Cross-linguistically, codas are often constrained against completely, or are only tolerated when filled by sonorant phones (Zamuner 2003). Choapan Zapotec is not unusual in this regard: when a word-final coda is present at all, only /j/, w/, or /n/ can fill it, and word-medial codas are almost unattested. However, liquids, which most phonological theories treat as more sonorant than nasals, can never be codas in Choapan. Furthermore, /n/, /j/, and /w/ exhibit special features word-finally that are never associated with consonants in other positions, including these same phonemes in onsets. Based on these positional and featural patterns, I analyze the word-final allomorph of /n/ in Choapan as a glide (cf. Ferre 1988). These data can contribute to theories regarding lenition in codas, as well as the putative position of nasal consonants in sonority hierarchies.

1 Phonological sketch of Choapan

Some basics:1

Oto-Manguean language spoken in the Sierra Norte of Oaxaca, Mexico
~10,000 speakers
VSO
V, CV, VCV and CVCV noun and verb stems, with CV and CVCV most common
No subject agreement, but pronominal enclitics common; aspect marked by proclitics

1.1 Consonants and vowels

Choapan Zapotec has 19 phonemic native consonants:
Throughout this paper, I write IPA /j/ as <y> and /r/ as <r>.
The phone in parentheses, (m), is phonemic in Choapan Zapotec, but only in Spanish loans. In the native lexicon, [m] is only present as an allophone, as is [n].

1I would like to thank my consultants, Antonio Arreola Valentín and Alejandra Estrada Yeskas, as well as Jonah Katz for his insightful discussion of the data and theory presented here. Of course, all mistakes are my own. I am supported by a Graduate Research Fellowship from the National Science Foundation.
Choapan Zapotec has four vowels:

```
  i  e  o
   a
```

The round vowel phoneme is always written here as /o/. However, in speech, it is realized as [o], [u], or somewhere between the two in the vowel space.

## 1.2 Vowel phonation types

- Like many other Mesoamerican languages, Choapan Zapotec has contrastive laryngealization on vowels.
- There is a three-way contrast in Choapan, between a plain vowel, $V$, a glottalized vowel, $V?$, and a laryngealized or broken vowel, $V?V$.
- Laryngealization on vowels does not seem to phonemically interact with tone.
- Any tone can occur with any vowel phonation type, including contour tones.
  - In the case of a broken vowel, a contour tone is realized as two separate pitches, one on either side of the glottal stop.

The following table lists minimal pairs for plain, glottalized, and laryngealized vowels:

<table>
<thead>
<tr>
<th></th>
<th>Labial</th>
<th>Alveolar</th>
<th>Post-Alveolar</th>
<th>Velar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stop</td>
<td>Fortis p</td>
<td>t</td>
<td></td>
<td>k</td>
</tr>
<tr>
<td></td>
<td>Lenis b</td>
<td>d</td>
<td></td>
<td>g</td>
</tr>
<tr>
<td>Fricative</td>
<td>Fortis s</td>
<td>f</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lenis z</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Affricate</td>
<td>Fortis ts</td>
<td>tʃ</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lenis dz</td>
<td>dʒ</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tap</td>
<td>r</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liquid</td>
<td>l</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nasal</td>
<td>(m)</td>
<td>n</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glide</td>
<td>w</td>
<td>y</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
1.3 Tone

- Five tones: three level tones, and two contour tones.
- Level tones are very frequently attested, and the contour tones considerably less so.
  - Most or all contour tones seem to be derived from what were formerly two tones, either diachronically (though syllable deletion) or synchronically (tone joining due to inflectional morphology).
  - Because of this, contour tones are infrequent.
- The three level tones: high, mid, and low.
  - Mid tone is the default tone, as it is realized on the highest number of vowels.
  - High and low tone are realized about equally

2 The problem: Choapan codas

2.1 What does a Choapan coda look like?

/n/, /y/, and /w/ are the only consonants that are consistently allowed in codas in Choapan. For example:

(1) ley-wi?
teeth-3s
‘his teeth’

(2) yö lâw tʃi tà
stone face egg
‘egg yolk’ (lit. egg’s eye)’
There several exceptions that prove the rule:

(4)  bi kw= édzi -ks =a? (AAV)
    NEG POT= cry -like.that =1s
    ‘I won’t cry like that’

(5)  bi kw= édzi -kaz =a? (AEY)
    NEG POT= cry -like.that =1s
    ‘I won’t cry like that’

In these examples, there is intra-speaker variation between a consonant cluster /ks/ and a syllable /kaz/.

Even for speaker AAV, however, kwédziksa? was syllabified and kwé.dzi.ksa?, versus *kwé.dzik.sa?.

Variation between /ks/ ~ /kaz/ in other words is consistent with these data:

(6)  la?= kazí (AEY)
    still- like.that
    ‘even though’

(7)  la?= kísí (AAV)
    still- like.that
    ‘even though’

For this word as well, speakers always prefer word-medial consonant cluster /ks/ to syllabify as an onset, and never as a coda of the first syllable: la?=ksí, not la?k.sí.

When vowel deletion creates the potential for a non-sonorant coda, speakers regard this syllabification as non-optimal; intra-speaker variation shows that vowel deletion (and therefore creating the option for a consonant to be in a coda) is not preferred by all speakers.

Consonant deletion to avoid non-sonorant codas, however, applies regardless of dialect. Following the general conspiracy in the language, this deletion only applies to stem-final /g/, and is not overwhelmingly common:

(8)  gitfog -a?
    head -1s
    ‘my head’

(9)  gitfo -ba?
    head -3ANML
'its head (of an animal)'

(10) gitʃo yoʔo
    head house
    ‘roof’

In these examples, the final /g/ of gitʃo ‘head’ is only realized when followed by a vowel, i.e., when it can be syllabified as an onset and not a coda. When /g/ comes immediately before a consonant or is word-final, it is deleted. This same process occurs on verb stems:

(11) r- tʃiːlog -g -n
    CONT- scatter -1s -INAN
    ‘I am scattering them [the seeds]’

(12) r- tʃiːlo -bɨ -n
    CONT- scatter -3s -INAN
    ‘He is scattering them [the seeds]’

Though /g/ deletion always requires that phonological information in the stem is erased, this is still preferable to /g/ syllabifying as a coda. Given evidence from /ks/ word-medial clusters, it is more likely that the other option, for /gb/ to syllabify as an onset, would happen. However, there are no attested velar+bilabial stop sequences in word onsets in Choapan, so there is reason to believe that this ordering of stop clusters is constrained against.

While deletion for avoidance of non-sonorant codas is fairly common in Choapan, there is a single example of syllabification judgments that support avoidance of all codas:

(13) b= e= ywa? =bɨ =n
    CMPL= ITER= carry =3s =INAN
    ‘she carried it’

(14) y= wâ?= =bi =n
    POT= carry =3s INAN
    ‘she will carry it’

(15) bi y= wâ?= =bi =n
    NEG POT= carry =3s INAN
    ‘she won’t carry it’

Speakers syllabify all of the above sequences of /Vyw/ as V.yw, and not *V.y.w. This is consistent with the general conspiracy against having codas in Choapan. (15) is especially important: if the proclitic ‘POT’, which is usually realized as i=, were a TBU, then the H tone associated with bɨ, ‘NEG’ would delink and a single H would be linked to i=, with no contour tone on the following syllable. However, y= is not a TBU, which is why the stem
has a contour in (15).

### 2.2 Tone and codas

As noted above, Choapan Zapotec does have contour tones; however, these are uncommon in the language and seem to be derived. In some instances, contour tones seem to be the result of diachronic syllable loss:

<table>
<thead>
<tr>
<th>Choapan</th>
<th>proto-Zapotec</th>
<th>gloss</th>
</tr>
</thead>
<tbody>
<tr>
<td>byō</td>
<td>(*kitik)</td>
<td>chicken</td>
</tr>
<tr>
<td>bè</td>
<td>*kweketiʔ</td>
<td>butterfly</td>
</tr>
<tr>
<td>yō</td>
<td>*keʔyek</td>
<td>flower</td>
</tr>
<tr>
<td>byō</td>
<td>(*ni kola)</td>
<td>male, man</td>
</tr>
<tr>
<td>něʔ</td>
<td>*naʔa (!)</td>
<td>1s (independent)</td>
</tr>
</tbody>
</table>

For verbs, the only instances of contour tones are derived; unlike nouns, there are no verbs with underlying contour tones. The juxtaposition of two segments with different linked tones seems to create contours:

(16) \[ w= y =āʔ yoʔo \]
    \[ \text{FUT=} \text{make} =1s \text{ house} \]
    ‘I will build a house’

The low tone on stem of the verb ‘make’, -ē-, delinks from its TBU when it devocalizes to /y/ before pronominal enclitic =a?, which is then associated with both a high and a low, a contour tone. This can be contrasted with the same verb marked with a different pronoun:

(17) \[ w= è =bíʔ kölè \]
    \[ \text{FUT=} \text{make} =3s \text{ favor} \]
    ‘he’ll do a favor’

Since there is no deletion of a TBU here, the tone of the verb stem does not delink.

Syllables with codas can also have contour tones. In some cases, this is due to high tones from a preceding syllable de- and relinking:

(18) \[ w= e =n \ bè \]
    \[ \text{FUT=} \text{make} =\text{INAN wind} \]
    ‘it will be windy’

(19) \[ bi \ w= è =n \ bè \]
    \[ \text{NEG FUT=} \text{make} =\text{INAN wind} \]
    ‘it won’t be windy’
The negative particle, *bi*, is associated with a high tone, which sometimes delinks and is realized on the following syllable. Again, ‘make’, -è- is typically linked with a low tone, and the combination of H + L > F(alling).

However, there are many cases in which the INAN marker, =n, seems to be associated with a low tone as well:

(20) á g= aw =ró
    Q. POT= eat =1.INCL
    ‘Are we going to eat?’

(21) wje -râ g= aw =rò =n
tomorrow -Foc POT= eat =1.INCL =INAN
    ‘It’s tomorrow that we’ll eat’

When there is no inanimate object marker, =n, then the tone on =ró ‘first person inclusive’, is realized as a high. However, when followed by =n, a falling tone appears. Depending on the tone of the preceding enclitic, it is not always the case that the inclusion of =n as an object creates falling tone:

(22) b= elâ =w =n
    Cmpl= loosen =2s =INAN
    ‘you loosened it’

Unlike =ró, 2s enclitic =o? is not normally associated with a high tone, and so =n INAN yields a rising tone instead. This is not the only coda that can affect tone of the TBU in its rhyme, however:

(23) ka b= dâ =w? nèyògé
    should Cmpl= eat =2s yesterday
    ‘you should have eaten yesterday’

When =o? is devocalized to =w?, it can no longer be a TBU, and its tone associates with the previous syllable, deriving a falling tone. This is quite similar to (16) above, where devocalization of stem -ê- ‘make’ to -y- caused its low tone to delink and relink and be realized as half of a contour tone.

In certain cases, whole syllables can be reduced to a consonant\(^2\), and this frequently results in contour tones when an entire TBU is deleted:

(24) b= dibi =ró =n
    Cmpl =sew =1.INCL =INAN
    ‘we all sewed it’

\(^2\)I have only found instances of aba > aw and ibi > iw, but that doesn’t mean there aren’t other examples of syllable reduction.
Whether a syllable is reduced to a single consonant as in (26), or a stem vowel is deleted in hiatus with a pronominal enclitic as in (27), this results in a contour tone. However, when no deletion takes place, as in (24)-(25), no contours are derived.

2.2.1 Why does tone matter if we’re talking about codas?

- In most cases in Choapan, contour tones are a result of a change in the number of tone-bearing units.
- However, ‘INAN’ is also associated with a tone, but can never carry tone itself- /n/ is never a TBU.
- Though there are no morphemes that are underlyingly /y/ or /w/, they cannot be TBUs either; when vowel hiatus leads to devocalization, contour tones may arise due to delinking of tones.
- In a sentence: /n/, /y/, and /w/ can’t be TBUs, but they have effects on tone that other consonants in Choapan never do.

2.3 Vowel phonation types and /n/, /y/, /w/

Tone isn’t the only vowel-associated feature with which /n/, /y/ and /w/ interact. Glottalization is a phonation type of vowels in Choapan, but it can also affect all three of these consonants. Like contour tone, glottalization of sonorant coda consonants always seems to be derived. Sometimes this is most likely diachronic, as it appears on morphologically simple forms, most commonly with /n/:

(28) goŋ?
    mud
    ‘mud’

(29) giŋ?
    pepper
‘pepper’

(30) gyeta yoŋʔ?
tortilla soft
‘soft tortilla’

In some cases, it is clear that glottalization of word-final /n/ is part of a syllable deletion process:

(31) beneʔ? ~ beŋʔ?
   person ~ person
   ‘person’

(32) bi naʔ? ~ binʔ?
    3s(Pr) that ~ 3s.OHER
    ‘that person’

Several discourse particles have a similar phonological shape. While there is no evidence that these are the result of phonological reduction of longer words, it seems quite likely:

(33) dēŋʔ?
    and.then
    ‘and then’

(34) tfāŋʔ?
    if
    ‘if [it were that...]’

It seems possible that /n/ glottalization word-finally is a result of diachronic syllable deletion, and this is indeed the case synchronically for (32)-(31). There are very few examples of glottalized /y/ in Choapan Zapotec, and they are always word-final:

(35) gyēʔ?
    cooked
    ‘cooked’

(36) sēʔ7
    atole
    ‘cornmeal drink’

Without evidence like (32)-(31) for glottalized /y/, and less than 10 examples of this phonation type on /y/, it seems safe to conclude that while this is phonotactically allowed in Choapan, it is not a part of any regular process, diachronic or otherwise.
However, /w/ is frequently glottalized, both as part of a single morpheme and when it is the result of devocalization of 2s enclitic =o7:

(37) daw?
    small
    ‘small’
(38) idáw7
    church
    ‘church’
(39) da í= nà =w7
    CMPL POT= say =2s
    ‘your opinion’

In (37)-(38), /w/? is not derived, but in (39), it is underlyingly an /o/, and is only realized as /w/ to repair vowel hiatus. /w/? is quite frequent in Choapan, and most commonly when it is an allomorph of 2s enclitic =o7:

(40) r= wè =n xwè =w?
    HAB= make =INAN hangover =2s
    ‘you’re hungover’
(41) bá b= da =w?
    already CMPL= eat =2s
    ‘you already ate’
(42) batá b= la =w?
    when CMPL= arrive =2s
    ‘when did you arrive?’

These examples suggest that devocalization of /o/ to /w/ disregards the vocalic status of a segment, and only requires that the entire morpheme, phonation type included, be expressed.

2.3.1 Why does glottalization matter?

• /n/, /y/, /w/ are special because they can have phonation types that are normally associated only with vowels.
• Coda position is also unique, because these consonants can only be glottalized in codas and nowhere else.
• So, not only do /n/, /w/, /y/ interact with tone in interesting ways, but they can have more vowel-like properties with phonation type, as well.
Unlike tone, which can delink and relink, vowel phonation in Choapan does not seem to be moveable, and has to stay wherever it was originally assigned, even if the segment bearing the phonation type was diachronically or synchronically deleted.

In codas, /n/, /y/, /w/ can participate in parts of the phonology that are normally unique to vowels.

3 Nasal glides (Ferre 1988)

Nasal ‘absorption’:

...“processes which neutralize a consonant’s point of articulation which certain nasal consonants have, depending on their position in the word”

Absorption occurs when nasals are so weakly articulated that they are no longer obstruent-like at all, and are actually nasal glides.

When [N], a placeless nasal, is not completely deleted (only to be realized as nasalization on a vowel), it is often taken for a weakly articulated velar nasal, either because it’s actually velarized superficially, or linguists systematically hear and transcribe it that way.

On the markedness of [ŋ]:

“the number of languages which have [ŋ] is approximately half the number of languages which have [m] or [n]” > palatal or velar nasals predicts that there will also be an alveolar nasal in a language.

Many languages, like Choapan, contrast stop POA at the velar articulation, but not velar nasals with other nasals.

Languages avoid having [ŋ] as a phonological segment because it’s hard to make, and even cross-linguistic nasal assimilation processes avoid velar nasals, but not bilabial ones, for example.

Place feature spreading is subject to filters when it might yield a velar nasal.

This, and other evidence, suggest that what are interpreted as nasal stops might not really be stops at all, but are articulated as glides.

Ferre shows that properties of being a nasal glide can operate at both the phonological and phonetic levels.

Relating this to Choapan:

/ŋ/ > [ŋ] / _#_

Allophonic process that seems to neutralize place features on /ŋ/

But if /ŋ/ is debuccalized, does it really become velar? Ferre explains in great detail how languages might avoid just that thing, having velar nasals.
• What if /n/ in coda position is lenited to the point of becoming a glide, just as Ferre
demonstrates for so many other languages?

Nasal glides fit well in Choapan:
• If what I transcribe as [ŋ] were a nasal glide, this would fit well with all of the data
described above:
  – The glides /y/, /w/, and [ŋ] affect tone in ways that other consonants don’t
  – Glides /y/, /w/, and [ŋ] can also be glottalized, a vowel phonation type that’s
    never realized on other consonants.
• Instead of /n/ being special when it’s in a coda, and glides /w/ and /y/ doing the
  same thing, there’s a better generalization to be had: glides in Choapan exhibit
  unusual properties in coda position.

4 The lessons

What does this tell us about natural classes in Choapan?
• The class of glides in this language includes an allomorph of /n/, an alveolar nasal
  stop.
• Articulatorily and phonologically, [ŋ] acts as a glide.
• Type and place of articulation of a phoneme, and the natural class categorizations
  therein, do not necessarily apply to all allomorphs of that phoneme.
• Glides in Choapan exhibit special properties not found on other consonants:
  – They can have vowel phonation types that other consonants never do, which shows
    they can sometimes be part of the nucleus.
  – They can affect tone and/or sometimes alternate with syllabic segments, which
    other consonants do not do. Sometimes they are even explicitly linked to a tone.
  – But, they can’t bear tone, which is a commonality among all consonants in Choa-
    pan.

In traditional sonority scales, glides are considered to be the most sonorous segments after
vowels:

Vowels > Glides > Liquids > Nasals > Fricatives > Stops

Liquids, which have thus far not been mentioned in this paper, especially with regards to
Choapan, are supposed to be more sonorous than nasals. And yet, in Choapan, /n/ has a

3Or what I am transcribing as [ŋ].
glide allomorph, but liquids never participate in the same alternations that glides do, and pattern only with other consonants.

Ohala and Kawasaki-Fukumori 1997:

- From an acoustic perspective, sonority is a really bad metric to use, anyway (emphasis mine):

- “Sonority” and its cousin “strength” do not exist and should be abandoned for the sake of explaining universal sequential constraints. They should be replaced by a measure of the degree of modulation in several acoustic parameters (amplitude, periodicity, spectral shape, FO) and the notion that the survivability of a given segmental sequence is proportional to the strength of this modulation.”

Taking this into consideration, if glides, including nasal glides, share similar acoustic properties to vowels, but are nevertheless acoustically or phonologically still consonants, then this can help account for why codas in Choapan pattern as they do.

This can also point to why liquids, though predicted by sonority sequencing scales to be able to do more glide-like things, are completely prohibited from appearing in Choapan codas. Most likely, liquids in this language don’t have a strong enough acoustic signal to appear in codas and be reliably disambiguated from each other and other phonemes in the language.

5 Conclusions

Even though the data discussed here are a small part of one particular language, they are in line with predictions that could be made on the basis of Ferre 1988, Ohala and Kawasaki-Fukumori 1997. It is promising, especially with regards to re-examining sonority sequencing as a metric for determining syllable structure, that codas in Choapan do not pattern the way the sonority scale would predict. I do not claim that these data can debunk the idea of sonority sequencing, but that they can support broader acoustic studies that have these aims.

Furthermore, the natural class of glides that I have posited in Choapan is an example of an unusual language-specific pattern that has support from cross-linguistic articulatory and phonological studies (Ferre 1988). Again, the data from Choapan can add to typological knowledge with regards to lenition processes, specifically of nasals.

References


