

# A TYPOLOGICAL STUDY OF THE INTERACTION BETWEEN LEVEL TONES AND DURATION

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## ABSTRACT

It has often been claimed that vowel duration tends to be inversely related to approximate average  $f_0$  cross-linguistically. In this study, we test the empirical adequacy of this observation by conducting a rigorous typological survey of sound patterns involving level tones and duration. Our data reveals a robust negative correlation between tone height and duration (i.e. the lower the tone, the longer the duration). Counter-examples are explained away as the results of mismatch between phonological representation and phonetic realization or inadequate phonetic information.

**Keywords:** tone, duration, typology, sound change

## 1. INTRODUCTION

Beyond differences in fundamental frequency ( $f_0$ ) height and contours, tonal contrasts in the world's languages are often accompanied by systematic differences in duration and phonation. It has been observed that there is a cross-linguistic tendency for vowel duration to be inversely related to the approximate average  $f_0$  [4]. Much discussion has focused on vowels bearing rising tones being longer than those with falling or level tones [4, 6, 7, 21]. Of particular interest here is the observation that vowels bearing low tones are phonetically longer than those with high tones [4]. The negative correlation between tone height and duration is not without exception, however. Shanghainese is reported to have shorter low tone syllables than high and mid tone syllables [20]. A particularly puzzling case is found in Cantonese, which has been claimed that, among the level tones in the language, the syllables with mid level tone (33) are the longest, syllables with the mid-low level tone (22) are intermediate, and syllables with the high level tone (55) are the shortest [10]; of the six tones in Cantonese, the longest is the low-mid to high rising tone (25). These counterexamples cast doubt on the validity of Gandour's typological claim about the relationship between tone height and duration.

In this study, we conduct a rigorous typological survey of patterns of duration-tone interaction.

As there already exist comprehensive surveys of the interaction between contour tone and duration [6, 7, 21], the present survey will focus on the interaction between level tone and duration. Our typological sample indicates that there are two main patterns of interaction between level tones and duration:  $L > H$  and  $H > L$ , where  $>$  stands in for "has a longer duration than." The majority of the sample confirms [4]'s typological claim that syllables with low tone tend to be longer in duration than syllables with high tone (i.e.  $L > H$ ). A minority (roughly a third) of our sample shows the opposite pattern; that is, syllables with high tone are longer than syllables with low tone in certain languages.

The structure of this paper is as follows. We begin with a presentation of the methodology for the construction of the typological database in Section 2.. Section 3. reports the general results of the survey, including presentations of representative languages that illustrate the typological patterns observed. Section 4. discusses potential reasons for the opposing typological patterns. Section 5. concludes with a discussion of the limitations of the present study as well as possible explanations for why the typological patterning of the interaction between level tone and duration is so skewed.

## 2. Methodology

For the sample that forms the basis of this survey, we assembled descriptions of 26 tone languages drawing from either clear impressionistic evaluations of duration-tone interaction or (preferably) instrumental confirmation of such an interaction (see Table 1). Judgments of relative length based on pitch tracks that were not normalized for time but were otherwise left undescribed were counted as impressionistic. We took as a starting point the selection of language descriptions listed in the World Atlas of Language Structures Online (WALS) [12, 8] and added other relevant descriptions not originally in the base sample such that they roughly maintained the sample's genetic balance (see Figure 1).

Descriptions were deemed acceptable for inclusion in the sample if the languages being described limit tone to a domain no larger than the syllable.

This ensures that the phonological tones under analysis are, in fact, dispensed with only over a single syllable, where vowel duration can easily be measured, rather than over an entire word or phrase, where phonetic effects are vastly more difficult to characterize *en masse*. As a result, the sample favors “lexical tone” languages to the exclusion of “pitch-accent” languages; entire families present in the sample in WALS [12], such as Japonic and Algonquian, were eliminated due to a tendency toward broad tonal domains. The one exception to the domain restrictions, Lhasa Tibetan, has word-level tone [2]; however, the instrumental descriptions consulted in classifying it within the sample measure the phonetic realization of tone over only monosyllabic words.

In analyzing the chosen descriptions we followed several additional criteria pertaining to the tones in the languages under consideration. Tones accompanied by differing phonation manners were not compared to one another to avoid potentially confounding effects on duration. Comparisons of tones across different syllable types (e.g., closed syllables and vowels of differing phonological length) were avoided, especially when examined in isolation. Additionally, if a language was found to lack multiple level tones, it was excluded from analysis. This unfortunately eliminates from consideration a large number of tone languages with deep phonetic documentation: languages such as Vietnamese and Standard Mandarin do not have more than one level tone for comparison. Tone languages also possessing contrastive stress were *not* excluded from the sample if the effects of stress could be controlled for.

### 3. RESULTS

The resulting sample contains 26 phonetic descriptions of tone-duration interaction in a diverse set of small-domain tone languages. We sort these into two categories based on the nature of the tone-duration interaction:  $L > H$  and  $H > L$ , as discussed above. A majority of languages analyzed fell into the group with phonetically longer low tones, while the remainder had the opposing interaction between tone and duration with varying degrees of regularity.<sup>1</sup> A detailed discussion of each group follows.

#### 3.1. $L > H$

The  $L > H$  languages show a negative relationship between vowel duration and  $f_0$ . A wide range of tonal systems are seen to follow this pattern. Zulu (Niger-Congo), for instance, with a simple H/L tonal opposition, slightly (10–20 ms) lengthens a vowel bearing a low tone following a depressor consonant, which induces low tone on the following vowel

**Table 1:** Sample by tone-duration interaction type. Impressionistic descriptions are marked with an asterisk (\*). Phonetic contour of phonemic level tones is marked with a dagger (†).

Language	Family
<b>H &gt; L</b>	
Chinantec (Palantla)*†	Otomanguean
Mambila†	Niger-Congo
Navajo	Na-Dené
Xiamen†	Sino-Tibetan
Yoruba†	Niger-Congo
Yucatec Maya†	Mayan
<b>L &gt; H</b>	
!Xóõ*†	Khoi-San
Bai	Sino-Tibetan
Burmese*†	Sino-Tibetan
Cantonese†	Sino-Tibetan
Dinka	Nilo-Saharan
Gwich'in*†	Na-Dené
Hu	Mon-Khmer
Kam (Gaoba)	Tai-Kadai
Khmu'	Mon-Khmer
Khoekhoe*†	Khoi-San
Mixtec (Chacaltongo)	Otomanguean
Otomi (Mezquital)*	Otomanguean
Phlong*	Tibeto-Burman
Picuris*	Kiowa-Tanoan
Punjabi*†	Indo-European
Tahltan	Na-Dené
Thai	Tai-Kadai
Tibetan (Lhasa)†	Sino-Tibetan
Zapotec (Choapan)†	Otomanguean
Zulu	Niger-Congo

[16]. Punjabi (Indo-European), with a system of three level tones, follows the  $L > H$  relationship, with L longer than M and M longer than H [5]. A more extreme case can be found in Gaoba Dong (Tai-Kadai): instrumental analysis of the language’s five level tones (evenly spaced at 55, 44, 33, 22, and 11) in isolated monosyllables demonstrates that each tone level is phonetically shorter than the next highest level by 30–40 milliseconds, although the high tone is roughly 100 milliseconds shorter than the second-highest tone [17].

A highly regular and gradient interaction between duration and tone height—duration moving from longest to shortest as one progresses from the lowest to the highest tone level—is typical of the  $L > H$  group. Also typical to some extent is a larger inventory of contrastive tones with more phonemic contours. A rough average of the contrastive tones in a  $L > H$  language is 3.95, as drawn from the phonemic analyses of our source descriptions, and the average number of phonemic contours in this group is 0.95. (Compare the  $H > L$  group, which has an average of 3.67 tones and 0.83 contours per language.)

**Figure 1:** Sample by genetic affiliation.

Sino-Tibetan	6
Otomanguean	4
Na-Dené	3
Niger-Congo	3
Khoi-San	2
Mon-Khmer	2
Tai	2
Indo-European	1
Kiowa-Tanoan	1
Maya	1
Nilo-Saharan	1
<b>Total</b>	<b>26</b>

### 3.2. H > L

The H > L languages show a positive relationship between vowel duration and  $f_0$ . One language exemplifying this, Yucatec Maya (Mayan), has contrastive high and low tones on long vowels; high-toned long vowels have a duration greater than that of low-toned long vowels by roughly 15 milliseconds [3]. Another example, Mambila (Niger-Congo), has four level tones (H, L, and two mid tones that differ little in  $f_0$ ); instrumental measurements show that although H and the pair of mid tones do not differ much in duration amongst themselves, they are consistently longer than the low tone [1].

The latter example, in which an expected additional lengthening of the high tone does not occur, underscores the fact that the positive relationship between duration and  $f_0$  is not as neatly linear for the H > L languages as for the L > H languages. Yucatec Maya itself has an additional tone, high, long, and glottalized, that is in fact longer on average than the modally-voiced H tone, despite the fact that one might expect shortening in a checked tone. As noted above, the H > L group also tends to have a somewhat smaller tonal inventory that involves fewer contours.

## 4. DISCUSSION

The sample above demonstrates that a negative relationship between the  $f_0$  of phonemically level tones and their duration is pervasive, but not universal, in the world's languages. Upon closer inspection, however, certain regularities strongly suggest that many of the languages of the H > L group might be in need of reclassification within our typology. That is, the so-called “level” tones in the H > L languages might be phonetically quite dynamic (and might be better analyzed as contour tones), and that others in this group can be ruled out from representing a counter-universal tendency due to interference from stress

phenomena. Taking these caveats into account, what remains in our sample leaves the L > H pattern as the universally observed tendency.

While not all of the languages realize their phonemically level tones as phonetic contours (one H > L and 10 L > H are not stated to have phonetic contours), many do, and there is a marked tendency for H > L languages to have a low “level” tone that is in fact phonetically falling. Three of the languages in question—Palantla Chinantec, Mambila, and Xiamen—exhibit a low-falling tone for phonemically level low tones [14, 1, 19], and Yoruba additionally realizes phonemic low tones as phonetic low-falling tones in the word-final environment used in our sample's source [9]. Yucatec Maya has a phonetically falling high tone, which has, as would then be expected, a greater duration than its level low tone [3]. Palantla Chinantec additionally exhibits an overlong high tone, phonetically rising-falling, and a considerably less dynamic low tone [14].

The findings reviewed thus suggest that the H > L languages as a group might be better treated as consisting, for the most part, of comparisons between level and contour tones, and thus should not be expected to follow the canonical tone-duration interaction pattern. Even after ruling out *any* language that exhibits phonetic contour in its tonal system, it is notable that 10 of the 11 remaining languages are L > H (see Figure 1). Furthermore, Navajo, the only H > L language in the sample that makes a comparison between phonetically level tones, may be affected by a “strategy to preserve marked information” closely approximating stress in its effect on phonetic duration, since the Navajo H tone is noticeably low-frequency in use [13].

## 5. CONCLUSIONS

In this study, we have conducted an in-depth survey of the phonetic and typological literature concerning the interaction between tone height and duration. The typological data strongly support the observation that low-toned syllables tend to be longer than high(er)-toned syllables. Languages described as H > L may be reanalyzed either as exhibiting a mismatch between phonological description and phonetic realization or as exhibiting phonetic interference from stress. This last caveat highlights the inherent difficulties in conducting research in phonetic typology. The evidence amassed in this survey should be treated with care since a sizable minority of the descriptive reports were based on impressionistic judgments. Even in those studies that provided instrumental data, the acoustic evidence was by and large not collected for the purpose of inves-

tingating the relationship between tone and duration, and thus the observed duration differences might be confounded by various influences not accounted for here (e.g., list effect in elicitation, segmental or contextual influences, intonational focus, etc.).

A particularly telling example comes from Cantonese. From the perspective of the present typology, Cantonese represents a curious outlier as it has been shown to have longer mid level tone than high and low level tones [10]. Yet, despite the fact that the evidence comes from a study designed to investigate how tone influences vowel duration, there remain serious questions regarding the soundness of the methodology used in that study. To begin with, the author only investigates the production of three subjects, one of whom is the author himself, who speaks a different variety of Cantonese than the other speakers. The target syllables are also embedded in a fixed carrier phrase. Given the substantial amount of tonal coarticulation in Cantonese, this raises questions as to whether the anomalous tone-duration correlation seen in this study might be confounded by the effect of tonal coarticulation. A similar coarticulatory effect may be visible in data on Xiamen, where all “level” tones can be seen to be phonetically falling due to a tonal elicitation environment preceded by a high tone and followed by a low tone [19]. Clearly, more careful phonetic studies must be undertaken to validate the empirical soundness of the typological tendencies concerning tone-duration interaction. This study thus represents only a beginning, rather than the definitive work on this issue.

Before closing, it is worth noting that the reason for the negative correlation between tone height and vocalic duration is not yet clear. This may be a general psycho-physiologically based propensity characteristic of the human perceptual system [15, 11]. It has also been suggested that the negative correlation between tone height and duration might be the result of compensatory lengthening as a strategy to achieve perceived duration equality between syllables with different tones [18]. However, it remains unclear what underlies the perceived duration differences in the first place.

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<sup>1</sup> There are a few outliers that do not fit neatly into these two groups. We discuss these in Section 5.