# ACOUSTIC CORRELATES OF STRESS IN AMHARIC: IMPLICATIONS FOR PHONOLOGICAL ANALYSES

Hannah Sande, Maya Barzilai, and Madeleine Oakley

Georgetown University
hannah.sande@georgetown.edu, mlb290@georgetown.edu, mo643@georgetown.edu

## ABSTRACT

The status of word-level stress in Amharic (Semitic, Ethiopia) is debated. Early work claims that there is no systematic stress assignment in the language, while Mullen [5] and Sande & Hedding (S&H) [6] each propose quantity-sensitive analyses of the word-level stress system. Mullen [5] and S&H [6] agree on many points about which syllables are stressed, but disagree in three key areas: 1) the number of stresses per word, 2) which syllables are heavy, and 3) whether heavy suffixes attract stress.

Here we present the first thorough acoustic investigation of cues to stress in Amharic, showing that intensity is the acoustic correlate. We then use these acoustic findings to determine whether one of the extant analyses makes better predictions about the contested data than the other. We find that neither analysis accounts for all aspects of the stress system, and make recommendations for future phonological investigations of Amharic stress.

**Keywords:** Amharic, stress, acoustic cues, intensity, duration

## 1. INTRODUCTION

This paper examines the acoustic correlates of stress in Amharic, an Ethio-Semitic language spoken in Ethiopia, based on data collected from three native speakers. An acoustic investigation of stress patterns in Amharic is necessary, because the phonological analysis of stress in the language has been a much debated topic.

Section 2 of this paper addresses previous work, phonetic and phonological, on Amharic stress. Section 3 introduces the methodology used for collecting acoustic data. Section 4 presents the results of our acoustic study, showing that high intensity, but not longer duration or higher pitch, is strongly correlated with stressed syllables in Amharic. Section 5 concludes, hinting at implications for the phonological analysis of the Amharic stress system.

## 2. BACKGROUND

The phonological analysis of stress in Amharic is debated. Much early descriptive literature on Amharic claimed that there was no systematic stress marking, and that prominence of specific syllables within a word was variable. Hudson [3] states that 'Stress is not prominent in Amharic' (p. 260). Leslau [4] agrees, stating 'In general, Amharic has an almost even distribution of stress on each syllable' (p. 44). Armbruster [2] says that 'stress - accent (i.e., word stress) in Amharic is in general less marked than in English' (p. 30). Alemayehu [1] claims that pitch plays a role in the intonational system of Amharic, but admits that this makes intonation difficult to tease apart from stress (p. 23). The observation that Amharic lacks a clear stress pattern is representative of a broader trend in the literature on Ethio-Semitic languages, 'Common to all Semitic Ethiopian languages is the 'instability' of accent' [8] (p. 297).

Despite the claims of the lack of a systematic stress pattern in Amharic, there are at least four distinct existing analyses of stress placement in Amharic, which vary in degree of completeness. First, in his 1995 grammar, Leslau, despite restating the observation that stress is not prominent, notes 'It is safe to state that the last syllable is not stressed...[and] the syllable preceding a geminated syllable is likely to be stressed' [4] (p. 16); however, he leaves a full analysis of the stress system for future work.

Alemayehu [1] claims that the initial syllable is stressed in 2- and 3-syllable words in Amharic, while the second syllable is stressed in 4-syllable words. It so happens that all 4-syllable words in the paper have a geminate at the end of the second syllable, such that syllables ending in geminate consonants, specifically the first syllable ending in a geminate consonant within a word, are stressed. They assume that high pitch is the phonetic cue associated with the stressed syllable, but do not show phonetic evidence supporting this claim. Due to the lack of independent evidence for this analysis (in fact, we find contradictory results), and the limited set of data that the analysis seems to have been based on, we do not

pursue this analysis further.

Mullen [5] presents an alternative, more complete analysis. For Mullen, all coda consonants contribute to syllable weight (p. 164). The final syllable is never stressed except in disyllabic words when the final syllable is heavy and the initial syllable is light. Otherwise, the rightmost heavy syllable is stressed. If there are no heavy syllables, the first syllable in a word is stressed. Mullen notes that there are numerous lexical exceptions to this pattern. Additionally, many suffixes, particularly those ending in geminates, do not conform to the above generalizations: 'No alternation of the original stress occurs when the pluralizing suffix -occ [...] is added' (p. 166). Under the generalizations above, the verb stem ˈsabbar, 'break' plus the first-person suffix [-ku] should surface with the rightmost closed syllable as stressed; however, this form is not possible, *sabˈbarku. Instead, the initial syllable is stressed, ˈsabbarku, 'I broke'. Mullen analyzes suffixes like the person-marking [-ku] as extrametrical, thus explaining away the exception.

For Sande and Hedding [6], who posit still another alternative analysis of the Amharic stress system, verbal forms such as ˈsabbarku are not exceptional. Instead, stress on the initial syllable in this case is claimed to be due to the fact that it is closed by a geminate. For Sande and Hedding, based on data from stress and infixing reduplication, only syllables closed by a geminate are heavy in Amharic, and all heavy syllables are stressed. In words without heavy syllables, the initial syllable is stressed (this is a point of similarity with Mullen), as are all odd-numbered syllables except for the final one.

While Mullen and S&H agree on some issues - the final syllable closed by a geminate is stressed in words with three or more syllables, as are initial syllables when no closed syllable is present - they disagree in other areas. While both analyses rely on quantity sensitivity, one crucial difference between the two is that, for S&H, only syllables closed by geminates, and not all closed syllables, attract stress. For the disyllabic word tagast, 'patience', S&H's analyses predicts the initial syllable to be stressed, while Mullen's predicts the second syllable to be stressed. Sande and Hedding also do not expect suffixes like /-otʃtʃ/ to act distinctly from stem-internal heavy syllables. S&H predict any syllable closed by a geminate consonant, suffix or not, to be stressed. Here we take the first step in differentiating between these possible analyses; we provide the first thorough acoustic examination of the Amharic stress system, making it possible to systematically test which syllables in a word are the stressed ones.

## 3. METHODOLOGY

Three consultants, all self-reported native Amharic speakers, produced the tokens for the present study. Speakers 1 and 2 are female between the ages of 18-40, and speaker 3 is male, between the ages of 20-24. Speaker 1 completed two elicitation sessions that lasted 1 hour each, and speakers 2 and 3 completed a single 1-hour elicitation session, due to time constraints[1]. During the elicitation session, participants were given oral instructions to translate a word or two-word phrase from English to Amharic and repeat the word or phrase three times. Full sentences were not elicited, as these could have been produced with confounding sentence-level intonation. The English wordlist was read orally by the researcher, and was designed to elicit each of the seven Amharic vowels in the full range of possible syllable shapes and word positions.

The Amharic words were spliced and annotated by hand in Praat. A Python script was used to extract duration, rms, and mean F0 across the duration of the vowel for each token. Phonological information about syllable shape and predicted stress of each vowel were noted by hand. Speaker 1 produced 953 vowel tokens, speaker 2 produced 426 vowel tokens, and speaker 3 produced 469 vowel tokens. A total of 1846 vowel tokens were usable and are included in the acoustic analysis.

The coded syllables were split into those upon which the Mullen and S&H analyses of Amharic stress agree (stressed vs. unstressed), the *Agree* set, and those upon which they do not, the *Disagree* set. There were 1314 tokens in the Agree data set, and each of these syllables was assigned a stress value of 1 if the phonological analyses predicted it to be stressed, and a value of 0 if the analyses predicted it to be unstressed. Half of these Agree tokens were randomly assigned to a training group, and the other half to a testing group. A mixed effects logistic regression model was run on the training group of data, using acoustic factors to predict the binary stress value. The fixed effects were rms, F0, and duration. The random effects were speaker, token, preceding consonant, following consonant, vowel identity, and syllable identity.

The results of this model were used to generate a prediction value between 0 and 1 for each vowel token in the testing group of the Agree tokens, based on its acoustic properties [7]. A prediction value near 0 indicated the syllable was likely to be unstressed while a prediction value closer to 1 indicated a likely stressed syllable. A correlation was run to determine the similarity between the stress values predicted by

the phonological analyses, 0 or 1, and the prediction values generated by the model, which ranged from 0 to 1.

The results of the model were also used to create prediction values for the 532 Disagree vowel tokens. As above, each syllable was assigned a value from 0 to 1, corresponding to how likely it was to be stressed based on its acoustic properties.

If the model is shown to be successful in predicting stressedness of the Agree testing data, the factors that come out as significant in determining the results of the logistic regression model will be assumed to be the primary acoustic cues to stress in Amharic. In this case, we will also be able to say that the shared predictions of S&H's and Mullen's analyses make good predictions about the data. Second, the results of the model tested on the Disagree data will shed light on whether the acoustics better align with Mullen's or S&H's predictions where the two disagree, or whether both analyses are flawed. If all of the syllables said to be stressed by Mullen come out as close to 1 (.8 or above), we will be able to confidently say that Mullen's phonological analysis of word-level stress is correct. Conversely, if the syllables predicted to be stressed by S&H come out as close to 1, we will be able to say that S&H's analysis more closely matches the acoustic data. If neither set of stressed syllables is correlated with results close to 1, we will propose that a new phonological analyses of word stress in Amharic is needed.

## 4. RESULTS

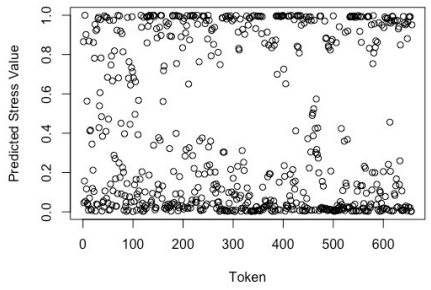
The results of the logistic regression are shown in Table 1. Rms achieved significance in predicting phonological stress, whereas neither F0 nor vowel duration was significant in the model.

**Table 1:** Mixed Effects Logistic Regression Results.

| Factor | P-value |
|---|---|
| rms | 0.001 * |
| F0 | 0.779 |
| Duration | 0.197 |

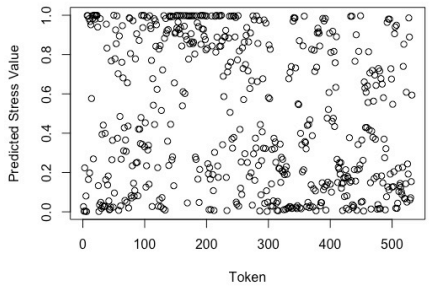
The predicted stress values generated from this model for the testing data of the Agree set were highly correlated with the stress values (1 or 0) predicted by the phonological analyses ($r=0.774$, $p<0.001$). Figure 1 shows the predicted stress values for all of the syllables in the testing set of the Agree syllables. There is a clear bimodal distribution, such that most syllables are predicted to be clearly stressed or clearly unstressed. Over 95% of the data falls below .2 (unstressed) or above .8 (stressed).

**Figure 1:** Generated prediction values (Agree).




When the results of the model were used to generate predicted stress values for the 532 Disagree syllables, these values showed a distribution that was less clearly bimodal, as presented in Figure 2.

**Figure 2:** Generated prediction values (Disagree).




Of the 532 syllables in this data set, 185 (approximately 35%) were assigned prediction values in the mid range, between 0.2 and 0.8, suggesting that the acoustics of these syllables were not entirely characteristic of either the stressed or the unstressed syllables in the Agree data set.

Table 2 presents the number of syllables in each of three prediction value ranges: $\leq 0.2$, predicted by the model to be unstressed, $\geq 0.8$, predicted to be stressed, and 0.2 - 0.8, representing tokens with acoustics that are not strongly characteristic of either stressed or unstressed syllables. These syllables are divided into those that the Mullen analysis predicts to be stressed and those that the S&H analysis predicts to be stressed.

For both analyses, the tokens that are said to be stressed fall almost evenly into three groups: those predicted by the model to be stressed, those predicted to be unstressed, and those in the mid range.

**Table 2:** Number of stressed tokens per prediction value, by phonological analysis.

| | Mullen | Sande & Hedding |
|---|---|---|
| $\geq 0.8$ | 60 (38%) | 112 (30%) |
| 0.2 - 0.8 | 43 (27%) | 142 (38%) |
| $\leq 0.2$ | 54 (34%) | 121 (32%) |

## 5. DISCUSSION

The results show that intensity, measured here as rms, is the primary cue to stress in Amharic. Neither vowel duration nor pitch were significant predictors for stress in these data. The significantly high correlation in the testing group between the stress values predicted by the phonological analyses and those generated by the acoustic model (r=0.774) suggests that these results are highly reliable. Additionally, the high correlation suggests that the agreed upon predictions of Mullen's and S&H's analyses closely match the acoustic data. The bimodal distribution in Figure 1 shows that even if there were some acoustic effects of phrase-level intonation, there were nonetheless acoustic differences that seem to be the correlates of word-level stress.

The results presented in Figure 2 are somewhat unexpected if we assume there is a binary distinction in Amharic between stressed and unstressed syllables. By revealing a lack of bimodal distribution, the acoustic analysis presented here suggests that neither of the phonological analyses compared here, [5] or [6], fully accounts for the Amharic stress system. Rather, there appear to be syllables that are neither fully stressed nor fully unstressed, based on their acoustic properties. It may be the case that there is a third type of syllable in Amharic, namely, those with secondary stress. This would explain the presence of the 185 syllables in the middle range in Figure 2.

Examining the identity of the 185 syllables in the mid-range, we find that with the exception of 26 syllables, mid-range syllables all fall into one of the following four categories: 1) They are the second stressed syllable in a word on S&H's analysis (the only one of the two analyses that allows for multiple stresses per word). 2) They are word-initial open syllables. 3) They alternate with a geminate-closed syllable (i.e. CV.**CV**.CV.CVG). 4) They are geminate-closed suffixes which Mullen specifically claims to be unstressed (-otʃtʃ). The first three of these suggest that the best analysis of word-level stress in Amharic should take into account secondary, as well as primary, stress.

The final group of syllables in the mid-range are suffixes that end with geminates. Note, however, that most geminate-closed suffixes fall into the high range ($>$0.8). For example, there are 121 instances of the plural suffix /-otʃtʃ/ in the Disagree data. 104 of these fall above 0.8, meaning they are acoustically very similar to the stressed syllables. This is predicted by S&H, but not by Mullen. The remaining 17 /-otʃtʃ/ syllables fall in the mid-range, and all above 0.5. Mullen, on the other hand, predicts these to be unstressed. None of the /-otʃtʃ/ syllables, in fact, fall into the unstressed range ($<$0.2). It seems that on this point, at least, S&H's analysis makes better predictions than Mullen's.

An alternative explanation for the 185 Disagree syllables in the mid range is that what we are calling *stress* in Amharic is in fact a combination of competing pressures for prominence. Perhaps both word-initial and heavy syllables compete for prominence, realized acoustically as high intensity, and the combination of these two pressures results in what looks like a stress system. In either case, our acoustic data not only provide clear evidence that intensity is the cue to stress in Amharic, but also suggests the need for a phonological analysis of Amharic stress that is more nuanced than existing ones.

## 6. CONCLUSION

Here we provide the first thorough inquiry into the acoustic correlates of stress in Amharic, concluding that intensity is the primary correlate. Pitch and duration do not significantly differ between stressed and unstressed syllables. This finding allows us to test phonological predictions about Amharic stress. We have also shown that neither extant phonological analysis of Amharic stress adequately accounts for the full range of data, and suggest that future phonological analyses of word-stress in Amharic consider at least three levels of stressedness.

## 7. ACKNOWLEDGEMENTS

Special thanks to Betel, Biruh, and Meriem, the three native Amharic speakers that contributed data for this study. Thanks also to the PhonLab working group at Georgetown University for their feedback on this work.

## 8. REFERENCES

[1] Alemayehu Haile, 1987. Lexical stress in Amharic. *Journal of Ethiopian Studies* 20, 19–43.

[2] Armbruster, C. 1908. *Initia Amharica: An introduction to spoken Amharic*. Cambridge: University Press.

[3] Hudson, G. 1997. Amharic and Agrobba. In: Hetzron, R., (ed), *The Semitic languages*. Routledge.

[4] Leslau, W. 1995. *Reference grammar of Amharic*. Otto Harrassowitz Verlag.
[5] Mullen, D. 1986. *Issues in the morphology and phonology of Amharic: The lexical generation of clitics*. PhD thesis U of Ottawa.
[6] Sande, H., Hedding, A. 2017. Amharic syllable weight. In: Newman, P., (ed), *Syllable weight in Africa*.
[7] Sneller, B. 2018. *Mechanisms of Phonological Change*. PhD thesis University of Pennsylvania.
[8] Ullendorff, E. 1955. The Semitic languages of Ethiopia and their contribution to general Semitic studies. *Africa* 25(2), 154–160.

[1] One limitation to consider is that Speaker 1 produced more tokens than Speaker 2 and Speaker 3 for the present study. In order to account for this fact during data analysis, 'Speaker' is included as a random effect in the Logistic Regression Model. As an additional limitation, production results are based on a small sample size, and future work is suggested to confirm the present findings