The Grounding Hypothesis and Javanese Vowels*

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1.0 The Problem

Distinctive feature theory (e.g. Chomsky & Halle 1968) proposes a variety of properties of phonological features, for example, that they are distinct entities, that they combine to produce the individual sounds of natural human language, that they are referred to in formally stating the sound patterns of natural human language, and that they have acoustic and/or articulatory correlates.

Distinctive feature theory has met with considerable success in formally characterizing natural language phenomena. At the same time, there are a number of asymmetries in feature distribution which distinctive feature theory alone fails to account for. Logically, there are more combinations of features than naturally occur in language. Furthermore, specific combinations are common cross-linguistically, such as [+high, +ATR], while others are rare, such as [+low, +ATR]. In fact, there is a full spectrum of feature combinations, ranging from nonexistent to occurring in virtually every language. This spectrum is not simply a property of inventories: specific combinations have significant roles in sound patterns and the roles taken by the rare and the common feature combinations differ in substantive ways from each other. These asymmetries are unexpected under distinctive feature theory.

The Grounding Hypothesis (Archangeli and Pulleyblank 1994) addresses these asymmetries. The observations at the heart of the Grounding Hypothesis are that phonetically sympathetic combinations are likely to occur, likely to induce sound changes, and likely to be created by sound changes while phonetically antagonistic combinations are unlikely to occur (i.e. be rare), unlikely to induce sound changes, and unlikely to be created by sound changes.

In this paper, I exemplify the Grounding Hypothesis with several examples from the distribution of vowels in Javanese, using data from Dudas (1976). I first briefly review the grounded conditions that are relevant, namely those involving [high], [low], and [ATR]. (For full discussion, see Archangeli and Pulleyblank 1994). I then illustrate the effect of these conditions in the vocalic alternations in Javanese. Of particular interest is the demonstration that even where antagonistic feature combinations are permitted within a language, the preference for sympathetic combinations is evident in the nature of sound changes within the language. Although the discussion here is not framed in terms of Optimality Theory (Prince and Smolensky 1993, McCarthy and Prince 1993a, 1993b, 1994), the role of the grounded conditions in Javanese -- namely that although they may be violated under certain conditions, they hold under other conditions -- is exactly the "soft" role of constraints in Optimality Theory, where some constraints may be violated in order to satisfy more general requirements yet those same constraints hold over other, less general, requirements.

2.0 The Grounding Hypothesis & Tongue Root and Body Features

The Grounding Hypothesis (Archangeli & Pulleyblank 1994:177) is stated in (1).

(1) **The Grounding Hypothesis**

a. Feature cooccurrence conditions invoked by languages are phonetically motivated.
b. The stronger the phonetic motivation for a condition C
   i. the greater the likelihood of invoking C
   ii. the greater the likelihood of assigning a wide scope to C in the grammar,

   and vice versa.

The features of interest for vowel distribution in Javanese are [high], [low], and [ATR/RTR].[1] As reviewed in Archangeli and Pulleyblank (1994), the phonetic literature shows that tongue root position and tongue body position influence each other. In brief, the tongue root and tongue body are physically connected and tongue is essentially incompressible (Ladefoged et al. 1972). As a result, a gesture in one direction correlates with a compensatory gesture in another direction. Tongue body raising and tongue root advancement correlate with each other as do tongue body lowering and tongue root retraction. The conditions in (2) formally characterize these observations. Those in (2a-c) relate tongue body raising and tongue root position while those in (2d-f) relate tongue body lowering and tongue root position.

(2) **Grounded conditions**: the formal expression of these observations

a. HI/TR: If [+high] then ATR
If [+high] then *not* RTR

b. ATR/HI: If ATR then [+high]
If ATR then *not* [-high]

c. RTR/HI: If RTR then [-high]
If RTR then *not* [+high]

d. LO/TR: If [+low] then RTR
If [+low] then *not* ATR

e. RTR/LO: If RTR then [+low]
If RTR then *not* [-low]

f. ATR/LO: If ATR then [-low]
If ATR then *not* [+low]

There are ten further logically possible conditions involving these features. These conditions, however, are not phonetically grounded and so are predicted to never play a role in any

natural language. Archangeli and Pulleyblank (1994) propose that neither [-high] nor [-low] may be the antecedent of a grounded condition since these features do not require displacement of the tongue body.

(3) **Ungrounded conditions: predicted to never be invoked by any natural language**

a. If [+high] then RTR
   If [+high] then not ATR

b. If ATR then [-high]
   If ATR then not [+high]

c. If RTR then [+high]
   If RTR then not [-high]

d. If [-high] then ATR
   If [-high] then not RTR

e. If [-low] then ATR
   If [-low] then not RTR

f. If [+low] then ATR
   If [+low] then not RTR

g. If ATR then [+low]
   If ATR then not [-low]

h. If RTR then [-low]
   If RTR then not [+low]

i. If [-high] then RTR
   If [-high] then not ATR

j. If [-low] then RTR
   If [-low] then not ATR

With this background, we are now prepared to consider vowel distribution in Javanese.

3.0 Predictions for Natural Language Sound Patterns

3.1 **Low advanced vowels are rare.** One of the strongest expectations, resulting from the gradient strengths of grounding conditions (1b), is that low advanced vowels are rare. This is certainly true of Javanese (Dudas 1976): low vowels are retracted except in two well-defined contexts. The first is when a low vowel appears in word final position, where it surfaces as [ɔ]. The two left-hand columns in (4) show the retracted low vowels followed by suffixes while the right-hand column has the word-final advanced counterpart. (To help in

identification, the critical vowels are underlined in the data figures.)

(4) **Prediction: [+low, +ATR] are rare**

	[+low, -ATR]		[+low, +ATR]	
a.	djiwa̲ku	djiwa̲ne	djiwɔ̲	'soul, spirit'
b.	ŋija̲ni		ijɔ̲	'yes'
c.	ŋəna̲ni	ŋəna̲ʔake	kənɔ̲	'can, may'
d.	medja̲ku	medja̲ne	medjɔ̲	'table'
e.	pana̲s	mana̲sake	--	'hot'
f.	ada̲ŋ	ŋada̲ŋake	--	'steam'
g.	baka̲r	mbaka̲ri	--	'roast'

This pattern is part of a larger generalization, namely that word-final vowels are advanced in Javanese.

(5) **Final ATR vowels, not RTR vowels**

	final ATR		final RTR
a.	mɛri̲	'envious'	--
b.	wɔlu̲	'eight'	--
c.	kere̲	'beggar'	--
d.	bodjo̲	'spouse'	--

Thus, the behavior of low vowels in this position is simply a general property of vowels, not a property specifically of low vowels. The generalization, given in (6), is consistent with the Grounding Hypothesis because it does not single out low vowels for being ATR.

(6) **Word-final vowels (including /a/) are ATR** (*after* Uhlenbeck 1949):

V --> ATR / _____ #

One issue that immediately arises with this alternation is why a low advanced vowel is realized as homophonous with a retracted mid back vowel, [ɔ]. In fact, cross-linguistically, low vowels are realized with a variety of different pronunciations. As the table in (7) shows, the realization of low advanced vowels ranges across mid vowels, back, front, or central, and retracted or advanced. Archangeli and Pulleyblank (1994) hypothesize that these varied realizations arise because [+low] and ATR are the most antagonistic of the tongue root/tongue body antagonisms and as such are the most difficult to realize physically.

(7) **Expectation: pronunciation of [+low, +ATR] variable**

language	[+low, +ATR]	sources (also A&P 1994)
Chukchi	[e]	Kenstowicz 1979
Okpẹ	[ɛ] or [e]	Hoffmann 1973, Omamor 1988
Menomini	[ɛ]	Bloomfield 1962
Wolof	[ə]	Ka 1988
Kinande	[a] or [ə]	Mutaka 1991
Javanese	**[ɔ]**	Uhlenbeck 1949, Dudas 1976
Maasai	[o]	Tucker & Mpaayei 1955

The distribution of low advanced vowels is somewhat more complex. When both vowels in a words are low and the final vowel is advanced, the preceding vowel is also advanced, as shown in (8). The left-hand columns, with suffixes, shows that the root has two low vowels. The right-hand column, unaffixed, has a word-final low advanced vowel and here we see that the preceding low vowel is also advanced: [djɔgɔ], *[djagɔ], 'guard, watch'.

(8) **Advanced harmony in low vowels**

	[+low, -ATR]		[+low, +ATR]	
a.	ndjag̱aṉi		djɔg̱ɔ̱	'guard, watch'
b.	ŋg̱aw̱aṉi	ŋg̱aw̱aʔake	g̱ɔw̱ɔ̱	'bring'
c.	ḵaṉtj̱aku	ḵaṉtj̱ane	ḵɔṉtj̱ɔ	'friend'
d.	ḻaṟane	ḻaṟaʔake	ḻɔṟɔ̱	'ill, painful'

I assume that this phenomenon is part of a general tongue root harmony pattern, whereby two identical vowels share the same tongue root position, namely that of the second vowel. I return to this harmony, and the exceptions to it, in section 3.3, where mid vowels are also discussed.

3.2 **High retracted vowels are possible, but also likely to be restricted in their distribution.** The Grounding Hypothesis predicts that in general high vowels are advanced, not retracted. In Javanese, we find that retracted high vowels do have a restricted distribution, similar to the advanced low vowels. In Javanese, high vowels are usually retracted in closed syllables. (I refine this generalization below.)

(9) **Prediction: [ɪ, ʊ] are possible, but also restricted**

	[+hi, +ATR]	[+hi, -ATR]		
a.	api̱ʔe	apɪʔ	apɪ̱ʔku	'good, nice'
b.	ndjupu̱ʔɔ	djupʊ̱ʔ		'go get'
c.	kluwu̱ŋe	kluwʊ̱ŋ		'rainbow'
d.	nuli̱sɔ	tuli̱s		'write'
e.	wiwi̱tan	wiwi̱t		'beginning'
f.	buri̱			'back, rear'
g.	ibu̱			'mother'
h.		muri̱t	muri̱tku	'student'
i.		tandʊ̱ʔ	tandʊ̱ʔku	'actions'

As noted in Archangeli and Pulleyblank (1994), the restricted distribution of retracted high vowels is found in a variety of languages, for instance Kinande (Mutaka 1991, Archangeli and Pulleyblank in prep), Menomini (Bloomfield 1962, Archangeli and Suzuki 1995), and Lango (Woock & Noonan 1979, Poser 1982).

In Javanese, although high vowels are typically retracted in closed syllables, there are exceptions. In the elative, the last vowel of the root is high, regardless of its original height, and advanced, regardless of the syllable structure. Thus, for example, the elative of [aŋɛl] 'hard, difficult' is [aŋil], with an advanced high vowel in the final syllable.[2]

(10) **Exceptions to [+high, -ATR] vowels in closed syllables: Elative Formation**

	adjective	elative	
a.	wani	wani	'bold'
b.	rinḍi?	rinḍi?	'slow'
c.	rame	ramì	`noìsy`
d.	*aŋɛl*	*aŋil*	*'hard, difficult'*
e.	edan	edin	'crazy'
f.	rosɔ	rosu	'strong'
g.	abɔt	abut	'heavy, hard'
h.	idjo	idju	'green'
i.	lurʊs	lurus	'straight'
j.	lugu	lugu	'ordinary'

The generalization about the elative is that the final vowel is [+high] and that the grounding conditions HI/TR and ATR/HI are both satisfied -- the final high vowel of the elative is always advanced.

(11) **Elative Raising**

$$V \text{ --> } [+high] \text{ / } \_\_\_(C)]_{elative} \text{ subject to HI/TR}$$

3.3 **Mid vowels, advanced and retracted, occur more freely.** The final general prediction is that mid advanced and retracted vowels occur relatively freely. This is because grounded conditions refer to both nonlow vowels and nonhigh vowels, and mid vowels are included in both groups. For example, RTR/HI states in part *if RTR then [-high]* and ATR/LO states in part *if ATR then [-low]*. In Javanese, we see that retracted mid vowels occur in a variety of environments, but otherwise mid vowels are advanced. First, in final closed syllables, mid vowels are retracted.

(12) **[ɛ] and [ɔ] in final closed syllables**

a.	idjɛ̲n	'alone'
b.	djeŋgɔ̲t	'beard'
c.	katɔ̲n	'appear'
d.	doŋɛ̲ŋ	'story'

Recalling the distribution of retracted high vowels in surface closed syllables (see (9) above), the generalization is simply that vowels are retracted in closed syllables: height is irrelevant.

(13) **Closed Syllable Retraction**

V --> RTR / ___C]▲

This observation is consistent with the Grounding Hypothesis since all vowels are treated alike. Although the effect in part is to create ungrounded high retracted vowels, the generalization does not overtly state that ungrounded vowels are created.

However, there is more to the story. Mid vowels -- but not high vowels -- are retracted if they are in "underlying" closed syllables, even when those syllables are open at the surface. Compare the two columns in (14). The first column shows an unaffixed root which ends with a mid vowel in a closed syllable. The second column shows the same root with a

vowel-initial suffix. The final root vowel is now in an open syllable, but the vowel is nonetheless retracted.

(14) **[ɛ] and [ɔ] in "underlying" closed -- but *surface open* -- syllables**

	closed syllable	open syllable	
a.	idjɛ̲n	ŋidjɛ̲ni	'alone'
b.	djeŋgɔ̲t	djeŋgɔ̲te	'beard'
c.	katɔ̲n	ŋatɔ̲ni	'appear'
d.	doŋɛ̲ŋ	doŋgɛ̲ŋe	'story'

The generalization here is that prior to affixation, RTR is assigned to closed syllables without violating HI/TR (in particular, *if [+high] then not RTR*). After affixation, the effect is more pervasive: RTR is assigned to closed syllables.[3]

(15) **Lexical Retraction**

V --> RTR / ___C]▲ subject to HI/TR, pre-affixation

Of particular significance is the fact that Javanese allows retracted high vowels [ɪ, ʊ] to surface, yet it does not allow the lexical tongue root retraction pattern to affect high vowels. *HI/TR holds of this pattern even though [ɪ,ʊ] exist in Javanese!*

The saga of mid vowels continues. If a word is of the shape CV_iCV_iC, and V_i is mid, then both vowels are retracted, not just the vowel in the final syllable. This general type of harmony has already been seen, with low advanced vowels (8). (CVC▲ words are extremely rare, and even more rare are words with mid vowels in the initial closed syllable. See footnote 4.) The data in (16a-d) show this pattern. The forms in (16e-f) show that if the mid vowels are different, retraction only affects the vowel in the closed syllable.

(16) **[ɛ] and [ɔ] in open syllables preceding [ɛ] or [ɔ] respectively**

a.	bɔ̲bɔ̲t	'weight'	
b.	ɛ̲ntjɛ̲r	'thin' (of liquids)	
c.	kɔ̲ḍ̲ɔ̲ʔ	'frog'	
d.	lɛ̲rɛ̲n	'stop, rest'	
e.	djɛ̲ŋgɔ̲t	'beard'	*djɛ̲ŋgɔ̲t
f.	dɔ̲ŋɛ̲ŋ	'story'	*dɔ̲ŋɛ̲ŋ

Recall from (8) that low vowels undergo advanced harmony: if the two vowels of a root are low and the second is advanced, the first is also advanced. With low and mid vowels, then, otherwise identical vowels are also identical with respect to tongue root position.[4]

(17) **Tongue root harmony in nonhigh identical vowels**

	ATR-ATR	ATR-RTR	RTR-ATR	RTR-RTR
E	ḍeḍe	*	*	ɛntjɛr
A	lɔrɔ	*	*	adaŋ
O	bodjo	*	*	bɔbɔt

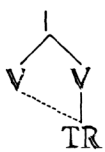
The picture differs when we consider identical high vowels. Here, there is agreement if both vowels are advanced (a-c), but there is no agreement if one vowel is retracted (d-f). (As already noted, words of the shape CVC▲ are extremely rare. The result here is that retracted high vowels are found only in the final syllable.)[5]

(18) **No RTR harmony in identical high vowels**

a.	titi	'careful'	
b.	tuku	'buy'	
c.	lugu	'ordinary'	
d.	djʊ̲pʊ̲ʔ	'go get'	*djʊ̲pʊ̲ʔ
e.	lʊ̲rʊ̲s	'straight'	*lʊ̲rʊ̲s
f.	rɪ̲nḍɪ̲ʔ	'slow'	*rɪ̲nḍɪ̲ʔ

The overall generalization is that there is TR harmony on otherwise identical vowels, provided that HI/TR is not violated: retracted high vowels are not created. *HI/TR holds of RTR harmony even though [ɪ,ʊ] exist in Javanese!*[6]

(19) **TR Harmony: subject to HI/TR**



The restriction is grounded. However, the restriction is only partial: (ungrounded) advanced low vowels are a possible result of this harmony because here there are no restrictions placed on low vowels.

A fifth environment for retracted mid vowels is in open syllables preceding high advanced vowels, illustrated below.

(20) **[ɛ] and [ɔ] in open syllables before [+high, +ATR] vowels**

a.	klɛ̲ru	'mistaken'
b.	kɔ̲pi	'coffee'
c.	mɛ̲ri	'envious, envy'
d.	wɔ̲lu	'eight'
e.	ɛ̲ntʊʔ	'get, obtain'

This appears to be a type of dissimilation for the effect is to maximize the difference between the two vowels, without creating any ungrounded vowels. Assigning RTR to nonhigh vowels is consistent with RTR/HI. The high advanced vowels that induce the change are picked out by ATR/HI and HI/TR.

(21) **Mid Retraction**

$$V \text{ --> } RTR \text{ / } \_\_\_ \ C_0 \ V$$

undergoing V subject to RTR/HI
triggering V subject to ATR/HI, HI/TR

In (20e) above, the vowel [ʊ] is due to the general phenomenon of retraction in closed syllables. This vowel violates HI/TR and RTR/HI; nothing further happens in this case. It is only the grounded advanced high vowel that induces the change. Furthermore, the effect on mid vowels is consistent with the Grounding Hypothesis.

The final mid vowel effect is found in the causative. Preceding the causative suffix [-ʔake], mid vowels are retracted, even if they are in open syllables.

(22) **Causative retraction** (refined below)

$$V \text{ --> } RTR \text{ / } \_\_\_]_{causative}$$

This is illustrated in (23a-d). Note that in these forms, the two vowels are identical and RTR harmony obtains between them.

(23) **Mid vowel changes in the causative**

		causative	
a.	bo̱do	mbɔ̱do̱ʔake	'stupid'
b.	bodjo	mbɔ̱djɔ̱ʔake	'spouse'
c.	ḍe̱ḍe	nḍɛ̱ḍɛ̱ʔake	'sun oneself'
d.	kere	ŋɛ̱rɛ̱ʔake	'beggar'

The oddity with the causative is finding retracted vowels in open syllables. However, once retraction is introduced, the harmony is perfectly regular: the otherwise identical mid vowels agree in tongue root position (see (19)).

The effects with high vowels are more entertaining, (24). The causative suffix also retracts high vowels. However, the net result of causative retraction on high vowels is not a *high* retracted vowel, but rather a *mid* retracted vowel.

(24) ***High vowel changes in the causative***

		causative	
a.	ɛlu̲	ŋelɔ̲ʔake	'accompany'
b.	mɛri̲	mɛ̲rɛ̲ʔake	'envious, envy'

We can understand this as satisfying both Causative Retraction (22) and RTR/HI: *if RTR then not [+high].* Causative Retraction is satisfied because the vowel is RTR. RTR/HI is satisfied because the retracted vowel is not high, but mid.

(25) **Causative retraction** (final)

$$V \text{ --> } RTR \text{ / } \_\_\_]_{causative}$$

result subject to RTR/HI

Again, the story continues. The erstwhile high advanced vowel fails to retract a preceding mid vowel (recall (20)): the [ɛ] of [ɛlu] shows up as [e] in [ŋelɔʔake]. A consequence is that the retraction of the initial [ɛ] in [mɛrɛʔake] cannot be due to the underlying final advanced high vowel. It must be due to some other cause. The most likely candidate is tongue root harmony, (19). Since the final high vowel has become mid, there is now a sequence of identical mid vowels and tongue root harmony holds. Both vowels are retracted.

For our purposes, the most significant fact about the causative is that all effects are achieved without creating an

ungrounded combination, and specifically without violating HI/TR. Rather, vowel height changes in order for both causative retraction and grounding to be satisfied. A preceding high vowel is realized as [-high]. A preceding nonhigh vowel (regardless of its source) is retracted. The result is that no high retracted vowels are created. *Again, Javanese admits [ɪ, ʊ], but does not allow this process to result in [ɪ, ʊ]!*

4.0 CONCLUSION

The Grounding Hypothesis formalizes the role of phonetic predispositions in phonological systems, without involving the full range of phonetic gradience. The essence of the Grounding Hypothesis is that phonetic sympathies and antagonisms between features exists and that phonological systems respect these sympathies and antagonisms in their own ways.

One of the most interesting predictions of the Grounding Hypothesis is that even where antagonistic feature combinations are permitted within a language, the preference for sympathetic combinations is evident in the nature of sound changes within the language. The varied tongue root and tongue height alternations in the Javanese vowel system is a particularly interesting example of this facet of the Grounding Hypothesis. Despite the range of effects seen in this language, involving low, mid, and high vowels in different ways, not one of the effects requires specific reference to an ungrounded combination of features. Javanese allows [+low, +ATR] vowels, but only in specific environments. Javanese allows [+high, -ATR] vowels, but only in specific environments. Javanese minimizes the incidence of antagonistic combinations, without an outright prohibition on them.

This property of the Grounding Hypothesis is near to the heart of Optimality Theory. A basic tenet of Optimality Theory is that languages hierarchize their constraints so that constraints of lesser rank may be violated only if such violation is necessary in order to satisfy a higher ranked constraint. We see this same type of effect with the grounded conditions in

Javanese. For example, the condition prohibiting retracted high vowels, HI/TR, may be violated in order to satisfy the desire for vowels in closed syllables to be retracted, yet it may not be violated simply to satisfy RTR harmony.

Notes

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[1]I am assuming that tongue root advancement is best expressed in terms of two features, ATR for advanced tongue root and RTR for retracted tongue root. Nothing in the discussion of Javanese hinges on this assumption however.

[2]As is discussed in section 3.3, mid vowels are advanced in open final syllables. Thus, in (10f) the final vowel must be an underlying low /a/, which surfaces as [ɔ] since it is word-final. Interestingly, in the elative this vowel corresponds to [u] ([rosɔ] - [rosu]) while the [a] in (10e) corresponds to an elative [i] ([edan] - [edin]). The suggestion is that the underlying final low /a/ has literally become a mid vowel. However, were that the case, then it is puzzling why there is no TR harmony between the otherwise identical mid vowels in a word like [rosɔ] 'strong' (10f). At this point, I have no formal explanation for this phenomenon.

[3]A complete formal analysis of the tongue root phenomena in Javanese must take into account the distinction between the "pre-affixation" and "post-affixation" retraction patterns. See Schlindwein (1988) for discussion of the comparable phenomena in Eastern Javanese.

[4]We might expect RTR-ATR sequences if the first syllable is closed and the second open. Dudas (1976:10-11) notes "...in native vocabulary, only the vowels a̲ and ə̲ are usually found in penultimate syllables...[W]hen other vowels are found in this position...the word is felt to be either "non-native" (i.e. borrowed) or "old"...and accordingly seems to fall outside the scope fo the normal phonological rules of the language." Nonetheless, borrowed words, such as *bɛnsɪn* 'gasoline' and

dɪkte 'dictation', follow the general pattern of retraction in closed syllables.

[5]Dudas (1976)offers one exception that her informant considered to be a native word, *gʊrdi* 'drill'. Note that the high vowel is lax in the closed syllable.

[6]This same generalization takes care of harmony induced when high vowels are lowered to mid retracted vowels [ɛ] or [ɔ]. See the discussion of (23).

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