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THE LEXICAL REPRESENTATION OF CONTOUR TONES

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0. The problem
1. Mazatec tone rules
2. Chatino tone rules
3. Conclusion

0. The distinction between two separate types of tone languages, register systems and contour systems, was accepted by traditional American linguistics as one of the foundational assumptions of tonal analysis.[1] This assumption continued unquestioned through the first decade of the development of the Generative Phonological paradigm. Thus, Wang (1967), in the first published attempt to provide distinctive features for tone, explicitly provided for both level tones and contour tones.

This assumption was first challenged by Woo[2] (1969). She based her challenge on a different assumption, namely, that "... the tonal phenomena of all languages are essentially the same, and therefore should be describable using only one set of distinctive features" (1969:46). Working from this presupposition, Woo claimed that all tonal systems are of the register type. From this claim, the following two consequences were deduced: there is no need for CONTOUR distinctive features, and all gliding tones[2] should be analyzed as a sequence of level tones. In order to support this analysis of gliding tones, Woo further claimed that gliding tones occur only when there are long vowels in the underlying representation.

This last claim is seemingly falsified by the numerous languages which have gliding tones occurring on short vowels, with no evidence for an underlying long vowel. Hollenbach (1973) summarizes several examples of this type from Amerindian languages. To account for this type of counterevidence, Leben (1971) modified Woo's original proposal, abandoning the claim that gliding tones are always associated with long vowels, and maintaining only the claim that there are no underlying contour tones. Rather, he claims that all gliding tones should be treated as a suprasegmental sequence of level tones in the underlying representation. These suprasegmental tones are mapped onto the corresponding segments at some late stage in the derivation. When two underlying tones are mapped onto the same segment, the result is a phonetic gliding tone.

Fromkin (1976) addresses this issue from a different perspective. She does not

1 Pike (1948:8) is one of the first explicit references to this distinction.

2 For the sake of clarity, "gliding tone" is used throughout this article to refer to any phonetically nonstationary tone, whether the lexical representation is a sequence of level tones or a single unit within itself; and "contour tone" is restricted to refer only to a lexical (i.e., underlying) nonstationary tone unit. The term "level-sequence analysis" (abbreviated as l-s analysis) refers to the analysis of a gliding tone as an underlying sequence of level tones, and the term "contour analysis" refers to the analysis of a gliding tone as a single underlying unit.

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assume an a priori tonal analysis, but is rather concerned with the *function* of the gliding tones in any given tonal system. She cites analyses of gliding tones in several African and Asian tone languages and concludes that some languages require phonetic gliding tones to be analyzed as underlying contour tones, whereas other languages require an "underlying sequence of level tones" analysis. The decision about the lexical representation of gliding tones in a given language does not depend on phonetic reality, but rather "... on the phonological functioning of the tones in the language system" (Fromkin 1976:58).

This criterion for determining the lexical representation has been ignored in most recent studies of gliding tones. Rather, it has been assumed that the lexical representation of gliding tones will always be the same, regardless of their function in the tonal system. This is a direct result of Woo's basic (unchallenged) presupposition about tonal phenomena and is obvious in the work of Leben (1971), Williams (1976), and many others. This claim is characteristically stated by Voorhoeve (1978:458), in a review of Fromkin's 1976 paper: "The evidence in favor of the analysis of contour tones in underlying combinations of level tones on one syllable... is more convincing than the evidence... for underlying contour tones." In other words, even when reviewing an article which demonstrates the necessity of *functionally* determining the lexical representation of gliding tones for each language, this proponent of the level-sequence analysis does not even mention the possibility of gliding tones functioning differently in different tonal systems. Rather, it is assumed that gliding tones must always have one analysis and that the best "universal" analysis is an underlying sequence of level tones.

It is important to note that the normal practice within segmental phonology is quite different from this approach. It has never been claimed, in regard to underlying representations, that the segmental phenomena of all languages are essentially the same. Correspondingly, there has never been an attempt to determine a universal underlying representation for a particular phonetic segmental phenomenon. For instance, consider how a segmental phonologist would approach the analysis of the segment [ñ] in a given language. If there were obvious morphophonemic alternations, such as the case where an affix /-ya/ is suffixed to a stem /bon-/ to give [boña], then there would be little question that [ñ] should have the underlying representation /ny/ (at least for the lexical items showing this alternation). However, if in another language no such alternation existed, then [ñ] would have the underlying representation /ñ/. No linguist would claim that [ñ] should have the same underlying representation in all of the world's languages. Rather, the lexical representation for any given language is determined by the function of the segment in that language (as shown by the morphophonemic alternations).

Similarly, the question of how to represent gliding tones lexically must be considered for each individual language. The search for a universal underlying representation of gliding tones seems to be misdirected. Furthermore, it can be shown that separate representations are required in order to provide analyses which are descriptively adequate.

A second issue involves the inclusion of contour tonal features in the universal set of distinctive features. Fromkin (1972) demonstrates that a contour tonal feature is necessary at least for descriptively adequate phonetic representations. However, much of the debate relating to this issue has also proceeded without reference to similar work within segmental phonology. Specifically, two major criteria have been utilized within segmental distinctive feature theory to evaluate the appropriateness of a given set of features. These are: (1) the extent to which the features adequately characterize the important differences found within a language, and between any two languages; and (2) the extent to which the features adequately describe the "natural classes" found in the world's languages, that is, those classes of sounds which frequently undergo the same phonological processes (Wheeler 1972).

If a given set of features is not capable of describing the class of segments which undergo certain phonological processes, then that set will be judged to be descriptively inadequate. The same is true with regard to the ability of tonal features to describe the classes of tones which undergo the same tonal processes. However, this criterion has been ignored in past discussions of tonal distinctive features. It will be shown here that contour tones do function together as a natural class in a way that is not describable by the level-sequence analysis. Thus, the necessity for contour features (as has already been established on the basis of criterion 1 by Fromkin) will be verified on the basis of criterion 2.

This article discusses the resolution of these issues in reference to the analysis of two Mexican tone languages. The first, Soyaltepec Mazatec, demonstrates the necessity of the level-sequence analysis for certain languages, as has been previously demonstrated by Leben, Woo, Williams, etc. It will be shown that the contour analysis cannot adequately describe the rules of a tonal system of this type. However, the analysis of the second language, Yaitepec Chatino, demonstrates the necessity of contour features in order to describe the necessary natural classes. At the same time, the contour analysis is shown to be the only descriptively adequate one for languages of this type. Finally, some criteria for determining the lexical representation of gliding tones in any given language are suggested.

The Mazatec data were taken from Pike (1956) and the Chatino data from Upson (1968). The reader is referred to these articles for further background information on the respective languages.

1. There has been little controversy over the analysis of gliding tones in Soyaltepec Mazatec. Pike (1956:57) refers to these tones as "tone clusters," although it is not clear what is meant by this terminology. She consistently used this term to refer to any gliding tone in any Mexican Indian language; therefore, it seems likely that she was not addressing herself to the contour versus level-sequence issue. However, Woo notes this terminology used by Pike and others and concludes that the level-sequence analysis is the standard analysis for Mexican Indian languages.[3] Regardless of the true intent of this terminology, Pike's analysis of Mazatec is at least not opposed to a level-sequence analysis. Therefore, since no one to date has specifically argued in favor of a contour analysis for this tonal system, it is not necessary to "prove" that these gliding tones are best analyzed as an underlying sequence of level tones. Rather, it is demonstrated here that this decision is dictated by the function of the gliding tones in this system, and that the contour analysis is not descriptively adequate for a system of this type.

The distinctive feature chart shown in table 1 could describe the tones of Mazatec under the contour analysis. Under the 1-s analysis, the following set of distinctive features could be used:

[3] In Pike (n.d.:20), the gliding tones of Chatino are also referred to as "tone clusters." However, whatever was meant by the use of this term, it can be demonstrated that the level-sequence analysis of Chatino is inadequate.

TABLE 1

	LEVEL	RISING	HIGH	MID	LOW
1	+	–	+	–	–
2	+	–	+	+	–
3	+	–	–	+	–
4	+	–	–	–	+
2-1	–	+	+	–	–
3-2	–	+	–	+	–
4-3	–	+	–	–	+
3-1	–	+	+	+	–
4-2	–	+	–	+	+
4-1	–	+	+	–	+
1-2	–	–	+	–	–
2-4	–	–	–	+	+
3-4	–	–	–	–	+

	HIGH	MID
1	+	-
2	+	+
3	-	+
4	-	-

The large number of possible tone sequences is one type of argument which might be presented against the contour analysis. However, more conclusive evidence comes from the function of these tones in the tonal processes. One of these processes states:[4]

$$2\text{-}4 + 4 \div \rightarrow 2 + 4 \div .$$

For example:

či^3*tu*$^{2\text{-}4}$ 'cat', +*ʔna*^{4} 'my', *či*^{3}*tu*^{2}*ʔna*^{4} 'my cat'

ra^3*ša*$^{2\text{-}4}$ 'orange', +*ʔe*^{4} 'his', *ra*^{3}*ša*^{2}*ʔe*^{4} 'his orange'

The contour analysis would formalize this rule as Rule 1C:

$$\begin{bmatrix}-\text{LEV}\\-\text{RIS}\\+\text{MID}\end{bmatrix} \rightarrow \begin{bmatrix}+\text{LEV}\\+\text{HI}\end{bmatrix} \;/\; \_\_\_ + \begin{bmatrix}+\text{LEV}\\+\text{LOW}\end{bmatrix}\#.$$

Standing by itself, this formalization accounts for the relevant data. However, the rule provides no explanation or phonological motivation for this alternation. The process itself is an example of tone "spreading." The importance of tone spreading and shifting processes in the tonal systems of African languages has been clearly demonstrated by Hyman and Schuh (1974). These processes are also important in the analysis of Mexican tone languages.[5] In Soyaltepec Mazatec, the diachronic development of this particular process was probably:

$$\$24\$4\$\# \rightarrow \$2\$44\$\# \rightarrow \$2\$4\$\#.$$

As can be seen, this analysis provides an explanation for the synchronic alternation between 2-4 and 2. Hyman and Schuh (1974:90) refer to this type of spreading as "absorption," that is, the situation where the endpoint of a gliding tone is identical to the (beginning) tone of the following syllable and is thus absorbed into that syllable. The formalization of this process under the 1-s analysis captures the fact that this is an absorption process, that is, Rule 1LS:

$$\begin{bmatrix}-\text{HI}\\-\text{MID}\end{bmatrix} \rightarrow \emptyset \;/\; \$\begin{bmatrix}+\text{HI}\\+\text{MID}\end{bmatrix}\_\_\$ + \begin{bmatrix}-\text{HI}\\-\text{MID}\end{bmatrix}\#.$$

The importance of the research of Hyman and Schuh to the argument of this article is that the formalization of spreading and shifting processes necessarily requires a level-sequence analysis, since

[4] The following notation is employed throughout this article: - indicates a gliding tone, that is, two phonetic tones realized on the same syllable; + indicates a morpheme boundary; # marks a word boundary; \$ marks a syllable boundary. In the tone rules for Mazatec, the tone features are abbreviated as follows: Level (LEV), Rising (RIS), High (HI), Mid (MID), Low (LOW).

[5] See Pankratz and Pike (1967:296) for an example of a process of this type from another Otomanguean language.

contour tone features make no reference to the beginning and ending points of a gliding tone. Furthermore, since these tones are regarded as indivisible units, it is not possible to move one of these endpoints as if it were a separate unit within itself. The fact that the contour analysis cannot adequately describe a spreading process is graphically illustrated by Rule 1C, which in no way suggests a process of this type.

Another rule from Mazatec demonstrates the inadequacy of the contour analysis for describing shifting processes. Consider the following:

nku$^{3\text{-}2}$ 'one', *cha*^{3} 'hand', *nku*^{3} *cha*^{2} 'one hand'

čʔei$^{4\text{-}2}$ 'take!', *ce*^{3} 'guavas', *čʔei*^{4} *ce*^{2} 'buy guavas'

te^{3}*nku*$^{3\text{-}2}$ 'eleven', *ti*^{4} 'fish', *te*^{3}*nku*^{3} *ti*$^{2\text{-}4}$ 'eleven fish'

čʔei$^{4\text{-}2}$ 'take', *chu*^{4} 'onions', *čʔei*^{4} *chu*$^{2\text{-}4}$ 'buy onions'

The following statements account for each of these corresponding data sets:

3-2 # 3 # → 3 # 2 #
4-2 # 3 # → 4 # 2 #
3-2 # 4 # → 3 # 2-4 #
4-2 # 4 # → 4 # 2-4 #

Under the contour analysis, the first two statements could be formalized as Rule 2C:

$$\underset{1}{\begin{bmatrix}+\text{RIS}\\-\text{HI}\\+\text{MID}\\\alpha\text{LOW}\end{bmatrix}}\ \#\ \underset{2}{\begin{bmatrix}+\text{LEV}\\-\text{HI}\\+\text{MID}\end{bmatrix}}\ \#\ \rightarrow\ \underset{1}{\begin{bmatrix}+\text{LEV}\\-\alpha\text{MID}\end{bmatrix}}\ \#\ \underset{2}{\begin{bmatrix}+\text{HI}\end{bmatrix}}\ \#$$

and the last two statements as Rule 3C:

$$\underset{1}{\begin{bmatrix}+\text{RIS}\\-\text{HI}\\+\text{MID}\\\alpha\text{LOW}\end{bmatrix}}\ \#\ \underset{2}{\begin{bmatrix}+\text{LEV}\\+\text{LOW}\end{bmatrix}}\ \#\ \rightarrow\ \underset{1}{\begin{bmatrix}+\text{LEV}\\-\alpha\text{MID}\end{bmatrix}}\ \#\ \underset{2}{\begin{bmatrix}-\text{LEV}\\-\text{RIS}\\+\text{MID}\end{bmatrix}}\ \#\,.$$

These two rules could be further collapsed as Rule 2, 3C:

$$\underset{1}{\begin{bmatrix}+\text{RIS}\\-\text{HI}\\+\text{MID}\\\alpha\text{LOW}\end{bmatrix}}\ \#\ \underset{2}{\begin{bmatrix}+\text{LEV}\\-\text{HI}\\\beta\text{MID}\\-\beta\text{LOW}\end{bmatrix}}\ \#\ \rightarrow\ \underset{1}{\begin{bmatrix}+\text{LEV}\\-\alpha\text{MID}\end{bmatrix}}\ \#\ \underset{2}{\begin{bmatrix}\beta\text{LEV}\\-\text{RIS}\\\beta\text{HI}\\+\text{MID}\end{bmatrix}}\ \#\,.$$

Although this analysis is formally slick, it carries no explanatory force. An examination of Rule 2, 3C provides no clue as to why this perturbation is taking place. Yet it is clear from the four original statements that the actual process here is simply shifting a tone 2 one syllable to the right, and deleting any nonlow tone which that syllable carried.[6] That is:

$$\$\begin{Bmatrix}3\\4\end{Bmatrix}2\,\$\,\#\begin{Bmatrix}3\\4\end{Bmatrix}\#\rightarrow\begin{Bmatrix}3\\4\end{Bmatrix}\#\,\$\,2\begin{Bmatrix}\emptyset\\4\end{Bmatrix}\$\,\#\,.$$

The shifting process is easily formalized under the l-s analysis as Rule 2LS:

$$\$\ \underset{1}{\begin{bmatrix}-\text{HI}\end{bmatrix}}\underset{2}{\begin{bmatrix}+\text{HI}\\+\text{MID}\end{bmatrix}}\ \$\ \#\ \underset{3}{\begin{bmatrix}-\text{HI}\end{bmatrix}}\ \#\rightarrow 1\,\#\,\$\ 2\ 3\ \$\,\#\,.$$

This process is then followed by one which deletes nonlow tones, that is, Rule 3LS.

$$\begin{bmatrix}-\text{HI}\\+\text{MID}\end{bmatrix}\rightarrow\ \emptyset\ /\ \$\ \begin{bmatrix}+\text{HI}\\+\text{MID}\end{bmatrix}\ \_\_\_\ \$\ \#\,.$$

These two rules apply in a natural feeding order. Obviously, the l-s analysis is not only simpler/more elegant from a formal point of view, but it alone can adequately describe the shifting process which is operative here.

Another process in Soyaltepec Mazatec has the effect of raising one of the endpoints of a gliding tone. For processes of this type, the l-s analysis is again the only adequate one. The following data illustrate the operation of this process:

6 Syllable boundaries are included in this notation only where it is necessary to represent two level tones cooccurring on the same syllable.

ši^{3}*ne*$^{2-1}$ 'lard', *chu*^{1} 'toasted', *ši*^{3}*ne*^{1}*chu*^{1} 'cracklings'
ni^{3}*su*$^{3-2}$ 'a dipper', +*hi*^{1} 'negative', *ni*^{3}*su*^{1} *hi*^{1} 'not a dipper'
ya^{3}*tyu*^{2} 'wooden beam', +*hi*^{1} 'negative', *ya*^{3}*tyu*^{1}*hi*^{1} 'not a wooden beam'
nče$^{4-2}$ 'cooked corn', +*hi*^{1} 'negative', *nče*$^{4-1}$*hi*^{1} 'not cooked corn'

The following statements describe these data sets:[7]

$$\begin{array}{llll} \$\ 2\ 1\ \$\ 1 & \rightarrow & 1\ \$\ 1 \\ \$\ 3\ 2\ \$\ 1 & \rightarrow & 1\ \$\ 1 \\ 2\ \$\ 1 & \rightarrow & 1\ \$\ 1 \\ \$\ 4\ 2\ \$\ 1 & \rightarrow & \$\ 4\ 1\ \$\ 1 \end{array}$$

Two rules are required in order to describe these processes under the contour analysis. The first three statements are described by Rule 4C:

$$\left\{\begin{array}{c} \begin{bmatrix} +\text{RIS} \\ -\text{LOW} \\ \alpha\text{HI} \\ -\alpha\text{MID} \end{bmatrix} \\ \left(\begin{bmatrix} +\text{LEV} \\ +\text{HI} \\ +\text{MID} \end{bmatrix}\right) \end{array}\right\} \rightarrow \begin{bmatrix} +\text{LEV} \\ +\text{HI} \\ -\text{MID} \end{bmatrix} \ / \ \_\_\_ \ \$ \begin{bmatrix} +\text{LEV} \\ +\text{HI} \\ -\text{MID} \end{bmatrix}.$$

The last statement can be described by Rule 5C:

$$\begin{bmatrix} +\text{RIS} \\ +\text{MID} \\ +\text{LOW} \end{bmatrix} \rightarrow \begin{bmatrix} +\text{HI} \\ -\text{MID} \end{bmatrix} \ / \ \_\_\_ \ \$ \begin{bmatrix} +\text{LEV} \\ +\text{HI} \\ -\text{MID} \end{bmatrix}$$

It may be possible to collapse these two rules. However, collapsed or not, the rules which result from this analysis again carry no explanatory power.

Intuitively, there seem to be two quite different processes operative here. The first raises a tone 2 to a tone 1 when preceding a tone 1, whether the tone 2 originally stood alone or was the endpoint of a gliding tone. The second process then deletes all nonlow tones in the proper environment. These processes can be formalized only under the l-s analysis, that is, Rule 4LS:

$$2 \rightarrow 1 \ / \ \$ \ (\left\{\begin{matrix} 3 \\ 4 \end{matrix}\right\}) \ \_\_\_ \ \$ \ 1$$

$$[+\text{HI}] \rightarrow [-\text{MID}] \ / \ \$ \ ([-\text{HI}]) \ \_\_\_ \ \$ \begin{bmatrix} +\text{HI} \\ -\text{MID} \end{bmatrix}.$$

The application of this rule would result in:

$$\begin{array}{llll} \$\ 2\ 1\ \$\ 1 & \rightarrow & \$\ 2\ 1\ \$\ 1 \\ \$\ 3\ 2\ \$\ 1 & \rightarrow & \$\ 3\ 1\ \$\ 1 \\ 2\ \$\ 1 & \rightarrow & 1\ \$\ 1 \\ \$\ 4\ 2\ \$\ 1 & \rightarrow & \$\ 4\ 1\ \$\ 1 \end{array}$$

Rule 5LS would then apply to derive the correct phonetic results. Rule 5LS:

$$\left\{\begin{matrix} 2 \\ 3 \end{matrix}\right\} \rightarrow \emptyset \ / \ \$ \ \_\_\_ \ 1 \ \$ \ 1$$

$$[+\text{MID}] \rightarrow \emptyset \ / \ \$ \ \_\_\_ \begin{bmatrix} +\text{HI} \\ -\text{MID} \end{bmatrix} \ \$ \begin{bmatrix} +\text{HI} \\ -\text{MID} \end{bmatrix}.$$

Rule 4LS and Rule 5LS apply in a natural feeding order.

The l-s analysis of this process is formally simpler than the contour analysis, and as such is to be preferred. Furthermore, the l-s analysis provides an explanatory analysis. This analysis receives further support in that an addition to Rule 4LS applies to any word-final tone which is in phrase-medial position, completely apart from the application of Rule 5LS. Consider:

ci^{3}*ni*^{3}*ʔna*^{2} 'my uncle', *ci*^{3}*ni*^{3}*ʔna*^{1} *hwuei*^{1} 'my uncle goes'
si^{3}*nka*^{2} 'shirt', *si*^{3}*nka*^{1} *cʔa*^{3}*ce*^{3} 'he bought a shirt'
kǫ$^{3-2}$ 'twenty', *kǫ*$^{3-1}$ *cu*^{1} 'he says twenty'
hǫ$^{3-2}$ 'six', *hǫ*$^{3-1}$ *nte*$^{2-1}$ 'six shoes'

This rule could be formalized as Rule 4LS(ADD):

$$2 \rightarrow 1 \ / \ \$ \ (\left\{\begin{matrix} 3 \\ 4 \end{matrix}\right\}) \ \_\_\_ \ \$ \ \# \ \text{T}$$

$$[+\text{HI}] \rightarrow [-\text{MID}] \ / \ \$ \ ([-\text{HI}]) \ \_\_\_ \ \$ \ \# \ \text{T}$$

[7] Actually, this process applies right-to-left iteratively, as can be seen from the following data: *ya*$^{2-1}$*čą*$^{2-1}$ 'forty', *ʔǫ*^{1} 'five', *ya*^{1}*čą*^{1}*ʔǫ*^{1} 'forty-five' *ntyu*$^{2-1}$*hwua*$^{3-2}$ 'water', *ti*^{1} 'it burns', *ntyu*^{1}*hwua*^{1}*ti*^{1} 'kerosene'.

where T stands for any tone. These two rules can be easily collapsed into Rule 4LS (REVISED):

$$[+\text{HI}] \rightarrow [-\text{MID}] / \ \$ \ ([-\text{HI}]) \ \_\_\_ \ \$ \ \begin{bmatrix} +\text{HI} \\ -\text{MID} \end{bmatrix}_{\#\text{T}}.$$

Thus, the l-s analysis of these data, which claims the application of two separate processes, Rule 4LS and Rule 5LS, is further verified in that these processes apply independently. There is no way the contour analysis can capture the similarity between the process formulated as Rule 4LS and that formalized as Rule 4LS-(ADD). Therefore, given the factors of formal simplicity, explanatory ability, and the most essential requirement of simply describing the processes which are operative, it can be concluded that the contour analysis is additionally unsuitable for describing processes which consistently raise or lower one of the endpoints of a gliding tone.

One final set of data provides an additional type of support for the l-s analysis of Mazatec. Certain morphemes in this language have a floating tone, which is realized on a "zero syllable," that is, a syllable with tone, but without any segmental phones (Pike 1956:66). For example:

ti^{3} 'boy', +^{4}*či*$^{2\text{-}1}$ 'small', *ti*$^{3\text{-}4}$*či*$^{2\text{-}1}$ 'small boy'

ca^{3} 'pocket', +^{4}*ri*^{3} 'your (sing.)', *ca*$^{3\text{-}4}$*ri*^{3} 'your pocket'

tǫ$^{4\text{-}3}$ 'money', +^{4}*ri*^{3} 'your (sing.)', *tǫ*$^{4\text{-}3\text{-}4}$*ri*^{3} 'your money'

This phenomenon can be easily analyzed in terms of two level tones coming together on the same syllable. However, it is contradictory to speak of two level tones coming together to form an underlying contour tone, as would be required by the contour analysis. Furthermore, the last example would be very difficult to account for under that analysis, requiring at least an inexplicable expansion of the distinctive feature chart; but it presents no complications for the l-s analysis.

Thus the level-sequence analysis is overwhelmingly the superior analysis for this dialect of Mazatec. However, the analysis of Chatino demonstrates that this is not universally so.

2. Four separate types of processes were referred to in order to demonstrate that the gliding tones of Soyaltepec Mazatec are a phonemic sequence of level tones, rather than phonemic contour tones. These processes are: (1) spreading (absorption), (2) shifting, (3) raising or lowering one of the endpoints of a gliding tone, and (4) combining a level floating tone with another tone (level or gliding) to form a gliding tone. The common factor in all of these processes is that they affect only one of the endpoints of a gliding tone. None of these processes changes an entire gliding tone as if it were an independent unit. It is this factor which results in the necessity of the level-sequence analysis.

A very different situation exists in the tonal system of Yaitepec Chatino. First of all, the phonetic tonal system of Chatino is symmetrical, as opposed to the highly asymmetrical system of Mazatec. This alone may indicate some difference in the tonal systems. Under the contour analysis these tones could be specified as shown in table 2. The following distinctive feature chart could describe the required four tone heights under the l-s analysis:

	HIGH(H)	MID(M)
1	+	–
2	+	+
3	–	+
(4)	–	–

The difference between these two languages is even more noticeable in a comparison of the function of the gliding tones in the respective tonal processes. As noted, Mazatec tone processes affect only one

TABLE 2

	HIGH (H)	MID (M)	FALLING (F)	RISING (R)
1	+	–	–	–
2	+	+	–	–
3	–	+	–	–
(4)	–	–	–	–
1-2	+	–	+	–
2-3	–	+	+	–
(3-4)	–	–	+	–
2-1	+	–	–	+
3-2	–	+	–	+
(4-3)	–	–	–	+

endpoint of a gliding tone. Conversely, Chatino tone processes consistently affect the entire gliding tone, raising or lowering the whole unit. Furthermore, the conditioning environments for these processes do not refer to level tones or to the endpoints of gliding tones. Rather, they refer to entire classes of gliding tones, considered as units. These factors, which indicate that Chatino gliding tones should be analyzed as lexical contour units, are noticeable from an inspection of the tonal system. However, the attempt to formalize these processes under both the l-s analysis and the contour analysis formally demonstrates that the contour analysis is in fact the only descriptively adequate one.

Contrastive tone occurs only on stressed syllables in Chatino. Stress is predictable, occurring only on the ultimate syllable. Therefore, in the examples cited, tone is marked only on these syllables (Pride 1963:19).

Two nontonal factors interact crucially with the tone system of Chatino. The first is the presence of contrasting long and short vowels. For instance, a tone 3 occurring on a long vowel (written 3:) conditions many tonal processes, whereas a short tone 3 does not condition any changes. The colon will be used to mark length in the rules. The second factor is the difference between those forms inflected for person versus those not inflected. These two classes act separately in the tone processes and therefore inflected forms will be indicated by I.

There are several tones which never condition a tone change, even though they can be perturbed themselves. These tones do not form a natural class and seem to be completely arbitrary (at least synchronically). Thus, they must be lexically marked as a class of exceptions to the conditioning environments of the tone rules. The tones which are included in this class are[8] 12, 12:, 2, 2:, 3, 12I, 23I, 2I, 2:1, 3I, 32:I. The tones specified in the environments of the following rules will not include any of these, since they are excluded from all tone rules.

There is a tendency in Chatino to lower a mid contour tone. The specific statements of this process follow.[9] Rule 1:

8 The following tones—4, 3-4, and 4-3 (both long and short), that is, all $\begin{bmatrix} \text{-H} \\ \text{-M} \end{bmatrix}$ tones—never occur in the underlying representation of a lexical item in Chatino (with the possible exception of a tone 4, short; Upson 1968:3). These tones, therefore, are also excluded from the conditioning environments of the tone rules.

9 Actually there are two further closely related rules:

$$23: \rightarrow 34: \ / \left\{ \begin{matrix} 1 \\ 1: \\ 1\text{I} \\ 1\text{:I} \\ 12\text{:I} \end{matrix} \right\} \ \_\_\_\_ .$$

$$32 \rightarrow 43 \ / \left\{ \begin{matrix} 1 \\ 1: \\ 1\text{I} \\ 1\text{:I} \\ 3\text{:I} \end{matrix} \right\} \ \_\_\_\_ .$$

However, since the formalization of these rules does not favor either the l-s or the contour analysis, they will not be discussed further in this article.

$$23 \rightarrow 34 \;/\; \left\{\begin{matrix} 1 \\ 1\text{:} \\ 1\text{I} \\ 1\text{:I} \\ 3\text{:} \\ 3\text{:I} \\ 21 \\ 21\text{:} \\ 21\text{I} \\ 21\text{:I} \\ 32 \\ 32\text{:} \\ 32\text{I} \\ 23\text{:I} \\ 12\text{:I} \end{matrix}\right\} \;\underline{\quad}\,.$$

Rule 2:

$$32\text{:} \rightarrow 43\text{:} \;/\; \left\{\begin{matrix}\text{same} \\ \text{environment} \\ \text{as Rule 1}\end{matrix}\right\} \;\underline{\quad}\,.$$

The following data sets illustrate these statements:

kaʔyu$^{1:}$ 'five', *šlyu*^{23} 'knife', *kaʔyu*$^{1:}$ *slyu*^{34} 'five knives'

katį$^{21:}$*ʔ* 'I will suck', *nguša*^{23} 'an orange', *katį*$^{21:}$*ʔ* *nguša*^{34} 'I will suck an orange'

ka^{1} 'nine', *ngwǫ*$^{32:}$ 'spider monkey', *ka*^{1} *ngwǫ*$^{43:}$ 'nine spider monkeys'

tsuʔwe^{32} 'good', *kya*$^{32:}$ 'tomorrow', *tsuʔwe*^{32} *kya*$^{43:}$ 'good tomorrow'

The l-s analysis represents both of these statements as separate processes. It cannot adequately describe the raising or lowering of an entire gliding tone, and furthermore it cannot capture the fact that both mid gliding tones (i.e., rising and falling) undergo the same process; that is, the process applies to any mid nonstationary tone, not to some particular level tone in a sequence of tones.

These inadequacies are shown by the formalization of these statements under this analysis. Rule 1LS:

$$\left\{\begin{matrix} \begin{bmatrix}+\text{H}\end{bmatrix} \\ \begin{bmatrix}-\text{H}\\+\text{M}\\+\text{LONG}\end{bmatrix} \end{matrix}\right\}$$

$$\begin{bmatrix}+\text{H}\\+\text{M}\end{bmatrix}\begin{bmatrix}-\text{H}\\+\text{M}\end{bmatrix} \rightarrow \begin{bmatrix}-\text{H}\\+\text{M}\end{bmatrix}\begin{bmatrix}-\text{H}\\-\text{M}\end{bmatrix} \;/\; \left\{\begin{matrix} \left[\$\begin{bmatrix}+\text{H}\\+\text{M}\end{bmatrix}\begin{bmatrix}+\text{H}\\-\text{M}\end{bmatrix}\$\right] \\ \left[\$\begin{bmatrix}\alpha\text{H}\\-\alpha\text{M}\end{bmatrix}\begin{bmatrix}+\text{H}\\+\text{M}\end{bmatrix}\$\right] \\ \begin{bmatrix}\$\begin{bmatrix}+\text{H}\\+\text{M}\end{bmatrix}\begin{bmatrix}-\text{H}\\+\text{M}\end{bmatrix}\$ \\ +\text{ INFLECTED}\end{bmatrix} \end{matrix}\right\} \;\; \$\underset{-\text{LONG}}{\underline{\quad}}\$\,.$$

Rule 2LS:

$$\begin{bmatrix}-\text{H}\\+\text{M}\end{bmatrix}\begin{bmatrix}+\text{H}\\+\text{M}\end{bmatrix} \rightarrow \begin{bmatrix}-\text{H}\\-\text{M}\end{bmatrix}\begin{bmatrix}-\text{H}\\+\text{M}\end{bmatrix} \;/\; \left\{\begin{matrix}\text{same}\\\text{environment}\\\text{as Rule 1LS}\end{matrix}\right\} \;\; \$\underset{+\text{LONG}}{\underline{\quad}}\$\,.$$

A second major difficulty with the l-s analysis of this process is that the resulting representation of the conditioning environment is not natural or explanatory in any sense. Feature counting as a means of evaluating alternative analyses is admittedly not an adequate device. However, any analysis which requires long disjunctive lists in the conditioning environments of the rules is obviously not describing the class which is actually functioning. This criticism certainly applies to the l-s analysis of these rules, as well as to the other processes which are described.

In contrast to this, the contour analysis provides an explanatory representation of this process, in that it can represent the lowering of an entire gliding tone-unit, and furthermore it can capture the class of tones which condition this change. Consider Rule 1C:

$$\begin{bmatrix}+\text{F}\\-\text{H}\\-\text{LONG}\end{bmatrix} \rightarrow \begin{bmatrix}-\text{M}\end{bmatrix} \;/\; \left\{\begin{matrix}\begin{bmatrix}-\text{F}\end{bmatrix}\\ \begin{bmatrix}+\text{F}\\+\text{I}\end{bmatrix}\end{matrix}\right\} \;\underline{\quad}\,.$$

Rule 2C:

$$\begin{bmatrix}+\text{R}\\-\text{H}\\+\text{LONG}\end{bmatrix} \rightarrow \begin{bmatrix}-\text{M}\end{bmatrix} \;/\; \left\{\begin{matrix}\begin{bmatrix}-\text{F}\end{bmatrix}\\ \begin{bmatrix}+\text{F}\\+\text{I}\end{bmatrix}\end{matrix}\right\} \;\underline{\quad}\,.$$

These two rules can be further simplified by combining them, which represents the identical application of this process to both rising and falling tones. Rule 1, 2C:

$$\begin{bmatrix}\alpha \mathrm{F}\\ -\alpha \mathrm{R}\\ -\mathrm{H}\\ -\alpha \mathrm{LONG}\end{bmatrix} \rightarrow [-\mathrm{M}] \;/\; \left\{\begin{matrix}[-\mathrm{F}]\\ \\ \begin{bmatrix}+\mathrm{F}\\ +\mathrm{I}\end{bmatrix}\end{matrix}\right\} \_\_\_.$$

A second process in Chatino does not have an obvious motivation or explanation under any analysis. The following statement represents this process. Rule 3:

$$3 \rightarrow 12 \;/\; \left\{\begin{matrix}23\\ 23{:}\\ 23{:}\mathrm{I}\\ 12{:}\mathrm{I}\\ 3{:}\\ 3{:}\mathrm{I}\\ 21\\ 21{:}\\ 21\mathrm{I}\\ 21{:}\mathrm{I}\\ 32\\ 32{:}\\ 32\mathrm{I}\end{matrix}\right\} \_\_\_.$$

For example:

msiʔi$^{3:}$ 'he bought', *nguta*^{3} 'seed', *msiʔi*$^{3:}$ *nguta*^{12} 'he bought seed'

sa^{23} 'cup', *tiʔa*^{3} 'water', *sa*^{23} *tiʔa*^{12} 'cup of water'

ku̥$^{21:}$ 'I will eat', *kula*^{3} 'fish', *ku̥*$^{21:}$ *kula*^{12} 'I will eat fish'

tsuʔwe^{32} 'good', *yka*^{3} 'tree', *tsuʔwe*^{32} *yka*^{12} 'good tree'

Even though this process intuitively seems unmotivated, its formal representation under the contour analysis is considerably simpler than under the l-s analysis, thus indicating that the contour analysis is at least closer to describing the process actually operative here. The l-s analysis has two difficulties in describing this process. The first is the attempt to describe a level tone changing into a gliding tone which does not have either endpoint equivalent to the original level tone. The second is the attempt to describe the class of tones which condition this change. In both of these respects the contour analysis is superior to the l-s one, as shown by the following formalizations. Rule 3LS:

$$\begin{bmatrix}-\mathrm{H}\\ +\mathrm{M}\\ -\mathrm{LONG}\end{bmatrix} \rightarrow \begin{bmatrix}\$ \begin{bmatrix}+\mathrm{H}\\ -\mathrm{M}\end{bmatrix}\begin{bmatrix}+\mathrm{H}\\ +\mathrm{M}\end{bmatrix} \$\\ -\mathrm{LONG}\end{bmatrix} \;/\; \left\{\begin{matrix}\left[\$ \begin{bmatrix}+\mathrm{H}\\ +\mathrm{M}\end{bmatrix}\begin{bmatrix}\alpha \mathrm{H}\\ -\alpha \mathrm{M}\end{bmatrix} \$\right]\\ \begin{bmatrix}-\mathrm{H}\\ +\mathrm{M}\end{bmatrix}\\ \left[\$ \begin{bmatrix}\alpha \mathrm{H}\\ -\alpha \mathrm{M}\end{bmatrix}\begin{bmatrix}+\mathrm{H}\\ -\mathrm{M}\end{bmatrix} \$\right]\end{matrix}\right\} \_\_\_.$$

Rule 3C:

$$\begin{bmatrix}-\mathrm{F}\\ -\mathrm{R}\\ -\mathrm{H}\\ +\mathrm{M}\\ -\mathrm{LONG}\end{bmatrix} \rightarrow \begin{bmatrix}+\mathrm{F}\\ +\mathrm{H}\\ -\mathrm{M}\end{bmatrix} \;/\; \left\{\begin{matrix}[-\mathrm{H}]\\ \\ \begin{bmatrix}\alpha \mathrm{F}\\ -\alpha \mathrm{R}\\ +\mathrm{H}\end{bmatrix}\end{matrix}\right\} \_\_\_.$$

The only remaining process of the Chatino tonal system[10] provides an indisputable demonstration of the inability of the l-s analysis to describe a process which is seen to be both plausible and formally simple under the contour analysis. This process affects all long low-mid tones which do not occur in isolation. Rule 4 and Rule 5 state the relevant changes. Rule 4:

$$3{:} \rightarrow 2{:} \;/\; \left\{\begin{matrix}23\\ 23{:}\\ 23{:}\mathrm{I}\\ 12{:}\mathrm{I}\end{matrix}\right\} \_\_\_.$$

Rule 5:

$$\left\{\begin{matrix}1\\ 1{:}\\ 1\mathrm{I}\\ 1{:}\mathrm{I}\\ 3{:}\\ 3{:}\mathrm{I}\end{matrix}\right\}$$

10 Actually, there is one other tonal process, which again does not affect the argument of this article:

$$\begin{matrix}2 \rightarrow 3\\ 2{:} \rightarrow 3{:}\end{matrix} \;/\; \left\{\begin{matrix}1\\ 1{:}\\ 1\mathrm{I}\\ 1{:}\mathrm{I}\end{matrix}\right\} \_\_\_.$$

$$3\text{:} \rightarrow 4\text{:} \ / \left\{\begin{matrix} 21 \\ 21\text{:} \\ 21\textsc{i} \\ 21\text{:}\textsc{i} \\ 32 \\ 32\text{:} \\ 32\textsc{i} \end{matrix}\right\} \_\_\_ .$$

For example:

kuhwi$^{23:}$*ʔ* 'he will sell', *kye*$^{3:}$ 'flower', *kuhwi*$^{23:}$*ʔ kye*$^{2:}$ 'he will sell a flower'

ndšę$^{12:}$ 'he is rolling', *šnį*$^{3:}$*ʔ* 'dog', *ndšę*$^{12:}$ *šnį*$^{2:}$*ʔ* 'the dog is rolling'

skwa^{1} 'six', *šnį*$^{3:}$*ʔ* 'dog', *skwa*^{1} *šnį*$^{4:}$*ʔ* 'six dogs'

tyų$^{3:}$ 'several', *kye*$^{3:}$ 'flower', *tyų*$^{3:}$ *kye*$^{4:}$ 'several flowers'

Under the l-s analysis, these statements are formalized as two entirely separate processes, both of which are extremely complex and seemingly arbitrary, that is, Rule 4LS:

$$\begin{bmatrix} -\mathrm{H} \\ +\mathrm{M} \\ +\mathrm{LONG} \end{bmatrix} \rightarrow [+\mathrm{H}] \ / \left\{\begin{matrix} \left[\$ \begin{bmatrix} +\mathrm{H} \\ +\mathrm{M} \end{bmatrix} \begin{bmatrix} -\mathrm{H} \\ +\mathrm{M} \end{bmatrix} \$\right] \\ \left[\$ \begin{bmatrix} +\mathrm{H} \\ -\mathrm{M} \end{bmatrix} \begin{bmatrix} +\mathrm{H} \\ +\mathrm{M} \end{bmatrix} \$\right] \end{matrix}\right\} \_\_\_ .$$

Rule 5LS:

$$\begin{bmatrix} -\mathrm{H} \\ +\mathrm{M} \\ +\mathrm{LONG} \end{bmatrix} \rightarrow [-\mathrm{M}] \left\{\begin{matrix} \begin{bmatrix} \alpha\mathrm{H} \\ -\alpha\mathrm{M} \end{bmatrix} \\ \left[\$ \begin{bmatrix} +\mathrm{H} \\ +\mathrm{M} \end{bmatrix} \begin{bmatrix} +\mathrm{H} \\ -\mathrm{M} \end{bmatrix} \$\right] \\ \left[\$ \begin{bmatrix} -\mathrm{H} \\ +\mathrm{M} \end{bmatrix} \begin{bmatrix} +\mathrm{H} \\ +\mathrm{M} \end{bmatrix} \$\right] \end{matrix}\right\} \_\_\_ .$$

In sharp contrast, these processes are seen to be quite natural and noncomplex under the contour analysis, and the two of them can be easily collapsed into one explanatory rule, Rule 4C:

$$\begin{bmatrix} -\mathrm{F} \\ -\mathrm{R} \\ +\mathrm{M} \\ +\mathrm{LONG} \end{bmatrix} \rightarrow [+\mathrm{H}] \ / \ [+\mathrm{F}] \_\_\_ .$$

Rule 5C:

$$\begin{bmatrix} -\mathrm{F} \\ -\mathrm{R} \\ -\mathrm{H} \\ +\mathrm{LONG} \end{bmatrix} \rightarrow [-\mathrm{M}] \ / \ [-\mathrm{F}] \_\_\_ .$$

Rule 4,5C:

$$\begin{bmatrix} -\mathrm{F} \\ -\mathrm{R} \\ -\mathrm{H} \\ +\mathrm{M} \\ +\mathrm{LONG} \end{bmatrix} \rightarrow \begin{bmatrix} \alpha\mathrm{H} \\ \alpha\mathrm{M} \end{bmatrix} \ / \ [\alpha\mathrm{F}] \_\_\_ .$$

In other words, a tone 3: raises to a tone 2: following any falling tone, and it lowers to a tone 4: following any nonfalling tone. The required natural class here divides Chatino tones into those units which are falling and those units which are not falling (i.e., level or rising). The l-s analysis is not able to make distinctions of this type.

3. This comparison of the tonal systems of Mazatec and Chatino has resulted in the following conclusions. (1) The tonal phenomena of all languages are not the same. (2) An expanded set of distinctive features is required, which includes both level and contour tonal features. (3) The phonological analysis of gliding tones in any particular language must be based on the function of those tones in the tonal system of that language.

In regard to this last conclusion, it has been found in this study that underlying sequences of level tones function in a manner which is characteristically different from underlying contour tones. If the gliding tones of a given language are a lexical sequence of level tones, then the tone rules of that language will usually affect only one of the endpoints of the glide (e.g., spreading, shifting, or raising/lowering one endpoint). Also, the presence of floating tones in a tonal system, which combine with other tones to form gliding tones, suggests a level-sequence analysis. On the other hand, gliding tones which are lexical contour tones function as indivisible units in the tone rules. This function can be seen in the tone alternations (e.g., if a gliding tone is raised or lowered as a whole unit) or in the classes of tones which function together in the rules (e.g., if all falling tones function together as a class).

A second distinction between the two types of systems may be found in the phonetic inventories of tones. If in a given language the gliding tones are lexically a sequence of level tones, then it is probable that the phonetic inventory of gliding tones will not be symmetrical; that is, there may be considerably more rising tones than falling tones, or vice versa, and the tones may not be related to each other in any obvious manner. Conversely, a system with lexical contour tones will probably have a relatively symmetrical phonetic inventory of gliding tones. This distinction is extremely tentative, since it is here based on a sample of only two languages. However, it will be interesting to determine in future research if the underlying function of gliding tones is indeed reflected in the phonetic inventory.

This study is by no means the final statement on this subject. Rather, it is intended only to demonstrate the existence of both contour and level-sequence type tonal systems, in the hope that future studies will investigate the universal characteristics of the tone rules of both types of systems.

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