

A CONSUMER'S GUIDE TO TONAL UNDERSPECIFICATION¹

Ryan Bennett (University of California, Santa Cruz) and Hiroto Uchihara (Tokyo University of Foreign Studies)

INTRODUCTION

We understand the term ‘tonal underspecification’ to refer to any situation in which vowels, syllables, or other tone-bearing units occur without an associated tonal target. As a term, ‘tonal underspecification’ is most frequently used in the context of languages with lexical and/or grammatical tone (Hyman 2001, Rolle 2018); it has also been employed in the analysis of intonational systems (e.g. Pierrehumbert & Beckman 1988). Theoretically, it is most closely associated with Autosegmental Phonology (Goldsmith 1976, 1990), though underspecification as a concept is not inherently tied to that framework.

The key insight expressed by tonal underspecification is a simple one: not every unit which *can* host a tonal target necessarily *does*. However, the actual application of underspecification to the analysis of tonal and intonational systems is often far less straightforward (e.g. Paster 2003; see also McCarthy & Taub 1992, Steriade 1995 for segmental underspecification).

The question we address in this paper is a practical one: what diagnostics can be used, with confidence, to *argue* for tonal underspecification in a particular analysis? We evaluate a range of diagnostics which have been used to identify tonal specification, both in published work and in our informal discussions with colleagues and students. Our intent is to unpack the logic of these diagnostics, to assess the conditions under which they can be successfully used to argue for tonal underspecification. In several cases, we argue that some seemingly reasonable diagnostics for tonal underspecification are not actually valid, and should be abandoned. In other cases, we suggest that even certain valid diagnostics must be applied with care. We also consider how to deal with cases in which multiple diagnostics seem to provide conflicting evidence for or against tonal underspecification. When possible, we provide illustrations and case studies from languages of Mesoamerica, particularly Otomanguean languages, which often have complex tone systems.

Underspecification has proven to be a very useful descriptive tool for tonal languages. However, underspecification is ultimately a theoretical concept, and its applicability is therefore

¹ Thanks to Ben Eischens, Shun Nakamoto, and participants at the Quinta Mesa de Trabajo del Seminario Phonologica for their feedback.

dependent on one's broader theoretical assumptions (often, but not always, the basic assumptions of Autosegmental Phonology). We think this point is sometimes lost in descriptive and analytical work on tonal languages, and so we try to highlight when particular diagnostics crucially depend on specific assumptions about tonal representations (e.g. Hyman 2001, 2011a,b) or phonological derivations (e.g. Steriade 1995, Pulleyblank 2004).

Our discussion draws heavily on prior research on underspecification and related notions like phonological markedness. We would particularly highlight Steriade (1995), Myers (1998), Hyman (2001, 2011a,b), Pulleyblank (2004), and Archangeli (2011) as important influences on our thinking, and direct readers to those sources for more detailed discussion and additional key references. For good general discussions of tone, which have also influenced the presentation here, we recommend Pike (1948), Snider (1999, 2018), Yip (2002), Gussenhoven (2004), Hyman (2006, 2009, 2011a,b), and Hyman & Leben (2021).

The title of our paper is a nod to Ohala (1986) "Consumer's guide to evidence in phonology", which provides a critical perspective on how particular types of data can and should be used to support and develop phonological theories. We hope that this paper will similarly provoke discussion about the relationship between data and theory in the domain of tonal underspecification, and underspecification more broadly.

FORMAL AND ANALYTICAL ASSUMPTIONS

Autosegmental representations

Though underspecification is not intrinsically linked to Autosegmental Phonology, tonal underspecification is commonly used in autosegmental analyses of tonal systems. For that reason, we adopt Autosegmental Phonology as a theoretical backdrop for our discussion here.

The core assumption of Autosegmental Phonology is that tones are independent phonological objects, rather than properties of individual segments (e.g. Goldsmith 1976, 1990, Hyman 2014, and references there). Tones *associate* with segments or other tone-bearing units, via association lines, in order to be phonetically realized (Fig. 1). We use the term 'tone-bearing unit' (TBU) to describe the smallest phonological element which is capable of hosting its own tone in a particular language: TBUs are typically syllables, vowels, or moras, and less commonly (non-moraic) consonants (e.g. Zhang 2001, Gordon 2006).²

² Tone-bearing units should be distinguished from domains of association. For example, in so-called 'word tone' languages, words may only bear a small set of overall tonal melodies, regardless of the number of TBUs they contain

Importantly, a single tone-bearing unit may host multiple tones in some languages (Fig. 1, left). Similarly, a single tone may be associated with multiple TBUs (Fig. 1, right). These many-to-one and one-to-many associations are a crucial tool for tonal analysis in Autosegmental Phonology. For example, the association of multiple tones with the same host (Fig. 1, left) formally characterizes *contour tones* in Autosegmental Phonology, which are treated as the linking of two or more level tones to a shared position (e.g. the same TBU).³ Similarly, the linking of a single tone to multiple TBUs (Fig. 1, right) can be used to formally represent tonal spreading or assimilation, and is important in the analysis of ‘across-the-board’ effects in tonal phonology, as we discuss below.

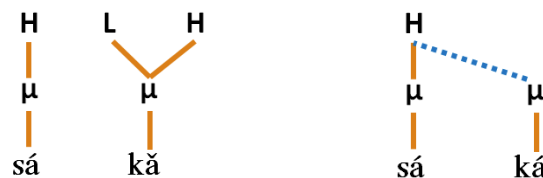


Figure 1. Some basic autosegmental representations for tone. ‘H’ = high tone, ‘L’ = low tone, ‘μ’ = mora. Dotted lines indicate new associations between tones and TBUs. Tonal diacritics on vowels follow standard IPA practice.

Given the formal independence of tones and TBUs in Autosegmental Phonology, so-called ‘floating tones’ may also occur: these are tones which are present in the phonological representation, but which are not linked with any TBU at all (Fig. 2, left). Similarly, not every TBU need be specified for tone: this is shown in the right panel of Fig. 2.



Figure 2. A floating L tone (left, circled) and a tonally-unspecified TBU (right).

(see e.g. McPherson 2022 for recent discussion). This suggests that the domain of tone *contrast* is the word rather than the TBU. However, even in these languages, tones are associated to, and realized on, TBUs of a particular size. See also Cassimjee & Kisseberth (2007), Hyman & Leben (2021).

³ In some languages contour tones behave, phonologically, like coherent units: for example, contours may spread wholesale in processes of assimilation. However, these patterns are typically *also* analyzed with representations in which contours consist of level tones associated to a single host, called the ‘tonal node’, which can itself undergo spreading or other tonal operations (e.g. Yip 2002, pp.47-56, Hyman 2011a,b).

The right panel of Fig. 2 thus illustrates TONAL UNDERSPECIFICATION: some, but not all TBUs are associated with tonal targets. Tonal configurations of this type are the focus of our discussion here.

At the outset, we have two minor notes about tonal underspecification. First, though tonal underspecification appears to be common, it is not a requirement of tone systems. For example, in Chichahuaxtla Triqui, every TBU is arguably specified for tone (Hernández Mendoza 2017, p.37). In some languages, all lexical roots (or lexical words more broadly) have tonal specifications, but function words or morphemes may be toneless. This is the situation observed in some Zapotec varieties (Sicoli 2007, pp.92-94) and in many Chinese languages, in which function words and morphemes appear to be phonologically toneless, possibly because they are systematically unstressed (e.g. Yip 2002, pp.181-5; Duanmu 2007, pp.72, 131, 241-2, etc.).

Second, we use the terms ‘unspecified’ and ‘underspecified’ as essentially synonyms here. At times the term ‘unspecified tone’ is used to refer to the default tone which is inserted on otherwise toneless TBUs, as discussed in the next section.

How are underspecified TBUs phonetically realized?

Phonetically speaking, every voiced segment is produced with vocal fold vibration, and thus with some fundamental frequency (f0) and associated pitch. Something must therefore be said about how underspecified TBUs acquire their values for f0 in the phonetics.

An unspecified TBU may acquire its tonal target in the phonology proper. Typically, this involves the insertion of a default level tone, as in the left panel of Fig. 3 (we discuss examples below). An unspecified TBU may also receive a tonal specification via tonal spreading from an adjacent TBU (Fig. 3, center). This occurs in e.g. Huehuetepec Tlapanec (Mè'phàà) (1) (Uchihara & Tiburcio 2020).

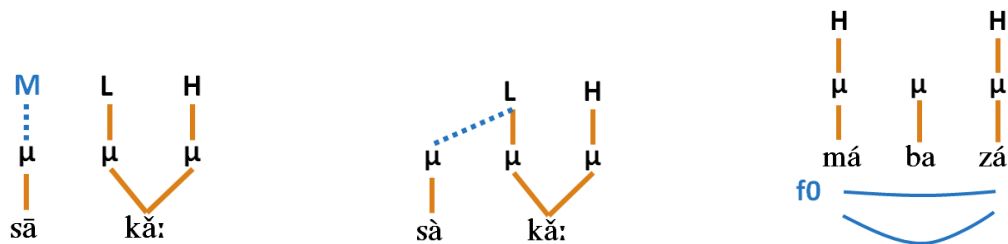


Figure 3. How unspecified TBUs acquire tonal targets: default tone insertion (left), tonal spreading (center), phonetic interpolation (right). ‘M’ = mid tone, f0 = fundamental frequency (\approx pitch).

- (1) Tonal spreading to toneless TBUs in Huehuetepec Tlapanec (Uchihara & Tiburcio 2020)
- a. /nī-tara-tsī/ (CMP-2SG-buy) → [nītārātsī] ‘you bought’ /M ∅ ∅ M/ → /M M M M/
- b. /mà-tara-tsī/ (POT-2SG-buy) → [màtārātsī] ‘you will buy’ /L ∅ ∅ M/ → /L L L M/

Lastly, if tonal underspecification persists past the end of the phonology, into the phonetics, an unspecified TBU may receive its value for f0 via *interpolation* between neighboring specified tones (Fig. 3, right; e.g. Pierrehumbert & Beckman 1988, Myers 1998; for non-tonal, segmental interpolation, see e.g. Keating 1988, Cohn 1990, 1993, Choi 1995, Shaw & Kawahara 2018). As Fig. 3 (right) shows, interpolation can be linear or non-linear. In the case of non-linear interpolation, transitions between specified targets may show a ‘sagging’ contour over an intervening unspecified region, among other possibilities.

Underspecification in Autosegmental Phonology

In the course of constructing a tonal analysis, two practical questions arise with respect to underspecification. First is the ‘unspecified TBU’ problem: how does one identify a TBU lacking a tonal specification on the surface? Second is the ‘default tone’ problem: how does one decide if a particular tone corresponds to the tone which is assigned, by default, to a TBU without tone?

Beginning with the ‘unspecified TBU’ problem, we take it as basically *definitional* of underspecification that if a TBU lacks a tonal specification, *the phonology should in some way behave as if the tone on that TBU were invisible*. We have a similar perspective on the ‘default tone’ problem: if a phonetic tone T_x corresponds to the *absence* of tone in the phonology (because it’s assigned by default to toneless TBUs), then again, *the phonology should systematically behave as if that particular tone T_x were invisible*.

However, an immediate complication arises. Default tones should only behave as ‘invisible’ in the phonology if they are assigned at the end of the phonological derivation (either in the phonology proper, or as part of the phonetic interpretation of the output of phonology). If toneless TBUs receive a default tone earlier in the derivation – for example, at the output of the

stem- or word-level phonology, in the terms of Lexical Phonology (e.g. Bermúdez-Otero 2018) – then there is no guarantee that default tones will actually behave as invisible for later phonological processes (see also Steriade 1995). This is the first instance in which we can see that underspecification is not purely a descriptive tool, but a theoretical concept which can only be applied to the analysis of data in the context of particular theoretical assumptions (e.g. the timing of default tone insertion). From a practical perspective, this observation also underscores the point that diagnostics for underspecification must be applied very carefully, as part of a broad analysis of the overall tone system of a language. We now turn to an evaluation of particular diagnostics for tonal underspecification.

RELIABLE PHONOLOGICAL DIAGNOSTICS FOR TONAL UNDERSPECIFICATION

Contour tones

In Autosegmental Phonology, contour tones amount to transitions between two (or more) level tones specified on a single host. For example, a falling tone can be represented as a high target followed by a low target on the same TBU (Fig. 4.) In this framework, there is no way to represent a contour tone involving an underspecified tone on a single TBU: since underspecified tones are simply the absence of tone, this would be equivalent to a single level tone, rather than a contour (to visualize this, imagine Fig. 4 without T_y attached; see also Hyman 2001; Pulleyblank 2004; Daly & Hyman 2007, p.173). This is true for phonemic (contrastive) contour tones, but also true of surface contour tones derived by the application of phonological rules.

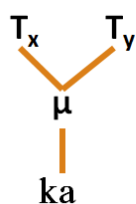


Figure 4. Representation of a contour tone.

An example comes from Peñoles Mixtec, where no monomoraic contours involve the mid tone, which is analyzed by Daly & Hyman (2007) to be underspecified $/\emptyset/$. The only monomoraic contour is $/LH/$. Lalana Chinantec has four level tones $/1, 2, 3, 4/$ in addition to underspecified $/\emptyset/$, which is realized phonetically as a low falling tone [21] on long vowels (contrasting with tone $/1/$, which is realized as a low-mid level [2] tone), and as a low falling tone with final

aspiration [21^h] on short vowels (again contrasting with tone /1/, which is realized as a low level [1] tone). The only contour tones are /12, 14, 21, 23, 31, 41/ (Nakamoto 2022); thus, the underspecified tone cannot form a contour. A similar case is reported for Yoruba (Pulleyblank 2004), which has contours involving L and H tone, but not M.⁴

Contour tones provide a positive test for tonal specification: if some contour includes T_x (on the smallest TBU), then T_x must be specified. But if there are no contours including T_x, that doesn't tell us much – for example, it could be an accidental gap, or reflect an independent prohibition against contours of a particular type. For instance, Tataltepec Chatino has three tone levels, low, high and superhigh. The only underlying contour tone in Tataltepec Chatino is high-low, and surface phonetic contour tones involving the superhigh tone are at best marginal (Sullivant 2015, pp.200-2, 215, etc.).⁵ The lack of contours involving superhigh tone is thus consistent with treating superhigh as underspecified. But as we've seen, this state of affairs is also consistent with treating superhigh as *specified*, if one is willing to assume constraints which ban contours of particular types, or just treat the lack of contours with superhigh tone as an artifact of historical change. In fact, superhigh tone is clearly a specified tone, since it is phonologically active: it (i) blocks the linking of floating tones, (ii) can itself float, and (iii) contrasts with TBUs which actually do appear to be underspecified because of e.g. their invisibility for the displacement and linking of floating superhigh tones (Sullivant 2015, pp.197-216).

In using contour tones to assess tonal specification, it's important to know what the smallest TBU is in the language in question. For example, if the TBU is the mora, then finding contours involving a particular tone on long vowels (with two moras) doesn't tell us much. The representation could look like Fig. 5, with one tonally-specified mora (where T_x is some tone), and one tonally-unspecified mora (eventually realized with a default tone, here an M tone). This occurs in Peñoles Mixtec, where the TBU is the mora, and M tone is argued to be underspecified (Daly & Hyman 2007). In this language, 'false' contours with phonetic M tone, resembling Fig.

⁴ A possible counterexample is found in Chiquihuitlán Mazatec, where an underspecified tone (represented with the symbol '1' in the original source) can form a contour tone /13/ (Nakamoto 2022), such as [tʃũ^{h13(4)}] 'woman'. Tone /1/ in Chiquihuitlán Mazatec otherwise shows the behavior of an underspecified tone, as we will see in the next subsection.

⁵ We say that contour tones involving the superhigh tone are 'marginal' in Tataltepec Chatino because they occur in some monomoraic forms – often loans from Spanish or Coastal Mixtec – but only in certain contexts. Further, most, if not all of these forms are historically polysyllabic, and in some cases could even be analyzed as synchronically polysyllabic (Sullivant 2015, pp.64, 104, 199, 200-5, etc.).

5, are found in bimoraic, monosyllabic forms such as [kǎá] ‘hatchet’, [ʒóʔǒ] ‘root’ (see also Campbell 2016, p.146 for Zenzontepec Chatino).

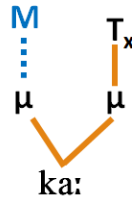


Figure 5. ‘False’ contour tone with an underspecified TBU = μ realized with default M tone.

Finally, this diagnostic also depends on the assumption that contour tones consist of simple (level) tones. If contour tones are analyzed to be unitary, as in Fig. 6, then we cannot apply this diagnostic. See Hyman (2001) for similar observations.

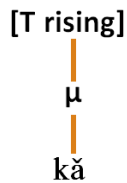


Figure 6. Non-atomic contour.

Invisibility for dissimilation and other tonal processes

Sometimes, certain tones seem to be ‘invisible’ for tonal dissimilation. It is common in tonal languages for tonal dissimilation to apply between adjacent tones $[T_x]+[T_x]$ of the same type (e.g. /HH/ \rightarrow [HL]). In some languages, dissimilation applies even when certain tones intervene between the dissimilating tones (Fig. 7). In such cases, it is reasonable to analyze the ‘invisible’ intervening tones as corresponding to phonologically underspecified TBUs, realized with a default tone on the surface.

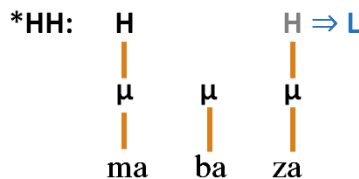


Figure 7. Toneless TBUs and invisibility for dissimilation.

For instance, Peñoles Mixtec has a dissimilation rule /LL/ → [LM] (= /L∅/), where the second /L/ is deleted when two L tones occur next to each other (Daly & Hyman 2007). This process is applied even when a surface mid tone intervenes; that is to say, the mid tone is invisible, i.e. underspecified (Fig. 8). Here, the low tone on [ndè] and the low tone on [tʃì] are separated by a surface mid tone on [kū], but the dissimilation rule still applies, and the L tone on [tʃì] is deleted, eventually surfacing as a phonetic mid tone.

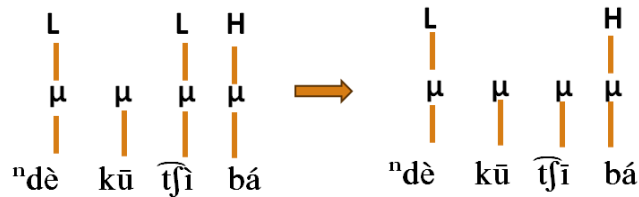


Figure 8. Peñoles Mixtec dissimilation: ‘there are goats’.

Further, Daly & Hyman show that L dissimilation can apply across multiple M tones, e.g. /ⁿdùkū ʒɪ̃-fì k^wǎʒú/ → [ⁿdùkū ʒɪ̃-fì k^wǎʒú] ‘her husband is looking for a horse’.

We can compare the behavior of mid tone in this context with that of high tone, which blocks the dissimilation rule applying to low tones (Fig. 9). Here, the low tone on [tʃì] is not deleted, since it is separated from the preceding L tone by the high tone on [dí]. This is because the high tone, unlike the mid tone, is phonologically specified, and thus visible for dissimilation.

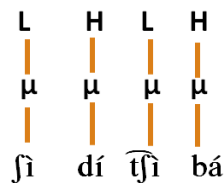


Figure 9. Peñoles Mixtec blocking of dissimilation by H: ‘goats are sleeping’.

A similar case of invisibility, involving tonal displacement rather than dissimilation, is found in Chiquihuitlán Mazatec (Nakamoto 2022). Here, an underlying tone 4 introduced in the middle of an intonational phrase is phonetically realized on the final TBU of that phrase (Fig. 10), skipping over any intervening underspecified TBUs (and ignoring some pronominal enclitics, such as [=naʔa] here). (In Chiquihuitlán Mazatec underspecified TBUs are phonetically realized, by default, with the lowest tone level [1].)

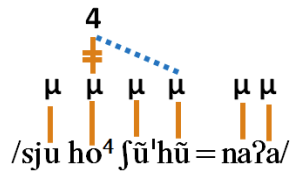


Figure 10. Displacement of 4 tone through an unspecified TBU with default 1 tone in Chiquihuitlán Mazatec: ‘my two papers are lying’. Double horizontal lines indicate removal of a tonal association.

A potential complication: invisibility for tonal spreading

A potential complication concerning tonal underspecification is that we know of no tonal pattern where an underspecified tone is totally invisible for tonal spreading. Tone spreading processes like /L H/ → [L LH], where the low tone spreads to a following TBU with a lexical high tone to form a LH contour, are quite common (Hyman & Schuh 1974, Hyman 2011a,b). But we know of no rules like /L ∅ H/ → [L ∅ LH] (Fig. 11), where the same spreading rule applies across an underspecified TBU (phonetically realized as e.g. surface [L M LH], with a default M tone).

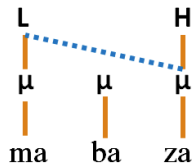


Figure 11. True invisibility for spreading.

Configurations like Fig. 11 are normally ruled out by locality constraints on spreading, which prevent the skipping of TBUs in tone spreading processes (e.g. the NOGAP constraint of Yip 2002, pp.84; see also Hyman 2014). Such constraints may be responsible for independently ruling out configurations like Fig. 11, thus accounting for the absence of such processes.

On the other hand, tonal invisibility for non-spreading tonal processes, including dissimilation and tonal displacement, does occur in various languages, as we have seen. Other potential cases of tonal invisibility in tone displacement include San Miguel el Grande Mixtec (Goldsmith 1990, pp.20-27; Tranel 1995, 1996, Yip 2002, pp.221-222), some Bantu languages (e.g. Giryama, Hyman 2011a,b and references there), and Lalana Chinantec (Shun Nakamoto, p.c.), which has a displacement process similar to the Chiquihuitlán Mazatec pattern discussed above.

Multiple linking

Some tone processes suggest that certain tones are linked to multiple TBUs, as in Fig. 12. Evidence for multiple linking comes from languages like Shona (Odden 2005), which has a high tone dissimilation rule where the second H in a sequence of two H tones dissimilates to L tone, as in /né-mbwá/ → [né-mbwà] ‘with dog’. When this dissimilation rule is applied to bimoraic forms with high tones on both moras such as /hóvé/ ‘fish’, then the high tones on both moras dissimilate to a low tone: /né-hóvé/ → [né-hòvè] ‘with fish’ (Fig. 11). This can be explained by assuming that the two moras are linked to one shared high tone, as in Fig. 12, and thus must dissimilate together as a unit. Assuming independent H tones on each mora would fail to explain why [hóvé] is acceptable on its own, given that sequences of H tones otherwise undergo dissimilation; it would also fail to explain why /né-hóvé/ dissimilates to [né-hòvè] (with H-LL tone) rather than *[né-hòvé] (with H-LH tone), which would also satisfy the constraint against adjacent H tones.

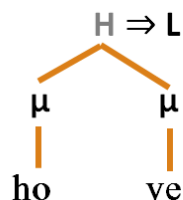


Figure 12. Multiple linking and dissimilation in Shona.

Similarly, Acatlán Mixtec (Aranovich 1994; Snider 1999, Ch. 6) has an upstepping rule, where a high tone is raised further after another high tone: $H \rightarrow \uparrow H / H_$. When this rule applies to a sequence of high tones, such in [díʔí] ‘mother’, both high tones raise to superhigh, as in [ʔíkú mí=ndá [↑]díʔí] ‘we have a mother’.⁶

A tone that corresponds to the lack of tone (i.e. an underspecified tone) cannot be linked to multiple TBUs. As such, when a tone manifests behavior like the H tone in Shona or Acatlán Mixtec, that tone cannot be underspecified. But like the inventory of contour tones, multiple linking cannot be used to confirm *underspecification*, only to show that a particular tone must be specified. This is true of most of the diagnostics discussed in this paper. The only direct, positive tests for underspecification we are aware of concern invisibility for tone rules like dissimilation

⁶ [díʔí] ‘mother’ is likely monosyllabic in Acatlán Mixtec, but since the TBU is the *mora*, as is typical in Mixtecan languages, our point about multiple linking still goes through (e.g. [tóʔò] ‘stranger’).

or displacement, and patterns of phonetic interpolation for pitch on toneless TBUs, discussed in the next section.

INTERPOLATION: A RELIABLE PHONETIC DIAGNOSTIC FOR TONAL UNDERSPECIFICATION

While our focus here is on the phonology of underspecification, evidence for underspecification in the *phonetics* has also provided compelling support for underspecification as a concept. The *locus classicus* for tonal underspecification is Pierrehumbert & Beckman (1988), which builds on their earlier work on the phonetics and phonology of intonation (e.g. Pierrehumbert 1980, Liberman & Pierrehumbert 1984, Beckman & Pierrehumbert 1986). We illustrate one of their key proposals with a simplified discussion of the analysis of Japanese intonation in Pierrehumbert & Beckman (1988, Ch.2).

The standard variety of Japanese, based on the Tokyo dialect, has a lexical contrast between words bearing a H*L (falling) pitch accent, and those lacking such an accent (e.g. Kubozono 2008 and many others). The position of accent is also contrastive, particularly in nouns (e.g. Kawahara 2015). The tonal specification of *unaccented* words has been the topic of some debate: phonetically, they seem to be realized with raised pitch, at least when following a High intonational tone. This has led some analyses to propose a rule of high-tone spreading from intonational H tones across a span of unaccented moras: $^H[\mu \mu \mu \mu \dots] \rightarrow ^H[\acute{\mu} \acute{\mu} \acute{\mu} \acute{\mu} \dots]$ (see e.g. Kawahara 2015 for a broad overview, and cf. Haraguchi 1999).

Pierrehumbert & Beckman (1988, pp.26-51) argue that unaccented moras do not show the phonetic profile of moras specified for a high tone. They demonstrate this by investigating the pitch profile of unaccented moras occurring between an intonational H tone and a following intonational L tone. In this context, f_0 on unaccented moras appears to be (i) predictable, but (ii) different from what would be expected for a specified H tone. Rather than being realized with a continuous H tone plateau (either flat or gradually declining), pitch on unaccented moras in this environment seems to be determined by a linear interpolation between the intonational H and L tones (Fig. 13): in a string of unaccented moras, the farther the unaccented mora is from the H tone, the lower (closer to L) its pitch is. In longer strings of unaccented moras, pitch declines more gradually than in short strings of unaccented moras, where it declines more quickly.

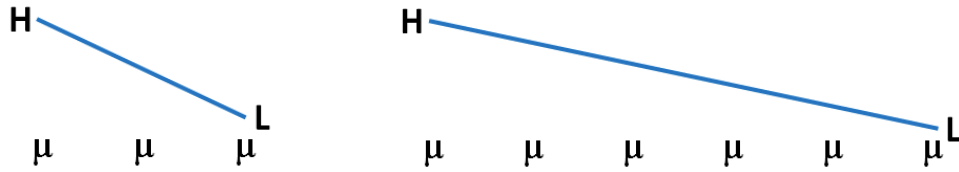


Figure 13. Schematic representation of pitch interpolation over toneless moras in Japanese (after Pierrehumbert & Beckman 1988).

Pierrehumbert and Beckman argue that the gradually lowering pitch in e.g. the righthand panel of Fig. 13 cannot be analyzed as phonetic pitch declination over a sequence of phonologically high-toned moras (e.g. Ladd 1984). Essentially, the pitch change in *short* spans of toneless moras (Fig. 13, left panel) is too large, and too quick, to be the consequence of gradual declination. Pierrehumbert and Beckman thus conclude that unaccented moras are toneless – underspecified for tone – and receive their phonetic value for f0 from their environment, according to regular and predictable phonetic principles which determine the transition between specified intonational H and L tones. This confirms the hypothesis that TBUs can remain unspecified, lacking their own tonal targets, past the end of the phonology proper, and into the phonetic implementation stage. Myers (1998) provides another excellent demonstration of this idea on the basis of phonetic data from Chichewa, arguing that TBUs previously analyzed as bearing L tone are in fact toneless, and receive pitch values from their context. (Myers’ analysis also provides an example of *non-linear* interpolation for pitch.)

Phonetic evidence for underspecification is compelling because f0 is directly measurable. Carefully-designed experiments can therefore be used to test and evaluate specific hypotheses about tonal specification. The downside, of course, is that this requires significant expertise in experimental design, data processing, and statistical analysis. Furthermore, phonetic data must still be carefully interpreted, as we discuss in more detail in a later section.

It’s important to note that languages with underspecified TBUs may nonetheless provide those TBUs with specific pitch targets prior to the surface phonetics. This is schematized in the first 2 panels of Fig. 3 above. An example comes from Serbo-Croatian (e.g. Zec & Zsiga 2010, Zsiga & Zec 2013). In Serbo-Croatian, words may have a specified H tone (e.g. /paradá/ ‘parade’), or may be toneless (e.g. /devera/ ‘brother-in-law’ (GEN.SG)) ; however, toneless words receive an H tone on their stressed syllable at the post-lexical (\approx phrasal) level of the phonology (e.g. [‘dé.ve.ra] vs. [pa.‘ra.dá]). By the time ‘toneless’ words are phonetically realized, they have

already received a specific H tone pitch target by default. Similarly, in Tokyo Japanese, lexically unaccented words may host phrase-level tone patterns, such as an initial LH rise (e.g. Ito & Mester 2013); here too, words lacking tonal specification at the word level nonetheless receive a certain amount of tonal specification in the post-lexical phonology.

LESS STRAIGHTFORWARD DIAGNOSTICS FOR TONAL UNDERSPECIFICATION

Allotonic rules

Tonal languages often have phonological rules which change the tonal specification of TBUs in particular contexts. These ‘allotonic’ rules can, in principle, be used to diagnose tonal specification (see e.g. Myers 1998). For example, in Zenzontepec Chatino, the enclitic /=ū?/ 3PL, which has an underlying mid tone, is realized with high tone after a host that has a mid tone M on its final mora, as in /nka-jnyā=ū?/ → [nka-jnyā=ú?] ‘they made (something)’ (Campbell 2016). This is clearly a rule of dissimilation, and it strongly implies that the mid tone M must be phonologically specified in Zenzontepec Chatino: since the M tone is phonologically active, it cannot simply be the phonetic realization of a toneless TBU.⁷ A similar case comes from downstepping in Teotitlán del Valle Zapotec, where in a sequence of two TBUs with high tone, the second high tone is downstepped, being realized with slightly lower pitch: /ʃsabá:d xwá:jn/ → [ʃsa'bá:d ↓xwá:jn] ‘Juan’s shoes’. Additionally, the enclitic /=ēn/ FOC, spreads its underlying M tone to the final mora of its host, if that host ends in a low tone, e.g. /gīts=ēn/ → [gīts=ēn] ‘paper.FOC’ (Uchihara & Gutiérrez 2019). This indicates that both H tone and M tone are specified in Teotitlán del Valle Zapotec.

As with many of the diagnostics discussed in this article, this test can be used to argue that a particular tone must be specified, but it cannot be used to confirm *underspecification*. Consider a hypothetical language with surface H and L tones, but no tonal rules referring to L. It could be that L is underspecified (e.g. Myers 1998, Anttila & Bodomo 2022). Alternatively, the language could have a *specified* L tone, but simply lack any rules referring to it. There is no logical requirement that a language have tone rules referring to each of its specified tones. It could also be that there *are* such rules, but as analysts we have not yet discovered them.

The basic premise of this diagnostic is that the phonological grammar can only refer to specified tones, and cannot refer to the *absence* of tone. Once again, this underscores the fact that

⁷ Assuming, that is, that default tones are inserted relatively late in the derivation; see our earlier discussion above.

diagnostics for underspecification are contingent on the broader theoretical assumptions we adopt. In this case, one could argue to the contrary that the phonological grammar *must* refer to toneless TBUs. For example, many languages do not allow toneless TBUs: in Optimality Theory, this implies that a constraint like *TONELESS-TBU is high-ranked (e.g. Yip 2002, p.83, McPherson 2011, Anttila & Bodomo 2022, etc.). The constraint *TONELESS-TBU clearly refers to the absence of tone. In rule-based frameworks, rules of default tone insertion must also refer to toneless TBUs, e.g. $\emptyset \rightarrow L$ (this is also true for autosegmental rules of this type, e.g. Odden 2005, p.302). But once our theory allows reference to toneless TBUs, it becomes possible to formulate phonological rules like $/H/ \rightarrow \emptyset / _ \emptyset$, which mimics an assimilation rule by ‘spreading’ tonelessness. Similarly, a rule like $\emptyset \rightarrow [H] / _ \emptyset$ can be formulated which mimics dissimilation by eliminating sequences of toneless TBUs.⁸ In this theoretical context, the inventory of phonological rules no longer serves as a valid diagnostic for tonal specification vs. underspecification.

Without doubt, the inventory of tonal rules in a given language can be *suggestive* as to tonal specification. In that sense, examining a language’s tone rules can be a very useful exercise when reasoning about underspecification. However, this diagnostic is crucially dependent on particular theoretical assumptions about the grammar, which need to be carefully scrutinized. For that reason, the inventory of tonal rules in a given language seems somewhat less reliable to us for identifying tonal underspecification than other diagnostics discussed above.

Floating tones

In Autosegmental Phonology, the independence of tones from segments and TBUs has an interesting consequence: tones may be present in the phonological representation without being hosted by a TBU at all (Fig. 14). Such ‘floating’ tones may be present in either underlying or surface representations, depending on the language.

⁸ Sullivant (2015, pp.214-6) identifies a potential case of dissimilation between toneless TBUs in Tataltepec Chatino, $/\emptyset \emptyset/ \rightarrow [\emptyset HL]$. Evidence for the tonelessness of the TBUs involved comes from their transparency to a process of superhigh tone displacement, and their susceptibility to overwriting by L-tone spreading (*ibid.*, pp.206-16). Sullivant notes that this dissimilation process is lexically restricted, and may be amenable to a different type of analysis, pending more investigation.

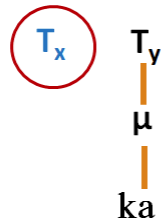


Figure 14. Schematic example of a floating tone (circled).

The motivation for positing floating tones comes from several empirical phenomena. We focus first on the use of floating tones as a tool for analyzing *morpheme-specific tonal effects*.⁹ For example, in Yucuquimi de Ocampo Mixtec (León Vázquez 2017, p.107), [θỳkỳ] ‘niece’ and [θỳkỳ] ‘neck’ are homophonous in isolation, but ‘niece’ has an idiosyncratic tonal effect on the following noun: the first mora of the following noun has to be realized with high tone (see also Pike 1948, Goldsmith 1990, and below for related discussion of San Miguel el Grande Mixtec).

(2) Idiosyncratic tonal phonology in Yucuquimi de Ocampo Mixtec

- a. [θỳkỳ b_á?ā] ‘good neck’ (with underlying tone on [b_á?ā] ‘good’)
- b. [θỳkỳ b_á?ā] ‘good niece’

A standard analysis of this pattern is to assume that the underlying representation of the word ‘niece’ includes a floating high tone, /θỳkỳ, H/, which is not associated to any TBU or segment. This high tone then docks to the first mora of the following word, overwriting its original tone, e.g. /θỳkỳ, H # b_á?ā/ → [θỳkỳ b_á?ā]. This use of floating tones thus attributes exceptional tonal behavior to the *representations* of individual morphemes: the noun [θỳkỳ] ‘niece’ idiosyncratically affects the tone of the following word because it is underlyingly represented with an extra, unassociated tone that other morphemes lack.

Floating tones can be used as a diagnostic for tonal specification. Floating tones are phonological objects, which the grammar can manipulate in various ways. Almost by definition,

⁹ The standard understanding of floating tones as tones which are not linked to a particular TBU (e.g. Goldsmith 1990, p.20) allows for the possibility of floating tones which are phonologically general, rather than morpheme-specific. For example, in Teotitlán del Valle Zapotec, the mid tone is *always* associated with a floating high tone (Uchihara & Gutiérrez 2019). However, we are not sure that such cases should be analyzed by means of underlying floating tones, rather than tonal rules, constraints, or other grammatical mechanisms which force surface mid tones to be followed by a high tone.

then, a tone which is floating as in Fig. 14 must be a specified tone which is present in the phonology proper.

The primary complication with this diagnostic is a theoretical one. Floating tones can be useful for analyzing morpheme-specific tonal effects like (2). However, there are other theoretical and analytical tools for analyzing morpheme-specific phonological behavior. In Optimality Theory, morpheme-specific behavior has sometimes been analyzed by assuming that different morphemes may belong to different phonological sub-systems, which have different phonological requirements (see e.g. Kenstowicz & Kisseberth 1979, Ch. 10 for earlier rule-based precedents). This can be accomplished using constraints which are indexed to particular morphemes (e.g. Pater 2010), or constraint rankings which are associated with particular morphemes or morphological contexts (e.g. Anttila 2002, Sande 2022, and references there). To illustrate, we reproduce here a simplified version of Inkelas & Zoll's (2007) analysis of morphologically-conditioned tone in Hausa (Newman 2000). In Hausa, imperative constructions replace the tone of the verb stem with an LH melody aligned to the right edge, e.g. [káràntá:] 'read' (H L H) → [kàràntá:] 'read!' (L L H). This pattern of tonal overwriting could be analyzed with floating tones, treating the underlying form of the imperative morpheme as simply /LH/, without any segmental content at all (see also the next section on grammatical tone). This /LH/ would then dock to the right edge of the word, spreading L leftward (Newman 2007, pp.678-9). In Mesoamerica, similar cases have been reported for Temalacayuca Popoloca where the tonal melody /L/ is assigned in augmentative forms (Nakamoto in press); Ayautla Mazatec where animal names have tonal melodies /3.3/ or /4.2.4/ (Nakamoto 2020: §4.2.3), and in Malinaltepec Tlapanec where the tonal template L.H.H.H is assigned to diminutives (Carrasco 2006, p.129).

However, Inkelas & Zoll (2007) adopt a different analysis for Hausa: they propose that imperative constructions are associated with a high-ranked constraint $TONE = LH$, which imposes an LH tonal melody on imperative verbs. It is this constraint – and *not* an underlying floating tone – which is responsible for tonal overwriting in the imperative. This analysis extends to suffixes which also overwrite the tone of their bases, e.g. [d̄zà:kí:] 'donkey' (L H) → [d̄zà:k-únà:] 'donkeys' (H - H L) (Newman 2007, p.679): these can be analyzed using constraints like $TONE = HL$ which are high-ranked in the context of specific morphological constructions, e.g. plurals of a particular noun class (Newman 2007, p.680). In contrast with the use of floating tones, this

analysis assumes that exceptionality is a property of the *grammar* associated with particular morphemes (or morphological constructions), and not just their underlying representations.

We can apply the same basic logic to the analysis of [θỳkỳ] ‘niece’ in Yucuquimi de Ocampo Mixtec. Schematically, if the construction [θỳkỳ] ‘niece’ + ADJECTIVE is associated with a constraint like FIRST-σ = H (or FIRST-μ = H), then we expect that [θỳkỳ] ‘niece’ will trigger a high tone on the following word, as in (2).

To be clear, we are not advocating for a grammar-centric view of morpheme-specific tonal behavior. We simply intend to illustrate the fact that morpheme-specific tonology can be analyzed in various ways, which somewhat limits the use of morpheme-specific tonal patterns as diagnostics for floating tones, and thus for tonal specification.

That said, floating tones have also been used to analyze other phonological patterns which seem harder to re-analyze in terms of morpheme- or construction-specific grammars. For example, in Efik, the first vowel in hiatus deletes (Clements 1979, Yip 2002, p.149), /àkám**á** **ù**bóm/ (L H H # L H) → /àkám **ù**bóm/ (L H # H H[↓]) ‘large canoe’. As the transcription indicates, the second high tone on [ùbóm] is downstepped, being realized lower than otherwise expected for a high tone in this context. Clements (1979) analyzes this by assuming that the H tone on the deleted final vowel of /àkám**á**/ associates to the initial vowel of /**ù**bóm/. As a consequence, the surface tonal pattern of [ùbóm] is actually H[↓]H, where superscript [↓] indicates a ‘hidden’ floating tone sandwiched between the high tones realized on the two vowels. This floating tone then triggers downstep of the second high tone in a phonologically predictable way. As far as we know these alternations are phonologically general, and so it seems inappropriate to analyze them using morpheme- or construction-specific phonological grammars.

Morpheme-specific grammars are also quite powerful, and can produce many more types of morpheme-specific phonological patterns than floating tones can. Whether that is a virtue or a vice of such theories remains to be determined (see also Zimmermann to appear).

Grammatical tones

As seen in the preceding section, certain morphological constructions often involve predictable tonal changes. For example, in San Martín Peras Mixtec, verb inflection may be expressed exclusively by tonal changes in certain contexts (3) (Eischens 2022).

(3) Grammatical tone in San Martín Peras Mixtec

- a. [ndá^{ht}ĩ sãà] ‘the bird flies’ (**H** H # M L)
- b. [ndá^{ht}ĩ sãà] ‘the bird flew’ (**L** H # M L)
- c. [ndá^{ht}ĩ sãà] ‘the bird doesn’t fly’ (**LH** H # M L)

We take the term ‘grammatical tone’ to refer to any pattern in which particular tone changes or tone patterns are associated with a specific morphological category or construction, as part of word-building processes (e.g. Rolle 2018, p.2). We use the term ‘grammatical tones’ to refer to those tones which are introduced by morphologically-conditioned tonal processes of this type, as illustrated by the grammatical H, L, and LH tones in (3).

Grammatical tones as floating tones

It is sometimes assumed that grammatical tones, like the aspectual and negative tones in (3), must be phonologically-specified tones. The logic is essentially the same as outlined for floating tones above, because grammatical tones are commonly analyzed as the result of floating tones associated with derivational or inflectional morphemes (see e.g. Rolle 2018). For that reason, the caveats we express above for floating tones often apply equally to the use of grammatical tone as a diagnostic for tonal specification.

Grammatical tones as tonal processes or paradigms¹⁰

There are also cases of grammatical tone which are difficult, if not impossible to analyze using floating tones. Chain shifts involving tone provide one example. In Guébie, imperfective aspect is marked by lowering the tone of the verb stem along a scale, so that e.g. high 4 tones lower to 3, 3 tones lower to 2, and 2 tones lower to 1 (simplifying somewhat; see Sande 2022 for details). This cannot be straightforwardly analyzed by means of a floating tone, since there isn’t any phonetic consistency in the surface tones associated with imperfective aspect. Similarly in Ozumacín Chinantec the tones /2, 3, 4, 5, 24, 35, 31, 41, 51/ are lowered by one level to /1, 2, 3, 4, 13, 24, 21, 31, 41/, respectively, in certain constructions: following the polar question proclitic [chi³=] or the counterfactual proclitic [jwa³=]; following a fronted constituent; in a subordinate clause; etc. (Nakamoto 2023).

¹⁰ This concept roughly corresponds to what Palancar & Leonard (2016) call ‘inflectional tone’ and Woodbury (2019) calls ‘tone ablaut’.

A similar point can be made with paradigmatically-organized grammatical tone systems. Kim (2016) argues that verbs in San Pedro Amuzgos Amuzgo must be organized into dedicated inflectional classes, in part because there are no consistent tonal exponents of inflectional categories (see also Palancar 2021). Kim suggests that 3SG verb forms correspond to the underlying lexical tone of the verb stem. However, the lexical tone of the stem does not predict its inflectional patterning. Stems with underlying /12/ tone may be marked with either /53/ tone or /12/ tone in 1SG forms, and either /31/ or /12/ tone in 2SG forms, depending on the verb in question. In contrast, stems with underlying /53/ tone may only be marked with /53/ in 1SG forms, and either /31/ or /53/ tone in 2SG forms. This is only a partial overview of inflectional patterns in Amuzgo verbs, and Kim shows that similar variation occurs for other lexical tones, and for other aspects of verbal morphology.

In sum, the choice of inflectional pattern for any given verb stem in San Pedro Amuzgos Amuzgo appears to be largely arbitrary. We see here an utter lack of any predictability between underlying tones, inflectional categories, and corresponding surface tones. It would be dubious to use floating tones to analyze these patterns, given that there is essentially no phonetic consistency in the tonal expression of person-number categories. Similar cases of grammatical tone that are not amenable to a floating tone analysis include exponents of the agent person categories in Mazatec (K. Pike 1948, Nakamoto 2020, Ch. 8), Popoloca (Nakamoto 2016), Chinantec (Merrifield 1968; Baerman and Palancar 2015; Castellanos Cruz 2021), Otomí (Palancar 2004, Hernández-Green 2021) and Teotitlán del Valle Zapotec (Uchihara & Gutiérrez 2020).

A related complication is that there appear to be ‘grammatical tones’ which are expressed by the *deletion* of tone. For example, in Tokyo Japanese, the genitive marker /=*no*/ deletes H*L accent from any (polysyllabic) host which has an accent on its final mora, e.g. /atama^{H*L}=*no*/ → [atama=*no*] ‘head=*GEN*’ (e.g. Kawahara 2015). The result of deletion is an unaccented word, which as argued above, corresponds to a word consisting exclusively of tonally-underspecified moras at the word level (at least in the analysis of Pierrehumbert & Beckman 1988). In this case ‘grammatical tone’ – in the broad sense of tonal changes associated with particular derivational or inflectional categories – is a bad diagnostic for tonal specification.

Zenzontepec Chatino (Campbell 2016, 2019) provides an example of tonal inflection involving both (i) paradigmatic organization, and (ii) the apparent deletion of tone in certain grammatical categories. Similar to Amuzgo, verbs in Zenzontepec Chatino are organized into

different inflectional classes for aspect marking, with tonal alternations across aspect categories that are at best semi-predictable. Campbell (2016) argues that the L tone corresponds to the absence of tone in Zenzontepec Chatino. Verbs which have HM tone in the completive aspect are realized with either HM or $\emptyset\emptyset$ (phonetic [LL]) tone in the potential aspect (Campbell 2016, p.158). If tone in the completive aspect corresponds to the underlying lexical tone, as Campbell (2019, p.54) argues, then potential marking for /HM/ verbs sometimes involves tonal deletion, /HM/ \Rightarrow / $\emptyset\emptyset$ / (phonetic [LL]). Again, this suggests that grammatical tone is a poor diagnostic for tonal specification, especially when morphological tones are organized into complex paradigms.

For theoretical frameworks which treat grammatical tone as the outcome of rules or constraints applying in particular morphological contexts – and not as the expression of morphologically-assigned floating tones – see e.g. Anderson (1992), Sande (2022) and references there.

UNDERSPECIFICATION VS. FAITHFULNESS AND MARKEDNESS SCALES

When a particular tone is uniquely susceptible to tone spreading or overwriting in a given language, that tone may be underspecified. The logic is that tone should be easier to change on an underspecified TBU (Fig. 15, left) than a TBU which already has a specified tone (Fig. 15, right). In Optimality Theoretic terms, changing tone on an underspecified TBU should incur fewer violations of faithfulness constraints.



Figure 15. Targets for spreading, with and without underspecification.

However, the selective overwriting of certain tones does not *require* underspecification. It can also be achieved by assuming that certain tones are relatively marked – that is, phonologically dispreferred – and therefore can be eliminated from surface forms more easily (e.g. Pulleyblank 2004). More or less equivalently, it could instead be assumed that certain tones are more protected than other tones, and thus more resistant to change. We demonstrate this in the

following section, then show that the same logic applies to certain other putative diagnostics for underspecification as well.

Susceptibility to tone spreading

We begin with data from Zacatepec Chatino, where low tone L is uniquely susceptible to high tone spreading (Villard 2015, §4.5.1). Example (4) shows a sentence where all words are unspecified for tone – realized phonetically with L tone on the surface – following Villard’s (2015) analysis. Underlining in (4)-(6) indicates a string of TBUs which are underlyingly toneless according to Villard, and thus potentially affected by high tone spread when preceded by an underlying H tone.

(4) Tonally unspecified string (phonetically L) in Zacatepec Chatino

[kwiton nkayako tsaka likya kula ndyikaa tsaan]

bee ate one sugarcane old every day

‘The bee ate an old sugarcane every day.’

When the first word of (4) is replaced by [kwīná] ‘snake’, with a M.H melody, the high tone on the second mora spreads to all subsequent words (5).

(5) H tone spreading across unspecified string in Zacatepec Chatino

[kwīná nkáyákó tsáká líkyá kúlá ndyíkáá tsáán]

snake ate one sugarcane old every day

‘The snake ate an old sugarcane every day.’

Unlike the L tone (5), mid tone M blocks spreading of high. In (6), high tone spreading is applied up to [lyūwā] ‘annona’, which blocks further spreading because of the M tone on the initial mora.

(6) Blocking of H tone spreading by specified M tone in Zacatepec Chatino

[kwīná nkáyákó tsáká lyūwā kula ndyikaa tsaan]

snake ate one annona old every day

‘The snake ate an old annona every day.’

This asymmetry in spreading may suggest that low tone is underspecified, while mid tone is specified. Underspecification has been employed to account for similar patterns in various Otomanguean languages, such as Tataltepec and Zenzontepec Chatino (Sullivant 2015, p.206, Campbell 2016), Chalcatongo Mixtec (Buckley 1991, Swanton & Mendoza Ruiz 2022), Acatlán Mixtec (Méndez Hord 2017, §3.9), Villa Alta Zapotec (Pike 1948), Chiquihuitlán Mazatec (Nakamoto 2018, 2022) and Huehuetepéc Tlapanec (Uchihara & Tiburcio 2020).

However, the susceptibility of L tone in Zacatepec Chatino to tonal spreading and overwriting is also compatible with the effects of the faithfulness scale $\{IDENT[H], IDENT[M]\} \gg IDENT[L]$ (Pulleyblank 2004). In Optimality Theory (Prince & Smolensky 1993/2004), *IDENT* constraints prohibit changing tonal specifications on TBUs (e.g. Yip 2002, pp.79-81). The faithfulness scale $\{IDENT[H], IDENT[M]\} \gg IDENT[L]$ therefore asserts that changing tone on a TBU with L tone is less costly than changing tone on a TBU hosting H or M tone. This is illustrated in the following schematic tableaux (Fig. 16), where the constraint *SPREAD!* is a placeholder for whatever constraint drives rightward tonal spreading.

/HLLL/	IDENT[H]	IDENT[M]	SPREAD!	IDENT[L]
[HLLL]			*!	
\Rightarrow [HHHH]				***
[HHLL]			*!	*

/HMMM/	IDENT[H]	IDENT[M]	SPREAD!	IDENT[L]
[HHHH]		***!		
\Rightarrow [HMMM]			*	

/LHHH/	IDENT[H]	IDENT[M]	SPREAD!	IDENT[L]
[LLLL]	***!			

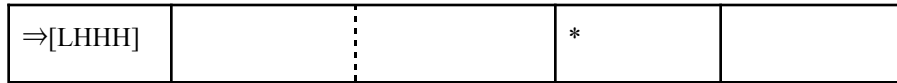


Figure 16. Tone spreading asymmetries as a faithfulness scale.

Importantly, the faithfulness scale $\{\text{IDENT}[\text{H}], \text{IDENT}[\text{M}]\} \gg \text{IDENT}[\text{L}]$ (i) allows for spreading to L-toned TBUs, but not other TBUs (Fig. 16, top two panels); (ii) produces spreading of H tone, but not L tone or M tone (Fig. 16, bottom panel); and (iii) does so without assuming any kind of tonal underspecification. In this analysis, L could be susceptible to tonal overwriting, while still being present and active for other phonological processes (e.g. dissimilation or contour tone formation). For instance in Huehuetepec Tlapanec, L can be overwritten by both M and H tones, but it can form a contour (LH and ML are attested; Tiburcio Cano 2017, p.60) and can float (for examples see below), and so is likely a specified tone. Hence, susceptibility to tonal overwriting cannot be used as a foolproof diagnostic for tonal underspecification.

The same effect can, in principle, be produced with the markedness scale $*[\text{L}] \gg \{*[\text{H}], *[\text{M}]\}$. This scale asserts that L tone is more marked – more dispreferred – than H or M tone. This scale can be also be used to produce selective overwriting of TBUs with L tone, under a schematic ranking like $*[\text{L}] \gg \text{DON'T SPREAD} \gg \{*[\text{H}], *[\text{M}]\}$; for reasons of space we omit a full explanation of this style of analysis here, as it makes essentially the same point as the faithfulness scale shown above.

Susceptibility to floating tone docking

In some languages, floating tones may selectively dock to TBUs bearing a particular tone. As with tonal overwriting, one might be tempted to assume that this is a diagnostic for tonal underspecification. The logic is that it should be easier for a floating tone to dock to a TBU without tone than to a TBU which already has a tone of its own (Fig. 17).

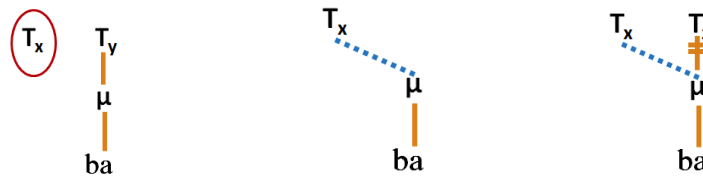


Figure 17. Anchoring of floating tones.

In Huehuetepc Tlapanec (Uchihara & Tiburcio 2020), for instance, a floating low tone associated with the 3PL agentive prefix /ni-, L/ docks to a toneless syllable in the stem, if there is one (Fig. 18, left), while it docks to the prefix itself when both syllables of the stem are tonally specified (Fig. 18, right) (underspecified TBUs are otherwise realized with a default M tone). A similar analysis has been proposed for Chiquihuitlán Mazatec (Nakamoto 2018, 2022), Temalacayuca Popoloca (Nakamoto 2016: §3.2.3, §3.3), Huehuetepc Tlapanec (Uchihara & Tiburcio Cano 2020), San Lucas Quiavini Zapotec (Uchihara 2016), and proto-Zapotec (Beam de Azcona 2023).

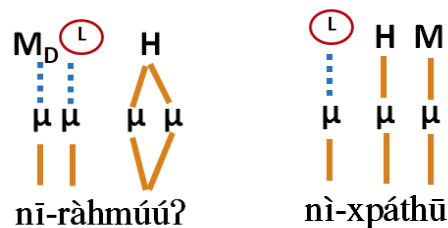


Figure 18. Floating tone docking in Huehuetepc Tlapanec [nīrāhmúúʔ] ‘they hobbled (CMP.3PL-hobble)’ and [nìxpáthū] ‘they hit (CMP.3PL-hit)’ (Uchihara & Tiburcio 2020). ‘M_D’ indicates a default mid tone inserted on otherwise toneless TBUs, circled superscript ‘^L’ marks an underlying floating L tone.

However, as with tonal overwriting in spreading, this asymmetry could instead be attributed to a faithfulness scale like {IDENT[H], IDENT[L]} ≫ IDENT[M], without assuming tonal underspecification.¹¹

Tones on epenthetic vowels and reduplicated vowels

Sometimes tones that appear on epenthetic vowels are argued to be underspecified. For instance in Navajo, an epenthetic vowel receives a low tone by default, as in /t-nìʃ/ → [tìnìʃ] ‘open-N.IMP.1ST’ (McDonough 2003, pp.45-7). One could argue that the low tone in Navajo is underspecified, based on such data.¹² However, such a situation can alternatively be analyzed with markedness scale, *[H] ≫ *[L] (Pulleyblank 2004). Furthermore, in Ayutla Tlapanec there

¹¹ Uchihara & Tiburcio (2020) argue that surface M tones may reflect either underlying /M/ or /∅/, based on the fact that not all surface /M/ tones show the same phonological behavior. A faithfulness scale like {IDENT[H], IDENT[L]} ≫ IDENT[M] would not, on its own, be able to reproduce this contrast.

¹² McDonough (1999, 2003) analyzes low L as a ‘default’ tone, but argues that L tone is not *phonetically* underspecified.

is evidence that even epenthetic vowels are tonally specified. In Ayutla Tlapanec the progressive aspect prefix is zero when the stem is disyllabic ([Ø-bijàʔ] ‘I am crying (PROG:1SG-cry)’), while a prothetic initial vowel [e] is inserted when the stem is monosyllabic, to satisfy a prosodic minimality requirement (Cornelio 2022, p.171). As can be seen in (7), the 1SG forms in (a,b) have a low tone on this epenthetic vowel (which spreads to the stem vowel), while the 3SG forms in (c,d) have a mid tone. The tone on this epenthetic vowel cannot be due to spreading from the stem tone, since the underlying lexical tones of the stems are not low, as can be observed from the 3SG forms (c,d), which involve a tonally-specified mid-tone prefix [ē-], rather than an epenthetic vowel. Thus, because the L tone on the epenthetic [e] in 1SG forms spreads, it is phonologically active, and must be specified.

(7) Spreading of specified L tone on epenthetic vowels in Ayutla Tlapanec

	1SG	3SG
‘say’	a. è-tàn	c. ē-ʔ-tán
‘do’	b. è-nì	d. ē-ʔ-nī

Similar observations hold for tones on reduplicated vowels. For instance in Yala Ikom (Armstrong 1968, Pulleyblank 1986, pp.106-8) verbal nouns are formed by reduplicating the verb stem and prefixing [ò-/ò-]. The reduplicated portion of this construction always has mid tone (8), argued to be an underspecified tone.

(8) Default M tone on reduplicants in Yala Ikom

a. ò-nyī-nyì ‘burying’	b. à-nyì ‘you buried’
c. ò-bī-bī ‘carrying’	d. à-bī ‘you carried’
e. ò-hārā-hàrà ‘accompanying’	f. à-hàrà ‘you accompanied’

As argued in Alderete *et al.* (1999), fixed segmental or tonal patterns on reduplicated material can reflect markedness hierarchies like {*[H], *[L]} ≫ *[M], rather than underspecification as such. The assumption here is that reduplicated material is not included in the input, and so markedness alone can determine some of the phonological content of the reduplicant.

Stability of tones

Another situation where it can be challenging to distinguish underspecification from markedness or faithfulness scales concerns the stability of tones resulting from the elision of a TBU (Pulleyblank 2004). For instance in Yoruba, when hiatus is resolved by vowel deletion, the mid tone in a high-mid sequence is deleted, as in /rí ǐǵbá/ → [rí ǵbá], *[rí ǵbá] ‘see squash’ (Akinlabi & Liberman 2000, Pulleyblank 2004). Similarly in Alcozauca Mixtec, the tone 3 in a sequence of tones 3 and 4 is deleted when a hiatus is resolved, as in /sa⁴ta³=e⁴/ → [sas⁴te⁴] ‘she buys’ (Uchihara & Mendoza Ruiz 2022). This could be because the mid tone and 3 tone are underspecified (and therefore impossible to retain following deletion), or because of a faithfulness hierarchy like Max[H] ≫ Max[M] or Max[4] ≫ Max[3] (where Max[T] constraints penalize deletion of particular tones).

Tonal neutralization

Lastly, the problem of distinguishing underspecification from markedness or faithfulness scales also arises with respect to tone in neutralization contexts. For instance, Teotitlán Zapotec contrasts 5 tones on stressed syllables (low L, mid M, high H, rising MH, falling HL) but only two tones, L (reflecting neutralization of L and M) and H (reflecting neutralization of H, MH and HL), can occur on pre-tonic syllables (see also Pride 1984, DiCanio 2008, Hernández Mendoza 2017 for similar cases in other Otomanguean languages). Such a situation can be accounted for by treating tone on pretonic syllables as underspecified, and determined from context. Alternatively, a markedness hierarchy like {*[M], *[MH], *[HL]} ≫ {*[L], *[H]} could be responsible for limiting the possible tones in pretonic position, with tones in stressed syllables being protected by a high-ranked faithfulness constraint like IDENT-TONE- σ (e.g. Beckman 1998).

AN UNRELIABLE DIAGNOSTIC FOR TONAL UNDERSPECIFICATION: BROAD PHONETIC VARIABILITY

Level tones are not always phonetically level: indeed, it is quite common for level tones to gradually rise or fall over the course of a TBU, or sequence of TBUs. For example, Campbell (2016) observes that ‘level’ L tone tends to decline across the length of the mora in Zenzontepec Chatino. The H and M tones in Zenzontepec Chatino gradually rise across the mora, though perhaps not as sharply as the L tone falls.

Campbell (2016) argues that this pattern of pitch lowering for L is consistent with the phonological evidence for treating L tone as essentially unspecified in Zenzontepec Chatino. The logic here is that unspecified TBUs lack a pitch target, and so should show greater phonetic variability, and greater contextual influence on f_0 , than specified tones and TBUs.

We strongly support the use of phonetic evidence as a diagnostic for underspecification. However, phonetic evidence of this type must be carefully interpreted. In our view, phonetic variability in and of itself is not sufficient to diagnose tonal underspecification. The problem is that there are *many* phonetic factors which go into determining f_0 on TBUs, most of which are independent from questions of phonological specification. We can illustrate this point with several counterexamples to the claim that phonological underspecification is correlated with phonetic variability, at least in a broad sense.

In Yoruba, sentences consisting of only L tone show a gradual decline in f_0 over the course of the sentence (at least for some speakers; Connell & Ladd 1990). In contrast, sentences consisting of only H tones or only M tones display relatively level f_0 . This is at least roughly parallel to what Campbell (2016) reports for Zenzontepec Chatino. However, in Yoruba, the best candidate for an unspecified tone is the M tone, not the L tone (e.g. Pulleyblank 2004). Therefore phonetic variability, in a broad sense, does not correlate with tonal underspecification in this language.

In Kaifeng Mandarin (Wang *et al.* 2020), the phonetic realization of low tone is quite variable across speakers: some speakers realize L as phonetically dipping, others as phonetically falling, and still others as phonetically falling with additional lengthening. The phonetic realization of H, LH, and HL tones is relatively consistent across speakers, at least when compared to the L tone. However, the L tone must be phonologically specified, because it participates in dissimilatory tonal rules, e.g. /H H/ → [HL H], /L L/ → [LH L]. Again, phonetic variability does not correlate with tonal underspecification in this language.

Lastly, in Yucatec Maya, the phonetic realization of H tone on long vowels varies with context: it is high-rising in phrase-initial position, and high-falling in phrase-final position (e.g. Fisher 1976, Kügler & Skopeteas 2006, Gussenhoven & Teeuw 2008, Sobrino Gómez 2010, and references there). However, there is no phonological evidence whatsoever to treat H tone as an underspecified tone in Yucatec Maya. Furthermore, Gussenhoven & Teeuw (2008) argue that both L and H tones are downstepped after H tones, which implies that H tones are phonologically

represented (see also Pike 1946). Similarly, they propose a phrase-level rule inserting L tone on a toneless TBU between two H tones; if correct, this would appear to be a dissimilatory rule which again implies that the H tone must be specified, despite its phonetic variability.

In short, phonetic variability in and of itself is not sufficient to diagnose tonal underspecification. Instead, it must be shown that toneless TBUs interact phonetically with their *environments* in a way that is (i) predictable, (ii) context-dependent, and (iii) distinct from the behavior of specified TBUs in the same environments. This can be accomplished by showing that toneless TBUs receive their phonetic values for f_0 via phonetic interpolation from neighboring lexical or intonational tones (e.g. Pierrehumbert & Beckman 1988, Myers 1998). Alternatively, toneless TBUs might be better hosts for intonational tones than specified TBUs (e.g. Gussenhoven 2004, Ch. 11.4, Kawahara 2015, p.449; though see above on alternative explanations for tonal overwriting). In Mesoamerica, such an analysis has been proposed for Otomian languages (E. Pike 1951, Bernard 1974), and above Mesoamerica, for Northern Tepehuan (Gil Burgoin 2021). Lastly, unspecified TBUs might behave differently when general phonetic parameters associated with pitch, such as overall pitch range, are adjusted as the result of information-structural effects like topic or focus (e.g. Bennett *et al.* 2022).

DIAGNOSTICS WHICH ARE NOT VALID FOR IDENTIFYING TONAL UNDERSPECIFICATION

In this section, we will look at some diagnostics which have been employed to establish tonal markedness, and show that they are invalid for identifying tonal underspecification.

Tone category

It has been argued that phonetically central tones (like mid M) are unmarked, while peripheral tones (like H, L) are relatively more marked (Maddieson 1978). If ‘unmarked’ tones are also taken to be underspecified tones – a position which we do *not* agree with – then one might expect that only non-peripheral tones should pattern as underspecified.

However, the pitch level associated with a particular tone does not determine whether or not that tone behaves as an underspecified tone. Thus, in a system with phonetic [H, M, L] tones, not only the intermediate M tone, but also *any* tone can be underspecified. For instance, the mid tone M appears to be underspecified in Yucatec Maya, a language with a four-way [HL, H, M, L] surface phonetic contrast (see Bennett 2016, p.498 for references). Zenzontepec Chatino has three

tone levels, but here the lowest level L is arguably underspecified on phonological grounds (Campbell 2016). Similarly, Chiquihuitlán Mazatec has four tone levels, and the lowest is underspecified (Nakamoto 2022), and Lalana Chinantec has five tone levels, with the lowest again underspecified (Nakamoto 2022). Finally, in the Bantu language Engenni, H is underspecified (Hyman 2001), while in other Bantu languages L is unspecified (Myers 1998), even though the surface phonetic inventory may be [H, L] in both cases. Similar patterns of variation occur in Athabaskan languages (Leer 2001), where surface two-tone systems differ in which tone patterns as default or underspecified.

Frequency

The frequency of occurrence of certain tones, whether token or type, is sometimes considered an index of their phonological status (Maddieson 1978). The assumption appears to be that tones which are more frequent in a given language are ‘unmarked’, and so should pattern as underspecified. However, neither type nor token frequency is a valid diagnostic for tonal underspecification. First, there is no logical connection between any type of frequency and the specification of tone on a particular TBU. Perhaps more importantly, there are counterexamples to the claim that more frequent tones pattern as underspecified. For instance, in Ganda, high tones are more frequent than low tones, but it is the low tone that is underspecified according to its phonological behavior (Hyman 2001). Another such example is Kaifeng Mandarin, where high tone is more frequent than low tone, but both high and low tones must be specified, as they participate in dissimilation rules (e.g. /H H/ → [HL H], Wang *et al.* 2020).

Nor is the frequency with which a certain tonal melody occurs in inflectional or derivational paradigms an index of underspecification. For instance, in San Pedro Amuzgos Amuzgo (Kim 2016, Palancar 2021), the tone 53 (high-mid) is assigned by default to verbs in the 1st or 2nd person singular (60% of all the verbs for 1SG and 61% for 2SG). But since the tone 53 can occur on short vowels (e.g. [ŋɛ⁵³] ‘sell.CPL.1SG’), neither tone 5, tone 3, nor tone 53 can be considered underspecified, given that underspecified tones cannot form part of a contour. This constitutes a counterexample to the claim that tones which are more common in particular morphological paradigms correspond to underspecified tones. Similar logic would apply to e.g. a language in which particular tones are the most common tones found in verbs or nouns: here too,

there is no logical connection between that notion of frequency and the formal, analytical concept of underspecification.

Loanword adaptation

The frequency with which particular tones occur in loanwords is not a valid diagnostic for underspecification. Nor is the observation that certain tones are assigned ‘by default’ in loanwords. Again, there is no logical connection between tone in loanword adaptation and tonal underspecification, and further, there are clear counterexamples. In Tokyo Japanese, loanwords from English tend to be assigned a specified H*L tone, as in *Anderson* → [an.dáà.son] (Kubozono 2008).¹³ In Uspanteko (Mayan), loans from Spanish tend to be assigned a specified high tone, as in *cruz* → [kú.ris] (Can Pixabaj 2007, Bennett *et al.* 2022). In many Otomanguan languages, certain uncommon, highly marked tones are assigned to loanwords. For instance in Teotitlan Zapotec high, falling or rising tones are rare lexically on native words, and must be specified tones because e.g. they form contours on monomoraic syllables, trigger tonal processes, and resist being replaced when tonal processes apply. But loans are generally assigned one of these specified tones, e.g. [du'rǎ:znn] ‘peach (< Spanish *durazno*)’; [‘llí:br] ‘book (< Spanish *libro*)’; [‘trâ:lǝ] ‘loom (< Spanish *telar*)’. In Ayutla Tlapanec, an H.H pattern on disyllables is very limited in the native lexicon, and the H tone is clearly specified since e.g. all tonal contours involve a high tone (MH, LH, HM, HL; Cornelio 2022), H tone can float, etc. However, specified H.H is the default pattern for loans: [kwété] ‘fireworks’ (< Spanish *cuete*); [lǎfǎ] ‘orange’ (< Spanish *naranja*), etc.¹⁴

ADDRESSING CONFLICT BETWEEN DIAGNOSTICS

In some cases, diagnostics for tonal underspecification may provide conflicting evidence. We illustrate with an example from Leggbo (Hyman *et al.* 2002, Paster 2003). In Leggbo, low tone is overwritten by tonal spreading in certain morpho-syntactic contexts, e.g. [l̩-tóól] ‘ear’ vs. [āwā l̩-tóól] ‘of an ear’. High tone resists overwriting, e.g. [l̩-dz̩l] ‘food’ vs. [āwā l̩-dz̩l] ‘of food’.

¹³ Kubozono (2023: 43) argues that the default pitch-accent pattern in Tokyo Japanese assigns H*L pitch-accent to the rightmost, non-final foot of the prosodic word, and that the default accentuation pattern discussed here would represent the emergence of the unmarked.

¹⁴ Many tonal patterns in loanwords in Mesoamerican languages can be accounted for by the reinterpretation of stress accent in the donor language (often Spanish) as an H tone or H-containing contour, particularly since stressed syllables in Spanish are frequently realized with an H* or LH* pitch accent (e.g. Ortega-Llebaria & Prieto 2011).

This might imply that low tone corresponds to a tonally-underspecified TBU. However, low tone can also function as a grammatical tone, analyzable as a floating tone, e.g. [bā m̄anā] ‘they trapped’ vs. [bā m̄aná] ‘they have trapped’. This might imply that low tone must be a specified tone in Leggbo. Here, our diagnostics for tonal specification appear to be in conflict.

A similar situation is found in Huehuetepic Tlapanec, where low tone is more susceptible to overwriting: both mid and high tones can spread to a mora with a low tone, while mid tone and high tone cannot be overwritten by tone spreading. This is illustrated in the following set of examples. In (9a), the second syllable has an underlying low tone, which surfaces in suffixed forms as in (9b). This underlying low tone is overwritten in bare forms by a high tone that spreads from the first syllable (9a). When the second syllable has a lexical mid tone, then high tone cannot spread to this syllable, as in (9c).

(9) H tone spreading overwrites L tone in Huehuetepic Tlapanec

a. /húbà/ → [húbá] ‘hill’

b. /húb(à)-uū/ (hill-3SG.B) → [hóbòō] ‘his hill’

c. /tʃágā/ → [tʃágā] (*tʃágá) ‘dewlap’

Similarly, mid tone can spread progressively to a following syllable with an underlying lexical low tone (10a), justified by the suffixed form (10b). Again, mid tone cannot spread to a syllable with a high tone, as observed in (10c).

(10) M tone spreading overwrites L tone in Huehuetepic Tlapanec

a. /ĩtsù/ → [ĩtsū] ‘bone’

b. /ĩts(ù)-uū/ (bone-3SG.B) → [ĩtsūù] ‘his bone’

c. /nī-yáfī/ (CMP:3SG-pick.up) → [nīyáfī] (*nīyāfī) ‘he picked it up.’

However, low tone can still spread and float, suggesting that low tone is in fact specified in Huehuetepic Tlapanec. In (11), low tone on the potential prefix /mà-/ spreads to the 2SG agentive prefix /tara-/ which is tonally unspecified. In (12), the 3PL agentive prefix /ni, L-/ is associated with a floating low tone, which docks to the first syllable of the stem. The (b) forms justify the underlying tones of the affected syllables.

- (11) L tone spread in Huehuetepc Tlapanec
- a. /mà-tara-tsī/ (POT-2SG-buy) → [màtāràtsī] ‘you will buy’
- b. /nī-tara-tsī/ (CMP-2SG-buy) → [nītārātsī] ‘you bought’
- (12) Floating L tone in Huehuetepc Tlapanec
- a. /ni^l-jahũ/ (CMP:3PL-work) → [nīṅàhũ] ‘they worked’
- b. /nī-jahũ/ (CMP:3SG-work) → [nīṅàhũ] ‘he worked’

In such a situation, several responses are possible. The first response is to reject the validity of at least one of the conflicting diagnostics. For example, we have suggested above that both tonal overwriting and grammatical tones are less reliable diagnostics for tonal (under)specification, largely because they can be analyzed without assuming underspecification or floating tones. If correct, then the apparent conflict observed for Leggbo or Huehuetepc Tlapanec may just be the result of using diagnostics for underspecification which are not particularly reliable in the first place.

Secondly, it could be that different levels of representation are involved for each of the diagnostics in question. For example, a particular tone T_x might correspond to an unspecified TBU at one level of the derivation (e.g. the word level phonology), but correspond to a specified tone at a different level of the derivation (e.g. the phrase level phonology; e.g. Zec & Zsiga 2010, McPherson 2011). In such a case, there would be no conflict between diagnostics, because each diagnostic refers to a different component of the phonological grammar.

Third, an apparent conflict between diagnostics might reflect a pattern of neutralization which masks underlying tonal differences. For example, imagine a language in which TBUs may be underlyingly /H/, /L/, or toneless /∅/. Now, imagine that toneless TBUs are realized with a default L tone on the surface, /∅/ → [L]. The result of this default tone rule is that there are two types of surface [L] tones, one corresponding to underlying /L/, and other corresponding to underlyingly toneless TBUs. Surface [L] tones corresponding to underlying /L/ tones might show the behavior of specified tones, while surface [L] tones inserted by default on toneless TBUs would show the behavior of *unspecified* tones. This scenario would lead to a conflict of

diagnostics, somewhat like the Leggbo case outlined above. (Conceptually, it is also related to the possibility that different diagnostics might refer to different levels of representation.)

Analyses of this type have been proposed for tonal languages. For example, McKendry (2018) proposes that SE Nochixtlán Mixtec has underlying /H, M, L/ tones, as well as underlyingly toneless TBUs. Those underlying toneless TBUs receive a default M tone, thus neutralizing an underlying /M ∅/ to surface [M]. Underlying [M] shows the behavior of a specified tone – for example, it can form part of a contour tone on short vowels, as in [ĩd̃d̃] ‘rabbit’, which McKendry analyzes as underlyingly /∅ ML/ (see also Uchihara & Tiburcio 2020 on Huehuetepc Tlapanec, and Cornelius 2018 on Oklahoma Cherokee). McKendry also argues that underlying /∅ M/ → [M] show different phonological and morphological behavior: for example, underlying /H L M/ sequences surface as [H M M], while underlying /H L ∅/ surfaces, opaquely, as [H L M].

Lastly, in cases of disagreement between diagnostics, it may be that we are learning something deeper about what underspecification actually *means*. More specifically, it may be that underspecification is a graded, continuous notion, rather than a binary and categorical one. We have in mind here research in the framework of Gradient Symbolic Representations (e.g. Smolensky & Goldrick 2016, Zimmerman 2018, among others). In the GSR framework, phonological objects may have different levels of ‘activity’ encoded as part of their representations. The notion of ‘activity’ here is continuous and numerical, with values ranging between 0 and 1. Activity is, intuitively, something like ‘strength’. Objects specified with lower activity are easier to change, because changing them violates faithfulness constraints to a lesser degree. Low-activity objects also provoke fewer phonological processes, because they violate markedness constraints more weakly than highly active objects.¹⁵

We can illustrate this general proposal using the Leggbo data described above. To capture the fact that low tone can serve as a (floating) grammatical tone, we assume that low tone is in fact specified in Leggbo and Huehuetepc Tlapanec. However, it is only *weakly* specified: it has

¹⁵ Gradient activity thus has similar effects to markedness and faithfulness scales, which we discuss in an earlier section. However, there are differences: for example, a ranking of markedness constraints $*L \gg \{ *H, *M \}$ would predict that low tones should be easiest to change, being most marked. But using GSRs, the same effect can be achieved by giving low tones a low activity value, so they violate faithfulness constraints to a relatively low degree. But in the GSR framework, that would also imply that low tones are *least* marked, being least active, rather than most marked.

an activity value of 0.5 (for example), while other tones have activity values of 1. This difference in activity explains why low tones are susceptible to overwriting, but high tones are not: high tones are more strongly specified than low tones are, and thus more resistant to change. This analysis depends on the assumption that tonal specification is not all-or-nothing: it is a *graded* notion, such that tones may be specified to greater or lesser degrees (see also Inkelas 2015).

Gradiently active representations have also been used to analyze exceptional tonal behavior. For example, Zimmermann (2018) uses gradient activity to analyze tonal patterning in San Miguel el Grande Mixtec (drawing on McKendry 2013). In this variety of Mixtec, the emphatic marker /βááⁿ/ is analyzed as having an unassociated floating /H/ tone, /βááⁿ, H/ (the superscript /ⁿ/ marks nasality in McKendry’s notation, p.17). This floating /H/ tone is posited to account for the fact that certain enclitics are realized with high tone after /βááⁿ/, as in (13a) (McKendry 2013, p.92).

(13) Morpheme-specific tonal exceptionality in San Miguel el Grande Mixtec

- a. /βááⁿ, H - t̃, H/ → [βáán-t̃] ‘3_{AN}.EMPH’
- b. /βááⁿ, H - ðē/ → [βáán-ðē] ‘3_{MASC}.HON.EMPH’

However, as (13b) shows, the enclitic /ðē/ retains its mid tone on the surface, rather than hosting the floating tone associated with /βááⁿ/.

Zimmermann analyzes this, and other aspects of San Miguel el Grande tonology, using GSRs. Simplifying her proposal for the purposes of illustration, we can assume that the enclitic /t̃, H/ comes with a low tone that is specified only weakly, e.g. $L_{Activity} = 0.5$. In contrast, the enclitic /ðē/ has a mid tone which is more strongly specified, e.g. $M_{Activity} = 1$. This accounts for the different tonal behaviors of these two enclitics: the weakly active L tone on /t̃, H/ should be easier to change than the more strongly active M tone on /ðē/.

Gradient Symbolic Representations can thus be used to express the intuition that tones may be more-or-less specified, in a continuous way. As we have seen, gradient tonal specifications may help reconcile conflicting diagnostics for tonal (under)specification, and also offer a useful perspective on morpheme-specific tonal behavior. (For similar ideas, see also work in ‘Canonical Typology’, e.g. Brown *et al.* 2013.)

CONCLUSION

In our view, the evidence for tonal underspecification is sufficiently strong that underspecification can and should continue to be used as a tool in the phonological analysis of tone systems. Cases like Peñoles Mixtec, in which a pair of L tones dissimilate across a potentially unbounded series of M tones, provide compelling support for underspecification in phonology. The phonetic evidence for surface-level tonal underspecification is also an important confirmation that tone-bearing units need not come with a tonal target of their own. On the view that phonological representations are *interpreted* by the phonetics (e.g. Pierrehumbert 1990 and many others), it seems reasonable to infer that surface phonetic underspecification ultimately reflects underspecification in the phonology as well (e.g. Myers 1998). That is, phonetic underspecification is likely *inherited* from underspecified phonological representations.

Evidence for underspecification is strongest when several distinct (and ideally, robust) diagnostics converge on the conclusion that a particular tone or TBU lacks a tonal specification of its own. We thus encourage researchers to search for convergent evidence in any analysis in which tonal underspecification is assumed.

At the same time, we have argued that underspecification is ultimately a theoretical concept, and not merely a descriptive tool. Tonal underspecification can be difficult to establish with certainty, in part because not all diagnostics for underspecification are equally effective or valid. This is due, in part, to the fact that many diagnostics are inextricably tied up with particular theoretical assumptions, beyond the basic representational commitments of Autosegmental Phonology. Those underlying theoretical assumptions may or may not be valid themselves, and at a minimum, should be carefully scrutinized. Overall, we are positive about the use of tonal underspecification in phonetic and phonological theory, but hope to have made the case that linguists should be meticulous in evaluating the evidence for tonal underspecification in any particular case.

REFERENCES

- AKINLABI, AKINBIYI & MARK LIBERMAN 2000. “The tonal phonology of Yoruba clitics”. In Birgit Gerlach & Janet Grijzenhout (eds.), *Clitics in phonology, morphology and syntax*, 31–62. Amsterdam: John Benjamins.
- ALDERETE, JOHN, JILL BECKMAN, LAURA BENUA, AMALIA GNANADESIKAN, JOHN J. MCCARTHY &

- SUZANNE URBANCZYK 1999. “Reduplication with fixed segmentism”. *Linguistic Inquiry* 30(3). 327–364.
- ANDERSON, STEPHEN R. 1992. *A-morphous morphology*. Cambridge, UK: Cambridge University Press.
- ANTTILA, ARTO 2002. “Morphologically conditioned phonological alternations”. *Natural Language & Linguistic Theory* 20(1). 1–42.
- ANTTILA, ARTO & ADAMS BODOMO 2022. “Tone and morphological level ordering in Dagaare.” *Phonology* 39(3). 443-471.
- ARANOVICH, RAUL 1994. “The tone system of Acatlán Mixtec and some exceptions to the OCP”. *Linguistic Notes from La Jolla* (1994), 17: 3-26. <http://grammar.ucsd.edu/sdlp/past.html>
- ARCHANGELI, DIANA 2011. “Feature specification and underspecification”. In Marc van Oostendorp, Colin Ewen, Elizabeth Hume & Keren Rice (eds.), *The Blackwell companion to phonology*, 1-23. Malden, MA: Wiley-Blackwell.
- ARMSTRONG, R.G. 1968. “Yala (Ikom): A terraced-level language with three tones”. *The Journal of West African Languages* 5(1): 49-58.
- BAERMAN, MATTHEW & ENRIQUE PALANCAR 2015. “The organization of the Chinantec tone paradigms”. *hal-01099323f*.
- BEAM DE AZCONA, ROSEMARY 2023. “The tonal morphology of the potential in Coatec Zapotec (Di’zhke’): Implications for early Zapotecan tone, *ʔ, and verb classes through internal and comparative reconstruction”. *Journal of Historical Linguistics* 13(1): 115–172.
- BECKMAN, JILL 1998. *Positional faithfulness*: University of Massachusetts, Amherst PhD thesis.
- BECKMAN, MARY & JANET PIERREHUMBERT 1986. “Intonational structure in Japanese and English”. *Phonology* 3(1). 255-309.
- BENNETT, RYAN 2016. “Mayan phonology”. *Language and Linguistics Compass* 10(10). 469–514. doi: 10.1111/lnc3.12148.
- BENNETT, RYAN, ROBERT HENDERSON & MEG HARVEY 2022. “Tonal variability and marginal contrast: Lexical pitch accent in Uspanteko”. In Haruo Kubozono, Junko Ito & Armin Mester (eds.), *Prosody and prosodic interfaces*, 187–226. Oxford, UK: Oxford University Press. doi:10.1093/oso/9780198869740.003.0007.
- BERMÚDEZ-OTERO, RICARDO 2018. “Stratal phonology”. In S.J. Hannahs & Anna Bosch (eds.), *The*

- Routledge handbook of phonological theory*, 100-134. Abingdon: Routledge.
doi:10.4324/9781315675428.
- BERNARD, H. RUSSELL 1974. "Otomi Tones in Discourse". *International Journal of American Linguistics* 40(2): 141–150
- BROWN, DUNSTAN, MARINA CHUMAKINA & GREVILLE G. CORBETT (eds.) 2013. *Canonical morphology and syntax*. Oxford: Oxford University Press
- BUCKLEY, EUGENE 1991. "Low-Tone Spreading in Chalcatongo Mixtec". In James E. Redden (ed.) *Papers from the American Indian languages conferences held at the University of California, Santa Cruz, July and August 1991*, 168-172. Carbondale, Illinois: Dept. of Linguistics.
- CARRASCO ZÚÑIGA, ABAD 2006. *Los Procesos Morfofonológicos de la Lengua Me'phaa*: CIESAS MA thesis.
- CASSIMJEE, FARIDA & CHARLES KISSEBERTH 2007. "Optimal domains theory and Bantu tonology: a case study from Isixhosa and Shingasidja". In Larry Hyman & Charles Kisseberth (eds.), *Theoretical aspects of Bantu tone*, 33-132. Stanford, CA: CSLI Publications.
- CASTELLANOS CRUZ, MIGUEL 2021. *La morfología flexiva y los cambios tonales en los verbos del Chinanteco de Quiotepec*: CIESAS PhD thesis
- CAMPBELL, ERIC 2016. "Tone and inflection in Zenzontepec Chatino". In Enrique Palancar & Jean Léo Léonard (eds.), *Tone and inflection: New facts and new perspectives*, 141-162. Berlin: De Gruyter.
- CAMPBELL, ERIC 2019. "Layered complexity in Zenzontepec Chatino verbal inflectional classes". *Amérindia* 41: 39-74.
- CAN PIXABAJ, TELMA 2007. *Gramática descriptiva Uspanteka*. Antigua, Guatemala: Oxlajuuj Keej Maya' Ajtz'iib' (OKMA).
- CHOI, JOHN D. 1995. "An acoustic-phonetic underspecification account of Marshallese vowel allophony". *Journal of Phonetics* 23(3). 323-347.
- CLEMENTS, GEORGE N. 1979. "The description of terraced-level tone languages". *Language* 55(3). 536–558.
- COHN, ABIGAIL 1990. *Phonetic and phonological rules of nasalization*. University of California, Los Angeles PhD dissertation. <https://escholarship.org/uc/item/1xq3d5hr>.
- COHN, ABIGAIL 1993. "Nasalisation in English: phonology or phonetics". *Phonology* 10(1). 43-81.

- CONNELL, BRUCE AND D. ROBERT LADD 1990. "Aspects of pitch realisation in Yoruba". *Phonology*, 7(1), pp.1-29.
- CORNELIO TIBURCIO, OSCAR 2022. *El acento y la estructura prosódica en el mè'pàà de la Ciénega del Sauce, Guerrero*: CIESAS MA thesis.
- CORNELIUS, SAMANTHA 2018. *Prosodic phonology in Oklahoma Cherokee*: UT Arlington PhD thesis.
- DALY, JOHN & LARRY HYMAN 2007. "On the representation of tone in Peñoles Mixtec". *International Journal of American Linguistics* 73(2): 165–207.
- DI CANIO, CHRISTIAN 2008. *The phonetics and phonology of San Martín Itunyoso Trique*: University of California, Berkeley PhD thesis.
- DUANMU, SAN 2007. *The phonology of standard Chinese*. Oxford: Oxford University Press.
- EISCHENS, BEN 2022. *Tone, phonation, and the phonology-phonetics interface in San Martín Peras Mixtec*: University of California, Santa Cruz PhD thesis.
- FISHER, WILLIAM 1976. "On tonal features in the Yucatecan dialects". In Marlys McClaran (ed.), *Mayan linguistics*, 29-43. Los Angeles: American Indian Studies Center, University of California, Los Angeles.
- GIL BURGOIN, CARLOS IVANHOE 2021. "Arguments for a Privative L Tone in Northern Tepehuan". In Ryan Bennett, Richard Bibbs, Mykel L. Brinkerhoff, Max J. Kaplan, Stephanie Rich, Amanda Rysling, Nicholas Van Handel, & Maya Wax Cavallaro (eds.), *Proceedings of the 2020 Annual Meeting on Phonology*. Washington, DC: Linguistic Society of America. <http://journals.linguisticsociety.org/proceedings/index.php/amphonology/index>
- GOLDSMITH, JOHN 1976. *Autosegmental phonology*: Massachusetts Institute of Technology PhD thesis. Published by Garland, 1979.
- GOLDSMITH, JOHN 1990. *Autosegmental and metrical phonology*. Oxford: Blackwell.
- GORDON, MATTHEW 2006. *Syllable weight: phonetics, phonology, typology*. New York: Routledge.
- GUSSENHOVEN, CARLOS 2004. *The phonology of tone and intonation*. Cambridge, UK: Cambridge University Press.
- GUSSENHOVEN, CARLOS & RENSKA TEEUW 2008. "A moraic and a syllabic H-tone in Yucatec Maya". In Esther Herrera Zendejas & Pedro Martín Butragueño (eds.), *Fonología instrumental: patrones fónicos y variación*, 49-71. Mexico, D.F.: El Colegio de México.
- HARAGUCHI, SHOSUKE 1999. "Accent". In Natsuko Tsujimura (ed.), *The handbook of Japanese*

- linguistics*, 1-30. Oxford, UK: Blackwell.
- HERNÁNDEZ-GREEN, NÉSTOR 2021. “Verbal inflection in Tenango Otomi and the typology of Grammatical Tones”. *International Journal of American Linguistics* 87(3): 303-337.
- HERNÁNDEZ MENDOZA, FIDEL 2017. *Tono y fonología segmental en el triqui de Chichahuaxtla*. Universidad Nacional Autónoma de México PhD thesis.
- HYMAN, LARRY 2001. “Privative tone in Bantu”. In Shigeki Kaji (ed.), *Cross-linguistic studies of tonal phenomena*, 237-257. Tokyo: Institute for the Study of Languages and Cultures.
- HYMAN, LARRY 2006. “Word-prosodic typology”. *Phonology* 23(2): 225-257.
- HYMAN, LARRY 2009. “How (not) to do phonological typology: the case of pitch-accent”. *Language Sciences* 31(2-3): 213-238.
- HYMAN, LARRY 2011a. “The representation of tone”. In Marc van Oostendorp, Colin Ewen, Elizabeth Hume & Keren Rice (eds.), *The Blackwell companion to phonology*, 1-25. Malden, MA: Wiley-Blackwell.
- HYMAN, LARRY 2011b. “Tone: Is it different?”. In John Goldsmith, Alan C.L. Yu & Jason Riggle (eds.), *The handbook of phonological theory*, 197-239. Malden, MA: Wiley-Blackwell.
- HYMAN, LARRY 2014. “How autosegmental is phonology?” *The Linguistic Review* 31(2): 363-400.
- HYMAN, LARRY & WILLIAM LEBEN 2021. “Tone systems”. In Carlos Gussenhoven & Aoju Chen (eds.), *The Oxford handbook of language prosody*, chap. 4, 45-65. Oxford, UK: Oxford University Press. doi:10.1093/oxfordhb/9780198832232.013.6.
- HYMAN, LARRY, HEIKO NARROG, MARY PASTER & IMELDA UDOH 2002. “Leggbo verb inflection: A semantic and phonological particle analysis”. In Julie Larson & Mary Paster (eds.), *Berkeley Linguistic Society (BLS)* 28, 399-410. Berkeley, CA: University of California, Berkeley Linguistics Society.
- HYMAN, LARRY & RUSS SCHUH 1974. “Universals of tone rules: evidence from West Africa”. *Linguistic Inquiry* 5(1): 81-115.
- INKELAS, SHARON 2015. “Confidence scales: A new approach to derived environment effects”. In Yuchau E. Hsiao & Lian-Hee Wee (eds.), *Capturing phonological shades within and across languages*, 45–75. Newcastle upon Tyne, UK: Cambridge Scholars Press.
- INKELAS, SHARON & CHERYL ZOLL 2007. “Is grammar dependence real? A comparison between cophonological and indexed constraint approaches to morphologically conditioned phonology”. *Linguistics* 45(1): 133-171.

- ITO, JUNKO & ARMIN MESTER 2013. “Prosodic subcategories in Japanese”. *Lingua* 124: 20-40. doi: 10.1016/j.lingua.2012.08.016.
- KAWAHARA, SHIGETO 2015. “The phonology of Japanese accent”. In Haruo Kubozono (ed.), *The handbook of Japanese phonetics and phonology*, 4454-4492. Berlin: Mouton de Gruyter.
- KEATING, PATRICIA 1988. “Underspecification in phonetics”. *Phonology* 5(2). 275-292.
- KENSTOWICZ, MICHAEL & CHARLES KISSEBERTH 1979. *Generative phonology*. Orlando: Academic Press.
- KIM, YUNI 2016. “Tonal overwriting and inflectional exponence in Amuzgo”. In Enrique Palancar & Jean Léo Léonard (eds.), *Tone and inflection: New facts and new perspectives*, 199-224. Berlin: De Gruyter.
- KUBOZONO, HARUO 2008. “Japanese accent”. In Shigeru Miyagawa & Mamoru Saito (eds.), *The handbook of Japanese linguistics*, 165-191. New York: Oxford University Press.
- KUBOZONO, HARUO 2023.『一般言語学から見た日本語の語形成と音韻構造』(*Japanese word-formation and phonological structure from a general linguistic perspective*, in Japanese). Tokyo: Kuroshio.
- KÜGLER, FRANK & STAVROS SKOPETEAS 2006. “Interaction of lexical tone and information structure in Yucatec Maya”. In *Proceedings of the Second International Symposium on Tonal Aspects of Languages*, 380-388.
https://www.isca-speech.org/archive/tal_2006/kugler06_tal.html.
- LADD, D. ROBERT 1984. “Declination: a review and some hypotheses”. *Phonology* 1: 53-74.
- LEER, JEFF 2001. “Shift of tone markedness in Northern Tlingit and Southern Athabaskan”. In Shigeki Kaji (ed.), *Cross-linguistic studies of tonal phenomena*, 61-86. Tokyo: Institute of the Study of the Languages and the Cultures of Asia and Africa.
- LEÓN VÁZQUEZ, OCTAVIO 2017. *Sandhi tonal en el mixteco de Yucuquimi de Ocampo*: CIESAS, MA thesis.
- LIBERMAN, MARK & JANET PIERREHUMBERT 1984. “Intonational invariance under changes in pitch range and length”. In Mark Aronoff & Richard Oehrle (eds.), *Language sound structure: studies in phonology presented to Morris Halle by his teacher and students*, 157-233. Cambridge, MA: MIT Press.
- MADDIESON, IAN 1978. “Universals of tone”. In Joseph Greenberg (ed.), *Universals of human language, vol. 2 (Phonology)*, 335-365 Stanford, California: Stanford University Press.

- McCARTHY, JOHN J. & ALISON TAUB 1992. “Review of Carole Paradis and Jean-François Prunet (eds.) (1991). The special status of coronals: internal and external evidence. (Phonetics and Phonology 2). San Diego: Academic Press. Pp. xvii-231.” *Phonology* 9(2): 363-370. doi:10.1017/S0952675700001664.
- McDONOUGH, JOYCE 1999. “Tone in Navajo”. *Anthropological Linguistics* 41(4): 503–540.
- McDONOUGH, JOYCE 2003. *The Navajo sound system*. Dordrecht: Springer.
- McKENDRY, INGA 2013. *Tonal association, prominence and prosodic structure in South-eastern Nochixtlán Mixtec*: University of Edinburgh PhD thesis.
- McKENDRY, INGA 2018. “Evidence for underlying mid tones in South-eastern Nochixtlán Mixtec”. In *Proceedings of the Sixth International Symposium on Tonal Aspects of Languages*, 173-177. doi: 10.21437/TAL.2018-35.
- McPHERSON, LAURA 2011. *Tonal underspecification and interpolation in Tommo So*: University of California, Los Angeles MA thesis.
- McPHERSON, LAURA 2022. “Word tone is epiphenomenal: A case study from Poko”. In Haruo Kubozono, Junko Ito & Armin Mester (eds.), *Prosody and prosodic interfaces*, 3-28. Oxford, UK: Oxford University Press.
- MÉNDEZ HORD, ESTEBAN 2017. *Tone in Acatlán Mixtec nouns*: University of North Dakota MA thesis.
- MERRIFIELD, W. R. 1968. “Palantla Chinantec grammar”. *Papeles de la Chinantla* 5, *Serie científica* 5. Mexico City: Museo Nacional de Antropología.
- MYERS, SCOTT 1998. “Surface underspecification of tone in Chichewa”. *Phonology* 15(3): 367-391.
- NAKAMOTO, SHUN 2016. *The morphology of person in Temalacayuca Popoloca (Ngiwa)*. Tokyo University of Foreign Studies BA thesis.
- NAKAMOTO, SHUN 2018. “Tone and tonal processes in Chiquihuitlán Mazatec”. Paper presented at *Sound Systems of Latin America III*, University of Massachusetts, Amherst, Oct. 19-21.
- NAKAMOTO, SHUN 2020. *Tonología mazateca: San Bartolomé Ayautla*. Universidad Nacional Autónoma de México MA thesis.
- NAKAMOTO, SHUN 2022.『オトマンゲ諸語の声調有標性について:マサテク語とチナンテク語の事例から』(“On tonal markedness in Otomanguan languages: from cases of Mazatec and

- Chinantec”, in Japanese). Paper presented at *Regular Conference at the Institute of Language Research*, Tokyo University of Foreign Studies, Nov. 10.
- NAKAMOTO, SHUN 2023. “Escalonamiento descendente con condicionamiento sintáctico en chinanteco de Ozumacín y la ruta entonacional en la evolución de sistemas tonales”. Paper presented at *COLOV*, Apr. 20-22.
- NAKAMOTO, SHUN In press. “Prosody of noun compounding in Temalacayuca Ngiwa (Popoloca).” *International Journal of American Linguistics*
- NEWMAN, PAUL 2000. *The Hausa language: An encyclopedic reference grammar*. New Haven, CT: Yale University Press.
- NEWMAN, PAUL 2007. “Hausa”. In Alan Kaye (ed.), *Morphologies of Asia and Africa*, vol. 1, 667-711. Winona Lake: Eisenbrauns.
- ODDEN, DAVID 2005. *Introducing phonology*. Cambridge, UK: Cambridge University Press.
- OHALA, JOHN 1986. “Consumer’s guide to evidence in phonology”. *Phonology* 3: 3-26.
- ORTEGA-LLEBARIA, MARTA & PILAR PRIETO 2010. “Acoustic correlates of stress in Central Catalan and Castilian Spanish”. *Language and speech* 54(1). 73–97.
- PALANCAR, ENRIQUE 2004. “Verbal morphology and prosody in Otomi”. *International Journal of American Linguistics* 70 (3): 251-78.
- PALANCAR, ENRIQUE 2021. “Paradigmatic structure in the tonal inflection of Amuzgo”. *Morphology* 31: 45-82.
- PALANCAR, ENRIQUE & JEAN LÉO LÉONARD (eds.) 2016. *Tone and inflection*. De Gruyter.
- PASTER, MARY 2003. “Tone specification in Leggbo”. In John M. Mugane (ed.), *Linguistic description: Typology and representation of African languages*, 139-150. Trenton: Africa World Press.
- PATER, JOE 2010. “Morpheme-specific phonology: constraint indexation and inconsistency resolution”. In Steve Parker (ed.), *Phonological argumentation: essays on evidence and motivation*, 123-154. London: Equinox.
- PIERREHUMBERT, JANET 1980. *The phonology and phonetics of English intonation*: Massachusetts Institute of Technology PhD thesis.
- PIERREHUMBERT, JANET 1990. “Phonological and phonetic representation”. *Journal of Phonetics* 18(3). 375–394.
- PIERREHUMBERT, JANET & MARY BECKMAN 1988. *Japanese tone structure*. Cambridge, MA: MIT

Press.

- PIKE, EUNICE 1948. "Problems in Zapotec tone analysis". *International Journal of American Linguistics* 14: 161-170.
- PIKE, EUNICE. 1951. "Tonemic-intonemic correlation in Mazahua (Otomi)". *International Journal of American Linguistics* 17(1): 37-41.
- PIKE, KENNETH 1946. "Phonemic pitch in Maya". *International Journal of American Linguistics* 12(2): 82-8.
- PIKE, KENNETH 1948. "Tonemic perturbations in Mazateco, with special emphasis on tonemic fusion". Chapter VIII of *Tone languages: A Technique for Determining the Number and Type of Pitch Contrasts in a Language, with Studies in Tonemic Substitution and Fusion*, 95-165. Ann Arbor: U. of Michigan Press.
- PRIDE, LESLIE 1984. "Tone contrast on the penultimate syllable in Tataltepec Chatino". In *SIL Mexico workpapers*, vol. 6, 73-92. Summer Institute of Linguistics in Mexico.
<https://www.sil.org/resources/archives/10857>.
- PRINCE, ALAN & PAUL SMOLENSKY 1993/2004. *Optimality Theory: constraint interaction in generative grammar*. Malden, MA: Blackwell. Available online as ROA-537, Rutgers Optimality Archive, <http://roa.rutgers.edu/>.
- PULLEYBLANK, DOUGLAS 1986. *Tone in Lexical Phonology*. Kluwer.
- PULLEYBLANK, DOUGLAS 2004. "A note on tonal markedness in Yoruba". *Phonology* 21(3): 409-425.
- ROLLE, NICHOLAS 2018. *Grammatical tone: typology and theory*. University of California, Berkeley PhD thesis.
- SANDE, HANNAH 2022. "Is grammatical tone item-based or process-based?". *Phonology* 39(3): 399-442.
- SHAW, JASON & SHIGETO KAWAHARA 2018. "The lingual articulation of devoiced /u/ in Tokyo Japanese". *Journal of Phonetics* 66: 100-119.
- SICOLI, MARK 2007. *Tono: A linguistic ethnography of tone and voice in a Zapotec region*: University of Michigan PhD thesis.
- SMOLENSKY, PAUL & MATTHEW GOLDRICK 2016. "Gradient symbolic representations in grammar: The case of French liaison". Ms., Johns Hopkins University and Northwestern University.
http://roa.rutgers.edu/content/article/files/1552_smolensky_1.pdf

- SNIDER, KEITH 1999. *The geometry and features of tone*. Summer Institute of Linguistics and the University of Texas at Arlington.
- SNIDER, KEITH 2018. *Tone analysis for field linguists*. Summer Institute of Linguistics.
- SOBRINO GÓMEZ, MARTÍN 2010. *Las vocales con tono del maya yucateco: descripción y génesis*: CIESAS MA thesis.
- STERIADE, DONCA 1995. “Underspecification and markedness”. In John A. Goldsmith (ed.), *The handbook of phonological theory*, 114-174. Cambridge, MA: Blackwell.
- SULLIVANT, RYAN 2015. *The phonology and inflectional Morphology of Cháʔknyá, Tataltepec de Valdés Chatino, a Zapotecan Language*: University of Texas, Austin PhD thesis.
- SWANTON, MICHAEL Y JUANA MENDOZA RUÍZ 2021. “Observaciones sobre la diacronía del tono en el Tu’un Savi (mixteco) de Alcozauca de Guerrero”. In Francisco Arellanes and Lilián Guerrero (eds.), *Estudios lingüísticos y filológicos en lenguas indígenas mexicanas. Celebración por los 30 años de Seminario de Lenguas Indígenas*. Instituto de Investigaciones Filológicas, Universidad Nacional Autónoma de México.
- TIBURCIO CANO, GREGORIO 2017. *La flexión verbal del me’phaa de Zilacayotitlán*: CIESAS MA thesis.
- TRANEL, BERNARD 1995. “On the status of universal association conventions: evidence from Mixteco”. In J. Ahlers, L. Milmes, J. Guenter, B. Kaiser and J. Namkung (eds.), *Proceedings of the Berkeley Linguistics Society* 21, 299-312.
- TRANEL, BERNARD 1996. “Rules vs. constraints: a case study”. In J. Durand and B. Laks (eds.), *Current trends in phonology: models and methods*, 711-30. Paris: CNRS, and Salford: University of Salford.
- UCHIHARA, HIROTO 2016. “Tone and registrogenesis in Quiaviní Zapotec”. *Diachronica* 33(2): 220-254.
- UCHIHARA, HIROTO & AMBROCIO GUTIÉRREZ 2019. “El texto Don Crescencio: ilustración del sistema tonal del zapoteco de Teotitlán del Valle”. *Tlalocan* 24: 127-155.
- UCHIHARA, HIROTO & AMBROCIO GUTIÉRREZ 2020. “Subject and agentivity in Teotitlán Zapotec”. *Studies in Language* 44(3): 548-605
- UCHIHARA, HIROTO & GREGORIO TIBURCIO CANO 2020. “A phonological account of Tlapanec (Mè’phàà) tonal alternation”. *Journal of Linguistics* 56(4): 807-863.

- UCHIHARA, HIROTO & JUANA MENDOZA RUIZ 2022. “Minimality, maximality and perfect prosodic word in Alcozauca Mixtec”. *Natural Language & Linguistic Theory* 40: 599-649
- VILLARD, STÉPHANIE 2015. *The phonology and morphology of Zacatepec Eastern Chatino*: University of Texas, Austin PhD thesis.
- WANG, LEI, CARLOS GUSSENHOVEN & JIE LIANG 2020. “How to pronounce a low tone: A lesson from Kaifeng Mandarin”. *Journal of the International Phonetic Association* 50: 199-219.
- WOODBURY, ANTHONY 2019. “Conjugational double-classification: The separate life cycles of prefix classes vs. tone ablaut classes in aspect/mood inflection in the Chatino languages of Oaxaca, Mexico”. In Enrique Palancar, Matthew Baerman & Timothy Feist (eds.), *Inflectional class complexity in the Oto-Manguean languages*. *Amerindia* 41: 75-120
- YIP, MOIRA 2002. *Tone*. Cambridge, UK: Cambridge University Press.
- ZEC, DRAGA & ELIZABETH ZSIGA 2010. “Interaction of tone and stress in Standard Serbian”. In Wayles Browne, Adam Cooper, Alison Fisher, Esra Kesici & Nikola Predolac (eds.), *Formal Approaches to Slavic linguistics (FASL)* 18, 536-555. Ann Arbor, MI: Michigan Slavic Publications.
- ZHANG, JIE 2001. *The effects of duration and sonority on contour tone distribution*: University of California, Los Angeles PhD thesis.
- ZIMMERMANN, EVA 2018. “Being exceptional is being weak: tonal exceptions in San Miguel el Grande Mixtec”. In Gillian Gallagher, Maria Gouskova & Sora Yin (eds.), *Proceedings of the Annual Meetings on Phonology 5*, Washington, DC: Linguistic Society of America. doi:10.3765/amp.v5i0.4240.
- ZIMMERMANN, EVA To appear. “Non-concatenative morphology”. In Peter Ackema, Sabrina Bendjaballah, Eulàlia Bonet, and Antonio Fábregas (eds.), *The Wiley Blackwell companion to Morphology*. Malden, MA: Wiley Blackwell.
- ZSIGA, ELIZABETH & DRAGA ZEC 2013. “Contextual evidence for the representation of pitch accents in Standard Serbian”. *Language and speech* 56(1). 69-104.