. nom.pl.
b.	sestřiny	[sɛstr̝i**n**i]	fem. nom.pl.
c.	sestřinych	[sɛstr̝i**n**ix]	gen.pl.

- Here the "strong" (palatalizing) front vowels are written *i*, *í*, and *ě*, and "weak" front vowels are written *y*, *ý*, *e*, and *é*; the latter are the reflexes of central vowels in Old Czech.
- A&B propose that weak *y* and *ý* are underlyingly /ɨ(ː)/ and strong *i* and *í* are /i(ː)/. We instead propose that weak front vowels are simplify underspecified with respect to the front vowels and the feature Back.

4.5 Taxonomy

- The following summarizes possible interactions between under-/prespecified segments.
  - Let the phonemic inventory be /x, y, X, Y/.
  - Suppose that /x/ is prespecified +x and /X/ is underspecified with respect to /x/ and this feature but otherwise identical, so that $x \setminus X = \{+\textsc{x}\}$.
  - Similarly, suppose that /y/ is prespecified +y and /Y/ is underspecified with respect to /y/ and this feature but otherwise identical, so that $y \setminus Y = \{+\textsc{y}\}$.
  - Then consider a rule which targets +x when followed by trigger +y.

[5]We have taken the liberty of adapting A&B's semi-orthographic transcriptions into IPA.

(90) Interaction taxonomy:

a.	x / __ Y:	inalterability	×	quiescence	⇝	no effect
b.	x / __ y:	inalterability	×	catalysis	⇝	no effect
c.	X / __ Y:	mutability	×	quiescence	⇝	no effect
d.	X / __ y:	mutability	×	catalysis	⇝	potential effect

- We'll see examples of (90d) in the next section.

4.6 Interactions between mutability and catalysis

Our taxonomy predicts that for a unification rule to apply, the target must be mutable and the trigger (if there is one) catalytic meaning that either target or triggers can prevent non-vacuous application (cf. Kisseberth 1970 on lexical exceptionality).

4.6.1 Blackfoot

- Frantz (2017: ch. 6) describes a breaking process in Blackfoot:

> The *s* following the future prefix in [*kit-áak-**s**-ipii* 'you will enter'] requires some discussion. The initial vowel of stem *ipii* 'enter,' unlike the initial vowel of *itsiniki* 'tell a story,' always causes a preceding *k* to be replaced by the affricate *ks*. We will speak of this phenomenon as breaking of *k*, and of the *i* which is involved as a breaking *i*. For any morpheme which begins with *i* we need to know whether that i is a breaking *i* or not; if it is a breaking *i*, then if it immediately follows a morpheme ending in *k* we know that the *k* will be replaced by *ks*. (82–83)

- Frantz's informal analysis of "breaking", catalytic *i* and non-breaking, quiescent *i* is quite similar to the situation in Barrow Inupiaq and Czech.[6]

(91) Quiescent /I/ ⊆ catalytic /i/:

	/i/	/I/
Syllabic	+	+
High	+	

- He also proposes, similarly, that there is a "rule that indicates that the difference between these two vowels is neutralized at the level of pronunciation" (89–90).

- But there is one wrinkle: the second person prefix *k*- is "always impervious to breaking" (93). Breaking also seems to require a distinction between inalterable and mutable targets.

[6] Note that Frantz uses capital *I* to denote the catalytic breaking *i*, whereas we use that symbol for the underspecified, quiescent vowel. He does not distinguish the two *k*'s; presumably he takes the 2nd person prefix, which is impervious to breaking, to be a lexical exception.

(92) Mutable /K/ ⊆ inalterable /k/:

	/k/	/$\widehat{\text{ks}}$/	/K/
Velar	+	+	−
DelRel	−	+	

(93) $\left[\text{Ⓚ}\right] \sqcup \left\{+\text{DelRel}\right\}$ / ___ $\left[\text{ⓘ}\right]$

(94) $\left[\text{Ⓚ}\right] \sqcup \left\{-\text{DelRel}\right\}$

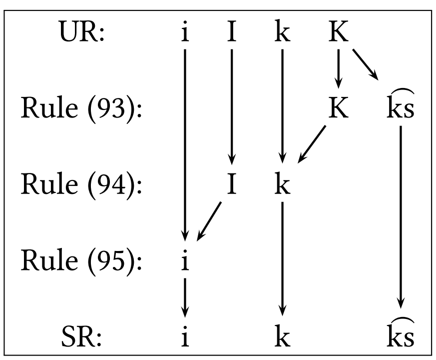
(95) $\left[\text{Ⓘ}\right] \sqcup \left\{+\text{High}\right\}$

(96) Critical ordering: (93) ≪ (94–95)

(97) Blackfoot derivations:

UR	ki	kI	Ki	KI
Rule (93):			$\widehat{\text{ks}}$i	
Rule (94):			kI	
Rule (95):		ki		ki
SR	ki	ki	$\widehat{\text{ks}}$i	ki

(98) Blackfoot segment mapping diagram:



- We can derive the Blackfoot pattern with just three unification rules.

4.6.2 English

- The *SPE* (*passim*) analysis of English velar softening (e.g., *electri*[k]/*electri*[s]*ity*) could easily be made parallel to our analysis of Blackfoot using:
  - underspecified targets contrasting with prespecified inalterable segments, in place of *SPE*'s ±Latinate lexical diacritic, and
  - prespecified triggers contrasting with underspecified quiescent segments, in place of *SPE*'s absolutely-neutralized contrast between /ǣ/ and the non-low front vowels.

4.7 Other patterns

We can generate even more patterns by applying subtraction rules.

4.7.1 More Hungarian

- There are roughly 60 Hungarian noun stems which are apparent exceptions to harmony in that they have a front vowel but select back-harmonic suffix allomorphs.

(99) Neutral and antiharmonic stems (Siptár and Törkenczy 2000:§3.2.2):

	nom.sg.	dat.sg.	abl.sg.	
a.	víz	víz-n**e**k	víz-t**ő**l	'water'
	rét	rét-n**e**k	rét-t**ő**l	'meadow'
b.	híd	híd-n**a**k	híd-t**ó**l	'bridge'
	héj	héj-n**a**k	héj-t**ó**l	'crust'

- Siptár and Törkenczy (henceforth S&T) refer to the (99a) pattern as "neutral" and the (99b) pattern as "antiharmonic". Most antiharmonic stems are in *i* or *í* [iː]; a few are in *é* [eː].
- S&T treat the front-harmonic suffix allomorphs as defaults because multisyllabic stems containing a back vowel followed by a front vowel select back-harmonic suffix allomorphs, suggesting that the front stem vowels in (99a) are neutral with respect to harmony.

(100) Back-neutral stems (loc. cit.):

nom.sg.	dat.sg.	abl.sg.	
kávé	kávé-n**a**k	kávé-t**ó**l	'coffee'
papír	papír-n**a**k	papír-t**ó**l	'paper'

- While antiharmonic stems are usually understood as lexical exceptions to harmony, LP can reanalyze them phonologically.
- We assume that the neutral vowels are underspecified with respect to Back and antiharmonic vowels are prespecified +Back.

(101) Hungarian vowel specification (partial):

	neutral *i*	antiharmonic *i*	*u*	*ü* [y]
High	+	+	+	+
Low	–	–	–	–
Back		+	+	–
Round	–	–	+	+

- Then, the following rules, applying after harmony, generate the surface forms of the stems.

(102) $\left[-\textsc{Round}\right] \setminus \left\{+\textsc{Back}\right\}$

(103) $\left[\ \right] \sqcup \left\{-\textsc{Back}\right\}$

(104) Critical ordering: (102) ≪ (103)

- Rule (102) gives neutral and antiharmonic front vowels the same underspecified representation (applying vacuously to the latter), and (103) ensures that both surface as −Back.[7]

(105) Hungarian derivations (height features omitted):

	neutral *i*	antiharmonic *i*	*u*	*ü* [y]
UR	−Round	+Back, −Round	+Back, +Round	−Back, +Round
Rule (102):		−Round		
Rule (103):	−Back, −Round	−Back, −Round		
SR	−Back, −Round	−Back, −Round	+Back, +Round	−Back, +Round

4.7.2 More Turkish

- Clements and Sezer (1982:§3.1) given an analysis of disharmonic Turkish roots which is extremely similar to our analysis of Hungarian antiharmonic roots.

4.8 Limitations

There are still a few problems in morphophonology which are not yet amenable to analysis with LP and pre-/underspecification.

- LP currently lacks an adequate theory of reduplication, metathesis and the like.
- Consider German umlaut, incompletely summarized below:

(106) Some umlaut patterns:

a. noun plurals:
Nuss 'nut' — N**ü**sse [nʏsə] 'nuts' — (cf. B**u**sse 'buses')

b. diminutive nouns:
Haus 'house' — H**äu**schen [hɔʏ̯sçən] 'little house' — (cf. **Au**t**o**chen 'little car')

c. 2nd/3rd singular present indicative verbs:
ich fange 'I catch' — du f**ä**ngst [fɛːŋst] 'you catch' — (cf. du b**a**ngst 'you fear')

d. comparative/superlative adjectives:
groß 'big' — gr**ö**ßerer [gʁ**ø**ːsɐʁɐ] 'bigger' — (cf. bl**o**ßerer 'more bare')

[7] Without the −Round condition in (102), these rule sequence would erroneously front the back round vowels *u*, *ú* [uː], *o*, and *ó* [oː], and would also "front"—in the style of the grand old Duke of York—the already-front round vowels *ü* [y], *ű* [yː], *ö* [ø], and *ő* [øː].

  - It seems likely that pre- and underspecification could be used to specify which stems undergo umlaut and which do not (cf. Lieber 1987:100f.).
  - LP rules could also account for both umlauted and un-umlauted forms of the stem.
  - But it is not clear that LP can account for the the (apparently morphosyntactic) contexts in which trigger umlaut—if it is in fact a unitary phenomenon.

- So-called "morphomic" patterns (Aronoff 1994)—if they in fact exist (cf. Luís and Bermúdez-Otero 2016)—also involve suppletive stem allomorphy conditioned by both lexical and morphosyntactic conditions, but not necessarily by phonological triggers amenable to LP.

References

Anderson, Stephen R. 1982. The analysis of French shwa: or, how to get something for nothing. *Language* 58:534–573.

Anderson, Stephen R., and Wayles Browne. 1973. On keeping exchange rules in Czech. *Papers in Linguistics* 6:445–482.

Archangeli, Diana. 1988. *Underspecification in Yawelmani Phonology and Morphology*. Garland. Revised version of 1984 MIT dissertation.

Archangeli, Diana, and Douglas Pulleyblank. 1994. *Grounded Phonology*. MIT Press.

Aronoff, Mark. 1994. *Morphology By Itself*. MIT Press.

Bale, Alan, Maxime Papillon, and Charles Reiss. 2014. Targeting underspecified segments: a formal anaylsis of feature-changing and feature-filling rules. *Lingua* 148:240–253.

Bale, Alan, and Charles Reiss. 2018. *Phonology: A Formal Introduction*. MIT Press.

Bale, Alan, Charles Reiss, and David Ta-Chun Shen. 2020. Sets, rules and natural classes: { } vs. [ ]. *Loquens* 6:e06.

Benz, Johanna, and Veno Volenec. 2023. Two logical operations underlie all major types of segmental alternations. Paper presented at the 30th Manchester Phonology Meeting.

Blevins, Juliette. 2004. *Evolutionary Phonology*. Cambridge University Press.

Bonet, Eulàlia. 1995. Feature structure of Romance clitics. *Natural Language & Linguistic Theory* 13:607–647.

Buckley, Eugene. 1994. Prespecification of default features: the two /i/'s of Kashaya. In *NELS 24: Proceedings of Twenty-Fourth Annual Meeting of the North East Linguistic Society*, 17–30.

Chomsky, Noam. 1982. *Some Concepts and Consequences of the Theory of Government and Binding*. MIT Press.

Chomsky, Noam. 2000. *New Horizons in the Study of Language and Mind*. Cambridge University Press.

Chomsky, Noam, and Morris Halle. 1965. Some controversial questions in phonological theory. *Journal of Linguistics* 1:97–138.

Chomsky, Noam, and Morris Halle. 1968. *The Sound Pattern of English*. Harper & Row.

Clements, G. N., and Engin Sezer. 1982. Vowel and consonant disharmony in Turkish. In *The Structural of Phonological Representations*, ed. Harry van der Hulst and Norval Smith, 213–254. Foris.

Dabbous, Rim, Marjorie Leduc, Fatemeh Mousavi, Charles Reiss, and David Ta-Chun Shen. 2021. Satisfying long-distance relationships (without tiers): A strictly anti-local approach to phonology. Ms. URL: `https://ling.auf.net/lingbuzz/006329`.

Dresher, B. Elan. 2009. *The Contrastive Hierarchy in Phonology*. Cambridge University Press.

Embick, David. 2010. *Localism versus Globalism in Morphology and Phonology*. MIT Press.

Embick, David. 2012. Contextual conditions on stem alternations. In *Romance Languages and Linguistic Theory 2010: Selected Papers from Going Romance Leiden 2010*, ed. Irene Franco, Sara Lusini, and Andrés Saab, 21–40. John Benjamins.

Flemming, Edward. 2009. The phonetics of schwa vowels. In *Phonological weakness in English: From Old to Present-Day English*, ed. Donka Minkova, 78–95. Palgrave Macmillan.

Fodor, Jerry. 1980. Reply to Putnam. In *Language and Learning: The Debate between Jean Piaget and Noam Chomsky*, ed. Massimo Piattelli-Palmarini, 325–334. Harvard University Press.

Frantz, Donald G. 2017. *Blackfoot Grammar*. University of Toronto Press, 3rd edition.

Gorman, Kyle, and Charles Reiss. 2024. Metaphony in Substance Free Logical Phonology. Ms. URL: `https://lingbuzz.net/lingbuzz/008634`.

Hale, Mark. 2003. Neogrammarian sound change. In *The Handbook of Historical Linguistics*, ed. Brian D. Joseph and Richard D. Janda, 343–368. Blackwell Publishing.

Harris, James W. 1969. *Spanish Phonology*. MIT Press.

Hayes, Bruce. 1986. Inalterability in CV phonology. *Language* 62:321–352.

Hualde, José Ignacio. 1991. *Basque Phonology*. Routledge.

Inkelas, Sharon. 1995. The consequences of optimization for underspecification. In *Proceedings of the North East Linguistic Society 25*, 287–302.

Inkelas, Sharon, and Young-Mee Yu Cho. 1993. Inalterability as prespecification. *Language* 69:529–574.

Inkelas, Sharon, and Cemil Orhan Orgun. 1995. Level ordering and economy in the lexical phonology of Turkish. *Language* 71:763–793.

Inkelas, Sharon, Orhan Orgun, and Cheryl Zoll. 1997. The implications of lexical exceptions for the nature of grammar. In *Derivations and Constraints in Phonology*, ed. Iggy Roca, 393–418. Oxford University Press.

Kaplan, Lawrence D. 1981. *Phonological Issues in North Alaskan Inupiaq*. Alaska Native Language Center.

Keating, Patricia A. 1988. Underspecification in phonetics. *Phonology* 5:275–292.

Kiparsky, Paul. 1982. Lexical morphology and phonology. In *Linguistics in the Morning Calm*, ed. Im-Seok Yang, 3–91. Hanshin.

Kiparsky, Paul. 1985. Some consequences of Lexical Phonology. *Phonology Yearbook* 2:85–138.

Kisseberth, Charles. W. 1970. The treatment of exceptions. *Papers in Linguistics* 2:44–58.

Lees, Robert B. 1961. *The Phonology of Modern Standard Turkish*. Indiana University Publications.

Lieber, Rochelle. 1987. *An Integrated Theory of Autosegmental Processes*. State University of New York Press.

Lightner, Theodore M. 1971. On Swadesh and Voegelin's 'A Problem in Phonological Alternation'. *International Journal of American Linguistics* 37:227–237.

Lombardi, Linda. 1995. Laryngeal features and privativity. *The Linguistic Review* 12:35–60.

Luís, Ana, and Ricardo Bermúdez-Otero, ed. 2016. *The Morphome Debate*. Oxford University Press.

McCawley, James D. 1974. Review of Chomsky & Halle (1968), *The Sound Pattern of English*. *International Journal of American Linguistics* 40:50–88.

Nevins, Andres. 2010. *Locality in Vowel Harmony*. MIT Press.

Ohala, John J. 2003. Phonetics and historical phonology. In *The Handbook of Historical Linguistics*, ed. Brian D. Joseph and Richard D. Janda, 669–686. Blackwell Publishing.

van Oostendorp, Marc. 2003. Schwa in phonological theory. In *The Second Glot International State-of-the-Article Book: The Latest in Linguistics*, ed. Lisa Cheng and Rint Sybesma, 431–362. De Gruyter Mouton.

Poser, William. 1982. Phonological representation and action at-a-distance. In *The Structural of Phonological Representations*, ed. Harry van der Hulst and Norval Smith, 121–58. Foris.

Reiss, Charles. 2003. Deriving the feature-filling/feature-changing contrast: An application to Hungarian vowel harmony. *Linguistic Inquiry* 34:199–224.

Reiss, Charles. 2021. Towards a complete Logical Phonology model of intrasegmental changes. *Glossa* 6:107.

Reiss, Charles. 2025. Delete the rich: On the non-existence of 'weak' schwa deletion. Ms., Concordia University.

Reiss, Charles, and Veno Volenec. 2022. Conquer primal fear: Phonological features are innate and substance free. *Canadian Journal of Linguistics* 67:581–610.

Scholten, Lydia. 1987. The interaction of syllabification and underspecification in Dutch. *Toronto Working Papers in Linguistics* 7:53–82.

Silverman, Daniel. 2011. Schwa. In *Blackwell Companion to Phonology*, ed. Marc van Oostendorp, Colin J. Ewen, Beth Hume, and Keren Rice, chapter 26. Wiley-Blackwell.

Siptár, Péter, and Miklós Törkenczy. 2000. *The Phonology of Hungarian*. Oxford University Press.

Steriade, Donca. 1995. Underspecification and markedness. In *The Handbook of Phonology*, ed. John Goldsmith, 114–174. Blackwell.

Volenec, Veno, and Charles Reiss. 2018. Cognitive phonetics: the transduction of distinctive features at the phonology-phonetics interface. *Biolinguistics* 11:251–294.

Volenec, Veno, and Charles Reiss. 2019. The intervocalic palatal glide in cognitive phonetics. In *Proceedings of the Forty-Ninth Meeting of the North East Linguistics Society*, 255–264.

Volenec, Veno, and Charles Reiss. 2025. Cognitive phonetics: the universal phonology-phonetics interface. In *Cambridge Handbook of Linguistic Interfaces*, ed. Antonio Fábregas, Laia Mayol, and Yanina Prystauka, to appear. Cambridge University Press.