

# INTERPRETATION OF LH INTONATION CONTOUR IN URDU/HINDI

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## ABSTRACT

This research investigates the nature of the LH intonation contour in Urdu/Hindi as pitch accents vs. phrasal tones. Data from a production experiment and a speech corpus was used to analyze if the tones aligned with the lexically stressed syllables or word edges in nouns with one, two, and three syllables. The results indicate that the stress based account predicts the alignment of low tone only in bisyllabic words. But in trisyllabic words, the low tone prefers to align with the left word edge than with the stressed syllables. The high tone prefers to align with the edge of the target noun (phrase) and not with the stressed syllable. Therefore, it is proposed that the LH tones in Urdu/Hindi are phrase boundary tones and occur at the edges of phrases. This provides evidence for [6]’s claim that Urdu/Hindi is an intonational ‘Phrase language’ and the LH tones mark the left and right edges of a phrase respectively.

**Keywords:** intonation, LH contour, intonation phrase languages, Urdu, Hindi

## 1. INTRODUCTION & LITERATURE REVIEW

The default intonation contour in Urdu/Hindi is a series of LH contours [10, 17, 20]. The final tone at the end of a sentence varies according to modality. Declaratives have a low falling tone (L%) [20] whereas the polar questions generally have a high rising (H%) boundary tone [2]. There have been a lot of studies on Urdu/Hindi intonation aiming to investigate the prosodic hierarchy and its interaction with syntax and pragmatics [4, 6, 7, 8, 9, 10, 14, 17]. However, there is lack of agreement about the interpretation of the basic LH contour. [10] poses questions about the precise interpretation of these low and high tones. He himself does not reach a definitive conclusion and sets out three possible ways of interpreting this contour: an accentual phrase with a lexically specified LH contour, L\* pitch accent followed by an H- phrase boundary, and a bitonal L\*+H/L+H\* pitch accent. As there is no evidence in existing literature to indicate that the tones in Urdu/Hindi are lexically specified, this analysis is ruled out. The

viable alternatives are the bitonal pitch accent and a pitch accent followed by a phrasal boundary tone. Interestingly, [10] did not consider the possibility of these tones as monotonal L\*/H\* pitch accents. In at least one discussion of Urdu intonation, [12] interpreted the low F0 on stressed syllables as L\*. He also reported the occurrence of H\* when the last syllable in a word was stressed. However, it was beyond the scope of [12] to determine the precise nature of those pitch accents, so the issue remains unresolved.

An alternative proposal regarding the interpretation of these tones was forwarded by [6] who claimed that Urdu/Hindi is an intonational ‘Phrase language’. She claims that the L and the H tones in the default LH contour mark prosodic phrase boundaries on the left and right edges respectively. [6]’s argument is based on the observation that lexical stress in Urdu/Hindi is not systematically perceived by native speakers and may not be used to explain the nature of tones. To probe this issue further, an overview of studies regarding the realization of lexical stress in Urdu/Hindi is presented in the following section.

### 1.1. Lexical stress in Urdu/Hindi

The issue of lexical stress in Urdu/Hindi is not uncontroversial. In his investigation of the acoustic correlates of lexical stress, [5] found that focus played a major role in the production of stress in Hindi/Urdu. In fact, if the data produced in the focused context were removed from his findings, it could be argued that there was no effect of stress on the F0 and duration of target syllables. Moreover, he found that Hindi speakers’ perception of stressed syllables was barely above chance. This is in line with [19] who reported that the native speakers of Hindi could not reliably identify the location of lexical stress in polysyllabic words. Furthermore, [18] showed that the production of lexical stress in Hindi varied among words in isolation as compared with the same words produced in carrier phrases.

However, other attempts have resulted in an algorithm to identify lexical stress in Urdu/Hindi. [11] pointed out that all the earlier reports of lexical stress in Hindi relied heavily on the mora structure of the last syllable in a word. Advancing this discussion

further, [12] proposed a mora-based algorithm to identify the position of lexical stress in Urdu. According to him, the first syllable with a (super) heavy mora on the right edge of a word is stressed. He also proposed that the first mora on the right is extrametrical. If a word has only light syllables, the initial syllable is stressed. He also showed that the stressed syllables have longer vowel duration and lower F0 in Urdu. As [12]’s is the only account combining the algorithm to determine the position of lexical stress and its acoustic correlates in Urdu/Hindi, we here use his algorithm to determine the lexically stressed syllables in our data and investigate if any of the low and high tones align with this syllable.

## 1.2. Research questions

The labeling of tones in the Autosegmental Metrical framework of intonation is largely based on the alignment of accent with lexical stress. Therefore, it is interesting to investigate if the L and H tones in Urdu/Hindi align with the stressed syllable. Based on the proposals presented by [10] and [6], the current study aims to investigate the following:

1. Does one of the tones in the LH contour align with the lexically stressed syllable in a word?
  - (a) If so, how is this tone associated with the other tone in the LH contour?
2. If these tones do not align with the stressed syllable, do they align with phrase boundaries?

If one of these tones does align with the stressed syllable, it will be interpreted as a pitch accent. This will further help to interpret the unstarred tone as either a part of the bitonal pitch accent or a phrase boundary tone. However, if the LH tones mark phrase boundaries, as suggested by [6], it is expected that the tones will not necessarily align with the stressed syllable. Moreover, if they are boundary tones, the distance between L and H tones will be affected by word duration and the distance between tones and the left and right word boundaries will be relatively constant [15]. To investigate the alignment of L and H tones, we used data from a small experiment carried out in very controlled segmental environment and compared its results with the data from a larger corpus of declarative Urdu sentences. In the following sections, we report the results to interpret the LH intonation contour in Urdu/Hindi.

## 2. EXPERIMENT

### 2.1. Material & participants

In both the experiment and the corpus, the target words were placed at the sentence initial position.

For the experiment, 10 monosyllabic, 10 bisyllabic, and 10 trisyllabic proper nouns were placed in the phrase ‘— was speaking.’. The monosyllabic nouns were CVC as it is not possible to have monosyllabic proper nouns with CV structure in Urdu. All the syllables in both bisyllabic and trisyllabic words, however, were CV. The last vowel in bisyllabic and trisyllabic words was always /a/. The first syllable in bisyllabic words and the second in trisyllabic words was stressed. Henceforth, the location of stress is indicated by ‘\*’ at the beginning of the syllable. An example of the target sentences is given below.

- 3a. **ma:n** bol raha t<sup>h</sup>a
- 3b. \***ma.la** bol rahi t<sup>h</sup>i
- 3c. **sa.\*ri.na** bol rahi t<sup>h</sup>i

The selection of participants for the experiment was based on convenient sampling and two female speakers of Urdu living in Konstanz were recorded. Each speaker was recorded three times and each session was separated by at least one day. In total, 180 tokens were analyzed for this experiment.

From the corpus, I used 4 monosyllabic and 5 bisyllabic nouns followed by a monosyllabic case marker (km) as well as 5 trisyllabic nouns without a case marker. The monosyllabic nouns were CVC and the syllables in the bisyllabic nouns were CV with lexical stress on the first syllable. All the three syllables in trisyllabic nouns were also CV and the second syllable was stressed. Thus the syllabic structure and the stress pattern of target words in the experiment and the corpus were directly comparable. As [14] have shown that focus type affects the alignment of H tone in Urdu/Hindi, all the target nouns in the corpus were produced in broad focus. The participants were shown target sentences on a PowerPoint slide and asked to pronounce them as naturally as possible. 20 speakers’ data was taken from the corpus. Not all speakers provided data points in each syllable category but there was considerable overlap. All the speakers were educated multilingual Pakistanis and spoke Urdu, English, and at least one regional language from Pakistan. The participants’ age ranged between 19 - 40 years. They were paid a small remuneration for participating in the recording. The participants of the experiment had not participated in data collection for the corpus. A total of 331 tokens were analyzed from the corpus.

### 2.2. Data Analysis

The data from the experiment was analyzed using PRAAT [3]. The target words were labelled manually to mark syllable boundaries. A Praat script was used to measure the F0 minima and maxima and their

timing in the target nouns in the experiment. Only the F0 minima preceding the high tone was measured to ensure that the script extracted values for only the LH contour in the target nouns. The measurement points were manually corrected when the algorithm’s measurements were affected by microprosody. The script also measured the beginning, end, and the duration of target nouns.

To extract data from the corpus, target words were labelled manually. When the LH contour was realized over the noun and the following case marker, the duration of the full noun phrase was measured. Local minima and maxima were marked manually in the target NP to label L and H tones. While labeling tones, microprosodic perturbations were taken into account and the tones were not marked on non-sonorant segments. In order to determine the effect of word duration, the duration of the NP as well as its beginning and end were measured.

For statistical analysis, separate Linear Mixed Effects Regression models were run for the data from the corpus and the experiment using ‘lme4’ [1] and ‘lmer’ [16] packages in R [21]. The number of syllables were added as a fixed factor and the speakers and items were added as random effects.

### 3. RESULTS

#### 3.1. Experiment

The analysis of monosyllables showed a regular pattern as both the low and high tone were realized within the target noun. The alignment of tones in bisyllabic nouns is also fairly regular (Table 1). The low tone aligns with the first (stressed) syllable while the high tone mainly aligns with the final syllable, the end of the noun. There are a few instances of high tone aligning with the stressed syllable but this appears to be an exception from the norm. In trisyllabic nouns, the high tone never aligns with the stressed syllable and instead is realized on the last syllable. The low tone in this context frequently aligns with the first syllable and rarely with the stressed syllable. Thus the overall pattern in both bisyllabic and trisyllabic nouns is the alignment of low and high tones with left and right word edges respectively.

The statistical analysis of the alignment of tones from the left edge of the word shows interesting results. In monosyllabic nouns, the alignment of low tone from the left edge is slightly later ( $\mu$ : 163ms, SE: 0.02) than the bisyllabic nouns but the difference is barely significant ( $\beta$ : 03ms, SE = 0.01, t.ratio = 2,  $p = 0.04$ ). There is no difference in the alignment of low tone in words with two and three syllables.

The alignment of high tone from the right edge

**Table 1:** Percentage of the alignment of tones in nouns in the experiment.

Syl.	T.	1st syl.	2nd syl.	3rd syl.
Bi-syllable	L	*100	0	-
	H	*4	96	-
Tri-syllable	L	85	*15	0
	H	0	*0	100

of the word shows a similar pattern. The high tone in monosyllabic words occurs slightly nearer to the right edge ( $\mu$ : 9ms, SE: 0.007) than the F0 peak in bisyllabic ( $\beta$ : 2ms, SE = 0.007, t.ratio = 2.9,  $p = 0.008$ ) and trisyllabic words ( $\beta$ : 2ms, SE = 0.007, t.ratio = 2,  $p = 0.004$ ). There is no difference in the alignment of high tone in words with two and three syllables.

Moreover, the distance between tones increases with the number of syllables. The distance between L and H in monosyllables ( $\mu$ : 162ms, SE: 0.03) is narrower than the distance in bisyllabic ( $\beta$ : -8ms, SE = 0.01, t.ratio = -6,  $p < 0.0001$ ) and trisyllabic nouns ( $\beta$ : -20ms, SE = 0.01, t.ratio = -16,  $p < 0.0001$ ). The distance between low and high tones in bisyllabic nouns is narrower than the distance between tones in trisyllabic nouns ( $\beta$ : -119ms, SE = 0.01, t.ratio = -9,  $p < 0.0001$ ).

#### 3.2. Corpus study

The analysis showed that the LH contour was frequently realized over the entire NP (noun+km) with L at the beginning and the H at the end of the NP. In the monosyllabic nouns, the L tone always aligned with the beginning of the noun and the H was always realized on the km. Thus, it was not the noun but the entire NP that carried the default LH contour. It could be argued that the H aligns with the case marker in order to avoid tonal crowding on the noun. However, as shown in the production of monosyllabic nouns in the experiment above, the entire LH contour can be realized on a monosyllabic noun when the noun is not followed by a case marker. Therefore the alignment of H tone with the case marker is not motivated by tonal crowding.

The pattern of alignment in bisyllabic and trisyllabic nouns is shown in Table 2. In the bisyllabic nouns, the L tone predominantly aligned with the stressed first syllable and the H aligned mostly with the case marker, the edge of the NP. Interestingly, the alignment of L with the second syllable never coincided with the alignment of H on the same syllable. The unstressed second syllable could occasionally carry the L or the H tone but mostly, the F0 on this syllable was the interpolation between the pre-

ceding L and the following H.

In the trisyllabic nouns, the L tone aligned overwhelmingly with the first syllable of the noun but very infrequently with the lexically stressed second syllable. Moreover, the H tone rarely aligned with the stressed syllable and preferred to attach with the last syllable of the word.

**Table 2:** Percentage of the alignment of tones in the corpus data.

Syl.	T.	1st syl.	2nd syl.	3rd syl.	Km
Bi-syllable	L	*96	4	-	0
	H	*0	7	-	93
Tri-syllable	L	89	*11	0	-
	H	0	*3	97	-

The results of the regression analysis show that the alignment of low tone from the left edge is not significantly affected by the number of syllables in the target words. The distance of H tone from the right edge of the NP, however, varies on the basis of syllable count. The high tone in trisyllables is aligned nearer to the right edge ( $\mu$ : 03ms, SE: 0.01) as compared with the high tone in monosyllables ( $\beta$ : -08ms, SE = 0.02, t.ratio = 3,  $p = 0.003$ ) and bisyllables ( $\beta$ : 106ms, SE = 0.01, t.ratio = 5,  $p < 0.0001$ ). The difference between the alignment of F0 peaks from the right edge in words with one and two syllables does not reach significance.

Moreover, the temporal distance between the low and high tones is narrower in monosyllabic words ( $\mu$ : 179ms, SE = 0.02) as compared with the distance between these tones in NPs with two syllables ( $\beta$ : -105ms, SE = 0.02, t.ratio = -3,  $p < 0.001$ ) and trisyllabic NPs ( $\beta$ : -137ms, SE = 0.02, t.ratio = -6,  $p < 0.0001$ ). The difference between NPs with two and three syllables fails to reach significance.

### 3.3. LH as phrase boundary tones

As explained earlier, if the LH tones are phrase boundary tones, their temporal alignment should be affected by word duration and they should be placed at a fixed distance from the phrase edges [15]. The results of both the experiment and the corpus data show this to be true for the alignment of low tone in bisyllabic and trisyllabic nouns. The deviation from this pattern found in monosyllabic nouns could be explained by the fact that both the low and the high tones needed to be realized on the exact same syllable, so their pattern of alignment varies from words with two and three syllables. The alignment of high tone from the right edge shows variation between the

data from the experiment and the corpus. The results of the experiment show that there is no significant difference in the alignment of H in bisyllabic ( $\mu$ : 73ms) and trisyllabic words ( $\mu$ : 72ms). In the corpus data, on the other hand, there is no significant difference in the alignment of high tone in words with one ( $\mu$ : 118ms) and two syllables ( $\mu$ : 140ms). These results show that while the alignment of low tone remains stable to mark the left edge of the target words, the alignment of high tones from the right edge is not fixed. Although, it is clear that the more the number of syllables, the later the high tone is realized in the target word. The variability in H alignment is in line with the findings of [13] who showed that Urdu speakers accepted as equally natural words with variable F0 peak alignment in narrow and corrective focus. Our results indicate that Urdu speakers are not fastidious in the alignment of high tones in wide focus either.

## 4. DISCUSSION & CONCLUSION

The results of this study show that the alignment of tones in the data collected in a controlled segmental environment in the experiment is similar to the tonal alignment in a varied context from the corpus. The pattern of the alignment of tones is robust enough to remain unaffected by the segmental context.

These findings also show that the stress based account of intonation in Urdu/Hindi could not predict the alignment of low tone in trisyllabic nouns as the L and H tones are only occasionally realized on the stressed syllable. This is in line with the data shown in [10]. Figures 7-10 in [10] show variable association of tones with the first or second (stressed) syllables in trisyllabic words. The data reported in this research supports an analysis of these tones as phrase boundary tones as proposed by [6]. However, it should be kept in mind that this analysis is based only on noun phrases. It remains to be seen if this pattern is verified in other types of phrases as well.

These findings indicate that the conventional concept of labeling phonological tones with reference to their alignment to and around the stressed syllable is not useful for Urdu/Hindi. This research also adds to the discussion about the intonational typology and provides further evidence for the claim that apart from the existing types of pitch accent, tone, and intonation languages, there is another type namely, the 'phrase languages'.

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