

The Morphology-Phonology Connection

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1. Introduction

This paper addresses several general issues in the connection between morphology and phonology, where morphology is understood to involve generalizations about form and meaning that relate words to one another within a language, and phonology is understood to involve generalizations about the sound patterns in that language. Morphology and phonology intersect insofar as the statement of morphological generalizations includes information about sound patterns (realizational morphology), and insofar as the statement of phonological generalizations includes information about morphology (morphologically conditioned phonology). This intersection is extensive, blurring the distinction between morphology and phonology in many situations. The recent literature features three approaches which focus squarely on the morphology-phonology interface: Cophonology Theory (Orgun 1996, Inkelas et al. 1997, Inkelas 1998, Anttila 2002, Inkelas and Zoll 2007), Stratal Optimality Theory (Kiparsky 2000; 2003b; a), and Indexed Constraint Theory (McCarthy and Prince 1995, Pater 2000, Itô and Mester 1999, Alderete 2001, and Smith 1997). This paper argues that Cophonology Theory succeeds best of the three in capturing three generalizations that unify morphologically conditioned phonology and realizational morphology:

SUBSTANCE: Morphologically conditioned phonology and realizational morphology involve the same operations

SCOPE: Morphologically conditioned phonology and realizational morphology have identical scope of application within a word

LAYERING: Morphologically conditioned phonology and realizational morphology are identical in their interactions in complex words

Sections 2 and 3 introduce examples of morphologically conditioned phonology and realizational morphology, and Section 4 introduces the theories being compared. SUBSTANCE, SCOPE and LAYERING are discussed in sections 5-7.

2. Morphologically conditioned phonology

Morphologically conditioned phonology is the situation in which a particular phonological pattern is imposed on a proper subset of morphological constructions (affix, reduplication, compounding) and thus is not fully general in the lexical phonology of the language. We will see three examples here.

In Mam, suffixes partition into two classes (Willard 2004, based on England 1983). ‘Dominant’ affixes cause long root vowels to shorten (1a); ‘Recessive’ suffixes preserve root vowel length (1b). Dominant vs. recessive status is not predictable; it must be learned individually for each affix.

(1)	a.	Dominant suffix: shortens long root vowel			
	facilitative	ličh’-	→	lich’-ich’iin	‘break/breakable’
	resultant locative	juus-	→	jus-b’een	‘burn/burned place’
	directional	jaaw-	→	jaw-nax	‘go up/up’
	participial	nooj-	→	noj-na	‘fill/full’
	b.	Recessive suffix: preserves root vowel length			
	intransitive	muq-	→	muq-oo	‘bury (n.)/bury (v.)’
	verbalizer	b’iitz-	→	b’iitz-oo [b’liitza]	‘song/sing’
	instrumental	luk-	→	luk-b’il	‘pull up/instrument for pulling up’
	remainder	waa-	→	waa-b’an	‘eat/remains of food’

In Malayalam, gemination applies at the internal juncture of subcompounds (compounds with head-modifier semantics) (b) but not at the internal juncture of cocompounds (with coordinate semantics) (c) (Mohan 1995:52):

(2)	a.	meeṣa	‘table’	petti	‘box’
		kasaala	‘chair’	-ka ə	(plural suffix)
	b.	[meeṣa-ppetti] _s -ka ə		‘boxes made out of tables’	
	c.	[meeṣa-petti] _c -ka ə		‘tables and boxes’	

In English, suffixes fall into two classes (Allen 1978, Siegel 1974, Chomsky and Halle 1968, Kiparsky 1982a): those which shift stress and those which do not.

(3)	Base	Stress-shifting suffix	Non-stress-shifting suffix
	párent	parént-al	párent-ing
	président	prèsidént-ial	présidenc-y
	áctive	àctív-ity	áctiv-ist
	démonstráte	demonstrative	démonstrátor

In all three of these examples, some morphological constructions in the language (affixation, compounding) are associated with a pattern that other constructions (other affixation, other compounding) are not.

3. Realizational morphology

Realizational (or process) morphology is the situation in which a morphological category is expounded by a phonological process other than concatenation of segmental morphemes. Three clear examples are cited below.

In Tohono O’odham, a well-known process of subtractive morphology derives perfective verbs from imperfectives by deleting a final segment. Before a final coronal consonant, a high vowel deletes as well. Examples come from Yu (2000:129-30), citing Zepeda 1984, and Anderson (1992), citing Zepeda 1983:

(4)	Imperfective	Perfective	gloss	data source
	síkon	síko	‘hoe object’	Yu 2000
	híwa	híw	‘rub against object’	Yu 2000
	hi:nk	hi:n	‘bark’	Anderson 1992

In Keley-i (Malayo-Polynesian), nonperfect aspect is marked by consonant gemination, providing a coda to what would otherwise be the leftmost light syllable (Samek-Lodovici 1992, citing original sources) (5a-c). In a word with all closed (heavy) syllables (5d), gemination is blocked.

(5)		(a)	(b)	(c)	(d)
	Base:	pili	duyag	□ agtu	duntuk
	Subject focus:	um-pilli	um-duyyag	Man-□ agtu	um-duntuk
	Object focus:	pilli	duyyag	□ agtu	duntuk
	Access. focus:	□ i-ppili	□ i-dduyag	□ i-□ □ agtu	□ i-dduntuk

English provides a familiar third example: stress shift marks the conversion from verbs to nouns in English (e.g. Kiparsky 1982b):

(6)	condúct	→	cónduct
	abstráct	→	ábstract
	recórd	->	récord

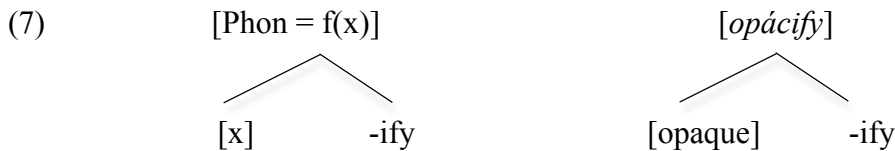
4. Sketches of three approaches to morphologically conditioned phonology

We turn next to a brief presentation of three theories designed to cover morphologically conditioned phonology. For maximum comparative effect, and given the limited space available, it is necessary in these sketches to portray the strictest version of each theory, ignoring nuanced variations of each.

4.1 Cophonology theory

In Cophonology theory (Orgun 1996; Inkelas et al. 1997; Inkelas 1998; Anttila 2002), a member of the family of construction grammar theories (Goldberg, et al.), the morphological grammar consists of a set of word-building constructions. Each construction embodies both a meaning function, which could be inflectional, derivational, or even the identity function, as well as a form function (cophonology), e.g. a set of ordered phonological rules or ranked constraints.

For example, the *-ify* construction in English is associated with a meaning function that takes a nominal stem as input and produces an output whose form is predictable from the form of the input by means of a phonological mapping that concatenates the stem with the string *-ify* and performs such phonological operations as (re)syllabification, stress shift, Trisyllabic laxing, and velar softening. In (7), only the form function is denoted, as $f(x)$, where f represents the cophonology and x represents the phonological form of the input string(s).



The cophonology of the comparative *-er* suffix in English differs from the cophonology of *-ify* in numerous ways: it is stress-preserving, not stress-shifting; it requires roughly monosyllabic inputs; it does not trigger Trisyllabic laxing or velar softening. In cophonology theory, each individual morphological construction has its own, potentially unique, cophonology; similarities among the cophonologies of constructions in the same language are captured with meta-generalizations formalized as a ‘grammar lattice’ in Anttila 2002. Precedents for cophonologies can be found in Poser 1984 and Bochner 1992.

4.2 Stratal Optimality Theory (Kiparsky 2003b)

A descendant of Lexical Morphology and Phonology (LMP; Kiparsky 1982), Stratal OT posits that every language has three strata, each with its own phonological system:



In Stratal OT, the phonological differences between *-ify* and *-er* would be modeled by assigning *-ify* to the Stem stratum, which imposes resyllabification, stress shift, Trisyllabic laxing and velar softening, and *-er* to the Word stratum, which imposes only resyllabification. Stratal OT thus can be characterized as a

very restrictive version of cophonology theory in which every morphological construction is associated either with the ‘Stem’ or the ‘Word’ cophonology.

4.3 Indexed constraint theory

Unlike **Cophonology theory** and **Stratal OT**, both of which assume that a language can have multiple cophonologies, Indexed Constraint theory assumes a single phonological grammar for each language. Because Indexed constraint theory was formulated within OT, it is always discussed with reference to OT constraints, though it also resembles the rule-based theory of *The Sound Pattern of English* (Chomsky & Halle 1968), which assumed a fixed set of general rules for each language, plus a contingent of minor rules indexed to particular lexical or morphological contexts. In Indexed Constraint Theory, morphologically conditioned phonology is handled by indexing constraints to individual morphological contexts, e.g Max-C_{root}, Max-C_{affix}, Max-C_{BR}, etc. Proponents include McCarthy and Prince 1995; Smith 1997, Itô and Mester 1999; Pater 2000, 2006; and Alderete 2001, among others.

With this brief introduction to the three theories being compared, we now test them, using evidence from realizational morphology and morphologically conditioned phonology, against the SUBSTANCE, SCOPE and LAYERING generalizations, to be motivated in the following sections.

5. SUBSTANCE

The SUBSTANCE generalization holds that realizational morphology and morphologically conditioned phonology overlap substantively to the point of being essentially indistinguishable. In a brief tour below, we will see seven different phonological effects, each instantiated once as realizational morphology and once as morphologically conditioned phonology.

5.1 Segment deletion

As seen earlier, in Tohono O’odham, final segment deletion marks the perfective category in verbs. Along similar lines, final vowel deletion marks nominative case in Lardil (9) (Blevins 1997:249, citing original sources):

(9)

NonFuture Accusative	Nominative	gloss
kentapal-in	kentapal	‘dugong’
ngaluk-in	ngalu	‘storey’
mayarra-n	mayarr	‘rainbow’
mela-n	mela	‘sea’

Segment deletion commonly occurs as a morphologically conditioned phonological process, as well. In Turkish, vowel hiatus arising at morpheme boundaries is repaired in most cases by glide epenthesis, but in one case – that of the progressive suffix *-Iyor* – by vowel deletion:

(10)

	C-final root		V-final root	
	‘do’	‘come’	‘understand’	‘say’
	yap	gel	anla	söyle
Facilitative/-Iver/:	yap-iver	gel-iver	anla-yiver	söyle-yiver
Progressive/-Iyor/:	yap-iyor	gel-iyor	anl-iyor	söyl-üyor

5.2 Gemination

In section 2 we saw gemination serving as the sole mark of nonperfect aspect in Keley-i, and as morphologically conditioned phonology in Malayalam, where it served as a phonological accompaniment to subordinate compounding. Here we see two additional examples. In Woleaian, denotatives are formed by geminating the stem-initial consonant (Kennedy 2003:174). This is realizational morphology:

- (11) fili → ffili ‘choose it/to choose’
βuga → bbuga ‘boil it/to boil’
tabee-y → ttabe ‘follow it/to follow’

In Hausa, prefixing pluractional verb reduplication includes a process of stem-initial gemination that other prefixing reduplication constructions do not exhibit (Newman 2000:235, 425). This is morphologically conditioned phonology:¹

- (12) búgà: → búbbúgà: ‘beat’
dànnè: → dáddànné: ‘press down, oppress’
gyà:rú → gyàggyà:rú ‘be well repaired’

5.3 Truncation to a prosodic constituent

Truncation can serve as realizational morphology, e.g. Spanish nickname formation (13) (Pineros 2000:71); it also commonly accompanies affixation, e.g. in Swedish nicknames (14) (Weeda 1992:121, citing original sources):

- (13) Ricardo → Rica
Armando → Arma
Jesus → Jesu
Concepción → Conce
- (14) a. alkoholist → alk-is ‘alcoholic’
laboratori:um → labb-is ‘lab’
b. mats → matt-e (proper name)
fabian → fabb-e (proper name)

¹ ‘ř’ represents trilled r, written in Hausa as an r-tilde. Plain ‘r’ is a rhotic approximant.

5.4 Dissimilation and ‘exchange’ rules

Both realizational morphology and morphologically conditioned phonology include effects where one segment surfaces with a value opposite either to its own input value (‘Exchange rules’, ‘toggles’) or to the the output value of another segment in the same word (‘dissimilation’). For a survey, see Kurisu 2001.

In Nuer (Frank 1999), input/output vowel length dissimilation marks the singular/plural distinction in nouns. (The language has multiple ways of marking the number distinction, of which this ‘exchange’ process is just one.)

(15)

	Nominative singular	Nominative plural	gloss
a.	ley	leey	‘animal(s)’
	wuɔk	wuɔɔk	‘(upper) arm(s)’
b.	kaat	kat	‘vulture(s)’
	yieer	yiër	‘river(s)’

In Hausa, ‘stabilizer’ clitics have a fixed segmental component (*ne:* for masculine, *ce:* for feminine) but exhibit tone polarity. The stabilizer surfaces with tone opposite from that of the preceding syllable (Newman 2000:160ff., 598):

(16)

...L-H		...H-L	
gwàdò né:	‘it’s a blanket’	kè:ké nè:	‘it’s a bicycle’
zó:bè: né:	‘it’s a ring’	nán nè:	‘it’s there (by you)’
mó:tà: cé:	‘it’s a car’	ákwálá: cè:	‘it’s a piece of junk’
gó:nâ-ř cé:	‘it’s the farm’	ri:gá: cè:	‘it’s a gown’

5.5 Stress/pitch-accent (re)assignment

Stress and accent shift commonly expone morphological categories on their own, as seen in the example of English verb-to-noun conversion in (6), and are also very frequently morphologically conditioned concomitants of affixation and other overt morphological processes, as in the example of English stress-shifting suffixes in (3).

5.6 Review

The phonological operations used to realize morphological constructions are essentially the same operations that can accompany overt affixation, reduplication and compounding. There is no clear basis for distinguishing the two (cf. Anderson 1975). A more comprehensive survey might well find that certain types of phonological effects are much more rarely found as the sole markers of morphological categories than others are, and that certain types of phonological effects are more likely to be morphologically restricted (in any way) than others

are. The reasons for this would be interesting to explore. However, for present purposes the overlap in type is more significant. It creates a problem of discriminability. Theories which offer separate treatments of realizational morphology and morphologically conditioned phonology require some criteria for telling the two apart, even when they resemble one another in form.

The practical criterion seems to be that a phonological alternation is classified as ‘realizational morphology’ if it is the sole exponent of a morphological construction, whereas it is classified as ‘morphologically conditioned phonology’ if it accompanies something else which is judged to be the primary exponent of a morphological construction (affixation, reduplication, compounding). All of the examples discussed in Section 5 were tacitly classified according to this criterion. The problem is that in many cases it is difficult or impossible to determine which phonological effect is the primary marker of a morphological construction (i.e. morphology), and which is the secondary phonological correlate (i.e. morphologically conditioned phonology).

In Hausa (Newman 2000), the dimensions of whether a morphological construction is tone-replacing and/or has overt affixation are independent, so that the same tone-replacement phenomenon in some cases is classified as realizational morphology () and in others as morphologically conditioned phonology ().

(17)	base tone replaced	base tone preserved
zero derivation	✓	✓
overt affixation	✓	✓

- a. No affixation; tone replacement (imperative formation)

ká:mà: → kà:má: ‘catch (!)’

bíncìké: → bìncìké: ‘investigate (!)’

nánnè:mó: → nànnè:mó: ‘seek repeatedly (!)’ (< né:mó: ‘seek’)

- b. No affixation, no tone replacement (Grade 2 verbal noun formation)

fànsá: → fànsá: ‘redeem/redeeming’

tàmbáyà: → tàmbáyà: ‘ask/asking’

- c. Overt affixation, tone replacement (various plural classes)

má:lám → mà:lám-ái ‘teacher-pl’ -LH

rì:gá: → rí:g-únà: ‘gown-pl’ -HL

tàmbáyà: → támbáy-ó:yí: ‘question-pl’ -H

- d. Overt suffixation, no tone replacement (various)

dáfà: → dáfà:-wá ‘cook-ppl’ -LH

gàjé:réz → gàjé:r-iyá: ‘short-fem’ -LH

hù:lá: → hù:lâ-ř ‘hat-def’ -L

For theories making any kind of analytical distinction between the two effects, treating exactly the same process, tone replacement, as morphology in (17a) but phonology in (17c) poses a duplication problem.

In Barasana, a paradox is actually created. A number of Barasana suffixes exert effects on stem tone. The Non3rdSubj suffix *-bɪ* causes H tone to align all the way to the right in words containing it, while the Interrogative suffix *-ri* causes H to align all the way to the left (Pycha 2005, citing Gomez-Imbert and Kenstowicz 2000):

(18)	baa-bɪ HH H	‘swim-non3rdSubj = I/you/we swim’
	baa-ri H	‘swim-Interr = did he/she/they swim?’

These suffixes exhibit what Pycha (2005) calls mutual partial blocking. Their segmental components cannot co-occur (18a), nor can their mutually incompatible effects on tone both be realized. In words where both meanings are desired, we find the segments of the Interrogative -- and the tones of the Non3rdSubj (18b):

- (19) a. *baa-ri-bɪ, *baa-bɪ-ri ‘did I/you/we swim?’
 b. baa-ri ‘did I/you/we swim?’
 HH H

Pycha’s interpretation of the facts in (18) is that both categories (Non3rdSubj, Interrogative) achieve exponence, by using the segments of one and the cophonology of the other. The paradox this poses for a theory that distinguishes realizational morphology from morphologically conditioned phonology is that the tone pattern of the Non3rdSubject must, by the criterion used above, be analyzed as morphologically conditioned phonology based on the fact that it co-occurs with a ‘primary’ exponent, namely the suffix *-bɪ*; yet its ability to expone the Non3rdSubject even when *-bɪ* is absent identifies it as realizational morphology. This is a paradox.

One possible way to avoid the problems illustrated in Hausa and Barasana would be to reduce everything to morphologically conditioned phonology, reanalyzing apparent cases of realizational morphology as zero derivation accompanied by morphologically conditioned phonology. This would, however, pose a problem in Barasana, where the morphologically specific tonal effects of the Non3rdSubj are present even when the affiliated suffix is not. Alternatively, we could try to reduce all morphologically specific phonological effects to realizational morphology, reanalyzing apparent cases of morphologically conditioned phonology as instances of ‘extended exponence’, the multiple marking of a morphological category (e.g. Matthews 1972; Stump 1991). Multiple exponence of overt morphology is a common enough phenomenon; in

Hausa, for example, the formation of class 13 noun plurals involves suffixation *and* reduplication, as well as tone replacement (Newman 2000:458):

(20)

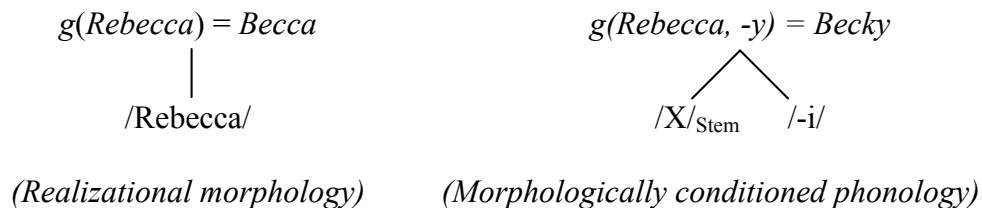
tsìrò:	→ tsìré-tsìré	‘shoot, sprout(s)’
kwánà:	→ kwàné-ksàné	‘corner, curve(s)’
há báicì:	→ hàbàicé-hàbàicé	‘innuendo(s)’

The challenge for any theory of morphologically specific phonological effects is in accounting for their overlap in substance, which makes them difficult to distinguish from one another and creating a potential duplication problem. Observations like these have been made before in the literature, leading to proposals that realizational morphology and morphologically conditioned phonology should be analyzed in the same way (Ford and Singh 1983; Poser 1984; Dressler 1985; Ford and Singh 1985; Singh 1987; Anderson 1992; Bochner 1992; Singh 1996). We turn next to a discussion of how the three theories compared in this paper do in this regard.

5.7 Theoretical discussion

Cophonology theory is naturally suited to capturing the overlap in substance between realizational morphology and morphologically conditioned phonology, since it uses exactly the same mechanism – a cophonology – to account for both. For example, truncation is modeled by a cophonology which maps an input to an output of a certain size. In the English examples below, the output of the truncating cophonology, $g(x)$, is two syllables. In the construction on the left, in which truncation is the sole mark of the construction, the input is the long stem *Rebecca* and the truncating cophonology produces the disyllabic output *Becca*. In the construction on the right, in which truncation to two syllables accompanies overt suffixation of *-y*, the input is *Becky*, with material from the stem and the suffix both competing for a spot in the disyllabic output. The inputs differ, because the constructions differ, but the cophonologies are the same.

(21) $g(x)$: a cophonology limiting the output to two syllables ($\sigma\sigma \gg \text{Max}$)



By collapsing the formal treatments of realizational morphology and morphologically conditioned phonology, cophonology theory eliminates the analytical ambiguity of cases of the type discussed in Section 5.6.

In Indexed Constraint theory, all phonological alternations are accomplished by the ranking of phonological constraints, and thus the expectation is that

Indexed Constraint theory should make essentially the same predictions as in cophonology theory regarding the substance of realizational morphology and morphologically conditioned phonology, even though the mechanism of relating phonological subpatterns to particular constructions is different from the mechanism used in cophonology theory. (We will come back to this issue in later sections.)

For example, Kurisu (2001) has proposed that the constraint REALIZE-MORPH (RM) could be responsible for many effects classified here as realizational morphology; RM essentially requires that the phonological output of a morphological construction be non-homophonous with the input, such that a construction with no overt affix or other morphological exponent would be required through RM to undergo some phonological change. The resulting change is predicted to be the least expensive one, as determined by the ranking of markedness and faithfulness constraints of the grammar. In Icelandic, deverbal nouns are formed by deleting the final vowel from the infinitive:

- (22)
- | | | | |
|--------|---|-------|-----------------------|
| klifra | → | klifr | ‘climb/climbing’ |
| grenja | → | grenj | ‘cry/crying’ |
| söotra | → | söötr | ‘sip/sipping’ |
| puukra | → | puukr | ‘conceal/concealment’ |

Kurisu derives this outcome by ranking Dep and RM above Max, such that the need to satisfy RM compels a Max violation.

(23)

	/klifra/	RM	DEP	MAX
a.	klifra	!*		
b.	klifr			*
c.	klifrata		*!	

RM is a type of indexed constraint; it is an anti-faithfulness constraint indexed to a morphological constituent, in this case deverbal noun. Indexed constraint theory commonly indexes faithfulness constraints as well: Base-Reduplicant Correspondence Theory indexes faithfulness constraints to Base and Reduplicant constituents, Smith indexes faithfulness constraints to nouns vs. verbs, etc. The same approach ought to be able to capture the morphologically conditioned phonological effects we have seen thus far. For example, Ito & Mester analyze a case of truncation in German comparable to the *Rebecca* → *Becky* example, above, exploiting an abstract morpheme TRUNC which is compelled, by indexed constraints, to be faithful segmentally to the full stem *and* to fit, with the German equivalent of *-y*, into two syllables. This constraints that participate in this analysis are very similar to the ones in a cophonology account, and while the theories differ in other ways they make similar predictions about substance.

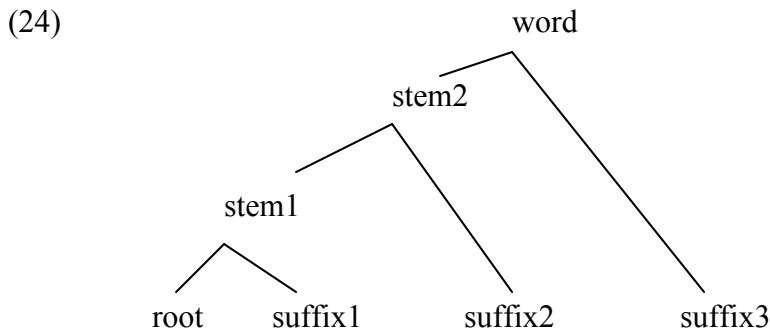
In contrast to cophonology theory and Indexed Constraint Theory, Stratal OT has little to say about realizational morphology or its relation to morphologically

conditioned phonology, making it hard to evaluate any predictions Stratal OT might make about substance. Like LMP, Stratal OT focuses on generalizations holding over stems and words, but ignores alternations that are construction-specific. Since not all stem morphology in English is truncating, Stratal OT cannot accomplish the truncation seen in *Rebecca* → *Becca* through Stem phonology. Instead it would require some constraint or constraint ranking specific to nickname formation – i.e. indexed constraints or cophonologies, merging Stratal OT with one or the other of the two approaches with which it contrasts.

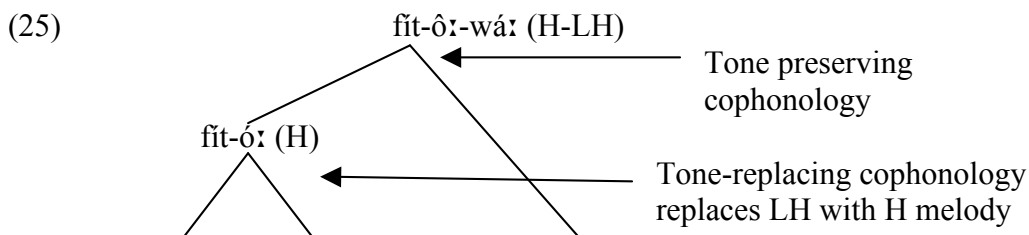
6. SCOPE

With both morphologically conditioned phonology and realizational morphology, the scope of the phonological effect(s) is the stem produced by the word formation process in question. By associating cophonologies with morphological constructions, Cophonology Theory predicts that the scope of each cophonology will be the morphological subconstituent built by the associated construction.

For example, in a word with three suffixes, cophonology theory predicts that the cophonology of Stem2 can affect the surface form of Stem1 and Suffix2, but that the cophonology of Stem2 *cannot* affect the surface form of Suffix3:



A case study from Hausa illuminates the significance of this type of prediction. Cophonology theory predicts that if a tone-replacing construction is embedded within a tone-preserving construction, it will not replace the tones of any affixes introduced by the outer construction; these are outside its scope. The ventive construction is tone-replacing (Newman 2000:663): *fitá:* (LH) ‘go out’ → *fit-ó:* (H) ‘come out’, *gángàrá:* (HLH) ‘roll down’ → *gángár-ó:* (H) ‘roll down here’, etc. As seen in (25), a ventive stem can be converted to a verbal noun through the suffixation of -`wá:, the tone-preserving verbal noun-forming suffix:

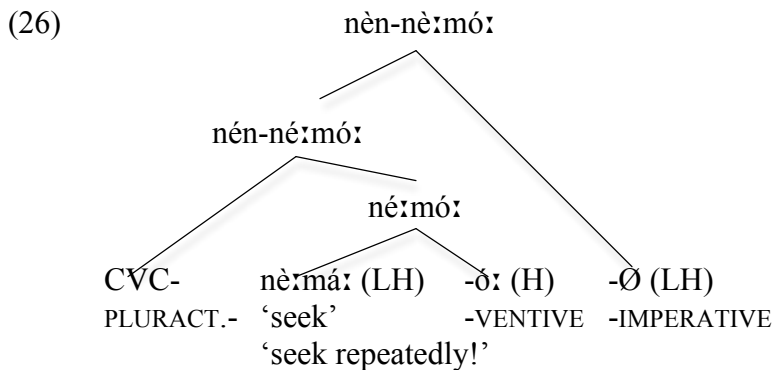


fitá: (LH)	-ó: (H)	-`wá: (LH)
‘go out’	VENTIVE	VERBAL NOUN FORMER
	‘coming out’	

The outer suffix retains its lexical LH tone pattern; it is immune to the tone replacement pattern which is imposed on the ventive stem subconstituent by the ventive cophonology. Scope effects of this kind are an intrinsic prediction of cophonology theory.

Stratal OT can handle some but not all scope effects. Like Cophonology theory, Stratal OT assumes a layered structure in which the cophonology of an higher (e.g. Word) level applies to the output of the cophonology of an earlier (e.g. Stem) level. Stratal OT thus predicts that the Word cophonology will have scope over Stems (and the suffixes combining with them to form Words), but that the Stem cophonology will not have scope over Word-forming suffixes.

The challenge faced by Stratal OT is describing the scope of morphologically specific phonological effects that are not general within Stems or Words. To model the division between tone-preserving and tone-replacing morphology in Hausa, for example, Stratal OT must assign one effect, e.g. tone replacement, to Stems, and the other, e.g. tone-preservation, to Words. However, tone-replacing and tone-preserving morphological constructions can be embedded in either order. In (26), the tone-replacing ventive construction is embedded within the tone-preserving pluractional, which in turn is embedded within the tone-replacing imperative (represented with a dummy suffix for graphical clarity). If Words and Stems are strictly ordered, Stratal OT cannot handle this case:



Indexed constraint theory faces two challenges in describing and predicting SCOPE effects. One, addressed here, is the question of what constraints are indexed to. (The other is layering, discussed in Section 7). The indexation issue can be illustrated in Hausa with the tone-replacing cophonology associated with the Ventive (and several other morphological constructions) and the tone-preserving cophonology associated with verbal noun-forming -`wá (and many other affixes). Cophonology theory would posit the constraint rankings in (27):

(27)	Ventive cophonology	Tone=H » Ident-tone, Tone = LH
	-`wáʔ verbal noun cophonology	Ident-tone » Tone=H

Indexed Constraint Theory has one constraint ranking for the entire language. The cophonologies in (27) could translate into indexed constraints as follows:

- (28) a. Ident-tone-`wáʔ » Tone=H » Ident-tone
 b. Tone=H_{Ventive} » Ident-tone » Tone=H

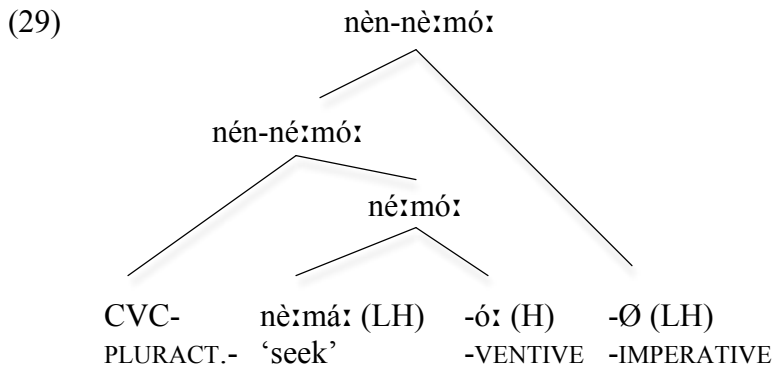
The ranking in (28a) indexes faithfulness: the verbal noun-former -`wáʔ is specially faithful, outranking the general markedness constraint Tone=H to which other stems are subject. The alternative ranking in (28b) indexes markedness constraints. All-H is the unmarked pattern for the Ventive, but faithfulness trumps markedness for other constructions, which are therefore tone-preserving. It does not matter here which method is chosen; the literature on Indexed Constraint Theory favors indexing faithfulness, rather than markedness constraints (see e.g. Alderete 2001, though cf. Inkelas & Zoll 2007).

On either option, capturing SCOPE requires indexed constraints to refer not to morphemes, but to complex stems. The H tone mandate of the ventive, captured in the constraint Tone=H_{Ventive}, must refer to the entire ventive stem, not just the ventive suffix -óʔ, in order to generate, for input *nè:máʔ*, the correct output *né:móʔ*.

For this reason, recent work in Indexed Constraint Theory has moved in the direction of cophonology theory by indexing constraints to constituents of words, not individual morphemes (e.g. Alderete 2001).

7. Layering

A corollary of the scopal prediction of **cophonologies** is layering, the effect in which, given a structure where X is a daughter of Y, the output of the cophonology associated with X is the input to the cophonology of Y. This prediction holds for both realizational morphology and morphologically conditioned phonology. A good illustration of this prediction can be found in example (26), repeated below, which contains two tone-replacing morphological constructions. The inner one (ventive) imposes all-H; the outer one (imperative) imposes LH. The word surfaces LH, as cophonology theory predicts.



The way two cophonologies in the same word interact depends intrinsically on the hierarchical structure of the word. The outer construction has the last say.

Stratal OT also predicts layering, to which Kiparsky 2000 has pointed as a possible explanation for phonological opacity. The problem for Stratal OT, as mentioned above, is simply that it does not provide *enough* layers to capture the richness of morphologically conditioned phonology and realizational morphology within a language.

In contrast to Cophonology theory and Stratal OT, in which the interaction between morphologically conditioned phonological patterns follows from the hierarchical structure of a given word, in Indexed Constraint Theory interactions of these types follow from constraint ranking, which is fixed in the language. To illustrate this, consider the constraint ranking needed to generate the imperative ventive word in (32), in which the LH imperative tone melody takes precedence over the all-H melody associated with the ventive.²

(30) Tone=LH_{imperative} » Tone=H_{ventive} » Ident-tone » Tone=H, Tone=LH

	[[nè:má: -ó:] _{Ventive} - Ø] _{Imper.}	TONE=LH _{Imper.}	TONE=H _{Vent}	IDENT
a.	nè:mó:	*!	*	*
b.	nè:mó:		*	

The outcome of this tableau is determined by the highest ranked morphologically indexed constraint, *not* by the hierarchical structure of the word.

If the morphological constructions involved always occur in a fixed order, then layering of cophonologies and ranking of indexed constraints make essentially the same predictions. However, there are good examples of languages in which the same constructions can occur in either order, with different phonological results. This was an important result of Mohanan 1986, in which it

² Note that this ranking indexes markedness constraints, rather than faithfulness constraints. An indexed faithfulness account would be much more challenging to develop.

was demonstrated that the two types of compounds in Malayalam could embed inside each other; a similar freedom of combination occurs in Turkish, as pointed out in detail in Inkelas and Orgun 1998, and in Cibemba, as pointed out by Hyman 1994. Indexed Constraint Theory does not capture the overarching generalization that scope is related to hierarchical position.

8. Conclusion

Cophonology theory has clear advantages over Indexed Constraint Theory and Stratal OT in capturing SUBSTANCE, SCOPE, and LAYERING. Yet cophonologies have been viewed with concern, principally over the issue of cophonology proliferation: without a lid on cophonology variability, a language might vary as much internally as unrelated languages can vary (see e.g. Benua). This concern has been addressed in two ways in the literature (Inkelas and Zoll 2007). On the formal side, Anttila (2002) has proposed that cophonologies in the same language must conform to a master ranking of constraints; only constraints left unranked in this master ranking are allowed to vary in their ranking across individual cophonologies. More substantively, researchers such as Bermudez-Otero and McMahon (2006) have observed that cophonological diversity arises from diachronic change, and that languages change too slowly and in too systematic a fashion to permit the kind of wildly divergent cophonologies that have been cited as a reason to avoid cophonology theory.

We have also seen in this study, however, that Cophonology theory, Stratal OT and Indexed Constraint theory have many properties in common, and whatever successor to these theories ultimately ends up being adopted will share their common goal of tying morphologically conditioned phonological effects to morphological subconstituents of complex words.

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