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Phonetic Evidence for Configuration Constraints

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PHONETIC EVIDENCE FOR CONFIGURATION CONSTRAINTS*

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1. Introduction

An area of interest in the recent phonological literature has been the degree of specification in phonological representations. Much evidence has been presented that full specification in underlying representations does not lead to an insightful view of phonology; yet there is much debate in the literature as to the degree of underspecification allowed, the way that underspecification should be constrained or restricted, and how rules interact with representations which are not fully specified (cf. Kiparsky 1985, Archangeli & Pulleyblank 1986, Steriade 1987, Christdas 1988, and Mester and Itô 1988, for discussion of these issues.)

Once one assumes that there might not be full specification in the phonology, a related question arises: what is the degree of specification leaving the phonology? Even under views of extreme underspecification, it has generally been assumed that there is full specification leaving the phonology, due to default fill-in rules. However, it has been argued that it is necessary to abandon the assumption of full specification leaving the phonology (cf. Pierrehumbert 1980 and Keating 1985, 1988). In this article, I will show, based on phonetic evidence from nasalization in Sundanese (an Indonesian language, spoken in West Java), that a certain level of underspecification must be maintained throughout the phonological derivation.

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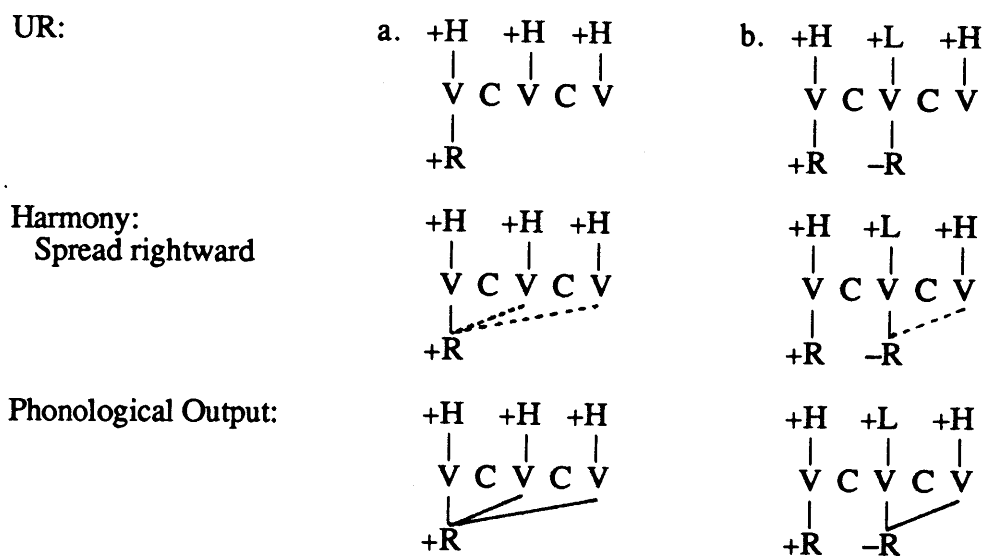
These results have direct consequences for the issue of how blocking effects in cases of long distance phonological spreading should be formally represented. The observed blocking effects of certain segments in Sundanese are argued to be due to general structural constraints rather than a result of redundant feature specification.

Let us start by considering the question of how blocking effects in phonological spreading (e.g. vowel harmony and nasal harmony) might be accounted for. What is at issue is the fact that in most harmony rules, some classes of segments are amenable to the harmony and others prevent further spreading. Consider a simple example.[1] In a vowel harmony system which harmonizes for the feature [round], all vowels in a word would typically agree in rounding: roots such as *iti* and *utu* would be well-formed, but **itu* or **uti* would not be. It is often observed that there are systematic exceptions to such patterns, with forms such as *utati* being well-formed. In such cases, /a/, being [+low], does not contrast for the feature [round] and in effect stops the harmonizing of the feature. The phoneme /a/ is then said to block the harmony or to be opaque to the harmony.

Since the development of autosegmental theory (Goldsmith 1976, Clements 1976), harmony has been widely viewed as spreading of an autosegmental feature (in contrast to previous views where harmony was thought to be feature changing). Following this view, blocking effects are commonly assumed to be due to the presence of a redundant feature specification. This view, which I call the Redundant Specification Approach, is schematized in (1), where I assume a rule which spreads [+round] rightward:

(1) Redundant Specification Approach R = [round], H = [high], L= [low]



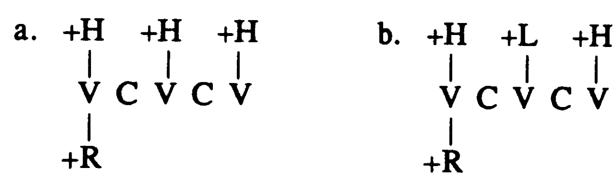
[1] The following example is a schematic version of a vowel harmony system. The facts are not unlike a simplified version of Turkish. For a discussion of Turkish vowel harmony in the context of views of underspecification, cf. Mester and Itô (1988).

In the underlying representation, [+round] occurs on some segments, some segments are unspecified for [round], and some are redundantly specified for [–round]. In (1a), the first segment is specified for [+round], but the following two segments are unspecified. The harmony rule spreads [+round] to both of these segments, giving the phonological output as shown. In (1b) the first segment is specified as [+round], the second is redundantly specified as [–round] (since /a/ does not contrast for rounding) and the third segment is unspecified. Here spreading of [+round] is blocked, by the prohibition on crossing of association lines. Assuming the rule is a symmetrical one, [–round] would spread to the final segment, giving the output as shown. This approach accounts for these types of patterns, but results in an unconstrained view of feature specification, since +, –, and Ø values are all used in the underlying representation of a single feature, a three-way distinction for a binary feature. Additionally, as will be shown below, this approach is empirically inadequate in accounting for the facts of nasalization in Sundanese.

Recently the nature and formal properties of phonological feature (under)specification have received extensive attention in the literature. Two approaches to underspecification have played a central role in the discussion: (a) the approach taken by Kiparsky (1985) and Archangeli and Pulleyblank (1986), often referred to as "Radical Underspecification", in which no reference is made underlyingly to either redundant or unmarked values; following this view, the unmarked value of a feature cannot be referred to underlyingly or in the phonology, until filled in by rule; (b) the approach taken by Steriade (1987), Redundant Value Underspecification, where in case of contrast, both feature values may be referred to in the underlying representation, but in the case of redundant specification, only one value is referred to.[2] Two important consequences of these two types of theories of underspecification are the following: (a) No redundant values are present in the underlying representation; and (b) default values must be assigned before phonological rules can refer to predictable values. Following such views, blocking effects in phonological rules cannot be achieved by the presence of a redundant value. The consequence is that the underlying representation for two forms such as those in (1) would be identical with respect to the representation of the particular feature (in this example [round]) as shown in (2):

(2) Underspecification Approach

UR:

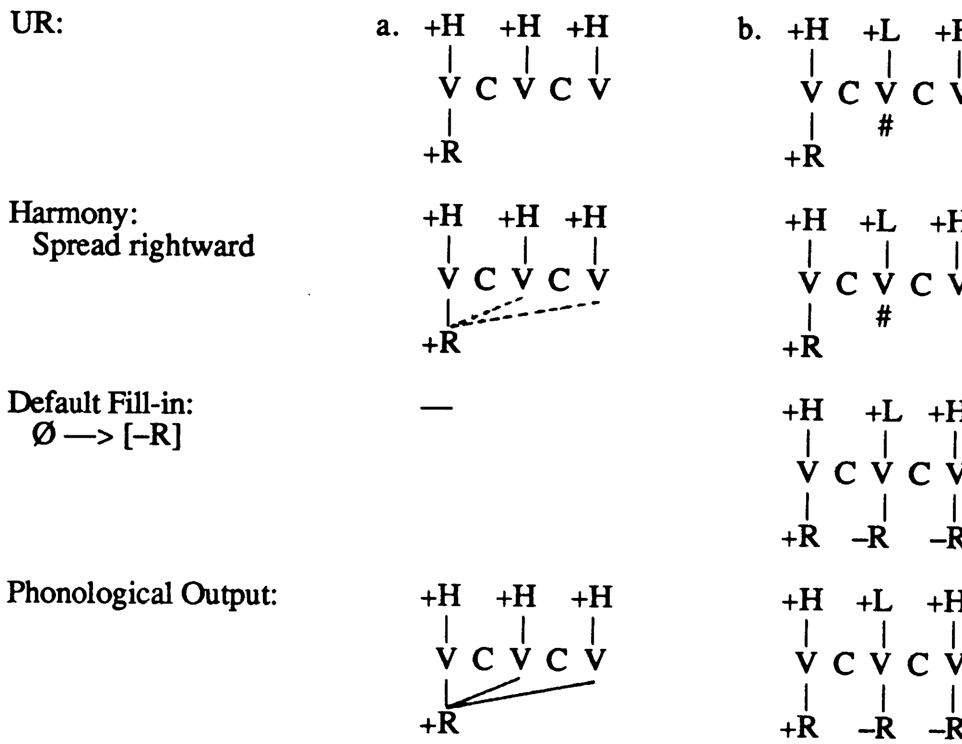


To maintain this type of view of underspecification, one in which redundant values do not occur underlyingly, one must appeal to more general structural principles to account for the different outputs in forms such as (1a) and (1b). Archangeli and Pulleyblank (1986) propose configuration constraints to account for

[2] Mester and Itô (1988) provide a lucid discussion of the development of underspecification theory and a comparison of these two views.

precisely such differences. Informally, a configuration constraint is defined as follows: a value α of feature F can/cannot co-occur with a value β of feature G. Such constraints may hold either lexically or both lexically and phrasally.[3] To account for the facts under consideration, a configuration constraint—[+round] cannot co-occur with [+low]—might be in effect. Following this approach, derivations would be as presented in (3) (where a # is used to indicate that such a configuration constraint is in effect.):

(3) Underspecification Approach R = [round], H = [high], L= [low]



In (3a), the derivation is similar to (1a). The unspecified segments get their values through spreading, bleeding the Default Fill-in rule which fills in unspecified segments at the end of the derivation. However in the case of (3b), there is no [–round] value present, rather there is a more general principle in effect in the grammar which says that [+round] cannot co-occur with [+low]; let us assume this holds lexically (in addition to underlyingly). Harmony is blocked by the configuration constraint. The unspecified segments then receive the redundant value by the Default Fill-in rule, giving the output as shown (effectively the same as in (1b)).

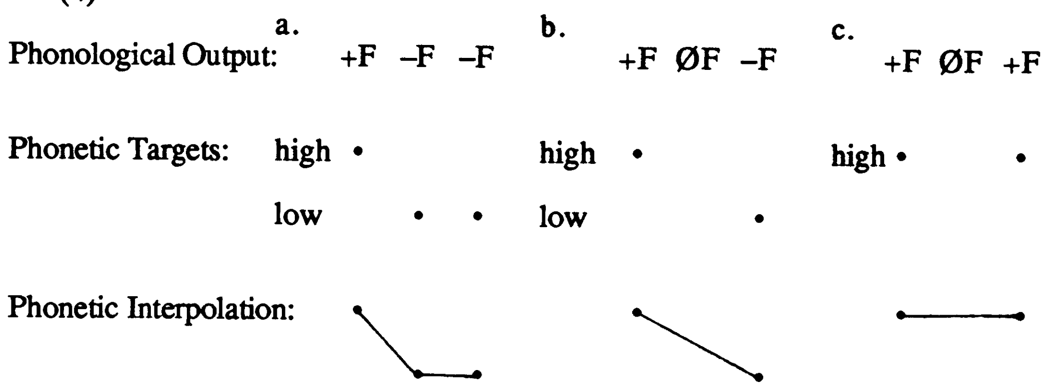
The choice of the Redundant Specification Approach or the Underspecification Approach for accounting for blocking effects has often

[3] This is not unlike Kiparsky's (1985) principle of Structure Preservation, but it differs in its formalization and makes different predictions about the role of such constraints in certain parts of the grammar.

depended on theoretical assumptions as to whether there is predictable information in the lexicon. Here I present a different motivation for maintaining underspecification of predictable values. In order to account for the phonetic facts of nasalization in Sundanese, I argue that blocking in the phonology must be due to general structural principles, not to redundant specifications.

First, it is important to make explicit certain assumptions about the relationship between phonology and phonetics. I assume that the mapping from phonology to phonetics consists of feature values leaving the phonology being translated into phonetic targets (cf. Pierrehumbert 1980): a + value translates to relatively more of the physical value that implements a particular feature than a – value. Second, in order to account for many observed phonetic effects, it is necessary to abandon the assumption that there is full specification leaving the phonology (Pierrehumbert 1980 and Keating 1985, 1988). Thus a + value of a feature should translate to a relatively high level; a – value to a low level, and an unspecified value would be expected to be determined by phonetic context. The rules of the phonetics evaluate the targets and connect them through interpolation. Three examples are given below:

(4)



In (4a) the form is fully specified for [F] leaving the phonology. Targets are assigned, along some scale for the particular feature. These targets are then hooked up through interpolation, showing a fairly rapid transition between the neighboring high and low targets. In (4b), the first segment is [+F], the second segment is unspecified leaving the phonology and the final segment is [–F]. Only the first and last segments receive phonetic targets. There is interpolation between the targets and the middle segment receives a transitional amount of feature [F] from the phonetic context. In (4c), both the first and last segments are specified as [+F] and the middle segment is again unspecified. Targets are assigned and in this case, there is interpolation straight through the middle segment. The unspecified segment receives a high amount of feature [F] through phonetic context, giving the (erroneous) impression that it had a relatively high target, when in fact it has no target of its own. With the theoretical background laid out, we are now ready to turn to the facts of nasalization in Sundanese.

2. Sundanese: Phonological Data and Analysis

As described by Robins (1957) and since discussed widely in the phonological literature, Sundanese has a rule of Nasal Spread: within the word, [+nasal] spreads rightward from a nasal consonant, until blocked by a supra-laryngeal consonant. Let us consider first the phonological facts. Representative examples are given in (5). Here | | is used to indicate phonological output as distinct from the phonetic output.

(5)

		Phonological Output	
a.	/ɲiar/[4]	|ɲĩãr|	'seek' (active)
	/ɲaur/	|ɲãũr|	'say' (active)
	/ɲaian/	|ɲãĩãn|	'wet' (active)
	/niis/	|nĩʔĩs|	'relax in a cool place' (active)
	/nuus/	|nũʔũs|	'dry' (active)
b.	/mahal/	|mãhãl|	'expensive'
	/mihak/	|mĩhãk|	'take sides' (active)
c.	/ŋatur/	|ŋãtur|	'arrange' (active)
	/ŋudag/	|ŋũdag|	'pursue' (active)
d.	/ŋuliat/	|ŋũliat|	'stretch' (active)
	/ŋaluhuran/	|ŋãluhuran|	'be in a high position' (active)
	/marios/	|mãrios|	'examine' (active)
	/ŋarahɨtan/	|ŋãrahɨtan|	'wound' (active)
e.	/ŋiwat/	|ŋĩwat|	'elope'
	/ŋawih/	|ŋãwih|	'sing' (active)
	/ŋayak/	|ŋãyak|	'sift' (active)

In (5a) there are examples of Nasal Spread from a nasal consonant onto a following sequence of vowels; and in (5b) there is spreading through a sequence of vowel-/h/-vowel. But, as shown in (5c), Nasal Spread is blocked by supra-laryngeal stops; as shown in (5d), it is blocked by liquids, both /r/ and /l/; and finally, as shown in (5e), it is blocked by glides, /w, y/. Thus we see that Nasal Spread is indeed blocked by non-nasal supra-laryngeal consonants.

Following the assumptions of Lexical Phonology (cf. Kiparsky 1982), Nasal Spread is shown to be a lexical rule by its interaction with morphology; it both precedes and follows infixation. This is exemplified here with the productive process of pluralization—infixation of *=ar=/ =al=*. The conditions on this regular phonological alternation are tangential to our discussion. Examples are presented in (6), where infixed forms, the plurals corresponding to the forms in (5), are

[4] In these examples, morphological structure not directly relevant to the discussion is not indicated.

presented. In each case, the infix occurs after the initial segment. There is nasalization of the vowel of the infix as well as the vowels of the root. We see here surface violations of the generalization that /r/ and /l/ block Nasal Spread, in that Nasal Spread overapplies: there is nasalization on the vowels following the liquid of the infix.

(6)

<table>
<tr><th></th><th>Singular</th><th>Phonological Output</th><th></th><th>Plural</th><th>Phonological Output</th></tr>
<tr><td>a.</td><td>/ɲiar/</td><td>|ɲĩãr|</td><td>'seek' (active)</td><td>/ɲ=al=iar/</td><td>|ɲ=ãl=ĩãr| [5]</td></tr>
<tr><td></td><td>/ɲaur/</td><td>|ɲãũr|</td><td>'say' (active)</td><td>/ɲ=al=aur/</td><td>|ɲ=ãl=ãũr|</td></tr>
<tr><td></td><td>/ɲaian/</td><td>|ɲãĩãn|</td><td>'wet' (active)</td><td>/ɲ=ar=aian/</td><td>|ɲ=ãr=ãĩãn|</td></tr>
<tr><td></td><td>/niis/</td><td>|nĩʔĩs|</td><td>'relax in a cool place' (active)</td><td>/n=ar=iis/</td><td>|n=ãr=ĩʔĩs|</td></tr>
<tr><td></td><td>/nuus/</td><td>|nũʔũs|</td><td>'dry' (active)</td><td>/n=ar=uus/</td><td>|n=ãr=ũʔũs|</td></tr>
<tr><td>b.</td><td>/mahal/</td><td>|mãhãl|</td><td>'expensive'</td><td>/m=ar=ahal/</td><td>|m=ãr=ãhãl|</td></tr>
<tr><td></td><td>/mihak/</td><td>|mĩhãk|</td><td>'take sides' (active)</td><td>/m=ar=ihak/</td><td>|m=ãr=ĩhãk|</td></tr>
</table>

As shown in (7), cyclic application, but not non-cyclic application, accounts for the apparent overapplication of Nasal Spread:

<table>
<tr><th>(7)</th><th>Non-cyclic Application</th><th>Cyclic Application</th><th></th></tr>
<tr><td>Input:</td><td>/ɲaliar/</td><td>Cycle 1:</td><td>/ɲiar/</td></tr>
<tr><td>Nasalization:</td><td>ɲãliar</td><td></td><td>ɲĩãr</td></tr>
<tr><td></td><td></td><td>Cycle 2:</td><td>ɲ=al=ĩãr</td></tr>
<tr><td>Nasalization:</td><td>NA</td><td></td><td>ɲ=ãl=ĩãr</td></tr>
<tr><td>Phonological Output:</td><td>*|ɲãliar|</td><td></td><td>|ɲãlĩãr|</td></tr>
</table>

Following the assumptions of Lexical Phonology (Kiparsky 1982), the fact that Nasal Spread applies cyclically follows from its interaction with morphology (applying in the characteristic fashion of lexical rules). These facts can be accounted for in a rule in which the feature value [+nasal] spreads rightward, cyclically:

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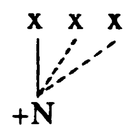
[5] Those familiar with the data presented by Robins (1957) will note that my data differs slightly in that I do not indicate denasalization of the first vowel following the liquid of the infix. There is evidence in my data that this process of denasalization is actually the result of a phonetic, not a phonological rule, and therefore it is not represented at this level of representation.

North East Linguistics Society, Vol. 18 [1987], Art. 6

(8) Nasal Spread:  applies cyclically

In order to consider the effects of consonants on spreading, I present the consonant inventory of Sundanese in (9):

(9) Sundanese Consonant Inventory

p	t	c	k		
b	d	j	g	[–nasal]	
	r				[–continuant]
m	n	ɲ	ŋ	[+nasal]	
		s			
	l				[+continuant]
w		y			
				h	

Following current views of the representation of /h/ (e.g. Clements 1985), I assume that /h/ is unspecified for [continuant]. Note that [nasal] is only distinctive for [–continuant] segments. Also, in terms of nasalization, /r/, a trill, patterns with the [–continuant] segments.[6] As shown above in (5), both [–continuant] and [+continuant] supra-laryngeal consonants block Nasal Spread ((5c) and (5d&e) respectively), yet [+nasal] is distinctive for [–continuant] segments and predictable for [+continuant] ones. This observation must be accounted for in the analysis. I argue that the blocking effects of the distinctive segments (those which are [-continuant]) and the predictable ones (those which are [+continuant]) are due to different formal mechanisms.

At the point that Nasal Spread applies, [–continuant] segments are specified for [nasal]. This can be accounted for either by early fill-in rules, following the approach taken by Archangeli and Pulleyblank (1986), or by assuming that for those classes of segments where a particular feature is contrastive, both values may be specified underlyingly, following Steriade (1987). Steriade's approach has an intuitive appeal here, as it is precisely the class of [–continuant] segments in which [nasal] is contrastive that both + and – specifications for [nasal] are necessary to capture the facts of Nasal Spread.

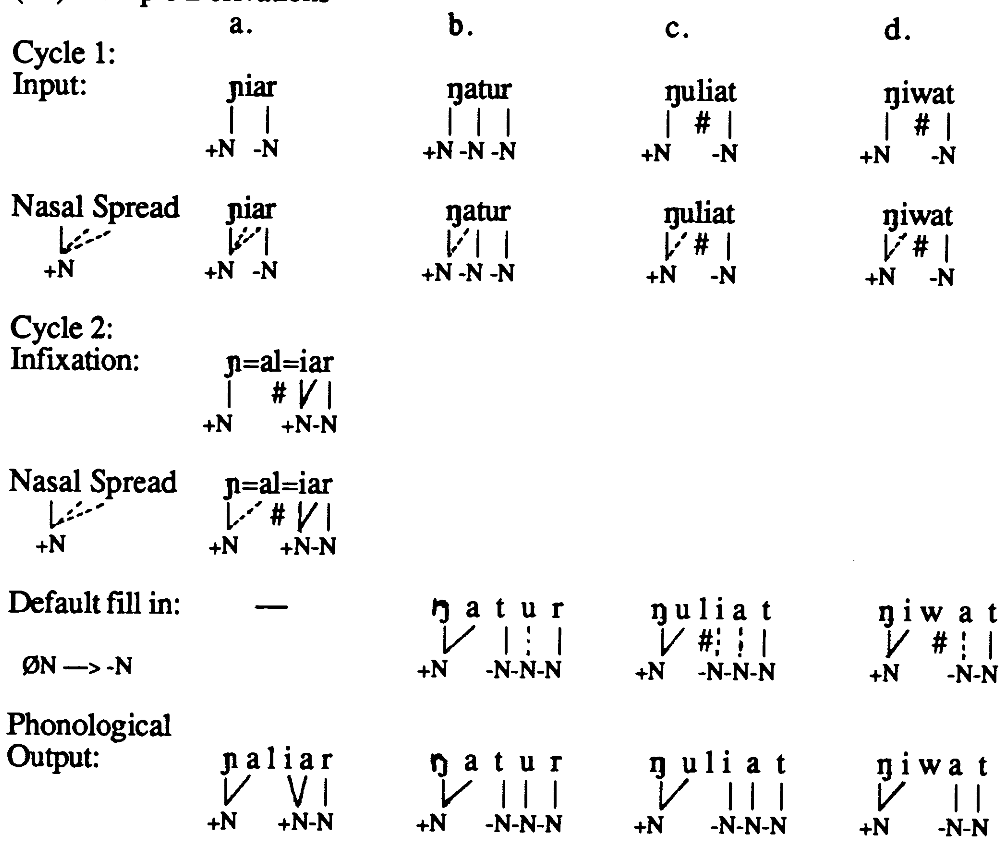
To account for the fact that [+continuant] consonants also block Nasal Spread, I assume that there is a configuration constraint as shown in (10):

[6] It is possible that the patterning of /r/ with the [-continuant] segments is a phonetic fact, not a phonological one. I will not pursue this issue here; for discussion of this point, cf. Cohn (forthcoming).

(10) *[nasal]
|
[+consonantal
+continuant]

The feature [nasal] cannot co-occur with [+consonantal] and [+continuant] (assuming that glides are [+consonantal]). This configuration constraint captures a cross-linguistic observation (which has very few exceptions) that [+continuant] consonants are not contrastive for the feature [nasal]. (Note, for example, a similar lexical restriction in Guarani nasalization, as discussed by Kiparsky (1985, p. 126), where unstressed continuants are unspecified for the feature [nasal].) I present an analysis assuming that such a constraint exists (referred to as the Configuration Constraint Approach) and then I will show why this must necessarily be so. This constraint, in effect, blocks nasalization from spreading to [+continuant] consonants. In the following derivations, # indicates that this constraint is in effect.[7]

(11) Sample Derivations

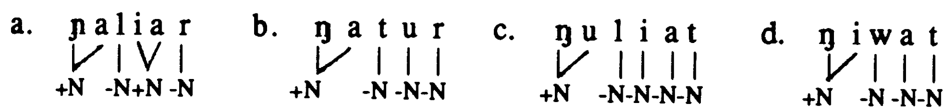


[7] In these derivations, I ignore the issue of where in the feature hierarchy [nasal] is located and I have not formalized infixation. These derivations do not start with underlying representations in all cases.

The input to the first cycle is as shown. Nasal Spread applies. In (11a), [+nasal] spreads to both vowels, but is blocked from spreading to the /r/ since it is already specified as [–nasal] at this stage in the derivation. In (11b), there is only spreading to the /a/ following the /ŋ/; further spreading is blocked by the /t/, specified as [–nasal]. In (11c) and (11d), again spreading is blocked past the first vowel, but in this case it is not due to a [–nasal] specification, but rather the configuration constraint which prohibits the co-occurrence of [nasal] with segments positively specified for both the features [continuant] and [consonantal]. In (11a) there is infixation on the second cycle. For concreteness, the [+nasal] autosegment is represented here as having been "cloned", that is, split by the infix, but following the Configuration Constraint Approach this might not be necessary. Nasal Spread then reapplies, causing the vowel of the infix to become nasalized in addition to the vowels of the root, already nasalized on the first cycle. There is phonetic evidence (presented below in (17)) that all vowels are specified for [nasal] leaving the phonology; therefore, I propose a Default Fill-in rule for the vowels, i.e. those not affected by Nasal Spread. After Default Fill-in applies, the phonological output is as shown, where the glides and /l/ are still unspecified for the feature [nasal] leaving the phonology.

If on the other hand, we assume that the blocking effects from the [+continuant] consonants are due to redundant values in the phonology (referred to as the Redundant Specification Approach, the phonological outputs would be as shown in (12):

(12) Phonological Output—following the Redundant Specification Approach:



The crucial difference is that in this case, there are no unspecified segments leaving the phonology; glides and /l/ are fully specified for the feature [nasal]. Let us turn now to the phonetic data, to see why the Configuration Constraint Approach is to be preferred.

3. Sundanese: Phonetic Data and Analysis

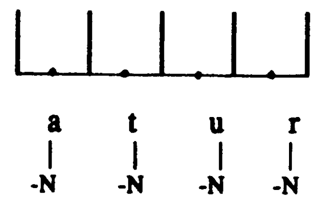
The phonetic data presented here are filtered nasal airflow traces. Three speakers of Sundanese were recorded, but the examples presented here are from a single speaker, the one whose phonological system most closely matches the phonological system described by Robins (1957). The nasal flow traces are an (indirect) indication of the phonetic output for the feature [nasal]. Each token is a representative example of multiple tokens. In the traces, vertical lines indicate segmentation (based on the flow records and spectrographic analysis of the audio signal) and the horizontal line establishes a baseline. Presented with the flow traces are schematic representations of the output from the phonetic rules. These phonetic mappings are greatly simplified, leaving aside issues such as subsegmental timing, the rapidity of transitions between nasal and oral segments, and the different levels of flow on nasals and vowels. (The reader is referred to Cohn (forthcoming) for a discussion of these and related issues.)

The first example of a nasal flow trace is |atur| shown in (13a).

(13) |atur| 'arrange'

a. Observed Nasal Flow

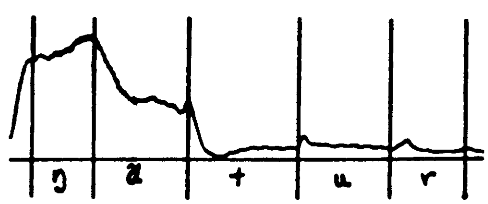
b. Output of Schematic Phonetic Rules



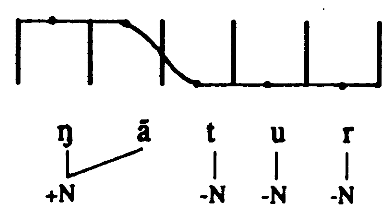
This example exhibits no significant nasal flow; this is as expected as there are no nasal segments in the token. This example sets an effective baseline for the other cases. In the schematized representation, shown in (13b), all the segments have low targets, all being [–nasal] leaving the phonology (under either approach). In (14), there are both nasal and oral segments, exemplified by |ŋātur|.

(14) |ŋātur| 'arrange' (active)

a. Observed Nasal Flow



b. Output of Schematic Phonetic Rules



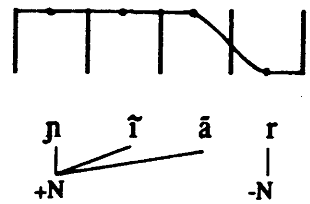
In (14a), there is substantial nasal flow on both |ŋ| and the following |ā|, but not on any of the subsequent segments. There is a rapid transition between |ā| and |t|, precisely the kind of transition we would expect to see between a [+nasal] and a [–nasal] segment. The marked difference in level of nasal flow between the nasal and the following vowel has a physical cause: during the nasal, all airflow is through the nasal cavity, whereas during the vowel, air flows out through both the oral and nasal cavities. As schematized in (14b), under either approach we would expect to see high targets for the first two segments |ŋā| and low targets for the following segments. There would then be interpolation between the targets.

In the next example (15), we see a case of Nasal Spread to a sequence of two vowels, in the form |ŋĩãr|.

(15) |ɲĩãr| 'seek' (active)

a. Observed Nasal Flow

b. Output of Schematic Phonetic Rules

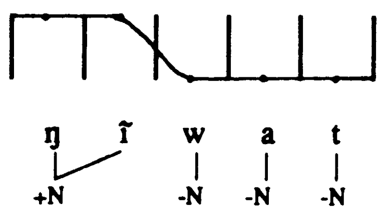


In this case, there is significant flow on the nasal and both of the vowels.[8] In (15b), there are three high targets followed by a low target with a similar transition as seen in (14b).

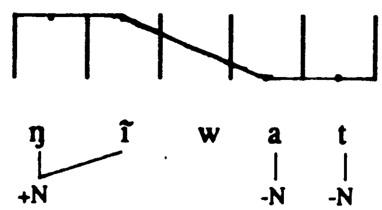
Let us turn now to the more interesting cases, where the two approaches—the Redundant Specification Approach, and the Configuration Constraint Approach—make different predictions. First consider the case where a [+continuant] consonant, either a glide or |l|, follows a vowel nasalized by Nasal Spread:

(16) Glides and |l| following a nasalized vowel
e.g. |ŋĩwat| 'elope'

a. Redundant Specification Approach



b. Configuration Constraint Approach

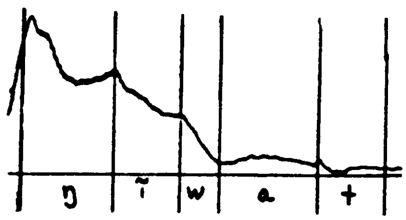


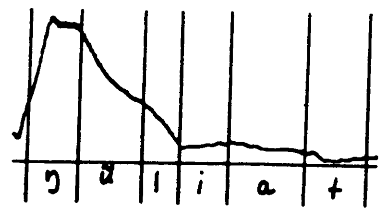
The prediction of the Redundant Specification Approach is as shown in (16a). We would expect to see high targets for the first two segments, then low targets for the subsequent segments, including the glide or |l|, since following this approach either would be specified as [–nasal] leaving the phonology. The transition would be expected to look like that seen in |ŋãtur| in (14). On the other hand, following the Configuration Constraint Approach, we would expect the first two segments to have high targets, the final two to have low targets, and the glide or |l| in the middle to have no target (since it would be unspecified leaving the phonology), as shown in (16b). Here we would expect to see a smooth transition throughout the glide or |l| from interpolation between the targets on either side of this segment. Looking at actual representative flow traces in (17a) and (17b), |ŋĩwat| and |ŋũliat| respectively, we see a transition throughout the glide and |l| as predicted by the Configuration

[8] The decreasing flow on the /i/ and /a/ is again physical in origin. It is due to the overall rate of airflow through the glottis in relation to the relative size of the oral opening (cf. House and Stevens 1956).

Constraint Approach, quite different from the types of transitions that we saw above in (14a) and (15a).

(17) a. |ŋĩwat| b. |ŋũliat|



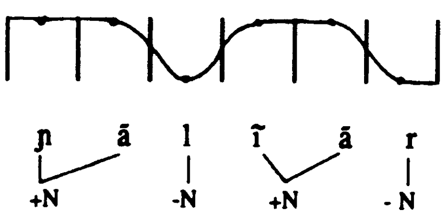


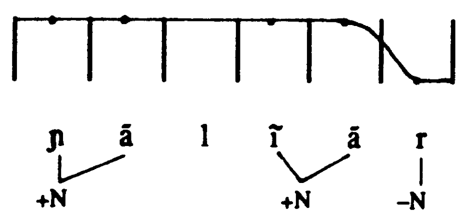
In these examples, we see the phonetic evidence for the Default Fill-in rule for vowels. Were the non-nasal vowels unspecified for the feature [nasal] leaving the phonology, we would expect to see a cline-like transition throughout not only the glide or |l|, but also the following sequence of vowels. This is not the case; rather the vowels are clearly oral. The fact that a fill-in rule should apply to the vowels (but not to the glides and |l|) is not surprising, since nasalization of vowels does play a significant role in the lexical phonology of Sundanese.

The most interesting case is that involving an infixed |l| (from the plural infix). Again the two approaches make different predictions, as shown in (18).

(18) Infixed |l| |ɲ=āl=ĩār| 'seek' (active, plural)

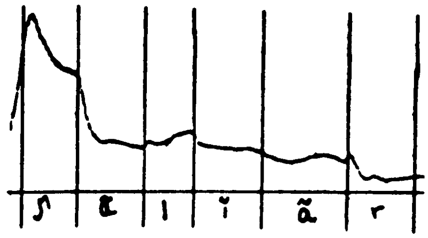
a. Redundant Specification Approach b. Configuration Constraint Approach





Following the Redundant Specification Approach, as shown in (18a), high targets would be expected for the first two segments, a low target for the |l| (since under this view, it would be specified as [–nasal] leaving the phonology) and high targets for the following two vowels. Thus there should be a large dip in the flow trace for the |l|. Under the Configuration Constraint Approach (shown in (18b)), the first two segments would have high targets, the following two vowels would also have high targets, but the intervening |l| would have no target (being unspecified leaving the phonology). In this case, we would expect interpolation straight through, giving the impression that |l| has a high target, when in fact it has no target. Looking at a representative nasal flow trace in (19) |ɲ=āl=ĩār|, we observe nasalization straight through, precisely as predicted by the Configuration Constraint Approach.

(19) |n=ãl=ĩãr|



In both of these final cases (17) and (19), the observed phonetic facts are as predicted by the Configuration Constraint Approach and cannot be accounted for in an obvious way by the Redundant Specification Approach. Following the Configuration Constraint Approach, these segments are unspecified for the feature [nasal] leaving the phonology; we would predict, therefore, that they would not get a phonetic target, but rather quantitative levels of nasalization assigned through interpolation. In contrast, under the Redundant Specification Approach these segments would be expected to be mapped as low targets, since the phonological blocking effects are achieved through the presence of [–nasal] specifications. This leads to a problem in accounting for the observed phonetic facts. To account for the phonetics, these low targets would have to be delinked, but only in specific cases. This is a very undesirable result if we want to maintain the idea of a systematic mapping from phonology to phonetics.

4. Conclusion

In conclusion, we have seen that phonologically [+continuant] consonants in Sundanese block Nasal Spread, but phonetically they are transparent to nasalization. Making the assumptions that first, phonological blocking effects must be accounted for by a structural constraint, such as a configuration constraint, rather than by redundant feature specification, and that second, there is not full specification leaving the phonology, we achieve a principled account of why the glides and |l| are opaque in the phonology but transparent in the phonetics.

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