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CV- versus X-Notation: A Formal Comparison

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Two competing skeletal theories, CV-Notation and X-Notation, are a source of controversy in recent work in phonological theory. X-Notation has generally been viewed as the more restricted theory, because it claims to use only one skeletal element label, while CV-Notation posits two. Though there have been arguments advanced for each framework, two questions have yet to be directly addressed: a) Is the power used by CV-Notation actually different from that used by X-Notation? b) Are CV- and X-Notation formally distinct theories, or notational variants? In this paper, I compare the two frameworks and argue that CV-Notation and X-Notation use the same number of primitives, and equivalent power. However, the two theories are not notational variants, and a characterization of the distinction between them is provided.

0. Background

Since it is now widely accepted that the feature [syllabic] is eliminated from the melodic level (following Guerssel (1986), among others), it is necessary to represent syllable peakhood on some other level of structure. In CV-Notation (McCarthy (1979), (1981), Clements and Keyser (1983), and others), syllable peakhood is encoded on the skeleton via the two skeletal categories, C and V. A V-element represents one timing unit which functions as a syllable peak, and a C-element represents one timing unit which functions as a non-peak.[1] Underlying representations consist of two unlinked levels, the skeletal level and the melodic level, which become linked either by convention or by language-specific rule. A sample underlying representation in this framework is given in (1):

(1) C V C
 [F] [F] [F]

In X-Notation (Levin (1983), (1984), Archangeli (1985), Guerssel (1986), and others), the skeleton consists of unlabelled timing slots, symbolized by Xs. Syllable peakhood is represented on a separate level, as N, unlabelled, or R, according to Levin, Archangeli, and Guerssel, respectively. (All three treatments are representations of a nucleus, or syllable head.) If underlying representation in this framework consisted of the unmarked skeleton and the melody, as shown in (2), then X-Notation would need only one underlying skeletal category as compared to CV-Notation's

two. X-Notation, then, would be the less powerful, and, therefore, stronger, theory. [2]

(2) X X X
[F] [F] [F]

However, we argue below, if the elements of the skeleton are to remain featureless, the type of underlying representation exemplified in (2) will not be adequate for all structures in all languages. Underlying representations in this framework must be able to stipulate three levels of structure: the melody, the skeleton, and the rhyme (or nucleus). A sample underlying representation in X-Notation, then, is given in (3):

(3) R
|
X X X
[F] [F] [F]

The argument that CV- and X-Notation are equivalent in power is made in two steps: 1) In order to account for data in which ambiguous melodies like i/y are phonemically distinct, X-Notation must include the abovementioned three levels of structure in underlying representation; 2) CV-Notation need not stipulate the rhyme level of structure in underlying representations. The syllabic structure that must be included in underlying representation in X-Notation is derived via a function on the skeleton in CV-Notation.

1. Phonemically Distinct Limbo Melodies [3]

When the distinctive feature [syllabic] was eliminated, the difference between some elements on the melodic level was also eliminated. For example, the difference between high vowels and the corresponding glides, between syllabic nasals and non-syllabic nasals, between syllabic liquids and non-syllabic liquids, etc., is no longer represented on the melodic level. The melodic representations for [i] and [y], which used to differ in their specification for the feature [syllabic], are now ambiguous between the two melodies. The distinction between [i] and [y] is a structural one: [i] is linked to a syllable peak and [y] is linked to a non-peak. In CV-Notation, this distinction is represented by the linking to a V-element (syllable peak), or to a C-element (non-peak), as shown in (4), where the i/y melody is arbitrarily represented as [i] on the melodic level:

(4) (a)	C	(b)	V
	[i]		[i]
	surface: [y]		surface: [i]

In Levin's (1984) X-Notation analysis of Klamath, most instances of the high vowel/glide melodies, (i.e., i/y and u/w, which are in the Limbo set for Klamath), were realized as non-peaks via syllabification rules incorporating onsets and codas. For those Limbo melodies that were not onsets or codas, a Default Nucleus-Placement rule was written: (Levin's (13))

(5) Default N-Placement:	[+hi, +son]
	X'
	X
	N

(where X' represents an unsyllabified X)

In this way, the ambiguous i/y and u/w melodies were realized as high vowels when they occurred after unsyllabified elements, and as glides elsewhere.

X-Notation would use fewer underlying skeletal category labels than CV-Notation, then, if each phonological structure in each language belonged to one of two sets: (A) the set of structures in which all skeletal elements are linked to non-Limbo melodies, or (B) the set of structures for which phonological rules can account for skeletal elements which are linked to Limbo melodies. There are, however, languages with phonological structures which are members of neither set A nor set B. In Turkish, there are structures with skeletal elements linked to Limbo melodies for which an N-placement rule cannot be written.[4] The Limbo set in Turkish contains only one member, the feature matrix ambiguously representing [i] or [y]. Thus, the i/y melody can be syllabified either as a syllable peak or as a non-peak in Turkish, exemplified respectively in (6.a) and (6.b):

(6.a)	˘pride˘	kibir	(b)	˘pitchfork˘	yaba
	˘building˘	bina:		˘oil˘	ya
	˘tongue, language˘	dil		˘mane˘	yele
	˘loofah˘	lif		˘village˘	køy
	˘beard˘	ris		˘wine˘	mey

However, the structural position of the melody does not necessarily determine whether it surfaces as a peak or a non-peak,

as seen in (7.a) and (b):

(7.a)	'restoration'	iade	(b)	'bright'	yal
	'donation'	iane		'toward'	yana
	'loan'	iare		'wound'	yara (also yare)
	'a feeding'	iase		'wet'	yaş
	'good, well'	iyi		'food'	yiyl

Moreover, i/y melodies do not always behave predictably with respect to suffix allomorphs. A rule of suffix allomorphy in Turkish deletes a suffix-initial consonant after a stem-final consonant, exemplified in (8) for the 3sg.poss. suffix, /-sI/. [5] (I is used to symbolize a high vowel that undergoes vowel harmony).

(8.a)		stem	3sg.poss.
	hand	el	eI-I
	garbage	çöp	çöp-I
	louse	bit	bit-I
	sea	deniz	deniz-I
(b)	hat	şapka	şapka-sI
	chin	çene	çene-sI
	gazelle	ahı	ahı-sI
	shrub	dalı	dalı-sI

In (9.a) the i/y melody behaves as a consonant, triggering suffix-initial consonant deletion, while in (9.b) the same melodic element in an analogous environment behaves as a vowel:

(9)		stem	3s.poss.
(a)	'prohibition'	nehy	nehy-I
(b)	'ending'	mutenahi	mutenahi-sI

In CV-Notation, this phonemic i/y distinction in Turkish is represented as the difference between a C-element and a V-element being linked to the Limbo melody. The underlying forms for 'prohibition' and 'ending' in CV-Notation are given in (10.a) and (b), respectively:

(10.a)	C	V	C	C	(b)	C	V	C	V	C	V	C	V
	n	e	h	i		m	u	t	e	n	a	h	i

In X-Notation, since an N-placement rule cannot be written in the case of phonemic Limbo melodies, there must be another means of representing the peak status of one subset and the non-peak status of the other subset. In his analysis of glides and high vowels in Berber, Guerssel (1986) represents a phonemic distinction between glides and their corresponding high vowels by stipulating some X-elements as lexically attached to syllable heads. According to this type of analysis, the underlying forms for 'prohibition' and 'ending' in Turkish would be those shown in (11):

(11.a)	R	(b)	R	R	R	R
	X X X X		X X X X	X X X X	X X X X	X X X X
	n e h i		m u t e n a h i			

Whether or not the [e], [u], and [a] melodies are dominated by Rs in underlying structure, or via redundancy rule, the theory must have the power to distinguish the stem-final element in (11.a) from the stem-final element in (11.b). Thus, in order to account for phonemically distinct Limbo melodies, one of two routes must be taken: either two skeletal element categories of plus and minus peakhood valences must be distinguished, or a third level of underlying structure must be allowed. (We note that a representation using only X labels, in which some X-slots are underlined, or marked with a tic, is still a representation with two skeletal element category labels: X-with-a-tic and X-without-a-tic.) Since the major tenet of X-Notation is that it does not use two separate skeletal element labels, the third level of underlying structure is necessary.

If CV-Notation also needs to posit syllabic structure in underlying forms, then X-Notation's claim to less power is well-founded, because X-Notation would need to posit only one underlying category of elements on the skeletal level, while CV-Notation uses two. Note, however, that the two underlying categories in CV-Notation are symbols for timing units of different peakhood valences. If CV-Notation does not need to posit underlying forms with rhyme-level information, then the number of skeletal element categories in CV-Notation will be equal to the number of skeletal element categories in X-Notation. In both frameworks there is a category of timing units that are underlyingly linked to syllable peaks, and a category of timing units that are not underlyingly linked to syllable peaks. The separation of syllable peakhood from the skeleton is significant, but it should not obscure the presence of separate underlying specification for different peakhood valences. In the next section, we argue that CV-Notation need not posit syllabic structure in underlying representation.

syllabic structure can be similarly derived in CV-Notation, until it is proven otherwise. [6]

Thus, CV-Notation does not need to stipulate a third level of structure in underlying forms, and X-Notation's use of lexically-marked syllable heads is unmasked as the equivalent of two skeletal category labels: X-underlyingly-linked-to-syllable-peak and X-not-underlyingly-linked-to-syllable-peak. In both theories, two separate underlying peakhood valences are encoded by two separate symbols. In CV-Notation, the peakhood valences are encoded in the symbols for the timing elements on the skeleton, while in X-Notation, the peakhood valences are represented as a combination of the skeletal and rhyme levels. The issue of relevance with respect to the number of skeletal element categories is the power of the theories using them. The power of a theory is not measured by its choice of symbolism, but rather by the primitives, underlying structure, and mechanisms it must use. Both CV-Notation and X-Notation represent skeletal timing as a primitive. Both CV-Notation and X-Notation use two valences of a syllable peakhood primitive. The fact that CV-Notation symbolizes the two peakhood valences on the same level of structure as the timing, and X-Notation symbolizes the two peakhood valences on a level other than the level representing timing, is irrelevant to the comparison of the theories' power. We have shown that both theories need the power to represent timing and two valences of syllable peakhood in underlying representation. Thus, with respect to timing and peakhood primitives, the two theories are equivalent in power.[7]

3. The Distinction between CV- and X-Notation

Even though we have argued that CV- and X-Notation use the same number of primitives, there are two independent features in which the theories differ: a) the range of the skeletal element category over syllable peakhood valences, and b) the structural level on which syllable peakhood information of underlying forms is encoded. In this section, we will examine the differences between the frameworks, and provide evidence that they are formally distinct.

3.1 The Range of the Marked and Unmarked Categories

In CV-Notation, the two skeletal element categories C and V encode opposite valences of syllable peakhood. It would be equivalent, then, to represent the two skeletal element categories as +P and -P, where +P denotes a timing unit that functions as a syllable peak and -P denotes a timing unit that functions as a non-peak. Furthermore, it would be equivalent to mark only the plus values on the skeleton, leaving the unmarked skeletal category to be interpreted as minus. Thus, we see that the marked

skeletal category in CV-Notation ranges over the set of syllable peaks and the unmarked category ranges over the set of non-peaks.

In X-Notation, those skeletal elements underlyingly linked to R-nodes can be symbolized as +P and those skeletal elements which are not underlyingly linked to R-nodes can be symbolized as P. Note that +P is used to represent the marked category in both frameworks, and P is used to represent the unmarked category in both frameworks. In X-Notation, the marked skeletal category again ranges over syllable peaks, but in this theory, it ranges over only a subset of the set of syllable peaks: those that are lexically designated. The unmarked category in X-Notation ranges over both non-peaks and those peaks that are not lexically designated.

It is possible, then, to distinguish the two theories by naming an element that is a member of the set +P in CV-Notation, but not a member of the set +P in X-Notation. For example, in Turkish, the word for "garbage", cɔp, contains no Limbo elements. The underlying representation in CV-Notation, along with its translation in terms of P and +P, is given in (14):

(14.a)	C	V	C	(b)	P	+P	P
	[c]	[ɔ]	[p]		[c]	[ɔ]	[p]

The underlying representation of the same word in X-Notation, along with its translation in terms of P and +P, is given in (15):

(15.a)	X	X	X	(b)	P	P	P
	[c]	[ɔ]	[p]		[c]	[ɔ]	[p]

CV- and X-Notation are thus shown to be non-equivalent with respect to the range of the categories used to mark syllable peakhood.

3.2 The Representation of Syllabic Peakhood

We have shown that in CV-Notation, syllable peakhood is encoded directly on the skeleton, whereas in X-Notation, syllable peakhood is represented on the rhyme level. In this section, we provide an example of a type of rule that can be stated using CV-Notation, but cannot be stated using X-Notation, further distinguishing the two theories.

As mentioned in Section 1, there are rules of allomorphic variation in Turkish which serve to delete suffix-initial consonants after stem-final consonants and suffix-initial vowels

after stem-final vowels. The forms in (16) illustrate the allomorphic patterning: (cf. Clements and Keyser, (1983:67))

(16.a)	stem	3sg.poss. /-sI/	2pl.poss. /-InIz/
	hand	el	eliniz
	stalk	sap	sapiniz
	garbage	ɖɖp	ɖɖpɪniz
	louse	bit	bitiniz
(b)	chin	ɖene	ɖenesi
	gazelle	ahu	ahusu
	shrub	ɖali	ɖalɪsi
	island	ada	adasɪ

In an X-Notation analysis of the Turkish data, Archangeli (1985) posits the following two rules: (Archangeli's (9) and (10))

(17) with the affix /-InIz/

$$\begin{array}{c} X \\ | \\ [F] \end{array} \rightarrow \emptyset / \underline{X}] \text{ ___ where } \underline{X} \text{ is a syllabified slot}$$

(18) with the affix /-sI/

$$\begin{array}{c} X \\ | \\ [F] \end{array} \rightarrow \emptyset / X'] \text{ ___ where } X' \text{ is an unsyllabified slot}$$

In the X-Notation analysis, then, it is relegated to coincidence that the deletion rules each match the peakhood valence of the target to the peakhood valence of the trigger. Furthermore, it is relegated to coincidence that all suffixes that must be listed with the first rule are vowel-initial, while all suffixes listed with the second rule are consonant-initial.

In CV-Notation, the two rules could be collapsed, as shown in (19), where +P represents a V-element, -P represents a C-element, and α is a variable ranging over + and - valences:

$$\begin{array}{c} \alpha P \\ | \\ [F] \end{array} \rightarrow \emptyset / \alpha P] \text{ ___}$$

Note that it is consistent with CV theory to have a rule referring to the indexed disjunction of the two skeletal element categories. (What would be inconsistent with CV theory would be to posit an underlying form without a peakhood-specific skeletal element category.) If we adopt the rule in (19), we capture in a single rule the peakhood valence matching generalizations that were merely coincidental in the X-Notation analysis. Not only is it impossible to collapse Archangeli's two rules into a unified deletion rule, but it is impossible to write rules in X-Notation that could be collapsed in this way, due to the fact that both syllable-initial vowels and syllable-initial consonants are syllabified by the universal syllabification rule. Thus, the X-Notation analysis is unnecessarily complicated, and CV-Notation is seen to be the superior theory with respect to the representation of syllabic peakhood.

4. Conclusion

In this paper, we have argued that CV- and X-Notation use the same number of primitives, and equal power, but are not notational variants. The theories are distinguished in two ways: 1) the range of the skeletal element categories over syllabic peakhood valences, 2) the structural level on which syllable peakhood information of base forms is encoded. An example of a rule of Turkish allomorphy was provided to suggest that the CV-Notation system of encoding syllabic peakhood directly on the skeleton is superior to the X-Notation system of encoding syllabic peakhood on a third level of underlying structure.

FOOTNOTES

[1] Clements and Keyser (1983:136) refer to C and V as primitives, but we will interpret their intent as to define peakhood as a primitive. In their view, and ours, syllabic peakhood is not a distinctive feature, and not able to be defined by articulatory or auditory properties. C and V, then, represent the concatenation of two primitives: timing and peakhood.

[2] The issue of whether or not the skeleton and melody are linked in underlying structure is not addressed in Levin (1983, 1984) or Guerssel (1986), but we have adopted Archangeli's (1985) version of the minimally specified theory.

[3] Following Waksler ((1985), (1986b)), we refer to those melodies which may be linked to peak or non-peak elements as "Limbo" melodies. The set of Limbo elements is defined as a function on the sonority scale for each language that chooses the Limbo resolution parameter. For further discussion, see Waksler ((1986b) and (forthcoming)).

[4] Cf. Guerssel (1986) for analogous examples from Berber. Guerssel's argument is for the elimination of the feature [syllabic], but his result of lexically-marked rhyme heads is the same as ours.

[5] This is an oversimplified characterization of the rule. For expanded discussion and formalization of Turkish suffix allomorphy, see Waksler (forthcoming).

[6] Syllabification of long vowels has not been treated here, but it does not necessitate the stipulation of rhyme structure in underlying representation in CV-Notation. For discussion of the syllabification of long vowels in CV- and X-Notation, as well as a mechanism that parses syllables rather than building them, see Waksler (forthcoming).

[7] A formalized version of this proof is given in Waksler (forthcoming).

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