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The Dual Interpretation of |I|, |A| and |U|

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0. Introduction[1]

In this paper I will propose a feature system for vowels. The system shares fundamental insights with the systems of Dependency Phonology and Charm Phonology, which will be discussed in section 1. In section 2, I will provide phonological and phonetic justification to support my proposal and, in section 3, I will apply the system to a variety of "test cases", mainly involving harmony processes.

1. Background

In this section I will briefly discuss two approaches to vowel features, that of Dependency Phonology (e.g. Anderson & Ewen 1987) and that of Charm Phonology (e.g. Kaye et al. 1985). I do not intend to give a detailed overview.[2] My purpose here is to make clear that my own proposal can be seen as a natural development of certain aspects of these approaches.

Dependency Phonology (DP) has four basic SINGLE-VALUED FEATURES:

(1) |i|, |u|, |a|, |ə|

The features are: [Front] represented as |i|, [Round] represented as |u|, [Low] represented as |a| and [Central], represented as |ə|. DP also has [Advanced tongue root] (henceforth [ATR]) to deal with harmony systems involving this feature, but it is not integrated into the system. I will represent it here as |+|. In this system, then, the vowel system in (2a) is represented as in (2b):

(2) a. /i/ /u/ b. {|i|} {|u|}

/a/ {|a|}

A vowel which is high, front and unrounded is quite simply and exhaustively represented in terms of the feature "set" {|i|}. More complicated vowel systems involve segments whose feature specifications are more complex. For example: a mid front unrounded vowel /e/ is represented as {|i|, |a|}, a front high rounded vowel /y/ is represented as {|i|, |u|}, etc.:

(3) a. /i/ /y/ /u/ b. {|i|} {|i,u|} {|u|}
/e/ /ø/ /o/ {|i,a|} {|i,a,u|} {|u,a|}
/a/ {|a|}

The centrality component, which was absent in early versions of DP (e.g. Anderson & Jones 1974), plays a role in the analysis of vowel systems having a series of central vowels:

(4) a. /i/ /ɨ/ /u/ b. {|i|} {|ə|} {|u|}
/e/ /ʌ/ /o/ {|i,a|} {|ə,a|} {|u,a|}
/a/ {|a|}

Another aspect of the DP system is the fact that DEPENDENCY RELATIONS are used to express various vowel heights, e.g.:

(5)

/i/	/e/	/ɛ/	/a/
i	i	a	a
	|	|	
	a	i	

In the case of /e/, this notation expresses that |i| "governs" |a|, or, alternatively, that |a| is "dependent on" |i|:

(6)

i	governor/head
|	
a	dependent

A final remark about the DP system, which I will come back to below, is that at least one proponent of this system, Lass (1984), has proposed to "split up" |u| into |ω| ([Round]) and |ɯ| ([Back] or [Velar]).

The second approach to be discussed here is "Charm

THE DUAL INTERPRETATION OF |I|,|A| AND |U|

Phonology" (CP), as proposed in Kaye et al. (1985). In the CP system the phonological primes are called ELEMENTS. Elements are not simply single-valued features; they are defined in terms of fully specified feature matrices and interpreted as "pronounceable" units:

(7)

|u|	|i|	|a|	|ɨ|	|ə|
+ROUND	-round	-round	-round	-round
+back	-BACK	+back	+back	+back
+high	+high	-HIGH	+high	+high
-low	-low	+low	-low	-low
-atr	-atr	-atr	+ATR	-atr

The binary features are not phonological primitives. They play a role, as we will see below, in the "fusion calculus", but for the phonology the elements are the primitives, rather than the features. Here I will disregard the difference between the interpretation of primitives as "features" (the DP position) or as "elements" (the CP position) and continue to use the "|u|" etc. notation.

In CP every element except |ə| has precisely one HOT FEATURE (intuitively representing its most salient property), capitalized in (7), but there is no element for which [low] is the hot feature. Elements characterize segments either on their own or when FUSED.[3] Kaye et al. provide a fusion calculus, which says that in a fusion one element, the OPERATOR, carries over its hot feature to another element, the HEAD:

(8)

-round		-round		-round
+back		-BACK		-back
-HIGH	.	+high	->	-high
+low		-low		-low
-atr		-atr		-atr
(|a|	.	|i|	->	/ɛ/)

Notice that an element functioning as an operator represents a subset of the properties which are represented by the same element functioning as a head. For example, the roundness aspect of |u| is "isolated" when |u| has the status of operator. In that case only |u|'s hot feature ([+round]) is of importance for the result of fusion. Notice that this "factoring out" of roundness bears some resemblance to Lass's suggestion to split up |u|.

As in DP, the fusion operation is asymmetric. Reversing operator and head leads to another vowel:

(9)

|i|.|a| -> [-round, -back, -high, +low, -atr] (= /æ/)

An aspect of CP which I want to draw attention to is that the element |ɨ| has special properties: it does not reside on an autosegmental line. In normal cases it cannot be the head or the only element exhaustively characterizing a vowel.

The preceding brief overview shows not only that DP and CP share the use of dependency relations between the phonological primitives, but also that the sets of the primitives are also highly similar. But we noted some developments and discrepancies. Early versions of DP started out using three components (|i|, |u| and |a|), |ə| being a later addition. A further expansion of the feature set occurs in Anderson & Ewen (1987), where |ɨ| is added. In two important respects, CP represents a modification of the DP system, firstly, in assigning a special status to |ɨ| and, secondly, in differentiating (implicitly) between operator and head propeties of elements. In the next section it will become clear that these developments and modifications in some sense "prefigure" my own proposal, which will involve a "return" to the position that we need no features other than |i|, |u| and |a|.

2. The proposal

The essence of my proposal is to give a substantive interpretation to the formal status of features. I propose that the status of the three features as either HEAD or OPERATOR is reflected by a dual phonetic interpretation. As in DP and CP, I assume that a feature can be either a head (or governor) or an operator (or dependent) and, as in CP, I take it that the two functions are associated with different phonetic aspects of the feature:

(10) Interpretation of |u|

Head:	Velar constriction
Operator:	Rounding

The two aspects of |u|, velar (head) and rounding (operator), correspond to different articulatory gestures which naturally go together in the sense that liprounding ENHANCES the acoustic effect of velar constriction (cf. Stevens et al. 1987). It is therefore far from arbitrary to give formal expression to the intimate relation between roundness and backness in the way proposed here.

I want to suggest now further that the features |i| and |a| have a similar dual status. An important consequence of this move is that we can dispense with the feature |ɨ|. A second innovation will be that a feature can occur both as head and as operator in the representation of a single vowel, a move which enables me to dispense with the feature |ə|, as we will see below. In (11), I suggest the dual interpretation of both |i| and |a|:

THE DUAL INTERPRETATION OF |I|,|A| AND |U|

(11) a. Interpretation of |i|

H: Palatal constriction
|
O: Advanced tongue root

b. Interpretation of |a|

H: Pharyngeal constriction
|
O: Openness

Above, we saw that it is reasonable to combine velar constriction and rounding under one feature, since these two gestures naturally go together to produce a certain acoustic effect. But what about the other dual interpretations? We know that palatal constriction arises from advancing the root of the tongue (cf. Wood 1982). It is therefore again not arbitrary to suggest that the feature [Advanced tongue root] is closely linked to the feature [Palatal constriction]. Similarly, Wood shows that o-type vowels are produced with a jaw opening which is wider than that for u-type vowels (although in addition the constriction location is also different).

Recall that in CP the feature |ɨ| has a somewhat special status in that it does not reside on an autosegmental line. It would appear then that the distinction between features residing on a line and features not residing on a line can be identified with the independently needed dependency relation, which leads to a reduction of the number of features needed.

The interpretation of |i|, |u| and |a| as linguistically relevant constriction locations ties in rather well with phonetic research regarding the analysis of vowel systems. Wood (1982) shows in some detail that the traditional tongue arch model in which vowels are characterized according to the location of the highest point of the tongue simply cannot be maintained in the light of X-ray pictures of actual vowel production. Rather than attempting a definition of vocalic features purely in terms of formant structure, he develops an alternative feature set which can be linked to both articulatory and acoustic events in a natural way. He proposes three features to characterize four constriction areas. The four constriction areas are non-random from an acoustic point of view. Wood argues that constrictions at these four places can be subject to mild variation without causing significant acoustic effects.

(12)

[Palatal]	[Velar]	[Pharyngeal]	
+	−	−	"Palatal i/e-type vowels"
+	+	−	"Palato-velar u-type vowels"
−	+	+	"Pharyngo-velar o-type vowels"
−	−	+	"Low pharyngeal a-type vowels"

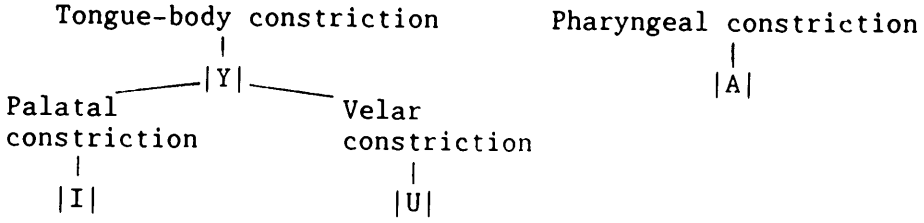
It will be clear that Wood's +-values correspond to our single-valued features where they function as heads. In addition to the place-features, Wood also has three other features, i.e [Round], [Open] and [Tense]. The first two can be identified with |u| and |a| as operators. Wood doesn't discuss the feature [ATR] and his discussion of [Tense] makes it clear that this is not

meant as a substitute for it. Cf. van der Hulst (1988) for a discussion of the feature [Tense].

Logically the three features as heads define seven "locations" (cf. 3), which is clearly to much. Wood however is not concerned with the generative capacity of the feature system. He represents u-type vowels as palato-velar, suggesting (translated into our system) that the feature |u| alone does not define a stable constriction location. Also, he represents /e/ type vowels as [+palatal, +open], suggesting that {|i,a|} is superfluous as a constriction location (if "constriction" is the right word to use here).

There are two possible ways of reducing the number of combinations of head features. We could say that head features simply do not combine, or that only |i| and |u| do not combine. Here I will take the stronger position and make no use of multiple-headed representations. In Ewen & van der Hulst (1988) it is further proposed that the three head features are hierarchically arranged as in (13):

(13)



It is argued there that the impossibility of combining |U| and |I| would follow straightforwardly if we regard them as VALUES of the feature |Y| ("tongue body constriction"). In addition, the fact that |A| can combine with |Y|, rather than with |I| or |U|, possibly relates to the fact that the former are at the same hierarchical level. Cf. Ewen & van der Hulst (1988) and van der Hulst (1988) for further discussion of this matter.

Having outlined the essence of the current proposal, I will discuss a number of issues involving the relation between operators and heads, without striving for completeness and leaving many issues "in the air".

In simple three or five-vowel systems, most Operator specifations are redundant (cf. 14). I will assume that head features redundantly have themselves as operators, unless the absence of an operator is distinctive within the system. (15) represents a general redundancy statement expressing this (from now on I will indicate head status of a feature with capitals, and operator status with lower case):

(14)

/i/	/u/	/a/
I	U	A

/i/	/e/	/u/	/o/	/a/
I	I	U	U	A
	|		|	
	a		a	

THE DUAL INTERPRETATION OF |I|,|A| AND |U|

(15) OPERATOR REDUCTION (OR)

```
I     U     A          I     U     A
|     |     |    <=>
i     u     a
```

Above, I showed how we dispense with the feature |+̇|. In both DP and CP there is still another feature, namely |ə|. This feature plays a crucial role in the characterization of central and back unrounded vowels, cf. (4). In the present proposal we can dispense with this feature in the following way. Nothing stops us from using the presence vs. the absence of an operator to express a phonemic distinction.[4] Consider the following representations:

(16) a. /ɯ/ /u/ b. /i/ /+̇/

```
     U     U          I     I
           |          |
           u          i
```

(16a) represents the distinction between a back unrounded and a back rounded vowel. The representation in (16b) might be taken as representing a distinction between either an advanced high front vowel and a non-advanced high front vowel or a clearly front and more centralized high non-back vowel. Whether or not the latter interpretation should be allowed if a language also has (16a) depends on the importance one attaches to the fact that no language appears to have a contrast between back unrounded and central unrounded vowels. This is not the point at issue here, however. The point is that we can represent either vowel type without a further component such as the centrality component used in DP.

Intuitively, this proposal says that something specified with |U| (a head) and nothing else is rounded (by virtue of 15), but only if this rounding is allophonic, which is not the case if there is a vowel which is minimally different in having |u| as an operator. One might suggest that this is an unfortunate move because the vowel /u/ is LESS marked but formally MORE complex than a non-front unrounded vowel /ɯ/. But one should not fail to notice that it is the presence of /ɯ/ in a system which causes this complexity. It is not clear that "system-complexity" should be reflected in the representation of the sounds whose presence presupposes the presence of certain other sounds.

Let us now investigate the consequences of allowing free combinations between sets of head features and sets of operator features. It will be clear that we allow more combinations than are allowed in DP and CP, because we allow one feature to occur twice in the representation of a segment. However, if we disallow combinations of two heads (roughly corresponding to the DP notion of mutual dependency), the total number of potential contrasts is not disturbingly great:

(17)

I	I	I	I	A	A	A	A
	|	|	|	|	|	|	
	i	a:i	a	i	a:i	a	

As we will see in section 3.3. some systems use a fairly large number of distinctions. In van der Hulst and Smith (1987b), we showed that various Kru languages offer quite severe problems for standard feature systems anyway, precisely in this "region" of the vowel space. Now consider the possible modes of combining |i| and |u|:

(18)

I	I	I	I	U	U	U	U
	|	|	|	|	|	|	
	i	u:i	u	i	i:u	u	

A system such as that of Kpokolo (Kaye et al. 1985) has six of the eight possibilities in (18), lacking the third and fourth representation; cf. (21) below.

Future research may lead to other formal or substantial universal constraints on possible vowel feature structures. I refer to van der Hulst (1988) for further discussion of the formal basis of the feature system. For now I leave this matter rest and proceed with a discussion of the analysis of some vowel harmony systems.

3. Harmony systems

In this section I intend to illustrate the most important characteristics of the feature system proposed here by offering analyses of a number of well-known harmony systems. I do not claim that these schematic analyses are complete, but limitations of space prevent me going into details. For a more elaborate discussion I refer to van der Hulst (1988), where I also discuss the merits of this approach to harmony systems as compared to other current approaches.

3.1. Advanced tongue root and Palatal harmony

Since the operator specification |i| represents ATR, it seems as if we cannot make a distinction at the phonologial level between ATR-spreading and palatal harmony, as for example in Finnish and Hungarian, on the assumption that only operator features spread. Indeed, I want to suggest that the two types of systems are closely linked, in that both involve the spreading of |i|. This is precisely what we want. Firstly, it has been claimed that there can be a diachronic development from one into the other (cf. Svantesson 1985 and section 3.2.), which suggest the two are closely related, and, secondly, no language has both palatal and ATR-harmony, which suggests that the two are

phonologically identical. I will assume therefore that the two do not in fact differ and that both involve the spreading of |i|. Take Finnish:

(19)

/i/	/y/	/u/	/e/	/ø/	/o/	/æ/	/a/
I	U	U	I	U	U	A	A
|	|		|	|	|	|	
i			a	a,i	a	i	

As is well known, the vowels /i/ and /e/ are TRANSPARENT. In binary approaches transparency is characterized by the apparent fact that [+back] can spread "through" these vowels without affecting them. Clearly, in this approach, only [-back], i.e. |i|, can spread. A spreading |i| can spread accross /i/ or /e/ because these vowels will end up having this property anyway. In other words there is no Feature Cooccurrence Constraint (FCR) blocking the association of |i| in these cases. Precisely because these vowels acquire |i| by a redundancy rules, it comes as no surprise that they can fail to trigger harmony.[5]

A ten vowel ATR-system then is characterized as follows:

(20)

/i/	/u/	/e/	/o/	/ə/	/ɪ/	/ʊ/	/ɛ/	/ɔ/	/a/
I	U	I	U	A	I	U	I	U	A
|	|	|	|	|			|	|	
i	i	a,i	a,i	i			a	a	

A more copmlex system, that of Kpokolo (discussed in Kaye et al. 1985), comes out as follows:

(21) a. /i/ /ɨ/ /u/ /ɪ/ /ɨ̞/ /ʊ/

/e/ /ə/ /o/ /ɛ/ /3/ /ɔ/

/a/

b.

/i/	/ɪ/	/ɨ/	/ɨ̞/	/u/	/ʊ/	/e/	/ɛ/	/ə/	/3/	/o/	/ɔ/	/a/
I	I	U	U	U	U	I	I	U	U	U	U	A
|			|	|		|	|	|	|	|	|	
i			i,u	u		a,i	a	a,i	a	a,i,u	a,u	

The advanced counterpart of /a/ in Kpokolo is /ə/. To handle this would call for a rule changing |A| to |U| just in case |i| associates, which is not very elegant. The "logic" of the present system allows for an alternative: non-high central vowels can be represented in a different way, by opposing them to the low vowel instead of opposing them to the back vowel:

(22)

/i/	/ɪ/	/+̇/	/ɨ/	/u/	/ω/	/e/	/ɛ/	/ə/	/3/	/o/	/ɔ/	/a/
I	I	U	U	U	U	I	I	A	A	U	U	A
|			|	|		|	|		|	|	|
i			i,u	u		a,i	a	i		a,i	a	a

In that case the reduction of the advanced low vowel to /ə/ is simply brought about by Operator Reduction:

(23)

/a/		/ə/
A		A
|	->	|
a		a,i

-OR->

A
|
I

Classical Mongolian has palatal harmony, which, according to Svantesson (1985), developed into ATR-harmony in Khalkha and Buriat, but not in West Mongolian (cf. van der Hulst and Smith 1987a, 1988). In this approach this is entirely a matter of phonetic interpretation. However, it might be argued that the difference between the palatal or advanced tongue root interpretation of |i| corresponds to a difference in head features. We might assume that the difference between Classical Mongolian and Khalkha is that in the latter but not in the former |U| is active. Suppose then that we say that the shift from Classical Mongolian to Khalkha was brought about by introducing the head feature |U|, which in turn might relate to the loss of the vowel /+/:

(24)

	/i/	/y/	/+̇/	/u/	/e/	/ø/	/a/	/o/
Class. M.	Y	Y	Y	Y	A	A	A	A
	|	|		|	|	|		|
	i	i,u		u	i	i,u		u
Khalkha	I	U		U	A	A	A	A
		|			|	|		|
		i			i	i,u		u

If this proposal is maintained then the representation of Finnish high vowels should be changed accordingly. Khalkha /i/ is transparent with respect to ATR-spreading. We account for this by in the usual way: /i/ does not get [i], but is not incompatible with it.

2.2. Palatal harmony and labial harmony

In Khalkha, we also have rounding harmony among the low vowels. High vowels, in particular the rounded vowels fail to trigger rounding harmony, but also block it. Given the representation in (24) high rounded vowels COULD NOT trigger harmony. The /i/ does not undergo, but nor does it interrupt the

spreading of roundness. The behaviour of the high vowels represents a notorious problem in vowel harmony theory. I shall not discuss it here (cf. fn. 5).

Let us now consider Turkish. We would like to say that we have two types of suffixes Y-specified and A-specified. This at least give us a straightforward picture:

(25)

/i/	/y/	/ɨ/	/u/	/e/	/ø/	/a/	/o/
Y	Y	Y	Y	A	A	A	A
|	|		|	|	|		|
i	i,u		u	i	i,u		u

We find a situation which is rather different from what was attested in Khalkha. |u| does NOT spread to A-specified vowels, but all |u|-specified vowels trigger rounding harmony. This time then the target condition is that undergoers should be Y-specified. Quite expectedly, /a/ and /e/ are opaque with respect to rounding harmony.[6]

Another type of reduced rounding harmony occurs in Uygur and Hungarian (cf. Sezer & Wetzels 1987). Here I only discuss the Uygur case (cf. van der Hulst 1988). There are three types of suffixes: æ/a, y/u and i/y/u. The surface vowel system of Uygur is as that of Finnish:

(26)

/i/	/y/	/u/	/e/	/ø/	/o/	/æ/	/a/
Y	Y	Y	Y	A	A	A	A
	|	|	|	|	|	|	
	i,u	u	a	i,u	u	i	

The three-way alternating suffix can be handled by including in the underlying inventory a vowel specified as {|Y|}. A segment structure rule will fill in the operator |u| in case neither |i| nor |u| spreads onto it. By adding an underlying vowel consisting of |Y| alone, we must assume that the representation of /i/ distinctively involves the operator |i|. In order to prevent rounding harmony on low suffixes, there is a target condition as in Turkish: undergoers must be |Y|-specified.

2.3. |a|-harmony

In van der Hulst & den Dikken (1987), it is shown that the harmony systems of Nez Perce, Chukchee and Middle Korean can be understood in terms of |a|-spreading. Consider Nez Perce:[7]

(27) a.

/i/	/u/
	↓
	/o/
/æ/ ->	/a/

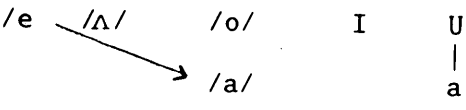
b.

/i/	/u/	/o/	/æ/	/a/
I	U	U	A	A
		|		|
		a		a

The vowel /æ/ is represented as {|A|}. A similar analysis, with a completely empty specification for /æ/ has been proposed by Anderson & Durand (1988).

Middle Korean is highly similar, but has central vowels:

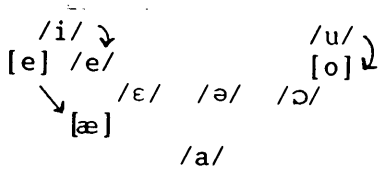
(28)a./i/ /ɨ/ /u/ b. /i/ /ʌ/ /ɨ/ /u/ /o/ /e/ /a/



In Middle Korean /i/ appears to be opaque.

Let us finally consider Chukchee, which has the most complicated system:

(29) a.



b.

/i/	[e] = /e/	[æ]	/u/	[o]	/ɛ/	/ə/	/ɔ/	/A/
I	I	A	U	U	A	.	A	A
	a	I		a	a,i	a	a,u	a

Two remarks are in order. First, the representation of /e/ apparently makes use of the multiple head specification. However, what I mean to say here is that the dependency relation has not been specified. Spreading of |a| forces a decision in favor of |A|-headedness, otherwise the default option is to take |I| as the head. Second, the schwa is represented as "headless". Some schwas do not trigger harmony and are also transparent. These will be represented without the operator |a|, which will, in that case, be added later on.

3. Conclusion

An idea which has guided much recent work in feature theory is that markedness considerations should be "built in" in the formalism for expressing phonological rules and representations. The use of underspecification or single-valued features represents an attempt to express directly the notion of marked value, introduced in Praguian phonology. However, markedness not only involves the "context-free" phenomenon that in the case of a binary opposition one value is marked, but it also involves "context-dependent" phenomena such as the fact that backness and roundness or highness and ATR-ness go together in the unmarked case. The present proposal represents a natural extension of this research program since it is an attempt to build the latter type of markedness into the formalism.

THE DUAL INTERPRETATION OF |I|,|A| AND |U|

Notes

1. This paper offers the outline of a proposal which is discussed in more detail in van der Hulst (1988). I am grateful to the following colleagues who have discussed with me ideas which are central to the proposal: Marcel den Dikken, Colin Ewen, Teun Hoekstra, Iggy Roca, Norval Smith and Keith Snider.

2. An more detailed overview of current theories of phonological features is offered in den Dikken & van der Hulst (1988).

3. Elements can furthermore be classified in terms of another property CHARM, but I will ignore that here. Cf. den Dikken and van der Hulst (1988) for a more detailed discussion.

4. There is a resemblance to Schane's (1984) Particle Phonology in that we allow a single feature to occur twice in the representation of a vowel, but also note that I am not allowing just any number of occurrences. It is limited to two, on principled grounds.

5. An attempt to deal systematically with the behaviour of invariant vowels in harmony systems is offered in van der Hulst and Smith (1986). In van der Hulst & Smith (1987a, 1988) special problems concerning rounding harmony in Mongolian and Tungusic are discussed. van der Hulst & den Dikken (1987) address similar problems in Nez Perce and Middle Korean. In van der Hulst (1988) show how the respective proposals can be integrated into the current approach.

6. As shown in Korn (1969) and Steriade (1981) the Turkic language family offer a wide variety of different reduced rounding harmony systems. For discussion see van der Hulst (1988).

7. References regarding the languages discussed here can be found in van der Hulst & den Dikken (1987).

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