VOWEL SHIFTS IN MIXE*

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The development of palatalized consonants has had profound effects on the vowel systems in Mixe, although secondary developments have partially obscured the central role of palatalization and have often given the impression that palatalization has been only passively involved in blocking shifts that were otherwise spontaneous. An analysis of these changes is presented which relates disparate facts reported by different researchers, and which directs these facts toward a motivated analysis of two innovative dialects. Theoretical implications of the Mixe data are discussed, and arguments are presented that particle phonology, a system of abstract representation recently proposed by Sanford Schane, allows a better analysis than standard distinctive features. A principle is proposed which helps limit the descriptive power of the framework. The classification of vowels in terms of relative quality is argued to be superior to the common classification in terms of absolute quality.

1. Introduction

The most striking fact about the development of the vowel systems in Mixe[1] dialects is the effect that palatalized consonants have had on neighboring vowels. This paper looks at the vowel shifts in Mixe from two perspectives. Historically, I focus on the changes in two dialects where the effects of palatalization have been most severe. I present an analysis which is not only a statement of sound correspondences, reflexes, and overall developments, but also an explanation of the facts, since it focuses on the central role that palatalization has played in triggering the sound changes, including changes that appear to be spontaneous.

Then, I examine the implications that Mixe has for issues in phonological theory, such as the characterization of tense/lax contrasts, the formal representation of vowels and vowel changes, and the nature of markedness. I argue that particle phonology provides a better account of the Mixe data than more conventional frameworks, and adopts a more useful perspective on various theoretical problems.

2. Effects of palatalization in Mixe[2]

Wonderly (1949) reconstructed the Proto-Mixe-Zoque vowel system to contain at least the following vowel qualities:[3]

(1)

*i	*ɨ	*u
*e		*o
*æ	*a	

However, he posited *æ only to handle certain deviant correspondences in Tapachulteca. Nordell (n.d., 1980) does not posit *æ for Proto-Mixe (PM), and his opinion is generally accepted. Most dialects have only six phonemic vowels, and dialects that have more than six (such as those discussed in this paper) are readily seen to have been derived from a six vowel system.

Guichicovi Mixe, the easternmost dialect, has reflexes which are apparently unchanged from Proto-Mixe.

(2)

i	ɨ	u
e		o
	a	

In particular, the vowel qualities in Guichicovi are unaffected by palatalization on neighboring consonants. All other Mixe dialects show some degree of vowel shift in the neighborhood of palatalization, with the most extreme changes occurring in western dialects.

In this paper I focus on three representative dialects: Coatlán (Co.)[4] in the Southeast, near Guichicovi; Tlahuitoltepec (Tl.) in the West; and Totontepec (Tot.) in the Northwest. These three dialects exemplify most of the shifts that occur in Mixe, although to give a more complete account I will refer briefly to other dialects.

The reflexes in each dialect are summarized in the following table. Where a pair of vowels separated by a slash is given, the first occurs next to a reconstructed palatalized consonant, the second occurs elsewhere. In Coatlán the variations are allophonic; in the other two dialects the shifts have resulted in synchronic morphophonemic alternations in verbs.[5] There are subdialectal complexities with *ɨ and *o in Tlahuitoltepec which will be explained shortly. Totontepec underwent the further change of dropping palatalization from most syllable-final consonants, so that the conditioning factor for the shifts is not superficially visible in modern speech.

(3) Reflexes of Proto-Mixe Vowel Qualities

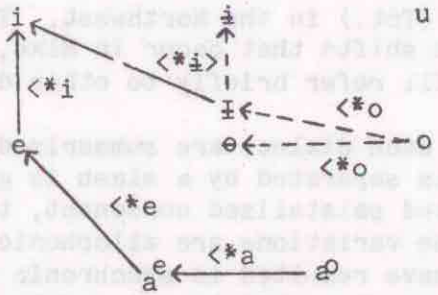
PM	Co.	Tl.	Tot.
*i	i/I	i/e	i
*e	e/E	e/æ^{e}	e/æ
*ɨ	ɨ	(i,ɨ,ɪ)	ɨ/â
*a	a	æ^{e}/æ^{o}	a
*u	u	u	u/U
*o	o	(ɪ,ɵ,o)	â/O

These correspondences are well-known among those working with Mixe. However, adequate data in support of them is not readily available, so I include a listing of cognate sets in an appendix.

Coatlán represents the simplest case of vowel shift: allophonic variation limited to front vowels. The variants [i] and [e] occur preceding palatalized consonants; [I] and [E] occur elsewhere.[6] The other Proto-Mixe vowels remain largely unchanged; other allophonic variation is irrelevant to this paper.

In Tlahuitoltepec the shifts are more extensive and involve more vowels than in Coatlán. The following chart shows approximate vowel qualities, and indicates which single vowels and synchronic morphophonemic alternations are the reflexes of each Proto-Mixe vowel. The arrows point in the direction of the synchronic rules. The solid arrows represent alternations found in all subdialects (D. Lyon 1967). The broken arrows represent alternations limited to certain subdialects (D. Lyon, personal communication).

(4)

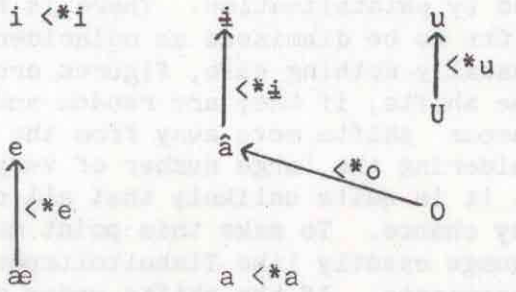


In several cases, synchronic assimilations appear not to have developed diachronically as assimilations, but as spontaneous changes in nonpalatalized environments. Both front vowels lowered and merged with the next lower vowel when not preceding a palatalized consonant; the result is synchronic raising in the palatalized environment. The fate of PM *ɨ varied in different subdialects. Some speakers have [ɪ] as the unconditioned reflex, but front and raise this to [i] if short and in the environment /__(h)CʸV. Other speakers have a third reflex [ɨ] which occurs preceding palatalized consonants in environments other than those which front [ɪ] to [i]. PM *a backed and rounded slightly to [æ^{o}] in most environments, but fronted to [æ^{e}] before a palatalized consonant.[7] PM *o is unchanged for some speakers, but others have [ɵ] (a central round vowel) or even [ɪ] before a palatalized consonant.[8] PM *u is

unchanged.

Totontepec shows the most extreme distortion in Mixe, having expanded from six to nine vowels in stressed syllables, all of which contrast with each other on the surface. Unstressed syllables retain the Proto-Mixe six-vowel system, as in Guichicovi. The following chart is based on the description of vowel qualities in stressed syllables given by Crawford (1963).

(5)



Totontepec shows the same phenomenon observed in Tlahuitoltepec; synchronic assimilations have developed from apparently spontaneous lowerings. The four vowels *e, *ɨ, *u, and *o lowered to [æ], [â], [U], and [O] when not preceding palatalized consonants. Much as in the one subdialect of Tlahuitoltepec, *o assimilated to [â] and merged with the nonpalatalized reflex of *ɨ. Unlike Tlahuitoltepec, *i and *a are unaffected by a following palatalized consonant. In addition to these changes, [e,a,â,ɨ] show allophonic variation conditioned by palatalization on the previous consonant.

After all the splits occurred, stem-final palatalization was a redundant feature in many environments, since all information formerly conveyed by palatalization was now conveyed by variations in vowel quality. Consequently, palatalization was lost where it was redundant, leaving nine contrastive vowel qualities.[9] Palatalization was retained following the vowel *a, since *a did not split, and thus palatalization was not redundant in this environment. There is one glaring exception to this analysis: palatalization <u>was</u> lost following *i, even though *i did not split either.

Another unusual characteristic of Totontepec is the heights of the back vowels. The second back vowel (transcribed here as U) is phonetically halfway between a true high open [U] and a mid close [o]. The third vowel, [O], is `higher than low back rounded [ɔ] but not as high as [o]´ (Crawford 1963:47). This is especially strange considering a tendency that is readily visible in the vowel inventories given by Crothers (1978). Most commonly, if the front and back vowels in a vowel system are of different heights, the back vowels are lower, not higher. I will suggest explanations for these oddities later.

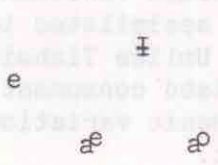
3. <u>Analysis of developments</u>

The preceding discussion reflects the general opinion of all Mixe researchers that I have consulted. In order to explain these facts, however, it is necessary to go beyond this statement of correspondences

and reconstructions, and to demonstrate how palatalization brought about the changes in each dialect. The explanation is not obvious, because of a striking feature of several shifts. One would normally expect palatalization to raise or front vowels, but instead it seems in many cases only to have blocked rules that shift them down or back. Although it is perfectly reasonable that palatalization could have blocked these shifts, the shifts themselves appear to be completely unmotivated.

A closer look suggests that they are not just random shifts that happened to be blocked by palatalization. There is too much similarity among the various shifts to be dismissed as coincidence. Why is it that palatalization, and usually nothing else, figures crucially in the environment of all the shifts, if they are random and spontaneous? Why do all these `spontaneous´ shifts move away from the palatal region of phonetic space? Considering the large number of very similar shifts in each western dialect, it is quite unlikely that all of them would happen in the same dialect by chance. To make this point more forcefully, suppose there was a language exactly like Tlahuitoltepec except that it lacked palatalized consonants. If the shifts under discussion really were spontaneous, we would expect that they could happen in this hypothetical language also, but this would have produced a very odd vowel system.

(6)



It is quite implausible to imagine all these shifts happening spontaneously in the absence of palatalized consonants.

Comparison with Sayula and Oluta Popoluca, the most closely related languages to Mixe (Nordell 1962), confirms this. These two did not develop palatalized consonants, and show no trace of the vowel shifts found in Mixe (Clark and Clark 1974, Clark 1981, Nordell 1980). Palatalization must have been involved actively in motivating the shifts and their direction, not just passively by restricting the environment in which they occurred.

Any analysis is incomplete if it fails to show how the vowel shifts are intricately involved with palatalization and fails to relate them to each other. I now present an analysis which avoids these problems. I argue that the vowels were split initially by assimilations in a palatalized environment. This analysis is supported by the fact that all of these assimilations are attested in at least one Mixe dialect. Many of them are quite widespread and/or occur in dialects neighboring on the dialects being analyzed. The modifications in the Totontepec and Tlahuitoltepec systems are thus seen to be a composite of shared innovations which converged in these two dialects. I also discuss the secondary developments triggered by palatalization which obscure the results of the assimilatory palatalization rules, giving the impression today of unmotivated sound shifts blocked by palatalization.

3.1. Front vowels

There is a noticeable similarity between the shifts in front vowels in the West and the allophonic variation in Coatlán. Furthermore, vowel shifts appear to be spreading from west to east; the effects of palatalization are greatest in the West, somewhat less in Central Mixe, only allophonic in Coatlán (in the Southeast), and nonexistent in Guichicovi (the easternmost dialect). Coatlán thus appears to exhibit an early stage of the splits in the West, and can shed considerable light on them.

The exact phonetic qualities of the allophones of Co. /i/ and /e/ are only vaguely described by Van Haitsma and Van Haitsma (1976:10): `The front vowels i and e usually are phonetically more open when not followed by palatalization and present more close variants when followed by palatalization.´ The terms `close´ and `open´ are ambiguous; they could refer to a variation only in height, or a variation that also involves frontness. A tape (in my possession) of a Coatlán speaker clearly shows that the lower allophones of each vowel are more central than the higher ones. This judgment is based both on auditory impressions and spectrographic measurements. Hoogshagen (1955) confirms this for /e/ by saying that there is a `raised and fronted´ allophone which precedes [y] and palatalized consonants, but he uses only the terms `close´ and `open´ to describe /i/. For the remainder of this paper I will use the terms `tense´ and `lax´ to describe this simultaneous variation of height and centrality in Coatlán, since the vowel qualities are reminiscent of tense and lax vowels in English and German.[10] Further justification for using these terms is given in Section 4.3.

In Coatlán tensing must be regarded as an assimilation, although a rather unusual one, to the following palatalized consonant. The diachronic origin of this variation is obvious: PM *i and *e were tensed to [i] and [e] preceding a palatalized consonant, and remained as lax [I] and [E] elsewhere. This implies that the phonetic quality of *i and *e must have been somewhat more lax than modern [i] and [e], which are quite tense. The vowel qualities in Guichicovi (where palatalization had no effect on vowel quality) tend to confirm this hypothesis, since Gui /e/ has only one allophone, which is midway between Co. [e] and [E].

If Guichicovi really does exhibit the phonetic quality of PM *e, then *e must have laxed slightly to modern Co. [E] in nonpalatalized environments. However, this is not surprising when one considers the heavy functional load borne by palatalization in Mixe. Palatalization marks several important inflectional categories, including third person possessor, third person verbal agreement, actor-oriented nonconjunct present, conjunct present, and conjunct past. Palatalization of a stem-final or stem-initial consonant is often the only marking of these categories. To perceive them accurately, speakers must perceive the contrast between palatalized and nonpalatalized consonants.

In Coatlán, tensing provided a new acoustic cue for recognizing the following consonant as palatalized. Once this cue was introduced, it would be natural for speakers to exploit it by widening the gap enough to make the tense/lax distinction, and consequently palatalization on

the following consonant, readily perceptible. The tensing induced by palatalization established the conditions under which laxing was natural. Laxing does not need to be viewed as a spontaneous process unrelated to palatalization.

If, as seems reasonable, Coatlán represents the first stage in the shifts that took place in Tlahuitoltepec and Totontepec, how can we account for the further changes in those dialects? In Tlahuitoltepec, the widening process was simply carried further. The lax variants *I and *E moved further away from their palatalized counterparts until they merged with the next lower vowel.

(7) $*i > \begin{cases} i & / \_\_C^{y} \\ *I > e & / \text{elsewhere} \end{cases} \qquad *e > \begin{cases} e & / \_\_C^{y} \\ *E > æ^{e} & / \text{elsewhere} \end{cases}$

Lax *E merged with the fronted variant of PM *a at [æ^e], which is about halfway between the two Proto-Mixe vowels. Lax *I may have been more central than tense *e, but I will argue later that a difference of centrality alone would not be sufficient to keep the vowels apart. In many languages with tense/lax distinctions (e.g. English), different degrees of length keep [I] and [e] apart, but there is no correlation with length in Mixe, so that a merger was highly likely once laxing began.

Totontepec on the other hand, does not exhibit merger involving front vowels. Only *e was split by palatalization, and the nonpalatalized variant became [æ], not [æ^e]. The development of [æ] was probably related to the loss of palatalization in Totontepec. Erosion of the conditioning environment would have removed the pressure to front the tense vowel. At the same time, functional load was being transferred from palatalization to vowel quality as the gap between the two variants widened. The two changes combined to place a more vertical orientation on the shift than occurred in Tlahuitoltepec. This eventually resulted in *E becoming [æ], which is more or less directly below [e]. In Tlahuitoltepec, the retention of palatalization kept the direction of the shift diagonal, so that the lax variant eventually became [æ^e]. [11]

The proposal so far is summarized in the following chart.

(8)

Tlahuitoltepec				Totontepec		
iC^y	iC	eC^y	eC	eC^y	eC	Proto-Mixe
iC^y	IC	eC^y	EC	eC^y	EC	Tensing and Laxing
				eC		Loss of palatalization (Tot. only)
	eC		æ^eC		æC	Secondary lowering
iC^y	eC	eC^y	æ^eC	eC	æC	Modern qualities

Unfortunately I lack a special symbol to distinguish tense vowels from the neutral vowels of Proto-Mixe.

The only thing left to explain is why *i (like *a) did not split in Totontepec, even though palatalization was lost following it (unlike *a). One possibility is that it split temporarily, and that its two allophones merged again later. Another (more likely) hypothesis is

that, prior to the development of allophonic variation from PM *e, PM *i had already palatalized all following consonants. This would explain two things at once: *i did not lower or lax because it was never in a nonpalatalized environment, and palatalization could be lost at a later stage following *i because palatalization had already ceased to be contrastive in this environment. Note that palatalization ceased to be contrastive following *e and other vowels for a different reason: vowel quality changes made palatalization a redundant feature. Neither of these changes applied to the sequence *aC(y), so that palatalized consonants remain contrastive in this environment even today. Thus this analysis allows the positing of two sound changes (the tense/lax split, and the loss of palatalization on consonants) in their simplest and most general form.

(9)

Totontepec						
iCy	iC	eCy	eC	aCy	aC	Proto-Mixe
	iCy					Palatalization following *i
iCy	iCy	eCy	EC			Tensing and Laxing
iC	iC	eC				Loss of palatalization when noncontrastive
			æC			Secondary lowering
iC	iC	eC	æC	aCy	aC	Modern qualities

Of course, we currently have no direct evidence for the change *iC > *iCy, since all stem-final consonants have been depalatalized following *i. However, we do know that *y+C combinations changed to yCy or Cy in many Mixe-Zoque dialects (Wonderly 1949, Nordell 1980), including Totontopec and Tlahuitoltepec which still exhibit metathesis of y+C → Cy across morpheme boundaries. Nordell (personal communication) reports that Sayula Popoluca palatalizes [c] before front vowels, and Guichicovi has a similar example of regressive palatalization. These changes are very similar to the one I am proposing here.

This analysis solves the problems noted earlier. The lowering of the vowels in nonpalatalized environments was not a spontaneous, unmotivated shift, but rather a natural and perhaps necessary response to an initial assimilation in palatalized environments. The direction of this secondary shift is explained, since the direction was already established by the assimilation; all the lowering did was to increase the distance in that same direction. Even the failure of *i to split in Totontepec can be related to palatalization, although this last hypothesis is less certain.

3.2. Achromatic vowels

The achromatic (i.e. nonfront unrounded) vowels of Proto-Mixe pose the least problem to analysis, since it is in this series that the assimilations are the most obvious. Fronting is the most common assimilation in these vowels in Mixe. In Tlahuitoltepec, PM *ɨ and *a fronted to [i] and [æ] before a palatalized consonant. Crawford (1963) notes that Totontepec achromatic vowel phonemes have fronted allophones which approach but remain distinct from phonemic front vowels. The fronted

variants occur especially following /c/and /y/, and the more common backed variants occur elsewhere. Fronting is also present in other dialects, especially in Central Mixe. Juquila and Jaltepec (Nordell, personal communication) front /ɨ/ to [e] or [i] next to palatalized consonants, merging it with the front vowels. Tutla fronts [a] to [æ]. All these synchronic rules reflect essentially the same diachronic change, with minor variations in each dialect.

One shift which does not fit this pattern, but which seems to involve spontaneous lowering, is visible in the reflexes of *ɨ in Totontepec.

$$(10)\quad *ɨ > \begin{cases} ɨ \;/\; \_\_\; C^{y} \\ â \;/\; \text{elsewhere} \end{cases}$$

Some speakers in Tlahuitoltepec show a very similar shift, but the lowered reflex is a slightly higher [ɪ].

However, the lowering of PM *ɨ to [â] or [ɪ] is mostly an illusion, fostered by the customary choice in the literature of the symbol `*ɨ´ to represent the higher Proto-Mixe achromatic vowel. It is almost certain that PM *ɨ was phonetically somewhat lower, probably [ɪ], on the border between high and mid. This is the quality of its nonpalatalized reflex in Tlahuitoltepec, its only reflex in Guichicovi, and its reflex in unstressed syllables in Totontepec. (I have no reliable information on its reflex in Coatlán.) A better symbol for the Proto-Mixe vowel would be *ɪ, which I will use from now on. Thus Tl. ɪ is apparently unchanged since PM *ɪ. The change *ɪ > [ɨ] in both dialects is clearly an assimilation to the height of the following palatalized consonant. In Totontepec the nonpalatalized reflex has lowered slightly to [â], but this can be seen as a natural consequence of the raising to [ɨ] which created a third phonemic vowel height; the three achromatic phonemes have simply spaced themselves evenly throughout the vertical space that they had available to them. This is analogous to the widening of the tense/lax variation in the front vowels.

A third shift affecting only the low vowel *a occurs in Tlahuitoltepec, in which *a seems to have backed and rounded slightly in nonpalatalized environments, thus widening the gap created by the fronting to [æ̟]. On the other hand, [ɑ̟] and low back unrounded [a˃] are quite common in Mixe, and it may be that PM *a was phonetically one of these qualities. I do not have the data to say anything more about this problem.

3.3. Round vowels

The two Proto-Mixe round vowels seem to behave as individuals in the two western dialects discussed in this paper. However, I treat them in the same section because they act as a natural class in other dialects, and possibly even in Totontepec. I will first discuss three changes which are attested in other dialects, then turn to the details of Tlahuitoltepec and Totontepec.

There are two common effects of palatalization on round vowels.

Synchronic fronting and unrounding occurs in Central Mixe before bilabial and velar palatalized consonants. Several other dialects appear to have inserted a front vowel between a back vowel and a following palatalized consonant. The inserted vowel matches the historically original vowel in height, and if the syllable nucleus is long, the length is carried on the inserted vowel, not the original one. Compare the following forms (referring to a type of wasp) from three representative dialects:

(11) hoom^{y} Guichicovi (no change from Proto-Mixe)
hweem^{y} San Sebastian Jilotepec (inserted front vowel)
heem^{y} Juquila (fronting)

Nordell regards insertion as the diachronic origin of the synchronic fronting rule in Central Mixe. After the front vowel was inserted, the original back vowel dropped out, and the result was the synchronic rule.

Another possible origin of fronting is that the Central Mixe dialects went through an intermediate stage of umlaut. However, the evidence is unclear, because the status of front round vowels is one of the loosest ends that remains to be tied up in Mixe dialectology. Miller (1937) and Beals (1973:135-138) both report their existence.[12] Both Crawford and Nordell (personal communication) report having heard isolated examples in at least three different towns, but no one has studied the matter very closely. Nordell knows of at least one clear case of umlaut. In Tutla, vowels are fronted between two palatalized consonants when the second one is bilabial or velar. For example:

(12) cuiik^{y} orange
cʸüiik^{y} his orange

(Third singular possessor is marked by palatalizing the first consonant of the possessed noun. The [ii] in both forms is inserted.) At any rate, umlaut appears to be a marginal phenomenon in Mixe, unless it can be demonstrated that it underlies the fronting plus unrounding in Central Mixe.

Returning to Totontepec and Tlahuitoltepec, both dialects show a centralizing and unrounding of *o under palatalization. In Totontepec this change has been completed, but in Tlahuitoltepec it still seems to be in progress. Recall that some Tlahuitoltepec speakers have no variation at all, others have [ɵ] as the palatalized allophone (a type of stunted umlaut), and still others have [â], as in Totontepec. These three subdialects represent three logical stages in the shift from *o to [â].

(13) *o > {ɵ > â / __ C^{y} ; o / elsewhere}

Presumably this same sequence of events occurred in Totontepec at an earlier date. Presumably Tlahuitoltepec is in the process of borrowing this sound shift (as well as the raising of *I) from Totontepec.

The development of *u in Totontepec is less certain, but it is still possible to demonstrate how palatalization could have initiated

its ultimate development to [u] and [U]. Considering the rules that are attested in neighboring dialects, the initial split of *u could have occurred in any of three ways: diphthongization by insertion (*u > *ui /__C^y), umlaut (*u > *ü /__C^y), or stunted umlaut (*u > *ʉ /__C^y). Because stunted umlaut appears to have occurred in Totontepec to *o, I am inclined to favor the hypothesis that *ʉ was the palatalized variant, but the exact quality is not crucial to the analysis. I will refer to the palatalized variant by the neutral symbol *uY for now, in contrast to *u for the nonpalatalized variant.

When palatalization was lost from final consonants, *uY and *u would have become separate phonemes. Since all three possible qualities of *uY are rather unusual, it would be natural for it to change back to a more common [u]. Considering that the two reflexes of PM *u carried the heavy functional load formerly carried by palatalization, it was not likely that they would reunite, and in fact they didn't. Instead, as *uY moved into [u], *u lowered to [U], and this in turn pushed *o down to [O].

It may be argued that one should not posit `yo-yo´ movements that involve changes in phonemic contrasts (like PM *u > *uY > [u] /__C^y; *u > U /elsewhere), since they are very rarely documented in other languages. (Compare also the assertion in Dressler 1974 that u > U is common, but U > u is rare.) I would simply respond that this is an artifact of the comparative method, which is our only empirical tool in the absence of written records. A midpoint (such as *uY) in a yo-yo change would not necessarily leave traces of its existence (e.g. an unchanged reflex in another dialect), but this does not mean it didn't exist. Phonemic yo-yo changes of the sort I posit here (where the vowel which changed first appears in retrospect not to have changed at all) may be quite common, but we just don't have the tools to detect them. In other words, the limited number of examples of yo-yo changes in other languages is due to the limitations of historical research, not to a limitation on possible sound changes. I know of no substantive reason why the generation of speakers that changed *uY to [u] would necessarily have any knowledge that their ancestors had derived *uY from PM *u, or (more importantly) why that knowledge would prevent them from moving it back to [u].

Three considerations suggest that the shifts in back vowels in Totontepec and Tlahuitoltepec may be fairly recent. The Tlahuitoltepec change is still in progress, and Beals's transcriptions of front round vowels suggest that as late as 1940 Totontepec may have had central round vowels.[13] Second, the fronting of PM *o seems to be relatively localized, being confined to Totontepec and some speakers in Tlahuitoltepec.[14] This would be expected if it was recent. Third, the unusually high phonetic values for the round vowels in Totontepec suggest that they may not yet have had time to adjust to the introduction of a new vowel at the top; they are still in the process of developing into a more normal configuration.

3.4. Summary

The preceding analysis explains how palatalization triggered even the apparently spontaneous vowel shifts in Totontepec and Tlahuitoltepec. It reveals their phonetic motivation and explains why they consistently point either towards or away from the palatal region, rather than heading in all sorts of random directions. This analysis provides a more complete understanding of the sound changes than does a superficial description of the reflexes or an overall characterization of the shifts which ignores intermediate stages and phonetic motivation. It explains why vowel shifting is absent in closely related languages that did not develop palatalized consonants.

It receives considerable support from attested rules in other dialects. The tense/lax splits in front vowels are just beginning in Coatlán, and the extra widening of the gap between the two variants is natural inasmuch as it increased the salience of stem-final palatalization. The split PM *ɨ > Tot. i̱,â is found in incipient form in Tlahuitoltepec. The frontings of PM *ɨ, *a, and *o in Tlahuitoltepec seem to be just further instances of the fronting found in many dialects. The developments in Totontepec round vowels are quite understandable if we assume that *u and *o underwent an early assimilation similar to the fronting of *o in Tlahuitoltepec (and probably also Totontepec).

This analysis shows that Totontepec is not as unusual as it looks at first; it simply has been one of the more progressive dialects and has adopted enough of the sound changes operating in Mixe to have drastically altered the shape of its vowel system. The unusual heights of the back vowels can be attributed to the recency of the changes. The failure of PM *i to split may also be a result of palatalization. The most unusual characteristic of Totontepec, its loss of stem-final palatalization, can be understood simply as a natural outgrowth of these shifts: it was the loss of a feature which was redundantly and more saliently present in a neighboring vowel.

4. Theoretical implications

In the course of the preceding analysis, it has been possible to state some conclusions with considerable certainty, while in other cases I can only present one or two good guesses. Considerable work is necessary in other dialects. However, the aim of the present study has been achieved: to provide an analysis which is as coherent, phonetically motivated, and empirically supported as possible, given the current availability of information on Mixe.

Despite its lack of completeness, it has brought to light several facts about Mixe which can help expand our general theoretical understanding of sound systems and how they change. In this final section I consider some of the most important of these. In particular, I show the utility of particle phonology for handling the Mixe data, thus providing a set of arguments in favor of this theoretical framework.

4.1. Assimilations to palatality

4.1.1. Analysis in standard features

There is a striking similarity between the shifts in Mixe and attested changes in the history of other languages. For example, something very much like Germanic umlaut operates in a few Mixe dialects, and the development of fronting and unrounding in Central Mixe may have paralleled the course of umlaut in English. Russian fronts [a] → [æ] before front vowels. The tensing of front vowels is similar in some respects to the widespread phenomenon of raising in front vowels, e.g. PIE *ei > Gmc., Lat. [ii]. Tekavčić (1972:61ff) provides details about metaphony in various Italian dialects, which involves fronting or raising of vowels before [i] or [y] in the next syllable. Zapotec, an Otomanguean language whose many dialects virtually surround Mixe, shows raising and fronting of vowels following palatalized consonants (Joseph Benton, personal communication). Further examples could probably be mentioned by any reader.

There are two aspects to the similarities in these shifts. First, palatalized consonants trigger the same sorts of changes as do the environments /__(C)i and /__(C)yV. This unity is captured in standard distinctive features by including the features [+high, -back] (or [+pal]) in the representation of palatalized consonants, y, and i. Second, there is something that fronting and unrounding of back vowels have in common with raising of front vowels in these environments; both are assimilations to the palatality of the environment.

It is generally accepted that the formal representation of assimilation in any theoretical framework should explicitly state the fact that an assimilating segment becomes more like some aspect of its environment. The more obviously this is stated, the better. Chomsky and Halle (1968:350) describe assimilation as `a process in which two segments are made to agree in the value assigned to one or more features´. For example, a simple case of umlaut preceding a palatalized consonant would be represented in standard features as

$$(14)\quad V > [-back] \;/\; \_\_ \begin{bmatrix} C \\ +high \\ -back \end{bmatrix}$$

The assimilation has been made explicit by copying the feature specification [-back] from the environment to the structural change.

It is also well known that standard binary features do not express height changes well. For example, the synchronic rule in Tlahuitoltepec that raises front vowels would be written something like this:

$$(15)\quad \begin{bmatrix} V \\ -back \\ \alpha low \end{bmatrix} \rightarrow \begin{bmatrix} -\alpha high \\ -low \end{bmatrix} \;/\; \_\_ \begin{bmatrix} C \\ +high \\ -back \end{bmatrix}$$

In this rule, [+high] in the environment conditions changes to [-low] and [-∝high]. The rule does not copy a feature specification, and the complexity of alpha notation tends to obscure the simple generalization that both vowels are raised. This undesirable formal result arises because vowel height has been expressed with two different features, not one. The usual solution to this problem is to posit one n-ary feature [high] which allows one to write the rule explicitly as an assimilation.

$$(16)\quad \begin{bmatrix} V \\ n\ high \end{bmatrix} \rightarrow [n+1\ high] \;/\; \_\_ \begin{bmatrix} C \\ 3\ high \\ -\ back \end{bmatrix},\ \text{where } n < 3$$

A similar, but more serious, problem occurs when stating the tensing rule in the development of Coatlán.

$$(17)\quad \begin{bmatrix} V \\ -back \end{bmatrix} > [\propto tense] \;/\; \_\_ \begin{bmatrix} C \\ \propto pal \end{bmatrix}$$

(The alpha notation is used to indicate that the feature [tense] was irrelevant at earlier stages.) This rule only states the facts; its assimilative nature is not straightforwardly expressed. It does not explain why palatalization should condition tenseness, since no feature has been copied.

This rule also fails to express an important generalization about naturalness. It would not be natural for a back vowel to tense (i.e. raise and back) in this environment. However, this rule is not preferable on formal grounds to an otherwise identical rule that applied to back vowels only, or to all vowels equally. Again the problem is with the feature specifications; there is no formal reason why [+pal] consonants should cause only [-back] vowels to become [+tense], since three separate features are used.

Changing the specification of palatalization to the more standard [+high, -back], or using Jacobsonian features, does not help. There does not appear to be a convenient solution in n-ary features. A more radical approach is necessary.

4.1.2. Analysis in particle notation

Schane (1982) proposes particle notation as an alternative to standard distinctive features in order to handle problems such as this. The features [high], [low], [back], [round], and [tense] are replaced as primitives by three elementary `particles´ of vowel quality. Each is named after the vowel which most exemplifies its basic quality: the particle |a| represents aperture (height), the particle |i| represents palatality (frontness), and the particle |u| represents labiality (roundness).[15] The particles |i| and |u| are called `tonality´ particles.

Vowels are represented as unordered complexes of particles. The

Proto-Mixe six-vowel system would be represented as follows:

(18)

*i = ¦i¦		*u = ¦u¦
	*ɨ = ¦ ¦	
*e = ¦ai¦		*o = ¦au¦
	*a = ¦a¦	

Front vowels contain the particle ¦i¦, round vowels contain ¦u¦, and achromatic vowels contain neither. All except the highest vowels in each series include ¦a¦ in their representation. Note that since *ɨ possesses the least aperture, labiality, and palatality of all six vowels, it is represented as empty, without any particles. The particles in each vowel are conventionally listed in alphabetical order.

Extra vowel heights require greater use of the aperture particle; lower vowels contain more aperture particles than higher ones. The modern Totontepec system would be represented as:

(19)

[i] = ¦i¦	[ɨ] = ¦ ¦	[u] = ¦u¦
[e] = ¦ai¦	[â] = ¦a¦	[U] = ¦au¦
[æ] = ¦aai¦	[a] = ¦aa¦	[O] = ¦aau¦

The possibility of the same particle occurring more than once in a vowel is analogous to an n-ary feature [high].

Particles must take their traditional phonetic interpretation from relationships within the overall vowel system, not from any absolute articulatory or acoustic properties. This can be seen in the above two inventories. In Proto-Mixe, ¦a¦ represents a low vowel [a], but in Totontepec it represents a mid vowel [â]. I will assume that particles represent relative spacing of vowels, but not absolute quality. A vowel with one aperture particle will be phonetically lower than a vowel with none. The converse is not necessarily true (as can be seen above); two vowels with the same number of aperture particles may differ in height phonetically.

Most of the shifts in Mixe involve copying of a particle ¦i¦ into a vowel, conditioned by the presence of the particle ¦i¦ in a following palatalized consonant.[16] For example, the shift PM *ɨ > Tl. [i] is represented in particles as ¦ ¦ > ¦i¦. Copying particles, as the formal representation of assimilation, explicitly represents the intuitive notion that a segment becomes more like its environment.

The particle representations of front rounded vowels contain both ¦i¦ and ¦u¦. For instance, [ü] would be represented as ¦iu¦ and [ʊ̈] as ¦aiu¦. Umlaut is simply the addition of the palatality particle to ¦u¦ and ¦au¦, producing ¦iu¦ and ¦aiu¦, respectively. I will assume that Tl. [ɵ] should also be represented as ¦aiu¦, since it is farther front than [o] (¦au¦), and rounder than [ɛ] (¦ai¦). This allows the stunted umlaut of *o > ɵ to be represented as an addition of the particle ¦i¦.[17]

Schane (1982) has proposed on independent grounds that tense/lax contrasts should be represented by positing an extra tonality particle in the tense vowel and an extra aperture particle in the lax vowel. For example, the tense/lax variation [e] vs. [E] in Coatlán is represented as ¦aii¦ vs. ¦aai¦. This directly mirrors the phonetic fact that lax front vowels are lower and less front than tense ones. The tensing rule which was so problematic for standard notation is formalized simply as the addition of the particle ¦i¦ to the vowels ¦i¦ and ¦ai¦ ([i] and [e]) to produce ¦ii¦ and ¦aii¦.

As a final bit of icing on the cake, fronting and tensing are both represented as the addition of ¦i¦, and can thus be viewed as the same process. The particle ¦i¦ explicitly represents both what these rules have in common with palatalized consonants and what they have in common with each other.

4.1.3. The Multiple Tonality Law

Tensing didn't happen by itself; the front vowels also laxed when not preceding palatalized consonants. In particle notation, ¦i¦ laxed to ¦ai¦, and ¦ai¦ laxed to ¦aai¦. It is of course nonsense to talk about tense vowels without implying that there are also lax vowels in the system, but at present there is nothing in the framework that motivates this intuitively natural change. However, a principle can be proposed that does so.

It has long been known that only two degrees of contrastive frontness (i.e. backness) need to be posited for the overwhelming majority of vowel systems. It would be very surprising to find a pair of front vowels in some language that exhibited surface contrast only in the degree of frontness, while being identical in height, length, etc. This would be so surprising that it is tempting to call it impossible. (A preliminary check through the UCLA phonological segment inventory database (UPSID 1981) reveals only four potential counterexamples in a sample of over 200 languages.) Even an allophonic variation of this sort is unusual. The difference between, e.g. [i<] and [i>] is apparently too small to support a contrast or to be useful as a redundant specification of some feature in the environment (i.e. to be a significant allophonic variation). Some formal principle must express the idea that such distinctions in tonality are minimally effective.

For present purposes, the following statement will suffice.

(20) The Multiple Tonality Law

If two vowels in the same tonality series differ only in the number of one tonality vowel, these two vowels will not be contrastive, and will be unstable as an allophonic variation.[18]

For example, the Multiple Tonality Law states that ¦ii¦ and ¦i¦ are too similar to each other to be contrastive, and that there is a natural tendency for one of them to change to something else if they are allophonic. In particular, in the case of tense vs. lax vowels, the allophonic variations that would arise by adding ¦i¦ to front vowels (and

doing nothing else) would be unstable. Subsequent (or even simultaneous) laxing of vowels in nonpalatalized environments would create a more stable system, and thus needs no special explanation.

Laxing of short vowels would be handled similarly. It is very common for long/short contrasts to be reinforced by tense/lax variations, as in English and German. Further, tense/lax variations frequently develop out of long/short contrasts. Schane (1982) represents this development as follows:

(21)

[ii]	[i]	[ee]	[e]	
¦i i¦	¦i¦	¦ai i¦	¦ai¦	Stage 1: length contrast only
¦i i¦	¦ai¦	¦ai i¦	¦aai¦	Stage 2: length plus tenseness
[ii]	[I]	[ee]	[E]	

Long vowels are distinguished from short vowels by possessing a space and an extra tonality vowel.

The analysis is the same in Mixe, except that the representations I have proposed for Mixe lack the space. In both languages the extra tonality particle at Stage 1 is conditioned by some other feature, either length, or palatalization on the next consonant. However, this allophonic variation is unstable (by the Multiple Tonality Law). Laxing reduces the instability of the system by increasing the distinction between paired tense/lax vowels. Thus the Multiple Tonality Law accounts for the similarity in development of tense/lax variations, whether they spring from length or palatalization.

Something like the Multiple Tonality Law is needed independently of the problem of motivating the laxing process. The framework of particle phonology will eventually need some formal constraint to replace the restriction in Chomsky and Halle 1968 that features have binary values when they are used for classification. There is nothing (besides common sense) to prevent one from positing ¦iiii¦ as the representation of [i] in some vowel system, implying that there were five degrees of frontness. The Multiple Tonality Law excludes this ridiculous application of the formalism.

The Multiple Tonality Law also explains why [y] cannot be palatalized in Totontepec (Crawford 1963:39) and Coatlán (Hoogshagen 1955) even in morphemic positions where other consonants are palatalized. Informally, the answer is obvious; it would be phonetically impossible to distinguish [y] from [yy]. In particles these two segments would be represented as ¦i̯¦ and ¦i̯i̯¦. (The half-moon placed under a raised particle is used to represent the non-syllabic portions of diphthongs. I am assuming that [y] is best represented as being entirely non-syllabic.) They differ only in the number of palatality particles, and thus fall under the censure of the Multiple Tonality Law.

The Multiple Tonality Law is not a restriction to binary features for frontness and roundness. Rather, it states that a minor difference

in degree of frontness or roundness by itself is not adequate to support a phonemic contrast. In fact, the Multiple Tonality Law allows the use of three degrees of frontness (0, 1, or 2 instances of ¦i¦) when the difference in palatality is reinforced by some other feature. This is the case with the formal representation of tenseness and laxness, which, as Schane 1982 and this paper demonstrate, is superior to the usual analysis with the feature [tense].

The point can be made more forcefully in Swedish. Fant (1971) reports that there are two long high front rounded vowels, [ʉ:] and [ʉ:]. These differ in that [ʉ:] is farther front and less round than [ʉ:]. Fant posits two new features, [extreme palatalization] and [extreme labialization] to account for these two vowels. Although he uses binary features, he is essentially proposing that frontness and rounding, like height, have three values. Schane (personal communication) has pointed out that Fant's analysis can be transferred very naturally to particle notation. One way to do this is to represent [ʉ:] as ¦iiu¦ and [ʉ:] as ¦iuu¦.[19] The Multiple Tonality Law does not rule this out, since the vowels differ in the numbers of two tonality particles, not just one. The simultaneous variation of labiality and frontness can support a contrast, even though either one by itself could not. The Multiple Tonality Law thus permits an analysis which directly reflects phonetic reality, but which would be ruled out by an across-the-board prohibition of n-ary features for tonality.

Certainly more work is needed to determine if the Multiple Tonality Law as stated here is a usable and correct generalization over a wide variety of languages. The observations here are offered as a first attempt towards solving a problem in the Mixe analysis in a nonarbitrary way.

4.1.4. Reanalysis of laxness as lowered height

In particle notation, the traditional notions of lowered height and laxness are both represented formally as the presence of an extra aperture particle. The aperture particle captures a generalization uniting these two notions, a generalization that is needed for cases such as English Open Syllable Lengthening, in which short lax vowels merged with the next lower vowel when lengthened (Schane 1982). The later changes in Tlahuitoltepec and Totontepec are another illustration of this. At some point, the extra ¦i¦ particle in the tense vowels was lost. In particle phonology, the spontaneous loss, or `decay', of a particle is viewed as an unmarked change, since the markedness of a vowel is directly reflected in the number of particles it contains. (For example, [æ] is more marked than [e] because it has one more particle.) Thus no special explanation is required.

In Tlahuitoltepec, the loss of ¦i¦ from tense ¦aii¦ resulted in a merger with ¦ai¦, and a major reorganization of the structure of the

system.

(22)

[iCV]	[iC]	[eCV]	[eC]	
i	i	ai	ai	Proto-Mixe
ii		aii		Tensing
	ai		aai	Laxing
i		ai		Decay
[i]	[e]	[e]	[æ]	

There are now three heights in front vowels and no tense/lax contrasts. In traditional terms, the lax vowels have been reinterpreted as vowels of lowered height.

In standard features it would be necessary to posit a clumsy context-free rule to state the reanalysis of *I and *E from lax vowels to vowels of lowered height.

(23) $\begin{bmatrix} V \\ -back \\ -tense \\ \alpha high \end{bmatrix} > \begin{bmatrix} -\alpha low \\ -high \end{bmatrix}$

In addition, there is no way to state the fact that the feature [tense] has now become irrelevant. In particle notation no special rule is needed. The reanalysis of lax vowels as low vowels happens automatically with the loss of tenseness from the system. The same analysis works for Totontepec, except that the whole process of tensing, laxing, and reanalysis was confined to the mid vowel *e.

4.1.5. Reanalysis of achromatic vowels

In particle phonology, the laxing of PM *e from ¦ai¦ to ¦aai¦ is related in a non-obvious way to changes in the central vowels. When ¦aai¦ was adopted by speakers as the representation for [E], [a] was necessarily re-analyzed as ¦aa¦, instead of simply ¦a¦. This is a consequence of the phonetic reality of particle representations (see the next section); since [a] was phonetically lower than [E], it could not be represented with less aperture particles than [E].

This now left two possible representations for *ɨ; it could have retained the former representation ¦ ¦, or could have become ¦a¦. Since the representation ¦ ¦ has been assumed to be marked because of its complete lack of particles, ¦a¦ would be the preferred representation. If this was so, then raising of PM *ɨ > Tl., Tot. [i] is represented as the loss of its only particle, i.e. ¦a¦ > ¦ ¦. This is still an assimilation, assuming that palatalized consonants lack aperture particles (cf. the standard feature treatment of them as [+high]).

4.2. The phonetic reality of particles

The use of the same particle representation for different vowels in different languages (such as the use of ¦a¦ for [a] in Proto-Mixe but for [â] in Totontepec) can give the impression that particle notation is not tied to phonetic reality. This is not necessarily the case, although the conception of phonetic reality assumed in this paper is somewhat different from what it is in some traditional approaches.

The impression of phonetic unreality seems to be based on an approach to classifying vowels which relies primarily (and perhaps unconsciously) on absolute quality. For example, a vowel is classified as [-back, -high, -low] if it is anywhere in the area of [e] or [E]. Any vowel that is significantly lower than this must be classified as [+low]. This approach seems to have developed more from a desire for pretheoretical phonetic accuracy than from any principled approach to classification. It is of course useful for objective cross-linguistic comparisons of phonetic detail, but objective reality is often irrelevant for linguistic purposes.

Standard features are not necessarily used in this absolute sense, although in actual practice many linguists will hesitate to use [-low] as a valid feature specification for [æ]. In the discussion that follows, I will continue to use standard features to illustrate classification by absolutes, even though in doing so I may be erecting something of a straw man. My purpose is not to argue against standard features, but to outline a reasonable conception of the phonetic reality of particle notation and to highlight the usefulness of conceiving of phonetic reality primarily in terms of relative, rather than absolute, quality.

In particle notation a vowel is classified according to its relative quality with respect to other vowels in the language. Absolute quality (with respect to some objective standard such as Daniel Jones's system of cardinal vowels) can be left entirely to language particular phonetic realization rules, which map particle representations to absolute qualities. However, this is not at all a random or unconstrained mapping; the absolute quality of vowels must be consistent with their relative qualities as expressed by their particle representations. Note that the need for rules specifying fine phonetic detail is shared by both approaches; neither has an advantage over the other in this regard.

It seems reasonable to assume that each particle representation in each type of vowel system (four-vowel, six-vowel, etc.) will have an unmarked normal value around which its quality in individual languages will cluster. For example, the unmarked quality of the second highest front vowel ¦ai¦ in five- or six-vowel systems is probably near [E]; this seems to be its most common quality in the inventories in Crothers 1978, but [e] and [æ] also occur. Thus particle phonology allows a larger amount of phonetic variability for a given abstract representation than is tolerated in the classification-by-absolutes approach, but always within the phonetic limits outlined above.

The two approaches to classification are different and can be empirically distinguished. Some evidence favoring the use of particle

notation can be given from Mixe. This evidence points out the undesirability of classifying vowels according to a predetermined `objective´ grid which is heavily biased toward the types of vowel systems found in European languages.

The first type of problem occurs with vowels that are located on the boundary between two absolute qualities, such as PM *ɨ and its unchanged reflexes in various dialects. [ɨ] is neither high nor mid (with respect to the front vowels [i] and [e]), but halfway in between. When classifying by absolute quality, it is necessary to make a choice between representing it as [+high] or [-high]. Whichever is chosen, this stretches the definition of the feature [high], either making [+high] be very low, or [-high] be very high. This stretching is an embarrassment in a classificatory system that is supposed to provide a reasonably close approximation of absolute phonetic position and which assumes that rigidly predefined features are equally applicable in all vowel systems.

This undesirable formal anomaly is completely avoided in particle notation. Regardless of whether [ɨ] is represented as ¦ ¦ or ¦a¦, its precise absolute quality is not a problem. Absolute quality does not enter into its classification, and may be expected to vary from one language to another.

Similar problems occur frequently in Mixe. Tl. [ɵ] is distinct from [o] phonetically, and the change *o > [ɵ] is just as much an assimilation as the change *ɨ > i, yet it cannot be represented in standard features if they must be interpreted in terms of absolute quality. The problem is that [ɵ] is [+back], and is thus formally indistinguishable from [o]. In particles the assimilation can still be expressed as an addition of ¦i¦ to ¦au¦ to produce ¦aiu¦. The added ¦i¦ represents the fact that [ɵ] is farther front than [o], but not how much farther. The argument is similar with the heights of the three back vowels [u,ʊ,ɔ] in Totontepec, especially since [ɔ] is probably a mid vowel, not a low one, judging from Crawford´s (1963) description given in section 2.

A more dramatic problem for classification by absolutes is found in Tutla Mixe and other dialects where the second highest front vowel is [æ], not [e]. Tutla fronts and unrounds back vowels as in Central Mixe.

(24) <u>to</u> <u>burn</u>

toy^{20}	(imperative)
tææpʏ	(nonconjunct present)

If standard features are interpreted as measures of absolute quality, the synchronic fronting rule not only must change the feature [back], but also the feature [low]. The change to [+low] needs to be made in addition to any fine phonetic detail specified by other rules, because [o] is mid and [æ] is low, in absolute terms. In particle notation, there is only one rule concerned with absolute height, the independently needed phonetic realization rule which maps ¦ai¦ to [æ]. (This rule is no different formally from the corresponding rule in other dialects

which maps ¦ai¦ to [e], although the phonetic quality is more unusual.) The fronting rule can be expressed as an assimilation ¦au¦ → ¦ai¦ without having to make any mention of height. Unlike a system that classifies vowels by absolute quality there is no need to state absolute height twice, once in the fronting rule and again in the rule dealing with fine phonetic detail. This simplifies the grammar and allows a more straightforward statement of significant generalizations.[21]

It could be objected that this particle analysis appears to be the same as an abstract analysis in standard features. Such an analysis would represent the second front vowel as [e] throughout the derivation, then lower it to [æ] by a late, context-free phonological rule. There are two important differences, however. First, standard features used in an absolute sense require this late rule in addition to the rules that state fine phonetic detail. In particle notation, no additional ad hoc rule is needed, since the independently needed phonetic realization rule does everything. Second, particle notation makes no claim that ¦ai¦ is ever [e]. Particle representations are abstract only in the sense that they contain no specification of absolute quality. Much of the furor in the abstractness controversy was over positing underlying representations that are drastically different in absolute quality from the surface representations. In the abstract analysis in standard features above, the feature specification of the abstract underlying form [e] conflicts with the specification for the surface form [æ]. Thus particle notation offers some resolution to the abstractness controversy by being able to state certain structurally well-motivated analyses without having to posit underlying representations that don't occur on the surface.

The removal of absolute quality from the formal representation of vowels has other advantages. The notation is useful for historical research, since it is often easier to determine the relative quality of reconstructed segments than it is to determine their absolute quality. It helps resolve the controversy over gradual vs. abrupt sound change (see Andersen 1973). For instance, it recognizes that the push chain in Totontepec back vowels (*uY > u, *u > U, *o > O) very likely involved a gradual progression of different vowel qualities. However, some generation of speakers abruptly reanalyzed the vowels with different particle representations. (The old representation was ¦iu¦ (or ¦u̯i¦), ¦u¦, ¦au¦; the new one ¦u¦, ¦au¦, ¦aau¦.) A similar case was mentioned earlier: the reanalysis of front lax vowels as vowels of lowered height when tense vowels lost their tenseness in Tlahuitoltepec and Totontepec. Most likely the loss of tenseness was a gradual process, but at some point tenseness had diminished to the point that the front vowels were reanalyzed from a tense/lax system to a system of three vowel heights. Reanalysis can occur in particle representations without any necessary abrupt change in absolute quality; the abrupt change is in how speakers classify vowels.

As a final note, particle notation offers a new perspective on markedness. Two types of markedness are recognized: markedness in the overall structure of a vowel system, and markedness in the phonetic realization of that system. Structural markedness depends on such factors as the number of particles in each vowel and general principles

such as the Multiple Tonality Law. Phonetic markedness depends on how much the actual phonetic qualities of vowels deviate from the unmarked norms. What the norm is for a given vowel will vary depending on the type of vowel system, but I would expect that the overriding principle in all types of systems would be equal spacing of vowels. Thus a three-vowel system [e,a,o] would be considered phonetically marked, since the tonality vowels are lower than normal for a three vowel system, but its structural configuration is identical to the very common three-vowel system [i,a,u]. Only time will reveal the usefulness of exploring these two aspects of markedness separately.

4.3. The characterization of `tense´ and `lax´

The characterization of `tense´ and `lax´ that I have adopted in this paper differs somewhat from that which is often assumed. Length does not enter into the characterization, which thus subsumes both the European type of tense/lax opposition and the Mixe type. Second, `tense/lax´ in this paper is explicitly defined, in terms of height and frontness; it is not left undefined as a phonological primitive formally unrelated to height and frontness, as it is with the feature [tense]. Given this conception, it is easy to understand tensing as an assimilation.

Particle phonology adopted this characterization of tense/lax contrasts on independent grounds. For example, it explains why lax vowels merged with the next lower vowels in English Open Syllable Lengthening (Schane 1982). The assimilatory nature of tensing in Coatlán provides another piece of evidence in favor of this characterization.[22]

At least for Mixe, we need not and should not posit [tense] as a phonological primitive. Whether [tense] is needed as a primitive for other languages is beyond the scope of this paper. However, the Mixe data is relevant to the larger debate, since there is more reason to consider this a true example of a tense/lax opposition than just the phonetic qualities of the vowels. The vowels I have called lax act as a natural class in that they lowered while their tense partners stayed put. If speakers had classified the front vowels only with regard to height, there would be no reason why [I] and [E] should act as a natural class; rather we would expect contiguous vowels (such as [I] and [e]) to act as a natural class. This is essentially the same reason that English vowels are classified in terms of both height and tenseness rather than just in terms of height: tense and lax vowels act as distinct natural classes with respect to such changes as the Great Vowel Shift.

4.4. Merger avoidance

One of the more impressive aspects of the developments in Totontepec is the number of times that mergers could have occurred, but didn't. Unlike Tlahuitoltepec, *i did not lower, and there was no merger with *e. Likewise, *e lowered to [æ], *a did not front, and no merger took place here either. Back vowels did not merge with front vowels as they did in Central Mixe, even though they fronted partially (as in the current allophonic variation in achromatic vowels, and the stunted umlaut of *o > *ɵ and possibly *u > *ʉ). When *uY returned to

[u], it could have remerged with *u, but instead it initiated a push chain. The only merger at all resulted from an apparently rather late development, the unrounding of *ɵ > [â]. In contrast, Tlahuitoltepec exhibits four mergers in a comparable number of shifts. Central Mixe dialects merge all back vowels with front ones in just one rule of fronting.

What could have caused this merger avoidance? It is likely that the loss of palatalization in Totontepec is somehow related. The functional load formerly carried by palatalization has now been transferred to vowel quality. Loss of palatalization combined with several vowel mergers might have created an unacceptably large number of homophones. Even so, it is not clear whether erosion of palatalization caused the shifts or was only made possible by them. Very likely there were other factors involved, perhaps sociolinguistic ones, but it is not clear what they were.

4.5. Summary

This paper has attempted to bring together disparate facts about palatalization in Mixe dialects in order to explain some unusual sound changes in Tlahuitoltepec and Totontepec. It has also explored implications that these facts have for our understanding of sound changes and the nature of vowel systems. The Mixe data illustrate several advantages that particle phonology has over standard generative phonology, especially as regards the analysis of the splits in front vowels. Its explicit use of an abstract representation based on relative phonetic quality gives it a distinct advantage over a system that is rigidly tied to classification by absolute quality.

APPENDIX: Cognate Sets

The following chart of cognate sets illustrates the sound correspondences among Coatlán (Co), Tlahuitoltepec (Tl), and Totontepec (Tot). The Coatlán data, which are phonemic, are from Van Haitsma and Van Haitsma (1976) and Searle Hoogshagen (in press, personal communication). The Tlahuitoltepec data are from Don and Shirley Lyon (1967, personal communication). I have given forms only from the most conservative Tl. subdialect. The Totontepec data are from Schoenhals and Schoenhals (1965). In addition to the following cognate sets, I have relied on internal reconstruction based on the synchronic alternations in each dialect in order to arrive at the analysis given in the body of the paper. This has been especially necessary in Tlahuitoltepec, due to the relatively small amount of data available. None of this reconstruction is controversial among researchers on Mixe; I include data only because it is not readily available elsewhere.

I have given two forms for verbs: the first is usually the conjunct timeless and illustrates stem-final protopalatalization; the second is usually the nonconjunct timeless (no stem-final protopalatalization). A few forms show an assimilation n → m /__p; this p is a suffix and is shown in parentheses. With these exceptions, I have omitted inflectional morphology, and have included only stems.

There are a few deviant correspondences due to other sound shifts not relevant to this paper. Other sources of minor confusion include the fact that [y] causes palatalization in some dialects and not in others, and the fact that fronting of achromatic vowels in Tlahuitoltepec is limited for the most part to V, Vh and sometimes V´ nuclear shapes. There are two Co. forms that show stem-final palatalization in correspondence with the unpalatalized variants of vowels in the other two dialects. These problems are apparently the result of local innovations whose details remain obscure at present. Correspondences of nuclear shape are beyond the scope of this paper.

Co.	Tl.	Tot.	Gloss
i	i/e	i	
miiidzY	mehc	mic	you (sg)
cYii	xYem	xi,xim	there
cikY		cik	to harvest
cihk		cihk	
minY		min	to come
miin		miim(-p)	
niikxY		nii´kx	to fade, wither
niikx			
xi´ikY		xi´ik	to laugh
xiik		xiik	
´ixY		´ix	to see
´ihx		´ix	
e	e/æ	e/æ	
petY		pet	to ascend
peht	pæt	pæht	
pedi´ikY	pe´etY	pe´et	to sweep
pedi´ik	pæt	pææt	
he	hæ	hæ	the
ke´ekY		kuke´ek	to run away
keek		kukææk	
´e´ekY		´ee´k	to skin, peel
´eek		´ææk	
nepY		nep	to kick
nehp		næhp	
i	i/I	i/â	
nikxY	nihkxY	nihkx	to go
nikx	nIhkx	nâhkx	
pin	pIn	pân	who, whom
mih	mIk	mâh,mihit	big
miiy	miiy	mââhy	grass, zacate
´iiidzY	Ihc	âc	I, me
hicY		hic	to grind
hihc		hâhc	
´iiy		´iv	to sing; the second
´iiw		(´ââva)	Tot. form means `music´
pi´kxY		pi´kx	to powder; to hit
pi´kx		pâ´kx	
a	æ/æ	a	

Co.	Tl.	Tot.	Gloss
tɨnaay	tæˀnæˀæˀpʏ		to stand up
tɨnaay	tæˀnaˀaˀʏ		
kay	kæˀʏ	kay	to eat (tortillas)
kaay		kaay	
yahcaacʏɨ´ɨy	cæˀæˀcʏ	caacʏa	to wound
		caacʏip	
cʏam	ɪxyaˀm	ixyam	now
tu´´ay	tuu´æˀhpʏ	tUU´aahʏ	in the road
hatʏ		hatʏ	to know how;
haht		haht	to understand
yahwa´acʏ		va´acʏ	to clean
		vaac	
mɨnaanʏ		va´anʏ	to say
mɨnaan		vaam(-p)	
u	u	u/U	
cu´ucʏ		cu´uc	to bite
cu´c	cu´uc	cU´c	
tun		tun	to work
tuun	tum(-p)	tUUm(-p)	
´uuum		´uu´m	to be unable to speak
´uum		´UU´m	
tu´utʏ		tu´ut	to lay eggs
tuut		tUUt	
		xuhpx	to peck, fight
xupx		xUhpx	
o	o	â/O	
	tookʏ	tââ´k	to sell
took	took	tOO´k	
wooʏ	wopʏ	vâp	to hit
wohp		vOhp	
pohʏ		pâh	to be windy, to
poh	poh	pOh	blow; the wind
pokʏ	pokʏ	pâk	sin, wrongdoing; Tot. witchcraft
pok	pok	pOk	jicalpestle, type of gourd
mayhʏotʏ	maˀaˀhyotpʏ	maa´hyââtp	market, plaza; in the plaza, in the midst of a crowd
co´okʏ		câ´âk	to heal, save
cook		cOOk	
		kâv	to play (e.g. a guitar);
koow		(kOOva)	the 2nd Tot. form means `music´
potʏ		pât	to break (e.g., a rope)
poht		pOht	
mo´oy		mâ´â	to give
mooy		myOOy	

FOOTNOTES

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[1]Mixe is spoken in the northeastern corner of the state of Oaxaca, Mexico, extending west from the Isthmus of Tehuantepec across high rugged terrain. It, together with Popoluca, Zoque, and Tapachulteca, comprise the Mixe-Zoque family. There are probably 5 to 10 mutually unintelligible dialects of Mixe. The various systems of transcription used in different sources have been standardized in this paper, using the following special symbols:

â	schwa [ə]
I,E,U,O,ɨ	lax or lowered vowels corresponding to i,e,u,o,ɨ (the exact interpretation of these as lax vowels or simply vowels of lower height depends on context)
ʉ,ɵ	central rounded vowels
æ̟	slightly fronted [a]
æ̠	backed and rounded [a]
V,VV,VVV	three degrees of vowel length (see Hoogshagen 1959)
V´V	long vowel with laryngealization at the internal mora boundary
´	glottal stop [ʔ]
x	voiceless alveopalatal retroflexed grooved fricative [š]. (exception: in the name `Mixe´ it is a velar fricative.)
c	voiceless alveolar affricate [ts]
Cʸ	palatalized consonant
cʸ,dzʸ,xʸ	alveopalatal grooved affricates and fricatives [tš,dž,š] written morphophonemically (these are the palatalized variants of c, dz, and x)

[2]In addition to the published materials cited, much of this section is based on conversations with John Crawford (Totontepec), Searle Hoogshagen (Coatlán), Don Lyon (Tlahuitoltepec), and especially Norman Nordell (all dialects, but especially Guichicovi), whose knowledge of Mixe dialectology and history far exceeds anyone else´s, especially mine. Any information in this paper about general dialectology or history can be assumed to have come from him if I don´t include a specific citation. I trust that he will accept this vague expression of gratitude in place of repeated references acknowledging my debt to him. Of course, errors and omissions are my own.

[3]Vowels also show contrasts in stress and nuclear shape. `Nuclear shape´ refers to combinations of vowel length, glottalization, and [h] in syllable nuclei. For example, Coatlán shows contrasts of V, VV, VVV, V´, Vh, and V´V. Most verbs show morphophonemic alternations of nuclear shapes in stressed syllables. See D. Lyon (1967), Schoenhals

(1962,1979), Crawford (1965), and Van Haitsma and Van Haitsma (1976) for more details on this system in individual dialects. Except where noted, all vowel quality shifts discussed in this paper occurred in all nuclear shapes, for the most part independently of them.

[4]The dialect spoken in Coatlán is essentially the same as the dialect of El Paraíso described in Van Haitsma and Van Haitsma 1976. I will use the name `Coatlán´ to refer to them both.

[5]Most dialects show palatalization of the stem final consonant in the past and timeless tenses of the conjunct mood. (For example, Tl. pe´etʏ is one form of pæt `to sweep´.)

[6]The allophone [i] also occurs following Cʏ, and in a couple of other positions not relevant to this paper (Van Haitsma and Van Haitsma 1976).

[7]This shift is limited to essentially the same nuclear shapes as the fronting of *ɨ.

[8]Lyon (personal communication) suspects that the [ɪ] derived from *ɨ, for those speakers that have it, may be higher and farther forward than the [ɪ] derived from *o. However, the difference is so small that he is not sure, and no native speakers were available to check this detail.

[9]This appears to be an instance of a principle enunciated by Schane (1971): `If, on the surface, a feature is contrastive in some environments but not in others, that feature is lost where there is no contrast.´

[10]There is no correlated variation in length, unlike English and German; length is contrastive in Mixe (Hoogshagen 1959).

[11]This assumes that the direction of the secondary shift (the widening of the gap) was determined by the relative position of the two vowels. If [e] was further forward than [E], the shift was diagonal; if they were directly above each other, the shift was vertical.

[12]Beals (1973) even cites five words from Totontepec with front round vowels. These appear in the Schoenhalses´ (1965) dictionary with round or achromatic vowels. It is not clear how to resolve this discrepancy. A comparison of these words with their cognates in Coatlán shows that only one of these words had a final palatalized consonant in Proto-Mixe, so that even if Beals´s data is correct, it may not be relevant.

[13]Beals 1973 was originally published in 1939. See footnote 12.

[14]A tape from nearby Zacatapec also contains examples of ɵ, but this dialect has not been studied, so it is not known how this vowel fits in the overall system.

[15]I use `¦´ to delimit particles and particle representations of

vowels.

[16]Particle representations for consonants have not been worked out. I am assuming that if ¦xxx¦ is the particle representation for a given consonant, ¦xxx$^{j}_{\sim}$¦ or something similar will be the representation for the corresponding palatalized consonant.

[17]I am further assuming that new allophones produced by a historical change may be represented using particles, i.e., that particle notation may be used to distinguish two conditioned variants of the same phonemic vowel. This has the effect of making my particle representations less abstract, but it is not clear at this time whether this assumption is compatible with the overall framework.

[18]Schane has suggested a slightly stronger principle in unpublished work, but has further noted that his principle may be too strong.

[19]I am omitting length from the particle representations for simplicity.

[20]The semivowel [y] does not act like a palatalized consonant with respect to vowel shifts in many dialects.

[21]This discussion assumes that particle phonology will also prove useful for synchronic studies, although up to this point it has primarily been applied to diachronic problems.

[22]There is some possibility that what I have been calling tense/lax in Mixe is actually an instance of advanced and retracted vowels, as in many African languages (Lindau 1978). The tape of Coatlán mentioned earlier seems to suggest this. One instance of [e] sounds rather muffled in comparison to [E], which would be expected if the pharynx was expanded for [e]. In the absence of stronger evidence, e.g. from x-rays, I hesitate to present this as established fact, and have retained the terms `tense´ and `lax´ throughout this paper. If the contrast is really advanced vs. retracted, then it probably would be best to reserve the terms `tense´ and `lax´ for use in describing the European type of tense/lax contrast, in which length varies as well as height and frontness.

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