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Finding a way into a family of tone languages: The story and methods of the Chatino Language Documentation Project

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We give a narrative description of our ten-year path into the elaborate tonal systems of the Chatino languages (Otomanguean; Oaxaca, Mexico), and of some of the methods we have used and recommend, illustrated with specific examples. The work, ongoing at the time of writing, began when one of us (Cruz), a native speaker of San Juan Quiahije Chatino, entered the University of Texas at Austin as a Ph.D. student and formed, together with the other of us (Woodbury), a professor there, the Chatino Language Documentation Project, ultimately incorporating five other Ph.D. students and two other senior researchers. We argue for the importance of an interplay among speaker and non-speaker perspectives over the long course of work; a mix of introspection, hypothesis-testing, natural speech recording, transcription, translation, grammatical analysis, and dictionary-making as research methods and activities; an emphasis on community training as an active research context; the simultaneous study of many varieties within a close-knit language family to leverage progress; and the use of historical-comparative methods to get to know tonal systems and the roles they play at a deeper level.

0. PREAMBLE. Emiliana: My first language was Chatino. I started primary school when I was six years old. At that time, I did not speak Spanish. Spanish was the language of instruction, but the teacher was bilingual in Chatino and Spanish. He was an "indigenous educator," *castellanizador* ('Castillian-izer') in the parlance of that time. I learned how to write in Spanish before ever speaking it. I then learned English as an adult.

Writing my native language was always a passion. Before graduate school, I would often translate from Spanish into Chatino; I would write Chatino using the Spanish alphabet. I wanted to write in Chatino, but this goal seemed to me unrealistic. When I read back what I wrote, the words were always incomprehensible. In college, I wrote short stories in Spanish, though I conjured them in Chatino. I always felt that there was something missing in the translation.

I realized that language was crucial for the formation of someone's identity and that Chatino was disappearing due to the predominance of Spanish in the Mexican education system. I decided that language was what I wanted to study. I especially wanted to study Chatino.

After graduating from college, I opened a café in Oaxaca City. One of the first customers to walk in was Joel Sherzer, professor of anthropology at the University of Texas

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at Austin. He asked me if I knew where to find *narco* music. I thought, "This guy must be an anthropologist." I sent him to the Mercado de Abastos to buy pirated music. It was a good way to test his mettle as an anthropologist. The typical tourist stays clear of that market, which is filled with pick-pockets. He returned to the café the next day with lots of pirated music! He struck up a conversation. When he asked about my plans, I told him that I wanted to go to graduate school and study my native language. He was amazed at my words; and more amazed when, hearing him ask whether I spoke Chatino, I responded "yes". I remember him telling me: "You need to come to the University of Texas."

Everything happened quickly. I remember my bus from Mexico arriving late in Austin, Texas, when I went to see the university for the first time. Joel told me he waited for me at the city's Greyhound terminal for four hours. What Joel never told me was how long it would take for me to understand the fundamentals of Chatino. In my mind, in a few months I was going to write my native language just like I did Spanish or English. That's the story of how my study of Chatino started.

Tony: Earlier—a lot earlier—I was a finishing graduate student wandering around on the last day of the American Anthropological Association meeting, wishing I'd had more job interviews when suddenly Joel Sherzer looked at my name tag and said "Hey! I've been looking for you! Come on right now, I'll get my colleagues! We'll do an interview!" Well I didn't get the job—which was in Anthropology—but I did get a Linguistics job at Texas that was also on offer that year. In 2001, after many years working together with Joel, promoting the documentation of the languages of the Americas, we were able to recruit Nora England to Texas, where she founded a Center for Indigenous Language of Latin America (CILLA), dedicated to offering doctoral training in linguistics and related disciplines to speakers of Latin American languages. Emiliana was one of the first to join, as a doctoral student in Anthropology. As for me, I'd recently become department chair, and with it came a reduction in courses. I figured I had time on my hands. So I took Spanish so I might help with CILLA. And I volunteered to work with Emiliana on her language, San Juan Quiahije Eastern Chatino. We quickly realized that it had a *lot* of tones.

1. INTRODUCTION.[1] Our goal in this paper is to offer some suggestions on how to study a tone language. We do this in part by presenting and evaluating specific methods that had a part in our own work on Chatino languages. These suggestions, and our results with them, must be understood in terms of the wider context of our work, including the nature and

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diversity of the tonal systems we have worked on; our research trajectory through these systems as we encountered them; the social and political context of our work; and our individual positionings as field workers and collaborators (already outlined in the Preamble above). We do this by first giving a narrative account of our earliest and most tentative steps into the tonal systems represented in this language family: how we did it; how we might have done it better; and how we might have been both helped, and limited, by our methods and our assumptions about the nature of each system. To make the discussions concrete, we also provide sketches of several Chatino systems as they revealed themselves to us piece by piece.

Although the goal of our work on Chatino languages has been broad-spectrum documentation and description, we have been very occupied by tone. Why? A simple and sufficient linguist's answer is that it is a part of the basic phonology of Chatino languages, and therefore must be accounted for. Moreover, Chatino tone enters, to an astonishing degree, into the working of a full range of linguistic levels and functions, as argued in Emiliana's dissertation (Cruz (2011)): tones are also exponents in all Chatino inflectional morphology; they are often specialized to particular parts of speech, to expressive words, or to loan words; and their elaborate sandhi processes give evidence for word domains and phrasal juncture. In short, Chatino tone cannot be ignored on linguistic grounds, despite how daunting it may be.

But there is also a social and political context within Chatino communities for a focus on tone. In her remarks above, Emiliana articulates a desire to write Chatino. We see that this desire is widespread in all the Chatino communities we know, and that it is set against a long background of colonial discourses designating Chatino as *dialecto*, unwritten, and even unwriteable. Indeed, without analysis, training, or orthographic conventions for writing tone, this slur might even seem true. We found that by showing that Chatino, with its tones, could be written, we engaged many people's interest. Linguistic and community agendas converged powerfully, giving us a strong practical basis for connection with others in Chatino communities interested in promoting the language and culture.

After briefly introducing the Chatino language family and its context (§2), we narrate our path of discovery (§3), including our beginning work on San Juan Quiahije Eastern Chatino, Emiliana's variety, our expansion to the typologically quite distinct San Marcos Zacatepec Eastern Chatino, and the formation of the Chatino Language Documentation Project. We then (§4) give a catalog of methods we used in that and other work which we can recommend, discussing advantages and limitations of each; and showing how they extended our understanding of the two varieties that were the focus of §3, as well as of two others. In §5 we discuss our experience and methods combining research, speaker training, and language activism. We end with some general conclusions (§6).

Underlying our work and methods are a few basic principles. First, we believe and hope to show that progress is achieved through the interplay among native speaker and non-speaker perspectives, such as took place in our work with each other, and with other speaker and non-speaker collaborators. Second, we place a strong emphasis on community training, and see the collaboration that comes from it as a crucial source of new ideas and of idea testing. Third, we see the study of tone as advancing by means of a range of descriptive and documentary linguistic research activities, including introspection, hypothesis-testing, natural-speech recording, transcription, translation, grammatical analysis, and dictionary

making. Fourth and finally, we see the simultaneous study of many varieties within a close-knit language family as a way to leverage progress as well as to understand tones, tonal systems, and the roles they play in dynamic, historical terms.

2. THE CHATINO LANGUAGE FAMILY. The Chatinos are subsistence farmers and pastoralists who traditionally inhabit a small part of a mountainous area in Oaxaca, Mexico, that lies between the valley of Oaxaca and the Pacific coast, and is contained within a quadrant from 15º39' to 16º 35' N latitude and from 97º 04' to 97º40' W longitude. The Chatino population in 2008 was about 50,000.

- Otomanguean (Many subfamilies)
  - Zapotecan
    - Zapotec (Many varieties)
    - Chatino
      - Zenzontepec Chatino [ISO 639-3 czn] (ZEN)
      - Coastal Chatino
        - Tataltepec Chatino [cta] (TAT)
        - Eastern Chatino
          - San Juan Quiahije Eastern Chatino [ctp] (SJQ)
          - Santiago Yaitepec Eastern Chatino [ctp] (YAI)
          - San Marcos Zacatepec Eastern Chatino [ctz] (ZAC)
          - Santa Lucía Teotepec Eastern Chatino [cya] (TEO)
          - Santa María Yolotepec Eastern Chatino [cly] (YOL)
          - San Miguel Panixtlahuaca Eastern Chatino [ctp] (PAN)
          - (About 9 others)

TABLE 1: The Chatino languages: External and internal relationships

Chatino is a shallow language group coordinate with Zapotec in the Zapotecan family of Otomanguean (Kaufman 1993, Upson & Longacre 1965), as shown in Table 1. Over half of contemporary Chatinos are speakers of 17 or so distinct local varieties of Chatino, many of which are mutually unintelligible. Almost a century ago, Franz Boas (1913:78) recognized that these village language varieties could be classified into three main "dialects" (which we consider distinct languages): Zenzontepec Chatino, Tataltepec Chatino, and all the rest, which we call Eastern Chatino. Campbell (2013) sustains Boas's classification by demonstrating, based on shared innovations, that all the Eastern Chatino varieties form a distinct genetic unit (but he leaves flat the considerable diversity that it contains).[2]

[2] ISO 639-3 codes slot the Eastern Chatino varieties into four groupings (ctz, ctp, cya, cly), described in Pride & Pride (2004) and based on Lewis et al (2013), who cite evidence from mutual intelligibility tests among some of the varieties. However, that same data was also cited in Egland 1978 [2006]:10-11, who shows it not to sustain the [ctp] grouping. Moreover, although intelligibility data is useful, it still does not constitute proof for genetic subgrouping, which must be based on evidence of shared innovations, in keeping with the comparative method. So far no one has turned up such evidence, and therefore we agree with Campbell (2013:417) that at this point, any subgrouping claims within Eastern Chatino "should be rejected until proven valid with the comparative method".

He furthermore shows that Eastern Chatino and Tataltepec Chatino form a proper subgroup, Coastal Chatino, that is coordinate with Zenzontepec Chatino, the family's farthest outlier.

The varieties are named for the localities in which they are spoken and vary considerably with respect to their populations and vitality: Table 2 gives a basic overview for the main varieties we will discuss.

Variety	Locality type	Population	Speakers
ZEN	Large municipality, many agencies	17,897	~8000[3], incl. children
TAT	Municipality, main town only	2621[4]	<500, >35 y.o.
SJQ	Small municipality	3628	most, incl. children
YAI	Small municipality	4122	most, incl. children
ZAC	Agency	1034	<300, >45 y.o.
TEO	Several agencies & outlying areas	3329	~2600[5], incl. children
YOL	Agency	461	most, incl. children
PAN	Small municipality	6161	most, incl. children

TABLE 2: Community contexts of the Chatino varieties in focus. Municipalities (*municipios*) are county-like units which contain a main town, and in some cases, also satellite towns designated as agencies (*agencias*), which are administrative subunits of municipalities. Population statistics are from INEGI 2012, based on the 2010 national census; speaker counts are based on estimates by ourselves and our colleagues.

3. PATHS INTO CHATINO TONE: A NARRATIVE ACCOUNT. We began in 2003 with a focus on the tonal system of SJQ Chatino. In 2005, we branched out to a second—but typologically quite different—Eastern Chatino tonal system, ZAC. In this section we trace these early paths (SJQ in §3.1 and §3.2, ZAC in §3.3), describing our methodological steps and missteps. We show how our ideas about each system evolved; and give brief descriptions of the systems as they came into view. We end by describing how this work led us to join with others, forming the Chatino Language Documentation Project and tackling tone in other Chatino varieties.

3.1. INITIAL WORK ON SJQ CHATINO. Our work on SJQ Chatino tone began with a Spring, 2003 "independent study" class aimed at reading the literature on Chatino and ascertaining how SJQ Chatino—then undescribed—fit in. We read Rasch's (2002) Yaitepec (YAI) Eastern Chatino grammar (where tone is marked only in the tone section, pp. 38-49);

[3] Eric Campbell, p.c.; The population count covers the entire municipality, which includes agencies that are not ethnically Chatino; thus the preservation rate is better than 50%; at the same time, Chatino is moribund in some agencies.

[4] Ryan Sullivant, p.c., based on clinic records for the main town and surroundings.

[5] Justin McIntosh, p.c.; the population count is based on just the agencies where TEO is spoken, indicating a high rate of preservation.

and two earlier treatments, Pride (1963) and Pride & Pride (1997), where tone is marked throughout. Our sources marked tones using '1', '2', '3', and '4', where '1' was highest and '4' lowest (the so-called 'Mesoamerican' notation system, opposite to the more widespread system where '1' is lowest and '5' highest, cf. Yip 2000:18-21). Contour tones were marked by combinations, thus '14' was a steeply falling tone and '41' a steeply rising tone.

We were quite quickly able to adapt the segmental orthographic approaches of our sources to SJQ; Emiliana made a specific proposal in Cruz (2004). Tone was another matter. As in YAI, words (except compounds and certain loans) were monosyllabic; and each monosyllabic word bore one of apparently very many distinct tones: some level, some rising, and others falling. But there was little clear connection between their tonal transcriptions and what we were hearing for SJQ.

Still, the YAI work led us to regard the monosyllabic word as the tone bearing unit; and to expect many tones. We then tried to assemble minimal sets; but to our dismay, we usually could only find minimal sets of three or four words at most—none large enough to cover the large tonal inventory we thought we were hearing. It was frustrating—Tony recalls arranging and rearranging the match-up points among the sets that we had but not being quite convinced of a good fit. Emiliana describes the process as 'blurry'; she was perplexed that she could hear and produce the tones perfectly, and yet not reliably say if they were level, rising, or falling. She found it valuable, however, to listen to other speakers and compare their speech to her own. And she began transcribing recorded speech, both with and without tone, as a way of forging ahead. Interestingly enough, when we look back at those transcriptions we are surprised at how good they were, all things considered.

In summer of 2003, we went to SJQ and another Eastern Chatino community—Santa Lucía Teotepec—to teach what we had learned, but we focused on segmental issues rather than tone (nor were we equipped to tackle the very different Teotepec tone system (now described in McIntosh 2010). We were joined there by Hilaria Cruz, Emiliana's sister, and on the basis of that experience, Hilaria made plans to apply to the Ph.D. program in linguistics at the University of Texas, which she entered in 2004. From that point on we had two native speaker linguists working on SJQ tones, and we believe their interaction and cross-checking on both theories and data was a key advantage.

Once back in Austin, Emiliana continued to transcribe; and we collected more lexicon, sorting it into groups of words that appeared to have the same tone, then checking and rechecking them for similarity. Our final breakthrough came in May, 2004, just before leaving for a second summer of teaching in SJQ. During several mornings at a café hashing out our analysis, we finally recognized that two almost identical-seeming mid tones were subtly different: *kta*^{LM} 'chepil' (*Crotalaria longirostrata*, an herb) has a very slightly rising mid-ish tone which we eventually represented as /LM/, while *kta*^{M} 'flour' has a mid-ish tone that falls ever so slightly, eventually represented as /M/. They are contrasted here: 🔊 see also §4.8 for phonetic discussion. With that, we had solved the last perplexing surface contrast. Table 3[6] shows our analysis, which in all distinguished

[6] Chatino segments are represented in this article using IPA symbols except as follows: <x> = [ʃ], <ch> = [tʃ], <ty, dy, ny, ly> = lamino-postalveolars [t̪ , d̪ , n̪ , l̪] , <y> = [j], <kw> = [kʷ], <j> = [h], and ogonek <˛> marks nasalized vowels, and doubling of the vowel symbol marks vowel length.

nine tones that contrast in isolation context.[7] And we felt ready to teach speakers who wanted to write tones.

Tone type	Tone	Examples
Level	H	kwna^{H} 'snake', skwa^{H} '*mole*', skwa^{H} 'Easter', nsne^{H} 'is sprinkling'
	M	kta^{M} 'flour', kwna^{M} 'thief', ke^{M} 'flower'
	L	kta^{L} 'tobacco', yja^{L} 'tortilla', nda^{L} 'bean', kna^{L} 'mirror', ke^{L} 'rock'
Rising	M0	si^{M0} 'turtle', kya^{M0} 'tomorrow', ta^{M0} 'will give'
	MH	sʔę^{MH} 'scorpion', ke^{MH} 'your (SG) head'
	LH	ta^{LH} 'shrimp', ke^{LH} '(his/her) head'
	LM	kta^{LM} 'chepil', kwa^{LM} 'swept'
Falling	HL	tʔwa^{HL} 'cold', ntę^{HL} 'people'
	ML	tʔwa^{ML} 'forty', skwa^{ML} 'six', ntyʔą^{ML} 'will see'

TABLE 3: First analysis of surface-distinct tones in SJQ Chatino, May, 2004. Superscripted letters L, M, H, 0 mark low, mid, high, and super-high tone levels; combinations of letters mark contours. Nine distinct tone patterns were identified and classified as level, rising, or falling. (However, in our original analysis, tones were represented with numbers, and the tone designated as /LM/ was treated as a level tone in between /L/ and /M/).

The students learned quickly. Emiliana found it effective to give them charts like Table 3, identifying one word from each tone class as an exemplar or prototype for testing the tone of a 'new' word. For example, *kta^{LM}* 'chepil' and *kta^{M}* 'flour' might be taken as the exemplars for their respective tone categories, so that a student, confronted by a new mid-ish-tone word s/he was unsure of, could speak the word beside the exemplars to determine which was the better match.

After returning to Austin, we received confirmation for our analysis of an unexpected kind. Jeff Rasch wrote us that he and Martín Suárez Martínez of Yaitepec had worked all summer and arrived at a completely new analysis of YAI tones, saying it superseded what was in his dissertation; he sent us recordings and transcriptions of about 150 words, grouped according to each tone they had identified. To our amazement, his groups corresponded almost perfectly to our own (with a few splits and mergers). The "coincidence" was such that we each knew the other had to be on the right track.

3.2. DISCOVERING SJQ CHATINO TONE SANDHI. In late 2004, we stumbled on what we called the *ʔi*-test, named for the 3rd person possessive marker *ʔi* 'his/her/its/their', whose pitch in isolation was [L] but whose pitch changed depending on the tone of the possessed noun it followed. For example, we found that when preceded by *kta^{LM}* 'chepil', the tone of *ʔi* sounded like the [ML] found in words of the /ML/ group in Table 3; but when preceded

[7] In fact there are 11 surface tones, but we missed two of them: a rising L0 that is restricted to certain first person singular verb and possessed-noun forms; and a falling 0L that is restricted to a few interjections (see Table 4 in §3.2).

by *kta*^{M} 'flour', its tone sounded like the [H] of the /H/ group. This is shown in (1) and the accompanying sound clip:

(1)	a.		kta	+	ʔį	-->	kta	ʔį	'his chepil'
			chepil		his				
		Phonemic:	/LM/		-				
		Phonetic:	[LM]		[L]		[LM]	[ML]	
	b.		kta	+	ʔį	-->	kta	ʔį	'his flour'
			flour		his				
		Phonemic:	/M-(H)/		-				
		Phonetic:	[M]		[L]		[M]	[H]	

Phonemically (as shown in (1)) we guessed that *ʔį* was toneless, but realized with a [L] tone in isolation; that its [ML] sound in (1)(a) was due to assimilation after the preceding [LM]; that its [H] sound in (1)(b) was due to an UNLINKED or FLOATING /H/ tone associated with the preceding /M/ word that then linked to the toneless *ʔį* to give it a realization as [H]; and that phonemically, the 'flour' set bore a tone sequences /M-(H)/, where parentheses mark the unlinked tone.

The *ʔį*-test was a breakthrough because *ʔį* not only showed up as [ML] and [H], respectively, after the 'chepil' and 'flour' sets as in (1); following other sets it variously showed up as [L], [ML], [MH], or [0], each serving as a signature for the preceding tone and making its "diagnosis" much easier. Moreover, the test could be used with almost any noun, as well as with verbs taking dative complements since *ʔį* is also the dative preposition ('to him/her/it/them'). It also proved an excellent teaching tool. Beginning in 2005, we combined the exemplar-matching approach with the *ʔį* test: for example, when in doubt about a mid-ish tone word, we had the students place *ʔį* after the word and then compare the result to *kta*^{LM} *ʔį* ^{ML} *'his chepil'* vs. *kta*^{M} *ʔį* ^{H} 'his flour' to seek a match. We found children as young as 8 years old were very capable of performing this test, and it helped them quickly become proficient at tone discrimination.

Beyond diagnosis, the *ʔį*-test and several other, similar tests revealed that certain groups which sounded the same in isolation had internal divisions, for example:

(2)	a.		skwa	+	ʔį	-->	skwa	ʔį	'his *mole'*
			mole		his				
		Phonemic:	/H/		-				
		Phonetic:	[H]		[L]		[H]	[ML]	
	b.		skwa	+	ʔį	-->	skwa	ʔį	'his Easter'
			Easter		his				
		Phonemic:	/H-(0)/		-				
		Phonetic:	[H]		[L]		[H]	[0]	

Although *skwa*^{H} *'mole'* and *skwa*^{H} 'Easter' sounded the same to us in isolation (sound clip in (2)(a)), each affected *ʔi̱* differently (sound clip in (2)(b)); and this led us to place them in two different tonal classes, which we represented as /H/ vs. /H-(0)/. After the 'mole' class, as in (2)(a), the toneless *ʔi̱* appeared to assimilate to the preceding /H/ as [ML]; whereas after the 'Easter' class, as in (2)(b), an unlinked super-high tone (0) linked to the toneless *ʔi̱,* rendering it as [0].

We also discovered that some members of our putative /L/ group—to which we assumed *ʔi̱* belonged—underwent the same contextual changes as *ʔi̱*, while others remained as /L/ in those contexts. That led us to believe that variable-L words like *ʔi̱* were inherently toneless, while the invariant-L words actually bore a fixed /L/ tone. This is shown in (3) for *yja* 'tortilla' vs. *nda* 'bean'. Both words sound identically [L] in isolation (first sound clip in (3)). But after /H/, supplied by the preceding preposition *ʔo*^{H} 'with', 'tortilla' becomes [ML] after /H/ (like *ʔi̱* in (2)(a)); while 'bean' remains as [L] in the same context (second sound clip in (3)). We therefore represent 'tortilla' as toneless, and 'bean' as bearing tone /L/:

(3)	a.		ʔo	+	yja	-->	ʔo	yja	'and tortillas'
			with		tortilla				
		Phonemic:	/H/		-				
		Phonetic:	[H]		[L]		[H]	[ML]	
	b.		ʔo	+	nda	-->	ʔo	nda	'and beans'
			with		bean				
		Phonemic:	/H/		/L/				
		Phonetic:	[H]		[L]		[H]	[L]	

Patterns like these eventually led us to posit 14 different tone classes in all. Once we had these classes, we considered the pairwise combinations of them—that is, 14 x 14, or 196 in all. From that, we got an idea of what general tonal rules operated from one word to the next, including the assimilation and linking rules implicit in (1)-(3). We presented this in Cruz & Woodbury (2006). Table 4 below shows the 14 classes, where each (non-toneless) class is marked with a linked tone or, in the case of /L-0/, a pair of linked tones (which create a contour in isolation but break up when a toneless word follows). For some classes, there follows one of three kinds of unlinked (floating) tone: ((0), (H), or (MH)).

We see that the two stages of analysis represented by Tables 3 and 4 closely track the stages of tone discovery posited by Hyman (2010:179):

(i) In Stage I the goal is to determine the surface tonal contrasts. This is first done by considering words in isolation.

(ii) In Stage II the goal is to discover any tonal alternations (morphotonemics) which may exist in the language. This can be done either by putting words together to make short phrases or by eliciting paradigms.

(iii) Stage III comprises the tonal analysis itself, the interpretation of what has been discovered in Stages I and II. At this point one typically draws on theoretical constructs and formal devices, e-g. autosegmental notation, to help express one's insights as to how the tone system works.

Tone type	Tone sequence	Examples	Set
Level	H-(0)	skwa$^{H-(0)}$ 'Easter', nsne$^{H-(0)}$ 'is sprinkling'	D/K
	H	kwna^{H} 'snake', skwa^{H} '*mole* (sauce)'	E
	M-(H)	kta$^{M-(H)}$ 'flour', kwna$^{M-(H)}$ 'thief', ke$^{M-(H)}$ 'flower'	C
	L	kta^{L} 'tobacco', nda^{L} 'bean', ke^{L} 'rock'	A2
	toneless	sntę̨ʔ 'my cloth', yja 'tortilla'	A1
Rising	M0	si^{M0} 'turtle', kya^{M0} 'tomorrow', ta^{M0} 'will give'	H
	MH	sʔę̨^{MH} 'scorpion', ke^{MH} 'your (SG) head'	I
	L-0	skwą̨$^{L-0}$ 'I threw', kna^{L-0} 'I will cry'	1SG
	LH	kta^{LH} 'shrimp', ke^{LH} '(his/her) head'	G
	LM	kta^{LM} 'chepil', kwa^{LM} 'swept'	F
Falling	0L-(0)	tyu$^{0L-(0)}$ 'cute!', tyi$^{0L-(0)}$ 'dear!'	B!
	HL-(0)	tʔwa$^{HL-(0)}$ 'cold', ntę$^{HL-(0)}$ 'people'	B1
	ML-(MH)	nty ʔą̨$^{ML-(MH)}$ 'will see', nʔne$^{ML-(MH)}$ 'does'	B2
	ML	tʔwa^{ML} 'forty', skwa^{ML} 'six'	J

TABLE 4: Analysis into 14 lexical tone categories based on Cruz & Woodbury 2006 (where we used numbers instead of letters to mark tone), and Cruz 2011. Parentheses mark unlinked floating tones. Toneless words sound [L] by default. The letters given in the 'Set' column are used to designate Eastern Chatino tonal cognate correspondence sets that we will refer to later on.

Table 3 matches Stage I; while Table 4 matches Stage II, with a little of Stage III to the extent we were able to offer perspicuous representations and rules.

And yet, the process seemed anything but linear. We still ask ourselves: "How did it take us so long?" "Why were we so disorganized?" And "Why did we worry so much about defective minimal pairs?" Yet we are still amazed we got as far as we did. Tony for one did not think he could handle a system with so many tones. And if our path was haphazard, we at least see in it some seeds of what we advocate in tone study, namely, learning and corroborating through training; a mix of introspection, listening, text analysis, and experimentation; and seeking ideas and corroboration from work on a related language (which failed at first but succeeded in the end).

Perhaps we succeeded because we had absolute confidence that tones can (eventually) be solved and accounted for. Emiliana describes feeling sure that Chatino had tones, and because it did, that they must be orderly and discoverable. Tony describes the same feeling, believing that tone has to be as orderly as anything else in phonology. We are pleased to find both of these principles in Hyman (2010).

3.3. BRANCHING OUT TO THE EASTERN CHATINO OF SAN MARCOS ZACATEPEC. In summer of 2004, we met a teacher from San Marcos Zacatepec (ZAC). We asked about her Chatino and were thrilled at the extent to which it preserved non-final vowels not present in SJQ Chatino (the comparative Table 12 shows this). We reasoned that ZAC Chatino might hold clues about what Chatino tone looked like before being squeezed onto a single syllable, as in SJQ.

Together with Emiliana's sister, Hilaria Cruz, we visited ZAC in summer, 2005, recording natural speech and eliciting tonal contrasts using a word list based on our own

lexicon, on the Yaitepec cognate list Jeff Rasch had given us, and on the 251-item (non-tone-marked) Chatino cognate list of Upson & Longacre (1965). We promised the authorities in ZAC that we would come back the next year with an orthography that included tone. We also did follow-up work with ZAC speakers in SJQ.

Although we got a lot of data in a short time, the words were uttered in isolation and were often overlain by list intonations and other distractions. But by studying such material from several speakers, Hilaria and Tony slowly began to hear tonal differences. They also assumed that the tonal system in ZAC would probably show regular sound correspondences to the systems of SJQ and Yaitepec, so they listened for a signature tone in each tonal correspondence set. Despite the obvious risk of circularity, in the end they had convinced themselves they could hear Zacatepec tones independently; and that the cognate matches to SJQ and Yaitepec Chatino were systematic and robust. In H. Cruz & Woodbury (2006) they laid out their understanding of Zacatepec tonal contrasts for words in isolation, i.e., Hyman's (2010) Stage I, shown in Table 5.

The analysis covered both disyllabic and monosyllabic words. In the disyllabic words, two-tone sequences linked one tone per syllable; in the monosyllabic words, both tones linked to the single syllable. Vowels in monosyllables were phonetically rather long, but were phonemicized as short since no length contrasts were noted among monosyllables (this was wrong, as will be seen in §4.1).

We did indeed return to ZAC a year later with an orthography that included tone. During that visit Stéphanie Villard, a beginning Texas graduate student, participated in teaching the orthography and began long term work on ZAC Chatino, joined since then by Tony for occasional visits to work further on tone. Subsequent work (Villard 2008; Villard & Woodbury 2012) confirmed all but one of the category divisions in Table 5 (and turned up several more), mostly vindicating the utility of the cognate-driven method, which is further discussed in §4.6. But it also radically recast the representation of ZAC tone and prosody, as will also be seen in §4.

ZAC	**Examples**	**SJQ**	**Set**
3-4	kya^{3}ja^{4} 'tortilla', ti^{3}la^{4} 'night', nda$^{3-4}$ 'bean', nkǫ$^{3-4}$ 'turtle'	-, L, HL	A,B
4-2	ki^{4}ta^{2} 'flour', ke$^{4-2}$ 'flower'	M	C
4-2'	su^{4}ká^{2} 'sugar', chi^{4}lyó^{2} 'knife' (´marks strong stress)	H-(0)	D,K
3-1	ya^{3}na^{1} 'copal', nką$^{3-1}$ 'coconut'	H	E
4-21	lu^{4}ti^{21} 'rope', ka^{4}la^{21} 'dream'	LM	F
3-24	su^{3}kwan^{24} 'corn dough', kǫ$^{3-24}$ 'sweet potato'	LH	G
[3]-41	yu^{3}sį^{41} 'turtle', kya^{41} 'tomorrow'	M0	H
[3]-14	to^{3}yo^{14} 'hole', lo$^{3-4}$ ke^{14} 'on the rock' (cf. ke$^{3-4}$ 'rock')	MH	I
2-4	tsu^{2}na^{4} 'three', ka$^{2-4}$ 'nine'	ML	J

TABLE 5: Zacatepec surface tones according to H. Cruz & Woodbury 2006, where '1' was highest and '4' lowest; Lexical 'tones' were really tonal sequences, with each tone separated by a hyphen. Square brackets [] marked tones that associated only with a penultimate syllable and did not show up in monosyllables. The corresponding SJQ tone class (based on Table 4) is indicated at right, followed by letter designations (A,B,C...) that were assigned to each putative cognate correspondence set.

3.4. STUDYING TONE IN THE REST OF THE CHATINO LANGUAGES. In 2004 or 2005, we, along with Hilaria, began to call our work the *Chatino Language Documentation Project.* Our goals were at once scientific, humanistic, and activistic. We wanted to document natural speech in many different settings in Chatino communities; we wanted to achieve the phonological and lexico-grammatical understanding necessary for transcribing, translating, and grammatically analyzing these materials and for describing and understanding Chatino linguistically; we wanted to study historical relationships among the Chatino languages and varieties; we wanted to promote and facilitate the writing of Chatino and the teaching of Chatino to Chatino children and adults; and we hoped to somehow emphasize Chatino linguistic and political unity even as we studied and taught its significant internal diversity.

In that ambitious context, the project grew in scope and complexity. We obtained several grants from the Endangered Language Documentation Project, beginning in 2007. We were joined by two senior colleagues: Jeff Rasch, who continued to explore YAI; and the late Thom Smith Stark of the Colegio de México, an experienced Otomangueanist and tonologist, who worked with us on SJQ (and whose acceptance and use of most of our SJQ Chatino tone analysis was for us a key confidence-builder). We also learned from him some methods which, in retrospect, would have simplified our prior work. We were also joined by four (non-Chatino) University of Texas Ph.D. students, and they made it possible for us to branch out to other Chatino languages: Stéphanie Villard for ZAC Eastern Chatino, as already mentioned; Justin McIntosh for Teotepec Eastern Chatino; Ryan Sullivant for Tataltepec Chatino, the highly endangered variety that is coordinate with the Eastern Chatino group; and Eric Campbell for Zenzontepec Chatino, the family's farthest outlier. Each has taken the broad scientific, humanistic, and activist perspective of the project in approaching the variety they study. And each has grappled with a complex Chatino tonal system that is related to the one we have outlined for SJQ Chatino, and yet substantially different. We will draw on all of their experience in our discussion and evaluation of methods in §4.

We also made it a goal to achieve at least a preliminary analysis of all 15 of the Eastern Chatino tonal systems. By 2013 we had visited and worked in all but one of them. Since 2011, we have done that as part of a program of linguistic training of young people who are speakers of different Eastern Chatino varieties. In §5 we discuss some research and teaching methods arising in that work.

4. A CATALOG OF DISCOVERY METHODS. We turn now to some of the methods we recommend based on our experience with them.

4.1. METHOD A: (I) SORT WORDS INTO GROUPS BY PROSODIC SHAPE; (II) GROUP SAME-TONE WORDS IN EACH SHAPE CLASS; (III) IF POSSIBLE, MATCH THE GROUPINGS ACROSS SHAPE CLASSES. When he visited us in Austin in 2007, Thom Smith Stark demonstrated his first-pass approach to a "new" tone language: in this case it was Betaza Zapotec, the language of Amador Teodocio Olivares, who was then a Texas graduate student. Together with Amador, Thom quickly put together a list of words—mostly nouns--and wrote them on slips of paper. He quickly sorted the slips by prosodic shape—into single open syllables, single closed syllables, double open syllables, and so on. Then, starting with the smallest non-function words, he sorted the slips into sound-alike piles. Whenever anyone said "these ones are mid-hi to low, these ones are high to mid-low,"

Thom smiled and said, "Never mind about that; as long as the tone sounds the same in each pile!" Once we had done that for all the prosodic groups, we started linking the member-piles across groups. Only at the end was it time to place a name on each group.

The method is essentially the same one presented by Pike (1948:48-54), discussed by Yu (this volume, Sec. 2.1) and Mazaudon (this volume, Sec. 3.2), and implemented in the software program TONEY (Bird, this volume). It has three parts (i)-(iii), as indicated above. At the heart is part (ii), which we will term 'Saussurian' in that it focuses on establishing contrast before probing phonetic content[8]. Parts (i) and (iii) are important only if there are prosodic differences among words. In the case of SJQ Chatino, there was just one easy-to-recognize prosodic shape: the monosyllabic (non-compound) word.[9] Therefore, our only task was to sort monosyllabic words into Saussurian groups, which we did.

But in the case of ZAC Chatino, it turned out that non-compound phonological words had all the prosodic shapes shown in Table 6. Most simple stems are dimoraic; most inflected verbs are dimoraic or trimoraic; whereas monomoraic words are quite rare and largely confined to function words. Our early analysis (Table 5) missed that vowel length is distinctive in final syllables (the tonological importance of which is underscored by Remejsen (this volume, Sec. 2) ; and it took note only of monosyllables and disyllables.

	Monomoraic	**Dimoraic**	**Trimoraic**
Monosyllabic	/σ/ | μ	/ σ / /\ μ μ	--
Disyllabic	--	/σ σ/ | | μ μ	/σ σ / | /\ μ μ μ
Trisyllabic	--	--	/σ σ σ/ | | | μ μ μ

TABLE 6: Prosodic shapes of non-compound words in ZAC Chatino, where σ = syllable, μ = mora; based on Villard & Woodbury 2012.

Therefore, applying Smith Stark's method to ZAC—as in Table 7—all three parts were relevant. (i) Each column showed a distinct prosodic type (but the trimoraic disyllable option is excluded). (ii) Within each column, words were sorted into six groups (there were more groups on a following page). And (iii), the rows represented judgments of correspondence from one column/prosodic type to the next. Finally, the first column ('Tonos') was an attempt to summarize and represent the underlying tonal sequence responsible for each entire row.

The Table 7 analysis of ZAC improved on that in Table 5. Table 7 represents the simi-

[8] Cf. de Saussure's (1972:166) famous dictum: "Dans la langue il n'y a que des différences, sans termes positifs." Pike 1948:53 expresses this by posing the question, "In a particular frame are the substitution items the same in pitch or are they different?"

[9] Syllables might have been subdivided into /ʔ/-final vs. vowel final, or nasalized vs. non-nasalized. But it turned out that the tone system was the same in all cases (unlike, e.g., Cantonese, where final /ʔ/ affects the inventory).

larity between dimoraic disyllables vs. dimoraic monosyllables as following from the idea that the mora is the tone bearing unit (TBU), whereas in Table 5, the tones are doubled on putatively monomoraic (but long sounding) monosyllables. Likewise, Table 7 shows that while dimoraic monosyllables are capable of linking to two tones, monomoraic monosyllables link to just one tone, further confirming the mora as TBU.

Regarding step (iii), the groupings were matched on the basis of the sequences in trimoraic words. For each trimoraic sequence of tones *a-b-c*, there is a dimoraic sequence *b-c*; for each dimoraic sequence there is a monomoraic sequence *c*. In only one case—where the final tone is '2'-- is it impossible (based on just these data) to tell exactly to which row the monomoraic words belong.[10]

	CV		CV.CV		CVV		CV.CV.CV	
TONOS								
[3]	[3]		[3–3]		[3–3]		[3–3–3]	
	no	*lo que; la que*	kita	*tabaco*	kee	*piedra*	ngayako	*lo comió*
	ne7	*ellos*	kola	*viejo*	ndaa	*frijol*	ngotza7an	*lleno*
	ngôn	*tortuga*	yosin	*arena*	kii7	*fuego*	ndosanê	*lo riega*
	jrê	*rey*	kyaja	*tortilla*	tzaan	*dia*	ndikalâ	*nube*
			kalâ	*veinte*	koô	*molerá*	tikatzôn	*caliente*
			lo7õ	*vivo*	ndziĩn	*guayaba*		
			ja7wâ	*plátano*	skaân7	*su moco*		
[(2)–2]	[2]		[2–2]		[2–2]		[3–2–2]	
	kãn7	*aquel*	jnyakẽ	*su cabeza*	kĩ	*carrizo*	somilõ	*sombrero*
	chõn7	*atrás*	kwitõ	*gallina*	koõn	*camote*	yo7wityã	*ampolla*
	ngwà	*fue*	skitãn7	*su uña*	jaã7	*petate*	tichakâ	*once*
	ni7	*adentro*						
[3–2]			[3–2]		[3–2]		[3–3–2]	
			kità	*harina*	keè	*flor*	ngajinyì7	*lo pidió prestado*
			jo7ò	*santo*	kìì	*zacate*	jromêyò	*medicina*
			kwanà	*ladron*	yaà7	*su mano*	korôsì	*cruz*
			môlyà	*mula*			mindîlè	*servilleta*
			pîxò	*peso*				
			pânyòn	*rebozo*				
[(2)–1]	[1]		[2–1]		[2–1]		[3–2–1]	
	7á	*muy*	kwiná	*culebra*	koó	*abeja negra*	ngajinyán	*pidió*
	xú7	*gente grande*	kitán	*hamaca*	ngaán	*coquito*	kona7án	*mujer*
			lo7ó	*con*	tyoó7	*adobe*		
[(3)–31]	[31]		[3–31]				[3–3–31]	
	kwă	*ese*	kită	*chepil*			ngasakwẽn	*lo subió*
	chă7	*palabra*	kală	*sueño*				
	nă	*cosa*	lo7õ	*corral*				
[(3)–30]	[30]		[3–30]		[3–30]		[3–3–30]	
	pi	*guajolote tierno*	yosin	*tortuga marina*	kyaà	*mañana*	tityokwà	*doce*
			mixtyòn	*gato*	lyaà	*escapará*	tijiwì	*chiflido*
			jikwin7	*lo tragará*	maà	*mamá*	ndijinyán	*pide*

TABLE 7: Page from a handout at a 2010 workshop for ZAC speakers. The columns were organized by prosodic type; words within each column were grouped by tone pattern; and rows indicated cross-prosodic correspondences. (Tonal notation: 0= super-high, 1= high, 2=mid, 3=low; accents reflect an analysis of phonemic tone that is also shown in the lefthand column.) The tone numbers here reflect Villard's (2008) re-assessment of pitch levels, which was much more accurate than those of 2006, in Table 5.

[10] But we will see in §4.5 that such 'ambiguity' is almost always resolvable: for nearly every disyllabic sequence there is a unique monomoraic sequence that can be detected on the basis of signature floating tones shared across the set, regardless of prosodic shape.

Step (iii) was well suited to ZAC, where there is a good match across the prosodic sets. But what if this is not how the system works? When first approaching tone in Zenzontepec (ZEN) Chatino in 2007, our colleague Eric Campbell found prosodic structures like those in Table 6 (which we consider the proto-Chatino system). For monomoraic words, he discovered three tonal options, which he identified as H, M, and no tone (realized as [(M)L] unless affected by spreading or downstep rules which he formulated). For dimoraic words, however, there were seven possibilities, involving seven of the nine logically possible combination of the three options found in monomoraic words. This is shown in Table 8.

Prosodic	**Tone sequence**	**Examples**
1 mora	X	jnya ‘griddle’, tsǫʔ ‘back, behind’
	M	jnē ‘money’, tsūʔ ‘toward’
	H	jnyá ‘work’, tsáʔ ‘word’
2 moras	XX	chaja ‘tortilla’, kee ‘rock’
	XM	kwitīʔ ‘frog’, keē ‘flower’
	MH	lūtí ‘vine’, nkāą́ ‘coconut’
	HM	tánēʔ ‘fabric’, yáā ‘prickly pear’
	HX	nkwítsą ‘child’, tyáą ‘throat’
	MM	jūtī ‘your father’, ntōō ‘your face’
	XH	xikǫ́ ‘your arm’, yaáʔ ‘your hand’

TABLE 8: Tone patterns for monomoraic and dimoraic words in ZEN Chatino, where H, M, and X indicate high, mid, and no tone, respectively (from Campbell & Carleton, in press). These are also marked on vowels with acute accent, macron, and no accent.

There is no clear way to link the monomoraic and dimoraic tone classes: the three monomoraic classes are not further subdivided in ways that would provide a unique monomoraic counterpart to each of the seven dimoraic classes. It is sufficient to say that the mora is the TBU, and that for each mora, there are three tonal possibilities (aside from the two missing dimoraic patterns, MX and HH).

4.2. METHOD B: WRITE WORDS ON FLASH CARDS AND ASK SPEAKERS TO CREATE SETS OF LIKE ITEMS; THEN RECORD THE RESULTING GROUPS. This is a version of Method A, but it relies on group interaction among speakers. The cards can first be prosodically sorted, per step (i) of Method A; or the prosodic sorting—if any—can emerge from the sorting process. Hilaria Cruz, Eric Campbell, and Tony used this method on their first visit to Tataltepec (TAT) (Figure 1). Like ZAC and ZEN, TAT preserves most of the prosodic divisions shown in Table 6.

As the pictures show, ten columns of cards were created, even though the isolation tonal distinctions in question reduced to just three categories, H, L, and null (Sullivant & Woodbury 2009; Sullivant 2013), regardless of mora count. The speakers chose to include prosodic shape and final glottal presence as sorting features in addition to tone (without any hint from the linguists).

FIGURE 1. Tataltepec de Valdés, June, 2008: Top: Sisters Flavia, Petra, and Socorro Mateo Mejía, the first two of whom are retired school teachers, with (l-r) school administrator Alvino Canseco Atilano, a school aid, Hilaria Cruz and Tony Woodbury. Bottom: Flavia reads back the columns, prompted by Hilaria (Photos by Eric Campbell)

4.3. METHOD C: BUILD MINIMAL SETS. Bothered by our early difficulties in constructing and interpreting minimal sets for SJQ, we set up an online document to collect them systematically (Table 9). There is still no syllabic string for which we have found an extant word in every tone class, although *kla*, in the bottom row, has nine. When compiled accurately, the lexical items across any given row should produce a striking pattern of tonal similarity (or at least an orderly variation, if prosody, glottal stops or other factors should influence tonal realization). The phonemic analysis is finally confirmed once there are enough separate minimal sets to indicate that every tone is in contrast with every other tone.

JUEGO	Tono	SKWA		SKWAN		NTEN	
A-debil	--			skwan4	*lo desplumó*		
A-fuerte	L	skwa4	*chayote*			nten4	*loma*
B	HL-(0)			skwan14+0	*lo vamos a desgranar*	nten14+0	*gente; entra (HAB)*
B'	ML-(MH)						
C	M-(H)			skwan2	*él lo tiró*		
E	H	skwa1	*comida; te acostaste*	skwan1	*tú lo tiraste*	nten1	*zancudo; entraste*
F	LM	skwa3	*se acostó*			nten3	*blanco; entró*
G	LH			skwan42	*masa*		
H	M0					nten20	*entras (HAB)*
I	MH						
J	ML	skwa24	*seis*				
D/K	H-(0)	skwa1+0	*Pascua*				
1s	L-0			skwan4+0	*lo tiré; me acosté*	nten4+0	*entré*

JUEGO	Tono	XKWAN		SNYI		KNA	
A-debil	--	xkwan4	*lo desplumará*				
A-fuerte	L			snyi4	*humo*	kna4	*huarache, espejo*
B	HL-(0)	xkwan14+0	*coserá*			kna14+0	*llorará*
B'	ML-(MH)						
C	M-(H)			snyi2	*su pene*	kna2	*ladrón*
E	H	xkwan1	*lugar caliente*	snyi1	*tu pene*	kna1	*culebra*
F	LM						
G	LH	xkwan42	*lo arrancarás*	snyi42	*agarraste*	kna42	*buscarás*
H	M0	xkwan20	*coserás*	snyi20	*agarré*	kna20	*llorarás*
I	MH	xkwan4	*arráncalo*				
J	ML						
D/K	H-(0)						
1s	L-0	xkwan4+0	*coseré; me acostaré*	snyi4+0	*mi pene*	kna4+0	*lloraré*

JUEGO	Tono	NTʔAN		KLA		KTA	
A-debil	--	ntʔan4	*casa*	kla4	*viejo, nacerá*		
A-fuerte	L	ntʔan4	*elote*	kla4	*pez*	kta4	*cigarro*
B	HL-(0)	ntʔan14+0	*lo ví*	kla14+0	*cantará*	kta14+0	*ganado*
B'	ML-(MH)			kla24	*veinte; llegará*		
C	M-(H)			kla2~kyla2	*hondura*	kta2	*harina*
E	H	ntʔan1	*se embarró*	kla1	*telar de cintura*	kta1	*foráneo*
F	LM			kla3	*se derretirá; sueño*	kta3	*chepil*
G	LH	ntʔan42	*lo vieron*	kla42	*llegrás*	kta42	*esperarás; camarón; te bañarás*
H	M0	ntʔan20	*lo embarra*	kla20	*cantarás; se abrirá*		
I	MH	ntʔan32	*anda*				
J	ML						
D/K	H-(0)						
1s	L-0						

TABLE 9: Online document of SJQ minimal sets. The tones or tone sequences are represented with numbers, where 4 is lowest and 0 is highest. Under *juego* 'set', we note the historical stem class designation.

4.4. METHOD E: Find simple sandhi tests in order to diagnose unlinked or floating tones, toneless moras, and other features which may be hidden in isolation forms.

The SJQ possessor *ʔį* 'his/her' test shown in §3.2 is an example. Villard (2008), examining pair-wise sandhi effects in ZAC, found that word that are all [L] in isolation divide

into two groups, represented by ‘tortilla’ and ‘banana’ in (4) (both appear as [3-4] in Table 5 and [3-3] in Table 7):

(4) a. kyaja ‘tortilla’ [L-L]
b. jaʔwa ‘banana’ [L-L]

We later found a convenient test frame (5) that easily brought out the differences, shown in (6), where ‘tortilla’ is super-high throughout ([0-0]) while ‘banana’ has the pattern [0-L]:

(5) tityukwa [L-L-0] <noun> kula [L-L]
twelve old
‘twelve old <noun>s’

(6) a.

tityukwa	kyaja	kula
[L-L-0]	[0-0]	[0-0]
twelve	tortilla	old

Twelve old tortillas

b.

tityukwa	jaʔwa	kula
[L-L-0]	[0-L]	[M-0]
twelve	banana	old

Twelve old bananas

We interpreted these effects in the following way. Inspired by Campbell’s analysis of a similar pattern in ZEN Chatino, we posited a spreading rule according to which a word-final superhigh (or high) tone phonetically spreads into phonemically toneless moras to the right. Since ‘tortilla’ and ‘old’ seem to undergo this phonetic spreading, we posited that both are toneless, as shown in (6’)(a), where toneless mora positions are indicated as ‘X’ and where moras themselves are marked with superscripts for each tone (leaving toneless moras unsuperscripted).

(6’) a.

tityu^{L}kwa^{0}	kyaja	kula
/X-L-0/	/X-X/	/X-X/

b.

tityu^{L}kwa^{0}	jaʔwa$^{L\text{-}(M\text{-}0)}$	kula
/X-L-0/	/X-L-(M-0)/	/X-X/

Meanwhile, in (6)(b), the super-high of ‘twelve’ spreads only as far as the first mora of ‘banana’, whose second mora is low. We interpreted that to mean that the first mora of ‘banana’ is toneless while the second bears tone /L/, as shown in (6’)(b). However, (6)(b) also shows a surprising second effect on ‘old’: rather than reverting to its isolation [L-L] pattern, it shows a pattern [M-0]. We interpreted the [M-0] as the result of a floating tone

whose origin was 'banana'. That is, we analyzed the tonal class to which 'banana' belongs as carrying the phonemic tonal sequence /L-(M-0)/, where /L/ is linked to the final mora of the word, and (M-0) links to adjacent unlinked moras in the next word domain. This is also shown in (6')(b).[11]

A modification of the test frame then demonstrates the independence of the unlinked floating tone behavior, as in (7), where the toneless word for 'one' fails to trigger spreading effects into the target noun, leaving (7)(a) entirely [L]; but still allowing the putative unlinked tone of 'banana' in (7)(b) to link to toneless 'old':

(7) a.

tsaka	kyaja	kula
[L-L]	[L-L]	[L-L]
one	tortilla	old

one old tortilla

b.

tsaka	ja?wa$^{L-(M-0)}$	kula
[L-L]	[L-L]	[M-0]
one	banana	old

one old banana

In sum, these two related tests show that although in isolation the tones of 'tortilla' and 'banana' are similar, their sandhi behavior couldn't be more different. More generally, this and similar tests (cf. footnote 8) became general tools for diagnosing toneless moras.

4.5. METHOD E: MAKE EXHAUSTIVE SANDHI MATRICES. With a tentative analysis of distinctive tone classes, you can study their combinatory behavior in sandhi matrices, based on syntactic collocations such as number-noun, noun-adjective, verb-object, and so on. Yu (this volume, Secs. 2.3.3 and 2.4) terms this a factorial design in which the tonal class of either member can be studied as an independent variable affecting the tone of its companion word. Table 10 is such a matrix for ZAC. Note that in that matrix, *kyaja* 'tortilla' and *ja?wa*$^{L-(M-0)}$ 'banana' show up differently in many, but not all, of the cells in which they occur, depending on the lexical tone category of what precedes them. This is a key step in achieving Hyman's Stage II, since it leads to exhaustive charting of tonal alternations.

The matrices made it possible to extend the diagnosis of empty moras and unlinked floating tones, leading eventually to a Stage III analysis of ZAC Chatino lexical tone classes, shown in Table 11. It superceded the old analysis of Table 5, which is referenced for comparison.

[11] Note that *tityu*^{L}*kwa*^{0} 'twelve' shows no tone on the first mora but /L/ on the second. This is because its phonetic tonal pattern in isolation is [L-L-0], but when it is preceded by a word ending in /H/ or /0/, that tone spreads into the first mora but not into the second, e.g., *nkaji*^{M}*nya?*^{H} *tityu*^{L}*kwa*^{0} *'he ordered twelve'* has the phonetic tonal pattern [M-H] [H-L-0].

Juegos de tono:				A			B			G			C		
			VERBOS:	yako	X-X		koô	X-3!		na7ān	2-2		ngayoò	X-X-2!	
	OBJECTOS			*comió*			*molerá*			*vio*			*molió*		
A	kyaja	X-X	*tortillas*	yako	kyaja	3-3	koô	kyaja	2^{+}-3	na7ān	kyaja	3-3	ngayoò	kyaja	1^{+}%
B	ja7wâ	X-3!	*plátanos*	yako	ja7wâ	3-3	koô	ja7wâ	2-2	na7ān	ja7wâ	3-3	ngayoò	ja7wâ	1^{+}-3
G	kwitō	2-2	*gallina*	yako	kwitō	2-2	koô	kwitō	2-2	na7ān	kwitō	2-2	ngayoò	kwitō	2-2
C	kità	X-2!	*harina*	yako	kità	3-2	koô	kità	2^{+}-2	na7ān	kità	3-2	ngayoò	kità	1^{+}-2
K	môlyà	3-2!	*mulas*	yako	môlyà	3-2	koô	môlyà	2-2	na7ān	môlyà	3-2	ngayoò	môlyà	2-2
E	kwiná	2-1	*culebras*	yako	kwiná	2-1	koô	kwiná	2-1	na7ān	kwiná	2-1	ngayoò	kwiná	2-1
F	kită	X-31	*chepil*	yako	kită	3-31	koô	kită	2^{+}-21	na7ān	kită	3-31	ngayoò	kită	1^{+}-21
H	mixtyǒn	3-30	*gatos*	yako	mixtyǒn	3-30	koô	mixtyǒn	3-30	na7ān	mixtyǒn	3-30	ngayoò	mixtyǒn	2-30
B'	ngwǐxî	30-3!	*tomates*	yako	ngwǐxî	30-3	koô	ngwǐxî	30-3	na7ān	ngwǐxî	30-3	ngayoò	ngwǐxî	30-3

Juegos de tono:				E			F			H			I		
			VERBOS:	ngayoó	X-2-1		ngala7ă	X-X-31		koǒn	3-30		kōo	2-3	
	OBJECTOS			*moliste*			*tocó*			*moleré*			*moleás*		
A	kyaja	X-X	*tortillas*	ngayoó	kyaja	1-1	ngala7ă	kyaja	1-1	koǒn	kyaja	0-0	kōo	kyaja	3-3
B	ja7wâ	X-3!	*plátanos*	ngayoó	ja7wâ	1^{+}-3	ngala7ă	ja7wâ	1^{+}-3	koǒn	ja7wâ	0-3	kōo	ja7wâ	3-3
G	kwitō	2-2	*gallina*	ngayoó	kwitō	2-2	ngala7ă	kwitō	2-2	koǒn	kwitō	2-2	kōo	kwitō	2-2
C	kità	X-2!	*harina*	ngayoó	kità	1^{+}-2^{-}	ngala7ă	kità	1^{+}-2^{-}	koǒn	kità	0-2^{-}	kōo	kità	3-2
K	môlyà	3-2!	*mulas*	ngayoó	môlyà	3-2	ngala7ă	môlyà	3-2	koǒn	môlyà	3-2	kōo	môlyà	3-2
E	kwiná	2-1	*culebras*	ngayoó	kwiná	2-1	ngala7ă	kwiná	2-1	koǒn	kwiná	2-1	kōo	kwiná	2-1
F	kită	X-31	*chepil*	ngayoó	kità	1^{+}-21	ngala7ă	kità	1^{+}-31	koǒn	kità	0-31	kōo	kità	3-31
H	mixtyǒn	3-30	*gatos*	ngayoó	mixtyǒn	3-30	ngala7ă	mixtyǒn	3-30	koǒn	mixtyǒn	3-30	kōo	mixtyǒn	3-30
B'	ngwǐxî	30-3!	*tomates*	ngayoó	ngwǐxî	30-3	ngala7ă	ngwǐxî	30-3	koǒn	ngwǐxî	30-3	kōo	ngwǐxî	30-3

(gris = sin cambio de sandhi; colores significan distintos tipos de sandhi)

TABLE 10: Sandhi matrix for ZAC verb-object collocations, 2009, based in part on Villard (2008). Words remaining in gray undergo no sandhi change; colors represent various sandhi changes, including the spreading rule (pink) mentioned in §4.4, where word-final high or super-high continues through toneless moras of the next word.

The new analysis was based on the mora as TBU (see §4.1). Each tonal set has a characteristic tone sequence that aligns to whatever moras are present, as the representa tions and examples show. It distinguished the 'tortilla' class vs. the 'banana' class (Sets A vs. B). It also merged Set J—distinct in SJQ and restricted to a few numbers—into Set A: in the earlier analysis we had imagined them to be distinct from Set A—as they were in SJQ—when in fact both sets proved to be toneless in ZAC on the basis of their sandhi behavior. Finally, it posited two new floating tone sequences in addition to the /(M-0)/ sequence discussed in §4.4: /(M-L)/ and /(M-H)/.[12] The sequences might be interpreted as morphological attributes to the extent that they show functional specialization, as can be seen from the set designations: by part of speech, loan status, or by inflectional category.

Methods D and E (sandhi tests and matrices) served well for SJQ and ZAC, for Teotepec Eastern Chatino (McIntosh 2010) and for the outliers TAT and ZEN, since all have extensive sandhi. So when we undertook our survey of "new" Eastern Chatino varieties in 2011, we carefully checked word-combinations in order to diagnose sandhi patterns at

[12] These unlinked floating tone sequences were later represented as single floating tones /(0)/, /(L)/, and /(H)/, respectively. The single floating tone links to the last available toneless mora in the following word; then a second rule inserts and links an M tone to all preceding toneless moras in that word (if any). (Villard, to appear).

Tone sequence	Examples	Table 5	Set
toneless	tya ‘corn kernel’, kyaja ‘tortilla’, tsuna ‘three’, ndaa ‘bean’, nkayaku ‘ate’	3-4 & 2-4	A, J
L-(0)	nkǫ$^{L-(0)}$ ‘turtle’, jaʔwa$^{L-(0)}$ ‘banana’, ntswaa$^{L-(0)}$ ‘*piper* sp.’, ntikala$^{L-(0)}$ ‘cloud’	3-4	B (nouns)
L-(L)	ʔa$^{L-(L)}$ ‘not’, ntuna$^{L-(L)}$ ‘hears’, koo$^{L-(L)}$ ‘will grind’, ntusane$^{L-(L)}$ ‘sprinkles’	3-4	B (non-nouns)
M-(H)	ngwa$^{(H)}$ ‘was’, kita$^{(H)}$ ‘flour’, kee$^{(H)}$ ‘flower’, nkasiʔi$^{(H)}$ ‘bought’	4-2	C
M-0-L-(L)	nkwi^{0}xi$^{L-(L)}$ ‘tomato,’ nta^{M}sa^{0}ne$^{L-(L)}$ ‘is sprinkling’, nda^{M}lo^{0}o$^{L-(L)}$ ‘is taking out’	-	D
M-H	ngwa^{H} ‘you (SG) were’, ya^{M}na^{H} ‘copal’, nka^{M}ą^{H} ‘coconut’	3-1	E
LH	na^{LH} ‘thing’, luti^{LH} ‘rope’, nkalukwa^{LH} ‘swept’	4-21	F
M-M	kąʔ^{M} ‘that’, su^{M}kwą^{M} ‘corn dough’, ko^{M}ǫ^{M} ‘sweet potato’, nkayu^{M}jwi^{M} ‘killed’, kwitye^{M}eʔ^{M} ‘ant’	3-24	G
L-0	pi^{0} ‘turkey’, pi^{L}i^{0} ‘white’, yu^{L}sį^{0} ‘sea turtle’, tityu^{L}kwa^{0} ‘twelve’, kwisa^{L}a^{0} ‘mite’	[3]-41	H
M-M-L	xka^{ML} ‘other’, nkya^{M}ko^{L} ‘is eating’, xu^{M}ne^{M}ʔę^{L} ‘scorpion’, to^{M}yo^{M}o^{L} ‘hole’	[3]-14	I
L-M-(0)	wra$^{(0)}$ ‘when’, pa^{L}skwa$^{(0)}$ ‘Easter’, mansa^{L}na$^{(0)}$ ‘apple’	4-2’	K (loans)
M	nkanąą^{M} ‘I searched’, nkasalǫ^{M} ‘I spilled’, nkaloǫ^{M} ‘I took it out’	-	1SG
L-M	ntu^{L}na^{M} ‘you hear’, nkasa^{L}lo^{M} ‘you spilled’	-	2SG

TABLE 11: Tonal sequences in ZAC Chatino, based on Villard & Woodbury 2012 and Villard (to appear). The early analysis of Table 5, and the comparative set label, are given at right. The tones are analyzed as level targets /L,M,H,0/ or, in one case, a rise /LH/. Sequences consist of a linking portion (no parentheses) followed in some cases by a nonlinking, floating portion (in parentheses). The linking portion links to moras one-to-one from right to left until either moras or tones are used up, as the examples show; remaining moras, if any, are toneless. Only in monomoraic words of Set I do two independent tones link to a single mora. A few marginal sequences are not listed. [13]

[13] Mazaudon (this volume, Sec. 5) distinguishes between syllable tone vs. word tone, arguing that in Tamang ‘the domain of tone is not the syllable but the word’, because the same four tones are spread over different prosodic shapes. Chatino languages occupy interesting intermediate, and more complex positions with respect to that distinction. In ZAC, the word is the domain not of tones but of the tonal sequences; the tones themselves link to moras according to prosodic shape. The sequences represent tonal morphology and correlate with inflectional and lexical categories, whereas the tones themselves are the tonal segments. In SJQ, the word is still the domain of the sequences, but the words are all monosyllabic and the sequences are mostly unary. In ZEN, as noted at the end of Sec. 4.1 and shown in Table 8, tones link to moras without organizing themselves into specific sequences. For discussion of an historical aspect of this question, see also footnote 14.

the outset. Ironically, it was just at that point that we encountered, one after another, five varieties—San Miguel Panixtlahuaca and four others—that appeared to have little or no productive sandhi. Tones in word combinations generally sounded just as they did in isolation, or sandhi was restricted to compounds or certain parts of speech. We spent a lot of time straining our ears to hear differences that turned out not to be there, when we could have been eliciting more material.

4.6. METHOD F: USE TONE GROUPINGS FROM A LANGUAGE VARIETY THAT YOU KNOW TO PROBE FOR COGNATE TONE CORRESPONDENCES IN A "NEW" VARIETY. We indicated in §3.3 that we used what we knew of SJQ and Yaitepec (YAI) Chatino tone sets to probe ZAC. We have continued to apply this method, which is also discussed by Mazaudon (this volume, Sec. 3.7) and particularly Rice (this volume). At its simplest, the method involves taking the analysis of one language and systematically eliciting examples of each of its lexical tonal categories in another. As noted, we made a wordlist based on SJQ and on comparative materials. After working on ZAC, we amplified the list to include, for each tonal class, examples from every ZAC prosodic shape (cf. Table 6): we (rightly) suspected that these differences might be important for understanding tone even in varieties losing much of that structure.

To give an idea of what cognate correspondences look like in Chatino, consider Table 12, based on Campbell & Woodbury (2010) and subsequent work. The table shows three Eastern Chatino varieties, ZAC, SJQ, and San Miguel Panixtlahuaca (PAN), and more distant ZEN. The cognate sets are organized in terms of the now-familiar "sets" scheme which emerged from comparative work on SJQ and ZAC. With respect to prosodic structure, SJQ and PAN have reduced all words to monosyllables by losing all vowels and some consonants from non-final syllables, and by losing distinctive vowel length; while ZAC and ZEN retain the conservative Chatino prosodic patterns, with consonants, vowels, and vowel length corresponding quite well.

With respect to tone, each language sounds substantially different. Yet the sets show quite regular correspondences: they are closest for SJQ and ZAC, which only differ by a few mergers and splits; PAN is slightly more divergent; and ZEN is significantly divergent from the Eastern set.

One very interesting result of comparing SJQ and ZAC is that SJQ offers confirmation of our assertion that ZAC's tonal sequences apply to words of different prosodic lengths. For example, all the ZAC words in Set E (sequence /M-H/) come out as /H/ in SJQ, regardless of whether the ZAC pattern is monomoraic (H), dimoraic (M-H), or trimoraic (X-M-H); and the same holds for most of the other correspondence sets. In retrospect, it was quite a piece of luck that we worked on SJQ first—it gave us a very strong hint of how to aggregate the tone patterns of ZAC words with dissimilar prosodic shapes!

SJQ also made us suspect that we would find a distinction between Sets A and B—words like 'tortilla' vs. 'banana', which are clearly distinct in SJQ but the same in isolation in ZAC. As discussed in §4.3, they turned out to be highly distinct in sandhi contexts.

We also were lucky to have studied ZAC before approaching PAN in 2011. Notice that in Set G, ZAC consistently has /M-M/; SJQ consistently has /LH/; but PAN splits the set into two subgroups, /M0/ and /ML-(0)/. But knowing conservative ZAC prosodic structure, we can see that PAN's pattern is the result of a conditioned sound change: when ZAC's final vowel is short, PAN has /M0/; when it is long, PAN has /ML-(0)/, even though PAN itself does not preserve historical vowel length.

Set	Gloss	Eastern Chatino ZAC	SJQ	PAN	Zenzontepec
A	tortilla	kyaja	yja	tyjɔ^{M}	chaja
	ate (it)	yako	yku	yku^{M}	yaku
	ear of corn	tya	tya^{L}	tyɔ^{M}	lita
	old	kula	kla^{L}	kwlɔ^{M}	kula
	bean	ntaa	nda^{L}	ndɔ^{M}	ntáā
B	turtle	nkǫ$^{L-(0)}$	kǫ$^{HL-(0)}$	kǫ$^{M'}$	nkoǫ
	banana	jaʔwa$^{L-(0)}$	ʔwa$^{HL-(0)}$	jʔwa$^{M'}$	--
	will.kill	k-u-jwi$^{L-(L)}$	kjwi$^{ML-(MH)}$	kjwe$^{M'}$	k-u-jwi
	will.take	k-o-loo$^{L-(L)}$	klo$^{HL-(0)}$	kwlɔ$^{M'}$	k-u-lōó
	people	natę$^{L-(0)}$	ntę$^{HL-(0)}$	ntę$^{ML'-(0)}$	nyatę̄
	will.cry	k-una$^{L-(L)}$	kna$^{HL-(0)}$	kwną$^{ML'}$	k-unā
C	was	nkwa$^{M-(H)}$	nkwa$^{M-(H)}$	nkwɔ^{ML}	nk(a)ā
	flower	kee$^{M-(H)}$	ke$^{M-(H)}$	ke$^{ML-(H)}$	keē
	flour	kita$^{M-(H)}$	kta$^{M-(H)}$	ktɔ$^{ML-(H)}$	ketā
	dog	xuniʔ$^{M-(H)}$	xneʔ$^{M-(H)}$	xnęʔ$^{ML-(H)}$	jnēʔ
D	is.heating (it)	nta^{M}kwa^{0}tsǫ$^{L-(L)}$	ntsǫ$^{H-(0)}$	ntsǫ$^{0'}$	nte-katsǭ
	is.sprinkling	nta^{M}sa^{0}ne$^{L-(L)}$	nsne$^{H-(0)}$	nsnę$^{0'}$	nte-senē
	tomato	nkwi^{0}xi$^{L-(L)}$	nxi$^{HL-(0)}$	mxe^{M}	nkwīxí
E	were.2SG	nkwa^{H}	nkwa^{H}	nkwɔ^{H}	nkw(a)á
	snake	kwi^{M}na^{H}	kwna^{H}	kwnąn^{H}	kwénā
	coconut	nka^{M}ą^{H}	nką^{H}	nkąn^{H}	nkāá꜀
	shelled (corn)	nka-su^{M}kwaʔ^{H}	skwaʔ^{H}	mskwaʔ^{H}	nka-súkwāʔ
F	this; that	kwa^{LH}	kwa^{LM}	kwɔ^{LM}	kwá
	rope; vine	luti^{LH}	ti^{LM}	ti^{LM}	lūtí
	cried	y-una^{LH}	yna^{LM}	ynąn^{LM}	y-ūná
G	pig	ku^{M}weʔ^{M}	kweʔ^{LH}	kwɛʔ^{M0}	kuweʔ
	saw (it)	na^{M}ʔą^{M}	nʔą^{LH}	nʔąn^{M0}	nkā-naʔą
	ash	ji^{M}i^{M}	ji^{LH}	ji$^{ML-(0)}$	jii
	ant	kwityeʔ^{M}	ktyeʔ^{LH}	kwtyɛʔ$^{ML-(0)}$	kwiteeʔ
H	tomorrow	kya^{L}a^{0}	kya^{M0}	kya^{LH}	kii
	cat	mi^{L}xtyǫ^{0}	xtyǫ^{M0}	xtyǫn^{LH}	mixtʸu
I	scorpion	xu^{M}ne^{M}ʔę^{L}	sʔę^{MH}	sʔęn^{0}	jneʔę
	your (SG) head	jnya^{M}ke^{L}	ke^{MH}	ke^{0}	īkē
	is.seeing (it)	nta^{M}-na^{M}ʔą^{L}	ntyʔą^{MH}	nʔąn^{0}	ntē-naʔa
J	ten	tii	ti^{ML}	ti^{H}	tíi
	forty	tuʔwa	tʔwa^{ML}	tʔwɔ^{H}	túʔwa
K	machete	ma^{L}xti$^{M-(0)}$	xtyi$^{H-(0)}$	xtyi$^{ML-(0)}$	ma(s)tī
	apple	mansa^{L}na$^{M-(0)}$	sna$^{H-(0)}$	nsnąn$^{ML-(0)}$	mantsanā
1SG	took.out.1SG	nka-loǫ^{M}	lǫ$^{L-0}$	nkwlǫn^{M}	nkā-lōó=ō꜀ʔ
	sat.1SG	nku-tukwą^{M}	kwą$^{L-0}$	rkwąn^{M}	nku-tūkwá=ā꜀ʔ

TABLE 12: Tone class correspondences among four Chatino languages, organized in terms of the Eastern Chatino correspondence sets. Data based on Villard & Woodbury 2012 (ZAC), Cruz 2011 (SJQ), Cruz et. al. 2012 and Kingston & Woodbury 2014) (PAN), Campbell & Carleton in press (ZEN).

Furthermore, our knowledge of Set B in SJQ and eventually ZAC allowed us to understand some perplexing patterns in PAN. PAN splits Set B words into two subsets: /M'/, merging or nearly merging with Set A; and /ML'/ (or for nouns, /ML'-(0)/), merging or nearly merging with originally-long Set G words and with Set K (loan) words. It might seem, then, that Set B is gone in PAN to the extent that the merging tones are no longer distinguishable. But by knowing Set B from ZAC/SJQ, we were able to make the following discovery, described in Kingston & Woodbury (2014). In PAN, the erstwhile Set B (and D) words show a lowering of the vowel quality of non-low oral vowels in open syllables; whereas the non-B or -D words show a raising of the oral /a/ vowel to /ɔ/ in open syllables, as well as striking, strong nasalization and final closure of nasal vowels in historical open syllables (written with a final <n>).

The ZAC forms also explain an anomaly of SJQ (and PAN), whose Set D tone has an extremely restricted distribution: it mainly occurs in certain progressive-aspect verbs. ZAC reveals how Set D arose. ZAC preserves /M/ on the progressive prefix. When combined with a Set B stem, a super-high (0) tone appears on the stem's penultimate mora, due, perhaps, to an unlinked tone once associated with the mid-tone prefix. In monosyllabic SJQ and PAN, the moraic independence of the prefix is destroyed, but its tonal effects live on through the maintenance of a distinct D class tonal sequence. Thus is born a tone that is functionally specific. Likewise the special 1SG set tones of ZAC and SJQ are probably relics of fusion with a tone-bearing clitic, as is even now the case for the ZEN cognates.

Clearly though, as linguistic relationships become more distant, cognate relationships are less sure a template for basic elicitation. For example, the ZEN toneless pattern corresponds not only to Set A, but also Sets G, H, I, and sometimes B. But correspondences among remote varieties can open more advanced questions: for example, the division of Set B found in PAN may correspond to a difference still present in ZEN (toneless vs. /XM/), prompting much more scrutiny of the Set B lexicon in both languages.[14]

[14] A reviewer comments: "The comparative method was particularly useful here with Chatino, but the main reason for this was that one could easily specify a limited number of tonal classes at a lexical level. Such a method would seem to be useful for languages at which tone could be identified at a lexical level. This is not the case for many tone languages though. In several families within Otomanguean (Popolocan and Mixtecan for instance), one simply multiplies the number of possible tonal patterns when additional syllables or morae are added to a word, e.g. three level tones per mora x up to 3 morae per word = 27 possibilities." We would suggest that in families with multiplicative distributions, the comparative approach remains useful: for historically one-mora etyma one might reconstruct fewer tone classes than for three-mora etyma; but one could still use those results to probe new varieties. ZEN is particularly interesting since its tone is multiplicative in the sense mentioned, even though its monomoraic words show quite orderly etymological affiliations with the Eastern Chatino lexical classes: ZEN monomoraic toneless words correspond to all the ZAC sets which normally correspond to ZEN toneless words (A, G, H, and I); while ZEN monomoraic /M/ words generally correspond to ZAC sets ending in M (except Set G, as just noted). As long as a pattern of correspondence can be detected in a family, it should be useful as a discovery heuristic when investigating new members.

4.7. METHOD G: MOVE FORWARD DOING BASIC LANGUAGE DOCUMENTATION AND DESCRIPTION. Before the tonal analysis is firmly in hand, it still is important to transcribe texts as best you can; analyze morphological paradigms; and collect lots of lexicon. You may find new kinds of evidence, especially if the language uses tone as a morphological marker, as in Chatino and many other Otomanguean languages. As Rice (this volume, Sec. 3) concludes from her own field work, '[t]he most important lesson is that data gathering, description, and analysis go hand-in-hand, each feeding the other.'

In our work on Chatino, morphological paradigms were a source both of new ideas and of perplexity. Consider the paradigm in (8), which is transcribed in terms of the surface tones we thought we heard. Assuming that the base form is the no-pronoun 3rd person form transcribed as *yta*^{L}, this [L]-marked form appears to show three distinct tonal ablaut changes (to [LH], [H], and [ML]) even in the no-pronoun context; and with an overt preverbal pronoun it shows even more variation (e.g., a 3rd person form with [ML] and an exclusive plural with [H]).

(8)	**Gloss**	**No pronoun**	**Preverbal pronoun**
	s/he/they bathed	yta^{L}	no^{L} kwa^{LM} yta^{ML}
	you (SG) bathed	yta^{LH}	ʔwen^{L} yta^{LH}
	you (PL) bathed	yta^{L} =wą^{L}	ʔwą^{L} yta^{L} =wą^{L}
	I bathed	ytą^{H}	naʔ^{LH} ytą^{H}
	we (INCL) bathed	yta^{ML} =ą^{MH}	na^{L} yta^{ML} =ą^{MH}
	we (EXCL) bathed	yta^{L} =wa^{LH}	wa^{LH} re^{M} yta^{H} =wa^{LH}

It took us a while to unscramble morphological changes—actual tonal ablaut—from changes due to automatic sandhi processes. Eventually we reanalyzed the paradigm as follows:

(9)	**Gloss**	**No pronoun**	**Preverbal pronoun**
	s/he/they bathed	yta	no kwa^{LM} yta
	you (SG) bathed	yta^{LH}	ʔwen yta^{LH}
	you (PL) bathed	yta =wą^{L}	ʔwą yta =wą
	I bathed	ytą^{H}	naʔ^{LH} ytą^{H}
	we (INCL) bathed	yta=ą^{MH}	na^{L} yta=ą^{MH}
	we (EXCL) bathed	yta =wa^{LH}	wa^{LH} re$^{M\text{-}(H)}$ yta =wa^{LH}

The [L]-seeming no-pronoun 3rd person form *yta*^{L} of (8) is reanalyzed in (9) as toneless, like the *ʔi* 'his' of the *ʔi*-test discussed in §3.2. It undergoes authentic tonal ablaut changes, but only for the 2SG and 1SG person, where its tone changes to /LH/ and /H/, respectively, a pattern that turned out to hold for most toneless 3rd person stems. But in the non-singular forms, the stem is also analyzed as toneless. The *ʔi*-test alternations accounts for the outcomes in (8) of all toneless instances of the stem except 1INCL. In the no-pronoun column, these forms all show up as [L], the default realization of a toneless word. In the

preverbal-pronoun column, the third person form becomes [ML] following the /LM/ of the pronoun. This was exactly the effect that the /LM/ word *kta*^{LM} 'chepil' had on following *ʔi* 'his'. And the exclusive plural form becomes [H] by linking to the unlinked /(H)/ of the pronoun *wa*^{LH}*re*$^{M\text{-}(H)}$ 'we (EXCL)', just the effect that the /M-(H)/ word *kta*$^{M\text{-}(H)}$ 'flour' had on following *ʔi*. Finally, the 2PL form of the stem *yta* 'bathe' takes [L] by default because it is preceded by a toneless pronoun.

As for the toneless 1INCL form, its vowel-initial clitic *=ą*^{MH} fuses with the stem to form a long vowel. For some stem classes, the vowel retains its original tone; but for toneless stems, the fusional allotone is [ML], leading to a sequence over the resulting long vowel of [ML-MH]. The process is general—not only restricted to verb marking—and thus must be seen as sandhi, not tonal ablaut.

When we puzzled over this and similar facts, it seemed too much at once. But solving it, we felt we had interlocking confirmations of our understandings of ablaut, sandhi, and fusion.

4.8. METHOD H: USE COMPUTATIONAL VISUALIZATION AND MEASUREMENT TOOLS SUCH AS PRAAT. This tool is mentioned last for a reason: we were long convinced that it was a poor way to detect a linguistic SYSTEM. It also encourages anecdotal observation (unless you construct careful experiments, along lines suggested by Yu (this volume) and Remijsen (this volume)). But we did grant that it allows you to visualize tone and (in both of our experience) trains you after a while to articulate and classify what you think you hear, e.g., as higher or lower; rising or falling; and so on. Sometimes, when a difference baffles you, it can help. An example is the elusive distinction among two kinds of mid tones in SJQ, discussed in §3.2 for *kta*^{LM} 'chepil' vs. *kta*$^{M\text{-}(H)}$ 'flour':

(10)	skwa^{LM}	'lay down'	skwan$^{M\text{-}(H)}$	he threw it
	nten^{LM}	'white'	snyi$^{M\text{-}(H)}$	his penis
	kla^{LM}	'will melt'	kna$^{M\text{-}(H)}$	thief
	kta^{LM}	'chepil'	kta$^{M\text{-}(H)}$	flour

Figure 2 shows Praat pitch tracks of the /LM/ words and the /M-(H)/ words, respectively. /LM/ is slightly lower (by about 11 Hz) than /M-(H)/; LM rises a bit at the end, while /M-(H)/ is level or a bit falling; and in some words, the amplitude is somewhat increasing in /LM/ but decreasing in /M-(H)/.

A general problem we had with visualization came when we saw that in word lists, even the same word uttered by the same speaker at different times can have a quite different overall pitch setting. Thus when we cut word lists into digital-audio snippets to visualize and establish groups of tones, we often found our by-ear and visual impressions at odds with each other. We ended up thinking it was better to teach native speakers to know and control their own tonal system so well, that eventually they could learn to demonstrate lists of same-tone words in a way that was phonetically consistent, reducing reliance on ad hoc visualization.

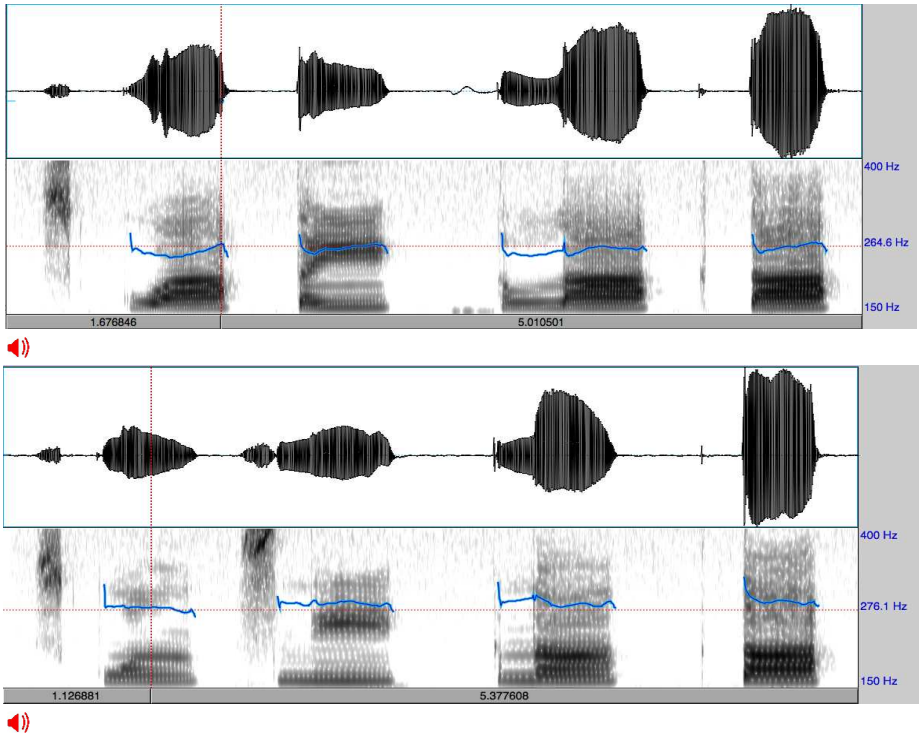

FIGURE 2: Pitch track of Hilaria Cruz producing the LM-set and the M-(H)-set from example (9), respectively.

4.9. METHOD I: MAKE SYSTEMATIC MEASUREMENTS OF KNOWN TONES AS A WAY OF ASCERTAINING THEIR RECURRENT, STABLE PHONETIC PROPERTIES. Despite our skepticism toward instrumental approaches, it was while training students, described in §5, that we ourselves learned better, more reliable techniques for measurement from our phonetician colleagues who taught with us, namely, the technique of averaging the pitch trajectories of many tokens of the same tone after time-normalizing the pitch trajectories, and then plotting the averages on a two-dimensional graph.[15] The method may have first been used in tone studies by Abramson (1962) and it is commonly used in phonetic studies of tone (e.g., Xu 1998; see also Coupe's (this volume, Sec. 4) careful description of this method.). Although a full explanation is beyond the scope of this paper, we can illustrate the concept with our first attempt at it for tonal sequences in isolation context in SJQ, in Figure 3. Crucially, the phonemic tonal categories were already well-known to us. The plot for each tone was created by dividing each token of that tone into 10 equal time units (hence bounded at 11 equally spaced points, from beginning to end, labeled 0,1,...10 on

[15] We particularly wish to thank John Kingston and Christian DiCanio. The following discussion benefits from commentaries and references provided by both of them. See also Remijsen (this volume, Sec. 4.1)'s brief for combining qualitative and instrumental approaches.

the x-axis of each plot), averaging the pitch at each time point, and plotting it. Finally we placed the averaged tone plots, intuitively, into four groups shown separately: shallow rises, steep (or scooped) rises, levels (or slight falls), and (steep) falls.

We found that the procedure worked well; and in particular we found that the four intuitive groups offered insight into pattern congruities among the tones. Nevertheless our uses of this technique have been rudimentary: we have not tested the statistical significance of the tonal separations that appear to hold; nor have we averaged across speakers.

And we were confronted with one surprise. The "level" tone designated as /0/ was generated from words from the /H-(0)/ category, spoken in isolation (see Table 4). We were convinced that in isolation, these words were tonally identical to words in the /H/ category. We even had a pair to "prove" it (cf. (2)). But evidently the incipient "unlinked" tone had a tiny upward effect on realization. Meanwhile the 'real' tone /0/, which only is heard in phrasal contexts like (2)(b), is very much higher.

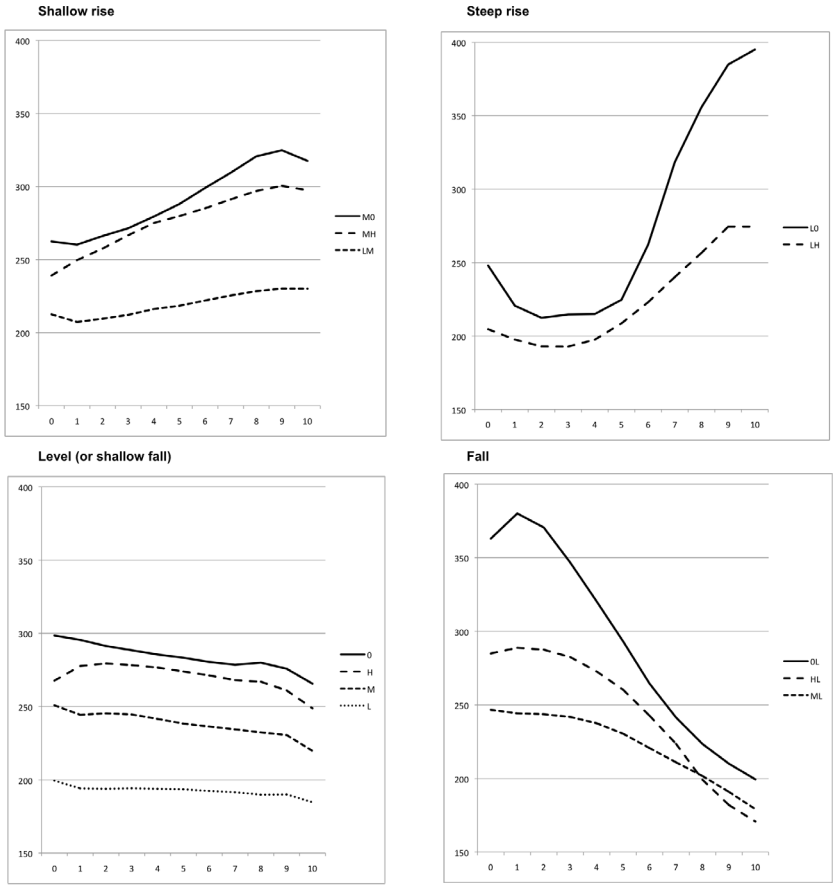

FIGURE 3: Averaged, time-normalized plots of SJQ tone sequences in isolation context (tokens spoken by Emiliana).

In our work with with "newer" varieties, such as PAN, we sometimes found tiny separations among tones that speakers told us were the same. In Table 12, the /M/ of Set A is on average flatter and a few hertz higher than the /M'/ of Set B; yet speakers judge *kwlɔ*^{M} 'old' from Set A as the same as *kwlɔ*$^{M'}$ 'will take' from Set B. Such issues are difficult to resolve without much more analysis of the underlying system.

5. RESEARCHING TONE THROUGH TEACHING. Until 2011, our approach to "new" Chatino varieties had been to make a tonal analysis, incorporate it in an orthography using numbers or letters for tone, prepare a guide, and teach workshops. We then began exploring ways to integrate research and teaching more closely. This happened in two phases.

In the summer of 2012, we held a 10-day workshop in Oaxaca City on tone for linguist-speakers of Otomanguean languages. We had about 50 students from many major Otomanguean groups including Zapotecs, Mazatecs, Mixtecs, Triquis, Chinantecs, Me'phaas, Matlatzincas, and, of course, Chatinos. Eight linguists from Mexican and US institutions were instructors, including ourselves. Morning lectures covered the phonetics and phonology of tone, methods of tone discovery and analysis, and illustrative Otomanguean tone systems; while afternoons involved tutorials for students according to their level, followed by breakout gatherings for each of the language groups.

The Chatino student group included speakers of seven Eastern Chatino varieties, including SJQ, PAN, TEO, and four that were new to us. The students were youngpeople, most of whom worked as grass-roots adult literacy trainers in a federal program, the Instituto Nacional para la Educación de los Adultos. In their work they were faced with a paradox: they only wrote in Spanish; whereas their adult clients often spoke only Chatino! They were eager to solve this problem by learning to write Chatino, including tone.We gave the students a list of words from conservative ZAC, organized by cognate "set" and covering different prosodic shapes; had them write their own cognate for each word, noting whether the tones were the same for each group (Method F); and then had them resolve the results into same-tone groups, subdivided prosodically if necessary (Method A). We then asked them to try to characterize the tone of each group by drawing it and classifying it as rising, level, or falling, and characterizing relative heights. We also did rudimentary pitch-averaging of tokens of each putative group (Method I) We transcribed the tones with superscript letters like those of Table 12. In general, we felt that it was easier to agree on the groupings for each variety, than on their phonetic characterization; and that learning seven sets of tone letters was a burden on their memories—and ours!

In the five weeks following the workshop, we traveled with the Chatino students to five Eastern Chatino villages to pursue the methods just described in more depth. By this approach, the students learned to be linguists not only by working on their own varieties, but by working on those of others as well; while we felt we had advanced our research to a point where we had Hyman Stage I type analyses for many more systems.

Our next workshop was in March, 2013, in San Miguel Panixtlahuaca, lasting a week and sponsored by the Mexican Instituto Nacional de Lenguas Indígenas. Its purpose was to standardize the writing of Eastern Chatino, a goal that had been endorsed by local adult education officials, in addition to being of interest to teachers that had joined us. Nowhere was the need for standardization more acute than for tone, given the welter of parochial tonal solutions we had created. The students spoke many Eastern Chatino varieties; and one student spoke TAT, the nearer of the two outliers to Eastern Chatino.

Figure 4: Top: Chatino and other students at the Summer, 2012 Oaxaca City Workshop on tone for linguist-speakers of Mesoamerican languages; Bottom: Doing field work afterwards in Santa María Yolotepec with Emiliana (left). (Photos by Gibrán Morales)

We used Methods A and F, as before. But this time we did not ask the students to characterize their tone groupings phonetically. Instead, we had them label their groupings by correspondence set (making a choice if two sets were merged for them); and then superscript the set label, as shown in Table 14. As is evident, this accomplishes significant standardization and interoperability among varieties. Moreover, we were amazed at how easily our trainees learned and worked with this system. Box 1 shows a sampling from their written essays in Chatino. (When typing, the students wrote the tone labels at the end of each word, set off by a hyphen, a convention they soon adopted for texting and posting to social media sites).

	Set	**Phonological tone notation**			**Set label notation**		
Gloss		**ZAC**	**SJQ**	**PAN**	**ZAC**	**SJQ**	**PAN**
'snake'	E	kwi^{M}na^{H}	kwna^{H}	kwnąn^{MH}	kwina^{E}	kwna^{E}	kwnąn^{E}
'rope'	F	luti^{LH}	ti^{LM}	ti^{LM}	luti^{F}	ti^{F}	ti^{F}
'sun'	G	ku^{M}cha^{M}	kcha^{LH}	kwchɔ^{M0}	kucha^{G}	kcha^{G}	kwchɔ^{G}

TABLE 14: Comparison of phonologically-based and set-label tone notation

The process showed us that the recognition of tone classes by native speakers does not require descriptive phonetic awareness, only awareness of similarities of tones or tonal sequences within sets of words. Of course, once speakers are confident of distinctions, it then is relevant—both at the research and practical levels—to proceed as usual with the phonetic and phonological study and interpretation of the distinctions.

In all, this experience has fortified our belief in the close interdependence of research and teaching. At the same time, we realize this method is best suited when dealing with a situation precisely like that of Chatino—many varieties with considerably different tonal systems, but related closely enough that correspondences are still robust. We got a sense of the limitations of the method when we attempted to extend it to TAT, as spoken by one student. While it was possible to adapt the set-label notation to TAT, tonal mergers and splits, as well as lexical differences, left the TAT and Eastern Chatino written products substantially different and scarcely mutually intelligible.

6. CONCLUSIONS. We understand that our methods, which we have tried to frame in general terms, still bear the imprint of the languages and social contexts of our work. The languages, as we have seen, are all tonally rich. They all divide the lexicon into many classes, based on the tone or tonal sequence; and they link individual tones to moras. Some such as ZAC and ZEN link tones or tone sequences to sets of words having a variety of prosodic shapes; others like SJQ and PAN distinguish similar sets, but squeezed onto monomoraic words. Some have unlinked floating tones, others do not. In our path from one variety to the next, we found ourselves, on the one hand, learning from previous systems; but on the other hand, limiting ourselves: After monosyllabic SJQ, we anticipated most of the lexical classes of ZAC, but failed to take in its full prosodic variety. After learning from SJQ and ZAC how to use floating tones as discovery tools, we spent too much time trying to find them in PAN, where they were only weakly present.

Now, when we approach a "new" Chatino variety, we find it best to have all methods

at the ready for what may unfold. Our core practice is to use our historically based cognate list to elicit words, quickly checking whether cognate patterns are evident in the new system (Method F); organize the material in prosodic groups if there is prosodic diversity and make "Saussurian" groupings (Method A); test for "classic" Chatino minimal tone sets (Method C); and make time-normalized, averaged plots of the pitch trajectories from each putative group (Method I). At that point, we elicit verb paradigms (Method G) and short phrases to see if we can find sandhi patterns and tests (Methods D & E). From there, it is possible to begin to achieve more explanatory (Hyman Stage III) accounts in terms of representations and rules.

This in turn leads to a further kind of explanation. By working on tone in a whole language family, we have come to the view that no one variety tells the entire story: what is obscure or mysterious in one variety is vivid and transparent in the next. By studying how Chatino tonal systems have diversified, we witness the results of a profound set of natural experiments that yields insight into tone as a historical process well beyond its deployment in individual systems. We highly recommend working on complex tone systems in close-knit language families.

In all of this, we also emphasize the continued role of teaching and speaker-training in local contexts. This has been possible, we believe, because of the high levels of interest and appreciation of Chatino in Chatino communities, and the view that writing is a way for the language to receive respect. We believe that research can be more exact when speakers, though linguistic study and through learning to write, become critically aware of the tonological systems of their languages. And for our part, by going over material slowly, again and again, with sharp, inquisitive speakers, we never stopped learning.

BOX 1: Sample student writing from the 2013 normalization workshop, San Miguel Panixtlahuaca, using set labels to notate tone or tonal sequences. (<q> = glottal stop; <n> after a vowel indicates nasalization) Spanish translations are by the students.

Nkchen^{A} ke^{G} xin^{E}

Leticia Vásquez Sánchez, Santiago Yaitepec

Ndiya^{B} qa^{A} tinq^{H} nkchen^{A} ke^{G} xin^{E} ndiya^{B} qa^{A} sqen^{I} kaa^{I}, sqen^{I} kti^{F} sqen^{I} ka^{B} ntiqya^{B} neq^{A} tiknyoq^{A}. Naq^{B} ka^{B} tiyeen^{BI} chaaq^{F}i ja^{I} tsa^{B} ti^{E} chaq^{F} tnyan^{A} nkchen^{A} ke^{G} xin^{E} naa^{B} ndiya^{B} qa^{E} tinq^{B} ka^{B} sqan^{H} chaq^{F} tnyan^{A}.

Pueblo Yaitepec

Me gusta mi pueblo. Hay lugares que son sagrados. Dónde prenden velas y ponen otras ofrendas. Yo quiero que mi lengua de Yaitepec no desaparezca. A mí me gusta mucho aprender sobre el chatino.

Liyaa^{B} loqo^{E} kwintu^{G} qi^{A}

Gema Galgani Cruz Cruz, Santa María Yolotepec

ntyukwiq^{A} Liyaa^{B} yaq^{A} kichen^{A} seqen^{D} yinan^{A} ntyukwiq^{G} renq^{A} loqo^{E} tsaka^{A} ndaten^{B} dxaaq^{F} ndaqan^{I} tsaka^{A} kwichi^{C} ndaa^{E} nan^{E} sinyeq^{A} loo^{A}. chika^{I} ndaten^{B} yukwiq^{A} req^{A} loqo^{E} Liyaa^{B} dxaaq^{F} yuku^{A} kwichi^{C} kanq^{G} qi^{A} tsaka^{A} nu^{A} kunaqan^{E} nu^{A} ndaqan^{I} loqo^{E} sinyeq^{A} xkwila^{B} nu^{A}. nan^{E} prescoolaa^{B} qin^{A} nga^{B} ndaten^{B} ngisen^{G} renq^{A} yaq^{C} ndaqan^{I} kwichi^{C} kanq^{A} loo^{A} kichen^{A} loo^{A} sinyeq^{A} nu^{A} kunaqan^{E} kanq^{A} nginan^{G}. siye^{F} a^{A} ndiya^{I} qa^{A} jyaqan^{E}.

María con sus chismes

Dice María que en el pueblo de Santa María Yolotepec escuchó que estaban hablando sobre una persona y un león. El león según anda buscando a su hijo. Las personas le dijeron a María que el león se había comido a una mujer que andaba con su hijo por donde está la escuela preescolar. Toda la gente del pueblo estaba muy asustada porque el león andaba por el pueblo. El hijo de la mujer que había sido comida por el león estaba llorando mucho porque ahora ya no tenía mamá.

sqwa^{C} nyqan^{B} ntya^{A} neq^{B} ntskwaq^{B}

Maricela Aragon Cabrera, San Francisco Ixpantepec

kwlo^{G} nyqan^{B} neq^{B} chaq^{F} kyqya^{B} kyo^{A} qo^{C} ra^{C} nu^{A} ba^{C} nkwtsaq^{A} lo^{A} yu^{I} janq^{G} in^{I} kanq^{G} nu^{A} ba^{C} tsa^{B} neq^{A} sqwa^{B} neq^{A} ntskwaq^{B} niq^{C} tiyu^{I} qo^{C} kanq^{G} ta^{H} neq^{A} sqen^{A} tyjin^{B} snuq^{A} tsan^{A} kanq^{H} tsa^{A} nqan^{G} neq^{A} si^{E} ba^{C} ntksu^{I} kla^{A} chaq^{F} nu^{A} ba^{C} tyi^{E} sna^{C} qnyi^{D} neq^{A} kwenta^{C} qin^{A} na^{F} qo^{C} ra^{C} nu^{A} ba^{C} ntkwa^{F} kxinq^{C} niq^{C} na^{F} kanq^{G} in^{I} nu^{A} wa^{C} qnyi^{A} neq^{C} kwqna^{C}. qin^{A} na^{F} chaq^{F} tywi^{H} sqen^{A} ntkwa^{F} na^{F}.

Como siembran el maíz

Primero las personas tienen que esperar para que llueva. Cuando la tierra ya está mojada, las personas van a sembrar maíz. Se deja que pasen ocho días, después de eso van a ver al lugar de la siembra para ver si ya está naciendo la milpa. A partir de ahí empiezan a cuidarla. Si hay otro tipo de plantas, eso se arranca, debe de quedar limpio donde están las milpas para que de buena cosecha.

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