Preboundary lengthening in Somali

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Abstract

Preboundary lengthening (PBL) refers to the phenomenon whereby segments located immediately before certain boundaries are longer than segments located earlier in the utterance. Together with boundary tones, PBL constitutes one of the most consistent phonetic correlates of prosodic structure cross-linguistically.

Somali is a Cushitic language with tonal-accent. To date, very few studies have investigated Somali prosody at the sentence level. Downstep and the use of boundary tones have been reported but both processes seem to have inconsistent characteristics and to be speaker-dependent. To our knowledge, the issue of segment duration in this context has not been addressed yet.

This paper aims at filling this gap. We conducted a production experiment with four Somali native speakers reading a controlled corpus. We measured vowel duration (VD) before three syntactic boundaries that were defined so as to instantiate different levels of strength. Since pauses frequently appear, we also measured VD before pause. We compared the values obtained for VD in these contexts with word-internal VD.

The results show a significant effect of syntactic boundary strength and pause, leading to four distinct degrees of VD. We discuss the implications of this result on Somali prosodic structure in the light of current relevant theories.

Index Terms: Preboundary lengthening, prosodic structure, Somali, vowel duration, pause.

1. Introduction

Spoken utterances are parsed into prosodic units, which play an important role both in speech production and speech perception. One of the central questions in prosody concerns the manifestation of these prosodic units at the phonetic level and at the phonological level.

From the point of view of speech production, prosodic units constitute domains where various phonological processes apply (*e.g.* sandhi phenomena, distribution of stress), and their boundaries are the locus of specific segmental and prosodic phenomena.

Tonal specification constitutes an important phonetic and phonological cue marking prosodic boundaries [1], [2]. In a large number of languages indeed, prosodic boundaries are indicated by specific intonational contours and edge tones. Tonal cues also include pitch range resetting before and after a prosodic break.

Another consistent phonetic correlate of prosodic structure is preboundary lengthening (PBL). PBL refers to the phenomenon whereby segments located immediately before

particular linguistic boundaries are longer than segments located earlier in the utterance. PBL has been observed in numerous languages (*a.o.* [3]–[7]). PBL has been shown to be closely related to the prosodic and/or syntactic hierarchical structure: PBL tends to be longer at major prosodic/syntactic boundaries than at minor boundaries.

Furthermore, various experimental studies have shown that the initial position of the prosodic domains is cross-linguistically manifested by a spatio-temporal expansion of the articulatory and acoustic correlates of the initial segment (see [6] for a recent review). Initial strengthening has been found to increase cumulatively with each level in the prosodic hierarchy.

Finally, pauses have also been found to often co-occur with a prosodic break, though optionally [8]–[12].

Somali, an East-Cushitic language of the Afroasiatic family, is a tonal- or pitch-accent language whose tonal bearing unit is the vocalic mora [13]–[16]. Tonal-accent (TA) consists of a high pitch target (a high tone) realized with an intensity peak. Vowel or syllable duration is not a phonetic cue of TA [15], [17], [18]. There is at most one TA per prosodic word (ω), which occurs either on the penultimate or on the final mora of ω. Somali opposes accented and unaccented (lexical) words. The latter surface with a flat or slightly declining F0 in the speaker's mid or low pitch range. TA plays an essential role in morphology and syntax: its presence/absence and its position distinguish gender and number features, grammatical cases, verb inflectional categories *etc*.

While the properties of Somali TA have been extensively described at the word level, the properties of prosodic structure at higher levels has received little attention in the literature. Recent work addressing this topic [19]–[21] examines the distribution of TA – and/or sandhi phenomena - within the NP and the phonological phrase (φ) from a phonological point of view.

[22], [15], [23] investigate the patterns of F0 at the sentence level in an experimental setting. They report that some speakers optionally realize boundary tones and downstep and/or tone lowering at the end of certain domains (utterances or intonation phrases), *cf.* also [13], [18], [24], [25]. However both boundary tones and downstep do not seem to be consistent across utterances and speakers. [15] also reports that pauses are frequently inserted, especially after topic phrases, but also within NPs [20].

[26] thoroughly examines the acoustic properties of word-initial /b, d, g/ in different syntactic contexts. They show that the properties of word-initial /b, d, g/ are identical with those of word-internal geminate /bb, dd, gg/ in all syntactic contexts. By contrast, word-internal /b, d, g/ surface as approximants. It thus seems that Somali exhibits word-initial gemination, *i.e.*

initial strengthening. However this process is not cumulative: the acoustic cues of word-initial voiced stops do not vary depending on the syntactic/prosodic context. In that, it differs from the "standard" cases of initial strengthening.

To the best of our knowledge, no study on segment duration in domain-final position has been undertaken so far.

The purpose of the present study is to determine whether PBL occurs in Somali and if so, whether it is a consistent cue of prosodic boundary. We adopt the production experiment conducted in [26], which studies the acoustics of Somali /b, d, g/ in syntactically and phonologically controlled environments. We measure the vowel duration (VD) at the end of nouns inserted in three different syntactic contexts and before pause, and compare final VD with word-internal VD. We first present the methodology and the results, and then discuss the implications on Somali prosodic structure in the light of current relevant theories.

2. Methodology

2.1. Material

Our speech material consists in declarative sentences, which have the following structure:

$$[\text{X } \underline{\text{N1}} \text{ (N2) } waxaa \text{ VC Y}] \tag{1}$$

N1 is the noun containing the vowel whose duration is measured. This vowel is either in word-final position, or in word-internal position. N1 is followed by another noun (N2) in all sentences testing the word-final context. "X/Y" are noun phrases or temporal/locative adverbial phrases. VC is the "Verbal Complex", *i.e.* the verb potentially preceded by particles. *Waxaa* ([wáha:]) is one of the obligatory focus particles. It focalizes the last constituent of the sentence [24], [27], *i.e.* "Y". X, N1 and N2 are thus in topic positions and interpreted as such [24], [27].

N1 is inserted in three different syntactic contexts, which represent three degrees of syntactic (in)dependence between N1 and N2: 1) N1 is the subject of the sentence followed by an object N2, *i.e.* N1 and N2 are two independent NPs (thereafter "Ind" condition); 2) N1 and N2 form a NP together, more specifically an indefinite genitive construction (Gen) and 3) N1 and N2 form a nominal compound together (Cmp).

To ensure a valid interpretation of VD of the final vowel in these three contexts, we measured VD of word-internal vowels both before singleton /b, d, g/ (WdC) and before lexical geminate /bb, dd, gg/ (WdCC).

The speakers realized a significant number of pauses after N1 in Gen and Ind: 18.4% of N1 were followed by a pause in Gen and 61.5% in Ind. We therefore include two additional modalities for the analysis of PBL: Gen-P and Ind-P.

Somali has a five vowel system /i, e, a, u, o/ with front harmony, and a length contrast between short and long vowels. The target vowel of this study is short /i/: final /o, e/ involve a final morpheme or a latent consonant [28], [29], and final /a, u/ are rare in lexical categories (they mostly appear as inflectional markers). In all sentences, /i/ was unaccented and was the nucleus of the 5th syllable starting from the beginning of the sentence. N2 begins with a /Ca-/ sequence, in which C is one of the three voiced stops /b, d, g/.

The duration of final /i/ was compared to that of word-internal /i/. As mentioned above, [26] show that initial singleton /b, d, g/ and word-internal lexical geminate /bb, dd,

gg/ display the same acoustic properties. Word-internal /i/ was unaccented and, like word-final /i/, it constituted the nucleus of the 5th syllable of the sentences.

Based on these principles, we drafted a corpus, that was subsequently amended by three consultants, who were not aware of the purpose of the experiment: one linguist expert in Somali and two native speakers of Somali. As a result, the corpus used in the experiment consists of 83 sentences. Table 1 below provides examples of carrier sentences in the five contexts.

Table 1: *Examples of carrier sentences (orthographic transcription)*

	X	N1	(N2)	*waxaa*	VC		Y
Ind(-P)	*Berrito*	*Cali*	*Batuulo*	*wuxuu*		*bari doonaa*	*Gadiid*
	Tomorrow	Ali	Batuulo	FOC.3s		introduce will.3S	Gadiid
	"Tomorrow Ali will introduce Gadiid to Batuulo."						
Gen(-P)	*Saaka*	*bateri*	*baabuur*	*waxaan*	*ka*	*soo iibasaday*	*Kulmiye*
	This morning	battery	car	FOC.1S	from	bought.1S	*Kulmiye*
	"This morning I bought a car battery from Kulmiye."						
Cmp	*Wasiirku*	*cilmi-*	*baaris*	*wuxuu*	*ku*	*bixiyay*	*$8.000.000*
	minister.the	science-	research	FOC.3S	on	spent.3S	$8.000.000
	"The minister spent eight million dollars on scientific research."						
WdC	*Sanad ka hor*	*libaaxyo*		*waxay*		*dileen*	*Diiriye*
	a year ago	lions		FOC.3P		killed.3P	Diiriye
	"Lions killed Diiriye a year ago."						
WdCC	*Abuubakar*	*dhibbaannadiisii*		*wuxuu*	*ku*	*daaweeyey*	*jeermitire*
	Abubakar	wounds.his		FOC.3S	with	treated.3S	disinfectant
	"Abubakar treated his wounds with disinfectant."						

2.2. Participants and procedure

Four Somali native speakers were recorded: three male speakers and one female speaker, all aged between 43 and 50. They were all born and raised in Somalia, and currently live in London. All of them claimed to use both Somali and English on a daily basis. Two of them come from the Hiiraan district (central part of Somalia); the two other speakers come from the area around Mogadishu. Following [30], [31], Hiiraan and Mogadishu are parts of the same dialectal group, Benadir Somali.

The four speakers were recorded under the same conditions in one recording session for each speaker. The session took place in the recording studio of the School of Oriental and African Studies (London) in March 2019. The speakers were recorded with a high-quality electret condenser microphone (Audio-Technica AT4033) and a digital recorder Marantz PMD671. The recordings were digitized in the WAV format at 44100 Hz and 24-bit.

None of the speakers was aware of the aim of the experiment. Each sentence of the corpus was printed on a specific sheet. These sheets were randomized and presented by the experimenter to the speaker one by one. The speaker could interact with the experimenter in order to check the meaning of the intended sentence, and exclude a wrong interpretation. The speakers were asked to produce the sentences in the most natural way, at a normal speech rate, avoiding the insertion of unnatural breaks. The recordings involving a hesitation were discarded, and the speaker was asked to produce the sentence again. Each sentence was produced at least three times. The number of repetitions was chosen so as to ensure at least 15 recordings for each consonant in each condition.

2.3. Measurements

In total, 1244 sentences were recorded. 32.1% of the total number of sentences were discarded due to the following reasons: i) the realization of an unexpected prominence on the vowel /i/ (mostly in Ind), ii) fuzzy boundaries between /i/ and the following consonant (in WdC, where /b, d, g/ are realized as approximants) and iii) in N1 N2 genitive constructions, N1

and N2 exhibit each one TA [13], [24], however in some cases, genitive constructions were realized as compounds, *i.e.*, they were produced with a single TA on N2. We considered this subset to constitute a specific condition whose status is not immediately clear.

VD and pauses were measured with Praat [32]. VD was defined as the interval between the onset and offset of the /i/'s F2. Pause duration (PD) was measured between the end of /i/ and the beginning of the voicing of following /b, d, g/ (which were all voiced with voicing starting before the release burst, see [26]).

3. Results

Table 2 and Figure 1 below report the mean duration of the vowel /i/ in the seven conditions.

First, there is no difference in VD in both WdC and WdCC, *i.e.* the length of the following consonant has no influence on VD. Second, the results show a rather unexpected fact: VD at the end of N1 in Cmp is similar to that found in word-internal position (WdC/WdCC). Finally, VD is longer at the end of a phrase, and it increases linearly by about 10 ms depending on the importance of the syntactic boundary, and the presence of a pause. VD in Gen-P is longer than VD in Ind-P, but VD is highly variable in these contexts.

To test these observations, we performed a one-factor ANOVA with context as fixed factor. The results confirm the observations: there is a significant *Context* effect [$F(6, 836)$= 71.52, $p<0.001$]. Follow-up post-hoc pairwise comparisons (Tukey) reveal no significant difference between WdC, WdCC and Cmp but significant differences between these contexts and the other four conditions ($p<0.001$). VD in Gen, Ind, Ind-P and Gen-P significantly differ as follows: Gen *vs* Ind ($p<0.05$); Gen *vs* Ind-P/Gen-P: ($p<0.001$); Ind *vs* Ind-P ($p<0.05$); Ind *vs* Gen-P ($p<0.001$). However, there is no significant difference between Ind-P and Gen-P ($p=0.22$). In sum, we arrive at four levels of VD, which pattern as follows:

$$\text{WdC=WdCC=Cmp} < \text{Gen} < \text{Ind} < \text{Ind-P=Gen-P} \qquad (2)$$

Table 2: *Mean vowel duration in milliseconds, standard deviation and number of items*

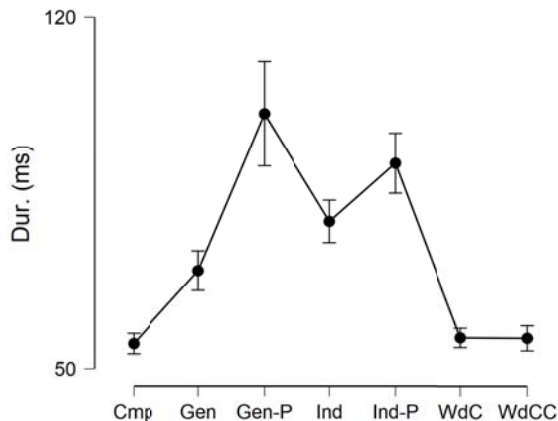| Context	Mean	SD	N
Cmp	55.0	14.4	191
Gen	69.6	25.6	164
Gen-P	100.9	31.0	37
Ind	79.5	15.3	52
Ind-P	91.1	27.4	83
WdC	56.2	13.2	181
WdCC	56.1	14.8	135

Figure 1: *Plots for mean vowel duration (ms) with confidence interval (95%).*

Results for PD are given in Figure 2 below. PD in Ind-P (mean=229, SD=142.4) is slightly longer than PD in Gen-P (mean=181, SD=124.6). An independent sample t-test (Student's) however shows a marginally significant difference between Gen-P and Ind-P ($p=0.075$).
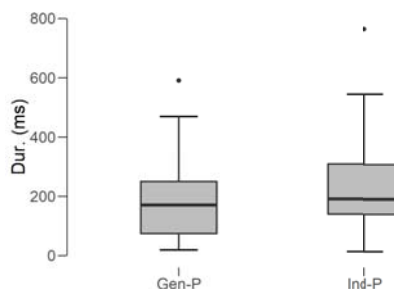

Figure 2: *Boxplots (median) for pause duration (ms)*

4. Discussion

In this section, we discuss the implications of these findings on Somali prosodic structure. Two issues are at stake: 1) How many prosodic constituents are needed to account for the results? 2) How do these constituents relate to the syntactic structures involved in the experiment?

4.1. The prosodic structure of compounds

Let us begin with nominal compounds. VD at the end of N1 is similar to VD in word-internal context. This suggests that there is no prosodic boundary between N1 and N2 in Cmp. In addition, compounds have one TA (on N2), only [13], [24]. These two observations suggest that compounds form a single ω (prosodic word), on a par with simplex nouns:

Compounds: (N1 Ń2)ω   Simplex nouns: (Ń)ω   (3)

However, [26] show that N2 in Cmp is characterized by the strengthening of its initial stop, a phenomenon that stands in sharp contrast with the spirantization observed for word-internal stops. This suggests the presence of a prosodic boundary before N2 in Cmp.

We are thus faced with a paradox. In order to solve this paradox, we consider a proposal that has been made for various Afroasiatic languages in the CV-phonology framework [33], [34]. According to this proposal, all major

categories, *a.o.* nouns, are preceded by an empty skeletal unit ("CV"). [26] implement this proposal in order to account for the phenomenon of initial strengthening that they observe in all syntactic contexts, including compounds. N1 N2 compounds have the representation in (4), with the initial CV of N2 represented in bold and underlined. Initial /b/ of N2 spreads to the C-position of the initial CV. The phonological representation of the resulting stop is identical with that of a word-internal lexical geminate (5). This analysis thus accounts for the fact that noun-initial stops are realized like lexical geminates in Somali: both are associated with two skeletal C-slots.

$$\text{Cmp } \textit{cilmi-}\underline{\textit{b}}\textit{aaris} \quad {}_\omega\left[\begin{array}{l}...\text{C V }\mathbf{\underline{C}}\text{V C V C V}...\\ \;|\;\;|\;\;\;\;\diagdown\;\;\vee\;\;\vee\\ \text{cilmi}\quad\text{b a r i s}\end{array}\right]_\omega \quad (4)$$

$$\text{WdCC } \textit{di}\underline{\textit{bb}}\textit{aannad} \quad {}_\omega\left[\begin{array}{l}\text{C V }\mathbf{\underline{C}}\text{V C V C V}...\\ |\;\;|\;\;\vee\;\;\vee\\ \text{d i b a n a d}\end{array}\right]_\omega \quad (5)$$

Note that an initial empty CV-position is assumed to be present in front of major categories, only. This hypothesis makes predictions on the realizations of initial voiced stops of minor categories, *e.g.* the determiner *-da* (feminine)/*-ga* (masculine). In N-Det sequences, we expect initial *d/g* to surface as an *approximant*, not as a stop. This prediction is borne out: all instances of Det in N-Det sequences in our recordings are realized as approximants (*e.g.* /magaalo-da/ → [maɣaːláða] "city-the") and fit in with what has been previously reported in [17], [24], [35].

By contrast, lenition of the initial stop of Det is problematic under a prosodic phonology approach. For instance, [19], [21] assume that each suffixed Det may constitute an ω, which is grouped into a higher ω in a recursive structure, exactly like N2 in N1 N2 compounds. N-Det are thus expected to behave like compounds. However, the initial voiced consonant of Det is realized as an approximant, while the initial voiced consonant of N2 in a N1 N2 compound surfaces as a stop.

In sum, the assumption of representation (4) for compounds straightforwardly accounts for: i) the initial strengthening phenomenon observed for N2, ii) the absence of PBL (there is no internal prosodic boundary), iii) the fact that there must be only one TA in compounds. It further explains the fact that the initial consonant of Det is lenited, and it renders any additional (recursive) prosodic level superfluous.

4.2. Prosodic boundaries in Gen(-P) and Ind(-P)

In genitive constructions without pause, N1 is characterized by an increased duration of its final vowel. In addition, each noun in Gen exhibits one TA [13], [15], [18], [24]. We thus propose that in genitive constructions, N1 and N2 each form their own ω. In other words, the increase of VD in Gen is a process of PBL indicating the ω-boundary. In Ind without pause, N1 is realized with longer PBL. To account for this additional lengthening, we propose that N1 consists of an ω, which is included in a phonological phrase ϕ. The prosodic boundaries for Gen and Ind are given in (6) below.

$$\text{Gen: } (\text{Ń1})_\omega \; (\text{Ń2})_\omega \qquad \text{Ind: } (\text{N1})_\omega \;)_\phi \; ((\text{Ń2})_\omega \qquad (6)$$

Finally, it is before pause (Gen-P and Ind-P) that the final vowel has the greatest possible duration. A closer look at the data, though, reveals somewhat contradictory results concerning VD and PD in relation to the syntactic context. On the one hand, PD is slightly shorter in Gen-P than in Ind-P, which is consistent given the syntactic structures of both contexts. On the other hand, VD is longer in Gen-P than in Ind-P, which is rather unexpected. Nevertheless, the statistical analysis reveals that the differences in VD and PD between both contexts are not significant. They involve, at most, a marginal effect of the syntactic context on PD.

These observations lead us to the following proposal. Pause is not an additional and optional cue for ω and ϕ. Rather, it is the phonetic exponent of either the Intonational Phrase or the Intermediate Phrase, together with long VD. Further research will determine whether an appropriate description of the phrasing in Somali requires these two prosodic levels, or if only one is enough. In this study, we will use the label "ι", only.

In terms of prosodic structure, this proposal is coherent with what has been found in the literature on pause occurrence. More specifically, it is generally accepted that pauses can occur between ιs, and not elsewhere, in read speech [11], [12]. Our results also fit in with what has been previously reported by [15] about pause insertion in Somali. Investigating the intonation of sentences with similar syntactic structures, [15] found that topicalized XPs are very often followed by a pause.

We conclude this section with a note on boundary tones. Recall that N1s ending with a high tone were discarded from the analysis (section 2.3). In fact, this final H tone almost always appears in Ind(-P) contexts. It is unlikely to be a TA for two reasons: i) N1s in Ind are in subject position and belong to the noun classes that have no TA in the subject case [13], [16], [24]; ii) most of the N1s in Ind are masculine and, as such, regularly marked by penultimate TA [13], [16], [24]. One could imagine that the speakers realize an optional H tone in the subject case. However, H is always located in *final* position, and not in penultimate position. We therefore conclude that final H is not a TA. It must be interpreted as a boundary tone that optionally indicates the right edge of ι (and possibly of ϕ as well).

5. Conclusion

We have shown that PBL does exist in Somali. It constitutes a robust phonetic correlate of prosodic boundaries. In this respect, it contrasts with the instability of boundary tones realized in our data and in other studies. We distinguish four levels of VD, which are closely related to the syntactic structure and the occurrence of a pause. We propose to assume three different prosodic levels, where the highest level is manifested by PBL and pause. In order to account both for the absence of PBL and for the strengthening of the initial consonant of N2 of compounds, we adopted the proposal of an empty skeletal position at the beginning of major categories, on which the initial consonant propagates.

6. Acknowledgements

7. References

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