Mora count and the alignment of rising pitch accents in Iron Ossetic

Lena Borise¹, David Erschler²

¹Hungarian Research Centre for Linguistics, Hungary
²Ben-Gurion University of the Negev, Israel
lena.borise@nytud.hu, erschler@bgu.ac.il

Abstract

Based on instrumental results, this paper provides an Autosegmental-Metrical analysis of the patterns of formation and acoustic marking of Phonological Phrases (PPs) in Iron Ossetic, an understudied East Iranian language of Russia. We demonstrate that (i) nominal phrases in Iron Ossetic correspond to PPs, (ii) left periphery edges are consistently marked with stress-aligned rising pitch accents, (iii) there are two distinct rising pitch accents, which we label L+H and L*+H, and (iv) the anchoring of individual tones to metrical targets is determined by the moraic structure of the stressed syllable. We account for these facts by extending the analysis of rising pitch accents in Romance in [1] and the analysis of Franconian prosody in [2]. We argue that stressed vowels carry a rising pitch accent. Strong vowels are bi-moraic; when stressed, the two morae can either carry L and H (with H undergoing secondary association with the next syllable), producing L+H*, or both carry L, with H docking on the next syllable, producing L*+H. Mono-moraic stressed vowels can only host L, with H realized on the next syllable, producing L*+H. Our account, therefore, provides further support for the contrastive metrical structure approaches to tonal phenomena [2]–[6].

Index Terms: stress, pitch accent, alignment, mora count, Iron Ossetic, Iranian

1. Introduction

1.1. Rising accents in the Autosegmental-Metrical theory

The key insight of the Autosegmental-Metrical (AM) theory, one of the main approaches to the analysis of intonation, is that intonation can be described as a sequence of tonal targets, aligned with specific hosts in the prosodic structure [7]–[10]. The values of tonal targets are relative and can be high (H) or low (L). The tonal targets that align with stressed syllables are called pitch accents. They can be simple/mono-tonal (H*, L*) or complex/bi-tonal.

Within a complex pitch accent, the two tones are taken to be of unequal importance: the tone that is understood to be the main one is asterisked, with a leading or trailing tone preceding or following it (e.g., L+H*, L*+H). The relative importance of the two tones is decided based on which tone is more closely aligned with the stressed syllable itself, as opposed to its edges or preceding or following syllables [9]. (Deciding on which component of a bidental pitch accent should be asterisked is sometimes non-trivial [11], especially in the face of cross-linguistic variation in tonal contours, but this issue is beyond the scope of the current paper.)

The analytical set-up of the AM theory leads to there being alignment-based contrasts between pitch accents. A canonical example is the contrast between L+H* and L*+H in English [12]–[15]. L+H*, with a rise on the stressed syllable preceded by a low tone on the pre-tonic syllable, conveys assertion and is commonly used to mark contrast. L*+H, with a low tone on the stressed syllable followed by a rise on the post-tonic syllable, conveys uncertainty or disapproval. The two pitch accents are, therefore, phonologically and pragmatically contrastive.

Alignment-based contrasts between pitch accents can be correlated with multiple factors. In Neapolitan Italian, different types of rising accents are found in different clause types: a combination of a low and a high tone (LH) with an early peak within a stressed syllable is characteristic of declaratives, and one with a later peak marks interrogatives [16]. In Peninsular Spanish, different rising pitch accents are found in different positions in the prosodic structure. In a prenuclear L*+H, often found in yes-no questions, the stressed syllable is low and flat, with a rise on the post-tonic syllable. In a prenuclear L*+H, often found in broad focus contexts, the stressed syllable carries a rise, and the tonal peak is reached on the post-tonic syllable (* indicates a delayed peak). In a nuclear L*+H*, the rise and peak are contained within the stressed syllable [1]–[17], [18].

As these examples show, alignment-based contrasts between pitch accents can correspond to different kinds of linguistic contrasts: those that have to do with a pragmatic effect, clause type, or the position of an accent in a clause. In this paper, we show that the opposition between two kinds of rising pitch accents in Iron Ossetic is, at least in part, determined by yet another factor, the moraic structure of the stressed vowel.

1.2. Prosodic organization of Iron Ossetic

Iron Ossetic is an East Iranian language spoken in North Ossetia (Russia) and in South Ossetia, a breakaway part of Georgia. Phrasal prosody of the language has not been subject to a detailed theoretical investigation (though see [19] for some descriptive generalizations). The existing grammars of Iron Ossetic ascribe a prominent role to prosodic phrasing, which is closely connected with word stress, and its intonational rendition. Descriptively, the first and second syllables in a prosodic word in Iron Ossetic comprise the ‘stress window’ – i.e., the part of the word where stress might be assigned. The location of stress within the stress window is determined by vowel quality [20]–[22]. Iron Ossetic has ’strong’ (s) and ‘weak’ (w) vowels: la, e, i, o, u and le, al, respectively. Stress targets the initial syllable if the first vowel of the stress window is ‘strong’ (ss: râldz ‘to run away’, jâbar ‘news’; sw: râjma ‘forward’, sólpo ‘ladle’), and the second syllable if the first vowel of the stress window is ‘weak’ (ww: kajf ‘young’, jëmâkk ‘lamb’; ws: beîl ‘tree’, yëdôn ‘shirt’). As an exception, personal names are uniformly stressed on the second syllable.¹
In connected speech, stress is described as assigned and realized within ‘prosodic groups’: nominal phrases – as well as other smaller constituents, e.g., postpositional phrases, and certain more complex contexts that include the verb and preverbal constituents – as opposed to individual prosodic words. The stressed syllable is determined according to the same principles, described above. That is, within a ‘prosodic group’, only the stress on the leftmost word is intonationally expressed; other words are described as ‘stressless’ [20], [21], [24], [26], [27]. The rules of the formation of ‘prosodic groups’, detailed in the grammars, have not been tested instrumentally, nor provided with a theoretical analysis.

2. Methods

Our stimuli consisted of 36 nominal phrases of the four stress-window types (SS: n = 9; SW: n = 8; WW: n = 9; WS: n = 10), as illustrated in (1) (the vowels within the stress window are boldfaced). Each nominal phrase consisted of a noun preceded by one or more (up to three) modifiers (adjectives, demonstratives, numerals, and possessive clitics).

(1) a. goli iron bogal
   ‘a mute Iron wrestler’

b. iwanda rewad banan-ə
   ‘eleven ripe bananas’

c. dawar legwan godaj-ə
   ‘two bald cats’

d. naundag gal-ə
   ‘a sacrificial bull’

The nominal phrases acted as subjects or objects in pre-constructed SOV clauses (subsequent analysis revealed no significant tonal differences in the realization of subjects and objects; therefore, they are considered together in the remainder of the paper).

The data came from two production studies. During the first one, conducted in Vladikavkaz (North Ossetia, Russia) in 2019, as part of an exploratory study on the prosody of Iron Ossetic, 13 speakers (8M, 5F, 20-60 y.o.) were recorded producing the WW and SW stimuli. In an additional study, ran in Vladikavkaz in 2021, 13 speakers (3M, 10F female, 20-65 y.o.) were recorded producing SS, WS, and some additional WS stimuli. All speakers had a complete or in-progress university degree and came from North Ossetia. Only one of the speakers took part in both studies. During the recording sessions, the utterances were presented to participants one at a time on a computer screen. Participants were instructed to first familiarize themselves with the utterance and then pronounce it using natural intonation.

In total, 468 nominal phrases were recorded and analyzed. The recordings were manually annotated in Praat [28] by trained research assistants, following the segmentation guidelines in [29], and checked by the authors.

3. Results

Nominal phrases of all sizes (in our data, those consisting of a noun and up to three modifiers) map onto single əφ. This is the case for both subjects and objects in SOV clauses. The signature property of a əφ is a single pitch accent, which is realized on the leftmost prosodic word of a əφ. The distribution of pitch accents, therefore, allows for tracking the size of əφs; these results provide an instrumental validation to the existing descriptions of Iron Ossetic, as discussed in Section 1.2.

Pitch accents found in all stress-window types consist of two tonal targets, L and H. In all stress-window types, the post-tonic syllable is the locus of a rise and peak in F0. That is, when the first vowel is stressed (in SS and SW stress windows), the F0 peak is reached on the second syllable; when the second vowel is stressed (in WW and WS stress windows), the F0 peak is reached on the third syllable. If the stressed syllable is final in a prosodic word, the rise is found on the initial syllable of the next prosodic word, as long as the two words are part of the same əφ. Mean F0 peak locations in the stress windows of the four types, time-normalized so that each syllable’s duration equals 1, are provided in Table 1.

<table>
<thead>
<tr>
<th>Stress window</th>
<th>mean F0 peak location</th>
</tr>
</thead>
<tbody>
<tr>
<td>SS</td>
<td>1.77</td>
</tr>
<tr>
<td>SW</td>
<td>1.67</td>
</tr>
<tr>
<td>WS</td>
<td>2.74</td>
</tr>
<tr>
<td>WW</td>
<td>2.38</td>
</tr>
</tbody>
</table>

In SS and SW stress windows, where the stressed initial vowel is strong, the stressed syllable can have two different realizations. It may carry a rise in F0, which means that there is a continuous tonal rise throughout the stressed and post-tonic syllables, reaching its peak on the post-tonic syllable. We label this pitch accent L+H* (the reasons for using this label, which stem from the anchoring of the two tones, are provided in Section 4). Alternatively, the stressed syllable may receive a low and flat realization, with the F0 rise and peak contained within the post-tonic syllable. We label this pitch accent L*+H. The two realizations are illustrated in Figures 1 and 2, respectively, with the same əφ example, we’re my poor belon ‘your (pl.) tame pigeon’. In Figure 1, the stressed syllable, we’re, carries a rise in F0; in Figure 2, it receives a flat realization. In both, the F0 peak is reached on the post-tonic syllable, may. The two realizations are also obtained in SW examples; illustrations are omitted in the interest of space.

![Figure 1: A SS stress window, L+H*](image1)

![Figure 2: A SS stress window, L*+H](image2)

Similarly, we find that WS stress windows, with the stressed second vowel (strong), can also carry an L+H* or L*+H pitch accent. Here, the F0 peak is on the third syllable, and the stressed one can have two different realizations.
are illustrated in Figures 3 and 4, respectively, with the example \textit{we bur babǝʒ ‘your (pl.) brown duck’}. With the L+H* pitch accent in Figure 3, the stressed syllable, \textit{bur}, carries an F0 rise; with the L*+H pitch accent, \textit{babǝ} has a flat levelled tone. In both cases, the F0 peak is on the post-tonic syllable, \textit{ba}.

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{fig3.png}
\caption{A \textit{w}s stress window, L+H*}
\end{figure}

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{fig4.png}
\caption{A \textit{w}s stress window, L*+H}
\end{figure}

Finally, \textit{w}s stress windows are the only context where the stressed vowel is weak, and only one of the pitch accents is attested for these contexts. In our \textit{w}s examples, the rise on the post-tonic syllable is preceded by a low flat contour on the stressed syllable, which corresponds to the L*+H accent. This is illustrated in Figure 5 with \textit{we bulon ‘your (pl.) pigeon’}.

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{fig5.png}
\caption{A \textit{w}s stress window, L*+H}
\end{figure}

\section{Optimality Theory account}

To account for the distribution and alignment of pitch accents in Iron Ossetic, we offer an analysis couched in the classic (monosyllabic) Optimality Theory (OT) framework.

First, let us derive stress placement. We propose that strong vowels are bi-moraic (S = \textit{mu}), and weak vowels are mono-moraic (W = \textit{mu}) (cf. [30]). We also assume that Iron Ossetic has binary iambic feet, under a moraic analysis. This is enforced by constraints \textit{Ft-Bin} and \textit{Ft-FORM=I} [31], as defined in (2a-b). Parsing proceeds from left to right, which means that a foot can consist of a single strong vowel or two vowels if the vowel in the first syllable is weak. Feet are left-aligned in a prosodic word. This is enforced by the constraints \textit{ALIGN-Ft-L} and \textit{PARSE-SYLL} [32], as defined in (2c-d). \textit{PARSE-SYLL} is ranked below the other constraints. The derivation of stress placement in the four stress-window types is provided in the tableaux in Table 2.

Let us derive stress placement in Figures 3 and 4, respectively, with the example \textit{we bur babǝʒ ‘your (pl.) brown duck’}. With the L+H* pitch accent in Figure 3, the stressed syllable, \textit{bur}, carries an F0 rise; with the L*+H pitch accent, \textit{babǝ} has a flat levelled tone. In both cases, the F0 peak is on the post-tonic syllable, \textit{ba}.

\begin{table}[h]
\centering
\begin{tabular}{|c|c|c|c|}
\hline
\textbf{Foot Type} & \textbf{Align-Ft-L} & \textbf{Ft-Form=I} & \textbf{Parse-Syll} \\
\hline
\textit{LIGN} & \textit{A} & \textit{I} & \textit{I} \\
\textit{LIGN} & \textit{A} & \textit{I} & \textit{I} \\
\textit{LIGN} & \textit{A} & \textit{I} & \textit{I} \\
\textit{LIGN} & \textit{A} & \textit{I} & \textit{I} \\
\hline
\end{tabular}
\caption{Tableaux deriving stress placement in \textit{ss}, \textit{sw}, \textit{ww}, and \textit{w}s stress windows.}
\end{table}

With respect to tonal alignment, we propose that, if the stressed vowel is weak, as in \textit{w}s contexts, the single mora that it contains carries \textit{L}, and the post-tonic syllable carries a trailing tone \textit{H}. This accounts for the low and flat F0 contour on the stressed weak vowel, and the F0 rise being confined to the post-tonic syllable, as in Figure 5. Accordingly, we label this pitch accent L*+H; the asterisk marks the tone realized on the stressed syllable.

In contrast, a strong stressed vowel contains two morae, which means that there are more possibilities for tonal alignment. When the stressed strong vowel has a flat contour and the post-tonic syllable carries a rise, as in Figures 2 and 4, we take it to be the L*+H accent. We propose that, in these cases, \textit{L} is aligned with the first mora of the stressed vowel and undergoes secondary association [1] with the second mora, while \textit{H} docks on the post-tonic syllable. The other attested realization of strong stressed vowels is a continuous F0 rise throughout the stressed and post-tonic syllables, as in Figures 1 and 3. Here, we propose, only the first mora of the stressed vowel carries \textit{L}, and the second one carries \textit{H}. \textit{H} also undergoes secondary association to the post-tonic syllable, which accounts for the further rise in F0 on the post-tonic syllable. We label this pitch accent L+H*, to reflect the presence of the high tone on the stressed syllable. \textsuperscript{3}

Our OT account of tonal alignment is the following. Within a \textit{φ}, the position of the word in which stress is intonationally realized (i.e., leftmost) is derived by a high-ranking constraint \textit{ALIGN-L(Ho-PrWd, φ)} [31], not shown in the tableaux. The alignment of the LH tonal contour with the stressed syllable is derived by \textit{ALIGN-L(T, σ)} and \textit{ALIGN-L(σ, T)}, (3a-b). The anchoring of the pitch accent tones, \textit{L} and \textit{H}, obeys the constraints $μ_1 \rightarrow T$ and *CONTOUR(μ), as defined in

\begin{itemize}
\item[a.] \textbf{Ft-Bin}
Feet are binary (under a moraic analysis).
\item[b.] \textbf{Ft-Form=I}
The foot type is iambic.
\item[c.] \textbf{Align-Ft-L}
Feet are aligned with the left edge of a prosodic word.
\item[d.] \textbf{Parse-Syll}
All syllables should be contained in a foot.
\end{itemize}
Because high tones in Iron Ossetic are rises, we assume that a high tone cannot be realized on a single mora, which is enforced by the constraint \(*H(j_{in})\). Note that \(*H(j_{in})\) is realized on the first word of a sentence. The ranking is ALIGN-L(T, \(\sigma\)), ALIGN-L(\(\sigma\), T) \(\gg\) *CONTOUR(\(\mu\)), \(j_{in} \rightarrow T\), *H(j_{in}).

(3c-d), [2]. Because high tones in Iron Ossetic are rises, we assume that a high tone cannot be realized on a single mora, which is enforced by the constraint \(*H(j_{in})\). Note that \(*H(j_{in})\) in Iron Ossetic, as far as we can tell, only applies to the morae contained within the foot. The ranking is ALIGN-L(T, \(\sigma\)), ALIGN-L(\(\sigma\), T) \(\gg\) *CONTOUR(\(\mu\)), \(j_{in} \rightarrow T\), *H(j_{in}).

- **Table 3:** Pitch accent placement in \(w\) stress windows

<table>
<thead>
<tr>
<th>((\mu, \mu)) L(H)</th>
<th>ALIGN (T, (\sigma))</th>
<th>ALIGN ((\sigma), T)</th>
<th>(j_{in} \rightarrow T)</th>
<th>*CONTOUR ((\mu))</th>
<th>*H(j_{in})</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\mu, \mu) L(H) a. ((\mu, \mu)) (\sigma)</td>
<td>(\mu)</td>
<td>(\mu)</td>
<td>(\alpha)</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>(\mu, \mu) L(H) b. ((\mu, \mu)) (\sigma)</td>
<td>(\mu)</td>
<td>(\mu)</td>
<td>(\alpha)</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>(\mu, \mu) L(H) c. ((\mu, \mu)) (\sigma)</td>
<td>(\mu)</td>
<td>(\mu)</td>
<td>(\alpha)</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>(\mu, \mu) L(H) d. ((\mu, \mu)) (\sigma)</td>
<td>(\mu)</td>
<td>(\mu)</td>
<td>(\alpha)</td>
<td>*</td>
<td>*</td>
</tr>
</tbody>
</table>

- **Table 4:** Pitch accent placement in \(w\) stress windows

<table>
<thead>
<tr>
<th>((\mu, \mu)) L(H)</th>
<th>ALIGN (T, (\sigma))</th>
<th>ALIGN ((\sigma), T)</th>
<th>(j_{in} \rightarrow T)</th>
<th>*CONTOUR ((\mu))</th>
<th>*H(j_{in})</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\mu, \mu) L(H) a. ((\mu, \mu)) (\mu)</td>
<td>(\mu)</td>
<td>(\mu)</td>
<td>(\alpha)</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>(\mu, \mu) L(H) b. ((\mu, \mu)) (\mu)</td>
<td>(\mu)</td>
<td>(\mu)</td>
<td>(\alpha)</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>(\mu, \mu) L(H) c. ((\mu, \mu)) (\mu)</td>
<td>(\mu)</td>
<td>(\mu)</td>
<td>(\alpha)</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>(\mu, \mu) L(H) d. ((\mu, \mu)) (\mu)</td>
<td>(\mu)</td>
<td>(\mu)</td>
<td>(\alpha)</td>
<td>*</td>
<td>*</td>
</tr>
</tbody>
</table>

- **Table 5:** Pitch accent placement in \(w\) stress windows

<table>
<thead>
<tr>
<th>((\mu, \mu)) L(H)</th>
<th>ALIGN (T, (\sigma))</th>
<th>ALIGN ((\sigma), T)</th>
<th>(j_{in} \rightarrow T)</th>
<th>*CONTOUR ((\mu))</th>
<th>*H(j_{in})</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\mu, \mu) L(H) a. ((\mu, \mu)) (\mu)</td>
<td>(\mu)</td>
<td>(\mu)</td>
<td>(\alpha)</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>(\mu, \mu) L(H) b. ((\mu, \mu)) (\mu)</td>
<td>(\mu)</td>
<td>(\mu)</td>
<td>(\alpha)</td>
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<td>*</td>
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<tr>
<td>(\mu, \mu) L(H) c. ((\mu, \mu)) (\mu)</td>
<td>(\mu)</td>
<td>(\mu)</td>
<td>(\alpha)</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>(\mu, \mu) L(H) d. ((\mu, \mu)) (\mu)</td>
<td>(\mu)</td>
<td>(\mu)</td>
<td>(\alpha)</td>
<td>*</td>
<td>*</td>
</tr>
</tbody>
</table>

5. Discussion and conclusions

Our results show that (i) Iron Ossetic consistently maps nominal phrases onto \(\varphi\)s and (ii) left \(\varphi\)-edges are marked with stress-aligned rising pitch accents. This confirms the observation made in the grammars that ‘stress’ in Iron Ossetic is only realized on the first word of a ‘prosocic group’. We propose an OT account of stress distribution, based on the idea that Iron Ossetic has binary iambic feet, under a moraic analysis, and strong and weak vowels contain two and one mora, respectively.

The results further show that (iii) Iron Ossetic has two types of stress-aligned rising pitch accents, which we label \(L^*H^\#\) and \(L+H^\#\). In our OT analysis, we demonstrate that (iv) the anchoring of individual tones to metrical targets is determined by the moraic structure of the stressed syllable. Weak stressed vowels can only carry \(L^*H^\#\). The single mora of the vowel houses \(L\), and \(H\) is realized on the subsequent syllable. This results in a flat low tone on the stressed vowel, followed by a rise on the post-tonic one. When a \(L^*H^\#\) pitch accent is realized on a bi-moraic stressed vowel, \(L\) aligns with the first mora and undergoes secondary association with the second mora of the stressed vowel. In the \(L+H^\#\) accent, which only anchors to strong stressed vowels, the two morae of the stressed vowel house \(L\) and \(H\), respectively, and \(H\) undergoes secondary association with the following syllable. This tonal alignment results in a rising contour spanning the stressed and post-tonic syllables.

On the theoretical front, our account of the Iron Ossetic facts makes two contributions. First, it contributes to the growing typology of rising pitch accents and demonstrates that the anchoring of the individual tones in different kinds of rising pitch accents may be determined by the moraic weight of the stressed vowel. Second, it provides further support for the so-called contrastive metrical structure approaches to tonal phenomena: approaches that derive tonal contrasts from metrical contrasts like mora/syllable count, as opposed e.g., storing tone shapes in the lexicon [2]-[6].

6. Acknowledgements

We are grateful to Andzhela Kudzoeva, Ruslan Bzarov, Rustem Fidarov, and Tsara Dzhanavae for their help in organizing the recordings in Vladikavkaz, and to Andzhela Kudzoeva and Tsara Dzhanavae for the help with preparing the stimuli. We thank the speakers of Iron Ossetic who participated in our study. For feedback, we thank Irina Burukina, Marcel den Dikken, Gorka Elordieta, Katalin É. Kiss, Aleksei Nazarov, Xico Torres-Tamarit, and three anonymous reviewers. This project was supported by the Hungarian Scientific Research Fund’s grants NKFIH KKP-129921 and NKFIH K-135958. All remaining errors are our responsibility.
7. References


1 Some cases of unexpected initial stress have historically had an initial /s/, which has since been lost but still affects stress placement [20]. Additionally, if the second syllable in a SW context is heavy, it may attract stress [21], [23]. Further variability in stress placement in 8S contexts is discussed in [24], [25].

2 Glosses used: ACC – accusative, NUM – suffix appearing on a noun in the presence of a numeral.

3 A reviewer suggests that L>*+H, borrowed from the analysis of Spanish intonation, may be a more accurate label for the accent that we call L-H*, because it explicitly refers to a delayed F0 peak. This label, however, is only meaningful in opposition to a pitch accent in which the F0 peak is reached within the stressed syllable itself. We find no such opposition: in all the data reported here, F0 peaks are reached on post-tonic syllables. Accordingly, we refrain from implementing L>*+H at this time, though it might be called for once we know more about the full tonal inventory of Iron Ossetic.