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**Title**

Mayan phonology

**Permalink**

<https://escholarship.org/uc/item/7h78j2xh>

**Journal**

Language and Linguistics Compass, 10(10)

**ISSN**

1749-818X

**Author**

Bennett, Ryan

**Publication Date**

2016-10-01

**DOI**

10.1111/lnc3.12148

Peer reviewed

# Mayan phonology

Ryan Bennett\*  
Yale University

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## Abstract

This paper presents an overview of the phonetics and phonology of Mayan languages. The focus is primarily descriptive, but the article also attempts to frame the sound patterns of Mayan languages within a larger typological and theoretical context. Special attention is given to areas which are ripe for further descriptive or theoretical investigation.

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## 1. Introduction

This article provides an overview of the phonology of Mayan languages. The principal aim is to describe the commonalities and differences between phonological systems in the Mayan family. I have also tried to highlight some phonological patterns which are interesting from a typological or theoretical perspective. There are many intriguing aspects of Mayan phonology which remain understudied; I've noted a handful of such phenomena here, with the hope that other researchers will take up these fascinating and difficult questions.

Apart from phonology proper, this article also touches on the phonetics and morpho-syntax of Mayan languages (see also Coon this volume). Most work on Mayan phonology has focused on basic phonetic description and phonemic analysis. A much smaller portion of the literature deals directly with phonotactics, alternations, prosody, morpho-phonology, or quantitative phonetics. Since phonology connects with all of these topics, I have tried to be as thematically inclusive as possible given the current state of research on Mayan sound patterns.

The phonemic systems of Mayan languages are comparatively well-studied, thanks to the efforts of numerous Mayan and non-Mayan scholars. This article has drawn heavily on grammatical descriptions published by the *Proyecto Lingüístico Francisco Marroquín* (PLFM), *Oxlajuuj Keej Maya' Ajtz'ib'* (OKMA), and the *Academia de Lenguas Mayas de Guatemala* (ALMG); many of these works were written by native-speaker linguists. Other important sources include the various dissertations written on Mayan languages from the 1960s onward, as well as overviews like England (1988, 1992, 2001), Kaufman (1990), García Ixmatá et al. (1993), and Law (2011, 2014). Many of these resources are in Spanish, though certainly not all.

There is a certain bias in this article toward the Eastern Mayan languages, and to a lesser extent, languages of the Q'anjob'alan branch. This is a consequence of two factors. First, these languages have some of the best-described phonologies of the family (though other languages, such as Yucatec, have also been the subject of substantial phonological study). Second, my own background encourages a skew toward Eastern Mayan, given that I have primarily worked on languages of the K'ichean branch.

A few notes on the transcriptions are in order. Whenever possible I have tried to give data in both the IPA and in the local Mayan orthography of each particular language. The IPA transcriptions are fairly narrow (at least to the level of gross allophonic variation), though

sources differ as to the amount of phonetic detail they provide. In many cases I have reproduced transcriptions as written in the original source material, albeit with some modifications to meet current IPA standards. Even then, I have sometimes added allophonic details that were missing from the original transcriptions if such details were explicitly mentioned in a grammatical sketch of that particular variety. In other cases I have inferred phonetic transcriptions by interpreting orthographic forms according to prose descriptions of their phonetic value. In the process of reconstructing allophonic transcriptions I have almost certainly committed major errors; readers are strongly encouraged to consult the original sources for data and description. Spanish glosses have also been translated into English, and readers should be wary of errors here too. Lastly, I have sometimes been forced to guess at an appropriate orthographic transcription for particular examples, especially when discussing languages that currently lack an orthographic standard (as is true for many of the Mayan languages spoken in Mexico).

I make no claims to exhaustive coverage of either data or citations in this article. The Mayan languages are too diverse, and the literature too vast, to do justice to all aspects of Mayan phonology in a single article. I do hope, however, that the contents are rich enough to be of use to both Mayan specialists and the general phonological community.

## 2. Vowel Inventories

Proto-Mayan most likely had a ten-vowel inventory contrasting short /a e i o u/ with their long counterparts (Fox 1978, Kaufman & Norman 1984, Campbell & Kaufman 1985; cf. the richer inventories in Kaufman 1969 and Brown & Wichmann 2004).<sup>1</sup> This inventory has proven quite stable, and despite some 4000 years of development has persisted into the majority of modern-day Mayan languages.<sup>2</sup>

(1) Vowel contrasts in Ixil, Nebaj variety (Mamean, Guatemala; Poma et al. 1996, Chel & Ramirez 1999)

a.	<i>xan</i>	[ʃan]	‘adobe’	b.	<i>xaan</i>	[ʃa:m]	‘(s)he walks’
c.	<i>sel</i>	[se:l]	‘type of basket’	d.	<i>seel</i>	[se:l]	‘brushed’
e.	<i>rip</i>	[rip <sup>h</sup> ]	‘bat’	f.	<i>b'iil</i>	[βi:l]	‘little’
g.	<i>q'ol</i>	[q <sup>ʔ</sup> ol]	‘turpentine’	h.	<i>q'ool</i>	[q <sup>ʔ</sup> o:l]	‘musician’
i.	<i>ul-</i>	[ʔul-]	‘to come’	j.	<i>uul</i>	[ʔu:l]	‘stomach’

Vowel length distinctions may be reinforced by differences in quality, with short vowels being somewhat more centralized than corresponding long vowels (e.g. DuBois 1981, England 1983, Dayley 1985, Edmonson 1988, Barrett 1999, Baird 2010). There are also Mayan languages in which vowel length contrasts are realized by duration alone, at least impressionistically (England 2001). The actual durational difference between long and short vowels varies on a language-by-language basis (England 2001), but relative durations of about 2:1 have been reported for [V:]~[V] contrasts in K'ichean and Yucatecan languages (Berinstein 1979, Dayley 1985, Baird 2010; Frazier 2009a, Sobrino Gómez 2010, Herrera Zendejas 2014:Ch.10). Kaufman (1969) gives a ratio of just 1.25:1 for the vowel length contrast in Tektitek; see Herrera Zendejas (2014:Ch.7) for Huastec.

Not all Mayan languages evince a contrast between short and long vowels. For one, vowel length distinctions are mostly absent from Western Mayan (encompassing Greater Tzeltalan and Greater Q'anjob'alan).

(2) Vowel contrasts in Q'anjob'al, Santa Eulalia variety (Q'anjob'alan, Guatemala; Raymundo González et al. 2000)

- |    |            |       |            |    |            |       |              |
|----|------------|-------|------------|----|------------|-------|--------------|
| a. | <i>ka'</i> | [kaʔ] | 'mortar'   | b. | <i>xe'</i> | [ʃeʔ] | 'root'       |
| c. | <i>si'</i> | [siʔ] | 'firewood' | d. | <i>hon</i> | [on]  | 'your paper' |
| e. | <i>kuk</i> | [kuk] | 'squirrel' |    |            |       |              |

Akatek and Mocho' are unique among Western Mayan languages in having phonemic long vowels (England 2001, Law 2014).<sup>3</sup> Vowel length contrasts in Mocho' are apparently a proto-Mayan retention (Palosaari 2011, Law 2014), while phonemic vowel length in Akatek is instead a recent innovation which emerged primarily from a [Vx] > [V(:)] sound change, as in Akatek *nojnaq* [no:nax] vs. Q'anjob'al [noxnaχ] 'full' (Kaufman 1976b, Zavala 1992, Raymundo González et al. 2000). The reduction of postvocalic [Vx] or [Vh] to [V(:)] has been a common source of long vowels throughout the development of the Mayan languages (Kaufman 1974, Campbell 1977, England 1992, Kaufman 2003, Brown & Wichmann 2004).<sup>4</sup>

In Kaqchikel (K'ichean, Guatemala), the proto-K'ichean (and proto-Mayan) length opposition has been transposed into a system based primarily on vowel tenseness, or centralization (Campbell 1977, Chacach Cutzal 1990, Cojtí Macario & Lopez 1990, García Matzar et al. 1999, Majzul et al. 2000, Léonard & Gendrot 2007, Léonard & Tuyuc Sucuc 2009). In the Kaqchikel of Santa María Cauqué, for instance, all vowels except /e/ have a lax counterpart, written *ä i ö ü* (*ë* and *e* are both realized as tense [e]).

(3) Vowel contrasts in Kaqchikel, Santa María Cauqué variety (K'ichean, Guatemala; Majzul et al. 2000)

- |    |             |        |              |    |             |        |          |
|----|-------------|--------|--------------|----|-------------|--------|----------|
| a. | <i>kär</i>  | [kær]  | 'fish'       | b. | <i>par</i>  | [par]  | 'skunk'  |
| c. | <i>xël</i>  | [ʃ-e]  | '(s)he left' | d. | <i>tew</i>  | [tef]  | 'cold'   |
| e. | <i>k'ix</i> | [kʔiʃ] | 'shame'      | f. | <i>q'ij</i> | [ç'iχ] | 'day'    |
| g. | <i>jöb'</i> | [χɔβ]  | 'rain'       | h. | <i>kow</i>  | [kof]  | 'hard'   |
| i. | <i>jül</i>  | [χv]   | 'pit, hole'  | j. | <i>chuw</i> | [tʃuf] | 'stinky' |

Outside of Kaqchikel vowel systems based on a tense-lax opposition are found only in a few dialects of K'iche', such as the variety spoken in Chichicastenango (Larsen 1988, López Ixcóy 1994, 1997, England 1992, 2001, Baird 2010).

Phonemic lax vowels are typically lower and more centralized than tense vowels, though lax *ä* may be raised relative to tense *a*. The precise quality of lax *ä* varies widely across dialects: common realizations of this vowel include [a ə ï ɜ], but [ɛ ɪ ʌ y ɯ ʉ] have also been reported as possible variants. The rationale for treating lax *ä* as the counterpart of tense *a* is essentially phonological: whatever its phonetic value, lax *ä* alternates with tense *a* in the same environments where other tense-lax alternations are observed (sections 2.4, 5.2).

(4) Tense-lax alternations in Comalapa Kaqchikel (Chacach Cutzal 1990)

- |    |                |                           |                 |    |               |          |                       |
|----|----------------|---------------------------|-----------------|----|---------------|----------|-----------------------|
| a. | <i>ninb'an</i> | [n-in-βɛn]                | 'I make it'     | b. | <i>b'anöl</i> | [βan-ɔ]  | 'maker of...'         |
| b. | <i>nintik</i>  | [n-in-tik <sup>h</sup> ]  | 'I sow it'      | d. | <i>tiköy</i>  | [tik-ɔ]  | 'sower of...'         |
| e. | <i>ninchüp</i> | [n-in-tʃüp <sup>h</sup> ] | 'I turn it off' | f. | <i>chupüy</i> | [tʃüp-ɔ] | 'power switch for...' |

The phonetic diversity of lax *ä* raises interesting questions about the extent to which tense-lax alternations can be treated as a uniform phonological process in Kaqchikel, both within and across dialects; see Léonard & Tuyuc Sucuc (2009) for some discussion.

The merger of tense-lax vowel pairs is quite common in Kaqchikel, such that any given dialect may have between five and ten contrastive vowel qualities. Distinctions between tense *a* and lax *ä* are frequent, but dialects with a contrast between *o/ö*, *u/ü*, and especially *e/ë* are harder to find (Majzul et al. 2000, England 2001, Baird 2010). Tense-lax contrasts may also be cued by durational differences (as in English; Peterson & Lehiste 1960), but such durational differences are smaller in magnitude than true vowel length distinctions, and may show inter-speaker variation (England 2001, Léonard & Tuyuc Sucuc 2009).

The greatest number of contrastive vowels is found within the Yucatecan branch. Along with the five vowel qualities of proto-Mayan, Mopan, Itzaj, and Lacandon have a short central vowel *ä* [i̯], yielding eleven distinctive vowels in total (or even more if ‘rearticulated’ vowels are counted, section 2.3) (Fisher 1973, Schumann Gálvez 1971, 2000, Dienhart 1986, Hofling 2000, Cohuoj Caal et al. 2001, Zocal Chayax et al. 2001, Bricker & Orié 2014, Herrera Zendejas 2014:Ch.10).<sup>5</sup>

(5) Some vowel contrasts in Itzaj (Yucatecan, Guatemala; Hofling 2000)

a.	<i>k'äx</i>	[kʔi̯f]	‘tie’	b.	<i>k'ax</i>	[kʔaf]	‘knot’
c.	<i>k'aax</i>	[kʔaxf]	‘forest’	d.	<i>ka'an</i>	[kaʔan]	‘sky’
e.	<i>ek'</i>	[ʔekʔ]	‘star’	f.	<i>kil</i>	[kil]	‘when’
g.	<i>kok</i>	[kok <sup>h</sup> ]	‘stingy’	h.	<i>suk</i>	[suk <sup>h</sup> ]	‘tame’

Phonemic *ä* [i̯] alternates with [a] under certain complex conditions, e.g. Mopan *k'al* [kʔal] ‘close (antipassive)’ ~ *k'älik* [kʔil-ik<sup>h</sup>] ‘close (it)’ (Fisher 1976, Cohuoj Caal et al. 2001, Lois & Vapnarsky 2003, Hofling 2011, Bricker & Orié 2014, Herrera Zendejas 2014:Ch.10).<sup>6</sup> Yucatec itself has a basic ten-vowel system, but non-phonemic [ə] is used as an epenthetic vowel to resolve otherwise illicit consonant clusters (e.g. *kche'* /k-tʃeʔ/ → [kətʃeʔ] ‘our tree’, Orié & Bricker 2000, Bricker & Orié 2014).

One last major vowel inventory, built from the six short vowels /a e i o u i̯/, is found in the Western Ch'olan languages (Ch'ol and Chontal; Keller 1959, Knowles 1984, Pérez González 1985, Schumann Gálvez 1973, Attinasi 1973, Warkentin & Scott 1980, Coon 2010, Vázquez Álvarez 2011). This system is the result of a chain shift \*/a:/ > \*/a/ > \*/i̯/ which occurred early on in the development of Common Ch'olan (Kaufman & Norman 1984, Law 2014).<sup>7</sup> The \*/a/ > \*/i̯/ merger was blocked in some environments, giving rise to synchronic phonotactic restrictions on the distribution of [i̯], as well as synchronic [i̯] ~ [a] alternations reminiscent of Kaqchikel and the Yucatecan languages (Kaufman & Norman 1984, Law 2014). Other Greater Tzeltalan languages use a simpler five-vowel system /a e i o u/.<sup>8</sup>

## 2.1. INTERNALLY COMPLEX VOWEL NUCLEI

### 2.2. DIPHTHONGS

Vowel quality is typically monophthongal in Mayan, though as with many phonetic characteristics of these languages, more instrumental work is needed to verify this impressionistic description. Heterorganic /V<sub>α</sub>V<sub>β</sub>/ sequences are usually realized with a hiatus-breaking glottal stop [V<sub>α</sub>ʔV<sub>β</sub>] or glide [V<sub>α</sub>jV<sub>β</sub>], not as diphthongs or adjacent vowels (see section 2.4 for more discussion of hiatus in Mayan).

(6) Hiatus-resolving [j]-insertion in Ch'ol (Ch'olan, Mexico; Attinasi 1973, Coon 2010, Vázquez Álvarez 2011)

- a. *tyi wäyiyōñ* /tʰi wiʝi-oŋ/ → [tʰi wiʝiʝoŋ] ‘I slept.’  
 b. *tyi imekʰeyety* /tʰi i-mekʰ-e-etʰ/ → [tʰi imekʰeʝetʰ] ‘She hugged you.’

However, some K'ichean-branch languages have developed diphthongs from historical long vowels, through the breaking of mid /e:/ and /o:/ (England 2001). Diphthongs of this type are reported for various dialects of Tz'utujil, Kaqchikel, Poqomam, and Poqomchi'. In Tz'utujil and Kaqchikel these diphthongs contrast with what appear to be historically newer instances of long (or tense) /e: o:/, but not in Poqomam or Poqomchi' (Smith-Stark 1983, Dayley 1985, Majzul et al. 2000, Malchic Nicolás et al. 2000).

- (7) Contrastive diphthongs in Santiago Atitlán Tz'utujil (K'ichean, Guatemala; Dayley 1985)
- |                   |           |                 |                    |           |              |
|-------------------|-----------|-----------------|--------------------|-----------|--------------|
| a. <i>ch'uob'</i> | [tʰʷuopʰ] | ‘pineapple’     | b. <i>tiew</i>     | [tʰieϕ]   | ‘cold’       |
| c. <i>ch'oob'</i> | [tʰʷo:pʰ] | ‘cajete tree’   | d. <i>ch'eech'</i> | [tʰʷe:tʰ] | ‘metal, car’ |
| e. <i>muuj</i>    | [mu:x]    | ‘shadow, shade’ | f. <i>b'iix</i>    | [bi:f]    | ‘song’       |

Polian (2013:108,116–7) has also observed an innovative [æ̃] diphthong in Oxchuc Tselal, derived by diachronic metathesis of [i] as in *atimal* [ʔæ̃etmal] < [ʔatimal] ‘to bathe’.

### 2.3. 'REARTICULATED' VOWELS

The descriptive literature on Yucatec has traditionally recognized a set of ‘rearticulated’ vowels [V<sub>α</sub>ʔV<sub>α</sub>] as unit phonemes that contrast with both short and long vowels of the same quality (Pike 1946, Blair 1964, Blair & Vermont Salas 1965, McQuown 1968, Fisher 1973, Straight 1976, among many others). These vowels are also characterized as ‘glottalized’, ‘laryngeal’, ‘broken’, ‘echo’, or ‘double’, and can be found in all Yucatecan languages.

- (8) Vowel shape contrasts in Yucatec (Yucatecan, Mexico and Belize; Sobrino Gómez 2010)
- |                |        |         |                 |          |           |
|----------------|--------|---------|-----------------|----------|-----------|
| a. <i>pak'</i> | [pakʰ] | ‘wall’  | b. <i>páap</i>  | [pá:pʰ]  | ‘spicy’   |
| c. <i>paal</i> | [pà:l] | ‘child’ | d. <i>pa'at</i> | [páʔatʰ] | ‘to wait’ |

The proper analysis of these rearticulated vowels has been a perennial problem in the study of Yucatec phonetics and phonology. The central point of contention is whether such vowels should be treated as trisegmental sequences [V<sub>α</sub>]+[ʔ]+[V<sub>α</sub>], or as monosegmental, but internally-complex nuclei [V<sub>α</sub>ʔV<sub>α</sub>]. There are several arguments in favor of the monosegmental analysis. The first is distributional: the vowels in a morpheme-internal [VʔV] sequence are sharply restricted, with an internal coherence that points toward a single, complex segment. To wit, the vowels flanking [ʔ] must be identical, they must be short, and they must have a high-falling tonal pattern [V̌<sub>α</sub>ʔV<sub>α</sub>] (section 6.2). These restrictions are quite specific to rearticulated [V<sub>α</sub>ʔV<sub>α</sub>], as tone, quality, and length combine much more freely in other segmental environments, even for vowels flanking the other laryngeal [h] (e.g. *mahaan* [mahà:n] ‘loan’ and *naapul* [nà:pul] ‘direct’, Orié & Bricker 2000). Furthermore, short vowels are generally toneless (or perhaps low toned) in Yucatec, even before glottal stop (e.g. *cho'* [tʰoʔ] ‘clean’; section 6.2). The exceptionless high-falling tone on morpheme-internal [V̌<sub>α</sub>ʔV<sub>α</sub>] is thus unexpected on a multisegmental analysis.

The second argument for a monosegmental treatment of [V<sub>α</sub>ʔV<sub>α</sub>] comes from root phonotactics (section 5.1). As in other Mayan languages, roots in Yucatec are overwhelmingly [CV(:)C] in form (particularly verbal and positional roots). A large number of roots are of the shape [CV<sub>α</sub>ʔV<sub>α</sub>C] (e.g. *-ni'ik'* [-niʔikʰ] ‘move’), suggesting that rearticulated [V<sub>α</sub>ʔV<sub>α</sub>]

patterns as a single vowel for root phonotactic restrictions (Blair 1964, Lois & Vapnarsky 2003). Voice alternations in verbal derivation may also be marked by changes in root-internal vowels, e.g. *ka k'axik* [k-a k<sup>2</sup>aʃ-ik] 'you tie it' ~ *ka k'aax* [k-a k<sup>2</sup>à:ʃ] 'you tie' (Straight 1976, Coon this volume). Rearticulated [ $V_{\alpha} ?V_{\alpha}$ ] participates in such alternations (e.g. *ku juuch'* [k-u hù:tʃ<sup>2</sup>] 'she grinds' ~ *ku ju'uch'ul* [k-u hú?utʃ<sup>2</sup>-ul] 'it is ground'), which provides another indication that [ $V_{\alpha} ?V_{\alpha}$ ] patterns as a unit phoneme in Yucatec morpho-phonology (Fisher 1973, Bricker 1978, Lois & Vapnarsky 2003). Analogous arguments can be constructed for rearticulated vowels in other Yucatecan languages (see also Coon 2010 on Ch'ol and England 1983 on Mam).

Defenders of the multisegmental analysis of Yucatec [ $V_{\alpha} ?V_{\alpha}$ ] are harder to find, but arguments in favor of this view are given in Orié & Bricker (2000). On balance, however, the evidence clearly favors a monosegmental treatment of rearticulated [ $V_{\alpha} ?V_{\alpha}$ ] vowels.

Attinasi (1973) and Coon (2010) argue for another type of complex nucleus in Ch'ol: 'aspirated' [ $\widehat{Vh}$ ] (analyzed as [ $V\widehat{V}$ ] by Attinasi; see also Brown & Wichmann 2004). The evidence is quite parallel to the evidence for complex laryngealized vowels in Yucatecan, e.g. the existence of underived [CVhC] roots like *sajk'* [sahk<sup>2</sup>] 'grasshopper' (see also Coon this volume). For general discussion of complex laryngealized vowel nuclei in Mesoamerican languages, see Macaulay & Salmons (1995), Silverman (1997), Gerfen (1999), Avelino (2004), Arellanes Arellanes (2008), DiCanio (2008), Chávez Peón (2010) and references there.

### 2.3.1. Phonetics of 'Rearticulated' Vowels

The notation [ $V_{\alpha} ?V_{\alpha}$ ] implies that Yucatecan rearticulated vowels are produced with a complete glottal closure in the medial portion of the vowel (i.e. with true 'rearticulation'). This is at best an oversimplification. It has long been known that the 'rearticulated' vowels are more often produced with weak laryngealization (creaky voice) than with a true glottal stop in Yucatecan languages (see comments to this effect in Pike 1946, Blair 1964, Blair & Vermont Salas 1965, Fisher 1973, Straight 1976, Fox 1978). Frazier (2009a,b, 2013) provides an extensive phonetic documentation of Yucatec vowels and tones which confirms these fieldworker descriptions using instrumental methods. She shows that rearticulated vowels are most commonly realized with initial high tone, and with creaky voice in the medial or final portion of the vowel (though Frazier finds some sparse examples of full glottal closure [ $\widehat{V} ?V$ ] as well). For this reason, she advocates calling these vowels 'glottalized' rather than 'rearticulated', and transcribes them as [ $\widehat{V}\widehat{V}$ ].<sup>9</sup> Frazier (2013) further points out that the sequencing of tone and creaky voice as [ $\widehat{V}\widehat{V}$ ] in glottalized vowels runs counter to the typological tendency to realize lexical tone *after* non-modal phonation on the same vowel (Silverman 1997). Lastly, Frazier (2009a) finds that glottalized vowels are as long as, or even longer than [ $\widehat{V}:$ ] and [ $\widehat{V}:$ ] in Yucatec (Sobrinó Gómez 2010 reports similar durations, as does Herrera Zendejas 2014:Ch.10 for Lacandon). See section 3.3.2 for comparison with [ $V?$ ] sequences in other Mayan languages.

## 2.4. VOWEL PHONOTACTICS

### 2.4.1. Vowel Length and Tenseness

The distribution of vowel length is conditioned by stress in several Mayan languages. In some varieties of K'iche', for example, long vowels are restricted to stressed (word-final) syllables (9). In other languages, such as the Ixtahuacán variety of Mam (10), long vowels may occur in any position as long as they are stressed.

- (9) Long vowels in K'iche' (K'ichean, Guatemala; López Ixcoy 1994, 1997)
- |  |  |
|--|--|
| a. <i>kunaneel</i> [kun-an-'e:l] 'doctor'                    | b. <i>kunanelaab'</i> [kun-an-el-'a:ɬ] 'doctors'                       |
| c. <i>xkich'ikimijj</i> [ʃ-ki-tʃ'ikim-'i:ɣ] 'they pushed it' | d. <i>xch'ikiminik</i> [ʃ-tʃ'ikim-in-'ik <sup>h</sup> ] '(s)he pushed' |
| e. <i>keem</i> [k <sup>j</sup> 'e:m] 'weaving'               | f. <i>xukemaaj</i> [ʃ-u-k <sup>j</sup> em-'a:x] '(s)he weaved it'      |
- (10) Long vowels in Ixtahuacán Mam (Mamean, Guatemala; England 1983, 1990, Pérez Vail & Jiménez 1997)
- |                                     |  |
|-------------------------------------|--|
| a. <i>q'uulan</i> [q̣'u:laŋ] 'warm' | b. <i>q'ulaniix</i> [q̣'ulan-'i:ʃ] 'become warm'               |
| c. <i>qiinan</i> [q̣'i:naŋ] 'rich'  | d. <i>tq'inamiil</i> [t <sup>h</sup> -q̣'inam-'i:l] 'richness' |
| e. <i>xjaal</i> [ʃx'a:l] 'person'   | f. <i>nxjaalala</i> [n-ʃx'a:l-al-a] 'my people'                |

As these examples show, underlying long vowels shorten when unstressed in these languages. Long vowels also attract stress in Ixtahuacán Mam (section 6.1), and so shortening is only observed in words that contain more than one long vowel in their underlying form.

Other languages are more permissive with vowel length. Unstressed long vowels are freely allowed in Sakapultek (final stress) and in Huastec (quantity-sensitive stress).

- (11) Long vowels in Sakapultek (K'ichean, Guatemala; DuBois 1981, Mó Isém 2007)
- |  |  |
|--|--|
| a. <i>b'aateek</i> [ba:t'e:k <sup>h</sup> ] 'it was rolled up' | b. <i>weet-'aam</i> [we:t <sup>h</sup> ʔ'a:m] 'I know it' ( <i>weetaam</i> ) |
| c. <i>ruuk'aa'</i> [ʃu:k <sup>ʔ</sup> 'a:ʔ] 'its horn'         | d. <i>tiiwila'</i> [ti:wil'aʔ] 'Y'all look at it!'                           |
- (12) Long vowels in Huastec (Huastecan, Mexico; Edmonson 1988)
- |  |   |
|--|---|
| a. <i>biilmeel</i> [bi:lm'e:l] 'becomes weak'                    | b. <i>miimlaab</i> [mi:ml'a:ɸ] 'lady'                                   |
| c. <i>tsapneetha'</i> [ṭsap <sup>h</sup> n'e:θəʔ] 'greeted him' | d. <i>waleekliyal</i> [wal'e:k <sup>h</sup> lija:l] 'cast the evil eye' |

Kaqchikel shows a restriction on lax vowels which parallels the distribution of long vowels in other K'ichean languages: lax  $\check{V}$  is only permitted in stressed, word-final syllables (see also López Ixcoy 1994 on K'iche'). Alternations like *xtab'an* [ʃtaβ'an] 'you will do it' ~ *tab'ana'* [taβan'aʔ] 'You do it!' are quite widespread (see also (4)). This restriction is somewhat unexpected, given that the lax vowels of Kaqchikel correspond to historical *short* vowels, which are basically unrestricted in K'ichean languages (e.g. Campbell 1977).

Finally, there are several languages in which long vowels are prohibited, or at least statistically underattested, before glottal stop [ʔ] (England 2001:36; see also Blair 1964:3, Campbell 1977:35, England 1983:35, Barrett 1999:23, Pérez et al. 2000, DuBois 1981:117, Frazier 2013). Here too Kaqchikel is the mirror-image of other Mayan languages: Maxwell & Hill (2010:68) point out that most transitive verb roots contain a lax (historically short) vowel /C $\check{V}$ C/ (e.g. *-tāq* /-təq/ 'send, order'), unless the final consonant is a glottal stop /CVʔ/, in which case the vowel must be tense (historically long) (e.g. *-ya'* /-jaʔ/ 'give').

#### 2.4.2. Hiatus

Mayan languages differ as to whether or not they permit hiatus [V.V]. To illustrate, hiatus is banned in Poqomam, and underlying vowel sequences are split by [ʔ]-epenthesis (13). This



can be compared with Ixil (14), where hiatus is not only permitted but also contrasts with [V.ʔV].

(13) Hiatus avoidance in Poqomam (K'ichean, Guatemala; Santos Nicolás & Benito Pérez 1998)

a. *ti'oka* /ti-ok-a/ → [tiʔokʲa] 'you enter'

b. *xin'oo'ato'* /x-in-ʔo:-a-toʔ/ → [xinʔo:ʔatoʔ] 'you came to help me'

(14) Contrastive hiatus in Ixil (Ayes 1991, Poma et al. 1996, Chel & Ramirez 1999)

a. *tx'aoni* [tʃʰa.o.ni] '(s)he washed'      b. *tx'a'oni* [tʃʰa.ʔo.ni] '(s)he ate'

c. *ia* [ʔi.a] 'grandchild'      d. *i'a* [ʔi.ʔa] 'to value'

Apart from Ixil, I am aware of only a handful of Mayan languages that clearly allow hiatus: Q'anjob'al (Raymundo González et al. 2000, Baquix Barreno et al. 2005), Akatek (Zavala 1992), Tzeltal (at least some dialects; Kaufman 1971, Gerdel 1974, Polian 2013), and Tsotsil (at least some dialects; Weathers 1947, Haviland 1981, Aissen 1987).<sup>10</sup>

Several hiatus-avoidance strategies are attested in Mayan languages. Within the K'ichean branch, [ʔ]-insertion (13) is the preferred repair; it is also found in Mamean (Pérez et al. 2000) and in Itzaj (Schumann Gálvez 1971, 2000, Dienhart 1986, Hofling 2000). Glide insertion is another strategy, attested within the Yucatecan (Orie & Bricker 2000), Ch'olan (6), Tzeltalan (Shklovsky 2012), and Mamean branches (England 1983, Pérez Vail & Jiménez 1997, Pérez et al. 2000). The insertion of laryngeal [h] is reported for Greater Tzeltalan languages, e.g. Petalcingo Tzeltal *tenelahe* /ten-el-a=e/ → [tenelahe] 'was buried' (Attinasi 1973, Shklovsky 2005; see Schumann Gálvez 1971, 2000 for Itzaj). Vowel deletion may also occur in /V.V/ clusters, e.g. Mam *ma chook* /ma tʃi-o:k/ → [ma tʃo:k] 'they entered' (England 1983:45). Deletion is attested in Greater Tzeltalan as well, e.g. Tsotsil *ak'bo* /akʰ-be-o/ → [ʔakʰ-b-o] 'give it to him' (Aissen 1987:278). Finally, Edmonson (1988) reports /V.V/ → [V:] 'fusion' in Huastec (for Chontal, see Knowles 1984 and Keller & Luciano 1997). Multiple patterns of hiatus avoidance may also co-occur within a single language, sometimes differentiating word-internal /V-V/ from word-external /V#V/ (e.g. Coon 2010, Vázquez Álvarez 2011; see also Casali 1996).

Against this background, a few caveats are in order. The morphology of Mayan languages favors [CVC] roots and C-final suffixes (section 5.1); as a result, hiatus configurations are quite rare at stem-suffix boundaries. In the prefixal domain, phonologically conditioned allomorphy is generally structured to avoid /V-V/ strings (section 5.2), which has the effect of minimizing stem-initial hiatus as well. This makes it very difficult to test the productivity of hiatus repair strategies in most Mayan languages. Furthermore, when hiatus does occur, the choice of repair strategy may depend on the morphemes involved (see e.g. Attinasi 1973, England 1983, Barrett 2011). Indeed, some alternations are limited to single morphemes, such as the apparent [w]-insertion in Kaqchikel *yinik'o* [j-in-ikʰo] 'I pass over' vs. *ik'owinik* [ʔikʰow-in-ikʰ] 'to pass over', or the [Ø]~[x] alternation in *k'o* [kʰo] 'there is' vs. *xk'oje'* [ʃ-kʰox-eʔ] 'there was' (Macario et al. 1998; both alternations are root-specific). These facts suggest that some cases of hiatus resolution might be better understood as morphological rather than purely phonological in character.

### 2.4.3. Initial [ʔ]-insertion

In contrast with the diversity of responses to hiatus, we find that Mayan languages consistently avoid word-initial vowels through [ʔ]-insertion.<sup>11</sup>

- (15) Initial [ʔ]-epenthesis in Tektitek (Mamean, Guatemala and Mexico; Pérez Vail 2007)
- |    |                        |                                      |                             |    |                |                            |                 |
|----|------------------------|--------------------------------------|-----------------------------|----|----------------|----------------------------|-----------------|
| a. | <i>wab'aj</i>          | [w-a:ʔaχ]                            | 'my stone'                  | b. | <i>ab'j</i>    | [ʔaʔχ]                     | 'stone'         |
| c. | <i>matz tz'itz'jik</i> | [maʔs̄ ts̄ʔ-it̄s̄ʔχik <sup>h</sup> ] | '(s)he was<br>already born' | d. | <i>itz'jik</i> | [ʔit̄s̄ʔχik <sup>h</sup> ] | 'to be<br>born' |

This appears to be an exceptionless pattern across Mayan, though with some additional intricacies. In Q'anjob'al, for instance, word-initial [ʔ] is phonemic and distinguishes minimal pairs like *ixim* [ʔiʃim] 'corn' from *hixim* [iʃim] 'your corn' (England 2001, Baquixar Barreno et al. 2005). Note however that almost all vowel-initial forms are possessed nouns; such forms are exceptions to [ʔ]-insertion in other languages as well (see below). Moreover, word-initial [ʔ] appears to be epenthetic even when contrasting with [∅]: compare *qjan* [ʔaxan] 'ear of corn' and *hajan* [axan] 'your ear of corn' with the prefixed form *wajan* [w-axan] 'my ear of corn', where no [ʔ] appears.

An understudied facet of [ʔ]-insertion is its interaction with prosodic structure (Garellek 2013 and citations there). One gets the impression that most descriptions of initial [ʔ]-epenthesis are based on isolation forms (though some researchers do discuss phrasal context, e.g. Keller 1959, Knowles 1984, Sarles 1966:17-8, Schumann Gálvez 1971:35, Fisher 1973:62, Straight 1976:71, DuBois 1981:100, Dienhart 1986:29, Edmonson 1988:34, Larsen 1988:54). As such, it remains unclear whether [ʔ]-insertion is really a word-level process across Mayan, rather than a phrase- or utterance-initial phenomenon (see also Warkentin & Brend 1974, Hoffling 2000:10). It would be worthwhile to investigate the effect of phrasal position on the phonetics and phonology of initial [ʔ] in greater detail.

At lower levels of prosody, Dayley (1985) observes that [ʔ]-epenthesis in Tz'utujil is optional for vowel-initial words of more than one syllable, e.g. *utz'iiil* [(ʔ)ut̄s̄'i:ɪ] 'goodness'. This may point to conditioning by stress, which is normally final in Tz'utujil (see Larsen 1988:54 for K'iche'). Dayley also notes that some vowel-initial function morphemes never carry an initial [ʔ], such as the possessive prefixes (e.g. *aatz'ii'* [a:ʔs̄'i:ʔ] 'your dog') and directional particles (e.g. *xel eel* [ʃ-ɛ̄ e:ɪ] 'he went out'). Flack (2009) interprets this data as evidence that Tz'utujil requires every prosodic word to begin with a consonant, and accounts for vowel-initial function morphemes by treating them as clitics external to the prosodic word (see also section 7.2).

Though initial [ʔ] is not generally distinctive in Mayan languages, in the sense that there are no contrasts between initial [#ʔV] and simple [#V], there do appear to be phonological differences between underlying initial glottal stops /#ʔV/ and epenthetic [#ʔV]. In Mocho', some initial glottal stops are invariant under prefixation (16a-d), while most disappear (16e-h), triggering prefixal allomorphy (Section 5.2).

- (16) Non-alternating [#ʔV] in Mocho' (Greater Q'anjob'al, Mexico; Palosaari 2011)

a.	<i>onh</i>	[ʔoŋ]	'go'	b.	<i>kii'onh</i>	[k-i:ʔoŋ]	'I'm going to go'
c.	<i>uub'</i>	[ʔu:ʔ]	'quail'	d.	<i>ii'ub'</i>	[ʔi:ʔuʔ]	'my quail'
e.	<i>ooki</i>	[ʔo:k-i]	'he entered'	f.	<i>kwooki</i>	[k-w-o:k-i]	'I'm going to enter'
g.	<i>oonh</i>	[ʔo:ŋ]	'avocado'	h.	<i>woonh</i>	[w-o:ŋ]	'my avocado'

Barrett (2007, 2011) catalogs parallel cases of non-alternating [#ʔ] in the K'ichean languages (see also Campbell 1974). Similar patterns have been documented for Mamean (England 1983) and Yucatecan languages (Blair 1964, Straight 1976, Orié & Bricker 2000, Hoffling 2000; in the Yucatecanist literature, non-alternating initial glottal stops are called 'firm').

Non-alternating [#ʔ] plausibly corresponds to a ‘phonemic’ (though non-contrastive) /#ʔ/ which is specified in the underlying representation of the lexical items in question. The lexicalization of initial [ʔ] may depend on the frequency of [ʔ]~[Ø] alternations: if a particular root normally occurs in its isolation form, with an epenthetic glottal stop [#ʔ], learners may re-analyze the initial glottal stop as being underlying instead. Among nouns, non-alternating [#ʔ] should then be most common for roots which resist being possessed, such as Q’anjob’al *asun* [ʔasun] ‘cloud’ (Baquix Barreno et al. 2005:92; see also Campbell 1974, Smith-Stark 1983:131–2, Larsen 1988:103, Barrett 1999:57–8, Orié & Bricker 2000, Kenstowicz 2013). It is unclear to me whether this expectation is actually borne out.

Not all instances of [#ʔ]-retention can be treated as simple phonemicization, however (see also Majzul et al. 2000:46). While some prefixes may block [ʔ]-insertion, other prefixes may systematically co-occur with epenthetic [ʔ]. For example, the [ʔ] in Kaqchikel *ik’* [ʔikʔ] ‘month’ is clearly epenthetic, because it alternates with [Ø] when a possessive prefix is added, *rik’* [r-ikʔ] ‘her period’. The initial [ʔ] is nonetheless maintained in forms containing the agentive prefix *aj*, as in *aj’ik’* [ax-ʔikʔ] ‘domestic worker’ (Barrett 2007). The retention of epenthetic [#ʔ] is extremely common for agentive prefixes and noun class prefixes in other Mayan languages as well (some of these are cognate with Kaqchikel *aj*-). This heterogeneous behavior cannot be explained by positing an underlying glottal stop; some higher grammatical principle is clearly involved, such as prosodic conditioning or morphological cyclicity (see also Bennett & Henderson 2014).

Similar patterns are observed in the verbal domain: in Popti’, for instance, the A1SG agreement prefix *w-* /w-/ bleeds [ʔ]-insertion (*oq’anh* [ʔoqʔ-an] ‘You cry!’ vs. *lanhan woq’i* [lanjan w-oqʔ-i] ‘I’m crying’), but not the completive aspect marker *x-* /s-/ (*x’oq’ naj* [s-ʔoqʔ naχ] ‘he cried’) or the B1SG agreement prefix *in-* /in-/ (*chin’oq’i* [tʃ-in-ʔoqʔ-i] ‘I cry’) (Day 1973, Jiménez Camposeco et al. 2001). Mayan languages differ as to which verbal prefixes bleed [ʔ]-insertion, and which do not (see Santos Nicolás & Benito Pérez 1998 for Poqomam, Pérez Vail & Jiménez 1997 for Mam, and DuBois 1981:156 for Sakapultek). This is clearly an area for further investigation.

#### 2.4.4. Vowel Deletion

The deletion of unstressed short vowels is pervasive throughout the Mayan languages. Example (17) illustrates the deletion of pre-tonic short vowels in Sipakapense.

(17) Pre-tonic syncope in Sipakapense (K’ichean, Guatemala; Barrett 1999, 2011, Tema Bautista 2005)

- a. *wxim* /w-ijim/ → [wʃim] ‘my corn’
- b. *chab’na’* /tʃ-a-βan-aʔ/ → [tʃ-a-βn-ʔaʔ] ‘Do it!’
- c. *xtqpxoj* /ʃt-q-poj-oχ/ → [ʃtʰqʰpʰoχ] ‘We are going to shatter it’

Vowel deletion has led to heavy lexical restructuring in Sipakapense, so that forms like K’iche’ /w-atʃootʃ/ ‘my house’ and /q(a)-/ ‘A1PL’ have cognates like /w-tʃotʃ/ and /q-/ in Sipakapense (Campbell 1977, Tema Bautista 2005, Barrett 2011).

Syncope processes like (17) have been described for Mamean languages (Mam: England 1983, Pérez et al. 2000; Tektitek: Pérez Vail 2007; Ixil: Ayres 1991), K’ichean languages (Uspantek: Campbell 1977, Can Pixabaj 2006, Bennett & Henderson 2013; Tz’utujil: Dayley 1985; Sakapultek: DuBois 1981, Mó Isém 2007; K’iche’: Larsen 1988), Tzeltal (Polian 2013), Yucatec (Krämer 2001, Sobrino Gómez 2007), Tojolab’al (Furbee-Losee 1976a,b),

Mocho' (Palosaari 2011), and Huastec (Edmonson 1988). Historical instances of syncope are described for proto-Ch'olan in Kaufman & Norman (1984). There are surely other cases of syncope in Mayan that have yet to be documented in detail.

Despite this prevalence of vowel deletion patterns, the conditions on syncope remain poorly understood. There are nonetheless some tendencies worth noting. First, deletion is typically limited to short unstressed vowels. Vowels in pre-tonic and post-tonic syllables are particularly susceptible; Bennett & Henderson (2013) take this as evidence that syncope is conditioned by metrical foot structure in Uspantek. Deletion may also be restricted by morphology. In Huastec, syncope exclusively targets vowels belonging to affixes (Edmonson 1988). Barrett (1999, 2011) suggests that vowel deletion in Sipakapense does not occur in verbal prefixes, e.g. *xinb'an* [ʃ-im-bán] 'I did it', \*[ʃmbán], cf. *xnmaj* [ʃ-nmaχ] 'he believed it' and *xb'now* [ʃ-bn-ow] 'who made it (agent focus)'. Certain roots may resist syncope, e.g. Sipakapense *sipil* [sip-il] 'gift-giver', \*[sp-il].

Syncope can also be restricted by purely phonological conditions. Word-initial vowels (surface [#ʔV]) may escape deletion. Consonant phonotactics play a role as well. Syncope can derive impressive consonant clusters, such as Sipakapense *katuruq* [k-at-wr-oq] 'Sleep!' (cf. *worb'al* [wɔr-ba] 'bedroom', (17c); Barrett 1999, 2011) or Mam *tzaj tɬq'o'n* [tsaχ t<sup>h</sup>lq<sup>o</sup>ʔn] '(s)he bought it' (cf. *loq'ol* [loq<sup>o</sup>ʔol] 'to buy'; Pérez Vail & Jiménez 1997, Pérez et al. 2000) (section 2.4.4). However, syncope may still be blocked when it would derive clusters that are illicit in the language in question, e.g. Tseltal *ajk'taj /ahk<sup>o</sup>ot-ah/* → [ʔahk<sup>o</sup>tah] '(s)he danced', but *akiltik* [ʔakiltik], \*[ʔakltik] 'grassland', Polian 2013; see also Palosaari 2011). Barrett (1999, 2011) and Bennett & Henderson (2013) report an 'antigemination' effect that inhibits the deletion of vowels between identical consonants in K'ichean languages, e.g. Uspantek *ajij* [ʔ'á.xix], \*[ʔ'áxx] 'sugarcane' (cf. McCarthy 1986, Odden 1988).

To close this discussion, it should be pointed out that syncope may yield opaque interactions with allophony, prosody, and morphology in Mayan languages. Space limitations prevent me from discussing such patterns in detail. For specific examples, consult section 5.2, DuBois (1981:106), England (1983:29), Edmonson (1988:87), Larsen (1988:46), Barrett (2011, 1999:35–6,56–8), and Bennett & Henderson (2013).

### 3. Consonant inventories

Table 1 provides an overview of the phonemic consonants found in Mayan languages. For simplicity I have omitted phonemes that are only attested in Spanish loans. The table is meant to be schematic: some non-contrastive phonetic detail is ignored (such as whether the implosives are voiced or voiceless, section 3.3), and other authors may have different interpretations of the appropriate underlying phones for a given language.

A few commonalities are immediately apparent. Mayan languages typically contrast a set of plain voiceless stops with a distinct set of 'glottalized' stops at the same place of articulation. The 'glottalized' stops may be ejective, implosive, preglottalized, etc. depending on the language and phonetic context (section 3.3), but are treated as a natural class because of their phonological patterning (section 3.4; see also Shosted 2009).<sup>12</sup> In addition to plain and glottalized stops, the coronal affricates /ts tʃ ts<sup>ʔ</sup> tʃ<sup>ʔ</sup>/ are also part of the canonical Mayan consonant inventory.<sup>13</sup> Though glottal stop /ʔ/ may not be contrastive in all positions (section 2.4), it is nonetheless phonemic in every Mayan language.

Among fricatives, the only constant is an opposition between /s/ and /ʃ/.<sup>14</sup> While proto-Mayan had a contrast between \*/h/ and \*/x/, just a few Mayan languages preserve this distinction (Law 2014). Most languages have either phonemic /h/ or phonemic /x/ (which

**Table 1. Mayan consonant inventories: (C) marks phonemic consonants missing from at least one branch; {C} marks rare phonemic consonants found in just one or two languages;  $C_a \sim C_b$  marks non-contrastive variation in the basic phonetic form of a phoneme across languages or dialects.**

	Bilabial	Dental/ alveolar	Post- alveolar	Retroflex	Palatal	Velar	Uvular	Glottal
Plain plosive	p {b}	t ts {ts̄}	tʃ	(ts̄)	{tʃ}	k (kʲ) {kʷ}	(q)	
'Glottalized' plosive	(pʔ) ɓ	tʔ tsʔ {ts̄ʔ}	{d}	tʃʔ	(ts̄ʔ)	{tʃʔ}	kʔ (kʲʔ) {kʷʔ}	(qʔ ~ ɕʔ) ?
Fricative		{θ} s {s̄}	ʃ	(s̄)		(x ~ χ)		(h)
Nasal	m	n			{ɲ}	(ŋ)		
Approximant	w ~ v/β	l (r ~ ɾ)			j			

may be uvular /χ/), but not both. In languages that have merged historical \*/h/ and \*/x/ the historical place difference may still be reflected in the synchronic morpho-phonology; see Orié & Bricker (2000) on Yucatec, Smith-Stark (1983:131–2,156) on Poqomam, and Anderson (1981) for general discussion.

The core sonorant inventory is composed of /m n l j w/. The phoneme transcribed as /w/ is more accurately /v/ or /β/ in some languages: this is true for certain varieties of Tsotsil (Haviland 1981, Aissen 1987, Herrera Zendejas 2014:Ch.9) and for Ixil (Ayres 1991, Poma et al. 1996). Romero (2009) provides a sociolinguistic analysis of /l/ allophony in Santa Maria Chiquimula K'iche', focusing on a typologically unusual pattern of lateral fricativization /VlV/ → [VðV].

### 3.1. COMMON PHONEMIC CONTRASTS

#### 3.1.1. Uvular Stops

All Mayan languages have stops at labial, coronal, and velar places of articulation. Eastern Mayan languages (Mamean, K'ichean) also retain the proto-Mayan uvular stops /q qʔ/, as do the languages of Q'anjob'alán Proper (Q'anjob'al, Akatek, and Popti'). This is shown for Q'eqchi' in (18).

(18) Contrastive uvular stops in Q'eqchi' (K'ichean, Guatemala and Belize; Tzul & Cacao 2002)

- |  |                                   |
|--|-----------------------------------|
| a. <i>kaq</i> [kaqˣ] 'red'                 | b. <i>k'al</i> [kʔal] 'cornfield' |
| c. <i>qas</i> [qas] 'our brother'          | d. <i>q'an</i> [qʔan] 'yellow'    |
| e. <i>kok</i> [kok <sup>h</sup> ] 'turtle' | f. <i>uk'</i> [ʔukʔ] 'louse'      |
| g. <i>toq</i> [toqˣ] 'Cut it!'             | h. <i>toq'</i> [toqʔ] 'gum'       |

While Popti' has a phonemic glottalized /qʔ/, it lacks the corresponding plain uvular stop /q/ (Day 1973, Jiménez Camposeco et al. 2001). The same may be true for Akatek (Zavala 1992, cf. Raymundo González et al. 2000). The uvular stops may be disappearing from Q'anjob'al and Akatek: plain /q/ is realized as the fricative [χ] in a wide range of environments, and /qʔ/ is frequently realized as either [kʔ] or [ʔ], especially among younger speakers (Zavala 1992, Raymundo González et al. 2000, Baquix Barreno et al. 2005).

### 3.1.2. Sub-coronal Place Contrasts

Along with the alveolar and post-alveolar sibilants /s t̥s t̥s<sup>2</sup> ʃ t̥ʃ t̥ʃ<sup>2</sup>/, some Mayan languages have an additional retroflex series /ʂ t̥ʂ t̥ʂ<sup>2</sup>/. These sibilants are attested in Q'anjob'alan and Mamean languages.

- (19) Sub-coronal place contrasts in Popti' sibilants (Q'anjob'alan, Guatemala; Jiménez Cam-  
poseco et al. 2001)
- |                            |                  |  |             |
|----------------------------|------------------|--|-------------|
| a. <i>tzima</i> [t̥sima]   | 'drinking gourd' | b. <i>sik'</i> [sik <sup>2</sup> ]     | 'cigarette' |
| c. <i>cheh</i> [t̥ʃeh]     | 'horse'          | d. <i>axhni</i> [ʔaʃni]                | 'to bathe'  |
| e. <i>txitam</i> [t̥ʂitam] | 'pig'            | f. <i>xib'al</i> [ʂip <sup>2</sup> al] | 'comb'      |

An even richer set of sibilant place contrasts has been reported for varieties of Ixil (Ayres 1991, Poma et al. 1996), Tektitek (Kaufman 1969, Pérez Vail 2007), and Mam (Pérez et al. 2000, England 2001). The dialects in question make a further distinction between apico-alveolar /s t̥s t̥s<sup>2</sup>/ and lamino-alveolar (or lamino-alveopalatal) /s̥ t̥s̥ t̥s̥<sup>2</sup>/, yielding the four-way coronal place distinction illustrated in (20).

- (20) Sub-coronal place contrasts in Todos Santos Mam (Pérez et al. 2000, England 2001)
- |                                       |                     |                        |            |
|---------------------------------------|---------------------|------------------------|------------|
| a. <i>shik</i> [ʂik <sup>h</sup> ]    | 'rabbit'            | b. <i>sii'</i> [si:ʔ]  | 'firewood' |
| c. <i>k'o'xh</i> [k <sup>2</sup> oʔʃ] | 'measure of liquor' | d. <i>xyeb'</i> [ʂjeβ] | 'comb'     |

The lamino-alveolar consonants are sometimes reflexes of /k<sup>j(2)</sup>/ (section 3.2.1), but may also descend from sibilants at other places of articulation. As far as I know such contrasts are only found in the Mamean branch.

Some of the Veracruz varieties of Huastec contrast retroflex /t̥ʂ<sup>(2)</sup>/ with post-alveolar /t̥ʃ<sup>(2)</sup>/. This two-way coronal place distinction corresponds to a post-alveolar /t̥ʃ<sup>(2)</sup>/ ~ apical /t̥s<sup>(2)</sup>/ contrast in other varieties of Huastec (Kaufman 1985, Norcliffe 2003:15,56–9, Herrera Zendejas 2014:Ch.7, Lucero Meléndez, p.c.).

### 3.1.3. Ejective /p<sup>2</sup>/

The voiceless labial ejective [p<sup>2</sup>] is commonly observed as an allophone of the implosive /β/, especially in final position (sections 3.3, 3.4.2). There are, however, a number of languages in which ejective /p<sup>2</sup>/ contrasts phonemically with the implosive /β/ and the plain labial stop /p/ (see also Ladefoged & Maddieson 1996:Ch.3).

- (21) Phonemic /p<sup>2</sup>/ in Chontal (Ch'olan, Mexico; Keller 1959, Knowles 1984)
- |                                    |             |                                    |                |
|------------------------------------|-------------|------------------------------------|----------------|
| a. <i>bab</i> [baβ <sup>2</sup> ]  | 'paddle'    | b. <i>pop</i> [pop <sup>h</sup> ]  | 'sleeping mat' |
| c. <i>p'os</i> [p <sup>2</sup> os] | 'sweepings' | d. <i>nap'</i> [nap <sup>2</sup> ] | 'lake'         |

Phonemic /p<sup>2</sup>/ appears to be an areal feature, attested in all the Yucatecan languages, most of the Greater Tzeltalan languages, and in the K'ichean branch, Poqomam and Poqomchi' (Campbell 1977, Kaufman & Norman 1984, Justeson et al. 1985, Law 2014).

### 3.1.4. Rhotics

Most Mayan languages lack a phonemic rhotic /r/. The modern reflexes of proto-Mayan \*/r/ include /j/ (Western Mayan, Yucatecan, Huastec) and /t/ (Mamean), along with some sparse cases of /t̥ʃ/ (Kaufman 1976a, Justeson et al. 1985, Law 2014). Phonemic /r/ is only

robustly attested in the K'ichean branch: while other languages may have scattered instances of /r/, in both loans and in the native vocabulary, it is essentially a marginal phoneme found mainly in 'expressive' morphemes like affect words and onomatopoeia (England 2001; see also Pullum & Zwicky 1987, Hall 2013 and Henderson this volume). In Yucatec, /r/ is mostly restricted to intervocalic position in polysyllabic expressive roots (Bricker et al. 1998:xii, Le Guen 2012; see Schumann Gálvez 1971, 2000, Dienhart 1986, Zocal Chayax et al. 2001 for Itzaj).

The Mayan rhotic is usually realized as a flap or tap; when devoiced (section 3.4), it may become a retroflex or post-alveolar fricative (cf. Howson et al. 2014 on Czech).

### 3.2. UNCOMMON PHONEMIC CONTRASTS

#### 3.2.1. Palatalized Velars

The palatalization of velar stops is a well-attested allophonic process in K'ichean Mayan languages, e.g. Tz'utijil *k'im* [k<sup>j</sup>ʔim̃] 'straw' (Dayley 1985, see also Campbell 1977, Ohala 1981, Palosaari 2011). In three Mamean languages (Mam, Tektitek, and Awakatek), palatalization has in fact become contrastive for the velar stop series.

(22) Phonemic palatalized velar stops in Awakatek (Mamean, Guatemala; Velásquez Mendoza 2001)

- |  |        |  |        |
|--|--------|--|--------|
| a. <i>kay</i> [kaj]                      | 'fish' | b. <i>kyaq</i> [k <sup>j</sup> aq <sup>h</sup> ] | 'red'  |
| c. <i>samlik'</i> [samlik <sup>ʔ</sup> ] | 'sand' | d. <i>xiiky'</i> [ʃi:k <sup>j</sup> ʔ]           | 'wing' |

As noted above, the pronunciation of palatalized /k<sup>j</sup>(ʔ)/ has shifted toward lamino-alveolar [t̪s̪<sup>(ʔ)</sup>] or [t<sup>j</sup>(ʔ)] in Tektitek and a few dialects of Mam. England (2001) suggests that some K'ichean languages may be developing phonemic palatalized velars as well.

#### 3.2.2. Palatalized Coronals

Ch'ol has developed an unusual set of alveolar stops (including the alveolar nasal): the phonemic inventory of the language includes 'palatalized' /t<sup>j</sup> t<sup>j</sup>ʔ n/, but not their plain unpalatalized counterparts (Schumann Gálvez 1973, Attinasi 1973, Warkentin & Brend 1974, Vázquez Álvarez 2011). This is clearly an innovation, as Ch'ol /t<sup>j</sup> t<sup>j</sup>ʔ n/ corresponds to /t t<sup>ʔ</sup> n/ in other Greater Tzeltalan languages.<sup>15</sup>

(23) Palatalized alveolars in Ch'ol (Warkentin & Brend 1974, Vázquez Álvarez 2011)

- |  |          |   |                     |
|--|----------|---|---------------------|
| a. <i>tyuñ</i> [t <sup>j</sup> uɲ]     | 'stone'  | b. <i>ty'uñ</i> [t <sup>j</sup> ʔuɲ]                                    | 'follow (the path)' |
| c. <i>tyiñäm</i> [t <sup>j</sup> iɲäm] | 'cotton' | d. <i>tyatymuty</i> [t <sup>j</sup> at <sup>j</sup> -mut <sup>j</sup> ] | 'rooster'           |

Non-palatalized /t/ exists only as a marginal phoneme, and [n] occurs only as an allophone of /ɲ/. Vázquez Álvarez (2011) suggests that the palatalized series may have developed under contact with Mixe-Zoquean languages. The articulatory details of the palatalized series are unknown: they may be true palatals (with raising and fronting of the tongue dorsum), or may be simple lamino-alveolars (see discussion in Ladefoged & Maddieson 1996:Ch.2). It would be surprising from a typological perspective to find true articulatory palatalization for Ch'ol /t<sup>j</sup> t<sup>j</sup>ʔ n/, given that languages typically favor consonants with simple articulatory requirements (Lindblom & Maddieson 1988).

### 3.2.3. Velar Nasal

Three languages in the Greater Q'anjob'alan branch (Popti', Chuj, and Mocho') have retained a phonemic velar nasal /ŋ/ from proto-Mayan (Kaufman 1976a, Campbell & Kaufman 1985, Law 2014).

(24) Phonemic velar nasal in Chuj (Chujean, Guatemala and Mexico; Hopkins 1967, García Pablo & Domingo Pascual 2007)

- |                           |         |                          |        |
|---------------------------|---------|--------------------------|--------|
| a. <i>nhab'</i> [ŋabʔ]    | 'rain'  | b. <i>inhat</i> [ʔiŋatʰ] | 'seed' |
| c. <i>yib'anh</i> [jiβaŋ] | 'above' | d. <i>namam</i> [namam]  | 'warm' |

Elsewhere in Western Mayan, proto-Mayan \*/ŋ/ merged with alveolar /n/. The same shift can be observed in the Yucatecan languages. More curiously, proto-Mayan \*/ŋ/ developed into the velar fricative \*/x/ in the Eastern Mayan languages (K'ichean and Mamean) and into /h/ or /w/ in Huastecan (Campbell 1977, Campbell 1999:195, Norcliffe 2003). See Ohala & Busà (1995) and citations there for relevant discussion of 'rhinoglottophilia' in sound change.

### 3.2.4. Implosive /d'/

The Yucatecan language Mopan has a three-way laryngeal contrast among coronal stops, illustrated in (25). The implosive /d'/ is the innovative phoneme in this case (Fisher 1973, Hoffing 2007, 2011).

(25) Phonemic /t tʔ d'/ in Mopan (Yucatecan, Guatemala and Belize; Cohuoj Caal et al. 2001)

- |                           |                 |                         |                |
|---------------------------|-----------------|-------------------------|----------------|
| a. <i>k'ati</i> [kʔati]   | '(s)he wanted'  | b. <i>jit'i</i> [hitʔi] | 'Weave it!'    |
| c. <i>k'ad'i</i> [kʔad'i] | 'it was joined' | d. <i>jed'i</i> [hed'i] | '(s)he rested' |

Voiced implosive /d'/ has been noted in other Yucatecan languages, but only in Spanish loans (Straight 1976, Hoffing 2000). Surface [d] is sometimes observed as an allophone of /tʔ/ in non-Yucatecan languages (e.g. Dayley 1985 for Tz'utujil; Hopkins 1967:19 for Chuj; Polian 2013:88 for Tselal; England 2001:26 for Tektitek).

### 3.2.5. Huastec

Huastec broke away from the other Mayan languages very early in the development of the family, as part of a northward migration of speakers which eventually settled in east-central Mexico, nearly 1000 miles from the Mayan homeland in Southern Mexico and Guatemala (McQuown 1964, Kaufman 1976a, Campbell & Kaufman 1985, Law 2013, 2014). As a result of this early linguistic and geographical divergence, Huastec (and its now-extinct sibling Chicomuceltec) has a number of features which clearly set it apart from other Mayan languages. Phonologically speaking, Huastec is the only Mayan language with a phonemic interdental fricative /θ/, and the only language with a phonemic contrast between plain velar /k kʔ/ and labialized velar /kʷ kʷʔ/ (Larsen & Pike 1949, McQuown 1984, Edmonson 1988).



- (26) Innovative phonemic /θ k<sup>w</sup> k<sup>wʔ</sup>/ in Huastec (Edmonson 1988)
- |   |  |
|---|--|
| a. <i>thakw</i> [θak <sup>wʰ</sup> ] ‘stone’            | b. <i>lekwʔtsiy</i> [lɛk <sup>wʔ</sup> tsij̥] ‘lit it’         |
| c. <i>ith</i> [ʔiθ] ‘sweet potato’                      | d. <i>katsiy</i> [katsij̥] ‘sliced it’                         |
| e. <i>kwatsiy</i> [k <sup>w</sup> atsij̥] ‘went to bed’ | f. <i>kwʔatsiy</i> [k <sup>wʔ</sup> atsij̥] ‘put corn to soak’ |

For enlightening discussion of the development of /θ k<sup>w</sup> k<sup>wʔ</sup>/ in Huastec, and the difficulties in reconstructing the linguistic history of these sounds, see Campbell (1999) and Norcliffe (2003).

The labial stops of Huastec also differ from Mayan languages with respect to their laryngeal specification. Edmonson (1988) reports a true voicing contrast for /b p/, with some allophonic spirantization and devoicing of /b/. Kaufman (1985) concurs, though he also notes that a conservative variety of Huastec (Chontla) possesses a glottalized /bʔ/ (presumably IPA /β̥/) which may have been present in proto-Huastecan as well. See Herrera Zendejas (2014:Ch.7) for more detailed discussion.

### 3.3. CONSONANT PHONETICS

#### 3.3.1. ‘Glottalized’ Stops

The ‘glottalized’ stops of Mayan have been studied in more depth than any other phonetic or phonological characteristic of these languages. The phonology of glottalized stops will be described in sections 3.4 and 5; here I focus on their phonetic properties.

The term ‘glottalized’ subsumes the phonemic ejectives and phonemic implosives in the Mayan languages. Glottalized stops are monosegmental in both phonetic and phonological terms, distinct from [Cʔ] and [ʔC] sequences.

- (27) Monosegmental glottalized stops in Sipakapense (Barrett 1999, Tema Bautista 2005)
- |  |   |
|--|---|
| a. <i>xaʔk</i> [ʃaʔk <sup>h</sup> ] ‘piece, sheet’ | b. <i>akʔ</i> [ʔak <sup>ʔ</sup> ] ‘chick’ |
| c. <i>kʔam</i> [k <sup>ʔ</sup> am] ‘to be taken’   | d. <i>kʔaam</i> [k-ʔa:m] ‘their spider’   |

Languages differ as to whether the glottalized stop at a particular place of articulation is realized as an ejective or an implosive. For example, the glottalized coronal /t<sup>ʔ</sup>/ is consistently produced as an ejective in Kaqchikel, but in closely-related Tzʔutujil it is either a voiced implosive [d] or ejective [t<sup>ʔ</sup>], depending on prosodic context (e.g. [dɔ:t<sup>ʔ</sup>] ‘snail’; Dayley 1985, Pinkerton 1986, Chacach Cutzal 1990, Majzul et al. 2000). Most of this variation occurs with labial /β/ and uvular /q<sup>ʔ</sup>/: velar /k<sup>ʔ</sup>/ and coronal /t<sup>ʔ</sup>/ seem to be reliably ejective in most Mayan languages.

There is a sizable literature on the phonetics of glottalized stops across Mayan. An incomplete list includes Campbell (1973), Kingston (1984), Pinkerton (1986), Russell (1997), Burnett-Deas (2009), Shosted (2009), Frazier (2009b), and Wagner & Baker-Smemoe (2013), as well as the many descriptive grammars which include phonetic detail in their discussion of ejectives and implosives.

Glottalized stops differ from the plain stops along a number of phonetic parameters. Perhaps the most consistent cue to glottalization is the laryngealization of adjacent vowels, which has been noted for a range of different languages in the family (e.g. Keller 1959, Blair 1964:10, Sarles 1966:25-7, Day 1973:12, England 1983:32, Dayley 1985:32, Edmonson 1988:40, England 1990:223, DuBois 1981:120, Herrera Zendejas 2014, etc.). Other differences may include voice onset time (ejective > {plain (unaspirated), implosive}), burst amplitude (ejective > {plain, implosive}), burst type (a period of silence

may follow ejective bursts), and pitch on following vowels ({ejective, plain} > implosive). Russell (1997) finds that the abruptness and sharpness of the vowel onset following stop release may also index the plain ~ glottalized contrast in Northern Mam (plain > glottalized).

I hasten to emphasize that the phonetic differences sketched above are at best tendencies. The overall picture that emerges from the literature is that the phonetic realization of glottalized stops in Mayan varies quite widely across languages, dialects, and perhaps even individual speakers. This makes it difficult to extract any robust, cross-language generalizations about the phonetic cues to the glottalization contrast.

To illustrate, consider the various manifestations of /β/, the voiced glottalized labial stop. Voiceless ejective [pʔ], voiced implosive [β], and voiceless implosive [β̥] are all reported as possible variants of this phoneme, and language descriptions will commonly note at least two of these realizations (28). Pre-glottalized realizations like [ʔb] are also attested, especially in the Greater Tzeltalan languages (Warkentin & Brend 1974, Haviland 1981, Polian 2013). Some of this variation is allophonic and may be restricted to particular contexts, but unconditioned variation clearly exists both within and across languages.

(28) Glottalized /β/ in three Mayan languages (Jiménez Camposeco et al. 2001, Majzul et al. 2000, Zocal Chayax et al. 2001)

- |                             |                   |            |                              |           |              |         |        |
|-----------------------------|-------------------|------------|------------------------------|-----------|--------------|---------|--------|
| a. Kaqchikel I: <i>jöb'</i> | [χoβ̥]            | 'rain'     | b. Kaqchikel II: <i>sib'</i> | [sipʔ]    | 'smoke'      |         |        |
| (Santa Maria Cauqué)        |                   |            | (Tecpán)                     |           |              |         |        |
| c. Popti':                  | <i>b'alunheb'</i> | [pʔalunβ̥] | 'nine things'                | d. Itzaj: | <i>b'äk'</i> | [β̥ikʔ] | 'meat' |

This is to say nothing of the more extreme allophonic (and diachronic) patterns which may target /β/, such as debuccalization to [ʔ], spirantization to [f/ϕ], and sonorization to [m<sup>(ʔ)</sup>] or [w<sup>(ʔ)</sup>] (Haviland 1981, Cojtí Macario & Lopez 1990, Par Sapón & Can Pixabaj 2000, Malchic Nicolás et al. 2000, Jiménez Camposeco et al. 2001, Caz Cho 2007, Herrera Zendejas 2014).<sup>16</sup>

The voiced labial /β/ is clearly the most variable of the glottalized stops, but as mentioned above, qualitatively similar variation is described for uvular /qʔ/ as well. Even for the 'stable' ejectives /tʔ kʔ/, caution is warranted: cross-linguistically, ejectives may be produced with differences in laryngeal dynamics which give rise to rather distinct acoustic consequences (e.g. Lindau 1984, Kingston 1984, Ladefoged & Maddieson 1996, Warner 1996, Wright et al. 2002, Ham 2004, Kingston 2005, Shosted 2009, and references there). At present, the range of articulatory and acoustic variation for Mayan ejectives is not known.

With that said, some of the apparent variation in the phonetics of 'glottalized' stops may be spurious, reflecting methodological differences rather than true phonetic heterogeneity. While some studies have collected direct articulatory data (such as oral airflow) to investigate glottal state contrasts for stops (e.g. Pinkerton 1986, Shosted 2009), others have relied exclusively on acoustic measures (Russell 1997, Frazier 2009b, Burnett-Deas 2009). Most descriptive studies seem to be based on simple auditory impressions; this may be one reason why different sources sometimes provide different phonetic descriptions for glottalized stops in the same language. Given that some laryngeal distinctions are both perceptually weak and non-contrastive (e.g. the difference between voiced [β] and voiceless [β̥]), it would be worthwhile to re-confirm these impressionistic descriptions using quantitative instrumental methods.

### 3.3.2. Glottal Stop [ʔ]

The phonetics of the glottal stop [ʔ] have been studied for Yucatec (Frazier 2009a, 2013), K'iche' (Baird 2011), and Q'anjob'al (Baird & Pascual 2011). Together with the larger descriptive literature, these works converge on a few basic generalizations about the phonetic patterning of [ʔ] (see also section 2.3 and Barrett 2007).

Glottal stop may sometimes be produced with full closure, yielding a brief period of silence in the acoustic signal. However, the primary phonetic cue for [ʔ] is its effect on preceding and following vowels. As with the glottalized oral stop series, the glottal stop [ʔ] is routinely described as inducing laryngealization on adjacent vowels (e.g. DuBois 1981:99, among many others). Creaky voice may occur with or without full glottal closure. Full closure seems to be most frequent in word-final position, though creaky /Vʔ#/ → [VV#] is certainly attested as well. Baird (2011) and Baird & Pascual (2011) find that full closure for intervocalic /VʔV/ is more common in K'ichee than in Q'anjob'al; they speculate that this difference may be related to the fact that Q'anjob'al allows hiatus, but K'ichee does not (section 2.4.2).

Glottal stop is sometimes produced with an 'echo' vowel, e.g. K'iche' *po't* [poʔ<sup>o</sup>t] 'huipil'. This is particularly common in pre-consonantal position, especially if the following consonant is voiceless. Such echo vowels are apparently rare in Q'anjob'al. Voiceless echo vowels are occasionally reported for word-final [ʔ] as well, e.g. Sakapultek *b'ee'* [βe:ʔ<sup>ə</sup>] 'sheep' (DuBois 1981; see also Sarles 1966:16, Attinasi 1973, Dienhart 1986, Larsen 1988:54, and others). These 'vowels' may correspond to allophonic aspiration rather than a true vocalic element (e.g. Barrett 1999:37, section 3.4).

Frazier (2009b) tentatively suggests that glottal stop may depress pitch on adjacent vowels in Yucatec, at least relative to fricatives and non-implosive stops (see England 1983:32 for Mam). Glottal stop is deeply implicated in tonogenesis in Mayan (section 6.2), and so pitch perturbations conditioned by [ʔ] are to be expected. Vowel lowering has also been noted in the environment of [ʔ] (Attinasi 1973:33, Furbee-Losee 1976b, England 1983:32).

### 3.3.3. Fricatives

I am aware of just two studies on the phonetics of Mayan fricatives. Preliminary work by Shosted (2014) suggests that Q'anjob'al may have a true sub-apical retroflex fricative *x* [ʂ], articulated with pronounced upward curling of the tongue tip ('sub-apical' means that a constriction is formed between the underside of the tongue tip and the area behind the alveolar ridge; Laver 1994, Ladefoged & Maddieson 1996). Q'anjob'al may therefore be an exception to Hamann's (2003) typological generalization that "retroflex fricatives do not involve the same [extreme] backwards bending of the tongue tip as retroflex stops".

Léonard et al. (2009) investigate the acoustics of Tseltal [x] and [h], comparing their spectral and durational characteristics. Their paper includes detailed discussion of inter-dialectal variation in the distribution of these two fricatives, which have merged in some varieties of Tseltal.

## 3.4. CONSONANT PHONOTACTICS

### 3.4.1. Final Aspiration and Final Devoicing

The plain stops /p t k (q)/ are typically aspirated in word-final position. The uvular /q/ may also be affricated, e.g. Mam *kyaq* [k<sup>a</sup>aq<sup>ʔ</sup>] 'hot' (England 1983).<sup>17</sup>

- (29) Final aspiration in Poqomchi' (K'ichean, Guatemala; Malchic Nicolás et al. 2000)
- |                                  |          |                               |           |
|----------------------------------|----------|-------------------------------|-----------|
| a. <i>tz'aplik</i> [tʰsʰapʰlikʰ] | 'closed' | b. <i>ch'upaq</i> [tʰʃʰupaqʰ] | 'amole'   |
| c. <i>ati't</i> [ʔatiʔtʰ]        | 'female' | d. <i>qajik</i> [qaxikʰ]      | 'lowered' |

The status of aspiration as an allophonic process can be illustrated with alternations like Kaqchikel *xusök* [ʃ-u-sokʰ] 'he cut it' ~ *sokanel* [sok-an-el] 'barber'.

Final aspiration is an exceedingly regular characteristic of Mayan languages. Of the roughly thirty Mayan languages spoken today, only Q'anjob'al and Lacandon lack predictable final aspiration—and even then, final aspiration is possible, though not required (Bruce 1968, Raymundo González et al. 2000).

- (30) Variable realization of plain final stops in San Pedro Soloma Q'anjob'al (Raymundo González et al. 2000, Baquixar Barreno et al. 2005)
- |                          |         |                            |            |
|--------------------------|---------|----------------------------|------------|
| a. <i>penek</i> [penekʰ] | 'knee'  | b. <i>hasat</i> [asatʰ]    | 'your eye' |
| c. <i>inup</i> [ʔinup]   | 'ceiba' | d. <i>saq</i> [saqˣ]~[saχ] | 'white'    |

Languages differ as to whether aspiration also occurs in medial position before other consonants, [TʰC]. By way of illustration, pre-consonantal plain stops are aspirated [TʰC] in Poqomchi' (29); variably aspirated [TʰC] in Mam (England 1983:25); and consistently unaspirated [TC] in Popti' (Jiménez Camposeco et al. 2001). It is unclear at present whether the environment for pre-consonantal aspiration should be stated in terms of syllable structure ('syllable-final') or linear context ('pre-consonantal'); this may vary language-to-language (see also Steriade 1999, Bennett 2010, sections 2.4.4 and 4).

Phrasal position may also condition the strength of aspiration. Warkentin & Brend's (1974) description of Ch'ol claims that "[plain voiceless] stops and affricates are...more heavily aspirated phonological sentence finally" (see also Weathers 1947, Straight 1976, Bennett 2010). AnderBois (2011) draws a parallel between word-final aspiration in Yucatec and two separate processes which derive coda [h], namely word-final stop debuccalization /T/ → [h] and phrase-final [h]-epenthesis. For AnderBois, all three processes are instances of 'laryngeal strengthening': [h] signals the right edge of particular prosodic domains. This is plausibly the phonologized reflex of gradient phonetic devoicing and laryngealization in phrase- or utterance-final positions (see also Barnes 2006, Blevins 2006, Garellek 2013, Myers & Padgett 2014).

A strikingly parallel pattern of word-final sonorant devoicing occurs in several Mayan languages, particularly in the K'ichean branch. This phenomenon is shown for Tz'utujil in (31).

- (31) Final sonorant devoicing in Tz'utujil (Dayley 1985)
- |                        |            |                        |        |
|------------------------|------------|------------------------|--------|
| a. <i>way</i> [waᵛ]    | 'tortilla' | b. <i>kow</i> [kɔᵛ]    | 'hard' |
| c. <i>jul</i> [xɔᵛ]    | 'hole'     | d. <i>q'or</i> [qʰɔᵛ]  | 'lazy' |
| e. <i>meem</i> [me:mᵛ] | 'mute'     | f. <i>naan</i> [na:nᵛ] | 'lady' |

Like final aspiration, the synchronic status of sonorant devoicing is reinforced by numerous allophonic alternations, e.g. Kaqchikel *tew* [teᵛ] 'cold' ~ *xtewär* [ʃ-tew-ər] 'it became cold' (Brown et al. 2010).

Final sonorant devoicing is more heterogeneous than final aspiration. First, it seems to be confined to languages in the K'ichean, Greater Tzeltalan, and Huastecan branches. In other branches sonorant devoicing may be restricted to phrase- or utterance-final position (e.g. Straight 1976); some of the Greater Tzeltalan languages may in fact belong to this cate-

gory (e.g. Weathers 1947, Sarles 1966, Warkentin & Brend 1974). Final sonorant devoicing is attested in Mamean but may require a preceding voiceless consonant, e.g. Tektitek *maa'y* [ma:ʔj] ~ [ma:ʔj] 'tobacco' (Pérez Vail 2007). Sonorants are similarly devoiced in final [VhC#] clusters in Ch'ol, e.g. [tsʰihŋ] 'yucca', though sources differ as to how they characterize final devoicing in this language (Schumann Gálvez 1973, Attinasi 1973, Coon 2010, Vázquez Álvarez 2011, etc.; cf. section 2.3).

Second, languages differ as to which sonorants undergo final devoicing. Devoicing of final nasals is attested in Tz'utujil (31), but in most K'ichean languages final devoicing only affects the approximants /w j l r/ (see also Stewart 1980, Caz Cho 2007 for Q'eqchi'). As with final aspiration, sonorant devoicing frequently occurs in medial position before another consonant, as in Uspantek *mortoom* [mɔtɔ:m] 'member of a brotherhood (cofrade)' (Can Pixabaj 2006). On the basis of comparisons like *worb'al* [wɔɾ-baɫ] 'bedroom' vs. *rmxu'x* [r-mʃuʔʃ] 'his belly button', Barrett (1999) argues that the environment for sonorant devoicing in Sipakapense must be stated in terms of syllable structure rather than simple linear context (but cf. Tema Bautista 2005 and Majzul et al. 2000).

The result of devoicing /w/ differs somewhat across languages and dialects. Majzul et al. (2000) report [w̥ f pʰ x] for devoiced /w/ in Kaqchikel; in other languages one finds [ɸ] and [β] as well (DuBois 1981, Dayley 1985, Cojtí Macario & Lopez 1990, Caz Cho 2007). See also Kaufman (1969), Pérez et al. (2000) on devoiced /j/ → [ʃ] in Mam.<sup>18</sup>

### 3.4.2. Glottalized Stops

The heterogenous realization of glottalized stops across Mayan precludes any blanket statements about their allophonics. Perhaps the strongest thing that can be said is that final position seems to favor voiceless and ejective realizations. I am unaware of any language in which velar /kʰ/ is realized as implosive. Also notable is the spirantization of glottalized /kʰ/ to [ɣ] in Chuj when followed by /Vʔ/, as in *mak'a* [maɣaʔ] 'Hit him/her!' (England 1988, García Pablo & Domingo Pascual 2007; see Herrera Zendejas 2014:Ch.9 for a similar pattern in Tsotsil). Herrera Zendejas (2014) suggests that the release bursts for ejective stops may be substantially attenuated before other consonants, possibly to the point of neutralizing with the bursts for plain stops.

For some theoretically-oriented discussion of the allophonics of Mayan glottalized stops, see Lombardi (1991, 1995), MacEachern (1999), Fallon (2002), Gallagher (2010).

## 4. Syllable structure

Syllable structure is a surprisingly thorny problem in Mayan languages. If we limit ourselves to bare roots, a few generalizations seem within reach. Roots are generally /CVC/, possibly indicating a dispreference for tautosyllabic clusters (section 5.1). Complex onsets are nonetheless attested in roots like Kaqchikel *-k'waj* [-kʰwax] 'carry, take' and *xkoya'* [ʃkojaʔ] 'tomato' (Brown et al. 2010). Complex codas are similarly evident in roots like Uspantek *k'a'n* [kʰaʔn] 'bold'; such clusters are typically /ʔC/, /hC/, or /NC/ in form (England 1983, 2001, Vázquez Álvarez 2011; see Campbell 1977, Smith-Stark 1983, Barrett 2011:108–110 for specific discussion of K'ichean). Triconsonantal clusters are essentially unknown in roots (at least in most Mayan languages), which may indicate an upper-limit on the complexity of syllable margins.

While these generalizations are fairly reliable within the class of roots, morphologically complex words permit substantially more phonotactic complexity. Affixation can derive extensive clusters, especially at the prefix-stem boundary. Forms like Tz'utujil *xtkamsaj na*

[ʃt<sup>h</sup>-k-amsax na] ‘he’ll kill it’ thus undermine any naïve ideas about a two consonant limit on initial clusters (Dayley 1985:84). Vowel deletion (section 2.4.4) can conspire with affixation to yield even more stunning consonant sequences, as in Mam *tkstaala* [t<sup>h</sup>-k<sup>h</sup>staxl-a] ‘your rib’ and *itz’jñqetl* [ʔits<sup>ʔ</sup>xñ-qeʔ-tl] ‘they have already been born’ (Pérez Vail & Jiménez 1997:30,39–47; England 2001). Complex consonant clusters are most common in highland languages, especially those belonging to Eastern Mayan, but derived clusters can also be found in lowland languages like Ch’ol and Tsotsil, albeit in a smaller range of morphological contexts (e.g. Ch’ol *kyem* [k-t<sup>ʃ</sup>em] ‘my chair’, Vázquez Álvarez 2011:47; Tsotsil *jmanoj* [h-man-oh] ‘I/we have bought it’, Aissen 1987:42; see Bricker & Orié 2014 on cluster resolution in Yucatecan languages).

The question, then, is how to interpret syllable structure in words with derived clusters. There are few (if any) phonotactic patterns in Mayan languages that clearly have the syllable as their domain (section 3.4). This makes it difficult to probe for syllabification through segmental diagnostics. Barrett (1999, 2011) claims that some syllable-based phonotactics in Sipakapense systematically fail to apply in prefix strings; this may indicate that prefixal consonants are extrasyllabic. These are again questions that should be addressed for each language individually; see Furbee-Losee (1976b), Knowles (1984), Barrett (1999) and England (2001) for more discussion.

Lastly, the prevalence of initial [ʔ]-insertion (section 2.4.3) and hiatus avoidance (section 2.4.2) plausibly indicate a preference for syllables with onsets, [CVX<sub>0</sub>]. Nasukawa et al. (2011) stake out a rather different position, arguing that the basic shape of syllables in Kaqchikel is [VC] rather than [CV].

## 5. Morpho-phonology

### 5.1. ROOT PHONOTACTICS

The canonical form for bare roots in Mayan languages is /CVC/ (Kaufman 1990). Roots like Tojolab’al *nah* /nah/ ‘house’, *-mak* /-mak<sup>ʔ</sup>/ ‘to hit’ and *-kul* /-kul/ ‘seated’ abound across all lexical categories (Furbee-Losee 1976a,b). The tendency toward /CVC/ holds equally for free morphemes like *tz’up* /t<sup>ʃ</sup>up/ ‘feather’ and bound morphemes like *-tz’ub* /-t<sup>ʃ</sup>uβ/ ‘to kiss’ (examples from Q’anjob’al, Baquix Barreno et al. 2005).

Though /CVC/ roots clearly predominate, there are exceptions to this template. Section 4 gave examples of roots containing clusters, like Kaqchikel *xpëq* [ʃpɛq<sup>x</sup>] ‘toad’ or *pwäq* [pwəq<sup>x</sup>] ‘money’ (Majzul et al. 2000). Some of these clusters occur in loanwords (e.g. Awakatek *spej* [spɛx] ‘mirror’ < Spanish *espejo*, Velásquez Mendoza 2001), while other root-internal clusters are derived from historical vowel deletion (e.g. Q’eqchi’ *sank* [saŋk<sup>h</sup>] and Sipakapense *snik* [snik<sup>h</sup>], cf. K’iche’ *sanik* [sanik<sup>h</sup>] ‘ant’; Kaufman 2003, Caz Cho 2007). Roots ending in /ʔC/ or /hC/ are by and large native Mayan lexemes (Campbell 1977, Kaufman 1990, 2003, Brown & Wichmann 2004).

Much less common (though still attested) are roots lacking a final consonant, such as Uspantek *b’a* /βa/ ‘head’, *jee* /χe:/ ‘tail’, etc. (Can Pixabaj 2006; see also DuBois 1985b). In contrast, there are numerous /VC/ roots like Chuj *ich* /itʃ/ ‘chile’ (García Pablo & Domingo Pascual 2007), though independent phonological factors ensure that such roots will always surface as [ʔVC] when unprefixed (sections 2.4.3 and 5.2).<sup>19</sup>

While verbal and positional roots overwhelmingly conform to the /CVC/ template, nouns and adjectives are more permissive (see also Coon, Henderson this volume). This lexical split holds for both segmental composition and for root length. Polysyllabic root nouns like Tsotsil *vinik* [vinik<sup>h</sup>] ‘man’ (Haviland 1981) are much more common than polysyllabic

roots belonging to other lexical categories. Long roots are often words of historically foreign origin, like K'iche' *tinimit* [tinimit<sup>h</sup>] 'town' and *masaat* [masa:t<sup>h</sup>] 'deer' (< Nahuatl *tena:mi-tl* 'fortified town' and *mazatl* 'deer') or Ch'ol *ake'* [ʔakeʔ] 'lizard' (< Mixe–Zoquean) (Kaufman 1976a, Campbell 1977, Larsen 1988, Campbell 1999, Vázquez Álvarez 2011). Disyllabic roots were also well-attested in proto-Mayan (Fox 1978, Kaufman 2003).

The proper synchronic interpretation of the /CVC/ root template remains somewhat obscure. The statistical skew toward /CVC/ roots is quite large, but exceptions are nonetheless plentiful. Questions naturally arise as to whether this root template is grammatically operative, and if so, at what level. Patterns of loanword adaptation may suggest an active preference for consonant-final roots (if not /CVC/ as such): in Yucatec, for example, vowel-final Spanish words are borrowed with an epenthetic /h/, as in *mamá* > *mamah* [mamah] (Orie & Bricker 2000; see also AnderBois 2011 on Yucatec, Attinasi 1973 and Coon 2010 on Ch'ol, and Baquix Barreno et al. 2005:36–7 for some intriguing [ʔ] alternations in Q'anjob'al).

For more in-depth discussion of Mayan root templates see Straight (1976), Furbee-Losee (1976b), Lois & Vapnarsky (2003), Coon this volume, and Henderson this volume. Furbee-Losee (1976b) specifically addresses the relation between root templates and surface syllable structure requirements.

### 5.1.1. Root-internal Restrictions on Stops

Mayan languages typically place restrictions on the consonants that co-occur in a /CVC/ root. Two common restrictions on co-occurring stops are listed in (32); restrictions on co-occurring sibilants are discussed in section 5.1.2.

(32) Common stop co-occurrence restrictions in Mayan (T = stop, T' = glottalized stop)

a. /T'VT'/ ⇒ /T'<sub>α</sub>VT'<sub>α</sub>/

If a /CVC/ root contains two glottalized stops, the stops must be homorganic.

b. /T'<sub>α</sub>VT'<sub>α</sub>/ ⇒ /T'VT'/ or /TVT'/

If a /CVC/ root contains two homorganic stops, the stops must have the same laryngeal specification.

Such restrictions have been most thoroughly documented for the Yucatecan, Greater Tzeltalan, K'ichean, and Huastecan languages (see Weathers 1947, Keller 1959, Straight 1976, Barrett 1999, Gallagher & Coon 2009, and the literature review in Edmonson 1988). There is little reason to doubt their presence in the Q'anjob'alan and Mamean branches, though I am unaware of work specifically addressing this point.

These root co-occurrence restrictions have been of substantial theoretical interest within generative phonology. Relevant work includes McCarthy (1989), Yip (1989), MacEachern (1999), Gallagher & Coon (2009), Gallagher (2010), and Hansson (2010).

Mayan languages differ as to the strength and content of stop co-occurrence restrictions. Straight (1976) reports that Yucatec obeys constraint (32b), and so does not allow roots like /kik<sup>ʔ</sup>/ which contain two stops with differing laryngeal specifications at the same place of articulation. But in K'ichean languages this is a perfectly licit root: /kik<sup>ʔ</sup>/ 'blood' is attested in every language in the branch. Mamean languages also have roots like /q<sup>ʔ</sup>aq/ 'black', as do Greater Q'anjob'alan languages. Roots violating (32b) are found in Huastec as well, though Edmonson (1988) reports that they are statistically rare, suggesting that some root co-occurrence restrictions are gradient rather than categorical in nature. This may also be true for other Mayan languages: apart from Smith-Stark (1983) and Lois & Vapnarsky (2003),

few studies have attempted to systematically quantify root phonotactics (see too Straight 1976, Gallagher & Coon 2009). Edmonson (1988) points out that the strength of these static phonotactics may vary across different lexical classes, and may also hold more strongly for /CVC/ roots than for roots with long vowels /CV(:)C/, ‘broken’ vowels /CV?VC/, or coda clusters like /CVhC/ or /CV?C/.

More idiosyncractic root phonotactics are attested in individual languages as well. For example, Furbee-Losee (1976a,b) claims that Tojolab’al does not allow /jVC/ roots where C is an oral continuant /s ʃ l r w j/, plain oral stop, or plain affricate. Roots like *yah* /jah/ ‘pain’, *ya* /jaʔ/ ‘to be watery’, and *-yak* /-jakʔ/ ‘to be shaking’ are however permissible. These generalizations are patently disregarded by other Mayan languages, as illustrated by Q’anjob’al *yas* /jas/ ‘injury’, K’iche’ *yaak* /ja:k/ ‘mountain lion’, and so on (Baquix Barreno et al. 2005, López Ixcoy 1997). To date, the extent to which these language-specific patterns reflect real, grammatically live restrictions on roots (rather than accidental lexical gaps) has not been conclusively established (see also Smith-Stark 1983).

There are two systematic exceptions to the phonotactic restrictions on co-occurring stops in /CVC/ roots: in many languages, the glottalized labial /ʙ/ and glottal stop /ʔ/ freely combine with roots at any place of articulation. These exceptions can be illustrated with roots like Tz’utujil *q’oob* /qʔo:ʙ/ ‘earring’ or Ixil *ch’u* /tʃʔuʔ/ ‘chest’ (Dayley 1985, Chel & Ramirez 1999). These exemptions are almost certainly related to the fact that /ʙ ʔ/ are not ejectives, which differentiates them from the other glottalized stops.<sup>20</sup> For discussion of these exceptions in a more theoretical context, see MacEachern (1999), Gallagher (2010).

As with the /CVC/ root template itself, the synchronic status of root co-occurrence restrictions in Mayan is unknown. Few authors have commented on this point: Gallagher & Coon (2009) offer some informal observations in favor of the cognitive reality of such restrictions for Ch’ol speakers, and Fox (1978) argues that some otherwise regular sound changes were blocked in particular lexical items when they would have led to violations of static phonotactic restrictions on roots.

### 5.1.2. Sibilant Harmony

Along with restrictions on root-internal stops, Mayan languages may also prohibit certain pairs of coronal sibilants within the same /CVC/ root. The core generalizations are as follows: if a root contains two plain (non-glottalized) sibilants, they must be entirely identical, as in the Yucatec examples (33).

(33) Anteriority restrictions on root-internal sibilants in Yucatec (Bricker et al. 1998)

- |                           |                         |                              |
|---------------------------|-------------------------|------------------------------|
| a. <i>xáax</i> [ʃá:ʃ]     | ‘to sift (antipassive)’ | b. *[ʃá:s], *[tʃá:ʃ], etc.   |
| c. <i>tsaats</i> [tsà:ts] | ‘fat’                   | d. *[tsà:tʃ], *[sà:ts], etc. |
| e. <i>chúuch</i> [tʃú:tʃ] | ‘stem’                  | f. *[tʃú:ts], *[tʃú:ʃ], etc. |

When a root contains just one glottalized affricate the identity restriction is relaxed such that sibilant fricatives and affricates may co-occur, provided they agree in anteriority. This is illustrated by Ch’ol roots like *sàts* [sàtsʔ] ‘stretch’ and *ch’ox* [tʃʔoʃ] ‘worm’ (Gallagher & Coon 2009). Roots with one glottalized affricate and one plain affricate, such as \*[tsʔetʃ] and \*[tsʔuts], are unattested. If both affricates are ejective, they must again be identical, pursuant to the stop co-occurrence restrictions (32) (e.g. Ch’ol *ch’ach* [tʃʔatʃʔ] ‘bush’).

Restrictions on root-internal sibilant pairs have been observed in the K’ichean (Smith-Stark 1983, Dayley 1985, Barrett 1999), Chujean (Hopkins 1967, Furbee-Losee 1976a,b),



Greater Tseltalan (Kaufman 1971, Gallagher & Coon 2009), Huastecan (Edmonson 1988), and Yucatecan branches (Straight 1976). As with stop co-occurrence restrictions, the exact details of sibilant patterning differ somewhat across languages (see again Edmonson 1988).

In some languages, such as those of the K'ichean branch, sibilant co-occurrence restrictions appear to be completely static statements about roots (much like the stop co-occurrence restrictions (32)). But in other languages, sibilant distributions may reflect an active process of long-distance sibilant harmony that also occurs across morpheme boundaries. By way of illustration, Aissen (1987:276–7) gives Tsotsil forms like *ta xkil* [ta ʃ-k-il] 'I'll see it' vs. *smeset* [s-meset<sup>h</sup>] 'refreshing himself' (see also Herrera Zendejas 2014:Ch.9 and references there). Sibilant harmony processes of one type or another can also be found in Ch'ol (Gallagher & Coon 2009), Tseltal (Kaufman 1971), Ixil (Ayres 1991:24), and Sakapultek (DuBois 1981:137).

Lombardi (1990) draws on sibilant distributions in Yucatec to argue that phonological representations do not specify the temporal order of the stop and fricative portions of affricates; phonologically, they are unordered bundles of the features [-CONT] and [+CONT] (cf. Anderson 1976, Sagey 1986). In a discussion of Ch'ol, Gallagher & Coon (2009) argue for a formal distinction between long-distance phonotactics which require total segmental identity (such as (32)) and those that only require agreement for particular features (such as anteriority); the latter are taken to be more local in nature, being grounded in articulatory factors (see also Hansson 2010).

Sibilant co-occurrence restrictions may be weak, or even inactive in those Mayan languages that have rich sub-coronal place distinctions (section 3.1.2). In Mamean, historical shifts in consonant place have given rise to forms that violate the sibilant phonotactics mentioned above (e.g. Kaufman 1976a, Lengyel 1991). This can be seen in roots like Ixtahuacán Mam *xoch* [ʃo:tʃ] 'well (N)' and Todos Santos Mam *tch'eex* [tʃ<sup>h</sup>e:ʃ] 'loan (N)' (Pérez et al. 2000).

Retroflex sibilants are also attested in Q'anjob'alan Proper (Q'anjob'al, Akatek, and Popti'), but I do not know what patterns hold for the distribution of sibilants in this branch. While a preliminary inspection of word lists (Cú Cab et al. 2003) suggests that sibilant co-occurrence restrictions do hold over [CVC] roots in these languages, this question merits more careful study.

## 5.2. PHONOLOGICALLY CONDITIONED ALLOMORPHY

Mayan languages show phonologically conditioned allomorphy (PCA) for both inflectional affixes (mostly prefixes) and derivational affixes (mostly suffixes; see Coon this volume and Kaufman 1990). The types of allomorphy observed in each affixal field are nonetheless different in character. Ergative prefixes typically vary in form depending on the initial segment of the stem to which they attach: C-initial stems take V-final allomorphs of the ergative markers, while V-initial stems take C-final allomorphs.

(34) Ergative allomorphy in Uspantek (K'ichean, Guatemala; Can Pixabaj 2006)

- |                             |                 |                                |                    |
|-----------------------------|-----------------|--------------------------------|--------------------|
| a. <i>qóoj</i> [q-ó:χ]      | 'my avocado'    | b. <i>qatiko'n</i> [qa-tikoʔn] | 'our planted corn' |
| c. <i>xatuk'</i> [ʃ-a-tukʔ] | 'you pushed it' | d. <i>xawil</i> [ʃ-aw-il]      | 'you saw it'       |

These alternations appear to be motivated by syllable well-formedness conditions in at least some languages (see Kenstowicz 2013 for Kaqchikel). To be more precise, the appearance of V-final ergative markers with C-initial stems avoids consonant clusters like \**qitiko'n* \*/q-tikoʔn/ (34b), while the use of C-final ergative markers with V-initial stems minimizes

hiatus configurations like \**qaóoj* /qa-ó:χ/ (34a) (see Mascaró 1996, 2007 for a theory-oriented discussion of similar patterns in Arabic). This is clearly suppletive allomorphy, as these alternations occur even in languages that permit clusters like /qt/ in other contexts (cf. Uspantek *tk'ixib* [t<sup>h</sup>k<sup>ʔ</sup>if<sup>h</sup>iβ̆] '(s)he became embarrassed'). In other Mayan languages, such as Mam, the prosodic motivation for ergative allomorphy is less clear (if such motivation even exists): here, ergative allomorphy in pairs like *npaaya* [m-pa:ja] 'my bag' vs. *wuu'ja* [w-u:ʔχa] 'my book' (Pérez Vail & Jiménez 1997) serves no obvious phonological purpose at all.

As mentioned in section 2.4.4 the interaction of allomorph selection with phonological processes like vowel deletion may also render the choice of allomorph opaque. An illustration is provided by Sipakapense: here vowel deletion may obscure the selection of the prevocalic ergative allomorph by deriving a C-initial surface form for the stem, e.g. *wɪz'om* /w-ats<sup>ʔ</sup>om/ → [w-ts<sup>ʔ</sup>om] 'my salt'; compare this with an underlyingly C-initial stem like *npoop* [n-p'ó:p<sup>h</sup>] 'my reed mat', as well as non-deleting V-initial stems like *waak'* [w-'a:k<sup>ʔ</sup>] 'my chicken' (Barrett 1999:55–62, Barrett 2011).

The suffixal field shows three main patterns of PCA: vowel dissimilation/assimilation; consonant dissimilation; and syllable-counting allomorphy. Vowel alternations are treated in section 5.2.1. Consonant dissimilation occurs with some /-VC/ suffixes, as in Kaqchikel lateral dissimilation *tz'uuyul* [ts'uj-ul] 'seated' vs. *tzalan* [tsal-an] 'lying on one's side' (Tummons 2010, Brown et al. 2010:184). This is clearly a case of allomorphy rather than a general phonological process of lateral dissimilation, given forms like *tulül* [tulü] 'zapote'. (On liquid dissimilations in other languages, such as English *coron-al* vs. *vel-ar*, see e.g. Ohala 1993, Nevins 2010, Bennett 2013 and references there.) Similar dissimulatory patterns have been noted for Tselal (Kaufman 1971, Polian 2013), Huastec (Edmonson 1988) and Lacandon (Bruce 1968).

Syllable-counting allomorphy is also attested in several languages. For example, the Tsotsil passive marker varies according to the length of its host, yielding alternations like *imuke* [ʔi-muk-e] 'he was buried' vs. *i'elk'anat* [ʔi-ʔelk'an-at] 'it was stolen' (Aissen 1987:65–6). The Tselal perfective marker *-ej/-oj* [-eh/-oh] provides another case of PCA conditioned by syllable count, with *-oj* appearing after monosyllabic stems and *-ej* appearing elsewhere (Kaufman 1971, Walsh Dickey 1999, Polian 2013). Paster (2005, 2006) points out that such alternations are problematic for the view that syllable-counting allomorphy reflects prosodic well-formedness conditions, given that these *-ej~-oj* alternations have no obvious benefit for the overall prosodic structure of the verb. On the other hand, polysyllabic stems are typically morphologically derived: since the difference between root and derived verb stems has a range of morphological consequences in Mayan (Coon this volume), some apparent patterns of syllable-counting allomorphy may in fact be morpho-syntactic rather than phonological in character.

Allomorphy may be observed for roots as well as for affixes. Vowel lengthening under possession is a common morpho-phonemic process in Mayan, exemplified by pairs like K'iche' *kar* [kaɾ] 'fish' and *nukaar* [nu-ka:ɾ] 'my fish' (Larsen 1976, DuBois 1985a, López Ixcoy 1994, Par Sapón & Can Pixabaj 2000). In Kaqchikel, possession may induce changes in vowel tenseness rather than length (section 2). Possession can trigger ablaut as well, as in Uspantek *kaa* [ka:ʔ] 'grinding stone' vs. *inki* [ín-kiʔ] 'my grinding stone' (Bennett & Henderson 2013), or even outright suppletion, as in Kaqchikel *jay* [χaj] 'house' vs. *wochoch* [w-ot<sup>h</sup>ʃot<sup>h</sup>] 'my house'. These are all root-specific phenomena, in the sense that some roots maintain their isolation forms under possession (for example K'iche' *waj* [w-aχ] 'my ear of corn', López Ixcoy 1997). Vowel length and quality alternations are also observed in ver-

bal voice paradigms; see sections 2 and 2.3 for examples. Various roots have final consonant alternations under suffixation, as the result of historical processes of consonant lenition (e.g. Tz'utujil *aaq'a'* [ʔa:q<sup>ʔ</sup>aʔ] 'night' vs. *aaq'ab'iil* [ʔa:q<sup>ʔ</sup>aʔ-i:l] 'time before dawn', Dayley 1985; also Day 1973:19, Barrett 2007).

### 5.2.1. Reduplication and Copying

Suffixes often copy segmental material from the roots to which they attach in Mayan. These suffixes may include some invariant segmental content along with a consonant or vowel taken from the root, or may consist entirely of copied segments.

(35) Some copying suffixes in Kaqchikel (Brown et al. 2010) ('X' = copied segment)

- |    |                  |                        |   |                                     |               |
|----|------------------|------------------------|---|-------------------------------------|---------------|
| a. | <i>-jotob'a'</i> | /-χot-∇6aʔ/            | → | [-χot-o6aʔ]                         | 'to raise up' |
| b. | <i>setesik</i>   | /set-∇C-ik/            | → | [set-es-ik <sup>h</sup> ]           | 'round'       |
| c. | <i>pik'il</i>    | /pik <sup>ʔ</sup> -∇l/ | → | [pik <sup>ʔ</sup> -i <sub>l</sub> ] | 'on tip-toes' |
| d. | <i>saqsöj</i>    | /səq-Cəχ/              | → | [saq <sup>h</sup> -səχ]             | 'whiteish'    |

Three aspects of these copying patterns are worthy of note. First, copying may be non-local, in the sense that root-initial consonants are preferentially copied even though the root-final consonant is closer to the suffix itself (see (35b,d)). Within generative phonology, non-local copying of this sort has been taken as diagnostic of true morphological reduplication rather than phonological spreading (e.g. Kawahara 2007 and references there). Second, patterns like (35b) appear to instantiate 'mirror reduplication', in that the linear order of segments in the base is inverted in the reduplicant. If this is the correct analysis, then Kaqchikel would counter-exemplify Marantz's (1982) generalization that mirror reduplication does not exist in natural language. Third, copying may be imperfect or partial: (35c) shows that the suffixal vowel may be lax even when the root vowel is tense (lax vowels are only permitted in final syllables, sections 2 and 2.4). See Warkentin & Brend (1974) for similar observations regarding [a]~[i] variation in copying suffixes in Ch'ol. For sketch analyses of some consonant and vowel copying patterns in Mayan see Steriade (1988), Nelson (2003), Hall (2003, 2006), Yu (2005).

Vowel copying patterns, sometimes described as 'harmony', are quite common among Mayan languages. Specific examples can be found in many of the descriptive works cited here; vowel harmony has also been discussed in a theoretical context by Orié & Bricker (2000) and Krämer (2001). Krämer (2001) suggests that vowel copying may be blocked over consonant clusters in Yucatec, yielding pairs like *lubul* [luβ-u] 'fall (imperfective)' vs. *t'ochbal* [t<sup>ʔ</sup>otʃ-β-a] 'be thought (imperfective)'. (Clusters are restricted to morphologically derived forms in Yucatec, Lois & Vapnarsky 2003, Bricker & Orié 2014; see Butler 2005 for a critique of Kramer's analysis that draws on this fact.)

Apart from copying suffixes, one also finds suffixes that show *dissimilation* in vowel quality (consonant dissimilations were discussed in section 5.2). Polian (2013) provides Tselal examples like *jamulay* [xam-ula:j] 'open many times' and *juxilay* [xuf-ila:j] 'scrape many times' which illustrate allomorphy conditioned by roundness dissimilation. Similar patterns are discussed for Yucatec in Blair (1964), Krämer (2001); Huastec in Edmonson (1988); Ixil in Ayres (1991); Mam in England (1983); and Poqomam in Smith-Stark (1983:158-9). Some of these dissimilation patterns are statistical tendencies rather than categorical requirements (England 1983, Smith-Stark 1983).

## 6. Word-level prosody

## 6.1. STRESS

Both fixed and mobile stress systems are attested in Mayan languages. Languages with fixed stress fall into two main sub-types: final stress and penultimate stress (Campbell et al. 1986, Kaufman 1990, England 1990, 2001). Final stress (36a) is the norm in K'ichean languages, though it is also found in Mamean (Tectitán Tektitek, Pérez Vail 2007:37–8; some varieties of Southern Mam, England 1990:225–6). Fixed penultimate stress (36b) is restricted to a few dialects of Southern Mam.

(36) Fixed stress systems in Mayan:

a. Tz'utujil (Dayley 1985): final stress

i. *xch'eyooni* [ʃtʃ<sup>h</sup>ɛjo:n'ɪ] 'he hit'      ii. *tewlaj* [teɸl'ax] 'very cold'

b. Southern Mam (Ostuncalco; England 1990): penultimate stress

i. *t-xmilaal* [t-ɬm'ila:l] 'his/her body'      ii. *kaab'aje* [ka:ɸ'axɛ] 'day before yesterday'

Even in languages with fixed stress there are pockets of exceptions: Kaqchikel, for instance, follows the typical K'ichean pattern of final stress, but non-final stress occurs in both loanwords (*anima* [ɾ'anima] 'spirit') and in some native words (*janila* [χan'ila] 'very').

Phrasal conditioning of various sorts has been reported for Mayan languages with fixed stress. In Q'anjob'al, phrase medial words take initial stress, but phrase final words carry stress on the last syllable instead.

(37) Phrasal stress in Q'anjob'al (Santa Eulalia dialect, Baquix Barreno et al. 2005, Mateo Toledo 2008; transcription is orthographic, '||' marks an intonational break, *Ŷ* a stressed vowel)

a. *sáqyin hab' no kaxhlán || no kámnaq tu*

'It is said that the chicken was white, that dead one.'

b. *éwi máxex wayajóq*

'You (all) fell asleep yesterday.'

Similar patterns have been noted for Greater Tzeltalan languages (Kaufman 1971, Attinasi 1973, Warkentin & Brend 1974, Haviland 1981, Coon 2010, Vázquez Álvarez 2011, Polian 2013), as well as Tojolab'al (Furbee-Losee 1976a), Popti' (Day 1973), Akatek (England 2001), and Itzaj (Schumann Gálvez 1971, Dienhart 1986, Hofling 2000). Hofling (2011) describes root-initial stress for Mopan.<sup>21</sup>

Various authors even imply that stress is assigned at the phrase level rather than the word level, particularly for languages with final stress (e.g. Weathers 1947, Gerdel 1974, Ayres 1991, Palosaari 2011, Polian 2013; see Jun & Fougeron 2002 for related discussion of French). While stress is impressionistically stronger in phrase- or utterance-final position (as fieldworkers have noted), many languages have segmental phonotactics which demonstrate that stress is phonologically present at the word level even when acoustically weak (sections 2, 3.4, and 6.1). Some of these putative patterns of phrase-level stress assignment may involve phrase-level intonational contours rather than true word-level stress (Gordon 2014); the same possibility holds for the phrasally-conditioned patterns of stress-shift described above. This is another empirical domain where more extensive investigation is needed.

Stress placement may be influenced by syllable weight; this occurs in the Mamean and Huastecan branches, and possibly in Lacandon (Yucatecan; Herrera Zendejas 2014:Ch.10).<sup>22</sup> In Huastec, stress falls on the rightmost long vowel, otherwise on the initial syllable (Larsen & Pike 1949, Edmonson 1988, Herrera Zendejas 2011; cf. Herrera Zendejas 2014:Ch.7 for apparent counter-examples). Northern Mam has an especially interesting pattern of quantity-sensitive stress. These varieties show a four-way weight distinction [V:] > [Vʔ] > [VC] > [V], which influences not only the position of stress but also the distribution of syllable types within the word (England 1983, 1990, Pérez Vail & Jiménez 1997, Pérez et al. 2000). Stress falls on the rightmost underlying long vowel /V:/ (38a); if there are no long vowels, stress falls on the rightmost short vowel followed by glottal stop /Vʔ/ (38b,c).<sup>23</sup> In the absence of long vowels and post-vocalic /ʔ/, stress falls on the last vowel of the root if it ends in a consonant (38d), otherwise on the penultimate root vowel (38e). Suffixes and enclitics are only stressed when containing /V:/ or /Vʔ/.

(38) Quantity-sensitive stress in Ixtahuacán Mam (England 1983, Pérez et al. 2000)

- |    |                   |                             |   |  |                |
|----|-------------------|-----------------------------|---|--|----------------|
| a. | <i>tq'ulaniil</i> | /t-q <sup>2</sup> ulan-i:l/ | → | [t <sup>h</sup> -q <sup>2</sup> ulan-'i:l] | 'warmth'       |
| b. | <i>pu'la'</i>     | /puʔlaʔ/                    | → | [puʔl'aʔ]                                  | 'dipper'       |
| c. | <i>i'tzal</i>     | /iʔtsal/                    | → | [ʔ'iʔtsəl]                                 | 'Ixtahuacán'   |
| d. | <i>awal</i>       | /awal/                      | → | [ʔaw'al]                                   | 'planted corn' |
| e. | <i>spiky'a</i>    | /spiki <sup>2</sup> a/      | → | [sp'ik <sup>2</sup> a]                     | 'clear'        |

Unstressed long vowels are disallowed and shortened, giving a surface distribution in which only one long vowel may occur per word (see Hyman 2006 for typological framing of this pattern). Certain suffixes idiosyncratically attract stress and/or shorten root vowels; England (1983), Pérez et al. (2000) provide more details. Unstressed /Vʔ/ is permitted (38b), but not in words that also contain a long vowel; see England (1983). The prosodic behavior of /Vʔ/ leads England (1983) and van der Hulst et al. (2010) to conclude that post-vocalic glottal stop is a suprasegmental vowel feature rather than a true segment in Mam; see also sections 2.3 and 6.2. Ayres (1991) describes a similar pattern of stress assignment in Ixil; see also McArthur & McArthur (1956) on Awakatek; and Kaufman (1969), England (1990, 2001:41) on Mamean more generally.

Not much work has been done investigating the role of abstract metrical structure in shaping phonological patterns in Mayan languages. Two exceptions are Barrett (2002), who provides a foot-based analysis of stress assignment in K'iche', and Bennett & Henderson (2013), who argue that the prosodic and segmental system of Uspantek is extensively conditioned by foot structure at the right edge of words.

### 6.1.1. Minor Stress Patterns

Only one Mayan language shows robust evidence for phonemic stress: in Chontal, minimal pairs like *u hok'i* [ʔu h'ok<sup>2</sup>i] 'he dug it out' and *u hok'i* [ʔu hok<sup>2</sup>'i] 'he called him' seem to be well-attested (Keller 1959, Knowles 1984, Pérez González 1985). Such contrasts are nonetheless marginal, as stress is generally predictable on the basis of stem and morpheme boundaries.

There is substantial debate as to where stress falls in Yucatec, or indeed as to whether the language has word-level stress at all. Fox (1978), Sobrino Gómez (2010) and Kidder (2013) provide overviews of past proposals; Kidder concludes on the basis of acoustic measurements and native speaker judgments that Yucatec has "no concrete pattern of obligatory stress on the word level". Gussenhoven & Teeuw (2008) take the anchoring of phrase-level intonational

contours in Yucatec as evidence for stress on long vowels and word-initial short vowels, though they concede that stress is “non-obvious...from a phonetic perspective” (see also Blair 1964:2-3, Krämer 2001). The elusiveness of stress in Yucatec may be connected to the fact that both pitch and vowel length are used contrastively within the phonological system, reducing their usefulness as cues for higher-level prosodic distinctions (section 6.1.2).

Evidence for secondary stress in Mayan languages is scarce. Though secondary stress is sometimes reported, such descriptions seem to be based on impressionistic judgments rather than any phonological diagnostics or quantitative phonetic measurements (examples include Mayers 1960, Hopkins 1967, Furbee-Losee 1976a, Barrett 1999, 2002, and others). Since secondary stress is notoriously difficult to transcribe, especially for non-native speakers, these reports should be treated with caution (for more on this point see Day 1973:13, de Lacy 2007, 2014). In some cases ‘secondary stress’ may actually refer to phrase-level stress or intonation (see discussion and references above), or to stress in compounded prosodic words (e.g. Edmonson 1988:40,300, Herrera Zendejas 2014:Ch.7). There are however a handful of cases in which secondary stress may have phonological consequences at the word level: these include Sakapultek (DuBois 1981:99,124,144-55) and Itzaj (Hofling 2000:25). See Herrera Zendejas (2014:Ch.10) for possible phonetic evidence of secondary stress in Lacandon.

### 6.1.2. Phonetics of Stress

Berinstein (1979) is a landmark study of the phonetics of stress in Mayan. Drawing on both production and perception data, Berinstein argues that stress in two K’ichean-branch languages (Kaqchikel and Q’eqchi’) is cued by raised pitch and amplitude on the stressed syllable. Strikingly, Berinstein also finds that duration is a cue to stress in Kaqchikel, but not in Q’eqchi’: she attributes this difference to the fact that vowel length is phonemic only in Q’eqchi’ (section 2). This was an important early demonstration that phonetic patterning may be restricted by phonemic contrast; see Stevens & Keyser (1989), Manuel (1999), Campos-Astorkiza (2007), Drescher (2009) for more recent discussion.

Apart from Berinstein (1979), the phonetic correlates of stress in Mayan languages are underdocumented. Descriptive grammars often mention that stress is realized by some combination of pitch, loudness, and length. The validity of these claims is unclear: instrumental confirmation is rarely if ever given, and the perceived cues to word-level stress may be confounded with phrase-level phonetic phenomena like initial/final lengthening and initial/final boundary tones. Bennett & Henderson (2013) and Herrera Zendejas (2014) offer some limited instrumental data on the phonetics of stress in three languages (Uspantek, Tsotsil, Lacandon), but their findings are not conclusive. Much work remains to be done in this area of Mayan prosody.

## 6.2. CONTRASTIVE TONE

There have been several independent cases of tonogenesis within the Mayan family. Contrastive lexical tone is attested in Yucatec (Yucatecan), Uspantek (K’ichean), Mocho’ (Greater Q’anjob’alan), and San Bartolo Tsotsil (Tzeltalan). Incipient tone has also been reported for two Mamean languages, Tektitek (Kaufman 1969, Pérez Vail 2007) and Mam (England 1983:32,35, England 1990). Southern Lacandon (Yucatecan) appears to have lexical tone, but the main descriptive source for this claim is an unpublished 1995 manuscript by Una Canger which is not widely available (e.g. Hofling 2006, Bergqvist 2008, and the Lacandon Cultural Heritage Project at <http://web.uvic.ca/lacandon/>). Larsen (1988:52-4) briefly alludes to some possible tonogenetic patterns related to vowel length in Zunil K’iche’.

In all clear instances of tonogenesis in Mayan the modern lexical tones are reflexes of historical laryngeals, particularly the postvocalic laryngeals in [CVhC] and [CVʔC] syllables (Kaufman 1972, Grimes 1972, Fisher 1973, Campbell 1977, Fox 1978, Palosaari 2011).<sup>24</sup> The loss of these laryngeals conditioned the development of low tone in some languages, and high tone in others (cf. Fox 1978:Ch.4, Sobrino Gómez 2010 for different proposals). Similar patterns of ‘split’ tonogenesis occurred in the Athabaskan languages, where laryngealized consonants led to distinct tonal patterns in different sub-families (Kingston 1984, 2005).

The existence of contrastive tone in Yucatec was firmly established by Pike (1946). Since then there have been a number of proposals regarding the basic tonal inventory of the language: overviews can be found in Fisher (1973, 1976), Fox (1978), Kügler & Skopeteas (2006, 2007), Kügler et al. (2007), Sobrino Gómez (2010). The present consensus, following Bricker et al. (1998), Kügler & Skopeteas (2006), Frazier (2009a, 2013), Sobrino Gómez (2010), seems to be that Yucatec has the following tonal specifications:

- (39) a. Short vowels [V]: no tonal specification, *kach* [katʃ̃] ‘split’  
 b. Long vowels:  
 (i) High tone [V̂:], *kaach* [ká:tʃ̃] ‘split slowly’  
 (ii) Low tone [V̇:], *kaach* [kà:tʃ̃] ‘fragment’  
 c. Rearticulated vowels [V̂<sub>α</sub>ʔV̂<sub>α</sub>]: high-falling tone, *ka’ach* [káʔatʃ̃] ‘be split’

These tones have a fairly stable phonetic profile, though the implementation of high tone [V̂:] varies by phrasal position (Pike 1946, Kügler & Skopeteas 2006, Gussenhoven & Teeuw 2008, Frazier 2009a,b). The low tone [V̇:] is typically realized as steady low pitch, sometimes with a gentle rise. The high tone [V̂:] may be realized with a high-falling pitch pattern, or with a high-rising pitch pattern, depending on phrasal context. The ‘rearticulated’ vowels [V̂<sub>α</sub>ʔV̂<sub>α</sub>] are consistently marked by a high-falling contour, with a higher starting pitch than [V̂:] and a sharper, more pronounced pitch drop. Short vowels, which are taken to be phonologically unspecified for tone, are realized with steady pitch in the low-mid range.

Uspantek provides the only robust case of lexical tone within the K’ichean branch. There are three tonal patterns in this language, which interact with vowel length and with stress (Can Pixabaj 2006, Bennett & Henderson 2013). First, there are toneless words, which have default final stress (*kojachape’* [koʒachap’eʔ] ‘You (sg.) grab us!’, *xinlowisaaj* [ʃinlowis’a:ɣ] ‘I sheperded it’). Second, there are words with final high tone and final stress: this pattern only occurs on long vowels (*inwúuj* [inw’ú:ɣ] ‘my paper’; long vowels are limited to the last syllable, section 2.4). Third, there are words that carry both stress and high tone on the penult; this only occurs in forms with a final short vowel (*wíxk’eq* [w’íʃkʔeq<sup>h</sup>] ‘my fingernail’). Bennett & Henderson (2013) analyze this system as a contrast between toneless words and words with a high tone specified on the penultimate vocalic mora, [...V̂<sub>μ</sub>V̂<sub>μ</sub>C<sub>0</sub>] or [...V̂<sub>μ</sub>C<sub>0</sub>V̂<sub>μ</sub>C<sub>0</sub>].<sup>25</sup> Tone shows extensive morphological conditioning in this language; see Bennett & Henderson (2013) for further morphological and phonological analysis, especially regarding tone-triggered stress shift.

Sarles (1966) describes lexical tone for the San Bartolo dialect of Tsotsil (see also Kaufman 1972). He reports a contrast between high and low tone, exemplified by forms like [ʔólíl] ‘half’ vs. [ʔólił] ‘child’ (low tone is unmarked). According to Sarles, tone may be morphologically conditioned, and adjacent syllables typically show an alternating tonal pattern, e.g. [wínikún] ‘I am a man’. The minimal detail supplied in this work makes it difficult to determine whether tone is actually distinct from stress, which is mentioned (p.15)

but not described. Sarles notes (p.19–26) that tone conditions consonant allophonics, which would be somewhat unusual for a true tonal system.

Herrera Zendejas (2014) provides a skeptical discussion of tone in San Bartolo Tsotsil, arguing that all systematic word-level pitch differences owe to word-final stress (pitch raising) or to the laryngealization of vowels preceding glottalized stops and [hʔ] (pitch lowering, section 3.3). It is unclear how Herrera Zendejas would account for the apparent tonal contrast between [ʔolil] ‘half’ and [ʔólil] ‘child’: perhaps the prosodic system of San Bartolo Tsotsil underwent a major change in the 50 years separating Herrera Zendejas (2014) from Sarles (1966). Unfortunately, Sarles (1966), Kaufman (1972) and Herrera Zendejas (2014:Ch.9) appear to be the only descriptive studies of this variety of Tsotsil.

Palosaari (2011) confirms earlier suspicions that Mocho’ has contrastive lexical pitch (see references there). She proposes a distinction between toneless vowels and vowels specified for falling (or high-falling) tone: this contrast only occurs on stressed word-final syllables, and only on long vowels. The resulting three-way vowel contrast is illustrated by sets like *k’anh* [kʔaŋ] ‘loud’ ~ *kaanh* [ka:ŋ] ‘four’ ~ *kaanh* [kà:ŋ] ‘sky’. Alternations like *poox* [pò:f] ‘medicine’ ~ *pooxoom* [pɔ:fɔ:m] ‘healer’ demonstrate the neutralization of tonal distinctions in unstressed syllables. Phonemic tone does not occur on verb roots, because obligatory suffixation prevents verbal roots from bearing the word-level stress needed to support the tonal contrast.

Tektitek appears to be in the early stages of tonogenesis. Pérez Vail (2007) reports that underlying /V:ʔC/ sequences are realized as [V̂ʔV̂:C], with a ‘broken’ vowel bearing a low-high pitch pattern. Examples like *npa’ach* /n-pa:ʔtʃ/ → [npàʔá:tʃ] ‘my twin’ contrast with words like *nme’al* [ŋmeʔa:l] ‘my daughter’ which contain an underlying /VʔV:/ string that is not realized with any additional tone.<sup>26</sup> This pattern may be conditioned by syllable position and/or stress (which is final), as Pérez Vail does not transcribe tone in forms like *q’a’nb’il* [ǵa:ʔnɓ’il] ‘medicine’ (p.34–6). He also observes that short vowels in /Vʔ#/ strings become tonal, carrying a broken high-low [V̂ʔV̂] pitch pattern as in *qchi*’ [qʰtʃíʔi] ‘our meat’. This description primarily pertains to the Tektitek spoken in Tectitán; while other varieties of Tektitek also have tones conditioned by post-vocalic /ʔ/, the conditions under which tone appears, and the surface melodies themselves, may be different (e.g. Kaufman 1969).

## 7. Phrasal prosody: the word and above

### 7.1. INTONATION AND PHRASING

Phrase-level phonology is a comparatively understudied area of Mayan linguistics (see also section 6.1). Many descriptive sources provide a basic inventory of phrasal melodies, which expectedly differ across questions, declarative statements, and other utterance-types. Readers are directed to those works for further details. One notable pattern that recurs across Mayan is the realization of simple declarative sentences with final rising intonation (e.g. Berinstein 1991, Aissen 1992, Palosaari 2011, Shklovsky 2011): this is typologically a minority pattern (Gussenhoven 2004:Ch.4 and references there). Mayan languages with falling intonation in declaratives are also attested (e.g. England 1983:249, Knowles 1984:63, Nielsen 2005).

Dedicated studies of intonation in Mayan languages include Larsen & Pike (1949), Berinstein (1991), Nielsen (2005), Shklovsky (2011), Burdin et al. (2015), among other work already cited above. Pye (1983, 1992) argues that final stress and intonation play an important role in language acquisition in K’iche’.

Not much work has investigated the effect of higher prosody on segmental patterning. A notable exception is AnderBois (2011), who argues that various phonological



processes affecting the distribution of laryngeals in Yucatec are conditioned by word and phrase boundaries. Similar facts are given for K'iche' in Henderson (2012). Bennett (2010) reports longer periods of aspiration for phrase-final aspirated stops in Tz'utujil (section 3.4.1). Other phenomena worthy of investigation in this area were noted in sections 3.3 and 3.4.

In languages with lexical tone, phrasal intonation may interact with word-level tone specifications, sometimes masking lexical pitch distinctions (e.g. Pike 1946, Kügler & Skopeteas 2006, 2007, Gussenhoven & Teeuw 2008, Avelino 2009; Sarles 1966; Palosaari 2011; cf. the discussion of pitch accent in Hayes 1995:49-50).

### 7.1.1. Prosody and Information Structure

There is a burgeoning literature on the interaction of intonation with both *in situ* focus and focus fronting (on which see Coon this volume). Aissen (1992) uses intonational differences between left-peripheral topic and focus constituents in three Mayan languages as a diagnostic for different structural positions in the syntax (see below on related discussion of prosodically-placed clitics). She finds that a major prosodic boundary may follow fronted topics (depending on the language), but not fronted foci. Similar patterns are reported for K'iche' in Can Pixabaj & England (2011), but cf. Yasavul (2013), Burdin et al. (2015). Velleman (2014) discusses interactions between *in situ* focus and prosody in Kichee', arguing that prosody cannot be the sole determiner of focus for post-verbal subjects; see also Henderson (2012). Curiel Ramírez del Prado (2007) provides an extensive description of the morpho-syntax and prosody of information structure in Tojolab'al, and reports parallel facts for the prosodic marking of topic and focus in that language.

In Yucatec, prosodic marking of information structure appears to be quite limited. Kügler & Skopeteas (2007) and Gussenhoven & Teeuw (2008) find no tonal or durational differences between *in situ* (non-fronted) focus constituents and unfocused constituents occurring in the same post-verbal position. Kügler & Skopeteas (2006), Kügler et al. (2007) report a similar null result for fronted (pre-verbal) topic and focus constituents, which are both reported to show the same tonal contours as matching non-focused constituents in the post-verbal field.<sup>27</sup> On the other hand, Avelino (2009) observes a large pause and pitch reset following pre-verbal topics, which he takes as evidence for a prosodic boundary following fronted topics (see also Shklovsky 2011 on Tsel'tal). Kügler & Skopeteas (2007) found that pause breaks also followed *in situ* constituents carrying contrastive focus in post-verbal position. Both Avelino (2009) and Kügler & Skopeteas (2006, 2007) note that phrasal prosody may have different effects on words bearing different lexical tones.

The extent to which prosodic variation across Mayan languages reflects syntactic differences between those languages is not currently known (though Aissen 1992 takes some important first steps). This is partially due to the relative underdocumentation of phrasal prosody in the Mayan family. A related question is whether constituent order might itself be conditioned by prosodic factors in Mayan; Clemens (2014) suggests that post-verbal word order in Ch'ol may reflect prosodic conditions on verbs and their arguments.

### 7.1.2. Dependent Morphemes and Phrasal Prosody

The term 'dependent morpheme' refers to both clitics and affixes, these being morphological elements which cannot occur in isolation. Mayan languages have a number of dependent morphemes whose appearance and/or positioning is conditioned by phrasal prosody.

Henderson (2012) shows that the distribution of certain verbal suffixes in K'iche' depends on prosodic structure: so-called 'status suffixes' like *-ik* 'rrv' are found only on verbs that

appear at the right edge of an intonational phrase: phrase-medial verbs do not carry these suffixes (see also Coon this volume). Henderson also shows that several functional morphemes, such as the irrealis marker *ta(j)*, are realized as [CV] in phrase-medial position, but [CVC] in phrase-final position (see also Barrett 2007). He attributes these alternations to a preference for heavy syllables in phrase-final position, since these are better hosts for the large intonational contours that occur at the ends of phrases (e.g. Nielsen 2005). These patterns thus support a model of grammatical computation in which morphological insertion has access to pre-constructed prosodic boundaries; see Hayes (1990), Keating & Shattuck-Hufnagel (2002), Ackema & Neeleman (2003), Henderson (2012) for more discussion.

Other Mayan languages have clitics with prosodically-determined distributional patterns. Tsotsil, for example, has a semantically vacuous enclitic *un* [=un] which optionally appears at the ends of intonational phrases (Aissen 1992). This clitic is typically marked “by the possibility of a significant pause, as well as phrase-final contour”. For Yucatec, Avelino (2009) observes that LH\* target tones are realized somewhat later in the presence of the phrase-final topic marking enclitic [=eʔ]. Skopeteas (2010) provides a useful overview of such ‘intonational clitics’ as observed in the Yucatecan and Western Mayan branches (see also Furbee-Losee 1976a, Polian 2013).

Aissen (2000) argues that the distribution of the Popti’ intonational enclitic *an* [=an] ‘A/BI’ marks out prosodic constituents (*t*Ps) which exactly mirror the domains in which null pronouns must find their referential antecedents. This observation, taken with the additional syntactic arguments provided by Aissen, provides evidence that the interpretation of pronouns can be prosodically rather than syntactically conditioned. For related findings outside of Mayan see Hirotani (2005) and references there.

## 7.2. OTHER CLITICS

Apart from the intonational clitics mentioned above, Mayan languages have a large number of word-level clitics belonging to a range of syntactic and semantic categories. A small selection is provided in (40).

- (40) a. Kaqchikel enclitic *wi* (marks adjunct extraction, Henderson 2007)  
*Akuchi xab'e wi?* ‘Where did you go?’
- b. Uspantek plural enclitic *aq* (Can Pixabaj 2006, Bennett & Henderson 2013)  
*jpoot'aq* ‘their huipils’
- c. Mam interrogative enclitic *pa* (England 1983)  
*Atpa aatz'an?* ‘Is there salt?’
- d. K'iche' negative/irrealis enclitic *ta(j)* (Henderson 2012, Yasavul 2014)  
*Man pa k'ayib'al ta xutijo* ‘It wasn't in the market that he ate it.’
- e. Ch'ol noun class proclitic *x* (Coon 2010, Vázquez Álvarez 2011)  
*x'ixik* ‘woman’
- f. Sipakapense directional enclitic *el* (Barrett 1999)  
*Xwor el* ‘(S)he slept behind something.’

These clitics are distinguished from affixes and words by typical diagnostics (e.g. Zwicky & Pullum 1983, Anderson 2005): they may have a relatively low degree of selection with respect to the syntactic category of their hosts (40a,c,d); they may be unstressed, or otherwise fail to participate in word-level stress assignment (40b,f) (Bennett & Henderson 2013; Pérez

Vail 2007:37–8); or they may fail to participate in word-level phonotactic processes, such as initial [ʔ]-insertion (40e) (section 2.4.3). It has also been suggested that the positioning of some clitics, such as the K'iche' negative/irrealis enclitic *ta(j)*, is prosodically-determined (Henderson 2012, Yasavul 2014). Space considerations prevent me from discussing these clitics in further detail; specifics can be found in the descriptive works cited throughout this paper.

Second-position clitics are found in the Greater Tzeltalan branch of the Mayan family. Aissen (1987:9) provides Tsotsil examples like *oy la jun vinik* 'There was a man (they say)', in which the evidential marker *la* occurs following the existential predicate *oy*. See Coon (2010), Vázquez Álvarez (2011), Polian (2013) for other examples. Aissen (1987:9) writes that these clitics are "very crudely" second position; this may suggest that the positioning of these clitics is conditioned by prosody instead of (or as well as) morpho-syntax, a possibility explored by Curiel Ramírez del Prado (2007) for Tojolab'al (see also Harizanov 2014 for Slavic languages).

One set of clitics merits special mention. Absolutive agreement markers may vary along two dimensions in Mayan languages: they may either precede or follow the predicate, and may be either clitics or affixes (see Coon this volume). This variation is observed both within and across languages, e.g. the Q'anjob'al B2SG marker in *jelan hach* [xelan=atʃ] 'you are intelligent' vs. *maxach wuqtej* [maʃ-atʃ w-uqte-x] 'I followed you' (*wuqtej* [wuqtex] is the verb in the latter example; Baquixar Barreno et al. 2005). Woolford (2011) argues that variation in the position of absolutive marking in Tsotsil is itself conditioned by phonological factors. See also Curiel Ramírez del Prado (2007) on Tojolab'al, Barrett (2011) on Sipakapense, and Bennett & Henderson (2014) on Kaqchikel.

## 8. Conclusion and future prospects

In this article I've tried to summarize a wide range of previous research on the phonetics and phonology of Mayan languages. In doing so I hope to make this rich body of work more accessible to non-Mayanists and to linguists who do not speak Spanish. Mayan languages have a number of typologically and theoretically interesting properties which should be of interest to linguists of any persuasion. For Mayanist readers I've tried to point out empirical domains that deserve to be investigated more closely. Despite many years of careful and intensive work on the sound systems of Mayan languages, there are quite a few gaps in our understanding which remain to be filled.

One such gap concerns the topic of prosody, at both the word and phrase levels. We need to move beyond impressionistic descriptions of stress and intonation in Mayan: these phenomena call out for more carefully controlled instrumental studies, especially given the murkiness surrounding some of the basic empirical facts in this area. The tonogenetic languages of Mayan (section 6.2) provide a particularly exciting opportunity to document the real-time birth of lexical tone. The interaction of prosody with segmental phonology, morphology, and syntax also presents numerous opportunities for fruitful research.

I suspect that instrumental phonetic studies will play a central part in future work on Mayan sound systems. The segmental phonetics of Mayan languages have yet to be documented in any serious detail. Major questions persist even for the description and analysis of glottalized stops, despite the fact that this segmental class has been studied more closely than any other topic in Mayan phonetics (sections 3.3.2 and 3.4.2). Though valuable in its own right, phonetic documentation may also help settle deeper questions about the phonological representation of segments, or about the proper characterization of allophonic variation.

And as just noted, such studies will be crucial for refining our understanding of the prosody of Mayan languages. Finally, the relation between citation forms and connected speech in Mayan languages is currently unclear: large-scale corpus studies of spontaneous speech would be valuable in this respect.

While the preceding topics could be investigated using acoustic methods, I would point out that two major areas of phonetic research—articulatory phonetics and speech perception—remain essentially unexplored for Mayan languages. Work in these fields has the potential to make enormous descriptive and theoretical gains. Furthermore, articulatory and perceptual studies could help lay the groundwork for research in speech pathology and language education, areas of practical value for Mayan communities.

The study of phonetic and phonological acquisition in Mayan has not yet begun in full. Work by Clifton Pye and collaborators suggests that Mayan languages have much to offer in this regard, as patterns of acquisition in e.g. K'iche' seem to be different from English in interesting and revealing ways (Pye 1983, Pye et al. 1987, Pye 1992, Pye et al. 2008, *et seq.*; see also Straight 1976, Espantay Serech 2006). As with studies of speech production and perception, studies of phonological acquisition could have significant tangible benefits for language education in the Mayan context. The study of phonological acquisition may also shed light on the numerous sound changes that have occurred in the development and diversification of the Mayan family (e.g. Ohala 1981, 1993).

The vast majority of information on Mayan languages is contained in written sources. Phonetic and phonological facts are not well-preserved in books: many of the empirical questions raised above could be answered with a small number of appropriately chosen recordings. Those of us who work on Mayan sound systems should expend considerable effort to produce (and share) high-quality field recordings of those languages, ideally in collaboration with native speaker linguists and community members. In light of the uncertain future of many Mayan languages, phonetic and phonological documentation acquires an urgency that should not be ignored.

### *Short Biography*

Ryan Bennett is an Assistant Professor in the Department of Linguistics at Yale University. He received a PhD in Linguistics from the University of California, Santa Cruz in 2012. His primary research area is phonology, with a particular emphasis on prosody and the interfaces between phonology and other grammatical domains. His current research is focused on the prosody of K'ichean-branch Mayan languages, as well as various topics in the study of Irish phonology.

### *Acknowledgements*

I thank Scott AnderBois, Pedro Mateo Pedro, and an anonymous reviewer for helpful comments on an earlier draft of this article

### *Notes*

\* Correspondence to: Ryan Bennett, Yale University, Department of Linguistics, PO Box 208366 New Haven, CT 06520-8366, USA. E-mail: ryan.bennett@yale.edu, <https://campuspress.yale.edu/ryanbennett/>

<sup>1</sup> Slash brackets /X/ mark phonemic (broad) transcription, and square brackets [X] mark allophonic (narrow) transcription. Stress is indicated with an uptick [ˈV] before the stressed vowel; though non-standard, this convention has the advantage of avoiding implicit claims about syllabification (section 4). Tone is indicated by acute [V̄] (high) and grave [V̄] (low) accents. The asterisk \*X marks either reconstructed forms or ungrammatical forms, depending on the context.

<sup>2</sup> The use of IPA /a e i o u/ to represent the five core vowels of Mayan is something of an idealization. In particular, the vowels transcribed as /a i e o u/ may be closer in phonetic terms to [ɑ/Λ ɪ ɛ ɔ ʊ], depending on the language and the segmental or prosodic context (see e.g. Bruce 1968, England 1983, Edmonson 1988 and other descriptive references in this section). This is no surprise: in many five-vowel systems, phonemic vowel categories range over fairly wide regions of contiguous phonetic space (e.g. Liljencrants & Lindblom 1972, Lindblom 1986, Rice 1995, Manuel 1999, Becker-Kristal 2010 and references there). In this paper I transcribe vowel qualities as they are reported in primary data sources for that language.

<sup>3</sup> Akatek is sometimes described as a dialect of Q'anjob'al (e.g. Raymundo González et al. 2000). See Kaufman (1976b), Zavala (1992), Kaufman (2003), England (2003) for discussion.

<sup>4</sup> It appears that the San Andreas dialect of Popti' may have also developed phonemic vowel length (Ross Montejó & Delgado Rojas 2000), though sources differ on this point (see e.g. Tuyuc Sucuc et al. 2001).

<sup>5</sup> Central *ā* is closer to [ə] in Lacandon (Bruce 1968, Bricker & Orié 2014, Herrera Zendejas 2014:Ch.10).

<sup>6</sup> Fisher (1976) argues that the development of [i] from [a] was conditioned by lexical tone; cf. Fisher (1973), Fox (1978), Sobrino Gómez (2010) and references there.

<sup>7</sup> In the Eastern Ch'olan languages, the Common Ch'olan \*/i/ ~ \*/a/ contrast was destroyed by a chronologically later \*/i/ > /a/ merger.

<sup>8</sup> Herrera Zendejas (2014:Ch.9) describes a variety of Tsotsil which has an innovative /a e i o i/ vowel system. The /o/ appears to be substantially raised in this dialect, presumably in response to the earlier /u/ > /i/ shift.

<sup>9</sup> Frazier (2013) also discusses the possibility that rearticulated vowels were produced with full glottal closure at earlier stages of historical development.

<sup>10</sup> While some descriptive work reports hiatus in Popti' (Day 1973) and Yucatec (Blair 1964) other researchers explicitly deny that hiatus is possible in these languages, being avoided through consonant epenthesis (Jiménez Camposeco et al. 2001, Delgado Rojas et al. 2007, Orié & Bricker 2000). Given that hiatus is generally limited to Western Mayan, it would not surprise me to find other cases of hiatus in Greater Tzeltalan, Greater Q'anjob'alan, or even Yucatecan languages. See also Hofling (2000:27).

<sup>11</sup> Some authors have treated alternations like (15) as the deletion of underlying /ʔ/ rather than [ʔ]-epenthesis (e.g. Craig 1977, Aissen 1987, Bricker et al. 1998, Hofling 2000:11–2). Since (i) initial [ʔ] is highly predictable, and (ii) there appear to be phonological differences between underlying and inserted [ʔ] (16), an analysis in terms of epenthesis seems more appropriate.

England (1983:34–6;41–2) also reports that native speakers of Mam have the intuition that initial [ʔ] is non-distinctive. Similar judgments presumably hold for speakers of the other Mayan languages, given that word-initial glottal stops are not represented in any standard Mayan orthography.

<sup>12</sup> Ejective /tʰ/ has a low lexical frequency in Mayan languages, e.g. England (2001:26), Palosaari (2011:18).

<sup>13</sup> Plain \*/ts/ has largely merged with /s/ in Poqomam, and to a lesser extent in Poqomchi' and some varieties of Q'eqchi' (Campbell 1977, Smith-Stark 1983:68, Malchic Nicolás et al. 2000:48–9, England 2001:28, Caz Cho 2007:32–3). Herrera Zendejas (2014:Ch.10) reports a similar merger for southern Lacandon.

<sup>14</sup> The fricative /s/ is marginal in Huastec, having shifted to /θ/ sometime after the split from Chicomuceltec (section 3.2.5; Edmonson 1988:36, Norcliffe 2003). Both the absence of /s/ and the presence of /θ/ are typologically uncommon features (Maddieson 1984).

<sup>15</sup> While palatalized or fronted coronal stops /tʰ tʰʲ/ are often reconstructed for proto-Mayan, these sounds are not the direct source of the palatalized coronals in Ch'ol (Kaufman 1976a, Kaufman & Norman 1984, Vázquez Álvarez 2011).

<sup>16</sup> The debuccalization of /β/ to [ʔ] is a recurrent pattern across Mayan languages, especially in word-final position (see e.g. Barrett 2007 for K'ichean). This may be a case of parallel innovation: debuccalization often occurs in some, but not all dialects of a language (ruling out shared inheritance), without any obvious geographical basis for its distribution (ruling out areal diffusion). Debuccalization of /β/ is presumably related to the weakness of the release burst in final [β#] and voiceless [β̥].

<sup>17</sup> Not all language descriptions report allophonic aspiration for the plain affricates /ts tʃ/ (ts̱ tʃ̱)/. This may represent a systematic difference across languages, or simply the relative difficulty of perceiving aspiration following the noisy sibilant release of a coronal affricate.

<sup>18</sup> Glide hardening is also observed in some Mayan languages, as in Q'eqchi' *winq* [ḵwinq̱h] 'man' and *yu'am* [ṯjuʔam] 'life' (Campbell 1974, England 2001, Tzul & Cacao 2002, Caz Cho 2007), or San Juan Sacatepéquez Kaqchikel *wokowik* [βokoviḵh] 'hollow' (García Matzar et al. 1999). Space considerations prevent me from discussing these patterns in more detail.

<sup>19</sup> It bears mentioning that initial glottal stop insertion is not directly motivated by the /CVC/ root template, as [ʔ]-insertion occurs in both polysyllabic roots (Kaqchikel *umül* [ʔumül] ‘rabbit’) and in inflected words (Kaqchikel *awixk’äq* [ʔaw-iʃkʰiqʰ] ‘your fingernail’; Majzul et al. 2000) (section 2.4.3).

<sup>20</sup> There are varieties of Poqomam in which the glottalized labial is uniformly produced as an ejective [pʰ], but remains exempt from root co-occurrence restrictions on stops (Smith-Stark 1983, Malchic Nicolás et al. 2000). In languages with a /pʰ b/ contrast, it is always the implosive /b/ which patterns separately from the other glottalized stops.

<sup>21</sup> Fox (1978) argues that proto-Mayan had initial stress, which may have interacted with both syncope and tonogenesis.

<sup>22</sup> Weight-conditioned penultimate stress is also found in K’iche’ and Uspantek (Barrett 2002, Henderson 2012, section 6.2). These languages differ from Mamean and Huastecan in limiting stress to a final two-syllable window.

<sup>23</sup> While there are clear examples of stress attraction to /VʔC/ and /Vʔ#/, England (1983, 1990), Pérez Vail & Jiménez (1997), and Pérez et al. (2000) are not explicit as to whether intervocalic /ʔ/ in /V.ʔV/ also draws stress to the syllable that precedes /ʔ/.

<sup>24</sup> This is not to suggest that tone is *only* found in words that descend from a proto-Mayan lexeme which contained a laryngeal. In modern Uspantek, for example, tone is associated with various morphemes for which no laryngeal is reconstructed (such as the A1SG and A2SG possessive markers; Grimes 1972, Campbell 1977, Osborne 1989, Can Pixabaj 2006, Bennett & Henderson 2013).

<sup>25</sup> Somewhat different characterizations of Uspantek stress and tone are given in Grimes (1971, 1972), Campbell (1977), Can Pixabaj (2006).

<sup>26</sup> The orthographic system of Tektitek has some idiosyncratic conventions for vowels: phonemic vowel length is not represented, and underlying /V:ʔ/ is written as V’V (Pérez Vail 2007).

<sup>27</sup> These observations may prove difficult for theories of focus such as Zubizarreta (1998) and Szendrői (2003) which directly tie focus movement to the prosodic prominence of focused elements (see also Féry 2013, Velleman 2014 and references there).

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