On the Geometry of Contour Tones
(with particular reference to Soyaltepec Mazatec)

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0. Introduction

At least since Kenneth Pike's 1948 investigation of the tone languages of Mesoamerica, linguists who have examined tone systems have concluded that there are two kinds of tone languages in the world: those where contour tones are phonemic primitives with some sort of unitary status, and those where they are analyzable as sequences of level tones. If, in the surface forms of a tone language, some syllables begin on one pitch but end on another, these "gliding tones" (E. Pike 1956) may each be a single complex segment, akin to an affricate or a prenasalized stop. Alternatively, they may have more in common with consonant clusters, which are made up of sequences of discrete segments. In order to dtermine which analysis is appropriate for any given tone language, it is necessary to see whether phonological processes treat the contours as single entities or as decomposable clusters.

In section 1, I will examine the basic distinction between unitary and non-unitary contour tones in more detail and present the autosegmental representational systems commonly used to describe contour tones. These proposals fall into two classes, each corresponding to one side of the unitary vs. non-unitary opposition. On the one hand, those Woo (1969) calls the "Asianists" attempt to capture the unitary status that contour tones in most South East Asian languages appear to have. On the other hand, the "Africanists" see contours as concatenations of level tones because that is the way they behave in the majority of African tone lanuages. The sorts of processes characteristic of both groups of languages and the ways in which the two sorts of representational systems presented in section 1 are applied to the analysis of these phenomena will be exemplified in section 2.

In section 3, I will provide an analysis of the tonal processes of Mazatec, an Otomanguean tone language described by E. Pike (1956). I will show that contour tones in Mazatec behave like units with respect to some processes, and like series of level tones with respect to others. The hybrid nature of Mazatec disrupts the neat two-class typology opposing African- and Asian-type tone languages. As a result, neither of the two representational systems developed to deal with the sorts of languages described in section 2 will prove capable of accounting for all the Mazatec data.

1. Toward a Typology of Contour Tones

According to K. Pike (1948), some tone languages have "contour systems", which are characterized by unitary, undivisible contour tones, while others, called "register systems," have surface contour tones analyzable as series of level tones or no surface contour tones at all. Pike claimed that the two kinds of systems have fundamentally different properties. Specifically, in contour systems,

(1) The basic tonemic unit is gliding instead of level.
(2) The unitary contour glides cannot be interrupted by morpheme boundaries as can the nonphonemic compounded types of a register system.
(3) The beginning and ending points of the glides of a contour system cannot be equated with level tonemes in the system, whereas all glides of a register system are to be interpreted phonemically in terms of their end points.

(4) ...contour systems have only one toneme per syllable[1], whereas some of the register tone languages .... may have two or more tonemes per syllable. (Pike, 1948:8)

Pike's first statement appears to be simply an assertion that, in some languages, contour tones are phonemic primes. (2) makes the specific claim that contour tones will not be broken up by morpheme boundaries just in case they are primitives of a language's tonemic system. According to (3), the "gliding" tones of a true contour system are not reducible to sequences of level tones but rather have some sort of special status. Pike's (4) gives the null hypothesis implied by a typology with two classes, namely that any given language has either a contour or a register system, but not both. That is, in a system with unitary contours, any sequence of phonetically distinct pitches on a single syllable are expected to constitute a single toneme. In no language do we expect to find evidence that some surface contour tones are underlyingly unitary while others are analyzable as sequences of level tones.

The advent of autosegmental phonology in the late 1970s made it possible to gain new insights into the operations of pitch level systems, as will be seen in section 2.2 below. However, the question of how best to represent unitary contours, if in fact such things exist, continues to be a topic of contention. In the following section, I will describe the main representational proposals which have been made in answer to this question, as well as outlining the tone cluster approach used to analyze languages with non-unitary contour tones.

1.1 On the representation of contour tones

1.1.1 Binary Feature systems: Wang /Newman

Wang (1967) used the "sandhi circle" of Xiamen (Amoy Hokkien) to argue that contour tones are in fact unary and that they are distinguished from level tones by the binary features [± falling] and [± rising]. While Wang's solution to the Xiamen problem has been hailed as "remarkably ingenious" (Anderson 1978: 157), numerous arguments against his use of contour features have been advanced by, among others, Woo (1969), Anderson (1978), Schuh (1978), and Yip (1989). I will therefore follow Bao (1990) in considering this proposal to have been suitably disposed of in the literature and not to require further discussion. It should be noted, however, that a similar suggestion for contour tone features has been advanced by Newman (1986) to account for the distribution and behavior of contour tones in Grebo, a Kru language spoken in Liberia. Using historical as well as synchronic evidence, Newman argues that contours in Grebo are phonemic primes. This may well be the case, but many of the objections voiced against Wang's contour features can equally well be applied to Newman's feature [± rising]. In other words, both Wang and Newman present evidence to support the claim that contour tones in some languages are unitary, but neither offers a viable representational scheme for capturing this fact.

1.1.2 The "Asianist" Perspective : Unitary Contour Tones

Within the autosegmental framework, the main arguments for both the unitary status of contour tones and for a particular representational apparatus for describing them have come from Yip (1989) and Bao (1990). Although they use different features to define the pitch heights of tones, their representations (1a and b) are quite similar.

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[1]Pike assumes that the tone bearing unit (TBU) is the syllable. Others (such as Hyman (1989) and Duanmu (1990)) argue that the TBU is always the mora. For present purposes, it does not really matter who is right. Pike's statement can be interpreted as saying that, in contour systems, contour tones count as single tonemes. In register systems, they count as multiple tonemes. Thus, whatever the basic TBU is, Pike is claiming that the former type of system maps tonemes to TBUs one-to-one, while the latter type may map many tonemes to a single TBU.

```
(1a) Yip (1989)          (b) Bao (1990)

      X                        X
      |                        |
      T                        T
      ^                        ^
     t t                      r c      r= register
                                ^      c= contour
                               t t
```

In both (a) and (b), the putative unitary status of contour tones is represented by showing the terminal tonal elements (t) defining a contour tone's beginning and ending points as daughters of a single tone root node (T). This approach is to be contrasted with the tone cluster representations advocated by those Woo (1969) terms "the Africanists" (see below).

Of particular interest here are Yip and Bao's claims about the role of register in contour tones. Unlike Pike, who used "register" to refer to systems with nonunitary contour tones, Yip takes the term to designate a devision of the pitch range into two sections: an upper section and a lower section. In Yip's representation (1a), the tone root node houses a binary feature [± upper], abbreviated as H or L. Because the relationship between the T and t nodes is one of dominance, the terminal elements of a contour tone are constrained to share a single register. The terminal nodes themselves provide information about the shape of the contour tone by being either h or l ([± raised], to use Yip's feature). This information, relativized to the register of the entire tonal unit, determines the overall properties of the contour. Thus, given a system with a four-way pitch contrast for level tones, the possible contours are those in (2)

```
(2a)  X   = high rising      (b)  X   = high falling
      |                           |
      H                           H
      ^                           ^
     l h                         h l

(c)   X   = low rising       (d)  X   = low falling
      |                           |
      L                           L
      ^                           ^
     l h                         h l
```

The main difference between Yip's representation and that of Bao is that Bao sees the register node as the sister of the structure encoding the contour's shape, rather than as its mother. The reason for this move on Bao's part is to allow register and contour shape information to spread independently of one another (a putative case of register spread according to Bao will be examined in section 2.1.3). However, Bao remains with Yip in maintaining that contour shape is relativized to register.

Thus, both representational schemes make a strong prediction about the number of contrastive contour tones any contour system may have: since there are only two registers, a language with four tone heights may have at most two contrasting falling tones (one H and one L) and two contrasting rising tones. In no single language do Bao and Yip expect to find, for example, a contrast among a low rising tone, a high rising tone, and a contour rising from the very lowest tone to the very highest tone. Presented with such a contrast, Bao and Yip's representational apparatus would be unable to distinguish all three rising tones or even to represent the third one at all.

Furthermore, Bao and Yip's use of both register and terminal node features defines natural classes and therefore makes predictions about what sorts of tonal alternations will be found. For example, the highest tone in a system with four pitch heights is [+upper] and [+raised] (the h of a H) and so shares the feature [+raised] with the second-to-lowest tone, which is [-upper] [+raised]. Because these two tones constitute a natural class, rules are expected to refer to them as such, or to convert one of them into the other by changing the value of the feature [±upper]. Conversely, the low tone of the upper register ([+upper] [-raised]) and the high tone of the lower register ([-upper] [+raised]) share no feature values, so rules treating them as a class should not exist or must, at the very least, be highly marked.

1.1.3 The "Africanist" Perspective: Tone Cluster Systems

Most African tone languages seem to operate within a level, rather than a contour system. That is, the majority of these languages provide no evidence suggesting that contour tones are anything but concatenations of level tones and do provide considerable evidence supporting the claim that they are exactly that. Therefore, most linguists working primarily with African data do not address the question of how unitary contours might be represented. For them, a surface rising tone is simply a sequence of L and H tonemes that happen to be linked to a single TBU, as in (3).

```
(3a)   X    = rising        (b)   X   = falling
       Λ                          Λ
      L H                        H L
```

On this view, the terminal elements making up a surface contour tone do not share any features crresponding to Yip's [±upper], which constrains contour tones to belong to a single register. This means that, in principle, the number of contrastive contour tones in a language is limited only by the number of contrastive pitch heights. If a language has four phonemic tone levels and shows up with surface contour tones, one would expect, a priori, to find all 16 logically possible combinations of two level tones attested.

When the question of register arises during analysis of tone cluster systems (as it does in Hyman (1986 and 1990) and in Inkelas (1989)), each elements of a tone cluster is assumed to have its own register specification. Since the parts of tone clusters do not share a root node, and since register for Bao and especially for Yip is intimately related to the tone root, it is difficult to see how the situation could be otherwise.

1.2 Predictions made by the typology

Translated into the autosegmental framework, Pike's generalizations from section 1. can be summarized in the following set of statements:

(1) Given a language with surface contour tones, one of two representational schemas will prove appropriate:

```
(a)   X          (b)   X
      |                Λ
      Λ               t t
     t t
```

(2) In languages with type (a) contour tones, contours will not be disrupted by morpheme boundaries or otherwise taken apart and spread over more than one syllable. Their integrity arises from the fact that their terminal elements are dominated by a single tone root node.

(3) Each TBU in a contour system may be linked to only one tone root, while TBUs in cluster systems may, in principle, be linked to multiple tones.

To this list, we should add Bao's reading of Pike's (3):

(4) "In a contour system, the end points of a contour tone result from the interaction of between the branching c node and the r node, hence contour is relativized to register; in a level system the end points are independent (Bao 1990: 162)"

That is, with type (a) contours, the number of possible contrasts is limited to the number of registers (=2) x the number of relative pitch heights (=2) = 4. In a language with type (b) contour tones, the number of contrastive contours is, in principle, limited only by the number of phonemic pitch levels for level tones. Another prediction, this one made by Yip, can be added for good measure:

(5) Distributionally, contour tones are free in a type (a) system but restricted to peripheral positions in a type (b) system (Yip, 1989)

Statement (5) follows from statements (1) and (3) plus some idea of universal association conventions. If unitary contour tones have a single tone root while non-unitary contours have two or more, and if tone roots are generally linked to TBUs one-to-one, then it follows that the only way to get surface contours in a type (b) language is to run out of TBUs before you run out of tone roots and to have to link the left over tones to the nearest TBU. This can only happen at the edge of a domain. In type (a) systems, on the other hand, a contour tone has only one tone root and so may be linked to any syllable. To allow for cyclic rule applications (see Pulleyblank (1986)), "peripheral position" must be taken to refer to the edges of morphemes rather than the edges of words or phrases. Furthermore, if one admits the possibility of prelinked tones in type (b) languages, Yip's claim must be further weakened to a statement that contours in such languages are restricted to peripheral positions except in exceptional circumstances.

We will now examine some of the types of evidence used to motivate the distinction in (1) above and to support statements (2)-(5).

2. The typology in action

2.1 Contour systems

2.1.1 *Danyang*

Data from Danyang, a Wu dialect, has often been used to support the claim that contour tones in some languages function as units. The Danyang facts can also be taken as evidence that the contours' unitary behavior results from a tonal geometry in which the terminal tonal elements of contours share a tone root, as they do in Yip and Bao's representations.

In Danyang, the tone patterns of multisyllabic phrasal compounds are determined by the historical origins of the first syllable in the compound (Bao 1990). As demonstrated in (4)-(5) below, the "word melody" (Chen 1991) picked out by the compound's initial element overrides any tonal information associated with subsequent elements.[2] Although (4a) *nu er* carries the tone pattern 42-24 in isolation, this melody is supplanted in compund phrases by tone sequences determined by the phrase-initial morphemes *san* (4b) and *si* (4c). No matter how long the phrase gets, the overall tonal pattern remains the same.

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[2]In the interest of remaining as neutral as possible (at least for the time being) on the question of tone height features, I will represent the pitch heights of tones using the notations commonly found in the literature as a discriptive convenience. For Asian languages, this means Chao letters - each syllable is associated with two numbers, one indicating its starting pitch and the other its ending pitch. If a syllable carries a level tone, the two numbers are the same. 5 is the highest and 1 is the lowest, but this does not mean that any of the languages discussed actually has five phonemic pitch heights. Rather, the Chao letters are supposed to reflect phonetic categories derived by dividing a speakers pitch range into five equal parts (cf. Duanmu (1991) for further discussion)

For African languages, the markers H, L and sometimes M are commonly used to describe pitch height.

The Pikes and other Americanists use numbers 1-4, with 1 being the highest and 4 the lowest. Unlike Chao letters, these numbers do seem to carry a phonemic claim, and syllables with level tones are assigned only one digit, rather than two.

(4a) nu er
42 24
'daughter'

(b) san nu er
42 11 11
'third daughter'

(c) si nu er
33 33 33
'fourth daughter'

(5a) yi niang
55 55
'aunt'

(c) qi yi niang
42 42 24
'seventh aunt'

(b) jiu jiu
11 11
'uncle'

(d) qi jiu jiu
42 42 24
'seventh uncle'

(e) ke ke qi qi
42 42 42 24
'polite'

Because compound phrases range from two to four syllables in length, it is necessary to somehow map the phrasal melody contributed by the first syllable to an undetermined number of subsequent syllables. In a case like (4c) *si nu er*, this is not a problem. It is enough to say tat *si* contributes a 33 phrasal melody which simply spreads to all additional syllables after their own tones have been delinked.

(4c) si [nu er]
33

33, being a level tone, could spread in this manner regardless of whether contours have a unitary status in Danyang or not. To derive the word melodies 42 24, 42 42 24, and 42 42 42 24, Chen (1991) posits an underlying tone pattern 42 24, contributed by the initial syllable but mapped from right to left with leftward spreading of the 42 contour tone.

(5e) ke ke qi qi
42 24

Yip (1989) suggests linking the same underlying melody from the edges in and then spreading 42 left to right in order to avoid having to spread left to right in all other word melodies but right to left when the melody is 42 24.

(5e) ke ke qi qi
42 24

Bao (1990) argues that the underlying tone of such compounds is simply 42, which spreads from the first syllable left to right exactly as 33 did in (4) above. After tier conflation, a late contour dissimilation rule applies to the last syllable of the compound, converting its falling 42 tone to a rising 24.

(5e)
```
ke ke qi qi
42
```

```
ke ke qi qi --> ke ke qi qi
42 42 42 42     42 42 42 24
```

Regardless of which of these three analyses one chooses to embrace (and, as noted by Duanmu (1991), they all have their drawbacks), each one crucially depends on the possibility of spreading a 42 contour tone as a unit. If the starting and ending pitches of this contour where represented as completely autonomous entities without a tone root node in common, such spreading could not occur without crossing of association lines. Rather, the predicted output of left to right spreading of 42 would be as in (6).

(6)
```
qi yi niang --> * qi yi niang
4 2               42  2   2
```

The data from Danyang therefore seem to constitute a strong argument in favor of recognizing unitary contour tones in some languages. Furthermore, because contour tones spread as units in Danyang, there must be some structural element linking the contour's parts together and serving as the locus of the spreading process, as in (7). If this were not the case, contour tones like 42 couldnot spread as units but would rather have to behave as in (6) above.

(7)
```
qi yi niang

4 2
```

2.1.2 *Changzhi*

Similar conclusions about the unitary nature and geometry of contour tones can be drawn from analysis of tone spreading in Changzhi, another Chinese dialect exhibiting sandhi processes which are difficult to represent using a system of nonunitary contours. When a noun in Changzhi is combined with the diminutive suffix [te?] or the adjectival suffix [ti], both of which carry the citation tone 535 (high dipping), the suffix tone is neutralized in favor of the tone of the head nominal (Bao 1990: 84).

(8a) 213 + 535 --> 213 213
suan ti "sour"

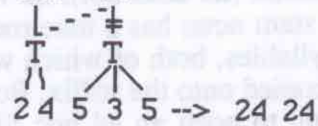
(b) 24 + 535 --> 24 24
lun te? "wheel"

(c) 44 + 535 --> 44 535
an ti "dark"

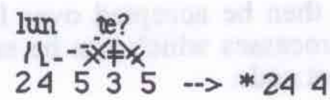
(d) 53 + 535 --> 53 53
teu te? "bean"

The most straightforward analysis of (8a), (b) and (d) is that proposed by Bao: the stem tone spreads to the suffix, causing the suffix's 535 citation tone to be delinked (9a). Given that the tones to be spread are all contours, this process cannot be captured by a representation system without unitary contour tones. In such a system, only the rightmost element of the contour would be free to spread. Even if the question of how to simultaneously delink all three tones associated with the suffix can be sidestepped, spreading would yield a surface tone pattern involving a contour tone followed by a level tone, rather than a sequence of two identical contours (9b).

(9a)



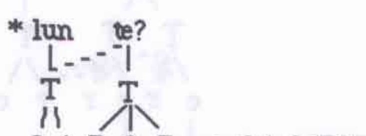
(b)



Duanmu (1991) attempts to argue against unitary contours by developing an analysis of Changzhi in which the noun's tonal melody is not spread to the suffix. Rather, a copy of the melody is made and then associated to the suffix TBU. On this account, it is not necessary to assume that contours are unitary. Strings of elements from a melodic tier can be copied and associated to new skeletal structures without necessarily forming a structural constituent (cf. Marantz (1982) on reduplication). However, Bao's contour spread analysis has two significant advantages over Duanmu's idea of melodic copying.

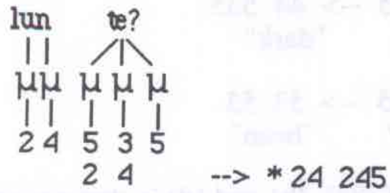
First, Bao's analysis comes with a built in account of what becomes of the 535 tone associated with the suffix. Specifically, Bao assumes that, although a tone root node may dominate more than one terminal element, each TBU may be associated with only one root node (as in statement (3) in section 1.2). Since the noun's tone spreads from the root, the node dominating the suffix's 535 contour must be delinked at the same time in order to avoid producing an ill-formed representation like that of (10) in which a single TBU is linked to two tone roots.

(10)



According to Duanmu, each element of a surface contour has its own tone root, the TBU is invariably the mora, and tones are always mapped one-to-one to morae. Taken together, these three claims would force Duanmu to assume that [te?] has three morae, since it manages to carry the citation tone 535. If a tone melody consisting of only two elements (for example, 24) is copied onto [te?], it could displace the tones from two morae, but this still leaves one mora unaccounted for and predicts a surface tone pattern of *24 245 (11).

(11)



A possible solution to this problem is simply to stipulate that the suffix tone is erased before copying occurs, but this move leads to a second problem for the melodic copying analysis.

To account for (8c) above, in which the sequence 44 + 535 surfaces not as *44 44, but rather as 44 535, Bao argues that nouns like *an* are toneless underlyingly and that 44 is a default tone. When spreading from stem to suffix occurs (9a), a toneless stem has no tone to spread, so the suffix tone is not delinked. Later, toneless TBUs are assigned 44 by a default rule, thus producing the correct surface sequence. In the melodic copying approach, the loss of 535 is not the result of spreading but instead is an independent process preceding copying of the nominal melody. If Duanmu accepted 44 as a default (he does not), he would predict that 535 should be erased regardless of whether or not the stem noun has a tone melody to be copied. The result of this operation should be two toneless syllables, both of which would get 44 tones by default. If 44 is not a default tone, then it must be copied onto the suffix. Both of these processes derive *44 44 as the surface form, leaving Duanmu to posit an ad hoc dissimilation rule converting the second 44 back into 535.

If Bao's account of Changzhi can then be accepted over Duanmu's, we must once again conclude that some languages have processes which can be satisfactorily represented only if contour tones are assumed to share a root node.

2.1.3 *Register Spread*

According to Bao and Yip, one of the definitive qualities of unitary contour tones is that they share a single register node. Bao's decision to separate register information from the tone root is based on evidence that register can spread independently of contour shape. If register spreading can affect contour tones, raising or lowering the pitch of both beginning and end points, then these points must share a root node. This is true even if, as Bao proposes, the register node is the sister, rather than the mother, of the contour (see (1b) in section 1.1). Because each tone root in Bao's system has exactly one register node, register spread to a non-unitary contour would require association lines to cross.

(12) register spread

(a) unitary contours (b) non-unitary contours

Evidence for register spread to contours (and hence for unitary contour tones) comes from Pingyao, where bisyllabic verb-object phrases show the following sandhi effects (Bao 1990: 89-91):

(13a) 35 + 13 --> 13 13
xa kuei 'start cooking'
t'un pan 'quit class'

(b) 13 + 53 --> 35 53[3]
ts'un mi 'grind rice'
tsi ma 'ride a horse'

Although the change of 35 to 13 before 13 could be analyzed as a straightforward spreading process like those seen in Danyang and Changzhi, the raising of 13 (low rising) to 35 (high rising) cannot be explained this way. Rather, the process at work must be as in (12a) above, where the H register of the second tone spreads to the entire first contour.

Further evidence of a similar nature is found in Wuyi (Duanmu 1990: 117), where 24 is the surface realization of a high rising tone.

(14) sa + $v^{w}o$ --> sa $f^{w}o$ 'half-cooked rice'
24 31 24 53

Here, the high register of the first tone has spread to the second tone, converting a low fall into a high fall.

In response to Bao's proposed tonal geometry, Chen (1992b) notes that the facts of Pingyao tone sandhi are somewhat more complicated than the examples in (13) above would lead one to believe. Notably, the combination of a low rising tone and a high rising tone (13 and 35) does not produce the sequence 35 35, as a register-spread analysis would predict. Rather, the output of such a juxtaposition is a low **falling** tone followed by a high rise, as in (15) (Bao 1990: 90)

(15) 13 + 35 --> 31 35
tseu ti 'rent land'
pu tan 'hatch an egg'

Cases like (15) force Bao to posit a rule of contour metathesis which converts a rising tone into a falling tone before a high register tone and which must somehow bleed the process of register spread to prevent outputs of 35 35 (by register spread alone) or 53 35 (by metathesis and register spread). The output of 13+35 combination is thus explained by extrinsicly oredered rules. As an alternative, Chen proposes to derive the surface forms of Pingyao phrases not by register spread but by register neutralization. Chen's rule, shown in (16), states that all contour tones have their registers neutralized to H before a rising tone and L before a falling tone.

```
                H  /__   c
                         Λ
                        h l
(16)  r-->
                L  /__   c
                         Λ
                        l h
```

Although a rule of metathesis is still necessary to derive (15) correctly, this alternative analysis of Pingyao avoids the problem of extrinsic rule ordering and, more important, allows Chen to argue against Bao's claim that register can spread independently of contour shape. Instead, Chen

[3] Actually, the suface form in these phrases is 35 - 423, but 53 tones apparebtly always surface as 423 phrase-finally, so this is not important.

favors a Yip-style analysis in which the tone root and register nodes are one and the same, meaning that register spread entails contour spread.

However, despite their differences, the analyses of both Chen and Bao rely on the notions that contour tones in Pingyao are structurally unitary and that unitary contour tones share a register specification, regardless of where in the tonal geometry that specification might be located. For Bao, as we have already seen, register spread cannot convert, for example, 13 to 35 unless contour tones share a tone root and a register node (see (12a-b)). Chen's register neutralization also requires that contour tones share a single register feature. If each half of a contour had its own register (where register = tone root), neutralization would affect only the right-most element of a contour, as in (17b), rather than neutralizing the register of the whole contour, as in (17a).

```
              tsi  ma  'ride a horse'    UR
(17a)          |    |
               L    H
               Λ    Λ
              l h  h l

              tsi  ma                    R-Neutralization
               |    |
               H    H
               Λ    Λ
              l h  h l

              tsi  ma                    output
              35   53

    (17b)     tsi     ma  'ride a horse'     UR
               Λ      Λ
              L L    H H
              | |    | |
              l h    h l

              tsi     ma                 R-Neutralize
               Λ      Λ
              L H    H H
                |      |
              l h    h l

            * tsi  ma                    output
              15   53
```

Therefore, the facts of Pingyao can be taken as evidence that, where contour tones behave as structural units, each contour tone must have a single register node which determines the surface pitch height of both the contour's terminal elements.

2.2 Cluster systems

2.2.1 *Mende*

Mende, a Mande language spoken in Sierra Leone, appears to be a paradigm case of a register (tone cluster) system. In this language, contour tones are formed when more than one independent toneme is associated to a single TBU and can be split apart across morpheme boundaries. Leben (1978) has argued that monomorphemic words in Mende have one of five tone patterns, regardless of how many syllables the words contain. These word melodies (H, L, HL, LH, and LHL) are associated with syllables according to the following rule of tone mapping, exemplified in (18) for the melodies LHL and LH:

Tone Mapping (Leben 1978: 186)

a) Associate the first tone with the first syllable, the second tone with the second syllable, and so on, until all the tones or syllables are exhausted.

b) Tones or syllables not associated as a result of a) are subject to the well-formedness condition [a universal constraint saying that every tone must be associated to a syllable and vice versa, meaning that left over tones are linked to the nearest syllable, while left over syllables are covered by left-to-right tone spreading - KP]

```
(18a) LHL melody
      mba  'companion'         nyaha 'woman'       nikili 'groundnut'
      /|\                      | /\                | | |
      LHL                      L HL                L H L

(b) LH melody
      mba    'rice'            fande  'cotton'      ndavula    'sling'
      /\                       |   |                |  V
      LH                       L   H                L  H
```

If Leben's analysis of Mende tone is rejected in favor of a representation using unitary contours, several problems arise. First, if the LHL contour tone on monosyllabic words like *mba* cannot be identified with the L-H-L sequence on a polysyllabic form like *nikili* (as per Pike's (3)) basic facts of Mende tonotactics defy explanation. Specifically, why should it be the case that the inventory of possible contour tones is identical to the inventory of word tone patterns? If *mba* 's LHL is not reducible to a sequence of level tones, one would expect words to have sequences of tones, for example HLH, not attested in contours.

Furthermore, as seen in (19), the behavior of Mende words when followed by the postpositions *-hu* 'in' and *-ma* 'on' strongly supports the claim that surface contour tones are simply the result of there not being enough syllables to go around.

```
(19a) mbu  'owl'          mbu - hu          mbu - ma
       /\                  |     |            |     |
       HL                  H     L            H     L

(b) mba  'rice'           mba - hu          mba - ma
       /\                  |     |            |     |
       LH                  L     H            L     H

(c) nyaha 'woman'         nyaha - hu        nyaha - ma
     | /\                  | |    |          | |    |
     L HL                  L H    L          L H    L
```

According to Leben's analysis, the suffixes *-hu* and *-ma* have no tones of their own. After they are suffixed to a noun stem, the tone mapping rule given above applies as usual, producing the alternating stem tone shapes shown above. If contours were unitary entities whose end points were not equivalent to level tones, this process would be difficult to represent. In addition, part (2) of Pike's statement on the differences between contour and register systems says that, in true contour systems, contour tones may not be disrupted by morpheme boundaries. Having translated this claim into autosegmental terms, we have said that terminal elements which share a root node cannot be broken up and spread over more than one syllable. Faced with Mende data which seems to involve exactly this type of contour disintegration, we can either discard Pike's principle or conclude that Mende has only tone clusters.

3. Soyaltepec Mazatec

Mazatec (or Mazateco) is an Otomanguean language spoken in the state of Oaxaca in Mexico. The Soyaltepec dialect was described by E. Pike (1956) as having "an extraordinarily complex system of tone sandhi (p.57)." All data here are taken from Pike, as are her conventions for transcribing surface forms. Pike recognizes four pitch levels, numbered 1 to 4, with 4 being the lowest and 1 the highest. In surface forms, almost all logically possible contour tones can occur, with the exception of 23 and possibly 14. Furthermore, under certain circumstances, contour tones seem to "take themselves apart" (Goldsmith, 1990). Initially, at least, it does not look as though contour tones in Mazatec have any unitary status. However, my analysis of Mazatec will show that, while certain sandhi processes apply to single tones regardless of whether they are in contours or not and so appear to treat contour tones as concatenations of level tones, other processes treat contour tones as unitary objects.

3.1 *2-Shift*

Depending on the tones of the morphemes which precede and follow it, a morpheme in Mazatec may surface with any one of several different tonal melodies, a situation which is described by Pike as the existence of "tonally differentiated allomorphs." For example, each of the morphemes in (20) has at least two realizations: one when pronounced in isolation, and a different one when in concatenation with the other morpheme in the example.

(20) tki$^{3\text{-}2}$ 'medicine' hni^{4} 'our'
tki^{3}-hni^{24} 'our medicine'

From looking only at this example, the autosegmentally-minded linguist will probably want to assume that all tones are unlinked in the lexicon, and to formulate a tone association rule closely modeled on Leben's tone mapping rule for Mende, saying "link tones to syllables, one to one and left to right, until you run out of syllables. Then link any extra tones to nearest syllable, regardless of what's already attached to it." The derivation of 'our medicine' would then be as in (21).

(21)

```
tki  hni --> tki - hni --> tki - hni
              :     /       |    / \
 3  2  4      3    2 4      3   2   4
```

On this view, contour tones are not unitary objects, but rather they are simply the result of there not being enough syllables to go around. As it stands, this hypothesis predicts that Yip's statement that, in register systems, contours should only appear on the last syllable of a phonological word will be born out, since tone association proceeds left to right and there are no prelinkages. However, as example (22) shows, contour tones do appear on non-word final syllables. In fact, the sort of rightward shift evidenced in (20) only occurs when the element to be shifted is a level-2 tone (examples (23) and (24)).

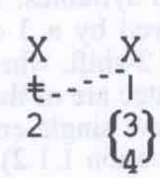
(22) nta^{31} 'good' ra^{4} 'probably'
nta^{31}-ra^{4} 'it is probably good'

(23) ce^{3}hẽ^{32} 'is visible' hõ^{3} 'soldier'
ce^{3}h^{3}ẽ -hõ^{2} 'the soldier is visible'

(24) ca^{3}we^1 'crazy' ra^4 'probably' ni^{32} 'it is' re^4 '3sg DAT'
ca^{3}we^1-ra^4-ni^3-re^{24} 'he is probably crazy'

The existence of examples like (22), in contrast to (20) and (23), means that we cannot get the right output in morphologically complex forms simply by linking all the tones up from left to right. We need some sort of a rule which will target only 2s, and which will move them over one syllable when they are followed by a 3 or a 4. A first pass at such a rule might be (25), which delinks any 2 and reassociates it to the syllable on its right if that syllable is linked to a low tone. At this point, Mazatec appears to resemble Kikuyu (Clements 1984), where H tones spread rightward and delink from their source syllables.

(25)



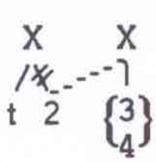
But, as the words in (26) and (27) show, 2s which are not part of a contour tone do not shift. The rule in (25) predicts that 'his father in law' should have a 24 contour tone on its last syllable, and some unspecified tone on the syllable which contributed the 2 tone in the first place (either the word should show up as 2 24, with the 2 linked to both syllables, or there should be some sort of default tone on the first syllable). This is not the case.

(26) na^{3}mi^2-sa^3 'yeast' (='sour thing')

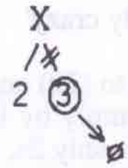
(27) c$^?$a^2-$^?$e^4 'his father in law'

The rule for moving 2s needs to be reformulated as in (28) (2-Shift), so that it targets only 2s which are the second elements of contour tones. If examples (20) and (24) are compared with (23), it becomes clear that another rule is necessary in order to derive surface forms like 'the soldier is visible' (23). When a 2 shifts onto a syllable which already carries a 4 tone, the 4 remains in place and the result is a 24 contour. However, when the syllable to which the 2 is being linked originally has a 3 tone, the result is not 23. Rather the 3 is deleted, leaving a plain 2 (as in (29) below). I cannot really give an explanation of why this should be, except to note that there seem to be no instances of 23 contours anywhere in Pike's data, whereas 24's abound. This fact leads me to suppose that 23 is for some reason tonotactically ill-formed. It is important to note that it is not the *sequence* of a 2 followed by a 3, per se, which is disallowed (see example (26) above), but rather the *contour tone* 23.

(28) 2-Shift :



(29)



The process of 2-Shift, then, affects only those 2 tones which are in contours. The specification of the environment for 2-Shift must crucially include the number and types of linkages which exist between individual tones and syllables. Merely specifying the required sequence of elements on the tonal tier (a 2 followed by a 3 or a 4) without mentioning the linkages is not sufficient. However, the existence of 2-shift, when considered in isolation, seems to provide clear evidence that contour tones in Mazatec are of the tone cluster type. If the 32 and 42 contours in the examples seen in this section were single entities sharing a tone root and a register node, as per Bao and Yip's proposals (see section 1.1.2), we would not expect pieces of these units to move independently of each other. In fact, the decomposable nature of Mazatec contour tones ending with a 2-tone is used to by Goldsmith (1990: 40) to argue that all surface contour tones are actually cases of many-to-one associations between tones and TBUs (ie, tone clusters). However, Goldsmith examines only a small subset of the Mazatec data and so does not attempt to analyze process that seem to contradict his conclusion.

3.2 *1-Spread*

Another process which at first looks like evidence that Mazatec is a tone cluster language involves the leftward spread of 1 tones. As examples (30) and (31) show, a 1 will spread to a syllable on its left which carries a 2 tone, even if that 2 is part of a contour, so at this point it looks as if the environment for 1-Spread treats apparent contour tones as analyzable sequences of level tonemes. Examples (32) and (33) show that a 1 will not spread to just anything, but only to a syllable with a 2 tone.

(30) ya^{3}tyu^2 'wooden beam' hi^1 'NEG'
ya^{3}tyu^1-hi^1 'not a wooden beam'

(31) nçe^{42} 'cooked corn'
nçe^{41}-hi^1 'not cooked corn'

(32) ça^4?a^1 'armadillo'

(33) kwi^3 'this' ce^1 emphatic particle
kwi^3-ce^1 'just this'

(34) 1-Spread:

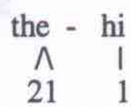
The rule of 1-Spread can then be formulated simply as (34), without reference to whether the 2 which is dislodged by the spread is part of a contour or not. However, there must be some mention of linkages, because it is not the case that, given any sequence of a 2 followed by a 1, the 2 is always deleted. If that did happen, then there should be no surface forms containing 21 contours. But 21 contour tones do surface, as in the words [the^{21}] 'rubbish', [ça^{3}kĩ ^{21}] 'firewood', [çʔã ^{21}] 'cold', and many others.

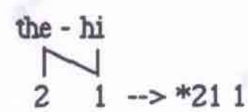
It is imporatnt to notice that, in forms like the ones in (35) and (36), it appears that 21 contour tones are also affected by 1-Spread. Any 21 or any sequence of 21's which is followed by a 1 will surface as a 1.

(35) the^{21} 'rubbish' hi^{1} NEG
the^{1}-hi^{1} 'not rubbish'

(36) thi^{21}ci^{21}sa^{21} 'he is working'
thi^{1}ci^{1}sa^{1}-hi^{1} 'he is not working'

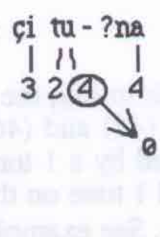
This process might look as though it requires another rule, which would spread a 1 leftward to a syllable carrying both a 2 and a 1, both of which would be delinked. Such a rule could only be formulated in a reasonable looking way if the two halves of the contour tone share a tone root. However, this is not the only possible explanation. If the parts of the contour tone do not have a tone root in common, then the underlying representation of 'not rubbish' will be contain an OCP violation, as in (37) below. One might predict that in such a situation, the violation will be resolved by deleting one of the 1's while retaining all the linkages of both tones. This move would create a structure like (38), where the single remaining 1 is multiply linked, but this will not explain the surface form (35).

(37)


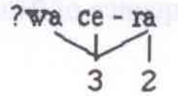
(38)


Fortunately, there are other combinations of morphemes which also produce OCP violations but which do not seem to be subject to any sort of spreading process, and this type of form can be used to examine how OCP violations are in fact resolved. For example, when two 4's end up next to each other, as in (39), it appears that one of them is deleted, and so are its linkages. Example (39) leaves open the question of whether the resolution of OCP violations involves deleting the first of two identical tones, or whether the first 4 is deleted here because another tone is linked to the same syllable as it. It turns out that the situation is quite complex, in that both linear order and number of tones per syllable contribute to the outcome. (40) shows that no linkages will be lost if it is the second identical tone which shares its syllable with something else, and, in (41), neither of the two tones is a member of a contour and, presumably, no linkages have been lost.

(39a) çi^{3}tu^{24} 'cat' ?na^{4} 'my'
çi^{3}tu^{2}-?na^{4} 'my cat'

(b)


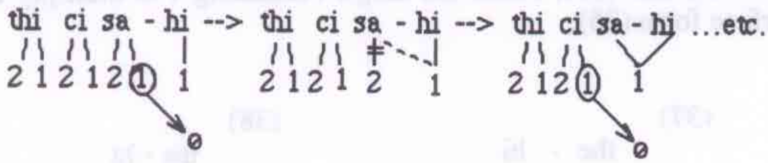
(40a) ?wa^{3}ce^{3} 'buy' ra^{32} 'I to you'
?wa^{3}ce^{3}- ra^{32} 'I will buy it for you'

(b) 

(41) ki^{4}ça^{4} 'metal' a^{4} 'this'
ki^{4}ça^{4}-a^{4} 'this metal'

In any case, a structure like the one in (37) is the same as the one in (39b), so, if both forms contian OCP violations and if (39) undergoes a change in order to resolve this violation, then presumably (37) will be subject to a similar process. That is, the first 1 is delinked and deleted, leaving a syllable with a level 2 tone followed by a syllable with a 1 tone. This new structure fits the environment for 1-Spread, so the surface form will have a 1 on both syllables. In the case of example (36), we would have to do the same thing over and over again, resolving each OCP violation as it is created and applying 1-Spread iteratively left to right, as in (42).

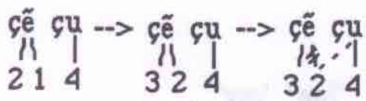
(42)



3.3 *Neutralization*

At first glance, the tonal alternations in (43) and (44) might look completely random. However, a clue to the process is provided by the previous analysis of 2-Shift. A 2 which is the second element of a contour tone will shift one syllable to the right, leaving behind its erstwhile syllable-mate. In (43), the 2 tone on the second syllable of 'animals are needed' must have come from the first syllable by 2-Shift, and what is left behind is a 3 tone. It seems, therefore, that the 21 of 'is needed' must have become a 32, and that 2-Shift was then applied, as in (43b).

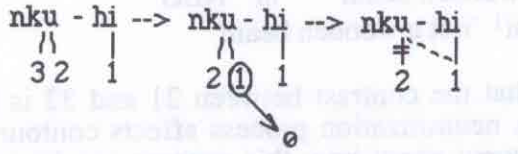
(43a) çẽ^{21} 'is needed' çu^{4} 'animals'
çẽ^{3}-çu^{24} 'animals are needed'

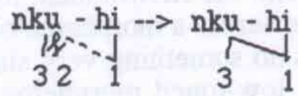
(b) 

(44) ci^{21} 'he makes' se^{3} 'thick'
ci^{3}-se^{2} 'he thickens'

Apparently, 21 becomes 32 before a 3 or a 4, which is to say, the register of the contour tone is lowered when it is followed by a low register tone. (45) and (46) show that this process is symmetrical. 32 must be raised to 21 when it is followed by a 1 tone. If this were not the case (45c), it is not clear how 1-Spread could produce a level 1 tone on the first syllable rather than a 31 contour (and 31 is a perfectly acceptable contour tone. See example (22) with [nta^{31}] 'good').

(45a) nku^{32} 'one' hi^{1} NEG
nku^{1}-hi^{1} 'not one'

(b)


(c)


(46) the^{32} 'itch'
the^{1}-hi^{1} 'does not itch'

Before trying to figure out how these processes, which together look very much like a register spread or neutralization, similar to that seen in Pingyao (section 2.1.3) can be represented, it would be a good idea to try out some alternate hypotheses of what is actually going on. One possibility is that a contrast between 21 and 32 is not being neutralized, but rather that there is no contrast there to start off with. That is, 21 and 32 are underlyingly the same (they are both 21, both 32, or both some unspecified third thing), and are in an allophonic relationship to each other on the surface. 21 shows up in certain environments (before a 1) and 32 in certain others (before 3 or 4), and this pattern begins to suggest complementary distribution. However, 21 and 32 clearly are contrastive: not only do both show up word finally and on monosyllabic word forms, but there are minimal pairs which reveal the contrast between the two contours. For example, we have [te^{3}ya^{21}] 'wide' vs. [te^{3}ya^{32}] 'deaf', and [the^{21}] 'rubbish' vs. [the^{32}] 'itch'.

Another hypothesis which needs to be examined is that (42)-(46) do show that a neutralization process is at work, but that this process treats contour tones exactly the way it treats everything else. Maybe any sequence of a 3 then a 2 is raised when a syllable with a 1 tone follows it, regardless of whether the 3 and the 2 are attached to the same syllable or not. Initially, it might seem that evidence that this is not the case will be hard to find. The test would involve a morpheme with the underlying shape $\sigma^3\sigma^2$, with another morpheme σ^1 attached to the end of it. If neutralization applies to any tonal tier sequence 3 2 + 1, then there should be an intermediate level of representation $\sigma^2\sigma^1$-σ^1, and the surface shape of the combined form should be $\sigma^1\sigma^1$-σ^1 (by OCP and then 1-Spread). If, on the other hand, neutralization applies specifically to 32 contours and not to any old 3 2 sequence, the hypothetical surface form should be $\sigma^3\sigma^1$-σ^1 (by 1-Spread alone).

The problem with this test is that it assumes that neutralization precedes 1-Spread. If 1-Spread could be ordered before neutralization, the spreading rule would apply to $\sigma^3\sigma^2$-σ^1 to produce $\sigma^3\sigma^1$-σ^1 in one step, and neutralization would presumably not apply at all because there would no longer be any 3 2 + 1 sequence for it to apply to. The existence of the surface form $\sigma^3\sigma^1$-σ^1 would then not be proof of anything at all. Luckily, we already have evidence that neutralization must be ordered before 1-Spread: if the order were reversed, the derivation of 'not one' (example (45)) would have to be as in (45c), which produces the wrong output, [*nku^{31}-hi^{1}]. In order to get [nku^{1}-hi^{1}], the correct form, the rules must be ordered as in (45a), with neutralization before 1-Spread.

The example which can now be taken to demonstrate that neutralization affects 32 contour tones but does not apply to just any 3 2 sequence was given as (30) above, and is repeated here as (47).

(47) ya^3tyu^2 'wooden beam' hi^1 'NEG
ya^3tyu^1-hi^1 'not a wooden beam'

If we can now accept that the contrast between 21 and 32 is being neutralized in certain environments, and that this neutralization process affects contour tones but not sequences of level tones, then we can worry about how this process can best be represented. There is an additional fact which contributes to the problem: the environment for neutralization requires that the target tone be followed by a 1, 3, or 4 tone across a morpheme boundary. It turns out that not only contour tones but also some level tones do something very similar in this environment. In (48) and (49), single 1 tones which precede low-toned morphemes surface as 2s. It is unclear whether a 2 before a 1 is raised to 1 in the same way, since this time the predicted outputs of neutralization and of 1-Spread really are the same.

(48) ñu^{3}me^1 'bumblebee' ?na^4 'my
ñu^{3}me^2-?na^4 'my bumblebee'

(49) cu^1 'he says' ya^3 'inside'
cu^2-ya^3 'he explains'

It seems that neutralization is something which happens to the element which appears in the right environment, or to the "thing" which precedes the low tone, where 21 and 1 are both "things." This implies that 21 contour tones are unitary at some level, which is to say that they share a node.

The next question concerns what and where such a node might be. Given that it is the pitch level that is being neutralized in all cases, while the basic shape of the tone remains the same (21 and 32 are both rising; 1 and 2 are both level), maybe it is a Bao and Yip's register node which is being affected.

4. The typology applied

4.1 Which sort of language is Mazatec?

Now that the processes characterizing contour tone behavior in Mazatec have been described, it is time to turn to the basic question raised by the typology in part 1: does Mazatec have unitary contour tones or only tone clusters? Or, as rephrased in autosegmental, tone geometry terms, do Mazatec contour tones share a tone root? Table (50) below summarizes the conclusions of the preceding section: while one process appears to require a tone cluster representation, another must affect true contour tones, and still another seems to treat contours as both unitary **and** non-unitary.

(50)

Unitary Contours		Non-unitary Contours
r-neutralization (contours are affected as units		*2-shift* (contours are decomposed
	1-spread?	
21 becomes 1		42 becomes 41

Based on the characteristics ascribed to cluster (or level) systems and exemplified by the analysis of Mende, it appears, at first blush, that Mazatec has many features in common with such systems. First, as noted already, most possible combinations of level tones surface as contours. Especially noteworthy is the five-way contrast among rising tones shown in (51).

(51) the^{21} 'rubbish' vs. the^{32} 'itch' vs. tõ^{43} 'money' vs. nta^{31} 'good' vs. nçe^{42} 'cooked corn'

The only logically possible contour missing from this set is 41, which does surface, as in [nçe^{41}-hi^{1}] 'not cooked corn', although I can find no example in Pike's data that clearly shows it on an underived monomorphemic word. Even without a phonemic 41 tone, a five-way contrast is simply unrepresentable in terms of two registers and two relative pitch heights. 21 and 43 can be handled easily enough by a Yip/ Bao style representation, as shown in (52), but 32, 31, and 42 do not even seem to belong to any particular register. 31, for example, has a starting pitch that is presumably in the L register, since it belongs to the lower half of the pitch range. The ending pitch of this contour is 1, which, as the highest pitch level in the system, must be in the H register. Thus, the two halves of a 31 contour tone appear to belong to different registers, rendering the whole unrepresentable in terms of a single, superordinate register feature

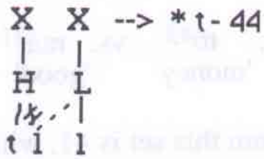
```
(52a)  X   = 21     (b)  X   =43      (c)  X   = 31
       |                 |                 |
       H                 L                 ?
       Λ                 Λ                 Λ
      l h               l h               l h
```

A Yip/Bao style representation could possibly be adapted to handle contrasts such as the Mazatec 43 vs. 32 vs. 21 if register can be redefined as either a multivalued feature or a complex of more than one binary feature. If, for example, we were to replace the binary register feature H/L (= [±upper]) with a three-way H/M/L contrast, a 32 contour tone could have the representation shown in (53), which is distinct from those shown in (52) for 21 and 43 rising tones.

```
(53)   X  =  32
       |
       M
       Λ
      l h
```

However, contrasts between tones that begin or end at the same pitch height but rise or fall different amounts remain problematic. For example, a 32 tone may be characterized as a rising mid, as in (53), but how is it to be distinguished from 31 or 42? The factor that makes 42 and 32 distinct is not register, but rather "interval", or rate of rise, something which cannot be captured in a system where the beginning and ending pitch heights of contours are defined by a binary feature relativized to register.

Another reason to suspect that Mazatec does not have unitary contours is the existence of the process of 2-shift. Contour tones "take themselves apart" and are disrupted by morpheme boundaries. K. Pike claims that this type of operation is restricted to cluster systems, and this stipulation seems to follow naturally from the idea that unitary contours share a tone root node, especially if this root node encodes register information. In such a representation, where a 2 tone is the l of a H register, 2-shift would presumably involve delinking only the left most terminal node (l) of a contour tone. This l would then have to be reattached to a new register node (attaching it directly to the target TBU is not an option because just l without any register would be meaningless). If the syllable to which the erstwhile 2 is shifting already carries a 4 tone, then this syllable must be linked to a tone root with a L register because 4 is the l of a L. This process, shown in (54), should produce a level low tone, 44, on the second syllable, rather than the correct 24.

(54) 

Finally, examples like (39) in the previous section, repeated here as (55), were said to involve the resolution of OCP violations.

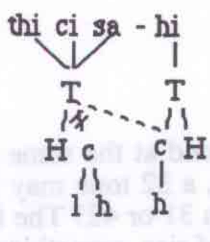
(55a) çi^{3}tu^{24} 'cat' ?na^{4} 'my'
çi^{3}tu^{2}-?na^{4} 'my cat'

If 24 is a unitary contour tone, then the sequence 24-4 does not contain an OCP violation, and it is unclear why anything should happen to it at all. If, as Pike and Bao both claim, the end points of a contour tone cannot be identified with level tonemes, then the correct surface form for 'my cat' can only be derived without recourse to the OCP, perhaps by positing some sort of contour simplification rule whose conditioning environment remains obscure.

On the other hand, if contour tones in Mazatec are not unitary, the process referred to above as register neutralization becomes difficult to understand, for reasons already indicated (see section 3.3). Furthermore, 1-spread is also problematic given only a tone cluster representation. Although the possibility of exploiting supposed OCP violations and applying 1-spread iteratively has been explored, this option for deriving (56) is much more complicated than a simple process applying to multiply linked unitary contour, as represented in (57). Using Bao's representation, this process emerges as an instance of contour spread.

(56) thi^{21}ci^{21}sa^{21} 'he is working' hi^{1}
NEG

thi^{1}ci^{1}sa^{1}-hi^{1} 'he is not working

(57) 

Not only does this account avoid the need to claim that 1-spread occurs over and over again, but it also begins to suggest a neat characterization of the target of the process: 1-spread applies to any tone with a H register, be it a contour or a single 2 tone. Unfortunately, this formulation of the environment for 1-spread cannot account for the fact that a 1 can spread to a 2 even when that 2 is part of a contour (cf. [nçe^{42}] 'cooked corn' vs. [nçe^{41}-hi^{1}] 'not cooked corn').

So it seems that, within 1-spread, we have the paradox of Mazatec in a nutshell. Contour tones seem to be unitary in that they act as single entities, but they appear to be simultaneously concatenations of level tones whose elements are exactly equivalent to the level tones found in non-contours. Clearly, the typology as it stands and the representational apparatus available to us are not up to the task at hand. The first step in resolving this puzzle will be to reexamine each of the statements given in section 1.2 to see whether discarding some or all of them might improve the picture.

4.2 Attempts to Resolve the Paradox

Our first and most radical option is to discard the entire typological premise as expressed in statement (1). However, it is not at all clear where such a move would lead. As demonstrated in section 1.3, contour tones in some languages do behave as unitary objects, while in other languages they appear to function as sequences of level tones. Insisting that all contour tones be represented the same way will not solve the problems of Mazatec, and in fact would confuse the otherwise satisfactory accounts of languages like Mende and Changzhi. A more reasonable and useful goal is to try to discover a representation which will allow contour tones to be simultaneously unitary and non-unitary. It should be noted that the Bao/Yip proposal does not constitute such a representation, since the relativization of contour shape to register prevents the terminal nodes from acting as truly autonomous entities.

A second option is to discard statement (2), which says that contour tones with a single root node cannot be split apart and distributed over more than one syllable. The feasibility of making such a claim depends in large part on the nature of the tone root node, and so will be returned to in conjunction with the fourth option to be discussed below.

A third option involves the rejection of Pike's null hypothesis (statement (3) in 1.2) which predicts that the contour tones of a particular language are all either unitary or non-unitary. Perhaps some of the contours seen in Mazatec are true contour tones, while others are actually tone clusters. This proposal might be worth considering if the processes that seem to require a unitary representation for contours affected only a certain subset of surface contour tones, while those which need a tone cluster representation targeted another, non-overlapping subset. However, the same tones fall prey to both sorts of processes. For example, 32 tones are subject to both register neutralization and 2-shift. In fact, in many cases the same morpheme can be seen to undergo both processes, as in (58).

(58a) 2-shift:
nku^{32} 'one' sa^{3} 'tiger'
nku^{3}- sa^{2} 'one tiger'

(b) neutralization (and 1-spread):
nku^{32} 'one' hi^{1} 'NEG'
nku^{1}- hi^{1} 'not one'

A variant of this proposal would be the claim that contour tones make use of first one representation and then another. This hypothesis would resemble some version of lexical phonology (Goldsmith (1990), Pulleyblank (1986)) in that it would involve rules applying at different stages of derivation having access to different sorts of information. That is, register neutralization would apply first and operate on structures given in a true contour representation of some sort. These structures would then be partially collapsed into a tone cluster representation, at which point 2-shift could apply and OCP violations would become apparent and be resolved. Tier conflation could then proceed the rest of the way to produce a phonetic output.

Unfortunately, 1-spread seems to require recourse to both sorts of representations and so would need to apply at both levels. Furthermore, the whole proposal seems rather ad hoc, given that cyclicity does not appear to be a factor. Since all the processes under consideration apply across morpheme boundaries, and since particular classes of morphemes (i.e. derivational, inflectional, etc.) do not trigger particular processes, there are no independent criteria available to determine which operations should take place at which levels.

The fourth (and most promising) option available to us is to retain the null hypothesis and the idea that true contour tones share a tone root while tone clusters do not but to reject the Yip/Bao version of the tone root's role (statement (4) in section 1.2). According to Yip and Bao, the tone root serves two purposes simultaneously: it holds the contour tone together and allows it to act as a unit, but it also encodes register information (directly in Yip's formulation, indirectly in Bao's).

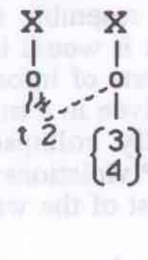
As seen in Bao (1990), the decision to relativize contour shape to register arises from three claims about the behavior of true contour tone systems. First, Bao asserts that cases in which unitary contour tones fail to share a single register or contrast more than two ways per contour shape are rare or underdocumented (Bao 1990: 171-174). Although Soyaltepec Mazatec could be considered both rare and underdocumented, it provides evidence that contour tones may act as units while still managing to cross registers and contrast multiple contours with the same shape (cf. (51) above with five contrasting rising tones), and this data must be dealt with somehow. Furthermore, Bing (1992) reports that distinctive cross-register contrasts are not uncommon in Vietnamese dialects, which are pretty well documented, and argues for a three-way contrast among rising tones in Wobé, a Kru language of Liberia.

Secondly, Bao claims that register may spread independently of contour shape (as in section 1.3.1 above) and so must be represented as a separate entity. Chen (1992), who reanalyzes most of Bao's data and concludes that independent register and contour spreading are not, in fact, shown by Bao to occur, retains the assumption that unitary contour tones share a single register. However, it may be possible to represent processes like the register assimilations found in Mazatec without positing a single, superordinate register specification for contour tones. This question will be addressed shortly.

Thirdly, Bao follows K. Pike in arguing that the terminal nodes of a true contour tone are not identifiable with level tonemes. In the Yip/Bao system, this claim is captured by relativizing contour shape to register. But is this assertion worth holding on to? In the case of Mazatec, it seems not to be. In fact, it is the assumed non-identity of contour tone elements and level tonemes that underlies most aspects of the Mazatec paradox. If a 2-tone in a contour can be featurally identical with a level 2 tone while remaining structurally distinct, as in (59), then 2-shift can be represented (60) and the contour can still behave as a unit for purposes of 1-spread (61). In these representations, the tone root node is a purely structural thing with no features associated with it. It thus manages to unify the contour tone structurally while not having any influence on the pitch heights of its daughters. For the time being, I will revert to the use of numbers to represent these pitch heights, postponing discussion of what features tones have.

```
(59)  X     vs.   X
      |           |
      o           o
      /\          |
     3  2         2
```

(60) 2-shift



(61) 1-spread (for 21 contour tones)

```
X   X
+ .  |
o    o
/\   |
2 1  1
```

However, abandoning register as a uniting feature of contour tones does not, by itself, solve the problem of Mazatec register neutralization. In fact, if register as understood by Bao and Yip is discarded, it might seem to be impossible to talk about a register neutralization process at all.

4.3 A possible line of inquiry

Stepping back from these representational troubles, let's remember what we are trying to represent when we talk about register neutralization. Certain contour tones in Mazatec are raised or lowered to assimilate to the height of a following tone. But when 21 is lowered, it does not move all the way from the top of the pitch range to the bottom to become 43. Rather, it goes down by exactly one contrastive pitch level, becoming 32.

A proposal which could capture this kind of graded lowering might be built on the representational schema and tone feature theory developed by Hyman (1990 and 1986). According to Hyman, every tone has both a tonal root node (TRN) and a tonal node (TN), as in (62) below, neither of which have any pitch features inherent in them.

```
(62)   TBU
        |
        o  = TRN
        |
        o  = TN
```

The primitive features responsible for tone height are H and L, which, as used in Hyman (1986), have the following values:

H = raise the pitch one unit above a neutral reference tone height
L = lower the pitch one unit above a neutral reference tone height

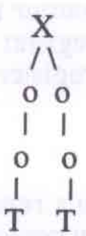
Unlike Bao, Yip and others who use low and high as pitch heights defined relative to each other, Hyman sees H and L as instructions to raise or lower a tone's pitch with reference to a neutral tone. As demonstrated by Hyman's representations of a mid in (63a), these features function additively. Instructions to raise the pitch one unit above a neutral height while simultaneously lowering it cancel each other out, resulting in production of the neutral pitch height (note that this structure does not represent a contour tone). Presumably the structure in (63b) (no instructions) also would produce a mid tone.

```
(63a) X    =    X    =   (b)  X
      |         |             |
      o         o             o
      |         |             |
      o         o             o
      /\        /\
      H L       L H
```

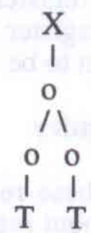
Given this apparatus, it is possible to represent, for example, a tone two steps lower than the mid point as having two Ls associated to its tonal node[4].

Hyman, who is interested primarily in African languages, represents a tone cluster as in (64a), with one TBU and two root nodes. If this is collapsed to one tone root, the result is a unitary contour tone in (64b).

(64a) Tone Cluster

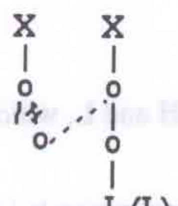


(64b) Contour Tone



(64b) is capable of representing even contour tones which cross register boundaries, like 32, and would not have any problem with Mazatec's five-way rising tone contrast, since contour shape is not relativized to register as it was in other representations of true contour tones. Furthermore, the TNs, taken as units represent fully specified tones, so 2-shift can also be handled, as in (65), where two is represented as the neutral tone (no instructions) and the disjunctive environment 3 or 4 as a tone with at one or two Ls.[5]

(65) 2-Shift



There are two reasons for believing that 2 is the neutral tone. First, in a system with four tone heights, one expects that 3, 2 or something in between will be the neutral pitch height. The latter case would be somewhat peculiar, since nothing between 2 and 3 appears on the surface, and a neutral tone might be expected to be unmarked and therefore to appear frequently. Secondly,

---

[4]This is probably not entirely in the spirit of Hyman, and owes more to particle phonology (cf. Schane 1984) than to anyone's ideas about tone. Specifically, in particle phonology the appeture particle lal functions additively to define the relative heights of vowels. Thus, a mid vowel like /e/ is defined as having a single appeture particle, while the low vowel /a/ has two. If the vowel system of some language had more than three contrastive vowel heights, additional levels could be defined by introducing more lal particles. Similarly, the tone languages discussed by Hyman tend to have only three contrastive tone heights, neutral, H, and L. In a language like Mazatec, where we find four phonemic pitch levels, the additional contrasts can be represented by using the L particle additively and defining a tone with two L particles as distinct from one with only one L.

[5]I will not address the question of how to prevent Hs and Ls from proliferating. Since they can cancel each other out, [HHHLLL] is as good a representation of a neutral tone as [HL] or [ ]. If this kind of situation is allowed to occur, then it becomes hard to write rules, since the environment "a tone with one or two Ls" will end up including [HHLL] = 2, [HHHLL] = 1, etc.

unlike 1, 2 does not qualify as a trigger for raising 32 tones to 21. This fact suggests that 2 is not really a high tone. By the same token, it does not cause lowering in preceding 21 tones, so it cannot be considered to have things in common with 3 and 4 either. 2's failure to trigger any register changing processes and the assymetry between the triggers for raising and lowering (1 alone for raising vs. 3 or 4 for lowering) can be explained if 2 is seen as neither high nor low, but rather neutral.

If 2 is accepted as the neutral tone for Mazatec, then converting a 21 to a 32 can be seen as adding a L feature to both halves of the contour; a 2 tone is neutral, so lowering it one level produces a 3 (a tone with one L), while a 1 tone has a H already, so adding a L causes the two instructions to cancel and the tone to surface as a neutral 2. The reverse process raises 32 to 21 by adding a H, converting 3 to 2 and 2 to 1.

```
          raising                              lowering
     (66) (add H to both                       (add L to
          sides)                                both sides)

            X  (= 32)-->      X (= 21)        X  (= 21)-->      X  (=32)
            |                 |               |                 |
            o                 o               o                 o
           / \               / \             / \               / \
          o   o             o   o           o   o             o   o
          |                / \  |               |             |  / \
          L               L  H  H               H             L  H  L
```

Clearly, the H which causes raising comes from a following 1 tone, while the L for lowering comes from a 3 or a 4. Problems reemerge when we attempt to spread the H and the L from one tone to another. Since both parts of the contour are affected, the target of spreading must be the tone root node. However, spreading to the TRN, does not look as though it should produce the desired result (actually, in Hyman, a structure like this should represent a downstepped tone).

```
     (67)  lowering?

           X       X
           |       |
           o       o
          / \ .    
         o   o  .  o
             |     |
             H     L
```

For (57) to yield a 32 contour, either the L must somehow percolate through the TRN to affect the tonal nodes, or 32 will have to be seen as some kind of downstepped 21.

Among other unresolved problems, the question of OCP violations and their resolution (see (55a) and (b)) remains unsolved. Hyman's representation might eventually provide some insight into this issue, since he sees the TRN and TN as existing on separate tiers. If this is the case, and if terminal elements inside of contour tones are indeed equivalent to those outside them, then perhaps a sequence of identical elements on the TN tier could be considered an OCP violation regardless of what kinds of associations there are. This question can to be addressed in future research.

5. Conclusion

In linguistics, as in most other areas of scientific inquiry, the basic procedure for developing a theory involves making generalizations over a limited corpus of data and formulating some means of describing and accounting for these observations.The account developed in this manner can then be tested against new data sets and falsified or modified as necessary. In the case of contour tones, the generalization arrived at by those who have examined large numbers of South East Asian and African tone languages is clear: in languages like Pingyao, Chanzhi, and Danyang, contours act as units, while in another class of languages, typified by Mende, they behave like analyzable, decomposable clusters of level tones. This is the conclusion reached by Pike (1948), Bao (1990), Chen (1992a), and many others.

Based on this observation, two sorts of contour tones representations have been developed within the autosegmental framework. For languages of the African type, tonal tier elements are linked directly to TBUs, and tonemes may associate many-to-one to TBUs. This representation captures the fact that, in some languages, contour tones do not act as units and can come apart and move around. For Asian languages, the unitary status of contour tones is represented through the addition of an intermediate level of structure intervening between the TBU and the terminal tonal elements. Based on data from Chinese dialects, Bao (1990) and Yip (1989) argue that this tonal root node encodes register information common to both terminal nodes of a contour. Thus, the contour's sub-parts are bound together not only as a structural constituent, but also by a kind of feature sharing. These two representations are summarized in (68)

```
        African Type               Asian Type
(68a)      X                (b)      X
          / \                        |
          t  t                       T = register
                                    / \
                                    t  t
```

The validity of this two-way distinction of true contour (Asian) vs. cluster (African) systems can be tested by applying it to a previously unanalyzed tone language. If the representations in (68) are a good reflection of a real, two-class typology of contour tones, then the contour tones in any new language added to the data base should fall into one of the two classes.

However, judging by the analysis of Mazatec presented in section 3, there appears to be something wrong with the typology as expressed in (68). In Mazatec, the process of 2-shift requires a cluster representation (68a), register neutralization is felicitously described only in terms of a contour representation (68b), and 1-spread appears to need recourse to both representations. Neither (68a) nor (68b) can fully account for the Mazatec phenomena on its own.

I have suggested that the main problem with the typology is not the notion of unitary vs. non-unitary contour tones as represented by the presence of a single tone root node in (68b) above. Rather, the trouble stems from the assumption that tone roots include register features.

In order to express all the processes shown to occur in Mazatec using a single representation, it is necessary to separate register from tone root and reject Bao and Yip's claim that, in true contour systems, contour shape is relativized to register. The result of this move is a Hyman-esque (1989) representation, as in (69). Here, the unity of contour tones is a purely structural property, unrelated to the features that determine pitch height.

(69) Mazatec Contour Tone

```
    X
    |
    o   = Tone Root
   / \
  o   o
  |   |
  T   T
```

At this point, one of three things can be concluded: either (1) all unitary contour tones have the representation in (69) rather than that in (68b), or (2) the typology actually has three classes, African-type, Asian-type, and Mazatec (Mesoamerican?)-type, corresponding to (68a), (68b), and (69). Alternatively, (3) the rigid typology could be discarded entirely in favor of some conception of unitariness for contour tones as a gradient, where Danyang marks one end, Mende marks the other, and Mazatec is somewhere in the middle. How such an idea could be captured in a formal representation is not clear.

To choose among these three alternatives, we would need to examine much more data. To support (1), it must be shown that all the Asian data previously taken as evidence for (68b) can be handled satisfactorily by (69). Support for (2) depends primarily on finding more languages in the Mazatec class and pinpointing this class's defining properties. (3) would be helped by the discovery of tone languages falling at other intermediate points on the Danyang-to-Mende continuum. All of these projects are well beyond the scope of this paper but hopefully will be explored in future research.

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