Segmental phonology, gestural phonetics: Explaining asymmetries between phonetic and phonological operations*

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1 Introduction

Phonological alternations are not always phonotactically general — in order to determine where and when a given alternation occurs, we must make reference to specific morphological domains, lexical items, or classes of roots. In previous work, a common strategy has been to give some lexical items a diacritic feature, which plucks out these items and forces a morphophonological alternation to manifest (e.g. Chomsky and Halle 1968: 138, Lieber 1980: 64). In Optimality Theory, this idea has been applied to constraints, where constraints may be indexed (e.g. Pater 2000) or re-ranked (e.g. Inkelas et al. 1996) according to morphological structure. The core similarity among these theories is that phonology is **uniform**: there is no substantive difference between phonotactically general and morphologically restricted alternations; the only difference is when they apply.

In this paper, I argue that this assumption of phonological uniformity is incorrect. When we examine morphologically restricted and language general phonology side by side, there are typological gaps. Based on a novel typological survey, I observe that there are three patterns absent from the typology:

(1) In phonological patterns that are fully general, with no exceptions or morphological conditioning...

a. No language copies a single consonant across an intervening vowel. (**Consonant Copying Gap**)

b. No language epenthesizes a voiceless obstruent in intervocalic positions. ([t]**-Epenthesis Gap**)

c. No language metathesizes segments — all cases of metathesis can be analyzed in terms of gestural overlap/coalescence. (**Segmental Metathesis Gap**)

While these generalizations are not all new, this is the first time that they have been tested extensively and presented in a unified fashion. Morphophonology and general phonology differ in the character of their alternations, both in terms of locality and segmental quality. The fact that these typologies are distinct suggests that morphophonology and general phonotactics must consistently use different mechanisms, and by extension, different grammars.

The paper is structured as follows: Section 2 provides three patterns that never surface as general phonology, forming typological gaps. Section 3 then describes two ways of handling this asymmetry, as rule restriction or representation restriction. Section 4 argues in favor of the representational approach, and demonstrates that if we adopt gestures as the relevant unit, then a new generalization can be stated: general phonology never completely rewrites gestural content or gestural order.

2 Three Arguments against Uniform Phonology

2.0.1 *Survey details.* A typological survey was conducted over a private collection of 2562 digitized grammars (1348 languages; 59 language families, 122 isolates or otherwise uncategorized). To assess the different typological gaps, the grammars were initially filtered for those containing the words “epenthesis”, “metathesis”, and “reduplication”, and then inspected for their relevant epenthesis and metathesis

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patterns. The reason why reduplication was also searched is because consonant copy epenthesis is expected to look quite similar to partial reduplication, and so a language with true consonant copy epenthesis could be described as one having several reduplicative prefixes and suffixes.

Each pattern was then analyzed with particular eye to whether a fully general analysis was possible, here defined as having a conditioning environment that can be stated in purely phonotactic terms (including morpheme boundaries, but not further details of morphological identity). In cases where no such analysis was possible, such as in patterns with overt exceptions, the pattern was labeled as morphologically restricted. Patterns that occurred only with only one or two morphemes were classified as having too little data to categorize, and were grouped with morphologically restricted cases.[1] Details on the raw data in the survey, as well as the languages selected, can be found in Mooney (2023).

2.1 *Consonant copy epenthesis.* Copy epenthesis refers to a pattern where an epenthetic segment inherits its quality from a non-adjacent segment. To illustrate, (2) presents a hypothetical case of consonant copy epenthesis, where a preceding consonant copies to prevent vowel hiatus across a morpheme boundary.

(2) Hypothetical pattern of consonant copy epenthesis (unattested!)

		bare	/-i/	/-en/	/-to/
a.	/patapka/	[patapka]	[patapka-ki]	[patapka-ken]	[patapka-to]
	/kotti/	[kotti]	[kotti-ti]	[kotti-ten]	[kotti-to]
	/silo/	[silo]	[silo-li]	[silo-len]	[silo-to]
b.	/tapat/	[tapat]	[tapat-i]	[tapat-en]	[tapat-to]
			*[tapat-ti]	*[tapat-ten]	

No cases of consonant copy epenthesis were found in the survey. I call this the Consonant Copying Gap, shown in (3), which was first observed in Kawahara (2007):

(3) **Consonant Copying Gap**: No language copies a single consonant across an intervening vowel as a phonotactically general, exceptionless consonant epenthesis strategy. (Kawahara 2007: 8)

The Consonant Copying Gap has no known counterexamples, but has been controversial due to the overgeneration problem it poses. In particular, *vowel* copy epenthesis patterns are widely attested in general phonotactics, as illustrated in (4) for Kolami (Dravidian; Emeneau 1955; Kawahara 2007).

(4) Kolami: Vowel copies to avoid coda clusters (Emeneau 1955: 18-19, via Kawahara 2007: 24)

a.	/ajk/	aja̲k-t	'sweep-PST'	cf. ajk-atun	'sweep-PRS'
b.	/erk/	ere̲k-t	'lit (fire)'	erk-ur	'light.fire-IMP'
c.	/sivk/	sivi̲k-tin	'became rotten'		
d.	/te dp/	te de̲p	'cloth'	te dp-ul	'cloth-PL'
e.	/tupk/	tupu̲k	'gun'	tupk-ul	'gun-PL'

Vowel copy epenthesis is typically analyzed with either autosegmental spreading (Steriade, 1990; Kawahara, 2007) or surface correspondence (Kitto and de Lacy, 1999; Stanton and Zukoff, 2018) in order to enforce identity between the stem vowel and epenthetic vowel. While both can account for vowel copy epenthesis, the surface correspondence theories overgenerate when it comes to the Consonant Copying Gap, because both vowels and consonants should be free to correspond on the surface. Earlier work has therefore contested whether or not this gap reflects a genuine restriction, or is merely incidental (Stanton and Zukoff 2018: 676).

The typological survey conducted here suggests that the Consonant Copying Gap is real. Non-local consonant copying only occurred in morphologically-restricted patterns. To illustrate, one such

[1] The motivation for this threshold was based on a more general consonant epenthesis survey that was being completed concurrently, where one core case study of a general pattern had a language with only three suffixes. Three morphemes was therefore the largest threshold that could be used while also maintaining consistency with that baseline.

case comes from Afar (Cushitic; Bliese 1981), where in certain plurals shown in (5), Afar copies the last consonant of the stem, preventing vowel hiatus across the morpheme boundary. No copying occurs in stems that are consonant-final in (6), suggesting that this pattern may be driven by pure phonotactics.[2]

(5) Afar: Consonant copy epenthesis occurs in the /-a/ plural (Bliese 1981: 177)

	singular	plural	gloss
a.	[aˈmo]	[amoo-ˈma]	'heads'
b.	[giˈle]	[gilee-ˈla]	'knives'
c.	[anˈgu]	[anguu-ˈga]	'breasts'
d.	[diˈji]	[dijii-ˈja]	'charcoal'
e.	[boosˈta]	[boostaa-ˈti]	'letters'

(6) Afar: No copy epenthesis in consonant-final words (Bliese, 1981)

	singular	plural	gloss
a.	[macoˈlim]	[macoliiˈm-a]	'teachers'
b.	[raˈkub]	[rakuuˈb-ˈa]	'camels'
c.	[banˈdug]	[banduuˈg-a]	'rifles'
d.	[xuˈtuk]	[xutuuˈk-a]	'stars'

The Afar pattern bears morphological restrictions, and so the Consonant Copying Gap holds. In similar contexts, vowel deletion occurs to avoid vowel hiatus at morpheme boundaries:

(7) Afar: Vowel deletion (not copying) occurs elsewhere (Bliese 1981: 177-178, 211, 263)

	UR	word	gloss
a.	/awka-i/	[awˈk-i]	'boy-NOM'
b.	/saaku-ih/	[saaˈk-ih]	'day-GEN'
c.	/ma-esser-inn-oto/	[m-esser-inˈn-o]	'NEG-ask-PERF-1PL'
d.	/bagu-itte/	[ˈbag-itte]	'abdomen-PL'
e.	/alsa-itte/	[ˈals-itte]	'moon-PL'

In OT, the Afar pattern could be initially analyzed as splitting of an input consonant (violating INTEGRITY) or as a kind of epenthesis that requires identity between the inserted segment and a consonant in the root (HE-IDENT). Both of these analyses present an overgeneration issue, because in their simplest instantiation, they would cast Afar epenthesis as a fully general pattern. Wherever hiatus occurs, consonant copying should apply. To reflect the morphological restrictions on Afar consonant epenthesis, we could: restrict the ranking to a particular Cophonology (8a.), use constraint indexation (8b.), or reanalyze the /-a/ plural as an infix (8c.), whose requirements may be met by consonant splitting.

(8)

a. **Cophonology Approach:** Splitting, but only in /-a/$_{PL}$ cophonology. (In later cophonologies: *V-V, INTEG. ≫ MAX, producing deletion.)

/am$_1$o-a/	*V-V	MAX	IDENT-IO	INTEGRITY
a. amo-a	*!			
b. am$_1$o-w$_1$a			*!	*
☞ c. am$_1$o-m$_1$a				*
d. am-a		*!		

b. **Indexed Constraint Approach:** MAX$_{/-a/.pl}$ is ranked high

/amo-a/	*V-V	MAX$_{/-A/.PL}$	DEP	HE-IDENT	MAX
a. amo-a	*!				
b. am$_1$o-w$_1$a			*	*!	
☞ c. am$_1$o-m$_1$a			*		
d. am$_1$-a		*!			*

c. **Infixation Approach:** The plural has a requirement to align with the rightmost stem consonant

/am$_1$o-a/	ALIGN(PL,RIGHT-C)	CONTIG	MAX	INTEG
a. amo-a	*!			
b. am<a>o		*!		
☞ c. am$_1$o-m$_1$a				*
d. am$_1$-a			*!	

[2] Note that this pattern is ambiguous between being (morphologically-restricted) copy epenthesis and partial reduplication. For our purposes here, I do not distinguish between these two analyses, since there are no clear diagnostics that separate the two.

While these analyses correctly describe the Afar pattern, they do not resolve the overgeneration issue for the Consonant Copying Gap. For instance, in the Cophonology approach, if the same ranking held at the final cophonology, we would expect consonant copying to arise as a default, fully general strategy. The INTEGRITY/HE-IDENT analyses also allow fully general copying to be generated whenever there is no higher-ranked lexically indexed constraint. Removing these predictions will require adopting top-down restrictions on the grammar or changing the basic representational unit, to be discussed in Section 3. For the time being, the question is why vowel copying is widely attested, whereas consonant copying never generalizes fully.

2.2 *Epenthesis of* [t] *between vowels.* Consonant epenthesis also displays an asymmetry between patterns that are general and those that are morphologically restricted. In the most general cases of epenthesis, epenthetic consonants tend to be sonorants — glides, liquids, laryngeals, and possibly nasals (Lombardi, 2002; Blevins, 2008; Uffmann, 2007; de Lacy, 2006). Voiceless obstruents, by comparison, occur rarely, and when they do, they always occur adjacent to a voiceless consonant or a word edge (Mooney, 2024). We can state the [t]-Epenthesis Gap:

(9) **[t]-Epenthesis Gap.** No language has intervocalic epenthesis of a voiceless obstruent as its general, exceptionless consonant epenthesis strategy.

No counterexamples to the [t]-Epenthesis Gap were found in the typological survey. Apparent counterexamples include Axininca Campa (Payne, 1981; McCarthy and Prince, 1993), which has been previously argued to have intervocalic epenthesis of [t]. However, following Morley (2015) and Staroverov (2014), I find that this pattern has morphological exceptions. For instance, [t]/∅ alternations are found between the stem and verbal affixes in examples like /i-ŋ-koma-i/ → [i-ŋ-koma-t̲i] vs. /i-ɲ-cʰik-i/ → [i-ɲ-cʰik-i] 'he will paddle/cut' (Payne 1981: 108). But, exceptions to this pattern are found in other morphological contexts. For instance, the 'in addition' suffix /-icʰi/ triggers vowel deletion, not epenthesis (e.g. /i-pina-ic̲ʰi-takawo/ → [i-pina-c̲ʰi-takawo] 'he has paid her, in add.', *[i-pina-t̲icʰi-takawo], Payne 1981: 45). Axininca Campa is therefore not a general pattern, and so is not a counterexample to the gap.

Notably, all other attested cases of intervocalic [t] epenthesis — or any other voiceless obstruent — bear similar restrictions. For instance, intervocalic [t] epenthesis has also been reported in Amharic (Broselow, 1984), Arapaho (Moss and Cowell, 2008), Blackfoot (Taylor, 1969), Odawa (Piggott, 1980; Lombardi, 2002) and Plains Cree (Wolfart, 1973), but these cases all bear morphological restrictions. Similar restrictions are also found for languages that epenthesize other obstruents; further details can be found in Mooney (2024).

By contrast, epenthetic consonants in general patterns tend to be laryngeals, glides, and liquids, often assimilating to the quality of surrounding vowels (Uffmann, 2007; Staroverov, 2014). Rarely, epenthetic obstruents arise, but these invariably inherit voicing from surrounding sounds: They are voiceless next to voiceless consonants, and voiced in intervocalic positions (Mooney, 2024). Mato (Austronesian; Stober 2013) has one such pattern, where [k] is epenthesized after voiceless consonants, and [g] after nasals:

(10) Mato: Epenthesis of [k, g] after consonant-final stems (Stober 2013: 21)

a.	/dV-xɑp-aŋ/	dɑ.xɑp.-k̲aŋ	'they got you (pl)'
b.	/∅-xɑŋ baxup=uba/	ˈɣɑŋ ˌba.ɣup.-ˈk̲u.ba	'he is going to eat a banana now'
c.	/dV-haiŋ=uju/	dɑ.haiŋ.-ˈg̲u.ju	'they are still ascending'
d.	/u-rɑxɑp-uti/	u.rɑ.ˈɣɑp.-k̲u.ti	'you (sg) shorten it'
e.	/lipux siɑŋ-ɑm/	li.ˈpu ˌsi.ɑŋ.-ˈg̲ɑm	'money person (businessman)'

(11) Mato: No epenthesis after vowel-final stems (Stober 2013: 20)

a.	/dV-tɑhɑ-ɑŋ/	dɑ.tɑ.ˈhɑŋ	'they hit you all'
b.	/dV-hɑli=uba/	dɑ.-ˌhɑ.li.ˈu.ba	'they are going to play now'
c.	/∅-haxa=uju/	ha.ˈɣau.ju	'he is still walking'
	/dV-hɑli=uju/	dɑ.ˌhɑ.li.ˈu.ju	'they are still playing'
d.	/dV-gaxu-uti/	dɑ.gɑ.ˈɣu.ti	'they chewed it'
e.	/lipux kɑbɑli-ɑm/	li.ˈpu ˌkɑ.bɑ.li.ˈɑm	'bush person'

Other languages with voiceless epenthetic stops also only allow them next to other voiceless consonants, such as in English intrusive stops (e.g. *some*[p] *thing*, *pronun*[t] *ciation*; Gick 1999).

In sum, consonant epenthesis is an area where general and morphologically-conditioned patterns diverge. While morphologically-restricted patterns may epenthesize a variety of segments, general patterns of consonant epenthesis tend to assimilate with existing sounds. The question remains why morphologically-restricted patterns — absent of this assimilatory pressure — never generalize further.

2.3 *Metathesis of segments.* Metathesis (the transposition of two segments) is a cross-linguistically rare pattern, which tends to arise with morphological restrictions (Mooney, 2023). When we examine the few general cases of metathesis that exist, however, we find that they may not be transposition at all, but rather a kind of coalescence. I call this the Segmental Metathesis Gap, which states that true transposition of segments is only attested in morphologically-restricted patterns:

(12) **Segmental Metathesis Gap**: No language transposes segments in a fully general pattern.

There are several properties that distinguish coalescence from true segmental transposition. In segmental transposition, the basic order has changed, and so we would expect for other phonology to behave as if the segments are in a new order. For instance, metathesis of segments should be able to change syllabification. If we transpose /CVCVC/ → CVCCV, we would transform a word with light-heavy (CV.CVC) syllable structure to one that is heavy-light (CVC.CV). We would also expect the resulting CVCCV word to behave as if it is vowel-final for the purposes of other phonology. Interactions like this are attested, but they only occur in morphologically restricted patterns.

In this section, I demonstrate how morphologically-restricted metathesis patterns may interact with weight-sensitive stress (Section 2.3.1) and allomorph selection (Section 2.3.2). These provide evidence that metathesis is in some sense complete, because other phonology behaves as if the segments have reordered. General patterns of metathesis lack these interactions, and so allow for other analyses that do not reorder segments.

2.3.1 *Interactions with weight-sensitive stress.* Syllable weight is another area where segmental metathesis is expected to have an effect. For example, Sierra Miwok has templatic verbal morphology that could be analyzed as a kind of metathesis. The primary stem has an unpredictable order, shown in (13), but the second, third, and fourth stems all have a fully predictable CV order.

(13) Four verbal stem types in Sierra Miwok (Freeland 1951: 94-95)

	Primary stem	Second stem	Third stem	Fourth stem
	variable	CVCVC:	CVC:VC	CVCCV
a. ‘to roll’	huˈt̪eːl	huˈt̪elː	ˈhut̪ːel	ˈhut̪le
‘to fall’	poˈlaːŋ	poˈlaŋː	ˈpolːaŋ	ˈpolŋa
‘to wrap’	t̪oˈpoːn	t̪oˈponː	ˈt̪opːon	ˈt̪opno
b. ‘to seek’	ˈwelšɨ	weˈlišː	ˈwelːiš	ˈwelši
‘to quit’	ˈčelku	čeˈlukː	ˈcelːuk	ˈčelku
‘to suck’	ˈkojpa	koˈjapː	ˈkojːap	ˈkojpa
‘to poison’	ˈt̪ujku	t̪uˈjukː	ˈt̪ujːuk	ˈt̪ujku

When we look to Sierra Miwok's stress system, we find that it is weight-sensitive. Stress always appears on the leftmost heavy syllable, shown in (14).

(14) Miwok stress is on the leftmost heavy syllable (Freeland 1951: 7)

a. *Initial heavy syllables are always stressed*
ˈpat̪.ka.jɨʔ
ˈčaː.ma.jɨʔ
ˈwit.ta.pɨʔ

b. *Leftmost heavy is stressed when HH...*
ˈjaː.jaː.liʔ
ˈčim.t̪e̯j̆.yaʔ
ˈhɨj.ʔɨk.sɨː

c. *Leftmost heavy is stressed when LH...*
ka.ˈwaː.čiʔ
wa.ˈtak.saʔ

The question is whether the segmental ordering changes in the verbal template can feed stress assignment. For instance, the second stem is CVCVC:, and so would be expected to have light-heavy syllable structure with stress on the final syllable. The fourth stem is CVCCV, and so should be heavy-light, with initial stress. As expected, stress lands on the leftmost heavy syllable regardless of the UR:

(15) Miwok verbs are not exceptions to leftmost heavy stress

UR	2nd stem	4th stem	gloss
/ˈčelku/	[če.ˈluk**:**]	[ˈčel.ku]	'to quit'
/huṯel/	[hu.ˈṯel**:**]	[ˈhuṯ.le]	'to roll'
if metathesis did not feed:		*[hu.ˈṯle]	

In more general patterns, syllable weight is not affected by metathesis. One example comes from Sevillian Spanish (Gilbert, 2022), in which coda /s/ can be debuccalized to [h] and optionally metathesized rightwards:

(16) Sevillian Spanish: /sC/ → Ch (Gilbert, 2022)

	Debuccalization	Metathesis	
a. /tʃispa/	[tʃihpa]	∼ [tʃipha]	'spark'
b. /pasta/	[patha]	∼ [pahta]	'pasta'
c. /boske/	[bokhe]	∼ [bohke]	'forest'

Gilbert (2022) tests whether Spanish metathesis changes syllable structure by examining the interaction between metathesis and a stress assignment. Spanish stress is lexical, but stress can never appear on the penult if the antepenultimate syllable is heavy:

(17) **Spanish ĹHL restriction**: An antepenultimate syllable cannot be stressed if the penult is heavy. (Harris, 1983; Fuchs, 2018)

For instance, a nonce form like *[lu.ˈma.fan.to] would be ill-formed according to this generalization, because it is LĹHL.

Gilbert uses this generalization to test whether metathesized sequences are treated as light or heavy.[3] In a forced-choice task using nonce words, speakers were presented with two forms and asked which made a better word of Spanish. On one hand, speakers received a metathesized word with antepenultimate stress, like /lu.ˈma.fas.to/ → [lu.ˈma.fa.tho]. They were then asked to compare this to either a LĹLL word, , like [lu.ˈma.fa.to], or a LĹHL word with a sonorant coda, like [lu.ˈma.fan.to]. If metathesis did change syllable structure from heavy to light, the metathesized words should be judged equivalently to the well-formed LĹLL words, and better than the ill-formed LĹHL words. Conversely, if metathesis does not change syllable structure, then a metathesized word (from /lu.ma.fas.to/) should always behave as if it were LĹHL.

In the task, speakers uniformly treated metathesized sequences as if they were heavy. Metathesized words were dispreferred relative to LĹLL words, and judged equally to LĹHL words with a sonorant coda.

(18) Sevillian Spanish: Metathesized sequences are judged the same as heavy syllables (Gilbert, 2022)

a.	/lu.ˈma.fan.to/		/lu.ˈma.fas.to/
	[lu.ˈma.fan.to]	is judged the same as	[lu.ˈma.fa.tho]
	ĹHL on surface		ĹLL on surface
b.	/lu.ˈma.fa.to/		/lu.ˈma.fas.to/
	[lu.ˈma.fa.to]	is judged as better than	[lu.ˈma.fa.tho]
	ĹLL on surface		ĹLL on surface

Sevillian Spanish metathesis thus contrasts with Sierra Miwok verbal templates in its interactions with stress. In Spanish, only the order in the underlying representation matters for syllable weight; metathesis appears to have no effect. In Sierra Miwok, the order in the verbal template is exactly the same order used to determine syllable weight. The morphologically-restricted metathesis in Sierra Miwok requires segment reordering to derive this interaction, whereas general patterns do not.

[3] Note, Spanish only permits sonorant and /s/ codas. A metathesized sequence in [tʃipha] should therefore only allow a light-light syllabification as [tʃi.pha] on the surface, as otherwise it would have an illicit stop coda (*[tʃip.ha]).

2.3.2 *Interactions with allomorph selection.* Here I present a case of morphologically-restricted metathesis from Chimariko that interacts with allomorph selection, supporting a segmental transposition analysis. Several suffixes in Chimariko have alternations in their consonant-vowel order. When the stem ends in a vowel, VC order is obtained, but when a stem ends in a consonant, we see CV order:

(19) Chimariko: Metathesis depends on preceding consonant/vowel in stem (Jany 2009: 41)

a. /qʰut/ 'in water'	qʰut / C#_	[ʔ-iwin-qʰut-ta]	'I dumped them in water'
	qtu / V#_	[j-eʔa-qtu-t]	'I get in the water'
b. /naʔči/ 'again'	naʔči / C#_	[h-uwu-m-naʔči-t]	'All went home'
	nʔači / V#_	[h-ama-nʔači-t]	'They all ate'

We can treat this alternation as a morphologically-conditioned metathesis rule or as phonologically-conditioned allomorphy. Both are compatible with the data, but for the purposes of the argument here, let's entertain the metathesis approach.

If segments have reordered, we expect for stems that end in forms like [-qʰut] to behave as if they are consonant-final, and stems that end in [-qtu] to behave as if vowel-final. We can test this with a different allomorph for an aspectual morpheme in (20), which occurs as /-ta/ after consonants, /-t/ after vowels.

(20) Aspectual morpheme has two allomorphs (Jany 2009: 40)

-ta / C#_	*-t* / V#_
[h-uwa-m-ta]	[h-iwo-t]
3-go-DIR-ASP	3-sit-ASP
'He went forth'	'He sat'

Chimariko metathesis is visible to allomorph selection, and so we get /-ta/ after [-qʰut], /-t/ after [-qtu].

(21) Chimariko metathesis is visible to aspectual allomorph selection

-ta / C#_	*-t* / V#_	
[ʔ-iwin-qʰut-ta]	[j-eʔa-qtu-t]	*-qtu-ta
1SG.A-dump-in.water-ASP	1SG.-get-in.water-ASP	
'I dumped them in water'	'I get in the water'	

While this may seem unremarkable, let us contrast this pattern with a case of general metathesis from Uab Meto (Austronesian). Uab Meto has a pattern of metathesis that coalesces a vowel onto the preceding syllable, so that it displaces past an intervening consonant, as in (22):

(22) Uab Meto: CV → VC metathesis

a. /ˈmanus/	ˈmanus	ˈmaʊ̯ns-es	'betel-INDEF'
b. /ʔa-ˈmepo-t/	ʔaˈmepot	ʔaˈmɐ̯opt-in	'worker-PL'
c. /ˈfafi/	ˈfafi	faɪ̯f-ˈʔanaʔ	'piglet (lit. pig-child)'
c. /ˈmepo/	ˈmepo	ˌmɐ̯op ˈleleʔ	'work the field'

The pattern is phonotactically general and is conditioned by prosody, reducing the number of syllables intervening between primary stress and the edge of the phrase (Mooney, 2022). For instance, a word like /ˈmanus-es/ → [ˈmaʊ̯ns-es] 'betel vine' transforms /*σ́σσ*/ → [*σ́σ*].

Unlike Chimariko, Uab Meto metathesis fails to feed allomorph selection. The plural suffix has several different allomorphs in Uab Meto, /-n/ after CV and /-in/ after consonants, shown in (23).

(23) Uab Meto: Plural allomorphy sensitive to final segmental order

-n / V#_			*-in* / C#_		
/tasi/	[tasi-n]	'sea-PL'	/tais/	[taɪ̯s-in]	'sarong-PL'
/ʔasu/	[ʔasu-n]	'dog-PL'	/manus/	[maʊ̯ns-in]	'betel-PL'

If Uab Meto were like Chimariko, we would expect for CVCV → CVVC words to behave as if they are consonant-final, selecting the allomorph /-in/. However, these words select the allomorph /-n/, consistent with their underlying form:

(24) Uab Meto metathesis is invisible to allomorphy
/ʔasu-n-e/ [ʔa͡us-n-e] 'dog-PL-DEF' *[ʔa͡us-in-e]

Chimariko metathesis feeds allomorph selection, but Uab Meto metathesis does not. While we could obtain this result from adopting a serial derivation, the basic fact is that the only evidence in favor of segmental transposition is found in morphologically-restricted patterns.

2.4 *Interim summary* To summarize, we can observe three asymmetries between morphologically-restricted and fully general phonological patterns.

- First, only restricted patterns can copy single consonants across an intervening vowel. General patterns can never copy non-local consonants (**Consonant Copying Gap**).
- Second, only restricted patterns can epenthesize voiceless obstruents between vowels. By contrast, general patterns can only epenthesize voiced consonants in the same position, as part of a larger tendency for these epenthetic sounds to assimilate with neighboring material ([t]**-Epenthesis Gap**).
- Third, only restricted patterns can metathesize two segments, as diagnosed by interactions with syllable weight, allomorphy, or interactions with other phonological rules. General patterns lack these interactions, and so could also be analyzed as a kind of coalescence that doesn't reorder segments (**Segmental Metathesis Gap**).

If these gaps are real, reflecting true cognitive limits on phonological generalizations, then it means that phonology must be non-uniform. Namely, the kinds of generalizations we make about general phonotactics are different from those we make about morphologically-restricted patterns. In a generative theory, this means that general phonotactics and morphophonology are characterized by different sets of transformations.

3 Types of Non-Uniform Architectures

In this section, I explore a two classes of non-uniform architectures that could explain these typological gaps: rule-restriction approaches and representational approaches. Then, in Section 4 I make an argument in favor of a representational approach that uses segments (for restricted patterns) and gestures (for general patterns). The desired explananda for our non-uniform model are in (25a.-d.).

(25) **Desired explananda** of our non-uniform theory
a. Consonant copying across a vowel only occurs in morphologically-restricted patterns (Consonant Copying Gap)
b. Epenthesis of intervocalic voiceless obstruents only occurs in morphologically-restricted patterns ([t]-Epenthesis Gap)
c. Metathesis can only affect stress assignment, allomorph selection, and other segmental phonology in morphologically-restricted patterns (Segmental Metathesis Gap)
d. Consonant epenthesis and metathesis both have a strong tendency to only occur with sonorants (cf. Uffmann 2007; Blevins and Garrett 1998)
e. Phonetically gradient patterns exist
f. Phonetically gradient patterns lack fine-grained morphological restrictions

Note that several influential theories also include phonetic gradience (25e.-f.) as some of their desired explananda (e.g. Lexical Phonology, Kiparsky 1985; phonetics/phonology interface, Cohn 1990, 2007; Zsiga 1997). Gradience has been found to emerge from a variety of sources, including frequency (Jurafsky et al., 2001; Bell et al., 2003) and neighborhood effects (Newman et al., 1997; Munson and Solomon, 2004), and so it may have limited value as a diagnostic. Gradience will therefore only be discussed as needed, but not as an adjudicating factor between models.

3.1 *Rule-Restriction Approaches* In order for phonology to be non-uniform, there must be substantive differences within phonological grammar, creating distinct modules. One way to enact this modular architecture is by imposing top-down restrictions on the grammar, so that modules differ in the kinds of transformations they allow.

Lexical Phonology (Kiparsky 1985, et seq.) is one example of a rule-restriction approach. Lexical Rules occur in a cyclic module that can only produce structure-preserving outputs. Post-Lexical rules, by contrast, are non-cyclic and may be non-structure preserving. The Lexical and Post-Lexical modules thus differ in their internal architecture and the fundamental types of rules they allow.

If we turn to the gaps explored in Section 2, a rule-restriction approach would need to impose some top-down restrictions on phonotacatically general rules. For example, in Lexical Phonology we could say that Post-Lexical rules cannot copy non-local consonants (Consonant Copying Gap), nor can they epenthesize [t] between vowels ([t]-Epenthesis Gap). In related theories like Cophonology Theory (Orgun, 1996; Inkelas et al., 1996), we would impose these same restrictions as limitations on the GEN of the final Cophonology, thus ensuring that these candidates are never winners, regardless of constraint ranking. The key problem with this approach is that it offers little insight into the typology. Each of these restrictions is statable, but there is no a priori reason to suspect that phonotactically general rules should bear these specific restrictions. We are thus left with a restatement of the gap but not an explanation.

Another observation from Section 2 was that some phonotactically general patterns have strong biases in favor of certain segment qualities. For instance, both consonant epenthesis and metathesis almost exclusively occur with sonorants and laryngeals. We could capture this sonorant bias as a restriction on rule forms. However, while restrictions on rule schemata are a necessary part of any rule-based grammar, it is again unclear why these particular rules should be subject to a restriction on segment quality. Explanations of this bias would likely turn to diachrony (Vaux, 2002), paradigm uniformity (Steriade, 2000), or perception (Steriade, 2001). Each of these explanations is promising, but it is worth observing that they are all external factors to the rule-restriction approach. That is, they do not follow from the architecture of the grammar, and therefore are possible explanations regardless of which theory we adopt. The sonorant bias thus remains unexplained within the bounds of a rule-restriction approach.

3.2 *Representational approaches* The second strategy is to have a representational split, where each module has a different representational unit in addition to different operations that manipulate them. Representational approaches of this type are common in work on the phonetics/phonology interface, where phonetics manipulates gestural representations and phonology manipulates segmental representations (Cohn, 1990; Zsiga, 1993; Hall, 2003). While segments are pointlike units composed of binary features, gestures are representations of articulatory movements that have both spatial and temporal content (Browman and Goldstein, 1992). By necessity, operations that transform segments must differ than those that transform gestures, due to their basic differences in form.

A representational split between segments and gestures thus also requires a split in the character of phonological operations. In the next section, I demonstrate that this will explain the typological gaps observed in Section 2. The basic idea is that some phonological patterns are modeled as manipulations of strings (or autosegmental structures), but other phonological patterns are modeled as manipulations of articulatory movements. Because articulatory movements are grounded in what can be produced by the motor system, this means that some types of patterns will never arise when the second module is in use.

4 Deriving Phonology-Phonetics Asymmetries with Gestures

Here, I have argued that phonology is non-uniform: the grammars that produce general phonotactic patterns and those with morphological restrictions are distinct. For ease of exposition, from here on I'll call the first of these phonetics, and the second phonology. However, I assume both to be language-specific knowledge that is controlled, abstract, and driven by grammar. There are alternative ways we could describe each of these modules — phonology and morphophonology, for instance — but the choice of naming convention will not affect the content of the proposal, so I proceed with phonetics/phonology.

I claim that phonology uses segments, but phonetics uses gestures (following Cohn, 1990; Zsiga, 1993; Hall, 2003). Segments are pointlike abstract units defined by contrastive phonological features, and can be manipulated by phonological rules that overwrite featural content. Phonetics, on the other hand, uses

gestures, which are abstractions of articulatory movements that have both spatial and temporal targets.

Following work in Articulatory Phonology, I also assume that phonetic grammar can manipulate the spatial or temporal extent of gestures, but that it cannot remove or insert them outright. I call this assumption *Gestural Preservation*:

(26) **GESTURAL PRESERVATION:** Phonetics cannot insert/remove gestures, it can only transform their spatial or temporal extent (Browman and Goldstein 1992: 173, Gick 1999)

There are two assumptions: (i) Non-Uniform Representation: there is a segmental/gestural split between phonology/phonetics, and (ii) Gestural Preservation: phonetics cannot insert or remove material entirely. I now proceed to demonstrate how these two assumptions derive the typological gaps seen in Section 2.

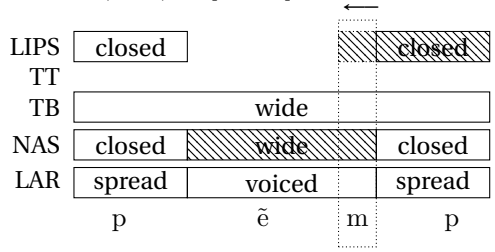
4.1 *Consonant Epenthesis* Consonant epenthesis displays two typological asymmetries: the Consonant Copying Gap and the [t]-Epenthesis Gap. Both are unattested in phonetic, fully general patterns.

Gestural Preservation forbids insertion of new gestures, and so a key prediction for epenthesis is that epenthetic sounds must be shaped from existing material in the input. For epenthetic consonants, this means that they can be shaped from existing consonants, as in (27a.), or from existing vowels, as in (27b.).

(27) Epenthetic consonants can arise from...

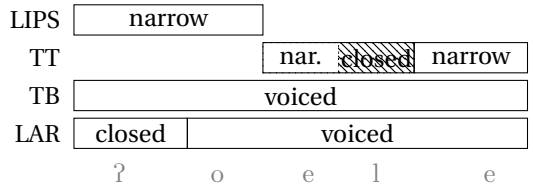
a. **Extending other consonants**

Example: /pẽp/ → [ˈpẽᵐp] 'warrior', Apinajé (de Oliveira 2005: 76-77)



b. **From constricting vowels**

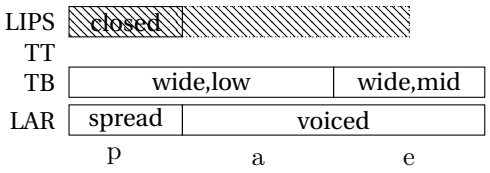
Example: /ʔoe-e/ → [ʔoe̲l-e] 'the water', Molo dialect of Uab Meto (Mooney, 2024)



Previous work has also proposed that epenthetic consonants can arise from existing sounds. In traditional accounts of the phonetics-phonology interface, consonant epenthesis has been analyzed as coarticulation (Millardet 1910: 48-51, Recasens 2017), where vowel-to-vowel transitions or consonant-consonant overlap lead to the percept of an epenthetic consonant. Staroverov (2014) argues that epenthetic consonants always come from vowel splitting, where a single vowel diphthongizes into a vowel-consonant sequence. Both of these precedents predict that intervocalic epenthetic consonants should be maximally vowel-like, a prediction shared with the proposal here.

4.1.1 *Consonant Copying Gap* In the case of the Consonant Copying Gap, we observed that consonants never copy across a vowel in phonetic patterns. This type of pattern cannot be generated by simple extension or constriction of a consonant gesture. For example, suppose in an input like /pa-e/ we wished to form an output like [pap̲-e]. If we were to extend the gesture, we would simply derive [pː-e], where the geminate consonant fully obscures the vowel.

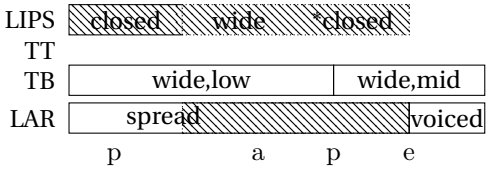
(28) *Hypothetical example:* /pa-e/ → [p:-e] (**not** [pap-e]!, cf. Kawahara 2007)



Deriving consonant copying in this case would require some kind of snapping operation, which splits the [p] closure into two distinct phases. As long as there is there is no snapping operation, such as a requirement for gestures to remain contiguous, we will correctly derive the Consonant Copying Gap.

As a brief aside, one could also imagine that another way to derive copying would be to simultaneously weaken and strengthen the consonant stricture. For instance, we could weaken the [p] to something like [ɸ], then narrow the constriction at the morpheme boundary back to a [p]. This is shown in (29).

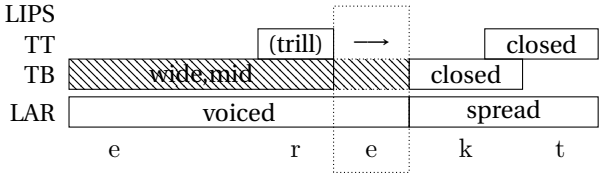
(29) Sequential weakening/strengthening derives copying, but requires multiple controlled constrictions
Hypothetical example: /pa-e/ → [p$^{\Phi}$å$^{\Phi}$p-e]



There is reason to think that this kind of simultaneous weakening and strengthening exceeds the limits of gestural representations. Speech sounds generally involve two phases of constriction, one that narrows, and another that widens (Steriade, 1993). In the few cases of speech sounds that involve multiple occlusions (like trills), it is often the aerodynamic pressure that causes the multiple constrictions, not distinct movements of the articulators. It therefore seems that articulatory movements can have at most one or two intervals of controlled constriction. A form as in (29) would require three intervals of constriction — closed-wide-closed — and therefore should be impossible as a single gesture.

Vowels, by contrast, do not face the same problem. Because vowels involve less stricture than consonants, they can be extended across the consonants in a single constriction phase. We then hear an epenthetic copy vowel (or intrusive vowel, Hall 2003), as illustrated in (30).

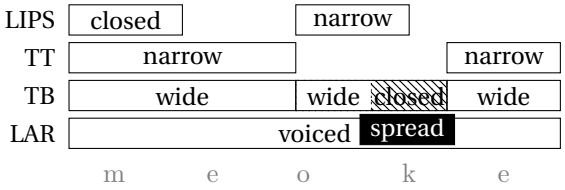
(30) Kolami: Gestural extension yields copy epenthesis
/erk-t/ → [ere̲k-t] 'lit.fire-PST'



The Consonant Copying gap is thus derived, provided that (i) phonetics obeys gestural preservation, and (ii) that individual gestures must be contiguous intervals with a single constriction phase.

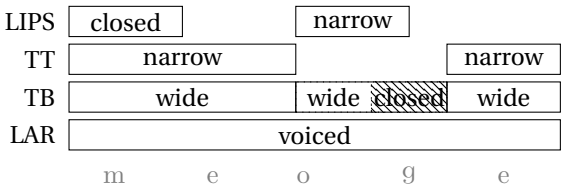
4.1.2 [t]*-Epenthesis Gap* The [t]-Epenthesis Gap can also be derived with Gestural Preservation. Recall, the [t]-Epenthesis Gap states that phonetics cannot epenthesize voiceless obstruents between vowels. Gestural preservation predicts that intervocalically, epenthetic consonants must be formed from vowels, since those are the only locally available gestures. Epenthetic consonants in these positions are expected to be as vowel-like as possible. Voiceless obstruents are unattested in this position because they require insertion of a spread glottis gesture, as shown in (31):

(31) [k] epenthesis requires insertion of spread glottis, violating Gestural Preservation
Hypothetical Example: /meo-e/ → *[meok-e]



By contrast, voiced obstruents would not require insertion of spread glottis, and so would not be ruled out by gestural preservation. Epenthesis of voiced obstruents like [g] is attested, as in (32):

(32) Epenthesis of [g] is permitted, because there is no gestural insertion (it obeys Gestural Preservation)
Uab Meto (Oekabiti Amarasi dialect): /meo-e/ → [meog-e] (Mooney, 2024)



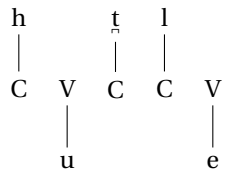
To summarize, the [t]-Epenthesis Gap is explained by Gestural Preservation, the assumption that phonetics cannot insert/remove new gestures outright. In intervocalic positions, the only source of material for epenthetic consonants are the vowels themselves, and so epenthetic consonants are expected to be as vowel-like as possible. Voiceless consonants, which differ in the basic laryngeal gestures present, cannot be produced without violating Gestural Preservation.

4.2 *Segmental Metathesis Gap* Segments can only be manipulated by phonology, and so the Segmental Metathesis Gap will closely follow from this representational split. Phonology, when it reorders, will reorder segments, which can affect both syllable weight and segment-conditioned allomorphy. Phonetics, on the other hand, will displace gestures by shifting their onsets/offsets, but will leave the segments untouched.

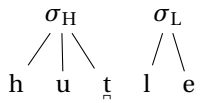
For example, Sierra Miwok verbal morphology involves an alternation between CVCVC forms and CVCCV forms (cf. Section 2.3.1). There are several ways we could analyze these forms, but I outline three in (33): (a) CV skeleta that gain melodic information from the root, (b) underspecified prosodic templates that likewise gain melodic information from the root, or (c) an instance of generalized alignment between certain stem forms and segmental material (e.g. fourth stem must end in a vowel).

(33) Sierra Miwok: Three analyses for templatic morphology, illustrated with 4th stem [ˈhut̪le] 'roll'

a. CV template approach
UR: /ht̪l,ue/, /CVCCV/



b. Prosodic template approach
UR: /ht̪l,ue/, /$\sigma_H\sigma_L$/



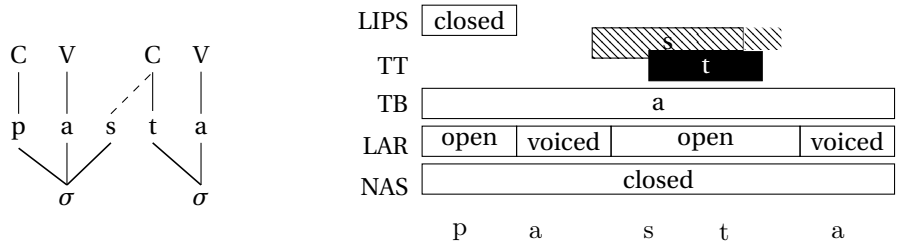
c. Alignment approach

/hut̪el/	WSP	ALIGN(4TH,R,V,R)	LIN
a. huˈt̪el		*!	
b. ˈhut̪le			*
c. huˈt̪le	*!		*

Regardless of which of these analyses we adopt, we can produce the desired interaction with weight. As long as stress assignment views the segments (or templatic content) to evaluate weight, metathesis will feed weight-sensitive stress assignment.

By contrast, general metathesis in Sevillian Spanish only reorders gestures. The gestures may shift rightwards as in (34b.) even though the segmental order in (34a.) is unchanged. If stress can *only* view the segmental structure in (34a.) (and not the gestures), metathesis will be invisible to stress assignment.

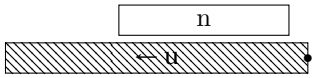
(34) Sevillian Spanish: Syllable weight remains unchanged (a) even though gestures have shifted (b)
a. Segmental representation b. Gestural representation *(shown with* /pasta/ → [patha]*)*



Similar arguments can also be made for allomorphy. Allomorph selection is based on segmental order, and so when segmental order is changed (as in Chimariko), so will the chosen allomorph. In comparison, metathesis is Uab Meto is only gestural, and so allomorph selection will proceed as if no reordering has taken place.

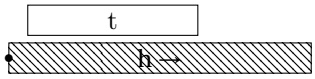
The metathesis gap directly follows from the representational split between gestures and segments, and while simple, this solution raises deep questions about how phonology and phonetics represent order. Precedence is straightforward when defined over atoms, but gestural representations require timing between intervals, which can be decomposed into ordering relationships in different ways. One preliminary generalization is that metathesis is often phonetically incomplete in general (gestural) patterns (Gilbert and Mooney, 2022). Phonetic incompleteness arises as tokens like /kosta/ → [kohtha] 'coast' in Spanish, or /manus-es/ → [mau̯nu̯s-es] 'a betel vine' in Uab Meto. Metathesis has shifted gestures left/right, but they have remained partially anchored in their original position.

(35)
a. Uab Meto: [mau̯nu̯s-es]



(Mooney, 2022)

b. Spanish: [kohtha]



(Gilbert, 2022)

One interpretation of this phonetic incompleteness is that they reveal another strong restriction on how phonetics can rewrite information. Specifically, the data in (35) suggest that phonetic reordering can only result in gestural containment — given an input order AB, the A gesture needs to start first OR the B gesture needs to end last. I call this restriction Order Preservation:

(36) **ORDER PRESERVATION (BETWEEN GESTURES):** When gesture A precedes gesture B in the input, then at least one edge of the output gestures must conform to the order in the input.

Order Preservation strongly mimics an earlier assumption we made, Gestural Preservation. Gestural Preservation stated that gestures could not be inserted or removed, instead all material must arise from transformations of the input gestures. Order Preservation is also a requirement against loss of information: Order can be changed, but only at one edge.

If Order Preservation and Gestural Preservation are both true, this suggests that there may be strong limits on what information phonetics can manipulate. The phonetics prohibits full modification of order, or full modification of the gestures present. Yet, the phonetics can modify constriction degree, constriction shape, and gestural timing (to some extent), otherwise we could not derive the epenthesis and metathesis patterns attested in the typology. Future work will need to explore more detailed forms of gestural and segmental representations to better differentiate these two kinds of information.

4.3 *Remaining issue: Sonority sensitivity.* There is one more generalization that is also supported by the representational split between phonology and phonetics, which concerns sonority. I call this the Sonorant Displacement Bias:

(37) **Sonorant Displacement Bias:** As sonority increases, sounds are easier to displace / permeate; as sonority decreases, sounds become more brittle (harder to displace / permeate).

In other words, sonorant inter-gestural timing seems easier to shift than that of obstruents. Empirically, this generalization can capture why both metathesis and epenthesis tend to occur with sonorants. Both metathesis and epenthesis are transformations of existing gestures, and both involve displacement.

The Sonorant Displacement Bias also predicts that other forms of displacement should have the same tendency. Nasal harmony, at least, obeys this prediction. Walker (2000) demonstrates that nasal harmony follows an implicational hierarchy based on sonority. As sonority increases, a sound is more likely to participate in nasal harmony, and it is more likely to be transparent to nasal harmony. This hierarchy closely parallels the typology seen in both metathesis and epenthesis. Adopting gestures thus allows us to offer unified treatment of the sonorant bias found in three previously unrelated areas of the typology.

5 Conclusion

Generative phonology has traditionally asserted that phonological grammar is uniform (Chomsky and Halle, 1968); where there is no substantive distinction between patterns that bear morphological restrictions and those that are fully general. In this paper, I have argued that this assumption of phonological uniformity is false. When we examine phonotactically general patterns and compare them to morphologically-conditioned ones, we find that there are typological gaps. General phonology never copies non-local consonants (Consonant Copying Gap), it never inserts voiceless obstruents between vowels ([t]-Epenthesis Gap), and it never reorders segments (Segmental Metathesis Gap). Together, these properties suggest that general phonology (a.k.a. phonetics) must largely preserve gestural and ordering information, and cannot overwrite it. By contrast, morphophonology exhibits each of these patterns, and so appears to be less fundamentally restricted in its transformations.

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