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Harmonizing Tonal Representation: An In-Depth Analysis of Models in Tonal Linguistics

Research Article

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Abstract

In the realm of tonal representation, considerable strides have been taken in the past few decades. Yet, a consensus remains elusive on a number of pivotal questions, including (1) the defining characteristics of a tonal language, (2) the elemental attributes of tones, (3) the identification of the tone-bearing unit, (4) the nature of tonal features as binary or privative, (5) the optimal representation of contour tones, and (6) the arrangement of register and tone features. This review paper embarks on an exploration of the diverse models that have significantly contributed to the abstract representation of tone. By examining the similarities and differences among these models, we aim to expand our comprehension of tonological studies and illuminate pathways for the future investigation of tone and tonal systems.

Keywords: tonal representation, primitive features, tone-bearing unit, feature value, feature geometry

1. Introduction

Tone, a distinctive feature of language, plays a crucial role in the sound systems of many of the world's spoken languages. It has garnered significant attention due to its prevalence, estimated at around 50% (Hyman 2011:198) or even as high as 60-70% (Yip 2002:1) among the world's languages. This distinctive linguistic phenomenon exhibits a highly areal distribution, encompassing regions such as Sub-Saharan Africa, south-central Mexico, East and Southeast Asia (Pike 1948; Wang 1967; Yip 2002; Hyman 2011), as well as parts of Amazonia and New Guinea (Donohue 2005; Hyman

2011). Tone behaves uniquely compared to other components of morphemes (Yip 1980:9) and the traditional suprasegmentals, namely, length and stress (Hyman 2011:517). It has been characterized as exceptionally versatile, with Yip (2002:65) summarizing five key characteristics, including mobility, stability, one-to-many, many-to-one, and toneless syllables. Hyman (2011:517) further adds depth to this versatility by proposing five properties of tone, encompassing syntagmatic, paradigmatic, ambiguous, abstract, and autosegmental aspects.

Given the typological diversity and versatility of tonal phenomena, substantial progress has been achieved over the past several decades, both in documenting tonal languages and in developing phonological theories to provide a comprehensive account of these phenomena. Various models have emerged to represent tonal features in Asian tonal languages (e.g., Wang 1967; Woo 1969; Yip 1980, 1989; Bao 1990; Duanmu 1990; Chang 1992; Fu 1995) and African tonal languages (e.g., Maran 1971; Halle & Stevens 1971; Clements 1981; Hyman 1993). The study of tone has significantly influenced the history of phonology and continues to contribute to our broader understanding of languages (Hyman, 2011).

However, despite the substantial body of work dedicated to the development of phonological theories for analyzing tone systems, a consensus remains elusive on fundamental issues. These unresolved questions encompass (1) the definition of a tonal language, (2) the identification of primitive features of tones, (3) the determination of the tone-bearing unit, (4) the characterization of tonal features as binary or privative, (5) the representation of contour tones, and (6) the arrangement of register and tone features. For instance, the definition of a tonal language varies among linguists, with varying criteria proposed by scholars such as Pike (1948), Gandour (1977), Yip (2002), Hyman (2006, 2011), and Maddieson (2013).

Moreover, as illustrated in Table 1, twelve influential tonal models exhibit substantial variations in terms of the number of tonal features, pitch levels, registers, register features, and pitch features. For instance, the number of tonal features ranges from a minimal 1 (Hyman 1993) to an elaborate 7 (Wang 1967), while the capacity to distinguish pitch height varies from 3 (Maran 1971; Halle & Stevens 1971) to an extensive 9 (Duanmu 1990; Hyman 1993). This diversity of approaches underscores the need for a comprehensive review to assess the state of the field and address these critical questions regarding tonal representation. This review aims to shed light on the various models and their implications for our understanding of tonal languages, paving the way for future research in this dynamic and evolving domain.

Table 1. Comparisons of different models for tonal feature representation

Model	Feature number	Level number	Register number	Register feature	Tone feature
Wang, 1967	7	5	1	[high], [central], [mid], [contour], [rising], [falling], [convert]	
Woo, 1969	3	5	1	[high], [low], [modify]	
Maran, 1971	2	3	1	[raised F0], [lowered F0]	

Halle & Stevens, 1971	2	3	1	[stiff], [slack]	
Yip, 1980	2	4	2	[upper]	[high]
Clements, 1981	2	4	2	[high]	[low]
Yip, 1989	2	4	2	[upper]	[raised]
Bao, 1990	2	4	2	[stiff]	[slack]
Duanmu, 1990	4	9	3	[stiff], [slack]	[above], [below]
Chang, 1992	3	4/6	2	[stiff]	[constricted glottis], [spread glottis]
Hyman, 1993	1/2	9	3	[high], [low]	[high], [low]
Fu, 1995	2	5	3	[high], [low]	[high], [low]

The phenomenon of tone in language presents a rich tapestry of variation and complexity. Attempting to distill this diversity into single, definitive answers to crucial questions may be an elusive pursuit. Nonetheless, it is paramount to advance our understanding by scrutinizing the various influential models, assessing their points of divergence, and identifying areas of convergence with respect to fundamental and representational challenges. This review paper undertakes the task of examining existing studies in the field of tonal representation with the aim of shedding light on how to appropriately handle tone and tonal systems in future research.

2. What are the primitive features of tones?

The quest to uncover the fundamental building blocks of tonal representation has led to a myriad of proposed distinctive features. Yet, questions persist regarding what constitutes the primitive features of tones, the requisite number of features for a comprehensive account, and the boundaries within which pitch levels and registers can be delineated.

Traditionally, the phonetic characterization of tone has been considered straightforward, with a monodimensional representation of pitch level. Many early proposals embraced this single parameter to elucidate various tonal distinctions, as seen in works like Wang (1976) and Woo (1969). However, the relative and variable nature of pitch has given rise to theoretical and practical challenges in tonal analysis, as noted by scholars like Pike (1948), Anderson (1978), Hyman (2011), and Fox (2000). For example, the same mid-tone may be specified as either [-high, +mid, -low] or [-high, -mid, -low]. It is against this backdrop that the concept of register was introduced in later models as a part of the distinctive feature set for tonal representation.

Various models can be categorized into a one-register system (e.g., Wang 1967; Woo 1969; Halle & Stevens 1971; Maran 1971), a two-register system (e.g., Yip 1980, 1989; Clements 1981; Bao 1990; Chang 1992), and a three-register system (e.g., Duanmu 1990; Hyman 1993; Fu 1995). In the one-register system, tonal features were incorporated within the feature matrix of vowels. In multi-register systems, different features for tones were structured hierarchically and separated from their associated units on a different tier. Register features were also introduced to encode the articulatory relationship between tonal pitch and segments. Concerning the relationship between tonal (pitch)

features and register features, four distinct patterns emerged: (1) register and tone are represented by different features with no overlapping (e.g., Yip 1980, 1989); (2) register and tone are represented by the same features with overlapping allowed (e.g., Hyman 1993); (3) register and tone are represented by the same features with no overlapping (Fu 1995); and (4) register and tone are represented by different features with overlapping allowed (e.g., Duanmu 1990).

However, the specific features involved vary across models, and the term "register" holds different meanings in the context of tonal studies. It can refer to voice quality distinctions such as creaky, breathy, and modal voicing for differentiating between phonation-type-based register languages and pitch-based tone languages. For instance, Fu (1995) and Zhu (2012) consider register in this context. Pike (1948) uses the term "register" to differentiate between a register system and a contour system in tonal languages, where register refers to level tone. Yip (1980) adopts this term to signify the subdivision of the tonal space into [+upper] and [-upper] registers. Register features, in conjunction with tone features (pitch height and/or pitch contour), create a hierarchical system to provide a formal account of tonal representation within the generative paradigm, especially within the autosegmental framework.

Furthermore, a consensus remains elusive regarding the number of contrastive pitch levels required (four, five, or nine) and the distinction of registers (two or three). The diversity of tonal systems across linguistic regions presents a challenge to the development of a unified interpretation. Wang (1967), for instance, employs three level features—[high], [central], and [mid]—to distinguish up to five tone heights, despite their functional differences. Bao (1990) and Yip (1980) employ articulatory features of [stiff] and [slack] to generate four levels of tone. Duanmu (1990) uses features [stiff] and [slack] to identify three different registers, further subdivided into three degrees of tone height with [above] and [below]. In his model, up to nine contrastive levels of tone can be produced. Hyman (1993) also distinguishes at least nine levels of tone but employs a different set of features.

3. How are contour tones represented?

The presence and distribution of contour tones significantly contribute to the typological categorization of tonal languages. In East Asia, contour tones are noted to occur as freely as level tones, with contour tones typically attached to the first tone-bearing unit. In contrast, most African languages are reported to possess contour tones only on the final tone-bearing unit of a domain, as observed in works by Pike (1948), Wang (1967), Yip (1989, 2002), and others.

This typology gives rise to intriguing questions about how contour tones can be abstractly represented. Wang (1967) suggests incorporating the [contour] feature into the feature system to distinguish stationary from non-stationary tones. Three additional features—[+rising], [+falling], and [+convex]—are introduced for tones specified as [+contour], allowing for the contrast of up to eight distinct contour tones in his model. Bao (1990) includes a contour node in his feature geometry to capture how tone behaves concerning the temporal duration of its bearing unit, specified by the laryngeal feature [slack].

Conversely, Woo (1969:78) challenges Wang's proposed features for contour tones and advocates considering ordering features. She treats dynamic tones as the "diphthongs" of the tone sets, arising from transitions between one level to another. Woo's perspective finds support among later scholars

such as Leben (1973), Goldsmith (1976), and Duanmu (1990), who express contour features in terms of sequences of level tones.

This introduction outlines the multifaceted nature of tonal representation, from the primitive features of tones to the representation of contour tones, emphasizing the ongoing discourse and the need for a comprehensive review to elucidate the complex dynamics within the field of tonal linguistics.

4. How are tonal features defined?

Defining tonal features is a pivotal aspect of tonal representation, with various models offering distinct perspectives based on perceptual, articulatory, and acoustic considerations.

4.1 Perceptual features

Many scholars have anchored their tonal features in the perceptual dimension of pitch. However, terminologies and reference levels vary considerably among these models. For instance, Yip (1980) introduces [upper] and [low], while Duanmu (1990) employs [above] and [below]. Wang (1967) delineates five pitch levels using [high], [mid], and [central] but introduces [contour], [falling], [rising], and [convex] for different pitch contour shapes.

The challenge lies in determining the reference level that reflects the relative nature of tonal categories. Yip (1980) splits the tonal space into two halves by introducing perceptual register [upper], further dividing each half by [high]. Duanmu (1990) utilizes [above] and [below] with the initial onset as the reference point, while Hyman (1993) and Fu (1995) apply [high] and [low] concerning the neutral pitch reference. Achieving a unified definition through the perceptual dimension remains elusive due to these variations.

4.2 Articulatory features

Articulatory features come into play to encode physiological correlations between tonal and segmental production, primarily to account for the relationship between vocal cord states and pitch levels. Halle and Stevens (1971) employ laryngeal features [stiff] and [slack] to specify three pitch levels based on vocal cord tension, distinguishing between [+stiff, -slack] indicating high pitch on a vowel with no voicing on a consonant and [+stiff, +slack] signifying low pitch on a vowel with no voicing on consonants. Zhu (2012) classifies three registers in terms of phonation types: falsetto, voiceless, and breathy phonation.

Nevertheless, consensus remains elusive regarding the physiological correlations between tones and segments. Halle and Stevens (1971) link pitch production with vocal cord tension states, while Duanmu (1990) correlates it with vocal cord thickness. Bao (1990) attributes register [stiff] to the cricothyroid muscle's action and associates tone feature [slack] with vocalis muscles' laryngeal activities. Chang (1992) introduces [stiff] to specify the correlation between tonal register and voicing of syllable onsets and employs [spread glottis] and [constricted glottis] to indicate different glottal statuses. Thus, articulatory definitions of tonal features remain open to interpretation, despite the widespread use of laryngeal terminologies.

4.3 Acoustic features

Although tonal features can be defined based on measurable parameters, this approach is less frequently employed in tonal feature specification due to the high variability and speaker-dependence of acoustic correlates like fundamental frequency (F0). Maran (1971) is one of the few scholars to adopt acoustically-based features, using [raised F0] and [lowered F0] to represent tones in African languages. The reluctance to employ an acoustically-based definition stems from its inability to capture the intricate phonetic mechanisms behind tonal production and the complex physiological correlations between pitch and other laryngeal features of segments.

5. Are tonal features binary or privative?

Tonal features, like other distinctive features in phonology, can be assigned binary values (presence or absence) in specific entities. Two primary approaches are evident in the literature.

Binary Values: Most models, including Wang (1967), Woo (1969), Yip (1980, 1989), Clements (1981), Hyman (1993), Bao (1990), Duanmu (1990), and Chang (1992), consider tonal features to be binary, with both values "+" and "-" actively participating in tonal contrasts. For example, high and low tones are represented as [+high] and [-high] (Yip 1980; Hyman 1993) or [-slack] and [+slack] (Halle & Stevens 1971; Bao 1990). This binary approach allows for a theoretical status similar to segmental features and enables the same rule application machinery developed for segmental features to be employed.

However, some argue that binary treatments can be overly generative and indeterminate, potentially over-predicting the number of contrastive pitch levels. For instance, Duanmu (1990) is said to generate more pitch levels than observed cross-linguistically.

Privative Values: Other scholars, such as Clements (1985), Hyman (1978), and Fu (1995), suggest privative features for a more streamlined explanation. They contend that only the positive value can serve a linguistic function, while the negative value appears extraneous and phonologically inert. Fu (1995) eliminates negative values in his model, specifying high tone/register as [high] and low tone/register as [low], with no feature specified for the neutral tone/register. Hyman (1993) defines various features for tonal representation as binary but functionally privative.

The choice between binary and privative values depends on factors like the tonal system being studied (African or Asian), the inventory of tonal contrasts, and the construction of the feature geometry.

6. What is the tone-bearing unit?

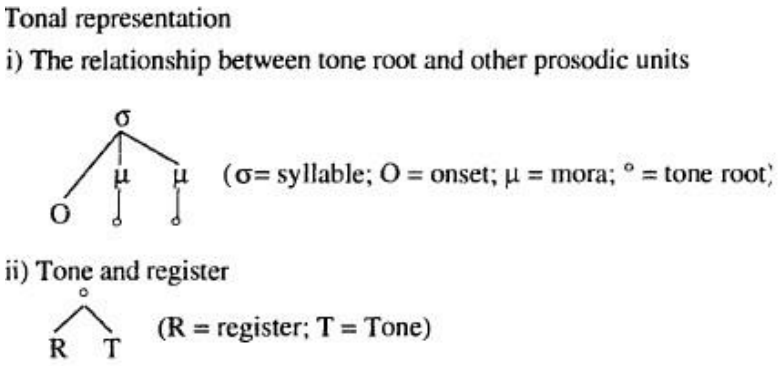
The question of what constitutes the tone-bearing unit (TBU) has received different answers in the literature, with various proposed units including the mora, syllabic segment, syllable, and morpheme.

For example, Woo (1969) adopts a segment as the domain of tonal features, while Wang (1967) considers the TBU to encompass the entire voiced portion of the syllable rather than being confined to a single segment. Halle and Stevens (1971) argue that the voicing of the obstruent and vowel constitutes the TBU in a tone, with the tone feature on a vowel being automatic. Duanmu (1990) supports the lexical representation of tone on a moraic segment, while Bao (1990) posits that the tonal feature may be aligned on a larger prosodic category, such as the entire phrase in Tangsic.

The issue of what domain a tonal feature aligns with at the underlying level is complex and may trigger various theoretical constraints to achieve an economical and adequate account of tonal representations. This includes considerations of how many tones a TBU can take, the tone-bearing ability of a TBU, constraints on contour tones, accommodation of tonal contour complexity, and the interplay between rhyme structure, tonal contour complexity, and the TBU.

The views on how many tones a TBU may bear also vary, with some arguing that a TBU can carry just one tone, while others propose that there is no universal upper limit to the number of tones a TBU may bear. The determination of the TBU and its tone-bearing capacity has implications for the analysis of tone in diverse linguistic contexts.

Figure 1. The relationship between tone root and other prosodic units in Fu (1990)'s system

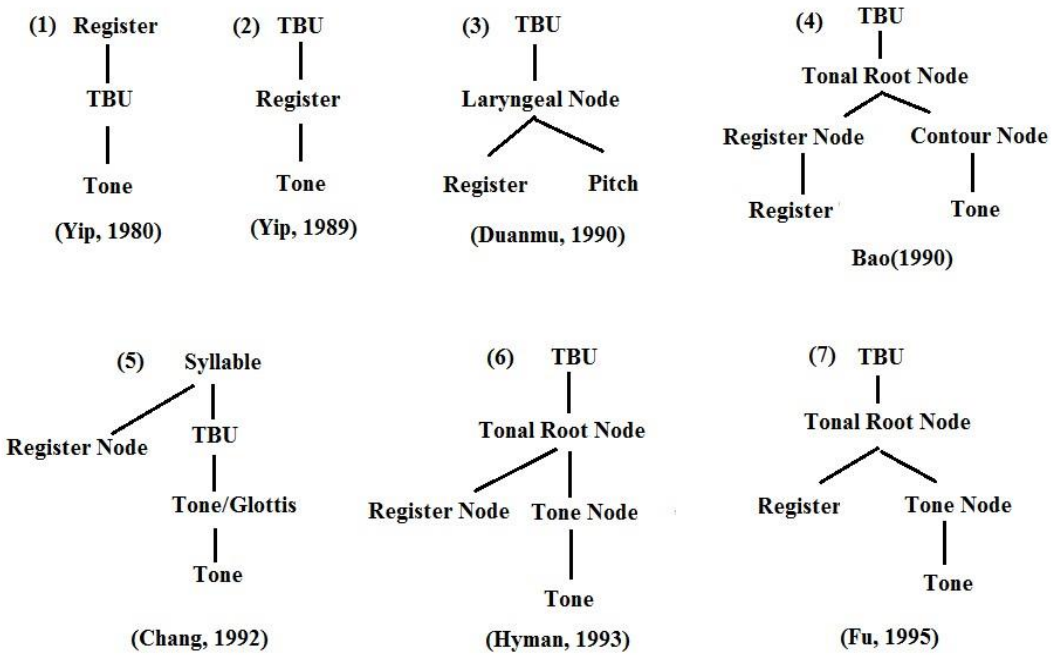


7. How are register and tone features arranged?

Traditionally, speech production has been perceived as a sequential, linear process within classic generative phonology. However, the advent of autosegmental phonology and feature geometry has led to a shift in the arrangement of distinctive features. These features are now considered to be organized hierarchically in a tree-like internal structure rather than being stored in a simple matrix (McCarthy 1988; Clements 1985).

The introduction of the register feature by Yip (1980) to encode the correlation between tones and segments marked the beginning of attempts to construct a feature geometry for tonal representation. Nevertheless, a consensus on how to structure the relationship between "register" and "tone" remains elusive, resulting in significant variations in the internal structures of feature geometry trees, as summarized in Figure 2. This lack of consensus leads to diverse approaches in the representation of register and tone features, reflecting ongoing debates in the field of tonal linguistics.

Figure 2. Comparison of the internal structures of different tonal models



8. Discussion

The widespread occurrence of tone in the world's languages and the significant contributions made to our understanding of tonal phonology have raised several interrelated questions regarding the establishment of tonal representation. These questions remain open, and the tentative answers provided are subject to revision. Furthermore, the physiological relations between segmentals and suprasegmentals can challenge the representability of existing models.

A comprehensive model is expected to address the overall economy of tonal systems and handle various tonal issues. These issues include the determination of the number of pitch heights and registers, the definition and value of tonal features, the specification of a tone-bearing unit, and the relationship between tone and register. Such a model should reflect the phonetic reality of tone as a crucial linguistic category and provide an adequate and elegant account of it.

While a single, definite model for representing tone may not be achievable due to the diversity and typology of tonal phenomena in natural languages, it is essential to extend our understanding of how influential models differ from one another and where they share common ground. This paper aims to shed light on the proper treatment of tone and tonal systems in future research, helping to advance our knowledge of this complex aspect of linguistic structure.

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Bio-note:

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