Hungarian Vowel Harmony

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0 Introduction

A system of phonological rules and representations has at least two aims: one is to describe the way in which words (and larger stretches of utterances) are realized in speech, and to state which logically possible streams of speech sounds are legitimate in the language under description – this is part of observational adequacy. The other aim is to capture the *pattern* of sounds characteristic of the language in question – this is part of descriptive adequacy. Phonological feature systems play a pivotal role in the realization of these two aims: on the one hand, they contribute to observational adequacy by virtue of their phonetic interpretation, which ties the abstract units (phonemes) employed in phonology to articulatory (and perhaps perceptual) correlates. On the other hand, they contribute to descriptive adequacy by classifying these units into 'natural classes' according to the phonemic patterning of the language.

In Section 1 I will argue that in the case of Hungarian vowels, the aims of observational and descriptive adequacy are in conflict, because the qualitative differences between short and long vowels are *only* phonetic: the phonological patterning of Hungarian vowels makes it necessary to treat long vowels as geminates. This result will not only call into question the existing treatments of Hungarian vowel harmony, but also raises a larger question: if phonetic facts do not serve as an infallible guide in feature analysis, what is the content of the features? I will argue that the substantive content of phonological theory is largely independent of the intrinsic content of the features, and that the predictive power of the theory lies with the restrictions it puts on the *use* of features.

In Section 2 I will provide the groundwork for a discussion of the use of features by presenting the pattern of vowel alternations in Hungarian in a pretheoretical, taxonomic fashion. I will argue that this pattern is more complex than the analyses based on the pioneering work of Vágó (1975,1976) suggest. In addition to the well-known 'binary' suffixes such as the dative *nak/nek*, I will describe the harmonic behavior of 'ternary' suffixes such as the allative *hoz/hez/höz* and 'quaternary' suffixes such as the accusative *at/et/ot/öt*, and

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discuss why these are problematic for Vágo's analysis. As we shall see, each vowel in Hungarian can show 'regular' or 'exceptional' behavior: this makes it necessary to use vowel features as *diacritics*.

In Section 3 I will investigate two opposing ways features can be used in rules of harmony: as structure-changing, or as structure building. I will give two competing accounts of the harmonic patterns in Hungarian. The first of these, developed by the author as part of a larger work dealing with the inflectional morphology of Hungarian (Kornai 1986) employs simplex (tridirectional) features: here the rules of harmony are necessarily feature-changing. The second account, developed jointly with Donca Steriade and Harry van der Hulst, employs the standard binary SPE features, and underspecification: here the rules of harmony are feature-adding. Since both analyses use a floating feature as a diacritic to mark the exceptional stems, they both handle quaternary alternation in the correct fashion. Thus we need some further considerations to select between the competing accounts: these will be discussed in Section 4.

1 The feature analysis of Hungarian vowels

In this section I will first present the vowel system of Hungarian and point out an important discrepancy between the phonetic facts and the traditional feature analyses of Hungarian vowels: although on the surface short and long *a* differ in rounding (and height), they are treated as having the same underlying value for the features Round (and Low). I will argue that this discrepancy is not accidental: rather, the pattern of short/long vowel alternations makes it compelling to analyze long vowels as geminates that differ from the corresponding short vowels only in the number of timing units they take.

Next I will address the larger issue of discrepancies between the underlying and surface representations. If such discrepancies exist at all, mere phonetic facts can not be fully sufficient to establish a feature analysis. As a first step in developing an alternative method for justifying a feature analysis, I will *deduce* a feature analysis for Hungarian vowels purely on the basis of vowel alternation patterns, without any reference to phonetic facts. I will briefly discuss the extent to which this deductive method is applicable for vowel systems (and phoneme inventories) other than that of Hungarian.

1.1 The received feature analysis

The vowel system of Hungarian is given in (1) below – in the rest of the paper, forms will be given in orthographic, rather than phonetic, transcription.

(1)	a [o]	e [ε]	i	o	u	ü	ö
	á [a:]	é [e:]	í [i:]	ó [o:]	ú [u:]	ű [ű:]	ő [ö:]

The vowels in the first and the second rows are traditionally called 'short' and 'long' vowels respectively. In standard phonological theory the phonetic difference between the two is encoded with the feature ±Long or ±Tense – in autosegmental theory it is encoded by the number of timing units associated to the vowel. There can be no doubt that the long vowels are true geminates. Phonetically, there is a clear distinction between a sequence of two identical short vowels and a long vowel: cf *koordináta* 'coordinate' vs. *kór* 'disease'; *kiindulás* 'starting' vs. *kín* 'anguish' etc.[1] Phonologically, the distinction is equally clear: rules sensitive to syllable structure (e.g. the rule of question intonation, which assigns a high tone to the penult) will always treat long vowels as belonging to one syllable, and sequences of two identical short vowels as belonging to two syllables.

Phonetically, there is little discernible difference between the quality of *i* and *í*; *o* and *ó*; *u* and *ú*; *ü* and *ű*; or *ö* and *ő*. However, the long vowel *á* is low, central, and unrounded, while the short vowel *a* is mid-low, back, and rounded. The long vowel *é* and the short vowel *e* do not differ in backness or rounding (they are both front unrounded), but they differ in height: *é* is mid-high and *e* is mid-low. These facts are to be compared to the following feature charts:

(2)	a	á	e	é	i	i	o	ó	u	ú	ü	ű	ö	ő
Back	+	+	-	-	-	-	+	+	+	+	-	-	-	-
High	-	-	-	-	+	+	-	-	+	+	+	+	-	-
Low	+	+	+	-	-	-	-	-	-	-	-	-	-	-
Round	+	-	-	-	-	-	+	+	+	+	+	+	+	+
Long	-	+	-	+	-	+	-	+	-	+	-	+	-	+

(3)	a	á	e	é	i	i	o	ó	u	ú	ü	ű	ö	ő
Diffuse	-	-	-	-	+	+	-	-	+	+	+	+	-	-
Flat	-	-	-	-	-	-	+	+	+	+	+	+	+	+
Tense	-	+	-	+	-	+	-	+	-	+	-	+	-	+
Grave	+	+	-	-	-	-	+	+	+	+	-	-	-	-

[1]For *a* and *e* the quality differences make the contrasts even more striking: *odaadás* 'devotion' vs. *dádá* 'spanking'; *leenyvez* 'glue down' vs. *lény* 'being'.

Originally, (2) was suggested in Szépe (1969:399) as part of the first attempt at developing a generative phonology of Hungarian. Vágó (1975) introduced the idea of taking *a* as underlyingly –Round, and started to use SPE feature names. In the subsequent literature, (2) has been adopted almost universally without any attempt to justify it. The emergence of autosegmental phonology did not change this situation: the 'standard' system was retained (with a separate tier for Front/Back) essentially in the same form as in (2) until quite recently, when the interest in feature geometry and underspecification called for a re-evalutaion of feature systems.

The only attempt at developing a different feature system is Becker-Makkai (1970:639), who presents her system, given in (3), in Jakobsonian terms. Unfortunately, this paper went largely unnoticed, in spite of the fact that it contains some of the quaternary data ignored in mainstream treatments. In the original system, the Grave values for *i* and *í* are underspecified[2], and I have added the value '–' in (3) in order to make it comparable to the fully specified SPE system in (2).

The two systems are highly similar: Tense is the same as Long, Diffuse is the same as High, and Grave is the same as Back (cf. SPE 4.2.1). Moreover, although Becker-Makkai notes that the –Flat specification for *a* "could be disputed on articulatory grounds", she opts for an abstract solution which makes her Flat equivalent to Vágó's underlying Round. The main difference between the two systems is in the treatment of short and long *a* and *e*: in (3), the only difference is in tenseness (=length), while in (2) there are other differences as well.

Working in the framework of SPE, which permits an underlying as well as a surface inventory, Vágó did not have to make a decision that flies in the face of phonetic facts in a case such as the roundness of *a*. Nevertheless, there are distinctions in Vágó's analysis which are completely arbitrary from a phonetic point of view. Nádasdy (1985) describes the phonetic height difference between *a* and *á* as mid-low vs. low: Vágó treats both as +Low. Nádasdy describes the phonetic height difference between *e* and *é* is mid-low vs. mid-high: Vágó treats *e* as +Low but *é* as –Low.

Vowel length is distinctive in Hungarian: it is easy to find minimal pairs like *kor* 'age' vs. *kór* 'sickness'; *vidd* 'carry!' vs. *vídd* 'fight!'; *üröm* 'artemisia' vs. *űröm* 'my space'; *öröm* 'joy' vs. *őröm* 'my guard'; *buja* 'lush' vs. *búja* 'his sorrow' that differ only in the length of the vowel in question. However, as we have seen above, *é* and *á* differ from *e* and *a* not only in quantity, but

[2] "The two blank spaces represent redundancies which do not need to be marked"

in quality as well, and a key question of the analysis is to understand why we should follow Becker-Makkai and adopt the same features for short and long vowels nevertheless.

In order to show that *a/á* and *e/é* belong to the same short/long series as the other vowels, I will consider two independent processes. First, there is a a rule of Low Vowel Lengthening (cf Vágó 1980:1.1.2) whereby stem-final *a* becomes *á* and *e* becomes *é* before most suffixes (including the accusative *at/et/ot/öt*, the dative *nak/nek* and the superessive *on/en/ön*).

Since the lengthening of stem-final *a* is triggered by exactly the same set of suffixes that trigger the lengthening of stem-final *e*, we have to treat Low Vowel Lengthening as a unified process i.e. we must suppose that the change from *a* to *á* happens along the same features as the change from *e* to *é*. Thus, if *a* and *e* have identical values for some feature, *á* and *é* must also have identical values for that feature, and vice versa.

The lengthening rule shows that *á* and *é* differ from *a* to *e* at least in length, but it leaves open the possibility of other differences such as raising or unrounding. Recall, however, that the height differences work in the opposite direction: *a* is *lowered* to *á* but *e* is *raised* to *é* by the same rule. In order to derive the correct values, Vágó is forced to posit two 'adjustment rules' (p 19) which can be collapsed only by using Greek letter variables referring to the opposite values of Low and Long. From this I conclude that the rule of Low Vowel Lengthening should be formulated so as not to affect height.

Another way of showing that length is the *only* feature that distinguishes *a* from *á* and *e* from *é* is by studying a process of shortening which affects a different set of stem vowels. In a lexically restricted set of consonant-final stems, certain suffixes, such as the the accusative *at/et/ot/öt*, the dative *nak/nek*, but *not* the superessive *on/en/ön* will trigger the shortening of the vowel in the last syllable of the stem. Examples:

(4)

tél/telet	'winter/ACC'
nyár/nyarat	'summer/ACC'
tűz/tüzet	'fire/ACC'
víz/vizet	'water/ACC'
nyúl/nyulat	'rabbit/ACC'

Again, the change is triggered by exactly the same set of suffixes for each stem, and this establishes the unity of the process. But here the non-low vowels show that the only feature the rule affects is length: thus it follows that this is the only change for low vowels as well. In particular, if we would permit the rule to round from *á* to *a*, we would mistakenly create a round vowel for *e* and *i* as well. Since this is completely unmotivated, we must derive the roundness of *a* by a late rule.

Before turning to the larger issue of discrepancies between the underlying and surface representations, let me summarize the implications of the preceding discussion. In order to maintain the unity of Low Vowel Lengthening, we must suppose that it operates on representations which are fairly distant from what one would propose on phonetic grounds. The shortening rule leads to exactly the same conclusion, namely that the only difference between corresponding short and long vowels is in the number of timing units they take, at least at the level where these rules operate. Therefore, the difference in the surface quality of *a* and *á*, or *e* and *é* can not be exploited to explain the purported asymmetry between the Low values of *e* and *é*, as it was done e.g. in Steriade (1987). Rather, we predict that the harmonic behavior of long vowels is identical to that of the corresponding short vowels. As we shall see in Section 2, this conclusion holds not only for the 'regular' vowels, but for most of the 'exceptional' ones as well.

1.2 Deducing the feature system

So far we have established that for the purpose of writing phonological rulas that preserve the unity of vowel shortening/lengthening processes in Hungarian, we need a feature system which is fairly removed from the phonetic characteristics of these vowels. This situation is typical: rules that capture linguistically significant generalizations can be far removed from surface 'naturalness' (Anderson 1981). This being the case, we can not make use of what I called at the beginning the 'observational' aspect of the features to argue for a particular feature analysis: rather, we are forced to make use of their 'descriptive', classificatory function. Let us first see how one can deduce the remaining features from the patterns of harmonic alternations in Hungarian. The basic 'binary' alternation involves, among others, the following suffixes:

(5)

nak/nek	'DAT'	dative
nál/nél	'ADE'	adessive
tól/től	'ABL'	ablative
nok/nök	'professional characterized by'	e.g. *szó* 'word', *szónok* 'orator'
unk/ünk	'1PLPOSSG'	1st plural possessive singular
ú/ű[3]	'having'	e.g. *nagy láb* 'big foot' *nagy lábú* 'having big feet'

This list is representative: there are no binary alternations involving other pairs of vowels. Disregarding exceptional stems for the time being, we can say that stems in which the last vowel is *a, o* or *u* (short or long) take the first alternant of the suffixes listed above, and that all other stems take the second alternant. (Except for stems in which an *a, o* or *u* is followed by one or more *i* or *e* – these will be discussed in Section 3.) Examples:

(6)

stem	2-ary *a/e*	2-ary *o/ö*	2-ary *u/ü*	gloss
bab	babnak	babtól	babunk	'bean'
báb	bábnak	bábtól	bábunk	'puppet'
rum	rumnak	rumtól	rumunk	'id.'
húr	húrnak	húrtól	húrunk	'chord'
bot	botnak	bottól	botunk	'stick'
drót	drótnak	dróttól	drótunk	'wire'
hit	hitnek	hittől	hitünk	'belief'
víz	víznek	víztől	vízünk	'water'
fej	fejnek	fejtől	fejünk	'head'
érv	érvnek	érvtől	érvünk	'argument'
tök	töknek	töktől	tökünk	'pumpkin'
bőr	bőrnek	bőrtől	bőrünk	'skin'
füst	füstnek	füsttől	füstünk	'smoke'
bűn	bűnnek	bűntől	bűnünk	'sin'

Thus, there should be a feature that distinguishes *a, o, u* from *e, i, ö, ü*:this, of course, is the feature 'I' (-Grave, or -Back).

[3]In ECH, or at least in the author's own dialect, this suffix is actually short. In a list of more than 3,000 suffixes and suffix-combinations (Veenker 1968) I have found only one more candidate: *tyú/tyű* as in *pattantyú, billentyű* etc. (The back alternant as well as the suffix *ú/ű* as in *szomorú, keserű* were suggested to me by Péter Siptár (who does not follow the SLH standard and pronounces these with short vowels.)

Next, we should note the existence of four-way[4] alternation as shown, among others, by the following suffixes:

(7)

at/et/ot/öt	'ACC'
ak/ek/ok/ök	'PL'
am/em/om/öm	'1SG POS'
as/es/os/ös	'having'

Quaternary suffixes, though ignored in standard treatments, are in fact anything but marginal: the most frequently encountered suffixes, such as the accusative, the 1st and 2nd sg possessive, and the plural are all of this form. Nor are they restricted to inflection: the last example, *as/es/os/ös* 'having, having to do with' is a high-frequency derivational suffix that forms adjectives from nouns. The distribution of the alternants will be discussed in detail in Section 2. For the purposes of the present discussion, it is sufficient to note that *a, e, o, ö* form a natural class because they are the only vowels that appear in four-way alternations. Thus, I will posit a feature that distinguishes these vowels from *u, i, ü*: I will call this feature 'A'.

In order to keep the seven vowels distinct, we need a third feature, which I will call 'U'. The values of this feature are established on the basis of two kinds of vowel alternations, namely ternary harmonic alternations (which are automatic and meaningless) and proximal/distal vowel symbolism (which is meaningful). Ternary suffixes include the allative *hoz/hez/höz* and the superessive *on/en/ön*. There are no vowels other than *o, e, ö* that take part in a three-way alternation. Again ignoring exceptional stem vowels, the basic pattern can be stated as follows: stems in *a, o, u* take the *o* alternant, stems in *e, i* take the *e* alternant, and stems in *ö, ü* take the *ö* alternant. Examples:

[4]In vowel-initial suffixes, the suffix vowel is dropped regularly after stems ending in vowels, and occasionally after consonant-final stems – for the investigation of vowel harmony, this phenomenon can safely be disregarded.

(8)

stem	SUE	ALL	gloss
bab	babon	babhoz	‘bean’
báb	bábon	bábhoz	‘puppet’
rum	rumon	rumhoz	‘id.’
húr	húron	húrhoz	‘chord’
bot	boton	bothoz	‘stick’
drót	dróton	dróthoz	‘wire’
hit	hiten	hithez	‘belief’
víz	vizen	vízhez	‘water’
fej	fejen	fejhez	‘head’
érv	érven	érvhez	‘argument’
tök	tökön	tökhöz	‘pumpkin’
bőr	bőrön	bőrhöz	‘skin’
füst	füstön	füsthöz	‘smoke’
bűn	bűnön	bűnhöz	‘sin’

The pattern exemplified in (8) divides the vowels that took the second alternant in the binary case into two groups, *i, e* and *ö ü.* These groups must be separated by the new feature U. The question is where the other vowels belong in this classification. In order to answer this question, I will invoke a ‘functionalist’ principle of maximal contrast which says that phoneme pairs that carry meaning distinctions should be maximally contrasted in form.

Hungarian has a pervasive system of proximal/distal distinctions in pro-forms: examples are *itt/ott* ‘here/there’, *ez/az* ‘this/that’, *így/úgy* ‘this way/that way’, *ekkor/akkor* ‘this time (now)/that time (then)’. In order to keep the representation of *i* and *u* maximally distinct, we must classify *u* with *ü, ö*, and similarly if we want to keep the representation of *i* and *o* maximally distinct, we have to classify *o* with *ü, ö.* By the same token, *a* would fall together with *ü, ö*, but if we want to keep the feature matrices of *o* and *a* distinct, we must put *a* together with *i, e.*

In Section 3.1 I will use a simplex tridirectional feature system as proposed by Rennison (1984), Kaye et al (1985), and others: thus, I will take I to be +Front (rather than –Back) and A to be –High (rather than +Low). In autosegmental notation, this system can be summarized as follows:

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(9)
        I                      U             I   U
  i  =   \          u  =      /      u  =  \ /
          V                  V              V
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      I                  U        I   U
       \                /          \ /
e  =    V     o   =    V     o  =  V       a  =  V
        |              |           |             |
        A              A           A             A
```

In sum, I have provided justification for three features, I, A, and U solely on the basis of vowel alternations. The probability of these features coinciding with the phonetically motivated Back-Grave, High-Diffuse, and Round-Flat is 1/840, even if we take it into account that the arguments used for these distinctive features provide no evidence as to which value should be taken as marked (+), or unmarked. Although the argument based on the principle of maximal contrast is less than fully compelling, the chances that the partially determined feature matrix developed on the basis of harmonic behavior alone should be compatible with (2) and (3) are still less than one percent. It is particularly noteworthy that the only case where the functional argument must be overridden by considerations of distinctness is the case of *a*, which is actually +Round on the surface.

Such an improbable 'coincidence' would call for an explanation even if it was restricted to Hungarian – but in fact the phonological patterning of languages is nearly always less abstract than what one would expect on the the basis of the apparent arbitrariness of the methods by which the feature analysis was established. In this paper, I can offer only the beginnings of an explanation: first, I would like to maintain that the process for discerning the phonological patterning is not really arbitrary.

Phonological rules can be stated without the aid of features, simply by referring to their input, output and context in terms of phonemes. For instance, a rule of nasal assimilation in Hungarian (see ch 2.5 of Vágó 1980) can be stated as n→m before {p,b,m}. Thus, by virtue of serving as environment in some rule, {p,b,m} is expected to be a natural class, sharing some feature X. Needless to say, a class can be natural also by virtue of undergoing, rather than triggering, some process. (For a discussion of the criteria we employ in distinguishing natural classes from 'unnatural' ones see e.g. Rubach 1982 ch 3.2)

Second, I would argue that in general we can deduce a feature analysis from the natural classes,[5] which are independently given to us (provided that the rules are given). From this perspective, the high degree of similarity between the abstract natural classes containing phonemes which behave similarly in rules, and the concrete natural classes containing phonemes which have similar articulatory properties is not really surprising: a rule with a simple articulatory (or perceptual) statement is easier to learn (or recognize) than one requiring a more complex statement. Thus, we expect the 'abstract' features emerging from the pattern given by the rules to be very similar (though not necessary identical) to the concrete, phonetic features which are universally given.

2 Harmonic alternations

In this section, I will first describe the suffixation patterns of non-derived stems in a theory-neutral, descriptive fashion. Next, I will describe the way suffix-combinations work in Hungarian, and argue that the standard treatment (Vágó 1975) fails to capture the basic pattern of binary, ternary, and quaternary harmony.

2.1 Stem classes

In order to avoid the problems stemming from the use of two different feature systems, let me introduce some terminology. As can be seen from the examples in Section 1.3, the basic pattern of harmonic alternations is the same for short and long vowels. Since this is also true of the exceptional patterns presented below, I will not mention the long vowels separately. For the sake of simplicity, *a o u* will be called *back*; *i e* will be called *neutral*; and *ü ö* will be called *front* vowels. Neutral vowels will *not* be called 'front', their featural classification and phonetic properties notwithstanding.

Exceptional vowels, such as the *í* of *híd* 'bridge' are well known in the literature: the fact that they take back suffixes (*hídnak, *hídnek*) rather than the regular front suffixes was taken as evidence for absolute neutralization rules (Ringen 1976). Indeed, they provide a clear counterexample to the Alternation Condition (Kiparsky 1968), and the problem posed by 'abstract vowels' could not be solved until the emergence of autosegmental phonology.

Here I will show that the set of abstract vowels in Hungarian is much more complex than previously suspected: in particular, not only neutral vowels have abstract counterparts. To see this, I will group stems together according to

[5] For a discussion of the details of this deductive method, see Kornai (1986: 2.1)

their harmonic behavior, i.e. according to the suffix-alternants they select. I will develop a taxonomy which is applicable not only to stems, but also to fully formed words that can undergo further suffixation. The classification presented below offers a theory-neutral descriptive framework encompassing all the non-vacillating Hungarian data.

In the binary case, all stems can be divided into two classes, 'BACK' and 'FRONT', according to the quality of the alternant they select. As we have seen in 1.3, binary alternants can be arranged in parallel series: if a stem takes *-nak* in the dative, it will take *-nál*, rather than *-nél* in the adessive, *-tól*, rather than *-től* in the ablative, etc. In a corpus of more than 35.000 nouns,[6] I was unable to find non-vacillating conterexamples that would take, say, *-nak* in the dative but *-től* in the ablative. Thus the generalization that binary suffixes can be arranged in parallel series is extremely robust, with no systematic counterexamples.

With the introduction of quaternary suffixes, a four-way partitioning results, depending on the quality of the vowel in the plural suffix *ak/ek/ok/ök*. Those stems that take *-ak* are grouped together in Class I, those that take *-ok* are in Class II, those that take *-ek* are in Class III or IV, and those that take *-ök* are in Class V. The difference between Class III and Class IV will be established shortly – until then, we will consider Class III and Class IV together.

It should be emphasized here that the classes are set up on the basis of the suffix vowels, rather than on the basis of the stem vowel. Since Hungarian has root-controlled harmony, there is a correspondence between the two. Class I contains the exceptional back vowel stems, and Class II contains the regular back vowel stems. Class III contains the regular neutral vowel stems, Class IV contains the exceptional front vowel stems, and Class V contains the regular front vowel stems. The distribution of exceptional vowels will be discussed in greater detail later on.

The partitioning into classes is justified by the fact that other quaternary suffixes will take the alternant with the same vowel. Indeed, no stem can subcategorize for *-ak* in the plural but *-ot* in the accusative, and in general the distribution of the quaternary alternants, as far as it can be established,[7] are completely parallel. In the following table, quaternary suffixes are represented by the plural.

[6] Most of the data discussed in this paper was gleaned from a dictionary databese (Kornai 1986a)

[7] The alternating vowel is lost after certain stems for some of the quaternary suffixes, e.g. we have *borok* 'wine-PL' but *bort* 'wine-ACC'.

(10)

	stem	4-ary	3-ary	2-ary *a/e*	2-ary *o/ö*	2-ary *u/ü*	gloss
I							
	had	hadak	hadhoz	hadnak	hadtól	hadunk	‘army’
	ház	házak	házhoz	háznak	háztól	házunk	‘house’
	lyuk	lyukak	lyukhoz	lyuknak	lyuktól	lyukunk	‘hole’
	kút	kutak	kúthoz	kútnak	kúttól	kutunk	‘well’
	hold	holdak	holdhoz	holdnak	holdtól	holdunk	‘moon’
	ló	lovak	lóhoz	lónak	lótól	lovunk	‘horse’
	híd	hidak	hídhoz	hídnak	hídtól	hidunk	‘bridge’
	héj	héjak	héjhoz	héjnak	héjtól	héjunk	‘crust’
II							
	bab	babok	babhoz	babnak	babtól	babunk	‘bean’
	báb	bábok	bábhoz	bábnak	bábtól	bábunk	‘puppet’
	rum	rumok	rumhoz	rumnak	rumtól	rumunk	‘id.’
	húr	húrok	húrhoz	húrnak	húrtól	húrunk	‘chord’
	bot	botok	bothoz	botnak	bottól	botunk	‘stick’
	drót	drótok	dróthoz	drótnak	dróttól	drótunk	‘wire’
	zsír	zsírok	zsírhoz	zsírnak	zsírtól	zsírunk	‘fat’
	cél	célok	célhoz	célnak	céltól	célunk	‘goal’
III							
	hit	hitek	hithez	hitnek	hittől	hitünk	‘belief’
	víz	vizek	vízhez	víznek	víztől	vizünk	‘water’
	fej	fejek	fejhez	fejnek	fejtől	fejünk	‘head’
	érv	érvek	érvhez	érvnek	érvtől	érvünk	‘argument’
IV							
	hölgy	hölgyek	hölgyhöz	hölgynek	hölgytől	hölgyünk	‘lady’
	tőgy	tőgyek	tőgyhöz	tőgynek	tőgytől	tőgyünk	‘udder’
	sült	sültek	sülthöz	sültnek	sülttől	sültünk	‘roast’
	tűz	tüzek	tűzhöz	tűznek	tűztől	tüzünk	‘fire’
V							
	tök	tökök	tökhöz	töknek	töktől	tökünk	‘pumpkin’
	bőr	bőrök	bőrhöz	bőrnek	bőrtől	bőrünk	‘skin’
	füst	füstök	füsthöz	füstnek	füsttől	füstünk	‘smoke’
	bűn	bűnök	bűnhöz	bűnnek	bűntől	bűnünk	‘sin’

The list in (10) is exhaustive in the sense that each surface vowel is exemplified in every class where it appears: for instance, there are no *i*-stems in Class IV or

Class V. Moreover, although the examples are all monomorphemic noun stems, each non-vacillating Hungarian word falls into one of these classes, irrespective of morphemic composition or lexical category.

As can be seen from (10), the selection of the suffix vowel in a quaternary suffix determines the selection of binary suffixes i.e. whether a stem belongs to the FRONT or to the BACK class: all stems that take *-ak* (Class I) or *-ok* (Class II) in the plural take back suffixes and the rest take front suffixes. In other words, the BACK class is made up from Class I and Class II, and the FRONT class is made up from the rest.

Hower, the choice of ternary alternant can *not* be fully determined from the fact that a stem takes the *e*-alternant of quaternary suffixes: such stems generally take the *e*-alternant (as expected), but not always. Those stems that take the *e*-alternant both in ternary and quaternary suffixes are grouped together in Class III, which contains the overwhelming majority of neutral vowel stems. But there are a number of stems in *ö* and *ü* that also take *-ek* in the plural: these are collected in Class IV.

It should be emphasized that the behavior of Class IV stems is qualitatively different from that of vacillation: forms like **hölgyhez, *tőgyhez, *sülthez*, and **tüzhez* are unacceptable in every idiolect, and in Educated Colloquial Hungarian (ECH)[8] the forms **hölgyöt, %tőgyöt,*[9] **sültöt*, and **tüzöt* are clearly unacceptable. Thus, the stems in Class IV require new kinds of abstract vowels.

I have mentioned above that the quality of the stem vowel determines the harmonic behavior of the stem to a large extent. If the stem vowel is front (*ö* or *ü*), the stem must be in Class IV or Class V, and if it is back (*a, o* or *u*), the stem will belong in Class I or Class II. As long as the last vowel of a polysyllabic stem (or word) is not neutral (*i* or *e*), the quality of the last vowel will decide the harmonic behavior of the whole stem. If the last vowel is neutral, the situation is more complex – the details will be discussed in Section 3.

The choice between Class IV and Class V is lexically determined, as is the choice between Class I and Class II. However, only the selection of Class I or Class IV has to be marked in the lexicon – the default case is Class II for stems in *a, u,* and *o*; and Class V for stems in *ü* and *ö*. This is particularly clear for Class IV, which contains roughly 20 monomorphemic stems, as opposed to the thousands of monomorphemic stems in Class V. That Class IV is the exceptionally marked class can also be seen from the fact that all recent loans

[8]The standard (Budapest) dialect. See Nádasdy (1985)

[9]This form has a decidedly *vidéki* 'rural' flavor for Budapest speakers, but is, perhaps, acceptable in some dialects. Note that different dialects can have different vowel inventories.

in *ü* or *ö* are in Class V. Although Class I is much larger (it contains more than a thousand monomorphemic members), it is still considerably smaller than Class II. It is also closed: nonce-words and recent loans in *a, u,* and *o* always belong in Class II. For the same reasons, the default is Class III for monosyllabic stems in neutral vowels.

Thus, the stems of Class I and Class IV must be marked by some diacritic. As we shall see shortly, there are reasons to suppose that this diacritic is the same for Class I and Class IV – let us call it +ML. For the time being, it is sufficient to note that each 'regular' vowel has a +ML counterpart, which is in Class IV if the vowel is front, and in Class I if it is neutral or back. The overwhelming majority of exceptional vowels is +ML. However, we find a few neutral vowel stems in Class II as well. For example the triple *híd, víz, zsír* shows that we must have two kinds of exceptional *í*-s. Unlike +ML stems, which can contain every surface vowel other than *e*, –ML exceptional vowels are restricted to *í* and *é* which appear only in a handful of monomorphemic stems and will require some other form of diacritical marking.

2.2 Suffix-combinations

The reader familiar with earlier treatments of Hungarian vowel harmony might wonder how a phenomenon involving thousands of stems and the most common suffixes like the accusative or the plural could have been ignored? I believe that this is because most of the literature on this topic is based on Vágó (1975), who addressed the problem posed by exceptional stems outside the framework of the investigation of vowel harmony. I will argue that Vágó's treatment was mistaken, and in fact the exceptional stems are fully integrated with the rest of the harmonic system. (In the following critical discussion, all page number references are to Vágó (1980), henceforth SPH.)

Although SPH starts with a discussion of vowel harmony (pp 1-30), we do not learn of the existence of Class I stems until Ch 4.3 (p 110), where "lowering stems" are discussed together with other (harmonically regular) classes of exceptional stems. On p 111 we learn that lowering stems are "historically old, unproductive, and constitute a closed set – a set that is large, to be sure". I will argue that this characterization of Class I and Class IV is only partially correct: although they are closed as far as non-derived stems go (as can be seen from the fact that all recent loans are in Class II, III or V), they are open in the sense that *every* non-derived non-neutral (and non-vacillating) Hungarian stem has derived forms that belong in Class I or Class IV.

To see this, let me recapitulate the defining property of lowering stems: a back stem is lowering (Class I) if and only if it selects the *a*-alternant of quaternary suffixes, and a front stem is lowering (Class IV) if and only if it selects the *e*-alternant of quaternary suffixes and the *ö*-alternant of ternary suffixes. Given an arbitrary stem of Class II or V, such as *rum* 'rum' or *'tök'* 'pumpkin', both the possessive and the accusative forms will show the regular quaternary o or ö – after all, this is why they were classified as belonging to their respective classes. But the possessive forms themselves will belong to Class I (or Class IV), because they take the *a* (or *e*) alternant of a following quaternary suffix:

(11)

stem	1SG POS	ACC	1SG POS+ACC	
rum	rumom	rumot	rumomat	*rumomot
tök	tököm	tököt	tökömet	*tökömöt, *tökömhez

The accuasative forms can not be tested because the accusative suffix is absolute word-final, but there are a number of other suffixes that have the same effect of turning regular stems into lowering stems. In the verbal paradigm, the past, imperative, and conditional markers all show this effect,[10] and in the nominal paradigm the 1st and 2nd singular possessive suffixes also create lowering forms. Suffixes of this sort are not restricted to inflectional morphology either. For instance, the names of the villages *Rum* and *Tök* are declined just as the corresponding common nouns but, being place names, they permit the addition of the denominal adjective-forming suffix *-i* 'characterized by the location', which derives *rumi, töki* 'inhabitant of Rum, Tök', which in the plural becomes *rumiak, tökiek* 'inhabitants of Rum,Tök' rather than **rumiok, *tökiök*.

The operation of such suffixes shows that Class I stands in the same relationship to Class II as Class IV to Class V. Let us see how SPH captures this generalization.

Vágó derives the *a*-alternant of quaternary suffixes by a minor lowering rule (MIN-LOW, p 111), which lowers and unrounds the quaternary vowel: this rule is triggered by the diacritic +ML which marks all lowering stems. In the description of MIN-LOW Vágó mentions only the fact that it takes *o* to *a*, but it is clear from the formulation of the rule and from the discussion of the Class IV stem *föld* 'earth' on p 112 that MIN-LOW also takes *ö* to *e*.

By positing a single rule for front and back lowering stems, Vágó correctly captures the fact that the irregularity of Class IV stems has the same source as the irregularity of Class I stems, namely arbitrary lexical marking. This

[10]For a detailed description, see Kornai 1986: Ch 4.1

approach predicts that the +ML class of stems can contain front and back vowels alike and thereby leaves only the *zsír*-type (surface) neutral vowels as truly exceptional. In fact, the distribution of abstract vowels strongly supports this conclusion. As discussed in 2.1, (surface) neutral vowels can show three kinds of behavior (Class I, II, or III), while all other vowels show only two kinds of behavior (Class I or Class II for back vowels, Class IV or Class V for front vowels).

However, the technical details of Vágó's system do not quite work. Ternary vowels are treated as underlying *o* (p 18), which is turned into *ö* by the rule(s) of binary harmony, and gets subsequently unrounded by the rule of Rounding Harmony (p 19) if the preceding vowel is unrounded. Quaternary vowels are introduced by a rule of o-Epenthesis (p 63, p 109), which feeds MIN-LOW: this correctly derives the quaternary forms. The problem is that MIN-LOW necessarily overapplies to ternary suffixes after lowering stems: because the underlying representation of the ternary and the quaternary vowel is the same, we necessarily derive the incorrect **hölgyhez* along with the correct *hölgyet*.

Another problem is that Vágó needs two distinct epenthesis rules, one for the suffix adjacent to the stem (o-Epenthesis), and and one for subsequent suffixes (a-Epenthesis) (p 110) to describe the fact that the vowel of quaternary suffixes shows up as binary *a/e* after certain suffixes, as exemplified in (11) above. These epenthesis rules are reproduced below:

$\underline{\text{a}}$-epenthesis

$$\emptyset \rightarrow \text{a}/C \begin{bmatrix} + \\ -\text{stem} \end{bmatrix} \langle\overline{\text{-VERB}}\rangle_{\text{a}}\text{C}\langle\#\rangle_{\text{b}}$$

Condition: if $\underline{\text{a}}$, then $\underline{\text{b}}$.

$\underline{\text{o}}$-epenthesis

$$\emptyset \rightarrow \text{o}/C+ \langle\overline{\text{+VERB}}\rangle_{\text{a}}\text{C} \begin{Bmatrix} + \\ \text{C} \end{Bmatrix} \langle\#\rangle_{\text{b}}$$

Condition: if $\underline{\text{a}}$, then $\underline{\text{b}}$.

As can be seen, these are very complex rules: they involve angled brackets (with Boolean conditions), reference to lexical category (a feature ±VERB), and reference to the fact that a certain +-boundary does *not* follow a stem. Moreover, the two rules can not be collapsed even with the powerful abbreviatory devices of SPE, because of the dissimilar environments and the ordering relation that obtains between them.

It is highly questionable whether angled brackets and Boolean conditions are permitted by phonological theory at all. But even if they are, the rules fail to capture the generalization that the relationship between the the quaternary vowel of a suffix, when following the stem, and the binary vowel of the same suffix when following another suffix can be subsumed under the rule of MIN-LOW, simply by marking the first suffix as 'lowering' (i.e. bearing ML in the lexicon).

The a-Epenthesis rule makes the incorrect prediction that a quaternary vowel must show up as binary whenever it is separated from the stem by another suffix. The following counterexample, which demonstrates the problem with this approach comes from the numeral system. The suffix *-ad/ed/od/öd* 'th' forms fractions when attached to a numeral base (or any form such as variable names that can be interpreted as having numerical value). As the second column in (12) below shows, *-ad/ed/od/öd* is a genuine quaternary suffix, which takes the same alternant as the accusative (third column) or any other quaternary suffix[11] for every stem. However, the accusative form of the stems formed by suffixing *-ad/ed/od/öd* never show up with *-at* (or with *-et* and *höz*):

(12)	stem	FRAC	ACC	FRAC+ACC	gloss
	öt	ötöd	ötöt	ötödöt	five
	hat	hatod	hatot	hatodot	six
	hét	heted	hetet	hetedet	seven
	nyolc	nyolcad	nyolcat	nyolcadot	eight
	iksz	ikszed	ikszet	ikszedet	x
	ipszilon	ipszilonod	ipszilonok	ipszilonodot	y
	sok	sokad	sokat	sokadot	much

It is easy to explain this paradigm as I do by not marking the fraction-forming *-ad/ed/od/öd* with ML. The SPH system, however, requires an extra rule which turns the epenthetic *a* into *o*. I would like to emphasize that the issue is *not* whether we have an epenthesis or an elision analysis of quaternary vowels, but rather the manner in which the quality of the vowel (epenthetic or otherwise) is determined by vowel harmony. To make this point even more clear, consider the the second person singular possessive *-ad/ed/od/öd*: this gives us minimal pairs like *nyolcadat* 'eight.POS2SG.ACC' vs *nyolcadot* 'eight.FRAC.ACC'; or *ötödet* 'five.POS2SG.ACC' vs. *ötödöt* 'five.FRAC.ACC'. The accusative suffix shows binary alternation after POS2SG, and ternary alternation after FRAC:

[11] Since in the accusative of *ipszilon* the vowel is elided, the plural is given instead.

this follows without further stipulations if we mark POS2SG by ML, but leave FRAC unmarked.

These minimal pairs show that the choice between o-Epenthesis and a-Epenthesis depends on the identity of the preceding morpheme and not on the position (stem-adjacency) of a suffix. Even if we take epenthesis for granted, we should eliminate the rule of a-Epenthesis in favor of a single rule that inserts the quaternary vowel, and derive the observed binary or ternary alternation by making this vowel subject to MIN-LOW.

Thus, even if we are interested only in front/back alternations such as the *a/e* alternation of the vowel preceding the *t* of the accusative (when it appears adjacent to the stem or in other positions), in order to capture the full pattern of *a/e* alternations we must come to grips with the fact that binary, ternary, and quaternary alternations are deeply intertwined in Hungarian. In addition to the effects of MIN-LOW, this can be also seen from the fact that in the same structural position, such as the noun-final position for case markers, we can find unary (*-ként*), binary (*-nak/nek*), ternary (*-hoz/hez/höz*), and quaternary (*-at/et/ot/öt*) suffixes. Moreover, suffixes can also change their arity as a result of morphological processes, as will be shown through an analysis of the possessive paradigm in (13) below.

In (13), one consonant-final stem is given for each harmonic class: *úr* 'master' (Class I); *sógor* 'brother-in-law' (Class II); *ember* 'man' (Class III); *hölgy* 'lady' (Class IV); and *őr* 'guard' (Class V).[12] The 1st, 2nd, and 3rd person forms are given in the 1st, 2nd, and 3rd columns respectively. With each stem, the first and second rows contain singular possesor forms, and the third and fourth rows contain plural possessor forms. The difference between the two rows is in the number of the possessed (the stem), which is singular in the first and third rows but plural in the second and fourth rows.

[12]The pattern of harmonic alternations remains the same if we include vowel-final stems, but in other respects the picture becomes much more complex. I will return to this question in 4.2.

(13)

I	*1st*	*2nd*	*3rd*	possessor	possessed
	uram	urad	ura	*sg*	*sg*
	uraim	uraid	urai	*sg*	*pl*
	urunk	uratok	uruk	*pl*	*sg*
	uraink	uraitok	uraik	*pl*	*pl*
II					
	sógorom	sógorod	sógora	*sg*	*sg*
	sógoraim	sógoraid	sógorai	*sg*	*pl*
	sógorunk	sógorotok	sógoruk	*pl*	*sg*
	sógoraink	sógoraitok	sógoraik	*pl*	*pl*
III					
	emberem	embered	embere	*sg*	*sg*
	embereim	embereid	emberei	*sg*	*pl*
	emberünk	emberetek	emberük	*pl*	*sg*
	embereink	embereitek	embereik	*pl*	*pl*
IV					
	hölgyem	hölgyed	hölgye	*sg*	*sg*
	hölgyeim	hölgyeid	hölgyei	*sg*	*pl*
	hölgyünk	hölgyetek	hölgyük	*pl*	*sg*
	hölgyeink	hölgyeitek	hölgyeik	*pl*	*pl*
V					
	őröm	őröd	őre	*sg*	*sg*
	őreim	őreid	őrei	*sg*	*pl*
	őrünk	őrötök	őrük	*pl*	*sg*
	őreink	őreitek	őreik	*pl*	*pl*

As can be seen, the plural possessed forms are derived from the corresponding singular possessed forms by infixing *i* after the first vowel of the suffix. This infixation creates a binary vowel (Vágó's epenthetic *a*) out of the preceding quaternary vowel in the first and second singular, and out of a binary *u/ü* in the first and third plural. As we shall see in 4.3, one of the differences between the two analyses developed in this paper is whether we insist on treating these changes as a unitary phenomenon or not.

To sum up, Vágó (1975,1976) fails to treat harmonic alternations in a unified manner. The subsequent literature, including Clements (1976), Phelps (1978), Jensen (1978), Vágó (1978), Ringen (1980) van der Hulst (1985), Goldsmith (1985), and Farkas and Beddor (1987) has continued to concentrate on binary harmony, and in particular on the treatment of neutral vowels and vacillating stems. This is somewhat unfortunate, inasmuch as the generalizations these systems intend to capture are not equally clear[13] – I will discuss this matter at length in Section 4.2. It is not always clear whether the proposed systems have the resources to remedy the technical problems with Vágó's solution by introducing different underlying forms for ternary and quaternary vowels. But for these systems, the length alternations discussed in 1.2 above are always problematic since these alternations call for parallel underlying representations for short and long vowels. In the next Section I will show that the harmonic alternations can be described even if we respect the larger pattern of Hungarian that dictates the same 'quality' features for short and long vowels.

3 The analysis

In this section I will develop two analyses of the data presented above. The first one, employing simplex tridirectional features, is based on two maximally simple spreading rules that interact with a single exception feature. Here the rules of harmony are feature-changing. The second analysis retains the idea of a single exception feature fulfilling the same function as ML above, but uses an additional feature, namely Low for this purpose.

From the perspective of the system deduced in 1.2, and put to use in 3.1, Low is completely redundant. In Section 3.2 we will see how the fourth feature can be exploited to construct representations in which Low is underlying, and other features are taken to be absent so that the rules of harmony are feature-adding. Although some of the relevant similarities and differences between the two solutions will be noted as we go along, the task of comparing the two systems from a wider perspective is deferred to Section 4.3.

[13] Although it will play no role in the subsequent argument, let me discuss here the following generalization (due to Esztergár (1971), and quoted in Vágó 1980:111): lowering stems always have an epenthetic vowel before the *t* of the accusative. SPH (fn 18 on p 134) gives a clear counterexample: *férfi* 'man' accusative *férfit (*férfiat).* As can be seen from the plural *férfiak*, this is clearly a lowering stem. Papp (1968) lists more than fifty lowering stems as taking *-t* in the accusative, including *hegyoldal* 'hillside', *magtár* 'granary', *szökőár* 'bore(tide)'. In addition, there is a systematic class of exceptions: denominal adjectives, formed from back vowel stems with the suffix *-i* discussed above, are all lowering (because *i* is lowering). Some of these, e.g. *szarházi* are epithets generally used as nouns. In addition, there are hundreds of lowering stems in which the quaternary vowel of the accusative is optional.

3.1 The solution with three features

The key observation concerning the data in (10) is that whenever there is a difference between the quality of the ternary and quaternary suffix vowels (*-at* vs *-hoz* in Class I, and *-et* vs *-höz* in Class IV), the quaternary suffix is lower and unrounded (provided that we take the 'abstract' underlying value rather than the surface value). Thus, we should mark the stems in both of these classes by the same exception feature which has a lowering and unrounding effect of quaternary (but not on ternary) vowels. In the tridirectional system both of these effects are captured by a single feature difference, namely +U vs. –U.

The most straightforward analysis of binary and ternary harmony, which will have to be supplemented by other rules later, is to spread the feature values for I and U onto the suffixes. For quaternary harmony, we have to adjust the underlying representation of lowering stems so that the spreading of U is blocked for them. This can be achieved by marking the stems in Class I and Class IV by a floating –U. By doing this, we replace the arbitrary rule feature ML with a feature which is chosen from a principled set of diacritics, namely that of *floating features*. Thus, the cornerstone of the three-feature analysis is the following pair of spreading rules:

(14A)

$$\begin{array}{ccc} \mathrm{I} & & \\ | & \ddots & \\ \mathrm{V} & \mathrm{C}_0 & \mathrm{V} \end{array}$$

(14B)

$$\begin{array}{ccc} \mathrm{U} & & \\ | & \ddots & \\ \mathrm{V} & \mathrm{C}_0 & \mathrm{V} \end{array}$$

Supposing that the vowel of quaternary suffixes is specified only for A, the rules in (14) will derive e.g. *tökök* from *tök* simply by spreading the I and U features of the stem vowel. This solution can readily be extended to ternary suffixes by supposing that their underlying representation contains a floating U which can dock only if the I feature of the stem did not spread.

The most important problem with this simple solution is that it does not capture the exceptional status of lowering stems. Without additional 'cleanup' rules we would have to mark the elements of Class II, rather than those of Class I, in the lexicon, in spite of the fact that Class II is productive, and Class I is closed. In order to deal with this problem, we must posit an independent source for the feature U that appears in the suffix of Class II stems. The field of computer science provides many examples of recently borrowed Class II stems such as *fájl/fájlok* 'file/PL', *ram/ramot* 'random access memory/ACC' which make clear that there must be a U in the representation of the quaternary suffixes themselves.

Adopting a proposal of Halle-Vergnaud (1982), I will take this U to be specified in the phonemic core.[14] For those features like A in Hungarian that do not harmonize there is no good reason to establish a separate tier. I suppose that the unmarked place for a segmental feature is on the segmental tier, and we autosegmentalize a feature only if there is some evidence for this. However, the segmental core remains a possible location even if the feature has been lifted to a separate tier – the present analysis will make use of this option only in the case of exceptional elements.

In sum, the underlying representation of quaternary suffixes contains the same features, namely A and U, as that of the ternary suffixes: the difference being that for the quaternary case the U is in the core and in the ternary case it is floating. This 'geometrical' difference will surface only after exceptional stems and after certain suffixes. Before turning to these, let me show first how the non-exceptional forms are derived.

In Class II, *zsír* and *cél* are exceptional (there are less then 10 monomorphemic *i* and *e* stems there) – the Class II pattern is regular only for stems in *a, o* and *u.* Since these do not contain the feature I, (14A) is inoperative. Whether (14B) actually spreads the feature U in the case of stems in *u* and *o* can not be decided on the basis of these forms, since both ternary and quaternary suffixes have an underlying U (albeit on different tiers).

I-spread gives the right result in Class III, provided that the U floating over *hoz/hez/höz* is stopped from linking up. This is achieved by a rule of floating U deletion:

```
(15)
 I-tier              /  I
                    /   |
CV-tier            /    VCoV
                  /
 U-tier   U-->0 /         ___
```

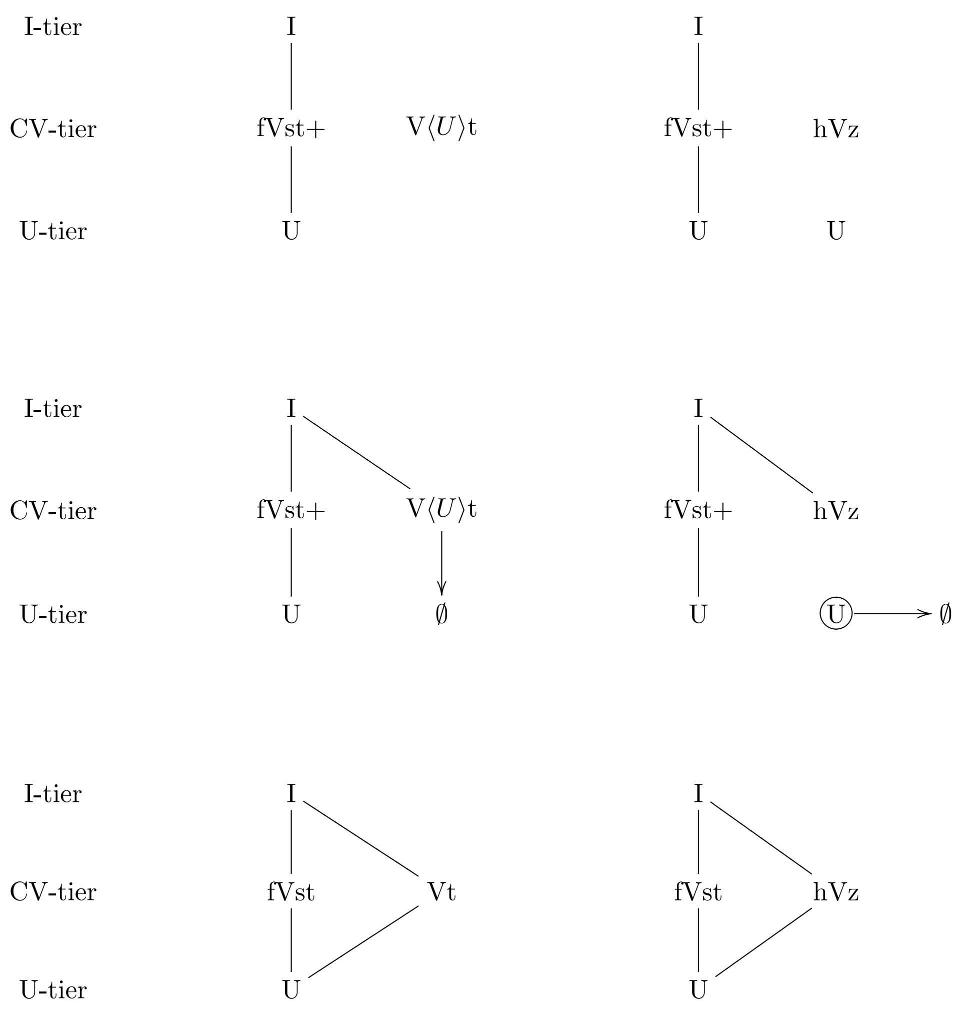
In the same environment, the core U of *ak/ek/ok/ök* must also be deleted:

```
(16)
 I-tier               /  I
                     /   |
CV-tier   V<U>-->V /     VCo__
```

[14]The root tier is omitted from the display, and the segmental core is identified with the CV tier. Nothing hinges on these simplifying assumptions.

Finally, in Class V, I-spread (14A), U-deletion (15-16), and U-spread (in this order) give the right result.[15] This is illustrated in (17) by the derivation of the forms *füstöt, füsthöz.* Notice, that the derivation is essentially the same for forms like *tököt, tökhöz*, as the presence or absence of A-specification plays no role in any of the rules. Although the suffixes in question are specified for A, the high-mid parallelism makes it possible to omit the As from the display altogether.

(17)



[15]Roughly speaking, (15) and (16) have the same effect as the 'Rounding Harmony' rule of Vágó (1980: 1.7).

The lack of negative specification in the rules means that we can interpret U, I, and A as *simplex* features representing privative oppositions.[16]

With the rules (15-16), the representations of non-exceptional items (*a á o ó u ú* in Class II, *i í e é* in Class III, and *ö ő ü ű* in class V) were kept simple. The exceptional items are treated as follows. In Class IV, we have to stop the core U of quaternary suffixes from taking effect, but we do *not* want to derive the *e*-alternant for ternary suffixes in the manner of SPH. To do this, let us suppose that the diacritic –U triggers the deletion of core Us:

```
(18)
CV-tier      V<U>-->V   / VCo__
                         /
 U-tier                 /   -U
```

In other words, for a negative feature 'spreading' to a positively specified core amounts to deleting the offending feature from the core. I will assume that the negative feature also disappears. This can be formulated as a general rule subsuming (18):

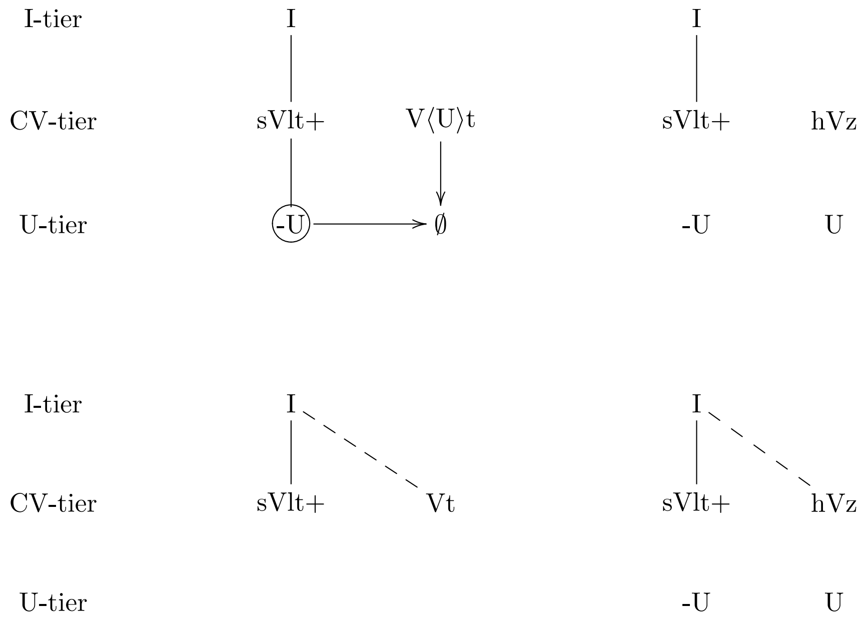
```
(19) Core/Neg  Annihilation

CV-tier       V<+X>-->V   / VCo__
                           /
 X-tier                   /   -X
```

This rule, ordered before the others, takes care of Class IV. Let us show this on the stem *sült*.

[16] Except of course for exception features which has to be mentioned by the rules explicitly. I will return to this question in Section 4.1, where the objections of Farkas and Beddor (1987) to treating I as privative in Hungarian are discussed.

(20)



At the top of (20) we find the underlying representations to which Core-Neg Annihilation (19) applies to yield the intermediate representations found in the middle section. At this stage, only I-spread (20A) will apply[17] to yield the surface representation given at the end of (20). Again, the derivation proceeds independent of the contents of the A-tier.

The remaining exceptional elements are treated as follows. The *i* of the *híd*-type words is specified for I in the core (therefore it will not spread); in addition, it will have a floating –U, which will derive the correct *hidat (*hidot).* The *í* of the *zsír*-type words is also specified in the core *(*zsírnek)*, but will have no other exceptional property: therefore, we derive the correct *zsírok (*zsírak).* The exceptional *é* of *héj* has I in the core, and floating –U giving us the correct *héjak, héjhoz*. The only stem in *e* or *é* paralleling the behavior of *zsír* is *cél* 'goal' which has I in the core but no other exceptional marking.

Every other exceptional element will be marked by a floating –U : the U specification (where present, e.g in *lyuk, hold, hölgy*) must be relegated to the core (CV tier). This simple and unified treatment of back stems in Class I is a highly desirable result, given the fact that Class I contains more than a thousand

[17]In particular, there is no U-deletion in the ternary form as the –U of *sült* is absent from the structural description of (15) – cf the previous footnote.

monomorphemic noun stems (and several thousand compounds) of this kind, while the remaining exceptional types are only sporadically represented.

Moreover, the use of the feature –U unifies the treatment of the exceptional classes: the only vowels we do not find in Class I are *ü* and *ö*: when these are marked by –U, they belong in Class IV. In addition, the tridirectional feature system captures the parallelism between the set *u ü i* of high vowels and the set *o ö e* of mid vowels. Since no rule makes reference to the feature A, we expect to find both +A and −A elements in every class. As can be seen from the data presented in (10) this expectation is fulfilled not only by the regular vowels, but by the irregular vowels as well.

The analysis can be extended to capture the behaviour of suffix-combinations with no epenthesis rule(s), simply by marking most quaternary suffixes (but not the fraction-forming *ad/ed/od/öd*) with a floating –U. By doing this, Core-Neg Annihilation will do not only the work of MIN-LOW, but also that of a-Epenthesis. Forms such as those in (13) can be derived without further complications.

The adjective-forming denominal suffix *as/es/os/ös* 'having (to do with)', which must also be marked this way, offers a particularly good way of testing the proposed mechanism. In isolation, a form containing this suffix can exhibit behavior characteristic of Class II forms:

(21)
ház 'house' házas/házasok 'married/PL' *házasak

However, if the same form appears in a non-lexicalized meaning, as in

(22) A kertes könyveket jobbra tedd, a házasakat pedig balra!
'Put those books (about) gardens to the right side,
and those (about) houses to the left'

its plural will be *házasak*.[18] This behavior can be explained only if we suppose that the exceptional marking introduced by *-as* is lost in the lexicalized form *házas*, but can be present if the form is derived anew, as required in (22). The derivations are given in (23) and (24)

[18] In ECH, %házasokat is tolerated, but hardly ever produced in (22) and similar contexts.

(23A)

$$\begin{array}{lcccc}
\text{CV-tier} & & & \text{hVVz+} & \text{V}\langle U\rangle\text{s} \\
 & & & | & \downarrow \\
\text{U-tier} & \emptyset & \longleftarrow \text{-U} & \text{-U} & \emptyset
\end{array}$$

(23B)

$$\begin{array}{lc}
\text{CV-tier} & \text{hVVzas} \\
\text{U-tier} & \text{-U}
\end{array}$$

(23C)

$$\begin{array}{lcc}
\text{CV-tier} & \text{hVVzas} & \text{V}\langle\text{U}\rangle\text{k} \\
\text{U-tier} & \text{-U} & \text{-U}
\end{array}$$

The only rule that applies in the derivation is Core/Neg Annihilation, which derives (23B) as the representation of the form *házas* from the underlying (23A). If the exceptional marking contributed by the suffix *as/es/os/ös* is retained, we derive (23C) on the next cycle. If the exceptional marking is lost, so that we start with (24A), we derive (24B) as the result of plural suffixation. Finally, since the plural form is not in the lexicon, the exceptional marking contributed by the plural suffix can not be lost, so in the last cycle we derive (24C) in both cases.

(24A)

$$\begin{array}{lc}
\text{CV-tier} & \text{hVVzas} \\
\text{U-tier} &
\end{array}$$

(24B)

CV-tier	hVVzasV⟨U⟩k
U-tier	-U

(24C)

CV-tier	hVVzasV⟨U⟩k	V⟨U⟩t
U-tier	-U	-U

This solution readily extends to cases like *aranyak* ‘gold pieces’ vs. *Aranyok* ‘books of Arany’ or *pirosak* ‘red(adj)PL’ vs. *pirosok* ‘red(n)PL’ where we have reason to suppose that a derived form re-entered the lexicon. In the case of *arany*, the common noun ‘gold’ is obviously the primary form. The proper name *Arany* retains the exceptional marking of this primary form (Aranyat/*Aranyot nem szerették a kortársai), but when the common noun ‘book of Arany’ is formed from the proper name, the exceptional marking is lost. Similarly, the primary color term is obviously *pír* (which has no exceptional marking) and the secondary color term *piros* is derived by the suffix *as/es/os/ös* which, as discussed above, adds the floating –U. The noun *piros* ‘the color red’ is formed from the adjective, and enters the lexicon with a loss of exceptional marking.

3.2 The solution with four features

As we have seen above, the key generalization concerning lowering stems is that they have the same (lowering and unrounding) effect both in Class I and Class IV. By marking lowering stems with a single diacritic feature, we also explain the distribution of lowering stems, i.e. the fact that every (surface) vowel can be lowering. In a four feature system, there are two features which can possibly trigger lowering and unrounding, namely +Low and –Round. For reasons to be discussed later, we will take +Low as the diacritic playing the role of ML.

The major advantage of having a fourth feature at our disposal is that we can resolve conflicts between underlying and surface feature values by means of underspecification. In a system containing only three binary features, we can describe at most eight phonemes as long as we interpret the features as privative: leaving one or more features out of the representation leads to other phonemes, rather than archiphonemes.[19] But if we can distinguish some phonemes by the fourth feature, the way is open for leaving the values of some other features underspecified. Let me illustrate this on the harmonic pair *a/e*, occuring e.g. in the dative suffix *nak/nek*.

In the tridirectional system, *a* is defined as +A –I –U, and *e* is defined as +A +I –U. Thus, the archiphoneme *a/e* should be defined as +A 0I –U. However, the absence of I in a privative feature system is equivalent to a negative specification, so that in fact we end up with +A –I –U, which is *a*. Thus, a system of three privative features simply has no room for archiphonemes: the only possible interpretation is that the suffixes alternating between *a* and *e* have underlying *a*, and the operation of harmony (I-spread) changes the I-value. In such a system, the conflict between the surface +Round of *a* and its underlying –U has to be resolved by late 'realization' rules.

In the SPE system we can define both *a* and *e* as underlying 0Round, and collect these vowels into an archiphoneme which is also 0Back. This archiphoneme can be kept distinct from other vowels and archiphonemes by defining it as +Low: as we shall see, the specification for Low will play a pivotal role in the definition of the ternary and quaternary archiphonemes as well. Before turning to these, let us define the remaining binary archiphonemes: *o/ö* = +Round –High –Low 0Back; *u/ü* = +Round +High (–Low) 0Back.

There are two ways to handle binary harmony in such a system: one is to suppose that both +Back and –Back spreads (so that the archiphoneme always receives its specification for backness from the stem), and the other is to suppose that only one of them spreads, and the other value is inserted by a later rule. In this respect, privative systems are more restrictive since negative value is encoded by the absence of a feature, so only the positive value can spread. Since the present system has the resources to spread both values, it is immune to the criticism levelled against privative backness by Farkas and Beddor (1987). This issue will be discussed in Section 4.1.

Thus, the basic pattern of binary harmony will be captured by a pair of spreading rules, which supply the backness value for the binary archiphoneme on the basis of the backness specification of the stem vowel:

[19] Leaving all features out would lead to the empty vowel, which has no phonetic realization in Hungarian.

(25A)

$$\begin{array}{ccc} \mathrm{F} & & \\ | & \ddots & \\ \mathrm{V} & \mathrm{C}_0 & \mathrm{V} \end{array}$$

(25B)

$$\begin{array}{ccc} \mathrm{B} & & \\ | & \ddots & \\ \mathrm{V} & \mathrm{C}_0 & \mathrm{V} \end{array}$$

In case the stem vowel is neutral, we have a number of options: first of all, we might take the surface frontness of neutral vowels as indicative of underlying frontness, and define neutral vowels as underlyingly linked to the autosegment F. Second, we might take the transparency of neutral vowels as diagnostic, and define them as underspecified for frontness (and suppose that they receive their final specification by a late rule). Third, we might suppose that the autosegment F floats over neutral vowels, and links up only at the end of the derivation.

Given the discrepancies between underlying and surface representations (cf the discussion in Section 1 above), we can not *a priori* exclude the remaining two possibilities, namely that neutral vowels are underlyingly linked to a B autosegment, or that B is floating in the underlying representation of neutral vowels. Although it is possible to invoke principles such as *structure-preservation* to rule out these combinations, it should be kept in mind that neutral vowels can show three kinds of harmonic behavior (two of which involve back suffixes), so that three out of the five logical possibilities are actually needed. At any rate, Stanley's (1967) objections against a 'ternary' use of binary features apply with even greater force in the framework of autosegmental phonology, since autosegmentalization gives rise to a possible five-way contrast in the underlying representations of neutral vowels.

Let us now turn to the case of ternary harmony. Since ternary alternation is between *o,e* and *ö*, we will suppose that the ternary archiphoneme is simply an otherwise underspecified mid vowel, given by 0Round –High –Low 0Back. If a back stem precedes, this archiphoneme receives a B by (25A) and thereby becomes *o*; the redundant +Round is supplied by a later rule. If a front round vowel precedes, both F and R spread: this is the rule of Ternary Harmony, given as (26) below.

(26)

$$\begin{array}{llll} \text{backness tier} & \mathrm{F} & & \\ & | & \ddots & \\ \text{CV tier} & \mathrm{V} & \mathrm{C}_0 & \mathrm{V}< -H > \\ & | & \cdot^{\cdot^{\cdot}} & \\ \text{rounding tier} & \mathrm{R} & & \end{array}$$

In case the stem vowel is neutral, the *e* alternant is derived by binary harmony, because there is no R to spread, and (26) remains inoperative. This leaves only quaternary harmony to be accounted for; as we shall see, this will follow from the rules we already have.

Since quaternary alternation is between *a,e,o* and*ö*, we will suppose that the quaternary archiphoneme is simply an otherwise underspecified non-high vowel, given by 0Round –High 0Low 0Back. Since this archiphoneme differs from binary *a/e* only in that the latter is +Low, we are in a position to recapitulate the correct part of Vágó's a-Epenthesis analysis simply by taking the feature ML to be +Low. The effect of this +Low is to turn the quaternary archiphoneme into binary *a/e* which will be subject to the rules of binary harmony. Before discussing in greater detail how this system works, let me summarize the underlying representations of the vowels and archiphonemes encountered so far.[20]

(27)	a	e	i	o	u	ü	ö	a/e	o/ö	u/ü	o/e/ö	a/e/o/ö
Back	+	-	-	+	+	-	-	0	0	0	0	0
High	-	-	+	-	+	+	-	-	-	+	-	-
Low	+	+	-	-	-	-	-	+	-	-	-	0
Round	0	0	-	+	+	+	+	0	+	+	0	0

Let us now see how the four-feature solution accounts for the harmonic behavior of the stems in each of the five classes. Class I stems are marked with a floating +Low: in addition, they are associated with a B autosegment. In the binary case, this B spreads – the floating +Low can not dock because all binary archiphonemes are specified for Low. In the ternary case, +Low can not dock because the ternary archiphoneme is specified as -Low, and Ternary Harmony is inoperative because there is no F to spread. Thus, the spreading of B gives us a back mid vowel, and a late rule, given as (28) below, will supply the redundant +Round to derive *o*. In the quaternary case, hower, the +Low can dock on the quaternary vowel, and thereby turns it into binary *a/e*, and the spreading of B will derive the correct *a*.

(28) –High αBack $\rightarrow$ αRound

Thus in the binary and quaternary cases we make use of the fact that rounding on short low vowels is redundant (determined by backness). In the ternary case we use (28) to determine the rounding of a mid vowel: given that *ö* is -Back but +Round, we must make use of the fact that (28) applies in a feature-adding rather than a feature-changing fashion. One way to assure this manner

[20]Since long vowels are treated as geminates, only the short vowels are given. The phonetic differences between short and long vowels are treated by late realization rules for *á* and *é*

of application would be to add 0Round to the structural description of (28) – but this would amount to adopting a three-valued feature system.

Class II stems are not marked with a floating +Low, but they are associated with a B autosegment. To be more precise, the B is associated with the vowels that appear in Class II regularly, namely *a,u* and *o*, and appears as a floating feature with neutral vowel stems. In Class I and Class II, neutral vowels are associated with F in the lexicon, and the unassociated B follows this F on the B/F tier. In the binary case, the B of the stem spreads (or if it was floating, just links up) to supply the backness of the following archiphoneme: in the case of *a/e*, (28) also applies. In the ternary case the derivation is the same as for Class I, but in the quaternary case the situation is different, because now there is no +Low to create a binary suffix, and the spreading of B leaves the quaternary vowel underspecified for Low, even after (28) has supplied the value +Round.

There are two ways of supplying the missing -Low: it can be inserted by *rule*, or it can be part of the *representation* of quaternary vowels as a floating feature. Since most quaternary suffixes are lowering the following suffix, we must suppose that they carry a floating +Low: this means that if we take the missing -Low to be part of the representation, we would have to presume a floating -Low +Low melody. Since the alignment of such melodies with the vowels appearing in suffix-combinations could not be achieved by straightforward Left-to-Right One-to-One mapping,[21] I will suppose that the -Low is in fact supplied by a rule, which is given in (29):

(29) –High → –Low

This rule also applies in a feature-adding fashion: it operates *after* the +Low of the stem had a chance to link up, but *before* the +Low of the suffix could link up (in the case of those suffixes which are themselves marked with a +Low).

Class III stems are not marked with a floating +Low, nor are they associated with a B autosegment. There is no reason to suppose that the neutral vowels are transparent in such stems, so I will simply assume that they are associated with an F autosegment. In the binary case, this F spreads on the suffix vowel, and for *a/e* rounding is again supplied by (28). In the ternary case, there is no Round for Ternary Harmony to spread, so we derive the unrounded front mid vowel *e* by (25A) and (28). In the quaternary case, we get the same result by

[21] In general harmonic systems do not have melodies (floating or otherwise) but the highly exceptional behavior of Class I and II neutral vowels made it necessary to assume an F-B melody for these. Notice, however, that this melody is still docked by the F, and thus can be made subject to the standard rules of autosegmental mapping.

applying (29) as well.

These derivations are fairly straightforward, except for the fact that the result is a mid, rather than a low *e* in the ternary and quaternary cases. Thus, we will need some cleanup rules for neutralizing the +Low *e*-s that we derive from binary *a/e* alternation and the –Low *e*-s resulting from ternary harmony. The need for such neutralization rules (which are arguably synchronic remnants of a diachronic neutralization process in Hungarian), is not unproblematic: I will return to this question in 4.3.

Class IV stems are marked with a floating +Low, and they are associated with an F autosegment. In the binary case, this F spreads on the suffix vowel, and for *a/e*, we also use (28). In the ternary case, the conditions of Ternary Harmony are met, and we derive the *ö*-alternant. Notice that (28) can not supply the –Round value, since (26) has spread the +Round from the stem, and (28) is feature-adding, rather than feature-changing. In the quaternary case, the +Low of the stem docks on the quaternary vowel, and thereby turns it into the archiphoneme *a/e*. Binary harmony then supplies the feature F, and –Round is given by (28). Notice that the quaternary *e* derived this way is +Low, while the quaternary *e* after Class III stems was -Low.

Class V stems are not marked with a floating +Low, and they are associated with an F autosegment. In the binary case, the derivations are the same as in Class III and Class IV, and in the ternary case the rule of Ternary Harmony applies the same way as in Class IV. In the quaternary case, Ternary Harmony applies, and the –Low feature is supplied by (29).

4 Neutral vowels

In this Section I will contrast and evaluate the solutions presented above. First I will discuss whether both Front and Back, or just one of them spreads. Next, in 4.2 I will present what I take to be the relevant data concerning neutral vowel stems, and issue some cautioning notes concerning widely accepted 'generalizations' about neutral vowels and vacillation. I will argue that the vacillation is not understood well enough to serve as a testing ground for descriptions of Hungarian vowel harmony, and that we need other data to decide between the the solutions offered above. Such data will be provided in 4.3 where I present the possessive paradigm and the possessive anaphoric suffix, and conclude that the three-feature solution can deal with these better than the four-feature solution. Finally, in 4.4 I discuss how features are *used* in the two solutions and what they *mean*.

4.1 Backness: privative or equipollent?

One of the major differences between the solutions presented in Sections 3.1 and 3.2 above is in the basic rule of binary harmony: in the three-feature solution I have supposed that only I (=Front) spreads, while in the four-feature solution the assumption was that both Front and Back spread. This difference corresponds to the traditional distinction between *privative* and *equipollent* features (Trubetzkoy 1937).

My starting point will be Farkas and Beddor (1987), who object to privative backness in Hungarian on the following grounds. First, privative feature analyses can not predict the pattern of abstract vowels, and second, non-harmonizing non-neutral suffixes such as the diminutive *-kó* are problematic for feature-changing accounts. Let us take these objections in turn.

An important advantage of the tridirectional system is that it predicts what kinds of binary alternations are possible in Hungarian. If an alternating pair is defined by the presence vs. absence of the feature I, *a* will be paired with *e*, *ó* will be paired with *ő* and *u* will be paired with *ü*. These are precisely the pairs attested in Hungarian. Moreover, since *i* is paired with the empty vowel, which is phonetically uninterpreted in Hungarian, the system predicts that *i* can not take part in alternations. As the definition of binary archiphonemes in (27) makes clear, the four-feature system does not make any comparable predictions.

However, neither the tridirectional nor the SPE system predicts the existence or the behavior of ternary and quaternary alternations, and both systems make wrong predictions concerning the distribution of abstract vowels. For instance, the tridirectional system would permit a fourth kind of *i* which has a floating –U but no other exceptional property,[22] and the SPE system would permit a floating Round. Thus it is true that both systems have the resources to describe harmonic behavior that can not be found in Hungarian – but this is no argument against privative backness in and of itself.

Let us turn to the problem of non-harmonic non-neutral suffixes. If the feature I spreads from the stem to the right in a feature-changing manner, how can we protect an invariant suffix such as *kó* from becoming *kő*? The privative approach makes it necessary to posit an internal word-boundary for such suffixes (cf SPH ch 1.6), as Farkas and Beddor correctly point out. However, the seriousness of this problem is proportional to the number of invariant back suffixes, and in Hungarian only a few invariant back suffixes can be found.

First, disyllabic suffixes in which the first vowel is neutral (e.g. *-izmus, -ista*)

[22] In the present system, all neutral vowels with a floating –U are specified for I in the core, rather than on the I-tier.

require no word boundary. They can be treated as containing a non-transparent neutral vowel, i.e. an I on the I-tier, which blocks the spreading of the stem I. (The blocker itself will not spread because the environment is not derived.) Second, some of the remaining suffixes are arguably harmonic, although SPH lists them as invariant. Most notably, the diminutive *-us* has an alternant *üs* (cf. *Tünde, Tündüs*), and the diminutive form of *Gergely*, *Gergő* makes it plausible that the diminutive suffix *kó* also alternates (cf. also *Anikó, Enikő*).

This leaves us with only one undisputably invariant back suffix, namely *-kor* '(temporal) at', and here a word boundary can be justified by the fact that *kor* also appears as a free form (in the meaning 'age'). Thus I conclude that in Hungarian no argument against privative features can be based on invariant back suffixes.[23]

4.2 Transparency, vacillation, and nonstandard harmony

The behavior of neutral vowels in Hungarian does not lend itself to clear-cut generalizations. In this section, I will first present the data concerning neutral vowels in suffixes, and then I turn to the more complex issue of neutral vowels in stems. After a brief discussion of the reasons why the solutions presented in Section 3. can not be told apart on the basis of vacillating data, I present some non-vacillating data that shows a neutral vowel in harmonic alternation with a back vowel morpheme.

The basic generalization concerning neutral vowels in Hungarian is that they are *transparent*, i.e. that they let the Front/Back feature of the preceding vowel spread onto the following suffix. For suffix vowels, this has been illustrated above on the denominal adjective-forming suffix *-i* 'characterized by the location', which derives e.g. *rumi, töki* 'inhabitant of Rum, Tök' from the place names *Rum, Tök*. As we recall, in the plural these become *rumiak, tökiek* 'inhabitants of Rum, Tök'. Since rounding harmony is always local, the second form is what we would expect on the basis of the fact that the *-i* is invariant –Round. Further, this form shows that the backness of the plural suffix *-ak* in the first form can not come from the preceding *-i* – we must suppose that it comes directly from the stem. Some further examples, using the (binary) dative suffix *nak/nek* are given below in (30):

[23]Both solutions predict the existence of invariant front suffixes. Apparently, no such suffixes exist in Hungarian.

(30)

stem	DAT	LOC	LOC+DAT	
ház	háznak	házi	házinak	‘house’
kert	kertnek	kerti	kertinek	‘garden’
nyár	nyárnak	nyári	nyárinak	‘summer’
tél	télnek	téli	télinek	‘winter’

This is somewhat problematic for the tridirectional feature system, since the *feature* I spreads, but the *vowel i*, which contains only this feature, leaves this spreading unaffected. This problem is solved by relegating the I specification of neutral vowel suffixes to the core, so that the I-tier remains available for spreading. In those cases where the harmonic spreading is actually affected (as in the invariant latinate suffixes discussed in 4.1 above), the I appears on the I tier and *blocks* the spreading.

In the four-feature solution, we can use underspecification insted of core-specification: this is also problematic, since the frontness of the neutral vowels is redundant only among non-low unrounded vowels, and so far we have treated rounding as predictable from backness. However, if we take the transparent suffix vowels to be lexically specified as –Round, the +Front specification can be supplied by a late rule.

In stems, the behavior of neutral vowels is quite complex. I will try to make sense of this complexity in terms of a probabilistic description below.

Roughly speaking, a single neutral vowel in the last syllable of the stem is transparent: if the preceding vowel is back, the stem takes back suffixes, otherwise it takes front suffixes. If the vowel preceding the final neutral vowel is also neutral, we encounter *vacillation*.[24] There are a number of vacillating stems that contain only one neutral vowel (e.g. *Ágnes*), and there are lots of non-vacillating stems with one or more neutral vowels. We can find a number of generalizations in the literature concerning vacillating stems: for instance, van der Hulst (1985: 276) lists the following:

- Stem-final *i, í, é* are typically transparent
- A stem containing a back vowel followed by *e* typically vacillates
- A stem containing a back vowel followed by two neutral vowels typically vacillates

[24]The literature in general makes no distinction between the cases where vacillation means idiolectal variation (i.e that each individual speaker uses either the front or the back alternants quite consistently), and the cases where we can speak of true vacillation in the sense that one and the same speaker uses both back and front alternants.

These 'generalizations' are listed in decreasing order of plausibility. It appears to me that stems containing a back vowel followed by two neutral vowels typically take front suffixes. The present paper is based on native speaker judgements[25] rather than on exhaustive testing – nevertheless, I think that the pre-theoretical, probabilistic model presented below gives a fair picture of the situation.

Let us model the decision process by which Hungarians decide on the quality of the suffix vowel by a three-state finite automaton that scans the stem right to left. In the initial state, called B, the back alternant is selected. As the automaton moves backwards, it can encounter front, neutral, or back vowels. If it encounters a back vowel first, the process has ended: the automaton stays in the initial state and we get the back alternant. Likewise, if it encounters a front vowel, it moves to state F where the front alternant is selected. The third, or N state comes into play when a neutral vowel is encountered first: in this case the automaton stays in state N and investigates the preceding vowel.

The results of this investigation are evaluated in the same manner. If the vowel is front, the automaton moves to F, if it's back it moves to B and if it is neutral, it stays in the N state *or goes to F* – it is this choice that gives the vacillating behavior. The more neutral vowels it encounters, the more likely the automaton is to fall into the F state, and if there are no more vowels to scan, the front alternant is selected.

In this model, vacillation corresponds to a probabilistic choice: there is no attempt to analyze the mechanism that leads to such choices. The most striking property of the automaton is that it scans right-to-left. Spreading is left-to-right in Hungarian of course. For the proper functioning of the model, right-to-left scanning is essential – the evidence for this direction comes from non-vacillating stems.

Disharmonic roots of the *föderativ* 'federal' type always take back suffixes, while those of the *zsonglőr* 'juggler' type always take front suffixes. Thus, the decisive factor is the last non-neutral vowel, although its effect might be obscured if two or more neutral vowels follow. The automaton given above will work with disharmonic stems without any modifications. The comparable automaton that scans left-to-right would have to be much more complex to handle disharmonic stems at all, because it would have to keep track of the backness of the last non-neutral vowel.[26]

[25] In particular, the judgments encoded in the 'Debrecen Thesaurus', which is the common source of Papp (1968) and the dictionary database (Kornai 1986a) that was my main source of data.

[26] Another argument in favor of right-to-left scanning, due to Péter Siptár, runs as follows. As long as we do not derive stem-internal harmony by rule we can suppose that there is no

In the three-feature solution, the treatment of neutral vowels in polysyllabic stems is based on the assumption that *i* and *e* have the feature I in the core unless they are stressed (= appear in the first syllable). In the four-feature solution the same vowels are treated as underlyingly –Round, with no specification for frontness. However, we do not have independent evidence that stress and harmony interact in Hungarian, so the decision to take the *first* neutral vowel in a neutral stem as the source of the spreading is quite arbitrary. As Farkas and Beddor (1987) points out, we could use the last (or the next to last) position just as well.

Let us see how the generalizations listed above fare in the light of the probabilistic model. If a stem ends in *i, í* or *é* the automaton moves to N, and in the next step, it will chose the B (or F) state if the preceding vowel is back (or front). This means that *i, í, and é* are indeed transparent. In contrast to the second generalization, the model predicts *e* to be also transparent.[27] Trisyllabic stems in which the first vowel is back and the other two are neutral are predicted to be vacillating by the third generalization listed above. My impression is that such stems show front harmonic behavior with a very high probability.

While previous papers have concentrated on vacillating stems, in the present paper I have shifted the emphasis onto exceptional, but non-vacillating stems where I believe it more properly belongs. The reasons for this shift are methodological. For every speaker of standard Hungarian, the exceptional (Class I and Class IV) stems show the same unambiguous lowering behavior irrespective of sentence stress, syntactic environment, register, etc. In the phonological study of vacillation it would be necessary to control for all of these factors, and perhaps for others as well – in contrast, the information on exceptionality is readily available from standard dictionaries.

The probabilistic model presented above is a temporary solution until more data become available. Until then, the following facts should be noted: First, there are suffixes which often form vacillating stems (perhaps the best example is *-né* 'Mrs'). Second, vacillation is not a transient phenomenon due to some recent sound change. The first systematic grammar of Hungarian, Szenczi (1610) mentioned a few vacillating stems such as *Józsué* 'Joshua'. Nearly four hundred years later, these stems are still vacillating. Third, as demonstrated by Kontra et al. (1987), vacillation is highly influenced by the harmonic properties of the preceding words.

spreading in non-derived environments. In this case the only possible location for a harmonic trigger is at the end of the stem.

[27] The continuing empirical investigations of Kontra and Ringen (1985, 1986) are expected to shed more light on this matter.

Given that vacillation is clearly influenced by factors such as the harmonic properties of the preceding words which are not taken into account by any of the existing models, there is no reason why the evaluation of these models should be based on vacillating data. If there is any conclusion that can be drawn on the basis of such data, it is the fact that a (probabilistic) description involves right to left scanning of the stem. However, even this conclusion can be established on the basis of the non-vacillating data presented in (31) below.

The following table gives the present tense paradigm of the stems *vár* 'wait', *kér* 'ask', and *tűr* 'suffer'. The items in the first, second, and third columns are first, second, and third person forms, respectively. With each stem, the first two rows give the singular, and the last two rows give the plural forms: the indefinite conjugation is in the odd rows, and the definite conjugation is in the even rows.

(31A)	*1st*	*2nd*	*3rd*	number	conjugation
	várok	vársz	vár	*sg*	*indef*
	várom	várod	várja	*sg*	*def*
	várunk	vártok	várnak	*pl*	*indef*
	várjuk	várjátok	várják	*pl*	*def*
(31B)					
	kérek	kérsz	kér	*sg*	*indef*
	kérem	kéred	kéri	*sg*	*def*
	kérünk	kértek	kérnek	*pl*	*indef*
	kérjük	kéritek	kérik	*pl*	*def*
(31C)					
	tűrök	tűrsz	tűr	*sg*	*indef*
	tűröm	tűröd	tűri	*sg*	*def*
	tűrünk	tűrtök	tűrnek	*pl*	*indef*
	tűrjük	tűritek	tűrik	*pl*	*def*

The first person suffixes show standard harmonic alternation, and the same holds for the first three second person suffixes and the indefinite suffixes in third person. The 3rd person definite forms (both for singular and plural) and the 2nd pl definite endings behave differently however.

The 3rd sg definite suffix appars as *i* with every stem that takes front suffixes, and as *ja* with all other stems (i.e the ones that take back suffixes). As we have seen in (5), the regular alternant of *a* is *e*. Thus, we would expect *ja/je* alternation, and the *i* form will have to be derived from *je* by a special rule.[28] Irrespective of the details of the analysis, it is quite clear that the change from one alternant to the other can not be accomplished just by spreading of the harmonic feature.

This is a clear case of morphophonemic alternation restricted to the 3rd definite and 2nd plural definite morphemes. Further evidence for the morphophonemic nature of the process comes from the fact that the *j* appearing in back harmonic contexts assimilates to a preceding sibilant while ordinary *j* in Hungarian does not (cf *rázza* 'shake-3SG-DEF' vs. *kézjel* 'handsign' = *kéz+jel* 'hand+sign' **kézzel*).

However, if morphological alternation can be conditioned by harmonic information, these morphemes are not only the sites, but also the triggers of the alternation since they must 'seek out' the harmonic feature. If this concept can be generalized from a small set of morphophonemes to harmonic archiphonemes in general, locality can be preserved only if we suppose that scanning happens from right to left, as suggested by the above treatment of vacillating data.

Needless to say, neither the three-feature nor the four-feature solution have the resources for right to left scanning. Because of this, both require a rather extraordinary rule that deletes the *j* if the preceding stem is front harmonic and takes the low *a* into high *i*.

4.3 Three features or four?

So far we found no evidence favoring one solution over the other and, as I argued above, the vacillating data is not firm enough to serve as a basis for a definitive conclusion. Here I will first discuss how the possessive paradigm is handled in the three-feature solution, and show that equally general rules are unavailable in the four-feature solution. Let me repeat the critical data here:

[28] Another solution would be to take the *i* alternant as basic, and adding a rule that turns *i* into *ja* in back vowel contexts. Since in Hungarian suffixes with *i* generally do not show harmonic alternation, I'll take the *ja* form as basic here, but nothing hinges on this assumption.

(13)

I	*1st*	*2nd*	*3rd*	possessor	possessed
	uram	urad	ura	*sg*	*sg*
	uraim	uraid	urai	*sg*	*pl*
	urunk	uratok	uruk	*pl*	*sg*
	uraink	uraitok	uraik	*pl*	*pl*
II					
	sógorom	sógorod	sógora	*sg*	*sg*
	sógoraim	sógoraid	sógorai	*sg*	*pl*
	sógorunk	sógorotok	sógoruk	*pl*	*sg*
	sógoraink	sógoraitok	sógoraik	*pl*	*pl*
III					
	emberem	embered	embere	*sg*	*sg*
	embereim	embereid	emberei	*sg*	*pl*
	emberünk	emberetek	emberük	*pl*	*sg*
	embereink	embereitek	embereik	*pl*	*pl*
IV					
	hölgyem	hölgyed	hölgye	*sg*	*sg*
	hölgyeim	hölgyeid	hölgyei	*sg*	*pl*
	hölgyünk	hölgyetek	hölgyük	*pl*	*sg*
	hölgyeink	hölgyeitek	hölgyeik	*pl*	*pl*
V					
	őröm	őröd	őre	*sg*	*sg*
	őreim	őreid	őrei	*sg*	*pl*
	őrünk	őrötök	őrük	*pl*	*sg*
	őreink	őreitek	őreik	*pl*	*pl*

As can be seen from (13), the 1st and 2nd sg suffixes contain a quaternary vowel followed by *m* and *d* respectively: in the three-feature solution they are represented as

```
(32)
        V<U>C     V<U>C
        |   | ;   |   |
        A   m     A   d
```

(For the sake of perspecuity, the internal geometry (see Clements 1985) of the core is 'magnified' here by representing the A-s on their own tier. Since A never spreads, this will not affect the argument in any way.) The 3rd sg, 1st pl, and

3rd pl suffixes show the ordinary *a/e* and *u/ü* binary alternations, and in the 2nd pl a quaternary vowel is followed by a ternary one.

(33)

```
       U


    V<U>CVC
    |   | |
    A   t k
```

In fact, the ternary vowel might be taken as a reflex of the quaternary vowel of the regular plural form. Recall the case of the numeral suffix discussed in 2.2, where the 'lowered' alternant *a* of the following suffix never surfaces because the numeral suffix itself is not lowering. The 2nd pl possessive in (33) could also be segmented as a non-lowering quaternary suffix *at/et/ot/öt* followed by the plural marker – one could even argue that this putative *at/et/ot/öt* comes from the 2nd sg possessive *ad/ed/od/öd* which lost its voicing and its exceptional –U marking. However, since this analysis can not be generalized to other persons, I will not pursue this matter here.

In the three-feature solution, the forms in rows 2 and 4 can be derived from those in rows 1 and 3 with a single rule which deletes the U (if any) of the first V and adds an A instead, and infixes an *i* after it:[29]

(34)

```
  V[U] -->  V[A]V<I>       /  -__ +POS PL
```

What happens here is that both the quaternary *a/e/o/ö* and the binary *u/ü* are replaced by the binary *a/e* before the inserted -*i*- which, as the data in (13) make it clear, marks the plurality of the possessed element. In fact, there is another suffix in Hungarian that markes possession, namely the possessive anaphoric *é*, and the plural of this *é* is *éi*. Thus, the grammar of Hungarian has to capture the fact that the plurality of the possessed element is marked by an *i* which follows the first vowel of the possessive marker, and an analysis that captures the concomitant changes in the first vowel in a single rule is clearly preferable to one in which these changes require separate rules for singular and plural possessor.

[29]The idea of treating the plural marker of the possessed as an infixed element goes back to Antal (1959,1963)

Phonologically, the unity of the processes of changing the quaternary *a/e/o/ö* to *a/e* and changing the binary *u/ü* to *a/e* lie in the fact that in both cases the feature U is replaced by A. In principle, the process of changing U to A can be decomposed into three steps neither of which involves more than the standard operations of feature association, delinking, insertion or deletion: first the feature U (if present) is deleted, no matter whether it was in the core or on its own tier, and second the feature A is added. (As a third step, if the resulting V is doubly specified for A, the OCP collapses the two As.) In practice, however, these three steps are always telescoped into a single, feature-changing operation.

In the four-feature solution, although the unity of the changes to the vowel preceding the inserted *i* can not be captured at all, the essential feature-changing nature of the process is still clear. Although we can turn the quaternary vowel into binary *a/e* by simply adding a +Low, we can not derive binary *a/e* from binary *u/ü* without actually changing its height specification. Moreover, the rule would have to delete the +Round specification of *u/ü*, since binary *a/e* is crucially underspecified for rounding.

4.4 Conclusion

The two competing accounts of Hungarian vowel harmony presented in Section 3 above presuppose radically different conceptions of feature use and feature content. In this concluding section, I will first address the problem of feature use, because this can be treated as a purely technical problem amenable to technical solutions. Next I will turn to the issue of feature content – this will be discussed from a broader, non-technical perspective.

The original aim of underspecification (leaving fature values blank) was to capture *archiphonemes*, i.e. underdifferentiated entities such as a 'placeless nasal' that will be fully specified only in the course of the derivation. In the case of vowel harmony this means that archiphonemes are similar to vowels in their featural composition, only they lack any specification for the harmonic feature, which will be supplied by spreading. Contemporary theories of *restricted underspecification* (Steriade 1987, Mester and Itô 1988) are based on the assumption that only redundant features can be underspecified. But in the case of harmony, the missing features are not redundant (cf. minimal pairs like *kor* 'age' vs *kör* 'circle'), so archiphonemes must be exceptional elements.

The exceptionality of archiphonemes is encoded as a condition on rule application in the four-feature system, where feature-filling rules are blocked from applying by the presence of underlying feature-specifications. In the three-feature system, a mechanism for filling in blanks is incompatible with the 'simplex' feature interpretation in which the lack of specification is equated with negative specification. There the exceptionality of archiphonemes is encoded in the representations by core specification.

For instance, if we take the dative suffix as underlying *-nak*, the alternant *-nek* will be derived by a feature-changing rule of I-spread (14A). However, we have to block U-spread (14B) from applying. In other words the *a/e* archiphoneme has to be –U throughout the derivation. This is achieved by specifying *a/e* as –U in the core. Core specifications do not spread, which is compatible with the view that negatively specified autosegments, when floating, will trigger the deletion of the following positively specified feature.

Although the three-feature solution does better on the possessive paradigm, its advantage over the four-feature solution is slight, especially in the light of the fact that it must make recourse to two kinds of exceptional devices, namely floating negative features and core-specification.[30] Whether these devices are just technical tricks that will be eliminated from the theory of phonology as soon as a better notation presents itself or whether they capture essential properties of the grammar, only time will tell.

However, the four-feature solution is also problematic, especially in the light of the general principle of *structure-preservation* (Kiparsky 1982). The source of the problem is the height specification of *e*. In binary alternation, as well as in quaternary alternation after lowering stems, *e* receives the value +Low. In ternary alternation and in the regular quaternary case (after non-lowering neutral stems), however, *e* surfaces with -Low specification. Since phonetically *e* is mid-low, the choice between low and mid is arbitrary. But no matter how we choose to represent *e*, one of the intermediate representations will violate structure-preservation. Again, only time will tell whether structure preservation represents an essential property of grammars. If it does, however, as I believe to be the case, the four-feature solution will have to be reworked completely.

In sum, the exceptional items (irregular vowels and archiphonemes) are formally closer to the non-exceptional items (regular vowels) in the four-feature solution than in the three-feature solution. Floating features are necessary in both solutions, but in the three-feature solution core-specification for the exceptional cases is also necessary, while in the four-feature solution blank entries are common to exceptional items and regular (non-alternating, non-lowering) vowels such as *a*. This homogeneity is bought at the price of an extra feature,

[30] This is the main reason why the U-deletion rules (15-16) and (18) could not be collapsed, and the U $\rightarrow$ A rule in (34) required nonstandard notation.

namely Low. The rest of this paper is devoted to a somewhat programmatic discussion of the role of this feature and the meaning of features in general.

Following Householder (1952) we can distinguish two polar opposites in the way we interpret phonological features. Under the 'God's truth' view, features, together with their phonetic interpretation, are part of Universal Grammar and as such, they are likely to be innate. Under the 'hocus-pocus' view, features are part of the descriptive machinery we call Universal Grammar, but they are not necessarily related to anything outside this grammar. In particular, they need not have a universal phonetic interpretation.

In 1.2 I have performed the hocus-pocus necessary to derive three features on the basis of vowel alternations (both harmonic and length alternations) in Hungarian, and concluded that that these three features correspond to the standard SPE features only to a limited extent. In particular, the derivation made it necessary to import the abstract -Round analysis of *a* into the system from the beginning, and to treat *e* and *é* as having the same height.

From this perspective, the feature Low is completely unmotivated, and the four-feature analysis, which makes essential reference to Low in order to keep the ternary and quaternary archiphonemes apart, must have its justification outside the domain of vowel alternations. Under the standard view this justification comes simply from the phonetic quality of the vowels: after all, *a* is low, and *i* is high, which is exactly what we need for the analysis to work.

However, this simple justification does not stand up in the light of the facts that *a* acts as -Round at every stage of the derivation and that the height differences between *a* and *e* on the one hand, and *á* and *é* on the other hand are not reflected in the underlying representations of these vowels. In fact, there is no reason to suppose that the use of four features involves any less hocus-pocus than the use of three features.

But if phonetic interpretation can not serve as an infallable guide in phonological analysis, what do the features mean? If the feature composition of a vowel is determined by the alternation patterns obtaining in the language, how do we interpret the feature matrices phonetically? I submit here that it is possible to view phonemes as primary and features as secondary, and to assign phonetic values to the phonemes more or less directly.

The view that the 'objective' (phonetic) relations between speech sounds can obscure the true 'psychological' (phonological) relations goes back at least to Sapir (1925). In the remainder of this paper, I will outline a version of phonology that fits into the mold of formal contemporary phonological theory but preserves Sapir's insight which I believe to be essentially correct. My starting point will be the observation that in the three-feature system there are three vowels (*a, u* and *i*) that have exactly one + in their feature matrix.

Following Cherry, Jakobson and Halle (1953) and Cherry (1956) I will treat the assignment of feature values as a mapping from the set of phonemes into a linear space of dimension n, where n is the number of features.[31] In other words, features are treated as a system of coordinates, and phonemes are expressed by coordinate vectors that describe their location in the abstract 'vowel space' generated by the features. Under this view, the fact that a certain vowel takes only one + value means that the vowel itself can serve as a basic vector i.e. we can *identify* the vowel *i* with the feature I, the vowel *u* with the feature U, and the vowel *a* with the feature A.

This means that the articulatory (or acoustic) properties of vowels should be expressed in terms of the basic vowels which now serve as features. Therefore, the articulation of such vowels can be taken as basic, and the articulation of all other vowels can be assumed to be made up from the gestures associated with the basic vowels. This provides an immediate explanation for the 'coupling' effect that can be observed across languages. Suppose that languages X and Y both have a five vowel system *i e a o u*, but in language X *i* and *u* are higher than in language Y. If *a* is the same in both languages, we expect the mid vowels to be spaced evenly so that they will be higher in language X than in language Y, the height difference being roughly half of what was observed in the case of high vowels.

The SPE theory has no way to predict this because the phonetic realization rule that relates the feature +High to a phonetic scale is only indirectly connected to the rule that relates -High to the same scale. In SPE, we need an extra principle of 'even spacing' to derive the desired result, while in the system sketched above, it will follow from the fact that mid vowels are created by combining high and low vowels.

This is not to say that the proposed system will be free of the kind of discrepancies between phonetic and phonological feature interpretation that we find in Hungarian – but these discrepancies appear in a different place. Since phonetic interpretation is built on the interpretation of the basic phonemes, roundness for instance can be taken as an inherent property of Hungarian *a*.[32] What needs to be explained is the fact that *e* is completely unrounded in Hungarian, in spite of the fact that *a* is one of its components.

[31] For a more rigorous statement, see Kornai 1986 ch 2.1

[32] Hungarian *á* is, of course, inherently unrounded – the 'late realization rule' analysis proposed here is tantamount to saying that *á* has to be a basic phoneme itself.

In general, the locus of discrepancies is shifted from the extremal points of the vowel space to the internal points, and this will always make the discrepancies smaller. For instance, in the case of Hungarian *e*, we expect a lesser degree of narrowing of the lip orifice, since *e* is composed of *a* (narrowing) and *i* (no narrowing) – what has to be explained is that we find no narrowing at all. But the difference to be explained is now between less narrowing and no narrowing, rather than between narrowing and no narrowing. In effect, the discrepancy is halved.

To sum up, the theory proposed in this section takes features as instruments for capturing the natural classes as manifested by the alternation patterns, rather than as direct bearers of phonetic content. Phonetic interpretation is based on the phonemes that turn out to be 'featural' in the sense of having only one + specification. There are two immediate consequences of this proposal, namely that 'even spacing' effects follow without further stipulations, and that the magnitude of the discrepancies between 'phonetic' and 'phonological' features is halved. Other consequences remain to be explored.

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