A Metrical Analysis of Ternary Vowel Quantity in East Frisian Low German

Tianyi Ni[1], Maike Rocker[2], Björn Köhnlein[1]
[1]*The Ohio State University*
[2]*Texas Tech University*

1 Introduction

Many human languages do not systematically contrast vowel length. In languages with vowel length oppositions, the typical pattern involves a binary contrast between short and long vowels (Maddieson, 1984; Maddieson and Precoda, 1989; Odden, 2011; Prehn, 2012). Danish, for instance, exemplifies this binary system with contrasts like /lɛsə/ 'load' and /lɛːsə/ 'read.' A much smaller subset of languages is reported to exhibit a typologically rare three-way contrast in vowel length, involving short, long, and overlong vowels (Prehn, 2012 for overview). In Shilluk (West Nilotic), for example, contrasts such as /lɛ́ŋ/ 'beat drum.NOM,' /lɛ́ːŋ/ 'throw.NOM,' and /lɛ́ːːŋ/ 'throw.NOM.PERT.PL' have been analyzed as corresponding to syllables associated with one, two, or three moras, respectively (Remijsen et al., 2019).

However, the trimoraic analysis of ternary vowel length has sometimes been challenged, in part based on the observation that ternary length contrasts are attested in only a few languages. Moreover, it has been argued that relevant oppositions can often be reinterpreted as an epiphenomenon arising from binary length distinctions interacting with other phonological features (Odden, 2011). Along those lines, what appears to be a three-way phonological contrast may instead reflect the interaction of vowel length with phonation, metrical structure, or tonal features, as argued for, e.g., Estonian (Prince, 1980; Odden, 1997), Franconian (Köhnlein and Cameron, 2024), or Scottish Gaelic (Ternes, 1973; Iosad, 2015; Morrison, 2019).

For instance, in Estonian, overlong vowels have sometimes been analyzed as metrically distinct from long vowels at the foot level, rather than as deriving from an opposition between bimoraic long vowels versus trimoraic overlong vowels. In this view, exemplified by the analyses of, e.g., Prince (1980) and Odden (1997), long vowels are found in the stressed syllable of a disyllabic foot, while overlong vowels occur in monosyllabic feet. Under the assumption that feet are assigned a certain duration, long vowels split the foot duration between a stressed and a following unstressed syllable (= normal length), whereas overlong vowels receive the duration of the whole foot in one syllable (= overlength). A comparable structural distinction has been argued for in Scottish Gaelic in Morrison (2019) , where the opposition between long and overlong vowels is also restricted to stressed syllables. Thus, in both Estonian and Scottish Gaelic, the ternary vowel length contrast can in principle be understood as a higher-level, foot-based metrical phenomenon rather than a purely moraic opposition. As Köhnlein (2015) notes, pitch and duration frequently interact in phonological systems, further supporting the potential usefulness of a metrical approach to ternary vowel length contrasts.

In this paper, we address the issue regarding the phonological nature of overlength further, empirically focusing on Low German. The language, spoken mainly in Northern Germany and the northeastern Netherlands, has also been described as having a ternary distinction in vowel quantity. Table 1 provides a few near minimal triplets. [1] In these examples, all short vowels are lax, while both long and overlong

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[1] SG: singular; PL: plural; NOM: nominative case; INF: infinitive verb form; PRES: verb form with present tense.

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vowels exhibit identical tenseness, with the distinction between them relying solely on surface vowel duration (Kohler and Todter, 1984; Kohler, 2001). Typically, descriptions of the ternary vowel quantity contrast are restricted to monosyllabic words, such as those listed in Table 1.

short	**long**	**overlong**
[zɪt] "sit.1SG.PRES"	[ziːt] "side.SG.NOM"	[ziːːt] "silk.SG.NOM"
[gɪs] "guess.1SG.PRES"	[ʁiːs] "rice.SG.NOM"	[ʁiːːs] "giant.SG.NOM"
[stɪk] "pencil.SG.NOM"	[steːk] "pierce.1SG.PRES"	[steːːk] "jetty.PL.NOM"

Table 1: Low German Minimal Triplets adapted from Prehn (2012)

Etymologically, the durational vowel distinction is linked to segmental properties of the post-vocalic consonants in their corresponding Middle Low German (MLG) forms (e.g., Prehn, 2012 for overview). For instance, the contrast between [ziːt] (from [ziːtə], MLG "side.SG.NOM") and [ziːːt] (from [ziːdə], MLG "silk.SG.NOM") arises from a voicing difference in the post-vocalic obstruents. While both schwa-final MLG forms with word-medial voiceless obstruents and those with voiced obstruents underwent apocope, lengthening to overlong only occurred in vowels that preceded voiced obstruents, while vowels before voiceless obstruents did not lengthen. Prehn suggests that this property is retained in the modern Low German system synchronically. That is, she argues that overlong vowels are always followed by a voiced obstruent with *incomplete* final devoicing rather than the often assumed full phonological devoicing common in closely related languages like Dutch or Standard German.[2] However, at least in the varieties investigated by Prehn (2012), she does not find a statistically significant difference in word-final obstruent voicing between etymologically voiced and etymologically voiceless obstruents. As such, Prehn's claims regarding incomplete devoicing have so far not been corroborated with clearcut phonetic evidence.

In addition to durational and (possibly) consonantal voicing contrasts, some scholars have claimed that, while vowel duration certainly plays a role, it may not be the primary cue distinguishing long and overlong vowels (Höder, 2010; Lücht, 2013; Prehn, 2007; Ruscher, 1983; Ternes, 2006). Instead, they propose that the key distinction lies in a tonal contrast associated with stressed vowels, a pattern absent in short vowels and unstressed positions. Phonetic support for such a tonal opposition, however, has only been provided in Prehn (2007). Notably, however, Prehn (2012) rescinds her earlier position, stating that "the findings presented in [the 2007] article are preliminary ones" (p. 42), and ultimately considers the long-overlong contrast to be a duration-based distinction, rather than a pitch-based one. Accordingly, systematic phonetic evidence of a tone-based contrast is still lacking.

In this paper, we aim to further our understanding of the phonetics and phonology of Low German ternary quantity. Based on fieldwork conducted in Leer, an East Frisian variety of Low German, our ultimate goal is to get a better sense of the phonological nature of the distinction between long and overlong vowels in (East Frisian) Low German. En route to addressing this overarching question, several prerequisite issues must first be resolved: a) Is there a significant durational difference between long and overlong vowels in Leer? b) If so, does this contrast extend beyond monosyllabic words to larger prosodic domains? c) Is final devoicing incomplete, as claimed by Prehn (2012)? d) Is there a tonal distinction that co-occurs with the vowel quantity contrast?

The remainder of this paper is organized as follows. §2 outlines the methodology for data collection and preprocessing, while §3 presents the acoustic analysis of vowel duration, tonal contours, and final devoicing. §4 develops a metrical analysis, and §5 concludes with broader implications for vowel quantity and prosodic structure in Low German varieties and beyond.

2 Methodology

2.1 *Data and fieldwork* A total of 10 East Frisian Low German speakers from the Leer district were recruited for this study, comprising 5 male (ages 53–72) and 5 female (ages 50–76) participants. All

[2] In Standard German, final devoicing occurs when voiced obstruents become voiceless in the syllable coda position. Specifically, the plosives /b, d, g/ and the fricatives /v, z/ will be devoiced and phonetically become [p, t, k] and [f, s], respectively (Wiese, 1996).

participants are bilingual in Low and Standard German, with Low German as their first language and Standard German acquired at school. The recordings were conducted by the second and the third author of this paper in 2021.

A production task was conducted in which the information encoded in the target token within each carrier sentence was manipulated using two variables shown below. While we also considered whether the token occurs in focal or non-focal position, this paper focuses exclusively on tokens in **focal** position. Accordingly, all reported results reflect data from focal positions within the carrier sentences.

- POSITION: whether the target token is in the **final** or **non-final** position of its carrier sentence;
- SENTENCE TYPE: whether the carrier sentence is **interrogative** or **declarative**.

Each speaker produced target words in the final and non-final positions of interrogative and declarative sentences. In total, each speaker produced 4 sentences for each target word. The study used 6 near-minimal pairs of words as target tokens, as shown in Table 2. Of the 12 target words, 6 were monosyllabic real Low German words, and the other 6 were disyllabic. In the disyllabic words, all long and overlong vowels of interest were located in the non-final stressed syllable (i.e., the first syllable). The phonological representations provided indicate the expected vowel duration and potential differences in word-final voicing to be tested; however, these representations are not intended to reflect underlying phonological forms.

Word	Gloss	Label	Word	Gloss	Label
/ʁiːs/	rice.SG.NOM	< Ries >	/ʁiːːz/	giant.SG.NOM	< Riez >
/ziːt/	side.SG.NOM	< Siet >	/ziːːd/	silk.SG.NOM	< Sied >
/ʃviːn/	pig.SG.NOM	< Swien >	/ʃviːːn/	pig.PL.NOM	< Swiien >
/laːtn̩/	let.INF	< laten >	/laːːdn̩/	load.INF	< laden >
/ʁiːtn̩/	tear.INF	< rieten >	/ʁiːːdn̩/	ride.PL.NOM	< Rieden >
/weːikn̩/	week.PL.NOM	< Weken >	/weːːign̩/	weigh.INF	< wegen >

Table 2: Target tokens used in the production task.

During the production task, each speaker was first instructed to listen to a Standard German sentence articulated by a native Standard German male speaker. Following this, they were asked to translate these sentences into Low German, preserving the original context in their verbal responses. An example of this translation process is illustrated in Table 3.

	Interrogative	Declarative
Final	Ist dat de Seit? "Is that Siet?"	Ja, dat ist de Siet. "Yes, that is Siet."
Non-final	Ist dat de Siet weerst? "Is Siet written?"	Ja, dat ist de Siet weerst. "Yes, Siet is written."

Table 3: Target words in carrier sentence examples; underline represents target words which are always in focus.[3]

2.2 *Annotations and measurements* The acoustic and auditory analysis of data was conducted manually with the help of the speech processing software package Praat (Boersma and Weenink, 2024). All statistical analyses were performed using the R programming language (R Core Team, 2023). A linear mixed-effects model (LMM) was constructed using the `lmer()` function (Bates et al., 2015) to examine differences on vowel and voicing duration.

[3] There is no standardized orthography for Low German. The spelling used in this study is based on the conventions found on the website `https://www.platt-wb.de/`.

When investigating whether tonal contour serves as a cue distinguishing long and overlong vowels, the F0 trajectory of each target word was extracted at ten equidistant time points using ProsodyPro (Xu, 2013), with F0 sampled at 100 Hz. Any instances of F0 tracking errors were manually adjusted. To ensure a more reliable analysis, only time points 2 through 9 were included, minimizing potential influences from surrounding consonants on F0 measurements.

3 Results

3.1 *Vowel Duration* The duration of the vowel in monosyllabic words and the penultimate vowel in disyllabic words were extracted and z-score normalized prior to analysis. To examine differences in vowel duration between long and overlong vowels, four factors are taken into consideration: SYLLABLE COUNT × VOWEL LENGTH × POSITION × SENTENCE TYPE, along with their interactions. A random effect of speaker was included to account for inter-speaker variation. Figure 1 illustrates the comparison between long and overlong vowels in different prosodic contexts.

The analysis revealed that VOWEL LENGTH had a significant effect on vowel duration ($\beta = 53.63$, $SE = 7.44$, $t(1056) = 7.21$, $p < 0.001$), with overlong vowels being significantly longer than long vowels. However, none of the other main effects reached statistical significance: SYLLABLE COUNT ($\beta = -8.70$, $SE = 7.37$, $t(1056) = -1.18$, $p = 0.238$), POSITION ($\beta = -5.84$, $SE = 6.67$, $t(1056) = -0.88$, $p = 0.381$), and SENTENCE TYPE ($\beta = 7.33$, $SE = 7.30$, $t(1056) = 1.00$, $p = 0.316$).

Among the interactions, only the interaction between VOWEL LENGTH and SYLLABLE COUNT was statistically significant ($\beta = 35.60$, $SE = 10.52$, $t(1056) = 3.38$, $p < 0.001$), suggesting that the effect of vowel length on duration differs between monosyllabic and disyllabic words. Additionally, an interaction between SYLLABLE COUNT, POSITION, and SENTENCE TYPE was marginally significant ($\beta = -28.73$, $SE = 13.45$, $df = 1056.000$, $t = -2.14$, $p = 0.033$). However, none of the other interactions reached significance ($p > 0.05$), including those involving VOWEL LENGTH, indicating that the effect of VOWEL LENGTH on duration remains robust across different prosodic contexts.

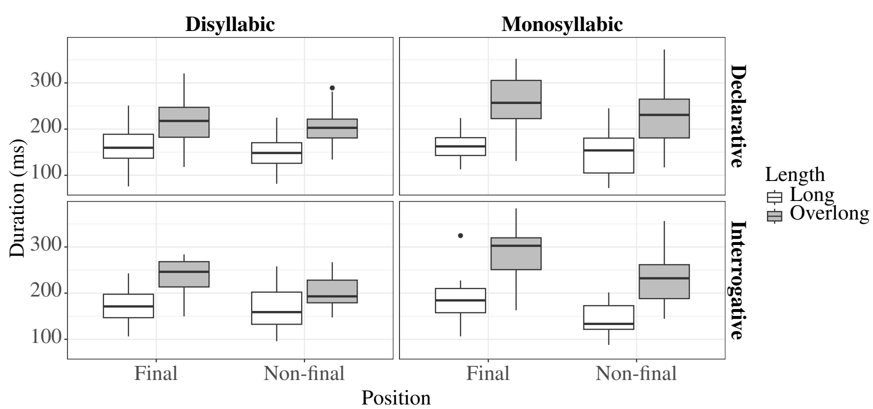


Figure 1: Effect of POSITION, SENTENCE TYPE and SYLLABLE COUNT on vowel duration in Low German.

Specifically, for monosyllabic target words, the mean duration of long vowels across all prosodic contexts was 157.61 ms, while overlong vowels averaged 250.85 ms, yielding an average ratio of $1 : 1.59$ between long and overlong vowels, excluding outliers. For disyllabic words, the mean duration of long vowels was also 163.68 ms, whereas overlong vowels had a mean duration of 214.18 ms, with an average ratio of $1 : 1.31$. This suggests that the duration difference between long and overlong vowels is more pronounced in monosyllabic words than in disyllabic ones. This pattern is further supported by the LMM results, where the interaction between SYLLABLE COUNT and VOWEL LENGTH was statistically significant ($\beta = 35.60$, $SE = 10.52$, $t(1056) = 3.38$, $p < 0.001$), indicating that vowel length distinctions are more robust in monosyllabic words.

3.2 *Tonal Contour* Generally, some speakers appear to produce an evident pitch distinction: overlong vowels show an earlier or more pronounced FALLING contour, while long vowels remain relatively LEVEL or only slightly falling. Figure 2 illustrates this phenomenon in /ziːt/ < Siet > vs. /ziːːd/ < Sied > under non-final declarative conditions, as produced by speaker 2 and 8. Notably, speaker 2 clearly distinguishes long and overlong vowels via a level vs. falling contour, respectively, whereas speaker 8 produces both vowel types with similarly falling contours, suggesting no strong pitch-based contrast in their realizations.

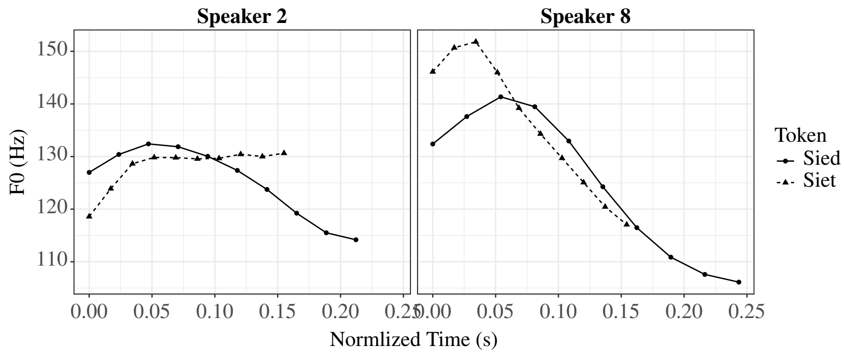


Figure 2: Examples of tonal contour phonetic realizations for long and overlong vowels.

To evaluate whether such tonal contrast inconsistency arises across different WORD PAIRS, SPEAKERS, and their interaction, we conducted a Generalized Linear Mixed Model (GLMM) analysis using a binomial logit model (Wood, 2017; Sóskuthy, 2021). The model was fit using the `glmer()` function (Wood, 2017), with optimization performed via the bobyqa algorithm (Powell, 2009) to ensure convergence. This approach allows us to determine whether tonal contrast is systematically influenced by speaker, word pair with vowel duration contrast, or their interaction, providing insight into the variability of tonal distinctions in different prosodic contexts.

Prosodic Context	β (Estimate)	SE	p-value	$\sigma^2_{\text{Speaker}}$	$\sigma^2_{\text{Word Pair}}$	$\sigma^2_{\text{Speaker:Word Pair}}$
Non-final Declarative	-1.64	0.59	0.005	0.4315	0.4714	0.0000
Final Declarative	-1.87	0.38	< 0.001	0.0000	0.0000	3.086×10^{-8}
Non-final Interrogative	-2.15	0.50	< 0.001	0.4201	0.1745	0.2220
Final Interrogative	-2.53	0.46	0.004	0.4673	0.3562	0.1902

Table 4: GLMM results for tonal contrast across prosodic contexts

Table 4 summarizes the GLMM results for tonal contrast across prosodic contexts. In non-final declarative sentences ($\beta = -1.64, p = 0.005$), tonal contrast is generally unlikely, with variability primarily attributed to both speaker and word pair ($\sigma^2_{\text{Speaker}} = 0.4315, \sigma^2_{\text{Word Pair}} = 0.4714$). However, their interaction remains negligible ($\sigma^2_{\text{Speaker:Word Pair}} = 0.0000$), suggesting that tonal contrast does not systematically depend on specific speaker-word pair combinations. In final declarative sentences ($\beta = -1.87, p < 0.001$), tonal contrast is almost entirely absent, with neither speaker nor word pair contributing meaningful variation ($\sigma^2_{\text{Speaker}} = 0.0000, \sigma^2_{\text{Word Pair}} = 0.0000$). In non-final interrogative sentences ($\beta = -2.15, p < 0.001$), tonal contrast remains inconsistent but shows significant speaker-word pair interaction effects ($\sigma^2_{\text{Speaker:Word Pair}} = 0.2220$), suggesting that some speakers maintain contrast for specific lexical pairs, though not consistently. In final interrogative sentences ($\beta = -2.53, p = 0.005$), moderate variability is observed across speakers and word pairs ($\sigma^2_{\text{Speaker}} = 0.4673, \sigma^2_{\text{Word Pair}} = 0.3562, \sigma^2_{\text{Speaker:Word Pair}} = 0.1902$). However, tonal contrast is not consistently maintained, and interrogative contexts introduce greater speaker-dependent variation.

Overall, tonal contrast is inconsistently realized across all prosodic contexts, with interrogatives exhibiting greater speaker-dependent variation than declaratives.

3.3 *Final Devoicing* To investigate final obstruent devoicing, we conducted a separate analysis of stop and fricative consonants. For stop consonants (i.e., /t/ versus /d/), production consists of three primary stages:

shutting, closure, and release, each corresponding to distinct temporal intervals (Johnson, 2011). Voiced stops are generally characterized by a longer closure duration than voiceless stops, as well as a shorter Voice Onset Time (VOT)—the interval between the release burst and the onset of voicing in the following segment. However, in natural speech, word-final stops are often unreleased or exhibit bursts too faint for reliable acoustic analysis. For instance, as shown in Figure 3, the monosyllabic word /zi::d/, occurring in a non-final position within the carrier sentence, exhibits an extremely light word-final stop /d/, making VOT an unreliable cue for distinguishing voiceless from voiced stops. Given that voiced stops frequently exhibit low-frequency periodicity during the closure phase—reflecting vocal fold vibration (Ladefoged and Johnson, 2014)—we used the duration of this low-frequency energy as a primary voicing indicator and compared it to the closure intervals of voiceless stops.

Similarly, for the fricatives (i.e., /s/ versus /z/), we also utilized the duration of periodicity as a primary measure, given that voiceless fricatives are acoustically aperiodic. Using the duration of frication with voicing could reflect the strength of voicing. The longer the duration of aperiodicity is, the stronger the voicing appears to be Jesus and Shadle (2003).

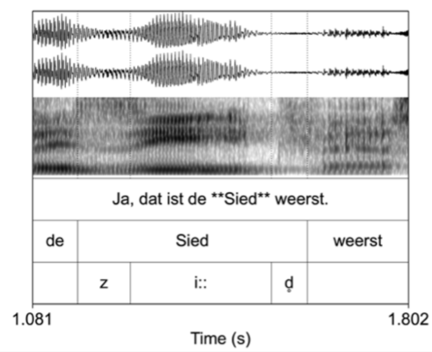


Figure 3: Target word zi::d with an extreme light /d/.

Figure 4 presents a comparative analysis of word-final stop consonant closures following long and overlong vowels in monosyllabic words across different prosodic contexts. The results indicate a statistically significant difference in closure durations following long versus overlong vowels when the target tokens appear in non-final POSITION ($t(31) = 1.17192, p = 0.0455^{*}$) within the carrier sentence, irrespective of SENTENCE TYPE ($F(1, 69) = 4.1983, p = 0.34740$).

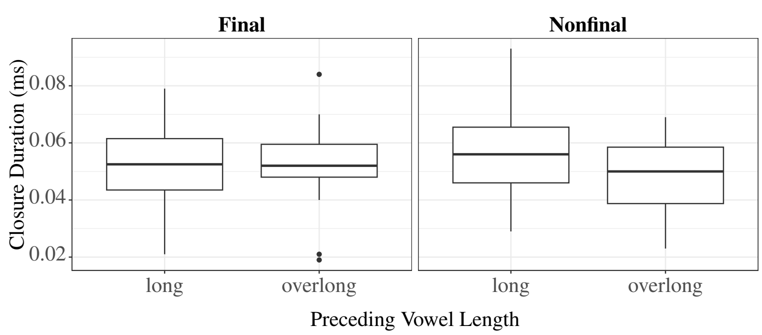


Figure 4: Closure duration between the vowel and the word-final stop consonant in different POSITION.

Figure 5 compares the voicing status of word-final fricatives following long and overlong vowels across various prosodic contexts. The y-axis represents the ratio of periodicity (voiced portion) to the total fricative duration. The results indicate a significant difference in word-final fricative voicing duration between long and overlong vowels ($\beta = 0.140, SE = 0.079, t(60) = 1.774, p < 0.05$), regardless of POSITION ($\beta = 0.099, SE = 0.079, t(60) = 1.255, p = 0.2144$) and SENTENCE TYPE ($\beta = 0.123, SE = 0.1101, t(60) =$

$1.118, p = 0.269$). These findings suggest a tendency for long vowels to precede devoiced fricative codas, while overlong vowels are more likely to be followed by fricatives that retain a greater degree of voicing.

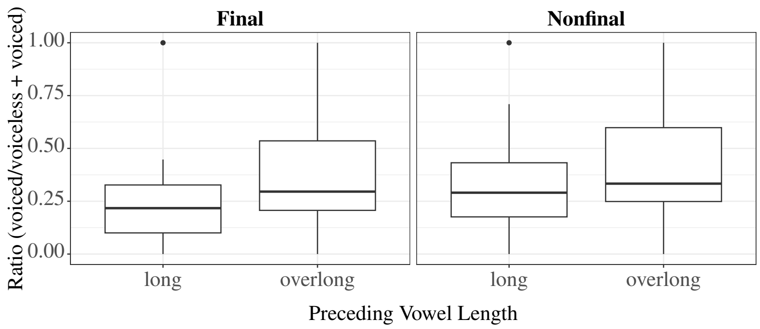


Figure 5: Relative voice duration of the word-final fricative consonants in different POSITION.

In summary, this analysis demonstrates that, unlike Standard German, Low German does not exhibit categorical final devoicing. The observed differences in voicing status following long and overlong vowels suggest that while Low German exhibits some degree of final devoicing, it is not as systematic or complete as in Standard German. These findings align with the observations of Prehn (2012), further supporting the claim that final devoicing in Low German is incomplete.

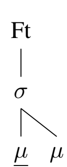
4 Discussion & Analysis

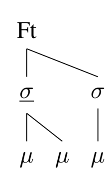
The acoustic findings presented above confirm a consistent durational contrast between long and overlong vowels across all focal positions. While this vowel length contrast tends to be accompanied by tonal differences, these contrasts do not appear to be reliably produced; for that reason, we choose not to treat them as phonologically meaningful here, and will not formalize them in the analysis. Such a systematic tonal contrast may be synchronically absent either because such distinctions were never phonologized to begin with, or are now being lost due to Standard German influence. However, unlike in Standard German, final obstruent voicing in Low German is not fully neutralized, suggesting that word-final voiced obstruents maintain a phonetic distinction from their voiceless counterparts; this is shown in (1).

(1)	a.	/ʁiːs/	[ʁiːs]	rice.SG.NOM	b.	/ziːt/	[ziːt]	side.SG.NOM
		/ʁiːːz/	[ʁiːːz̥]	giant.SG.NOM		/ziːːd/	[ziːːd̥]	silk.SG.NOM

To formalize relevant interactions, we orient ourselves on existing foot-based approaches to ternary quantity contrasts in Estonian (Prince, 1980; Odden, 1997), Franconian (e.g., Köhnlein, 2016), or Scottish Gaelic (Morrison, 2019). Specifically, we employ the approach advertised in (Köhnlein, 2011; Köhnlein, 2016), which is also utilized in Morrison's analysis of Scottish Gaelic. In this model, the level of branching determines the head status of metrical nodes. That is, the head of a foot is assigned at the highest branching level, with the strong branch serving as the foot head, as illustrated in (2), where all foot heads are underlined. In a moraic trochee (2a), the structure is binary at the moraic level but lacks syllabic branching, resulting in the first mora being the foot head and the second mora being the foot dependent. In contrast, a syllabic trochee (2b) does branch at the syllable level, making the foot-initial syllable the head, and the second syllable the dependent. The foot head establishes a so-called HEAD DOMAIN, whose extent is determined by its position in the metrical hierarchy. In a syllabic trochee (2b), both vocalic moras are strong at the foot level because they are licensed by the syllabic foot head. In the moraic trochee (2a), only the first mora is a head and strong at the foot level, while the second mora is a foot dependent and therefore weak.

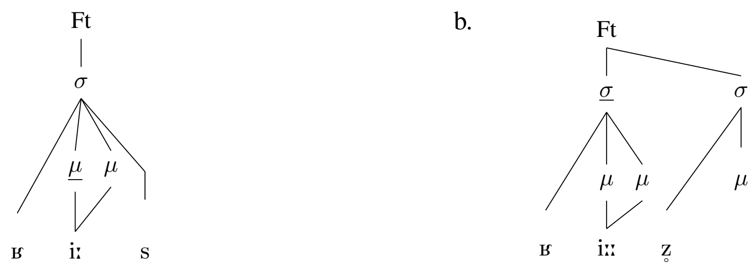
(2) a. *Moraic trochee* b. *Syllabic trochee*





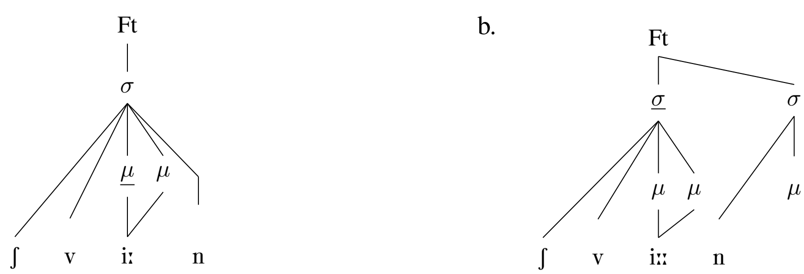
We argue that the structural differences between two types of feet account for the durational enhancement observed in Low German overlong vowels, such that elements within the head domain receive extra duration. Consider the surface representations for the examples provided in (1a), which are given in (3). As we can observe, both long and overlong vowels are phonologically bimoraic, but they differ in their metrical structure. In [ʁiːs], the long vowel forms a bimoraic trochee, where the first mora serves as the foot head and the second as the dependent, resulting in a long vowel. In contrast, [ʁiːːz̥] with an overlong vowel is parsed as a syllabic trochee, consisting of two underlying syllables. Under this representation, overlength is regarded as a phonetic, not phonological, phenomenon, which emerges as a consequence of foot structure contrasts rather than as a difference in mora count. The vocalic overlength is seated in the two strong moras dominated by the syllabic foot head, while the second syllable contains a segmentally empty mora, making the word-final obstruent syllabified as an onset rather than a coda; in other words, the second syllable is EMPTY-HEADED. This analysis also captures the observation that final obstruents in Low German exhibit incomplete devoicing—since these consonants are not in a coda position, they are exempt from complete phonological devoicing and hence do not undergo full phonetic neutralization.

(3) a. b.



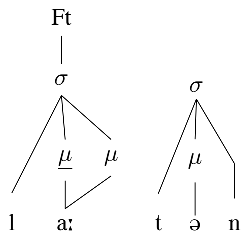
Notably, the proposed metrical account naturally extends to sonorant-final monosyllabic words, exemplified by the pair [ʃviːn] and [ʃviːːn]. Because sonorants do not undergo devoicing, the robust duration contrast here cannot be attributed to consonantal voicing specifications. Instead, the difference arises from whether the stressed vowel occupies the head of a bimoraic trochee ([ʃviːn]) or a disyllabic/"uneven" trochee ([ʃviːːn]). As shown in (4), in the overlong form, the entire vowel is parsed under the foot head, with the final sonorant serving as the onset of a second, empty-headed syllable. This metrical configuration alone suffices to generate the augmented duration typical of overlong vowels, demonstrating that the presence or absence of devoicing is not the sole driving factor behind overlength.

(4) a. b.

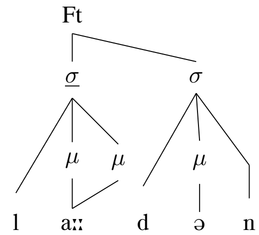


As for disyllabic words, the robust contrast in vowel duration is maintained, following a similar metrical distinction as observed in monosyllabic forms. In forms such as [laːtən], the first syllable constitutes a bimoraic trochee, with the first mora serving as the foot head, leaving the second syllable unparsed, as shown in (5a). This ensures that only the first mora of the vowel receives a phonetic boost, resulting in a long vowel rather than an overlong one. In contrast, in the overlong form [laːːdən], the foot consists of two syllables, forming a disyllabic trochee. In this structure, the entire first syllable functions as the foot head, governing both of its moras. As a consequence, the vowel in the first syllable undergoes double phonetic strengthening, yielding the percept of overlength.

(5) a.



b.



5 Conclusion

This paper has investigated the ternary vowel quantity contrast in East Frisian Low German, focusing on the distinction between long and overlong vowels. Our production data reveal a clear and consistent durational difference between these vowel categories in both monosyllabic and disyllabic words. Additionally, we found that word-final obstruents following overlong vowels exhibit incomplete devoicing, diverging from the fully neutralizing final devoicing observed in other Germanic languages (e.g., Standard German). Our phonetic analysis thus substantiates Prehn (2012)'s proposal that these final obstruents are not completely neutralized into a single voiceless segment.

By adopting a metrical approach, we have argued that overlength arises in syllabic (or "uneven") trochees, where stressed vowels receive additional phonetic reinforcement. This analysis underscores the broader point that metrical foot structure provides a unified framework for capturing multiple correlates—here, duration and voicing—within the same phonological machinery (see also Köhnlein and Cameron, 2024). Earlier accounts of Low German (with different dialects) have either proposed underlying three-way length distinctions (e.g., Chapman, 1993), derive overlength directly from final-consonant voicing (Prehn, 2012), or posit a tonal system (Höder, 2010); all of these approaches, however, face empirical challenges. For instance, the incomplete devoicing patterns are unaddressed by a simple ternary length model, while a strictly voicing-based analysis fails to explain overlength before sonorants. Likewise, a tonal explanation has not been supported by stable and consistent F0 evidence.

From a typological perspective, our findings contribute to ongoing discussions of how "ternary" contrasts in vowel length can emerge and persist. By showing that apparent three-way distinctions can be captured through metrical and segmental interactions rather than invoking a separate three-mora distinction or a fully tonal system, East Frisian Low German offers a revealing example of how prosodic structure can shape surface phonological patterns. We acknowledge that considerably more could be said about the relationship of Low German overlength to related phenomena, for instance regarding similarities and differences to closely related Franconian tonal accent, but we will leave these discussions to future work. In addition, further studies on Low German specifically might explore whether additional cues, such as partial tonal features, play a role in signaling overlength in certain dialects or sociolinguistic contexts. Additional production and perception studies, especially across different age or gender groups, would further elucidate the stability of incomplete final devoicing and the interplay between segmental and prosodic factors in maintaining overlength.

References

Douglas Bates, Martin Mächler, Ben Bolker, and Steve Walker. Fitting linear mixed-effects models using lme4. *Journal of Statistical Software*, 67(1):1–48, 2015. doi: 10.18637/jss.v067.i01. URL `https://doi.org/10.18637/jss.v067.i01`.

Paul Boersma and David Weenink. *Praat: Doing Phonetics by Computer*, 2024. URL `http://www.praat.org`. Version 6.2.23.

Carol Chapman. Überlänge in North Saxon Low German: Evidence for the metrical foot. An approach to vowel length based on the theory of metrical phonology. *Zeitschrift für Dialektologie und Linguistik*, pages 129–157, 1993.

Stephan Höder. Das Lautsystem des Altenwerder Platt. Eine phonetisch-phonologische Bestandsaufnahme. *Niederdeutsches Wort*, 50:1–27, 2010.

Pavel Iosad. 'pitch accent' and prosodic structure in scottish gaelic: Reassessing the role of contact. In Martin

Hilpert, Jan-Ola Östman, Christine Mertzlufft, Michael Rießler, and Janet Duke, editors, *New Trends in Nordic and General Linguistics*, pages 28–54. Mouton De Gruyter, Berlin, 2015.

Luis MT Jesus and Christine H. Shadle. Devoicing Measures of European Portuguese Fricatives. In *Computational Processing of the Portuguese Language*, pages 1–8. Springer, Berlin, Heidelberg, 2003.

Keith Johnson. *Acoustic and Auditory Phonetics*. Wiley-Blackwell, 2011.

Klaus J Kohler. Überlänge im Niederdeutschen. *Vulpis adolatio: Festschrift für Hubertus Menke zum*, 60: 385–402, 2001.

Klaus J Kohler and R Todter. Experimentalphonetische Untersuchungen zur Uberlänge im Nieder- und Hochdeutschen Schleswig-Holsteins Etudes de phonétique expérimentale concernant les voyelles extralongues dans le bas-allemand et le haut-allemand du Schleswig-Holstein. *Arbeitsberichte-Institut für Phonetik*, (21):61–131, 1984.

Björn Köhnlein. The complex durational relationship of contour tones and level tones: Evidence from diachrony. *Diachronica*, 32(2):231–267, 2015.

Björn Köhnlein. Contrastive foot structure in Franconian tone-accent dialects. *Phonology*, 33(1):87–123, 2016.

Björn Köhnlein and Ian S Cameron. What word-prosodic typology is missing: Motivating foot structure as an analytical tool for syllable-internal prosodic oppositions. *Natural Language & Linguistic Theory*, pages 1–37, 2024.

Björn Köhnlein. *Rule reversal revisited: Synchrony and diachrony of tone and prosodic structure in the Franconian dialect of Arzbach*. PhD thesis, Leiden University, 2011.

Peter Ladefoged and Keith Johnson. A course in phonetics: Cengage learning. *Inc., Boston, USA*, 2014.

Wiebke Lücht. Zur Überlänge“ im ostfriesischen niederdeutsch. *Zeitschrift für Dialektologie und Linguistik*, 80(2):131–151, 2013.

Ian Maddieson. Patterns of Sounds Cambridge, 1984.

Ian Maddieson and Kristin Precoda. Updating UPSID. *The Journal of the Acoustical Society of America*, 86 (S1):S19–S19, 1989.

Donald Alasdair Morrison. Metrical structure in Scottish Gaelic: Tonal accent, glottalisation and overlength. *Phonology*, 36(3):391–432, 2019.

David Odden. Some theoretical issues in Estonian prosody. In *Estonian prosody: Papers from a symposium*, pages 165–195. Institute of Estonian Language Tallinn, 1997.

David Odden. The representation of vowel length. *The Blackwell companion to phonology*, pages 1–26, 2011.

M. J. D. Powell. The bobyqa algorithm for bound constrained optimization without derivatives. Technical Report NA2009/06, University of Cambridge, Department of Applied Mathematics and Theoretical Physics, 2009.

Maike Prehn. Schwa loss and its results in Low German: Tone or Overlength? *Linguistics in the Netherlands*, 24(1):187–198, 2007.

Maike Prehn. *Vowel quantity and the fortis-lenis distinction in North Low Saxon*. LOT Utrecht, The Netherlands, 2012.

Alan S Prince. A metrical theory for Estonian quantity. *Linguistic inquiry*, pages 511–562, 1980.

R Core Team. *R: A Language and Environment for Statistical Computing*. R Foundation for Statistical Computing, Vienna, Austria, 2023. URL `https://www.R-project.org/`.

Bert Remijsen, Otto Gwado Ayoker, and Signe Jørgensen. Ternary vowel length in Shilluk. *Phonology*, 36 (1):91–125, 2019.

Maria DH Ruscher. *On the phenomenon of Schleifton in the dialect of Heikendorf*. PhD thesis, 1983.

Márton Sóskuthy. Evaluating generalised additive mixed modelling strategies for dynamic speech analysis. *Journal of Phonetics*, 84:101017, 2021. doi: 10.1016/j.wocn.2020.101017. URL https://doi.org/10.48550/arXiv.1703.05339.

Elmar Ternes. The phonemic analysis of Scottish Gaelic: based on the dialect of Applecross, Ross-shire. 1973.

Elmar Ternes. Tone Reversal in Franconian and elsewhere. *NOWELE*, 48:91–109, 2006.

Richard Wiese. *The Phonology of German*. Oxford University Press, Oxford, 1996.

Simon N Wood. *Generalized additive models: an introduction with R*. chapman and hall/CRC, 2017.

Yi Xu. ProsodyPro — A Tool for Large-scale Systematic Prosody Analysis. In *Proceedings of Tools and Resources for the Analysis of Speech Prosody (TRASP 2013)*, pages 7–10, Aix-en-Provence, France, 2013.