The consequences of Optimization for Underspecification

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This paper* proposes that underlying representation should be determined solely by optimization with respect to the grammar, and that no constraints are directly imposed on the lexicon. This approach has important consequences for underspecification, the situation in which a segment which surfaces with some phonological material M is not specified for M in the input to some phonological level[1].

Underspecification has been controversial since its earliest existence, drawing fire early from Stanley 1967 and more recently from Mohanan 1991, McCarthy and Taub 1992, Smolensky 1993, Steriade 1994, and others. Aside from Stanley, however, virtually all objections to underspecification have actually been objections to various principles designed to regulate its distribution. These fall into the general categories in (1):

(1) •**Markedness** (universal, language-specific, or contextual); unmarked material is underspecified (e.g. Kiparsky 1982, Pulleyblank 1983, Kiparsky 1993)
•**Redundancy**; redundant feature values (as determined by the segment inventory) are underspecified (e.g. Clements 1987, Steriade 1987, Mester and Itô 1989)
•**Predictability**: predictable material is underspecified (e.g. Ringen 1975, Kiparsky 1982, 1993; Archangeli 1984, Pulleyblank 1988, Archangeli and Pulleyblank 1989)

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1 In most discussions, M is featural and the level is initial. This paper will, due to lack of space, also be limited to discussing only underlying underspecification; however, nonfeatural structure will be considered.

Critics of underspecification have found flaws in each of these principles, a common conclusion being that underspecification is fatally tainted. Thus Smolensky 1993 and McCarthy 1994 have claimed it to be a virtue of Optimality Theory (Prince and Smolensky 1993) that underspecification is unnecessary in the analysis of various phenomena, e.g. transparency and neutralization, once thought to require it.

I argue that underspecification *is* necessary, even in Optimality Theory, but that it should be governed by very different principles from those in (2), which regulate under-specification without regard for the grammar or alternations in a language. I propose a theory in which underspecification is used to optimize input-ouput mappings in grammar.

1. The necessity of underspecification and full specification

We begin with a demonstration from Turkish that a contrast between underspecification and its opposite, full specification, is necessary to the pure description of certain alternations. Root-final plosives in Turkish exhibit three different types of behavior (Inkelas and Orgun 1994; see also Kaisse 1986, Rice 1990). Some alternate between being voiceless in the coda and voiced in the onset (2a); others are consistently voiceless (2b), while still others are consistently voiced (2c).

(2)	a. [t~d]	kanat	'wing'	kanat-lar	'wing-pl'	kanad-ɨ	'wing-Acc'
	b. [t]	sanat	'art'	sanat-lar	'art-pl'	sanat-ɨ	'art-Acc'
	c. [d]	etüd	'etude'	etüd-ler	'etude-pl'	etüd-ü	'etude-Acc'

This genuine three-way contrast requires the contrastive use of underspecification, as shown in (3). The alternating plosive in (2a) is unspecified for [voice], while those in (b) and (c) are prespecified as voiceless and voiced, respectively. Coda and onset voice specifications are assigned in a purely structure-filling manner, affecting only underspecified representations.

(3)	Underlying representations:	/kanaD/	Ø	(2a)
		/sanat/	[–voiced]	(2b)
		/etüd/	[+voiced]	(2c)

Similar examples, which I cannot discuss here, occur with tone in Margi (Pulleyblank 1986) and with vowel harmony in Turkish (Clements and Sezer 1982). In Margi, toneless, alternating morphemes contrast with H- and L-toned nonalternating morphemes; in Turkish, suffix vowels which alternate between [+back] and [–back] due to vowel harmony contrast with nonalternating [+back] and [–back] suffix vowels. Both cases require an underlying contrast between [+], [–] and [Ø] values for the same feature.

What all such examples show is that underspecification is determined by *alternations*. No grammar-blind principles can therefore be adequate. Before proceeding to outline a theory of underspecification that can capture ternary contrasts, however, it is necessary to dispense with an analytical device that undermines any debate over underlying representation, namely the use of exception features.

Recall the contrast in (2) between alternating [t~d] and nonalternating [d]. One alternative approach to such contrasts has been to assign both plosives the same under-lying representation (/d/) but mark one as an exception to the rule of Coda Devoicing[2]:

[2] Works using rule exception features include Lees 1961, Lightner 1965, Chomsky and Halle 1968, Harris 1969, Saciuk 1969, Kisseberth 1970, Kiparsky 1973, Zonneveld 1978, Ringen 1978; and many others.

(4) UR: /kanad/
/etüd/[–Coda Devoicing]

This type of approach transcends rule theory; its translation into Optimality Theory involves morpheme-specific constraint reranking (Kisseberth 1993, Kirchner 1993, Pater 1994). (5) shows, again, that the root-final plosives in (2a) and (c) can be given the same underlying representation as long as /etüd/ is associated with a special constraint ranking to protect its /d/ from devoicing. Assume that in the "regular", devoicing grammar, NO-VOICED-CODA outranks PARSE[VOICE]. The exceptional form is simply marked so as to reverse this ranking:

(5) UR: /kanad/
/etüd/[PARSE[VOICE] >> NO-VOICED-CODA]

Both approaches assign the two roots to different grammars. This kind of approach of course reduces the number of phonological contrasts needed underlyingly. The problem is that it reduces them too far (Inkelas, Orgun and Zoll 1994). Grammar multiplication ultimately renders underlying phonological representation entirely unnecessary, a scenario making it impossible to discuss underspecification at all. I will, therefore, proceed on the assumption that exception features are off-limits. Underlying representation *has* to matter, underspecification is necessary to capture three-way contrasts, and grammar-blind principles of underspecification cannot be right.

2. Underspecification: from unprincipled to principled

We have now concluded that we need a device, underspecification, which is governed by no known principles. In §2 I make a proposal to restore underspecification to principled status. The claim is that underlying form, including underspecification, should be determined solely by Lexicon Optimization and not by any constraints holding directly on underlying form. Lexicon Optimization, developed by Prince and Smolensky 1993 for Optimality Theory, is stated in (6):

(6) LEXICON OPTIMIZATION (Prince and Smolensky 1993:192):

Suppose that several different inputs I_1, I_2, ..., I_n when parsed by a grammar G lead to corresponding outputs O_1, O_2, ..., O_n, all of which are realized as the same phonetic form Φ — these inputs are all *phonetically equivalent* with respect to G. Now one of these outputs must be the most harmonic, by virtue of incurring the least significant violation marks: suppose this optimal one is labelled O_k. Then the learner should choose, as the underlying form for Φ, the input I_k.

This original principle dealt only with morphemes with a single phonetic realization; because the present paper deals with alternating morphemes, I offer an alternation-sensitive restatement in (7):

(7) Alternation-sensitive restatement of Lexicon Optimization:

Given a set S = $\{S_1, S_2, ... S_i\}$ of surface phonetic forms for a morpheme M, suppose that there is a set of inputs I = $\{I_1, I_2, ... I_j\}$, each of whose members has a set of surface realizations equivalent to S. There is some $I_i \in I$ such that the mapping between I_i and the members of S is the most harmonic, i.e. incurring the fewest marks in grammar for the highest ranked constraints. The learner should choose that I_i as the underlying representation for M.

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(8) illustrates the revised Lexicon Optimization at work in a toy grammar. In this Lexicon Optimization tableau, recognizable by the "LO" insignia in the upper left, row sets (a) and (b) contrast two underlying representations for a morpheme whose surface alternants are [ta] and [ta:]. (This language lengthens vowels in unsuffixed roots to satisfy a bimoraic minimality condition.) In the tableau, input candidate (a) wins because its mapping to surface forms incurs less serious violations than that of candidate (b).

(8)

LO			example context	PARSE -μ	INSERT-μ
☞a.	/ta/	[ta]	ta-loŋ		
		[ta:]	ta:		*
b.	/ta:/	[ta]	ta-loŋ	*!	
		[ta:]	ta:		

In what follows, I apply Lexicon Optimization in a range of typologically selected examples to illustrate that it selects underspecification in some contexts and not in others. The examples of interest all involve predictable structure. A preview of the results is shown in (9): underspecification is used only for alternating structure.

(9)

	Predictable	Unpredictable
Alternating	underspecification (§2.1)	full specification
Nonalternating	full specifiation (§2.2)	full specification

2.1 Alternating structure, all alternants predictable: underspecification

We turn first to Yoruba, whose ATR harmony has recently been analyzed by Pulleyblank 1988 and Archangeli and Pulleyblank 1989.

2.1.1 Yoruba ATR harmony

Yoruba has four [+ATR] vowels (/i, e, o, u/) and three [–ATR] vowels (/ẹ, a, ọ/). As shown in (10a,b), prefix vowels assimilate in ATR to the root. ATR harmony is potentially structure-changing, as shown in (10c-d), where the first stem in a compound loses its own ATR specification and takes on that of the second member.

(10)
a. ọ-dẹ 'hunter' (dẹ 'hunt') [A&P1989:188]
   ẹ̀-rọ 'machine' (rọ 'fabricate')
b. ò-kú 'corpse of person' (kú 'die')
   è-rò 'a thought' (rò 'think')
c. ọmọ + idan → omidan (*ọmidan) [A&P:189]
   'child' 'virgin' 'Miss'
   àwọ̀ + ejò → àwò ejò [Pulleyblank 1988:238]
   'color' 'snake' 'color of a snake'
d. ògbó + ẹni → ọ̀gbẹ́ni (*ògbẹ́ni) [A&P:190]
   'old' 'person' 'sir'
   owó + ọmọ → owọ́ ọmọ [Pulleyblank 1988:238]
   'money' 'child' 'child's money'

These data determine that the grammar of Yoruba is consistent with (11): the vowel harmony constraint outranks PARSE.

(11) Feature-changing harmony: VOWEL.HARMONY >> PARSE[ATR VALUES]

Given (11), Lexicon Optimization can select an underlying representation for the alternating prefix in (10). The tableau in (12) contrasts the three logical possibilities ([+], [-], and [ØATR]). Because harmony is structure-changing, both fully specified candidate inputs in (a) and (b) will work, but both incur PARSE violations (due to spreading of the root specification for [ATR]). Only the underspecified input in (c) violates no relevant constraints. Lexicon Optimization has opted for underspecification.

(12)

LO			example context	PARSE[+ATR]	PARSE[ATR]
a.	/o/	o	o-ku 'corpse'	*!	*
		ọ	ọ-dẹ 'hunter'	*!	*
b.	/ọ/	o	o-ku		*!
		ọ	ọ-dẹ		*!
☞c.	/O/	o	o-ku		
		ọ	ọ-dẹ		

An assumption I make in the above tableau is that markedness is encoded by grammatical constraints of the type proposed by Kiparsky 1994 (as opposed, e.g., to the constraints of Prince and Smolensky 1993 or Smolensky 1993). According to Kiparsky, each constraint has at least two versions: one holding generally over structure of a particular type (segments, place features, etc.) and one (or more) holding specifically of the marked structure of that type. Thus in (12) we find PARSE[+ATR], the specific constraint, and PARSE[ATR], the general constraint. No constraints refer to unmarked feature values, an important feature of Kiparsky's system. This will play a role later on.

2.1.2 Vowel harmony (Warlpiri)

In Yoruba, the harmony data totally determined the grammar. But what happens when the data leave the grammar underdetermined? Warlpiri, whose progressive roundness harmony is illustrated in (13), presents such a case.

(13) kurdu-kurlu-rlu-lku-ju-lu 'child-Prop-Erg-then-me-they' [Nash 1986:86]
maliki-kirli-rli-lki-ji-li 'dog-Prop-Erg-then-me-they'

Based on these data alone, either of two grammars could characterize Warlpiri:

(14) a. Structure-changing: VOWEL-HARMONY >> PARSE[+RD], PARSE[RD]
b. Purely structure-filling: PARSE[+RD], PARSE[RD] >> VOWEL.HARMONY

Whether harmony is feature-changing (a) or feature-filling (b), however, Lexicon Optimization arrives at the same result: the optimal inputs for the alternating suffixes in (13) are underspecified for the feature [round].

(15) Underlying representation for /-kirli ~ -kurlu/: /-kIrlI/
(by Lexicon Optimization given (14a); by descriptive adequacy given (14b))

So far the picture looks much like Yoruba. Things change, however, when (16) is taken into account. Roots whose final vowel is /a/ condition [+round] suffix harmony. This feature value does not result from spreading. It is either inserted or underlyingly present.

(16) minija-kurlu-rlu-lku-ju-lu 'cat-Prop-Erg-then-me-they' [Nash 1986:86]

The grammar is even less determinate now, and the underlying representations of the suffixes are in limbo. The tableau in (17) compares an underspecified underlying suffix (c) to fully specified [–round] and [+round] candidate inputs in (a,b). Without knowing the relative ranking of PARSE and FILL, we cannot decide which candidate is optimal:

(17)

LO			example context	PARSE[+RD]	PARSE[RD]	FILL
☞ a.	/-kirli/	kirli	maliki-kirli		*	
		kurlu	kurdu-kurlu		*	
		kurlu	minija-kurlu		*	*
b.	/-kurlu/	kirli	maliki-kirli	*	*	
		kurlu	kurdu-kurlu	*	*	
		kurlu	minija-kurlu			
c.	/-kIrlI/	kirli	maliki-kirli			
		kurlu	kurdu-kurlu			
		kurlu	minija-kurlu			*

Candidate (17c) clearly outperforms candidate (a), because their respective violation marks are in a subset relation, but the choice between (b) and (c) is up in the air:

(18) a. If FILL >> PARSE, /kurlu/ is optimal underlying representation
b. If PARSE >> FILL, /kIrlI/ is optimal underlying representation

This is where we appeal to a second principle, which I'll term Grammar Optimization. The idea, due to Kiparsky 1993 (in a non-Optimality framework), is that the best grammar is the most transparent, i.e. deletes the least.

(19) GRAMMAR OPTIMIZATION: The optimal grammar is the most transparent, i.e. the one in which alternations are maximally structure-filling (Kiparsky 1993).

In Optimality terms, this translates to saying that, all else being equal, PARSE outranks FILL. When applied to Warlpiri, Grammar Optimization selects the ranking in (20):

(20) PARSE[+RD], PARSE[RD] >> VOWEL.HARMONY >> SPREAD, FILL

This ranking induces Lexicon Optimization to pick underspecified input (17c), the only candidate not to violate PARSE. Lexicon Optimization, here aided by Grammar Optimization, once again opts for underspecification of predictable alternating structure.

2.1.3 Turkish glide-vowel-Ø alternations

Optimization can extend beyond feature values to the underspecification of entire segments. (21a) shows Turkish suffixes whose surface forms differ in the presence or absence of an initial vowel; those in (b) alternate according to the presence or absence of an initial glide. Both alternations have to do with syllable structure; the alternating vowel in (a) provides a nucleus for stems ending in a consonant, and the alternating glide in (b) provides an onset to prevent vowel hiatus.

(21) a.	bɨrak-ɨr	'leave-Aorist'	anla-r	'understand-Aorist'
	bul-un	'find-Passive'	anla-n	'understand-Passive'
	kitab-ɨm	'book-1sg.poss'	elma-m	'apple-1sg.poss'

b.	dön-en	'turn-relative'	söyle-yen	'say-relative'
	dön-ejek	'turn-future'	söyle-yejek	'say-future'
	kitab-a	'book-Dative'	elma-ya	'apple-Dative'

There is little consensus in the literature as to how to handle these alternations[3]. Two possibilities at the logical extremes are sketched in (22). The first posits minimal underlying forms and insertion; the second, maximal underlying forms and deletion.

(22) INSERTION GRAMMAR (vowel epenthesis into clusters; glide epenthesis into hiatus (in derived environments))

Grammar: PARSE >> NO.CLUSTER, NO.HIATUS >> FILL

Underlying representations: For [V~Ø], /Ø/; for [G~Ø], /Ø/

DELETION GRAMMAR: (vowel deletion in hiatus; glide deletion in CG clusters (in derived environments))

Grammar: FILL >> NO.CLUSTER, NO.HIATUS >> PARSE

Underlying representations: For [V~Ø], /V/; for [G~Ø], /G/

Although either grammar would work, Grammar Optimization selects the former, as PARSE is higher ranked. It thus follows that the suffixes in (21) will be underlyingly unspecified for the alternating segment. Once again we have opted for underspecification.

2.1.4 Consonantal morphemes

Much the same conclusion obtains for predictable, alternating metrical structure. Consider the three consonantal Armenian verb roots in (23) (e.g. Samuelian 1989):

(23)	a.	/k/	'come'	b.	/l-ats-ék/	'cry (pl.)!'
		/d/	'give'		/l-ál/	'to cry'
		/l/	'cry'		/l-ats-adz-é-m/	'cry-ext-ppl-TV-1sg (=I have cried)'

Like all verb roots in Armenian, these always join with a vowel-initial suffix. They never head a syllable and, for that matter, are often not even in the final (and only) stress foot. Given a choice between prespecification vs. underspecification of metrical structure, Lexicon Optimization confirms the intuition of most phonologists that consonantal roots should *not* be specified underlyingly for syllables or feet. As (24) shows, the optimal underlying form for the root /k/ is the underspecified (b). Only this candidate incurs no violations of PARSE.

(24)

LO			example context	PARSE
a.	F | σ | /k/	F | σ /\\ [kV...]	F | σ /\\ kal	*! (F, σ)
☞ b.	/k/	F | σ /\\ [kV...]	F | σ /\\ kal	

[3] Lewis 1967 generally opts for epenthesis; Underhill offers a mixed account with deletion in (21a) and epenthesis in (21b); Itô and Hankamer 1989 propose vowel deletion for the alternations in (21a) and, by implication, glide deletion for those in (21b).

In summary, Lexicon Optimization causes the underspecification of structure that is both predictable and alternating. When either condition is not met, however, Lexicon Optimization leads to the opposite scenario: full underlying specification. We turn to such cases in the next section, considering segmental, skeletal and moraic structure.

2.2. Nonalternating, predictable structure

The tableau in (25) illustrates a morpheme which always surfaces as [ti] in a language where Coronal is the unmarked value for C(onsonantal) Place, [–] the unmarked value for [voice], and [+high, –back] the unmarked specifications for V(ocalic) Place.

(25)

LO			INSERT[C-PLACE]	INSERT[VOICE]	INSERT[V-PLACE]
☞a.	/ti/	[ti]			
b.	/Ti/	[ti]	*	*	
c.	/TI/	[ti]	*	*	*

This morpheme is chock-full of predictable, unmarked feature values. But look what Lexicon Optimization predicts: full underlying specification! This is because any underspecified candidates simply incur gratuitous violations of FILL, the constraint against insertion of features.

This general result is foreshadowed in Prince and Smolensky 1993, who discuss the hypothetical case of a language in which syllables are always CV in shape and where vowels are therefore predictable from the number of consonants (p. 193). Prince and Smolensky show that Lexicon Optimization will nonetheless result in the prespecification of vowels (the winning candidate input in (26c)):

(26)

LO			INSERT-V
a.	/CCC/	[CVCVCV]	*!**
b.	/CVCC/	[CVCVCV]	*!
☞c.	/CVCVCV/	[CVCVCV]	

The result extends to moraic and other metrical structure as well. (27) shows data from Hausa, in which vowel length is contrastive (e.g. Newman and Newman 1977):

(27)

'woman' 'women' 'three days hence' 'bed'

While it is uncontroversial that unpredictable vowel length must be prespecified, Lexicon Optimization causes even short vowels, whose mora count is predictable, to be prespecified as well. This supports the original proposal of Hyman 1985 for the prespecification of moras on vowels.

2.3 Summary: Archiphonemic Underspecification

In general, whether the predictable structure is featural, as in (25), skeletal, as in (26), or metrical, as in (27), the same result will obtain: if it doesn't alternate, Lexicon Optimization will cause it to be prespecified. This crucial difference between alternating and nonalternating structure distinguishes the current approach from past approaches to underspecification. In placing so much emphasis on neutralization, the present approach actually bears some resemblance to the use of the Prague school archiphoneme (Jakobson 1929; Trubetzkoy 1929, 1936; Martinet 1936; see Akamatsu 1988). Of course, even leaving aside broad conceptual issues such as the status of the phoneme, there are a number of crucial practical differences between classical archiphonemes and the proposed underspecified representations:

(28) a. Underspecification is restricted to segments involved in alternations, while the archiphoneme was used for positional neutralization even if no alternations occurred
b. There is no extrinsic limit on the degree of underspecification, whereas the use of the archiphoneme was typically restricted to bilateral oppositions
c. There is no requirement that segments underspecified to different degrees have distinct phonetic realizations, whereas different archiphonemes must differ phonetically

Nonetheless, I dub my approach Archiphonemic Underspecification in honor of its forebears.

3. Advantages of Archiphonemic Underspecification

Archiphonemic Underspecification has a number of advantages over past theories of underspecification, beyond the issue of descriptive adequacy in three-way contrasts.

3.1 Solves notorious prelinking problems

The first is the prespecification of unpredictable stress or tone. (29) contrasts two words from Turkish, a language with regular final stress (Lees 1961, Lewis 1967, Underhill 1976). *baba* 'father' is regular; stress appears at the end of the word in all suffixed forms shown here. *masa* 'table', however, is a well-known counterexample to the final stress rule, retaining initial stress in all contexts.

(29)		-Plural	-Plural-Acc	gloss
	mása	mása-lar	mása-lar-ɨ	'table'
	babá	baba-lár	baba-lar-	'father'

In approaches where predictable structure is maximally underspecified, prespecification of a stress foot is an embarrassment. Though a workable analysis of the stress facts (Inkelas 1994; cf. Poser 1984, Barker 1989), it requires the prespecification of otherwise predictable mora and syllable structure to "host" the underlying foot. Thus *baba* and *masa* would differ underlyingly in their syllable structure even though both are CVCV strings and differ only in stress. A similar problem arises in the prespecification of tone, as Leben points out for languages in which the syllable is the tone-bearing unit:

(30) "If syllables were allowed to bear features, they would be the only feature-bearing units whose extension was completely predictable by an algorithm referring to other phonological units." [Leben 1973:192]

Archiphonemic Underspecification has no problem in this regard. Since the syllable structure of *masa* and *baba* (29) never alternates, and since vowels consistently form a syllable peak, Archiphonemic Underspecification predicts that the metrical structure needed to bear the underlying stress or tone will be prespecified anyway.

3.2 Solves notorious tone melody problems

A second advantage to Archiphonemic Underspecification is that it can represent tone melodies in languages like Kukuya, which contrasts L, H, HL, LH and LHL melodies (Hyman 1987, based on Paulian 1974; see also Mende (Leben 1978).

(31)	L	(k)-bàlàgà	'to change route'	HL	(kì)-káràgà	'to be entangled'
	H	(mà)-bálágá	'fence'	LHL	(ndÈ)-kàlə́gì	'he turns around'
	LH	mʷàrə̀gí	'younger brother'			

In a theory forcing universally unmarked feature values, here L, to be underspecified, these tone melody contrasts would incorrectly be neutralized. Past theories had to proliferate tone features or introduce otherwise unneeded tonal nodes to capture the simple contrasts in (31) (e.g. Pulleyblank 1986, Inkelas 1987, Hyman and Pulleyblank 1987); the current approach is unimpeded by extrinsic constraints on what may be prespecified, and can represent the melodies in their entirety in underlying representation.

3.3 Markedness reflected in, but not forced on, lexicon

A third virtue of Archiphonemic Underspecification is that it can handle both cases in which lexical representation does reflect markedness and cases in which it does not. An important result of past markedness theories of underspecification was the prediction of which segments will be inert, weak, or epenthetic. Pulleyblank 1988, for example, accounts for such behavior on the part of Yoruba /i/ by underspecifying the unmarked vowel for features underlyingly. Can Archiphonemic Underspecification derive this same result?

Consider the Yoruba data in (32) (Pulleyblank 1988:238-239). Vowel sequences arising in possessive constructions exhibit (mainly) regressive assimilation (a):

(32)	a.	owó + adé	→ owá adé		'Ade's money'
		owó + ẹmọ	→ owẹ́ ẹmo		'wine money'
	b.	ará + ìlú		*arí ìlú	'townsman'
		ẹrù + igi		*ẹrì igi	'bundle of wood'

If, however, the second vowel in the sequence is /i/ (b), no assimilation occurs. Pulleyblank attributes the inertness of /i/ to its underspecification: /i/ has no features to spread. Viewed from the perspective of Archiphonemic Underspecification, however, it is unnecessary to stipulate in advance that /i/ is underspecified. Given the type of grammar we have been developing, we can *prove* that /i/ must be underspecified. Recall Kiparsky's theory of markedness, in which no constraint may single out unmarked feature values. As shown in (33), the only possible spreading options are to spread all features (a), no features (b), or only unmarked feature values (c). No constraint ranking enables only marked feature values to spread. But since that appears to be going on in (32), it must indeed be the case that /i/ lacks feature values altogether — thus having nothing to spread. (In (33), AGREE stands for the constraint requiring assimilation.)

(33) a. AGREE >> SPREAD[FEATURE VALUES], SPREAD[MARKED FEATURE VALUES]
all feature values will spread
b. SPREAD[FEATURE VALUES] >> AGREE, SPREAD[MARKED FEATURE VALUES]
no feature values will spread
c. SPREAD[MARKED FEATURE VALUES] >> AGREE >> SPREAD[FEATURE VALUES]
only unmarked feature values will spread

Through the markedness theory of Kiparsky 1994, we thus achieve Pulleyblank's result — without having to stipulate in advance that /i/ is underspecified. Descriptive adequacy forces underspecification, as it did in the three-way contrasts discussed earlier. The lexicon reflects the markedness constraints in the grammar.

A second Yoruba phenomenon supports underspecification of unmarked feature values in a different way. In (34a), vowel sequences arising via morpheme combination are simplified by the deletion of the first vowel in the sequence (Pulleyblank 1988:242):

(34)	a.	oní + ẹmu	→	ẹlẹmu	'palm-wine seller'
		ra + ọ̀gẹ̀dẹ̀	→	rọ̀gẹ̀dẹ̀	'buy bananas'
	b.	ní + oko	→	lóko	'at the farm'
		wo + ilẹ̀	→	wolẹ̀	'look at the ground'

If, however, either vowel in the sequence is /i/, as in (34b), /i/ deletes regardless of its position. According to Pulleyblank, this follows from the assumption that /i/, the unmarked vowel, is underlyingly unspecified for vowel features. Without extrinsic constraints on underlying representation, however, the underspecification stipulation is unavailable. But we *can* derive Pulleyblank's result through Lexicon Optimization. The constraints in (35) account for the deletion patterns in (34). *VV, ranked above PARSE, mandates vowel deletion; PARSE[MARKED FEATURE VALUES] mandates that /i/ is a better deletion target than a more marked vowel would be; KEEP V2 states that (all else being equal), the second vowel in the sequence is retained.

(35) *VV >> PARSE[FEATURE VALUES], PARSE[MARKED FEATURE VALUES]
PARSE[MARKED FEATURE VALUES] >> KEEP-V2

This grammar achieves the right result regardless of whether /i/ is fully specified for features underlyingly (36) or completely underspecified for features underlyingly (37):

(36)

	/wo + ilẹ̀/	*VV	PARSE[MARKED FEATURE VALUES]	PARSE[FEATURE VALUES]	KEEP-V2
☞a.	wolẹ̀			* (i)	* (i)
b.	wilẹ̀		*! (o)	* (o)	
c.	woilẹ̀	*! (oi)			

(37)

	/wo + Ilẹ̀/	*VV	PARSE[MARKED FEATURE VALUES]	PARSE[FEATURE VALUES]	KEEP-V2
☞a.	wolẹ̀				* (i)
b.	wilẹ̀		*! (o)	* (o)	
c.	woilẹ̀	*! (oi)			

Lexicon Optimization, invoked to adjudicate between these two equally adequate inputs, will choose the underspecified one (37) because it requires less gratuitous feature deletion in the grammar. Thus we achieve Pulleyblank's representational result— but we *derive* underspecification, instead of assuming it in advance.

Of course, unmarked feature values are not always underspecified. We've seen several such cases already in the paper, and another is cogently made by Itô, Mester and Padgett 1993, who propose the prespecification of redundant, unmarked voicing on nasals in Japanese. As shown in (38), initial obstruents voice in the second members of Japanese compounds (a) unless, as in (b), a voiced consonant already occurs in the word (Itô and Mester 1986). As shown in (a), nasal consonants do not count for this purpose, and are presumably underspecified for [voice] when the alternation takes place:

(38) Rendaku voicing (Itô and Mester 1986):

a.	ori + kami	→	origami	'paper folding'
b.	ore + kugi		*oregugi	'broken nail'

However, as Itô, Mester and Padgett 1993 show, obstruents which voice via obligatory assimilation to a preceding nasal, as in (39a), do block Rendaku voicing (b):

(39)

a.	kam + te	→	kande	'chewing'
	kaŋgae		*kaŋkae	'thought'
b.	širooto + kaŋgae		*širootogaŋgae	'layman's idea'

As Itô, Mester and Padgett 1993 observe, (39b) can be accounted for only if those nasals that precede obstruents *are* specified redundantly for [+voice] when the Rendaku alternations take place. Using Lexicon Optimization to derive optimal inputs on the basis of the grammar they develop, Itô, Mester and Padgett 1993, 1994 conclude that nasals are prespecified for [voice] exactly when they precede obstruents; otherwise, sonorants are unspecified for [voice] underlyingly. Exactly in the spirit of this paper, underspecification distinguishes the nasals which participate in alternations from those which do not.

To summarize, in Archiphonemic Underspecification the lexicon reflects the grammar. If, as we have been assuming, markedness is encoded in grammar, the lexicon will reflect markedness. But it will reflect it only weakly, when alternations permit. Crucially, markedness and predictability are clearly *not* predictors of underspecification.

3.4 Requires no constraints to hold expressly on underlying representation

A final virtue of Archiphonemic Underspecification is that it requires no constraints to be imposed directly on underlying representation, thus overcoming certain technical difficulties encountered by theories that attempt to impose such constraints. In (40)-(41) we consider two such proposals. The first assumes that lexical entries which are not appropriately specified (according to some constraint(s) on input which I'll abbreviate as "PROPER.SPEC(INPUT)") simply fail to be parsed.

(40) Possibility #1: The grammar fails to parse inappropriately specified inputs
PROPER.SPEC(INPUT) >> ALL OTHER CONSTRAINTS (including M-PARSE)

Only morphemes that satisfy PROPER.SPEC avoid the null parse (Prince and Smolensky 1993:48) and manage to surface.

This solution is, however, counter to the spirit of Optimality Theory, in which ill-formedness is repaired by the grammar rather than rejected outright. The use of the null parse that would be required differs from the use to which it is put by Prince and Smolensky 1993, who discuss hypothetical inputs in Latin to which the grammar would be intrinsically incapable of assigning a well-formed output. In (40), however, there is no reason to think the grammar could not assign an output to improperly specified inputs. The ranking in (40) simply stipulates that this is not to be done.

A second possible implementation of constraints on underlying representation is suggested by Prince and Smolensky 1993, who propose the *SPEC constraint in (41):

(41) *SPEC: Underlying material must be absent. (Prince and Smolensky 1993:196)

The function of this constraint, which is ranked sufficiently low never to result in the null parse or affect derivations, is simply to induce Lexicon Optimization to produce appropriate specified lexical entries. This is sketched in more general terms in (42), where *SPEC is replaced by the more neutral PROPER.SPEC(INPUT):

(42) Possibility #2: PROPER.SPEC(INPUT) exists only to affect Lexicon Optimization
M-PARSE>> PROPER.SPEC(INPUT)

The problem with this approach is that it simply stipulates an arbitrary solution to the problem we are trying to understand. The linguist, not the data, determines the contents of PROPER.SPEC. No predictions are made; the hypothesis cannot be tested.

In Archiphonemic Underspecification, the *data*, and the grammar arrived at on the basis of that data, are what determine underlying form. Unfalsifiable constraints like PROPER.SPEC are avoided altogether, a desirable result.

4. Implications of Archiphonemic Underspecification

This section discusses further implications of Archiphonemic Underspecification.

4.1 Some arguments for cyclicity disappear

The first implication is that it will no longer be as easy to base arguments for cyclicity on morphological sensitivity to derived phonological structure in the base. Affixal selection for such predictable properties as stress or syllable structure has often been cited as evidence for phonology-morphology interleaving (e.g. Kiparsky 1982, Hargus 1993, Booij and Lieber 1993, Booij 1994); if, however, the structure in question is nonalternating, then Archiphonemic Underspecification will prespecify it; thus reference to it by morphology does not require the cycle at all. (Of course, there is still abundant evidence for cyclicity; this particular kind will simply have to be reevaluated.)

4.2 Ternarity can no longer be taboo

A second implication is that we will have to overcome the ternarity taboo that has dogged phonologists since Stanley 1967. Kiparsky, for example, takes care to point out that his (1982) theory of underspecification avoids the dreaded ternary use of a binary feature, and in general ternarity is avoided at all costs.

The analyses proposed in this paper would have been anathema to Stanley 1967, whose objections to underspecification are still widely cited. However, they pose no problem for Archiphonemic Underspecification. I contend that Stanley's conclusions were based on premises which no longer hold (see Ringen 1975, Archangeli 1988 and Broe 1993 for similar reasoning and conclusions.) The first such premise is stated in (43):

(43) Premise #1: underspecification is used solely to eliminate morpheme-internal redundancy.

This premise entails that the ternary use of a binary-valued feature is illicit. Consider (44), in which segments differ only in their specification for a single feature:

(44)	*Segment #1	Segment #2	Segment #3
	[+F]...	[–F]...	[ØF]...

As Stanley observes, this configuration makes no sense given the premise in (43). If one or another value of [F] is redundant, as it must be given the existence of Segment #3, then either Segment #1 or Segment #2 is redundantly specified, violating Premise #1.

Of course, as we have seen in this paper, underspecification has uses beyond that in (43). If underspecification is used to distinguish potentially alternating segments from systematically nonalternating ones, then the configuration in (44) is perfectly legitimate.

The second premise is stated in (45):

(45) Premise #2: the grammar evaluation metric counts the number of features mentioned in rules; in the best grammar, the fewest features are mentioned.

This premise entails that underspecification causes grammars to fare better in terms of the evaluation metric (since [Ø] is an invisible feature value); because this sort of simplification is specious, Stanley argued, it should not be used.

But not all theories evaluate grammars by feature-counting. In particular, Optimality Theory *could* not; since constraints are universal, all grammars would rate identically. A theory which rejects Premise #2 is not bound by its entailment.

In conclusion, Stanley's conclusions are inapplicable to contemporary phonological theory, which rejects the premises from which those conclusions are derived. There is simply no good methodological or theoretical reason to avoid the ternary use of a binary feature, or underspecification in general.

4.3 The role of underlying representation in explanation

A final implication of Archiphonemic Underspecification is that it is no longer possible to say, as Chomsky and Halle (1968:234) did of the putative underlying velar fricative in English, that underlying representation "explains" phonological phenomena:

(46) "The same [velar fricative] might be used to explain various other exceptions to trisyllabic laxing, as in the boldface positions of *nightingale* and *mightily.* Furthermore, we can use it to explain alternations such as *resign-resignation* ..."

Rather, the *grammar* explains such phenomena. Underlying representation is simply an artifact of the grammar and the data. In the case of the velar fricative in English, this conclusion is probably welcome. In other cases, it may require some rethinking.

5. Conclusion

I would like to close with a quotation from an illuminating paper on underspecification by Steriade (1994) who, in a critique of "opportunistic" approaches to underspecification, said (p. 3):

(47) "One hopes...that any discrepancies in feature specification between lexical and surface structure follow from general principles, not descriptive convenience."

I have argued that underspecification is necessary, that grammar (and alternation)-blind principles of underspecification cannot be maintained, that segments with predictable surface alternants are underspecified, and that Optimization is the best available strategy for determining underlying representation. It may be convenient, but it is also principled.

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