

Deconstructing metaphony

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This paper argues that the set of vowel raisings that define metaphony systems in Italian dialects, as in other Romance languages, do not result from a unified operation of height assimilation. Instead, metaphony is claimed to be the product of a restricted assimilation of high-mid vowels, and a subsequent vowel shift that conditions both the vowel raising and fronting. Low-mid and low vowels raise to fill in the gap created by assimilation of /e, o/ to /i, u/. This analysis accounts for striking parallels between the pattern of vowel movement found in diachronic vowel shift systems, as documented by Labov (1994), and the movement of vowels in metaphony systems. The proposed analysis appeals directly to acoustically-defined categories of vowel height, and avoids many problems encountered in existing analyses, which attempt to unify all metaphonic raising through the mechanism of a unified stepwise raising process that operates in terms of abstract phonological height features. The contrast-preserving nature of vowel shift is expressed through two constraints that function to preserve the underlying system of contrast by preserving constrictive height features and the relative height relations between contrastive vowels that undergo metaphonic raising.*

1. *The facts*

This paper addresses the phonological treatment of metaphony in Romance, focusing mostly on the well-documented patterns of metaphony in Italian dialects. The discussion is based on metaphony systems described in the following sources: Calabrese (this volume, 1985), Kaze (1989), Leonard (1978), Maiden (1991), and Nibert (to appear).

Metaphony refers to the raising of a stressed vowel in forms that bear a certain morphosyntactic feature, such as person, gender or tense. Metaphonic vowel raising is often accompanied by an overt trigger in the form of a high suffixal vowel, /i, u/, but in some dialects, reduction of the atonic suffix vowel has removed its conditioning high feature. Maiden (1991:1) characterizes the situation with the following table:

(1) Variation in the expression of inflectional categories

A	B	C
korro	korro	korra
korri	kurri	kurra
korre	korre	korra

'I run'
'you run'
'he runs'

Dialect A employs suffixation alone to mark subject person inflection. In dialect B, suffixation is accompanied by metaphonic raising of the stressed vowel. Dialect C also exhibits metaphony, but in this case the suffix vowels undergo atonic vowel reduction, and the underlying contrast between suffixal /i, o, e/ is neutralized in the single surface variant [ə], with the result that metaphony has no segmental conditioning element in surface form.

Dialects exhibiting metaphony differ significantly in both the input and output to raising. Drawing once again from Maiden's classification of metaphony in Italian dialects (1991:112), the individual vowel alternations that comprise metaphony in its various manifestations are listed as follows:

(2) The set of metaphonic alternations

high mid	/e/	→	[i]
	/o/	→	[u]
low mid	/ε/	→	[je], [je], or [e]
	/ɔ/	→	[wɔ], [wɔ], or [o]
low	/a/	→	[ε], or [je]

To this list we should add another set of alternations in which metaphony conditions the fronting of back vowels, as in La Valle Anzasca, where the front rounded high vowel /y/ is the metaphonic alternant for /o, u/, or Sonogno, where /ø/ is the metaphonic alternant for /o/, discussed further in section 5.2.

As we shall see below, there are patterns in the way the individual alternations of (2) group together in the metaphony systems of different languages and dialects. Informal observation of the data reported in the literature cited above reveal that the high-mid vowels display metaphonic alternation with the greatest frequency, followed by the low-mid vowels. The low vowel alternates in relatively few of the reported dialects. Furthermore, there is a strong tendency for dialects that display metaphonic raising of the low-mid vowels to also display raising of the high-mid vowels. Maiden claims that there is a descriptive implicational hierarchy, such that if a vowel of height *n* participates, then a vowel of height greater than *n* also participates. Thus, raising of the low vowel would imply raising of the low-mid vowel, which would in turn imply raising of the high-mid vowel.

2. The problem

The central problem that Romance metaphony poses for phono-

logical analysis, as viewed from the perspective of non-linear, generative phonology, is how to get a one-step, scalar vowel raising to follow from an assimilation of vowel height triggered by the high vowels /i, u/. Guided by this question, the focus of recent research on metaphony has been on defining the right set of vowel height features and feature geometry that will provide a unified expression of the entire set of metaphonic vowel alternations in (2).¹

In this paper, I argue that recent proposals for the analysis of metaphony as a unified phenomenon of vowel height assimilation do not fully succeed. The features and mechanisms adopted in these analyses fail on technical or empirical grounds, or confer excessive power to the theory, predicting a wide range of unattested assimilatory phenomena. I claim that the failure of these analyses derives from the assumption that metaphony constitutes a unified phenomenon of assimilation.

An alternative analysis is proposed here, in which metaphony is decomposed into two aspects: (i) the assimilation of the high-mid vowels /e, o/ to the high vowels /i, u/, within the stress foot; and (ii) vowel shift, a typically non-neutralizing phenomenon by which /a, ε, ɔ/ are raised one step. This analysis avoids the pitfalls of the "unified assimilation" analyses, and accounts for the many similarities between the properties of diachronic vowel shifts and synchronic metaphony systems. The proposed analysis does not impose any special requirements on a theory of vowel height features, or their place in a feature hierarchy, drawing instead on the functionally-based principle of vowel shift, augmented by a very restricted and unremarkable operation of height assimilation.

We begin in section 3 with a review of several contemporary analyses of metaphony as assimilation. Section 4 examines more closely, and critically, the assumption that metaphony constitutes a unified phenomenon of assimilation. Section 5 compares vowel raising in metaphony to similar vowel shifts in diachronic sound change, setting the stage for section 6, where the details of the proposed analysis are worked out, drawing on Labov's (1994) principles of vowel shift systems. Finally, section 7 outlines a role for assimilation in the proposed analysis, and puts forth an account of the unique behavior of the high-mid vowels in metaphony systems. Section 7 summarizes, and spells out several questions for future research.

3. Metaphony as assimilation

Recent analyses of metaphony can be divided into two groups. The direct assimilation analyses derive raising from the autosegment-

tal spreading of a unique vowel height feature from the triggering suffix vowel, while the indirect assimilation analyses employ rules other than spreading to directly manipulate vowel height features on the stressed vowel target. The latter type of analysis is assimilatory in only the loosest sense of the term, since assimilation results as a byproduct of the raising rules, which are formulated independently of the vowel height features of the 'trigger', and which may affect different vowel height features for different input vowels. Both groups of analyses have in common the property that all the metaphonic alternations result from a unified rule that operates on all stressed vowels by spreading, inserting, or deleting vowel height features. In the next three sections, we review the primary features of several direct and indirect assimilation analyses.

3.1. Spreading analyses with binary features

Calabrese (this volume, 1985) and Kaze (1989) analyze metaphony as the leftward spread of the feature [+high] from the suffix vowel onto a [-low] stressed vowel. For both Calabrese and Kaze, the low-mid and low vowels suffer feature clash upon assimilation of the feature [+high]. We focus on Calabrese's analysis here, but the discussion holds equally for Kaze's analysis, which differs from Calabrese's primarily in the specification the low-mid vowels.²

Calabrese recognizes three contrastive vowel height categories, specified with the binary features [high] and [low]. The low-mid vowels /ε, ɔ/ are treated as mid vowels, with the additional specification of [-tense], as follows:

(3) Vowel height specification with binary features

	i	u	e	o	ε	ɔ	a
high	+	+	-	-	-	-	-
low	-	-	-	-	-	-	+
tense	+	+	+	+	-	-	-

Furthermore, Calabrese assumes that metaphony applies to representations which are underspecified, as in (4).

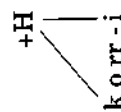
(4) Underspecified representations

	i	u	e	o	ε	ɔ	a
high	+	+	-	-	-	-	-
low	-	-	-	-	-	-	+
tense	-	-	-	-	-	-	-

With these underspecified representations, the vowels that undergo metaphonic [+high] assimilation are unspecified for the feature [high]. In addition, only the low-mid vowels bear a specification for [-tense]. It's easy to see that assimilation of the feature [+high] renders the underlying vowels /e, o/ non-distinct from their high counterparts /i, u/. For the low-mid vowels, assimilation of [+high] derives the features combination [+high, -tense]. Calabrese argues for a filter, or constraint, that bans this combination of features, observing that such a constraint accounts for the absence of high, lax vowels in the segment inventory of these Romance languages.³ The illicit feature combination is subject to one of three repair strategies: fission, delinking, or negation. Fission splits the offending features into two distinct bundles, deriving the diphthongal elements [ε, ɔ] with a [+high] segment followed by a [-tense] segment. Delinking removes one of the offending features, deriving a [+high] element [i, u], or a [-tense] element [ε, ɔ]. In the latter case, the output of the repair procedure is non-distinct from the input to metaphonic assimilation. Negation is a repair that affects both of the offending features, which are converted to the opposite value: [+high, -tense] becomes [-high, +tense], or /e, o/.

I find two problems with this sort of "spread and repair" analysis.⁴ First, applying any one of the three repair strategies to the output of assimilation completely undermines the autosegmental analysis of assimilation adopted by Calabrese, because it requires deconstruction of the autosegmental linked structure configuration. The autosegmental theory of assimilation (together with its sister theory of underspecification) is built around the idea that assimilation occurs when a single feature token becomes associated to multiple segments, through the insertion of association lines, as in (5).

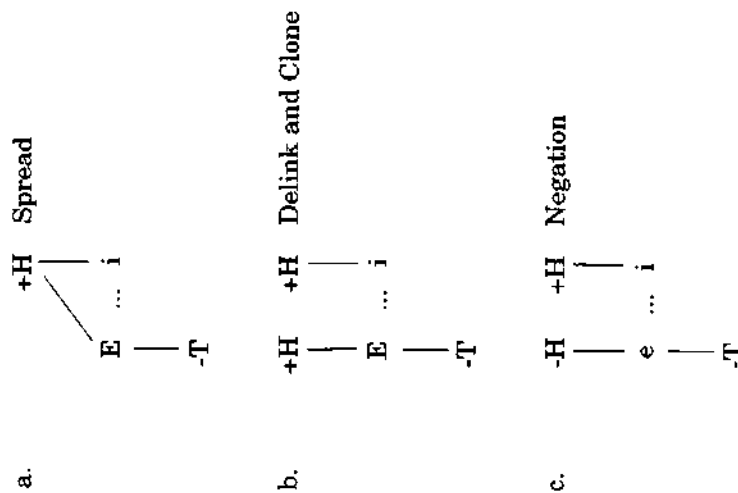
(5) Assimilation as multiple association



Furthermore, autosegmental theory maintains that in such a multiply-linked configuration, all the elements linked to [+high] must be equally affected by any subsequent rules that target [+high] segments – either all the elements will undergo the rule, or none will

(the "Inalterability Effect" of Hayes 1986, Schein & Steriade 1984). Yet, as Calabrese (this volume) concedes, in cases where a low-mid or low vowel assimilates [+high] and then undergoes one of the repair strategies, only the target vowel, and not the trigger, is affected. For example, consider the application of the Negation repair strategy to an underlying /e/ after [+high] assimilation has taken place. Negation yields the output configuration [-high, +tense], [e], without affecting the height of the triggering suffixal vowel. The only way to achieve this result is to delink the multiply-linked feature, cloning it onto each element individually prior to applying Negation, as in (6).

(6) Spread, Delink, Repair



These steps yield the correct output, but the analysis amounts to an admission that a fundamental prediction of autosegmental theory is false. The linked structure that is the hallmark of the autosegmental analysis is in fact a hindrance to the successful analysis of this system. If linked structures can be deconstructed when the facts dic-

tate, then autosegmental theory makes no predictions at all about the behavior of elements in an assimilation dependency. Facts like these raise questions about the appropriateness of the autosegmental treatment of assimilation (for further discussion see Cole & Kisseberth 1994).

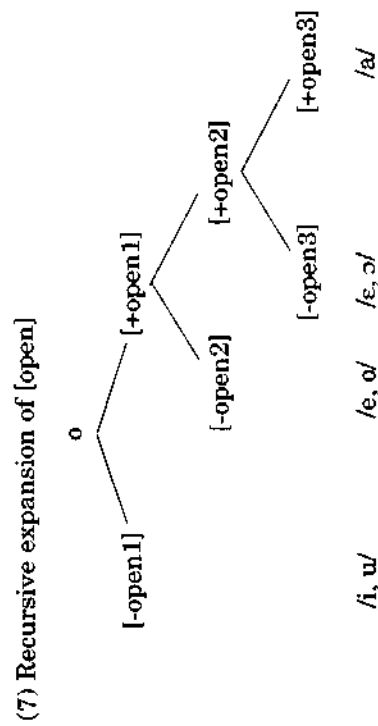
A second problem with the 'spread and repair' analysis concerns the repair strategy of Fission. Under this operation, two conflicting feature specifications, such as [+high] and [-tense], are sequenced over two segments. I question the viability of Fission as a general strategy to overcome feature co-occurrence constraints in systems of assimilation. Feature co-occurrence constraints play an important role in accounting for opaque and transparent segments in harmony systems, as demonstrated in Archangeli & Pulleyblank's (1994) work on Grounded Phonology. For instance, the constraint [+low, +ATR] is responsible for the opacity of low vowels in the ATR harmony systems of many languages, such as Akan (Clements 1981, Archangeli & Pulleyblank 1994). Yet there are no ATR harmony systems in which a low vowel participates in harmony, but then throws off its [+ATR] feature onto an adjacent vocalic segment, through an application of fission to the offending feature structure [+low,+ATR]. That is, there are no reported cases where underlying /a/ undergoes ATR harmony and surfaces as [ia], [æa], or any other diphthongal element with an initial (or final) [+ATR] element.

Similarly, although low vowels are opaque in many round harmony systems (eg., Turkish), there are no systems in which low vowels undergo round harmony, only to throw off their [+round] feature onto an adjacent vowel, producing diphthongal [ua], [oa] or even [ɔa]. Under Calabrese's axiomatic approach to repair operations, this striking difference between metaphony and other assimilation systems remains unexplained. We return to the treatment of diphthongization in section 6.3.

We have seen in this section that a theory with binary height features is genuinely challenged to identify a unique assimilating feature as the source for a multi-level, one-step raising of the sort found in some metaphony systems. Additional rules are needed to repair the structures that result from assimilation, which are otherwise predicted to be uniformly [+high]. A possible way out of this dilemma is to abandon the standard analysis of vowel height in terms of the binary features [high], [low], and [tense], adopting instead a feature set which will allow for a more direct expression of one-step raising. The next section reviews one such proposal.

3.2. Spreading analysis with recursive height features

Clements (1989) proposes an alternative to the analysis of vowel height in terms of the binary features [high] and [low]. He argues that the vowel space is divided into height categories by a succession of binary divisions. Clements employs a single binary height feature [open], which can appear in a recursive structure such as (7), where each [α open] branch of the feature tree can be further subdivided into [+open] and [-open] branches.



Nibert (to appear) applies Clements' model to the analysis of metaphony in the Servigliano dialect of Italian. Servigliano has the 7-vowel inventory /i, e, ε, u, o, ə, a/. Metaphony induces a one-step raising of both the high-mid vowels /e, o/ and the low-mid vowels /ε, ə/. Nibert specifies vowel height features for Servigliano as in (8). Note that this is a center-embedding structure, as opposed to the right-branching structure in (7). The choice between the center-embedding and right-branching analysis of a four-height system depends on the behavior of the mid vowels in an individual language. (7) best represents a system in which the low-mid vowels pattern with the low vowel with respect to vowel height, while (8) is an appropriate specification for languages like Servigliano, in which the low-mid and high-mid vowels pattern together.

(8) A 7-vowel system

	i	u	e	o	ε	ə	a
open1	-	-	-	-	-	-	+
open2	-	-	+	+	+	+	+
open3	-	-	-	-	+	+	+

Nibert shows that under this analysis of vowel height, the raising of /e, o/ requires assimilation of [-open2] from the triggering vowels. But spreading [-open2] onto /ε, ə/ yields the feature bundle [-open1, -open2, +open3], which doesn't correspond to any of the available vowel qualities. In order to raise /ε, ə/ one step to /e, o/ it is the feature [-open3] that must be assimilated. Nibert argues that metaphony can spread either feature, [-open2] or [-open3], subject to structure preservation, which bans the spread of [-open2] onto /ε, ə/. In fact, a stricter formulation is required to guarantee that [-open2] and not [-open3] spreads onto /e, o/, since spread of [-open3] would be vacuous, and would not accomplish raising. Nibert's rule must be modified to apply disjunctively, spreading [-open2] 'unless' spreading is blocked, in which case [-open3] will spread.

Nibert's approach fares even worse when applied to the analysis of metaphony systems in which the low vowel also participates, undergoing a one-step raising to [ε]. In such a system, a different [-open] feature would have to assimilate for each of the low, low-mid, and high-mid vowels. Under an assignment of height features as in (8), raising /a/ one step would require the assimilation of [-open1], in addition to the assimilation of the features [-open2] and [-open3] required for the raising of /e, o/ and /ε, ə/, respectively. Similar results obtain even if the vowel height features are assigned as in (7).

Nibert's application of Clements' model to the analysis of Servigliano metaphony succeeds in generating the correct output. But it does not succeed in delivering a unified analysis of high-mid vowel metaphony and low-mid vowel metaphony. Strictly speaking, the raising of these two sets of vowels is accomplished by distinct rules. The rules may be collapsed into a single rule format through the use of disjunctive notation, but they are nonetheless distinct, since they spread two distinct vowel height features. In fact, Nibert's analysis is formally equivalent to an analysis formulated in terms of the binary features [high] and [tense] (or perhaps [high] and [low]), spreading [+high] onto /e, o/ and [+tense] onto /ε, ə/. I further note that Nibert's appeal to structure preservation relies on a lexical constraint banning the feature bundle [-open2, +open3] to block spread of [+high] onto the low-mid vowels, which is parallel to Calabrese's reliance on the feature co-occurrence constraint [+high, -tense] in his treatment of the low-mid vowels.

Viewed in this light, Nibert's analysis adopting Clements model of vowel height fares no better than Calabrese's analysis, discussed above (or Kaze's, see footnote 2). In both types of analysis, metaphony

of high-mid, low-mid, and low vowels each requires fundamentally distinct mechanisms or rules. None of these analyses succeed in identifying a unique metaphony feature, which can assimilate to yield a one-step raising of high-mid, low-mid, and low vowels. This finding echoes Maiden (1991: 136), who argues that "the non-binary nature of metaphony is immediately apparent in the fact that there is nothing identifiable as a feature '[+metaphonic]'." In the next section, we turn to consider Maiden's analysis of metaphony, as illustrative of the 'indirect assimilation' approach.

3.3. *Metaphony as indirect assimilation*

Maiden (1991) argues that metaphonic raising is a natural, phonetically principled phenomenon of assimilation. Like other assimilation systems, its effects are seen most strongly on targets that are the most similar to the triggering elements, i.e., on the high-mid vowels. Maiden argues as well for the phonetic basis of the restriction, observed in many dialects, that limits metaphony to stressed vowels in open syllables. It is a well-known fact that languages often display lower vowel qualities in closed syllables. A lowered vowel is more distinct from the high vowels that trigger metaphony, and is therefore better able to resist assimilatory raising. However, while recognizing the assimilatory nature of metaphony, Maiden does not account for metaphonic raising through the mechanism of autosegmental spreading, primarily because this approach does not yield a unified analysis of the full set of metaphonic alternations.

Maiden adopts the theory of vowel height put forth in Dependency Phonology (Anderson & Durand 1986), which employs the component (or feature) 'a' to mark lowness. This component can appear in combination with other components marking palatality ('i'), roundness ('u'), and centrality ('ə').

In structures with combined components, one component dominates, or governs, another component. Thus, /e/ is specified as [i;a], with 'i' the governing component. Raising comes about through the demotion of the 'a' component. If 'a' is the sole component, it is demoted by introducing the 'i' component in a governed position. If 'a' is present as the governing component for 'i', then 'a' is demoted to governed position, and 'i' is promoted to governor. If 'a' is already the governed feature, it is deleted. The set of metaphonic alternations that Maiden proposes (p. 140) is illustrated in (9) with the non-round vowels.

(9) Metaphony as demotion of the 'a' component

input:	/i/	/e/	/a/
UR:	[i]	[i;a]	[a]
metaphony:	(N/A)	[i;a]	[a;i]
output:	[i]	[e]	[e]

It is evident that metaphony has a different effect on each of the input vowels in (9). There is no unified metaphonic operation. The demotion/deletion of 'a' is claimed to be assimilatory in nature, because it is triggered by the only elements which completely lack an 'a' component – the high vowels. Maiden formulates a rule of demotion, which subtracts an 'a' component from each target. This subtraction operation, then, must be interpreted not as simple deletion, or any other singular operation, but as the entire set of 'demotions' put forth in (9).

Maiden notes that component demotion is not in the original inventory of Dependency Phonology operations. In effect, component demotion is an abbreviation for a set of operations, of which only one applies to a given input. The individual operations comprising demotion apply disjunctively, just as the individual raising rules in the spreading analyses discussed above. Maiden's is a unified analysis of metaphony only to the extent that the individual operations involved in demotion are unified. The analysis requires establishing a hierarchy of component expressions, as in (10), such that the strongest expression with respect to the component α is the monoid with α as the sole component, and the weakest expression with respect to α is the one in which α is absent. With this ranking, metaphony can be expressed as an operation that alters an expression, by the insertion, deletion, or positional shift of components, so that the expression moves one position downward on the 'a'-hierarchy. Metaphony is then not just a demotion of 'a' on the 'a'-hierarchy, but a 'minimal' demotion of 'a'.⁵

(10) α -ranking of component expressions

$$[\alpha] \gg [\alpha;\beta] \gg \{\beta;\alpha\} \gg \{\beta\}$$

The ranking in (10) is a reasonable one, but it must be stipulated in the theory, because as far as I can determine it doesn't follow from any independent principles. Other plausible rankings can be imagined, such as one where the expressions (α) and ($\alpha;\beta$) are equally ranked, on the basis that α appears in an ungoverned position in

both. Such a ranking would not yield the same results for metaphony, since the minimal demotion of the vowel /a/ (= {a}) would yield /e/ (= {i;a}). Now, it might be proposed that the ranking itself is subject to cross-linguistic variation, but the details of such a proposal have not been worked out.

I have two comments on the 'a'-demotion analysis. First, the basis of the analysis is the ranking in (10), which is in fact a direct ranking of vowel height, and only notationally different from a ranking in terms of binary height features as in (11a), or for that matter a ranking of scalar height values such as proposed by Ladefoged (1971) (11b).

(11) Same ranking, different features

- a. [+lo, -hi, -tns] >> [-lo, -hi, +tns] >> [-lo, +hi, +tns]
 b. [height 4] >> [height 3] >> [height 2] >> [height 1]

Parallel to Maiden's rule of 'a'-demotion, we could also formulate rules of raising in terms of binary or scalar height features, inducing a one-step demotion along the lowness hierarchies for those features. The point being made here is that the analysis relies crucially on a hierarchy of height features, and can be implemented using unary, binary, or scalar features. The question of which analysis of vowel features is the right one is not determined by these data.

My second comment concerns the relation between assimilation and scalar rules like 'a'-demotion that operate on feature hierarchies such as the ones in (10) and (11). Scalar raising rules are well-attested in genetically diverse languages (Labov 1994, Goad 1993, Kiparsky 1995). There is some evidence to suggest that scalar lowering also occurs, though the data are not altogether clear (see discussion in Goad 1993). To my knowledge, there are no reported cases of assimilatory scalar lowering, eg., a one-step lowering of vowels triggered by a contextual low vowel such as /a/. Likewise, although it is possible to formulate a hierarchy of vowel rounding, there is no scalar rounding harmony system that operates, eg., to enhance the degree of rounding in the presence of highly rounded vowels like /u, y/. In fact all the scalar phenomena involving vowels attested in phonological systems appear to involve the dimension of vowel height. This asymmetry doesn't fall out of the algebraic or axiomatic analyses reviewed above, in which 'any' vowel feature or component can participate. Thus, parallel to the [+high] assimilation of

Calabrese's and Kaze's analysis, we might expect to find languages in which the spread of [+low] leads to assimilatory scalar lowering. In a unary feature approach like Maiden's, the scalar promotion of 'a' is no more complex than the demotion operation Maiden proposes, predicting an equal occurrence of scalar lowering systems. Furthermore, we expect to find scalar systems involving the other particles as well, such as scalar palatalization with 'i', scalar labio-velarization with 'u', and scalar centralization (?) with 'schwa'. Such a variety of scalar assimilation systems have not been attested.

3.4. Summary

This section has reviewed several approaches to the analysis of metaphony as a unified phenomenon of assimilatory vowel raising. Examination of the mechanisms these analyses adopt reveals that none succeeds in deriving the entire set of vowel raisings from a single operation. The mechanisms include post-assimilation repair rules, disjunctive rule ordering, and scalar promotion/demotion rules, sometimes in combination, all of which are invoked to deal with the fact that metaphony produces non-uniform output. By allowing these mechanisms to operate freely over any set of phonological features, the existing analyses predict a richer, more complex set of scalar and non-scalar assimilation systems than is attested in the vast literature on assimilation.

4. Reconsidering the nature of metaphony

The problems with existing accounts of metaphony, discussed above, arise because of two assumptions: (i) that metaphony is fundamentally a phenomenon of assimilation, and (ii) that the full set of vowel raisings that characterize metaphony define a single, unified phenomenon. These two assumptions are challenged in this section, preparing the way for the alternative account introduced below.

4.1. Metaphony as assimilation?

That metaphony involves assimilation of vowel height is assumed without discussion in most of the recent literature. A notable exception is Maiden (1991), who argues extensively that metaphony is a fundamentally a 'phonetic' phenomenon of assimilation, in opposition to the view of metaphony as a purely morphological phenomenon.

non.⁶ In support of his position, he observes that the input to metaphony form an implicational hierarchy such that if any vowel undergoes metaphony, then the high-mid vowels /e, o/ undergo metaphony. In other words, metaphony preferentially affects the high-mid vowels, which are themselves the closest in height to the high vowel triggers of metaphony. Maiden observes that one characteristic of assimilation phenomena across languages is that assimilation affects segments that are phonetically similar prior to assimilation. This argument is strongest as it pertains to the metaphonic raising of the high-mid vowels. Assimilatory alternations between /e, o/ and /i, u/ are perhaps the most common type of assimilatory height alternations, occurring in Menomini (Bloomfield 1962), and in several languages discussed by Goad (1993), including Yaka (van den Eynde 1968), Chichewa (Harris & Moto 1989), and the Pasiego dialect of Spanish (McCarthy 1984, Penny 1969a,b, Hualde 1989).

These observations support an analysis of /e, o/ metaphony as a complete and neutralizing assimilation of the height of the triggering vowels /i, u/. In contrast, the metaphonic raising of the low-mid and low vowels triggered by high vowels, which is an incomplete assimilation, finds no parallel in other systems of assimilatory raising, where assimilation is complete.⁷

More generally, in vowel harmony systems, assimilation is normally an all-or-nothing proposition: a vowel either undergoes assimilation of [+F] and surfaces as [+F], or it is neutral (transparent or opaque), in which case it surfaces as [-F] (unless [+F] is underlying or assigned by some other rule).

4.2. *Metaphony as a unified set of vowel raisings?*

As far as I can determine, nobody argues explicitly for the notion that all of the metaphonic raisings constitute a unified phenomenon. The desirability of such a unification stems, presumably, from formal considerations of rule generalization and economy.

It has been claimed that assimilation has a functional basis in principles of perception and articulation (Ohala 1990, Lindblom 1983, Cole & Kisseberth 1994). Assimilation promotes articulator stability and at the same time increases the perceptual salience of the trigger by increasing the duration of one (or more) of its contrastive features. Yet, neither of these functional goals is met in metaphonic alternations involving a partial raising of low-mid and low vowels. Arguably, unless the output vowel is [+high], it does not promote a stable [+high] constriction, nor does it serve as a cue for the contra-

stive [+high] feature of the trigger. Of course, there are metaphony systems where low-mid and low vowels do surface as [+high]; Maiden (1991: 179-87) discusses several Italian dialects of this sort. But these systems do not appear to be in the majority.

I note here that consideration of the evolution of metaphony does not provide direct support for the notion of unification. Maiden (1991: 118ff) contrasts two viewpoints which are represented in the literature. In what we may term the subtractive view, all metaphony systems have their origin in a proto-system in which metaphony affects every possible vowel, with no phonological restrictions on the environment. Evolution of this system involves removing individual components from the focus of the rule. The subtractive view is tenable within an analysis in which all metaphonic raising is accomplished by a single rule; the development of restrictions on metaphony would be attributed to restrictions on the input or to extra conditions on the triggering environment of the rule. But the subtractive view is also consistent with an analysis in which each metaphonic raising is accomplished by an independent mechanism, as long as there is some way to relate those mechanisms so that Maiden's input hierarchy still obtains, i.e., so that loss of high-mid vowel metaphony does not occur unless the low-mid and low vowel alternations are also lost.

The second viewpoint on the evolution of metaphony is the additive view, for which Maiden argues. Under this view, metaphony occurs first in the high-mid vowels, later extending to the low-mid vowels, followed in turn by the low vowels. This view is also consistent with either a unified or non-unified analysis of metaphonic raising. With a unified rule, extension of metaphony requires relaxing restrictions on the input to metaphony, and on the environments in which it occurs. On the other hand, if metaphony is distributed among independent rules, then extension occurs through the addition of rules to raise the low-mid and low vowels to grammars which already contain the rule raising the high-mid vowels. As above, under this account, there must be some way to relate the independent raising rules that operate on each vowel height, so that Maiden's input hierarchy obtains.

5. *Metaphony and Vowel Shift*

In this section, we consider the scalar nature of metaphony as it compares to other, non-assimilatory phenomena of scalar raising. Scalar assimilation appears to be restricted to the domain of vowel

height, but not all scalar raisings are assimilatory. Labov (1994) provides ample evidence of scalar vowel shifts in diachronic sound change. The motivating factors of vowel shift are not in all cases well understood, but Labov argues that in some cases, including the English Great Vowel Shift, the initiating force is the diphthongization of high vowels, which sets up a pull-chain.⁸ The mid vowels raise to high, occupying the space vacated by the diphthongized high vowels, while the low vowels raise to occupy the vacated mid space, as shown in (12).

(12) Aspects of the English Great Vowel Shift

(i	u
(e	o
(æ	ɔ

5.1. Peripheral vowels shift upward

There are some striking parallels between the diachronic vowel shifts that Labov discusses and the synchronic Romance metaphony systems under discussion here. For example, in his investigation of diachronic vowel chain shifts, Labov observes an asymmetry, namely that vowel shifts always operate to raise vowel height. Lowering shifts may occur, but only with lax vowels in systems with a robust tense/lax vowel contrast.⁹ Romance metaphony is consistent with this observation, in that vowels are raising in a system that lacks a robust tense/lax contrast. Furthermore, it is often observed that in some dialects metaphony is restricted to open syllables. Maiden expresses this restriction as an implication: metaphony of a vowel in a closed syllable presupposes metaphony of a similar vowel in an open syllable. This restriction can be understood, as Maiden notes, in terms of vowel tenseness, since in dialects with the open syllable restriction a tense vowel quality is reported in open syllables, while closed syllables condition vowel laxing.

5.2. Back vowels shift forward

A second, though less robust parallel between metaphony and vowel shift concerns the behavior of back vowels. Labov notes the existence of vowel shift systems in which back vowels are fronted. He subsumes this movement under the same principle which underlies pure raising shifts, arguing that fronting is just another way to

accomplish raising, since in terms of the acoustic vowel space (where the front-back dimension is measured by the F2 frequency) front vowels are actually higher than back vowels in the same phonological height category. Similarly, fronting of the back vowels has been reported in a number of metaphony systems such as Agnone (/a/ → /e/) and Crechio (/a/ → /e/), discussed by Calabrese (1985), where the low vowel both raises and fronts, as well as in La Valle Anzasca (/o, u/ → /y/ and /ɔ/ → /i/), with a wholesale fronting of back vowels, discussed by Kaze (1989). Note that the fronting of back vowels does not in any way follow directly from an analysis of metaphony as an assimilation of vowel height. Additional mechanisms are required to establish the typical fronting of the low vowel under metaphony, and the more radical fronting of the sort found in La Valle Anzasca.¹⁰

5.3. Non-assimilatory shifts

The vowel shifts in Labov's study are not assimilatory in nature. They arise through the redispersion of vowels in the vowel space, and are often said to be driven by either the 'push' force exerted by the raising of the low vowels, or the 'pull' force exerted by a vacancy in the high vowel space.¹¹

These parallels between metaphony and vowel shift can be explained by identifying vowel shift as the mechanism for at least some of the metaphonic alternations. An analysis of metaphony as a vowel shift system has two immediate advantages over the unified assimilation analyses reviewed in section 3.

First, vowel shift provides a mechanism for scalar raising that operates specifically, and asymmetrically, in the dimension of vowel height. Vowel shift is not formalized in terms of a general mechanism for scalar raising, and so makes no predictions about scalar shifts along other phonetic dimensions. Thus, the vowel shift analysis avoids the problematic prediction of widespread systems of scalar movement incurred by some of the earlier analyses. Instead, scalar assimilation can be ruled out altogether.¹²

The second advantage of attributing scalar raising to vowel shift is that the analysis is freed from the requirement of locating the source of all the raising alternations in a single vowel height feature, originating in the (possibly abstract) triggering vowel.

In the remainder of the paper, I develop an analysis of metaphony which results from the interaction of a restricted assimilation of vowel height with a systemic vowel shift. Section 6 presents a formal account

of scalar raising and argues that a restricted height assimilation of /e, o/ provides the pull force that sets vowel shift into action.

6. The analysis

6.1. The mechanism for scalar raising

Labov presents a unified account of diachronic vowel shift in which vowel shift results from the operation of a single vowel shift principle, specific to the phonetic parameter of vowel height.

(13) VOWEL SHIFT: (Labov 1994:176) In chain shifts, tense nuclei rise along a peripheral track.¹³

The vowel shift principle can be understood in acoustic terms. Both raising and fronting result in an increased distance between F1 and F2.¹⁴ It is interesting to note that in the majority of Italian dialects discussed in the literature, metaphony fails to affect the low vowel /a/, which contrasts maximally with the front and high vowels in that F1 and F2 are closer to one another in /a/ than in any other vowel. Thus, in systems where the mid vowels undergo metaphony and the low vowel does not, metaphony enhances contrast by maximizing the acoustic distinction between the mid and low vowels.

Under this view, vowel shift is a non-assimilatory operation with contrast-enhancing properties, which may sometimes follow an independent sound change that leaves a vacancy in the acoustic vowel space. It is specific to the dimension of vowel height, and does not imply any general mechanism for scalar shifts along other phonetic parameters. The possibility exists, however, that similar contrast-enhancing strategies may arise specific to other dimensions of contrast. Upward and fronting shifts in vowel systems have a particularly salient acoustic consequence, and upward shifts are scalar because the dimension of vowel height affords several perceptually contrastive subdivisions. Other phonetic dimensions with more than two contrastive divisions would include the voicing dimension, expressed in terms of voice onset time (VOT), which suggests the possibility of relating metaphony and diachronic vowel shift to scalar lenition/fortition phenomena that affect consonantal laryngeal properties.

The vowel shift principle accounts for the upward movement of vowels, but says nothing about the distance any individual vowel should move within a given system. If, as I have suggested, there is a perceptual basis for vowel shift, then it would seem that the optimal

vowel shift system would raise all vowels maximally. In fact, one of the interesting properties of vowel shift systems is that they are most often non-neutralizing: although vowels are shifted upwards in space, the movement is usually not maximal, and contrastive vowel height categories are very often preserved. The contrast-preserving character of vowel shift in metaphony systems is examined more closely in section 7 below, but before that, the following section introduces the final ingredient in the proposed analysis of metaphony.

6.2. A role for assimilation

Identifying vowel shift as a mechanism for metaphonic raising resolves some problems, but it also leaves the following questions unanswered:

1. What determines the restricted set of contexts in which metaphony occurs? Diachronic vowel shifts involve a systemic shift of vowels that operates independent of the morpho-phonological context in which the shifting vowels appear. In contrast, metaphonic vowel alternations are restricted by phonological and morphological conditions: raising affects only the stressed vowel, and occurs only in words that bear a specific morphological features marking, eg., person, gender, or tense.

2. What is the relationship between metaphony and the high suffix vowels that condition it, for systems where the suffix vowel emerges as an intact high vowel? One of the indisputable attractions of the assimilation analyses of metaphony reviewed above is the dependency that is determined between the upward movement of vowels undergoing metaphony and the height of the triggering vowel that is widely taken to be the historic source of metaphony. If, as suggested here, raising results from vowel shift, then the height of other vowels present in the representation is not expected to play any role in the occurrence of raising. Vowel shift does not require a trigger in the sense that assimilation does.

3. What is the status of Maiden's implicational hierarchy, which states that the raising of low-mid or low vowels presupposes the raising of high-mid vowels? The vowel shift principle, as stated by Labov, does not in itself differentiate between high-mid and low-mid vowels, such that the former would be preferred inputs for raising. Why should metaphony, as a system of vowel shift, prefer output in which underlying high and high-mid vowels are neutralized, while underlying low-mid and low vowels are most often not? Further, why are metaphony systems in which only high-mid vowels raise much

more common than systems in which only the low-mid vowels raise? There is no general evidence from the cross-linguistic examination of vowel inventories to suggest that high-mid vowels are phonologically unstable in comparison to low-mid vowels.

These questions can be answered by bringing a restricted vowel height assimilation into the analysis. As already noted, vowel shift is often driven by a pulling force, such as the diphthongization of high vowels, which leaves a vacancy in the high vowel position. Lower vowels raise to fill in the vacancy, pushing the entire vowel system into a higher portion of the acoustic vowel space. In the case of metaphony, a plausible pull force is the assimilatory raising of the stressed high-mid vowels in the presence of a high suffixal vowel. This assimilation, along with the concomitant vowel shift, can be considered an element of the synchronic grammar for languages which have preserved high suffix vowels. For those languages in which suffix vowels have undergone height neutralization or deletion, there is no overt high vowel to trigger assimilation. In such cases, assimilation is an historical event, whose effects are preserved in the modern language through lexical encoding of stem allomorphs. For such languages, assimilation and vowel shift are not active in the synchronic grammar, but are reflected in the pattern of stem allomorphy encoded in the lexicon.¹⁵

Viewing /e, o/ raising as assimilation to /i, u/ makes sense when one considers the functional basis of assimilation. Assimilation promotes perceptual salience by reducing or eliminating marginal contrasts between two phonetically similar segments (Cole & Kisseberth 1994). Small phonetic differences between the trigger and target of assimilation are resolved, and in many vowel harmony systems the target emerges as fully identical to the trigger. Thus, the assimilated target provides additional or extended acoustic cues for the identification of the triggering segment. In metaphony systems, only the raising of the high-mid vowels consistently yields output which is perceptibility. It can be argued that the incomplete, one-step raising of the low-mid or low vowels actually diminishes perceptibility by reducing the distance between the raised vowel and the triggering high vowel. Under this view, the raising of the low-mid or low vowels is not best characterized as assimilation, and requires an alternative mechanism, for which I propose vowel shift.

An assimilation analysis of /e, o/ raising also explains the asymmetric pattern of diphthongization in metaphony systems. While the metaphonic output for low-mid vowels is often a diphthong, the

metaphonic output for the high-mid vowels is a simple high vowel, [i] or [u], in all of the systems described in the studies of metaphony cited above. The fact that high-mid vowels do not diphthongize follows from the functional characterization of assimilation: assimilation promotes identity between the phonetically close trigger and target. A diphthong such as [ie, wo] would not serve to identify the [+high] feature of the triggering vowel nearly as effectively as a simple high vowel. The best output of [+high] assimilation is a vowel which is uniformly [+high]. Diphthongization of the low-mid and low vowels is discussed further in section 7 below.

To summarize, this analysis claims that all metaphonic raising derives directly or indirectly from height assimilation. Height assimilation determines a unique [+high] output, and is directly responsible for the raising of the high-mid vowels. Height assimilation indirectly derives raising of the lower vowels. It leaves a vacancy in the vertical dimension of the vowel space, and vowel shift takes place to raise the lower vowels, and thereby fill the gap.

This two-part analysis answers the three questions raised at the beginning of this section. First, regarding the positional restrictions on vowel shift, we have seen that vowel shift occurs in restricted environments because it inherits the phonological and morphological conditions imposed on vowel assimilation, which is a necessary precursor to vowel shift. Second, the fact that metaphonic raising is conditioned by high vowels is explained in part by the recognition that assimilatory raising, by definition, must be conditioned by a high element. Third, the implicational hierarchy, expressing the greater tendency for high-mid vowel raising, is explained by the causal relationship between assimilation and vowel shift. High-mid vowel raising is the sole result of assimilation, and directly triggers vowel shift. The proposed analysis predicts that vowel shift should come about only in systems in which a process, such as the assimilatory raising of high-mid vowels, creates a gap in the phonetic dimension of vowel height.¹⁶

6.3. Raising in Atonic Vowel Reduction

There is an interesting parallel between the raising of low-mid vowels due to vowel shift, and a similar raising of atonic low-mid vowels that occurs in many of the same languages. Kaze (1989) reports on the alternations that relate stressed vowels to their counterparts in unstressed position. His data from Servigliano and Bolognese show that the low-mid vowels are raised and neutralized with the high-mid vowels, while in Calvello a more thorough reduc-

tion neutralizes all the mid vowels with the high vowels, as in (14). The low vowel remains low in atonic position.

(14) Atonic vowel inventories

Calvello:	/u, ə, a/
Servigiano:	/i, e, a, o, u/
Bolognese:	/i, e, a, o, u/

Atonic vowel reduction is a phenomenon common to many languages that results in a smaller and typically less-marked vowel inventory. Atonic vowel reduction can be viewed as an optimization strategy, eliminating marginal contrasts and perceptually less-salient vowels from positions that lack stress prominence. The implication here is that raising of the low-mid vowels is a way to obtain a more optimal vowel inventory. This lends some support to the view of vowel shift put forth above, which attributes the metaphonic raising of the low-mid vowels to vowel shift, as a (not fully understood) mechanism for optimizing perceptual salience in the vowel system at large. The parallel between atonic vowel reduction and metaphony is not complete, however, as the former does not have an effect on the low vowel in the limited data reported by Kaze. It is less clear how the low vowel raising that sometimes occurs in metaphony systems might function to enhance overall contrast within the system, but I note that similar movements are typical of the diachronic vowel shifts in Labov's study.

7. Contrast preservation in scalar shifts

Under the vowel shift analysis outlined above, shift-induced raising results in output with increased distance between F1 and F2. A question for this analysis is why doesn't vowel shift yield /i/ as a uniform output for all input vowels? The vowel /i/ is the most raised/fronted vowel, and therefore defines the optimal output for vowel shift. Before answering this question, we must first recognize that there are indeed systems in which the low-mid and low vowels raise all the way to /i/ (or sometimes /u/ for back vowels). This type of raising is termed "hypermetaphony" by Maiden (*op. cit.*). In an extreme scenario, cited by Calabrese (1985) for Crecchio and by Maiden for Teramo, metaphony displays the uniformly high output vowels /i/ and /u/ for the input vowels /e, ε, a/ and /o, ɔ/, respectively. An underlying contrast between four vowel heights is reduced to one in the stressed

positions affected by metaphony. But there are many more systems in which raising is incomplete (or scalar, in the terminology adopted here). What mechanism limits raising for these cases? The answer must surely relate to the tension between vowel shift on the one hand, and the need to preserve underlying vowel contrasts, on the other.

In fact, there are two questions to ask about scalar raising. One is why the raising is incomplete, and and therefore a sub-optimal shift, and the other is why raising preserves the relative height of the underlying vowels. In other words, why is it that in systems with incomplete raising, the low vowel never raises to a level higher than that of the raised low-mid vowel? It seems clear that in such systems, metaphony is governed by a restriction that the relationship between contrastive vowel height categories be maintained.¹⁷

I refer to this as the principle of Contrast Preservation, formulated in two parts in (15).¹⁸

(15) Principle of Contrast Preservation

- No Neutralization: If two segments in underlying representation, X and Y, belong to contrastive categories along some phonetic dimension F, they must map onto segments in the surface representation, X' and Y', which belong to contrastive categories along dimension F.¹⁹
- Preserve Order: If two segments, X and Y, that contrast in underlying representation, are ordered X < Y in the phonetic dimension F, then they must map onto segments in the surface representation, X' and Y', which are ordered X' < Y', or X' = Y', but not Y < X.

Principle (15a) prohibits raising if the result is a neutralization of contrastive height categories, while (15b) requires raising to preserve the RELATIVE underlying height of raised vowels. These two dimensions of Contrast Preservation must be separate, because while neutralization of two contrastive height categories sometimes does occur, a change in the relative height of two categories does not. Metaphony can shift vowels upward and forward in the acoustic vowel space, but it cannot completely reorganize the system of contrast. Instead, metaphony typically results in a compression of the underlying system into a smaller region of the vowel space, at times collapsing two contrastive height categories into one. This mapping of underlying to metaphonic vowels is diagrammed in (16) for the metaphony system of Castro dei Volsci.

Labov (1994: 252ff) discusses the diachronic development of the rising diphthongs in Romance, and suggests that they arise from the upward movement of tense vowels when the second mora "falls behind" the first in attaining increased height. Differentiation of the two moras of tense vowels produces the glide-vowel sequence, and underlies the development of many diphthongs in vowel chain shift systems. Although this may be an appropriate account of the diachronic development of rising diphthongs in Romance, it's difficult to see how this account would fit into the synchronic analysis of metaphony, especially since the diphthongizing vowels are not described as being long or tense. Yet diphthongization does play a role in maintaining contrast: by diphthongizing a raised low-mid vowel, the surface form unambiguously identifies the contrastive category of the vowel, counteracting the neutralization that would otherwise result from compressing four contrastive height categories into three.

8. Conclusion

This paper has shown that a more restrictive and more principled account of metaphony is obtained by abandoning the traditional assumption that metaphony constitutes a unified phenomenon of assimilation. The analysis proposed here claims that metaphony has its origins in an assimilation of the high-mid vowels. The other component to metaphony is vowel shift, defined in terms of acoustic features, which conditions both the raising and fronting of vowels. Vowel shift is a direct response to the gap in the phonetic vowel space that results from assimilation of /e, o/. Lower vowels raise to fill in the gap, which results in a vowel system that is located in a compressed, higher region of the vowel space. This analysis accounts for the asymmetry observed in the uniform behavior of high-mid vowels on one hand, and the variable behavior of the low-mid and low vowels on the other.

Throughout the analysis, I have avoided reference to any specific set of phonological features for vowel height, relying instead on the phonetic categories of vowel height, which are acoustically defined. I maintain that the phonetic account is sufficient, and provides a better explanation for the variety of vowel movements that comprise metaphony, including fronting and diphthongal movements. The phonetic account also avoids the overgeneration problem of existing phonological analyses, which predict a wider range of scalar assimilation phenomena than is attested.

The analysis developed here is less than complete, though. Future research is needed to shed more light on the phonetic basis of

(16) Contrast Preservation in Castro dei Volsci

a.	e, o	→ i, u	
	e, ɔ	→ je, wo	
	a	→ ε	
b.	underlying vowels	raised vowels	
	i	i	u
	e	je	wo
	ε	ε	ɔ
	a		

Individual metaphony systems vary in the extent to which vowel height contrast is preserved. There are systems such as Creccio and Teramo, in which massive neutralization takes place, and there are systems such as Castro dei Volsci, in which even the low-mid and low vowels raise, but remain distinct from the high-mid and high vowels. This variation can be accounted for in a theory like Optimality Theory, where the tension between independent, conflicting constraints is resolved by constraint ranking. Varying the constraint ranking across languages yields different patterns in surface structure. In the case at hand, there is an interaction between the two parts of Contrast Preservation, and metaphonic vowel shift. In all cases, the Preserve Order part of Contrast Preservation (15b) is satisfied, suggesting a universal high ranking for this constraint, but the relative ranking between No Neutralization (15a) and vowel shift is variable. When vowel shift outranks No Neutralization, raising is complete and contrastive height categories can be collapsed. When No Neutralization outranks vowel shift, raising is incomplete and the output of vowel shift must preserve underlying contrast.

The Contrast Preservation principle provides us with further insight into the diphthongization that very often accompanies raising of the low-mid vowels, and sometimes occurs with low vowel raising as well. Some dialects which exhibit diphthongization are listed in (17).

(17) Diphthongization of low-mid vowels

e, ɔ	→ je, wo
Calvello (Kaze 1989); Ragusa, Castro dei Volsci, Arpino, Agnone, Ischia, and Arcevia (Maiden 1991)	

vowel shift, and its functional motivation. In a related vein, we can seek a better understanding of the development of diphthongs, and their evolution in language change. Finally, current phonological theories (both constraint-based and rule-based) do not specify a precise role for constraints relating to contrast, nor is it presently clear how contrast is encoded in phonological representations or grammars. Future work might reveal alternative ways to accomplish incomplete assimilation without reference to contrast preservation, as has been suggested by Kirchner (1996) (but cf. Homer (1998) for an opposing view).

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Notes

* The research reported here was supported in part through NSF grant SBR-9319368. I thank José Hualde, Robert Kirchner and an anonymous reviewer for their comments.

1. Oddly, in the literature reviewed here there is little discussion of the fronting alternations, and no attempt to integrate an analysis of fronting into the raising analysis.

2. Kaze assigns the feature [+low] to /ɛ, ɔ/. Assimilation of [+high] to these vowels leads to violation of the constraint [+high, -low], along the lines described below. Kaze appeals to the same feature co-occurrence constraint in his analysis of low vowel raising. To account for dialects where the low vowel does not raise, Kaze appeals to special conditions on raising which require specification for the feature [round], which /a/ lacks.

3. This feature co-occurrence constraint, among others, is attributed to Universal Grammar, and accounts for the relative markedness of high, lax vowels compared to high, tense vowels. See also Archangeli and Pulleyblank (1994).

4. See also Maiden (1991) for criticism of Calabrese's treatment of low-mid and low vowel metaphony, as well as Calabrese's rebuttal in this volume.

5. Maiden rejects the characterization of metaphony as a 'minimal' change, when considering analyses put forth by Anderson & Durand (1986). He comments that "A drawback of this general approach to vowel shifts is the stipulation of 'minimal increase' [...] such stipulated restrictions represent an illegitimate intrusion into specification of the process of details of the actual resolution of that process. I see no reason why [an operation promoting a component (JC)] should represent a 'minimal increase' rather than just an 'increase'" (p. 139). Clearly, though, the change in a component expression undergoing metaphony must effect only a minimal demotion of 'a', as argued here, for those systems where vowels are raised only one step.

6. Maiden does not reject a morphological component to metaphony, but emphasizes the need to recognize the phonetic (or perhaps phonological) basis of the rule in height assimilation.

7. I am aware of two potential counterexamples to the claim that height assimilation is always complete. The strongest example comes from Basque (Hualde, 1991), where /a/ raises to [e] following /i, u/ in the preceding syllable. This is not a

systemic height assimilation, though, as the mid vowels /e, o/ appear unaffected following a high vowel. Rather, this seems to be a phenomenon involving only the high and low vowels, which when they appear in close proximity, give rise to a mid vowel. The Basque case might be related to the phenomenon of articulatory blending, which produces mid vowels as the coalescent output of adjacent high and low vowels in many languages. I leave this matter unresolved here. A second potential counterexample comes from the Bantu language Sesotho, described by Duke and Mokofeng (1974), as cited in Hayes (1990) and Clements (1989). In Sesotho, the low-mid vowels /e, ɔ/ raise one step to /e, o/ when followed by any of the high vowels /i, I, u, U/. This appears to be an instance of assimilatory one-step raising, but unlike metaphony, it targets only a single vowel height, and is therefore not systemic. There is some question about the precise quality and status of the raised vowels in this system. Clements observes that the lax, high vowels /I, U/ also raise when followed by /i, u/ in the next syllable, but in this case the raising is claimed to be non-neutralizing; the output of raising only approximates the height of the triggering vowels /i, u/. Clements suggests that this raising is post-lexical and gradient. The raising of the lax high and the lax mid vowels, together with the fact that no raising is reported for the tense, mid vowels /e, o/, suggests the possibility that what is going on here is a neutralization of the tense contrast, and not an assimilatory raising. Of course, it is not clear why tensing of the mid lax vowels would be triggered by high lax vowels, but a more detailed analysis must be based on instrumental data indicating the actual height of the vowels involved in this system.

8. Diphthongization itself arises from the raising of high or mid tense vowels.

9. Labov uses the terms "peripheral/non-peripheral" in place of tense/lax, referring to the vowel's position within the acoustically defined vowel space.

10. Note also that the fronting of /a/ under metaphony cannot be taken as an automatic property of the rule, since there are instances where /a/ alternates with a higher back vowel, such as in the metaphony system of the Asturian dialect spoken in the Nalón river valley, where /a/ raises to [ɔ] (García-Alvarez, 1960; Rodríguez-Castellano, 1955). Thanks to José Hualde for bringing this example to my attention.

11. The idea of a dispersion principle governing vowel distribution is put forth in Disner (1983), and in Disner's chapter in Maddhesson (1984). A formal account of how dispersion functions in the phonology is developed by Fleming (1995), who cites Lindblom's (1986, 1990) "Theory of Adaptive Dispersion" as the basis for his model.

12. By scalar assimilation, I refer to any assimilation in which the target segment undergoes a one-step movement towards the feature(s) specified on the trigger. I do not deny the existence of GRADIENT assimilation, of the sort described for some long-distance nasal harmony systems such as Guarani (Kiparsky, 1985; Rivas, 1974), where there is a gradual reduction of nasalization as the assimilation progresses away from the trigger.

13. Labov calls this Principle I. Labov (1994: 174) defines TENSE as an abstract category that serves to organize vowels into major sets. [+Tense] is defined acoustically as being: closer to the periphery of two- or three- formant space, longer, and of greater amplitude, among other properties. Peripherality is defined relative to the system as a whole; in languages with no tense/lax contrast, all vowels are peripheral, and therefore [+tense].

14. Labov initially formulates two distinct principles for raising and fronting, but later collapses all the vowel shift principles into a single unified principle that accounts for movement in both directions.

15. Under this view of historical assimilation, the extension of metaphony patterns to new words entering the lexicon would have to be explained through analogy. This diachronic analysis also explains why in languages with no overt suffix

vowel to trigger raising, exceptions to metaphony are often forms which lacked the triggering high suffix vowel at the earlier stage of the language. An alternative approach, of the sort advanced in generative phonology, would be to posit an abstract underlying high suffix vowel which would trigger assimilation, followed by vowel shift, in the synchronic grammar. In such an analysis, both assimilation and vowel shift would be active in the synchronic grammar, and could thus account for the extension of metaphony to new forms. The abstract vowel analyses introduces the sort of opacity that is problematic for non-derivational approaches such as Optimality Theory (Prince & Smolensky, 1993). A pattern of surface form (metaphony) is determined by an element that is present only in the input (the abstract suffix vowel), which is a problem if the constraint that enforces metaphony is restricted to evaluating surface forms alone. Various solutions have been proposed within OT to deal with opacity (McCarthy 1995, Cole & Kisseberth 1995), but the solution which appears most promising to me is to resolve opacity by allowing grammatical constraints to make a direct comparison of two different output forms that are related through a morphological paradigm (Steriade 1995). But the possibility of paradigm constraints that compare surface forms provides an alternative to the analysis with an abstract underlying vowel. Paradigm constraints provide for the analysis of historical assimilation a method of accounting for the analogical extension of metaphony to new forms. Thanks to Robert Kirchner for illuminating discussion of these issues.

¹⁶ This prediction is at odds with the existence of metaphony systems in which 'only the low-mid vowels undergo raising. Of the authors whose work has guided the present study, only Maiden (1991: 114) cites a very small number of dialects that display this pattern. He dismisses such cases as counterexamples to his proposed implicational hierarchy, suggesting that "a possible explanation of this contradictory and, overall, exceptional situation is a chronologically differential spatial diffusion of metaphony from an epicentre in which metaphony did indeed generalize [from high-mid vowels in open syllables, to lower vowels, and in closed syllables (JSC)], in the manner I have reconstructed for the great majority of dialects" (p. 129). If Maiden is correct, then this exceptional pattern comes about through borrowing from dialects with conforming metaphony patterns, i.e., where the high-mid vowels raise. Data for the dialects with the exceptional metaphony pattern were not available to me, and so the question is left unresolved here.

¹⁷ But see Kirchner (1996) for an alternative account of incomplete assimilation in chain shifts within an extended model of Optimality Theory.

¹⁸ The reader familiar with Optimality Theory will recognize that the two parts to the Principle of Contrast Preservation are formulated here as correspondence constraints, governing the mapping between corresponding segments in underlying and surface forms.

¹⁹ It might be desirable to decompose this constraint further into two parts: 'X' and 'Y' must belong to contrastive categories, and the contrastive categories must be along the phonetic dimension measured by the feature F. See Homer (1998) for an account of contrast along these lines.

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