



Speech rhythm in Ghanaian languages: The cases of Akan, Ewe and Ghanaian English

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Abstract

Speech rhythm is language-specific, and provides important cues to language acquisition and processing. Rhythm studies have mainly focused on European languages. The present paper addresses the question of how West-African languages fit into rhythm typology [1]-[3]. We selected two Kwa-languages; Akan and Ewe; as well as Ghanaian English (GE), all spoken in Ghana, a West-African multilingual society, and American English (AE) as a control language. For the rhythmic analysis, speech was segmented into vocalic and consonantal intervals, and variability in the duration of these intervals was scored. Following [4]'s measures, vocalic information suggests that rhythm is mora-timed in Akan and Ewe, and syllable-timed in GE, unlike stress-timed AE. However, consonantal information suggests a stress-timed rhythm of all four languages. When controlling vocalic information for speech rate [5], Akan, Ewe and GE resemble syllable-timed languages. In sum, Akan and Ewe do not straightforwardly cluster with any of the traditional rhythm classes. Moreover, GE is rhythmically distinct from AE, probably because of transfer effects from contact languages spoken in the multilingual society. The results highlight the importance of studying understudied languages and linguistic cultures for our understanding of rhythm typology.

Index Terms: Rhythm, Rhythm classes, Mora-timed, Syllable-timed, Stress-timed, Akan, Ewe, Ghanaian English, Varieties of English, Understudied languages, Multilingual society

1. Introduction

Speech rhythm is traditionally categorized into rhythmic classes, with languages being either stress-, syllable-, or mora-timed. Accordingly, either the foot (e.g., AE), syllable (e.g., French) or mora (e.g., Japanese) represents the basic rhythmic speech unit [6], [7]. Following [8], modern analyses of speech rhythm no longer assume that rhythm classes are categorical, but that language rhythms range on a spectrum and to greater or lesser extents can show features of a stress-, syllable- or mora-timed rhythm pattern. Nonetheless, a number of surface cues provide an indication of the basic speech rhythm: stress-timed languages tend to have different syllable types (i.e., simple as well as complex syllables with consonant clusters and codas), while syllable-timed languages tend to have more simple syllables, and syllables in mora-timed languages are often restricted to CV and CVC [8]. Moreover, stress-timed languages tend to have reduced vowels in unstressed syllables, which is not the case in syllable- or mora-timed languages.

Interestingly, neonates are able to discriminate between languages from different rhythm classes, but not between

languages from the same rhythm class [9]. [4] explained the neonates' in light of rhythm correlating with low-level acoustic timing information. Following the hypothesis that infants initially are predominantly sensitive to vocalic information (potentially perceiving intervening consonants as mere noise), they assumed the duration of vocalic versus consonantal intervals in speech to be relevant information for neonates. Their work established two measures, namely the proportion of vocalic interval durations (%V) and the standard deviation of consonantal interval durations (ΔC), to account for neonates' speech discrimination performance. [5] followed up on this work and demonstrated that a vocalic interval duration measure normalized for speech rate (VarcoV, first developed by [10]) next to %V accounted best for differences between languages. Despite a wide range of discussion on the limitations of rhythm classification and its rhythmic measures [11]-[14], timing measures still serve as the relevant acoustic measures to approach the complexity of rhythm typology [13].

The goal of the present study is to analyze the speech rhythm of three rhythmically understudied languages shared by many Ghanaians [15]: Akan, Ewe and Ghanaian English. We use the most established measures; %V, ΔC and VarcoV; to classify the speech rhythm of these languages and to place them into the classical rhythm typology. Few studies have addressed the rhythm of these languages. Akan has been described as syllable-timed [3], [16] (but cf. [17] claiming Akan poetry to resemble that of stress-timed languages). GE has been classified as syllable-timed without empirical support [18, p. 88]. We are unaware of any studies on the speech rhythm of Ewe.

The present study is part of a larger project to understand what task infants face in discriminating languages if they receive input in multiple languages spoken in Ghana. Understanding the rhythm of the speech input allows us to generate hypotheses regarding Ghanaian infants' multilingual acquisition. Ghana is a multilingual society where over fifty different languages are spoken. Ghanaians usually speak Ghanaian English (GE), the language of education and (official) business, and minimally one other local language, if not two or three [15]. The languages spoken in addition to GE tend to be the majority language of the place of residence, and additional native languages that are spoken in a family context.

1.1. Rhythm in multilingual infant research

For our understanding of how speakers of different languages process and acquire their native languages, it is crucial to identify the type of speech rhythm they follow. These rhythmic units provide important language-specific cues for speech processing [19], and infants are sensitive to this information from birth: they can discriminate between a native and a non-native rhythm and show preferences for their native language

rhythm class [9]. Hence the suggestion that rhythm is an important bootstrap for language acquisition in early infancy [20].

From the perspective of multilingually raised infants, it is of particular importance that they learn to separate their native languages, and if their input languages differ rhythmically, this provides them with important low-level cues. Bilingually raised infants have been found to separate their native languages from birth, but only when they are rhythmically distinct: newborns of Tagalog-English bilingual mothers were able to discriminate these two languages and showed a preference for both their native languages when compared to a third non-native language, namely Mandarin Chinese, which is rhythmically in between Tagalog and English [21]. However, discrimination of two languages that fall into the same rhythm class is more difficult: infants bilingually exposed to syllable-timed Catalan and Spanish are only able to discriminate their two languages at the age of 4-5 months [22], [23]. Infants raised bilingually with syllable-timed Basque and Spanish show discrimination somewhat earlier than this (at 3-4 months), probably because the languages are distinct in terms of other prosodic characteristics [24]. Although it is not clear whether it is easier or more difficult for bilinguals to acquire rhythmically similar languages, these studies suggest that the languages' rhythmic features impact bilingual language development. Notably, in all infant studies, discrimination performance was explained by the low-level acoustic timing measures developed by [4].

In a society with a long history of multilingualism and language contact, like Ghana, the question remains as to whether speech rhythms of different languages in contact with each other would be rhythmically more distinct from or more similar to each other. Prior studies have found that Anyi, Ega and Ibibio, languages spoken in Nigeria, show similar rhythms [1]. Meanwhile, Nigerian English (NE) rhythm differs both from those languages and from British (BE) or American English (AE), in that it has a unique, more syllable-timed rhythm, indicating an influence of the contact languages on the NE variety [2].

1.2. The phonology of Akan, Ewe and GE

Akan is a Kwa language of the Niger-Congo language family and the most widely spoken language in Ghana [25] by about 8.3 million people [26]. Akan has 18 consonants and nine vowels [27]. Like many Ghanaian languages, Akan is a tone language with two level tones (High and Low) that have both lexical and grammatical functions (e.g., tense and aspect marking) [28]. Akan has three basic syllable structures: **V** (*æ.ni* 'eye'), **CV** (*kɔ* 'go') and nasal consonants as single **C** (*n.su* 'water') [28], [29] with a structural preference for unmarked CV (e.g. *dɔ.ko.ta* 'doctor'). Surface CVV is analyzed as disyllabic [24], each V being a tone-bearing unit. The surface CCV is the result of syllable reduction (CVCV) (e.g., in */kro/* ~ */kuro/* 'town', or */bre/* ~ */bɾe/* 'time' [28], [29]).

Ewe is also a Kwa language, which is spoken predominantly in the Southeastern part of Ghana. Ewe has 16 vowels [30]. Like Akan, Ewe contrasts two level tones (High and Non-high) [31], [32]. According to [31], Ewe has three basic syllable structures: **CV** (*dú* 'stop'), **CCV** (*flè* 'buy') and single phonemes, which can be either single **V** (*è* 'you') or single nasals **N** (*y.dɔ*). Ewe allows for CC clusters with the second C being either a glide or liquid [31], [32]. Whenever vowel sequences occur in Ewe, there are usually morpheme

boundaries between them [32]. Neither Akan nor Ewe seem to have lexical stress.

GE is an English variety originating from BE. Phonological properties of GE reflect contact with Ghanaian languages. GE has seven vowels /i,e,ɛ,u,o,ɔ,a/, which are phonetically similar to those of the contact languages. Compared to AE or BE, the syllable structure of GE is simpler. Consonant clusters are usually reduced, e.g. *artists* ~ [atis] [18]. Compared to AE, a tendency for syllable coda drop can be observed [*/gɔt/* ~ */gɔ/*, */æpl/* ~ */apɔ/*]. Diphthongs tend to be monophthongized. Length distinctions are neutralized.

1.3. Predictions for Akan, Ewe and GE

Based on syllable structure constraints, it is unlikely that Akan, Ewe and GE have a stress-based rhythm as AE, as these languages lack the typical syllable complexity and reduced vowels. Hence, we expect that Akan and Ewe show greater similarity with syllable-timed languages, see [3], [25], or mora-timed languages, as most languages with lexical tone (cf. [2]). GE should be rather syllable-timed than stress-timed AE.

2. Method

2.1. Participants

Four native speakers of Akan and GE (3m, age 27, 31 and 31; 1f, age 25) and two of Ewe and GE (1m, age 37; 1f, age 29) participated. A native speaker of Northern AE (m, age 39) served as a control speaker. The Akan speakers included the second author. All four Akan speakers were born and raised in predominantly Akan-speaking areas. The male Akan speakers were exposed to GE from around the age of 2 years, the Akan female speaker at the age of 1 year. Both Ewe speakers were born and raised in a predominantly Ewe-speaking area. She was exposed to GE from around the age of 1 year; he from around 4 years of age. All participants resided in Germany at the time of recording.

2.2. Stimuli

Fifteen sentences were created for the study; five sentences each translated into the three languages. The sentences were short declarative statements, carefully constructed to be natural sentences across the three languages (length: 13 to 19 syllables; average duration: 2.61s (SD = 0.62)). For more detail, see <https://osf.io/2nshr/>

2.3. Procedure

Three speakers of Akan and the AE speaker were recorded in a soundproof booth through a digital microphone using Audacity at the University of Potsdam. The fourth Akan speaker and the Ewe speaker were recorded in a quiet environment using a head-mounted microphone connected to a Marantz PMD 661 recorder. The male Ewe speaker was recorded in a soundproof booth at Goethe University Frankfurt using a condenser microphone and a Zoom H4n Pro recorder. All participants read the English sentences. The Akan and Ewe sentences were read by the native speakers. Participants familiarized themselves with the sentences prior to recording to avoid pauses or hesitations. Participants were instructed to read the sentences on a printed sheet at their own pace and as naturally as they would in a conversation.

2.4. Data preprocessing and analysis

Following [4], the data were segmented into consonant and vowel intervals using PRAAT [34]. A consonantal interval was determined to cover the duration of a consonantal sequence (C, CC, or CCC) starting and ending at its boundaries. Likewise, a vocalic interval was determined to cover the duration of a vowel sequence (V, VV, or VVV). Interval boundaries were determined using both visual (spectrogram and waveform) and auditory cues. Following the phonotactics of Akan and Ewe, glides were considered as consonants, whether in pre-vocalic or post-vocalic position. In English, glides were considered as consonants in pre-vocalic position and as vocalic if they were the part of a diphthong [4]. For an illustration, see (1-3), where consonantal intervals are underlined:

1. English: yesterday /jɛstədeɪ/, segmented as /j-ɛ-st-ə-d-eɪ/ (with pre-vocalic /j/ as consonantal and post-vocalic /t/ as vocalic)
2. Ewe: children /deviawo/, segmented as /d-e-v-ia-w-o/ (with pre-vocalic /w/ as consonantal)
3. Akan: girl /abaawɪwa/, segmented as /a-b-aa-ɔ-r-w-a/ (with pre-vocalic /ɔ/ and /w/ as consonantal)

Next, we measured the duration of each vocalic and consonantal interval within each sentence [4], [5]. Silent pauses within sentences were omitted. For a first analysis, following [4], we calculated %V within a sentence by taking the sum of the vocalic interval durations divided by sentence duration (excluding silences) multiplied by 100. Next, we calculated ΔC , the standard deviation of consonantal interval durations within each sentence. For a second analysis, following [5], speech-rate-normalized VarcoV was calculated by taking the standard deviation of the vocalic intervals divided by the mean vocalic duration multiplied by 100. A PRAAT script (by Tae-Jin Yoon) was used for extracting the scores from the manually segmented vocalic and consonantal intervals.

3. Results

Table 1: %V, ΔC & VarcoV per language, SD in brackets.

Languages	%V	ΔC	VarcoV
AE	43.2 (05.1)	60.7 (16.0)	59.2 (15.5)
GE	43.5 (05.3)	64.4 (18.1)	46.3 (09.0)
Akan	55.1 (16.6)	61.4 (22.0)	46.9 (12.6)
Ewe	69.3 (34.9)	54.4 (13.7)	48.7 (12.3)

Results are displayed in Table 1: for each language, we provide the average duration proportion of vocalic intervals (%V) and corresponding standard deviations (SD), the average standard deviation of the duration of the consonant intervals (ΔC) and their SDs, and the rate-normalized intervals (VarcoV) and their SDs. The languages are ordered from more stress-timed to least stress-timed on the basis of %V. Figure 1 illustrates the relation between %V and ΔC , following [4], who identified this relationship as most informative with regards to infants' rhythmic discrimination between languages. Akan and Ewe are situated in the top right of the plot. Ewe has the highest %V of all languages included in the figure; Akan patterns with Japanese, and both languages have a relatively high ΔC . GE is situated topmost, close to the present AE speaker, both with %V comparable to English in [4], but with slightly higher ΔC . Figure 2 illustrates the relationship between %V and VarcoV, following [5], who identified this relationship as most

informative with regards to rhythmic distinctions between languages. Akan and Ewe are situated most right of all languages included in the plot; GE is close to French in the left of the plot. The VarcoV of Akan, Ewe and GE is highly comparable.

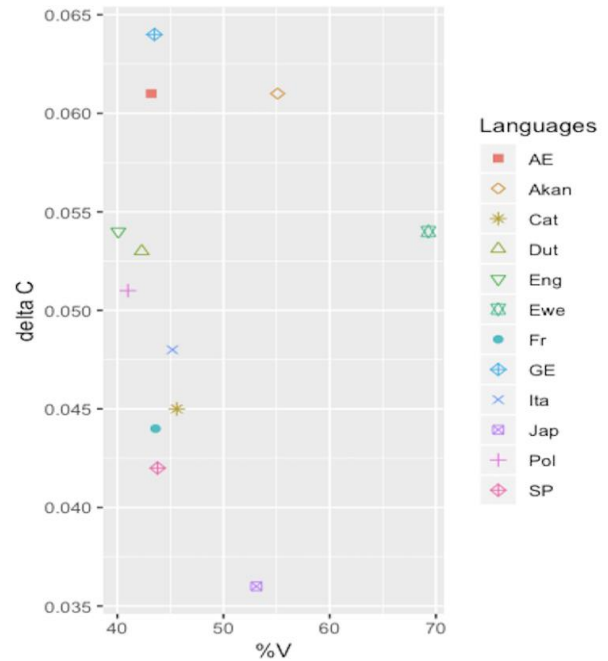


Figure 1: Distribution of %V (x-axis) and ΔC (y-axis) of the languages of the present study (AE, Akan, Ewe and GE) compared to the languages analyzed by [4] (Catalan, Dutch, English, French, Italian, Japanese, Polish and Spanish).

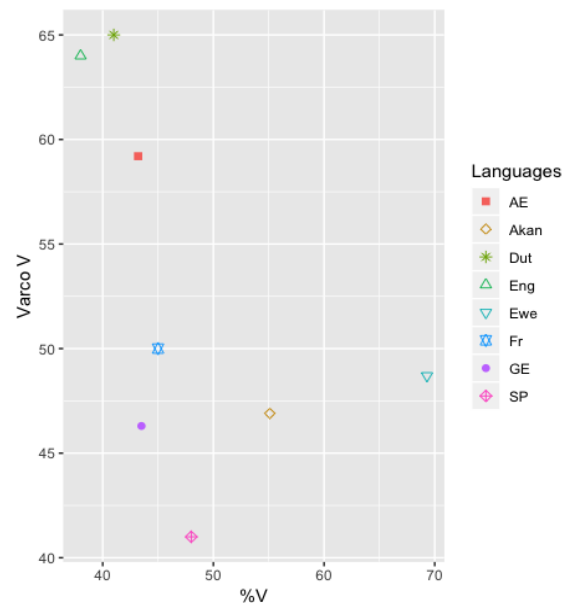


Figure 2: Distribution of %V (x-axis) and VarcoV (y-axis) of the languages of the present study (AE, Akan, Ewe and GE) compared to the languages analyzed by [5] (Dutch, English, French, Spanish).

4. Discussion

The goal of the present study was to study the speech rhythm of three rhythmically under-described Ghanaian languages; Akan, Ewe and Ghanaian English; in order to place these languages into the classical rhythm typology. This study is part of a larger project exploring the variety of speech rhythms from different languages that infants may be exposed to in a typical multilingual society. AE was used as a control language. Results indicate that the Ghanaian Kwa-languages Akan and Ewe do not form part of any of the typical rhythm classes of stress-timed, syllable-timed or mora-timed languages. Moreover, depending on the exact acoustic measure, results suggest that GE is rhythmically distinct from AE. Below, we discuss the languages' rhythmic characteristics in terms of their vocalic (4.1.), consonantal (4.2.), and normalized vocalic (4.3) interval durations, before presenting a synthesis (4.4.).

4.1. Vocalic intervals

Along the dimension of %V, [4]'s index of vocalic intervals' variability suggests that both the Kwa-languages Akan and Ewe are on par with mora-timed languages. GE and AE are highly similar. However, %V scores of GE are slightly more similar to syllable-timed languages than those of AE (similarly to NE, see [2]). For Akan, the present results do not replicate [3], where Akan speakers' %V was about 43, and, hence, more similar to that of speakers of languages classically described as syllable-timed. This might be a consequence of methodological differences: unlike [3], we coded voiceless vowels not as consonants but as vowels. Moreover, [3] coded post-vocalic glides as vocalic (as classically done for AE), while we coded them as consonantal in Akan and Ewe (following the languages' phonotactics).

4.2. Consonantal intervals

Along the dimension of ΔC , [4]'s index of consonantal intervals' variability suggests that all four of the languages are on par with stressed-timed languages, with Akan and GE being higher up the scale than Ewe. ΔC of AE and GE are highly similar, which may be surprising considering GE has fewer consonant clusters as a result of reductions compared to AE. Moreover, both Akan and Ewe have relatively simple syllables: they only allow CC clusters in onsets. The Akan results mirror [3]'s finding who also reports high ΔC scores of 69.4 and 73.0. Note that similarities between [3] and the present results are unaffected by differences in methodological decisions as described in 4.1.

To explore whether the presence of complex consonant sequences account for the high ΔC scores, we counted them in the participants' productions. There were 15 CC and 2 CCC sequences in AE, while GE speakers produced only 10 CC sequences on average, Akan speakers produced 9 CC sequences on average, compared to only 3 in Ewe, and there were no CCC sequences in GE, Akan or Ewe. These cross-linguistic differences suggest that additional factors must be responsible for the high ΔC scores in the Ghanaian languages. Future studies should assess whether length differences between consonants in the Ghanaian languages explain the variability in the consonantal interval durations.

4.3. Normalized vocalic intervals

Along the dimension of VarcoV, [5], [10]'s index of vocalic intervals' variability suggests that the three Ghanaian

languages; Akan, Ewe and GE; are on par with syllable-timed languages, while the AE data resembles that of stress-timed languages from prior studies. For Akan, this replicates results presented in [3], where the two Akan speakers had VarcoV scores of 50.8 and 50.7 respectively, which are also on par with speakers of languages classically classified as syllable-timed. The results of AE patterning with stress-timed [5], and GE patterning with syllable-timed languages [18] are in line with the literature.

4.4. Rhythm of Ewe, Akan and GE

The goal of the present study was to investigate how the Ghanaian languages Akan, Ewe and GE fit into rhythm typology. For this, following [4], [5], we measured the durations of vocalic and consonantal intervals. The results indicate the following: first, the rhythm of GE is similar to that of AE (and of NE [2]), when following [4]'s matrix of %V and ΔC (Figure 1), but when following [5]'s matrix of %V and VarcoV, GE patterns with syllable-timed languages (French, Spanish, see Figure 2). Hence, the basic unit could be either the foot or the syllable. Second, in both Akan and Ewe, the basic rhythmic unit could be the foot, as suggested by ΔC , the syllable, as suggested by VarcoV, or the mora, as suggested by %V (see Table 1). When following either [4]'s (Figure 1) or [5]'s matrix (Figure 2), we must conclude that Akan and Ewe do not pattern with any of the languages classically described as stress-, syllable-, or mora-timed. Moreover, it does not even seem to be the case that Akan and Ewe form their own rhythm class, as they are situated at different spots on the spectra, independent of which matrix is considered. It has previously been suggested that more than the three classically named rhythm classes may exist [4]. The present results suggest that Ewe and Akan may belong to previously undescribed rhythm classes.

One purpose of the present study was to generate hypotheses about infants' multilingual language development if they grow up with Akan, Ewe and GE. Would they be able to use rhythmic information for separating their languages, and what are the basic rhythmic units of the languages they acquire? Interestingly, circumstances for multilingual Akan-Ewe-GE acquisition may be ideal: the languages are rhythmically dissimilar, but still share a basic rhythmic unit, independent of whether infants rely on ΔC (which points to the foot as the basic unit), VarcoV (pointing to the syllable), or %V (pointing to the foot in GE and to the mora in both Ewe and Akan). Considering infants' language discrimination behavior is predicted by [4]'s measures [9], [21], and that infants attend more to vowels (i.e., %V) than to consonants [35], we assume that %V is most informative for generating hypotheses. We propose that the three languages' rhythm characteristics facilitate the discovery of a shared basic rhythmic unit, while being rhythmically distinct enough to support their separation from birth.

In sum, the present results indicate that Ewe and Akan follow speech rhythms that to this point have not been described—a finding that highlights the importance of adding understudied languages to rhythm typology research. Future studies, ideally including more participants and testing additional rhythm matrices, e.g., [36], should explore whether these languages represent cases of hitherto undescribed rhythm classes.

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6. References

- [1] U. Gut, E.-A. Urua, S. Adouakou and D. Gibbon, "Rhythm in West African tone languages: a study of Ibibio, Anyi and Ega," Proceedings of the Typology of African Prosodic Systems Workshop, Bielefeld University, Germany, 2001.
- [2] U. Gut and J.T. Milde, "The prosody of Nigerian English," in Speech Prosody 2002 Conference, Aix-en-Provence, France, Proceedings, 2002.
- [3] A. M. Olivo, "Exploring the speech rhythm continuum: Evidence from Ashanti Twi". *Journal of Speech Sciences*, vol. 1, no. 2, pp. 3-15, 2011.
- [4] F. Ramus, M. Nespor, and J. Mehler, "Correlates of linguistic rhythm in the speech signal," *Cognition*, vol. 73, pp. 265-292, 1997.
- [5] L. White and S. L. Mattys, "Calibrating rhythm: First language and second language studies," *Journal of Phonetics*, vol. 35, pp. 501-522, 2007.
- [6] D. Abercrombie, *Elements of General Phonetics*. Edinburgh: Edinburgh University Press, 1967.
- [7] K. Pike, *The Intonation of American English*. 2nd edition. Ann Arbor: University of Michigan Press, 1945.
- [8] R. M. Dauer, "Stress-timing and syllable-timing reanalyzed," *Journal of Phonetics*, vol. 11, no. 1, pp. 51-62, 1983.
- [9] T. Nazzi, J. Bertoni, and J. Mehler, "Language discrimination by newborns: toward an understanding of the role of rhythm," *Journal of Experimental Psychology: Human Perception and Performance*, vol. 24, no. 3, 1998.
- [10] V. Dellwo, "Rhythm and speech rate: A variation coefficient for ΔC ," in *Language and Language Processing: Proceedings of the 38th Linguistic Colloquium*, pp. 231-241, Frankfurt: Peter Lang, 2006.
- [11] A. Arvaniti and T. Rodriquez. "The role of rhythm class, speaking rate, and F0 in language discrimination." *Laboratory Phonology*, vol. 4, no. 1, pp. 7-38, 2013.
- [12] P. Prieto, M. del Mar Vanrell, L. Astruc, E. Payne and B. Post. "Phonotactic and phrasal properties of speech rhythm. Evidence from Catalan, English, and Spanish." *Speech Communication*, vol. 54, no. 6, pp. 681-702, 2012.
- [13] T. V. Rathcke and R. H. Smith. "Speech timing and linguistic rhythm: On the acoustic bases of rhythm typologies." *The Journal of the Acoustical Society of America*, vol. 137, no. 5, pp. 2834-2845, 2015.
- [14] A. Turk and S. Shattuck-Hufnagel. "What is speech rhythm? A commentary on Arvaniti and Rodriquez, Krivokapić, and Goswami and Leong." *Laboratory Phonology*, vol. 4, no. 1, pp. 93-118, 2013.
- [15] A. Bodo, J. A. Anderson, and J. Dzahene-Quarshie, "A kente of many colours: multilingualism as a complex ecology of language shift in Ghana," *Sociolinguistic Studies*, vol. 3, no. 3, pp. 357-379, 2009.
- [16] J. Anderson, "Preliminary to preliminary: Speech rhythm in Akan (Twi)," in *IUWPL8: African Linguistics Across the Discipline*, Working papers, 2010, pp. 133-143.
- [17] T. M. Purvis, "Speech rhythm in Akan oral praise poetry." *Text & Talk-An Interdisciplinary Journal of Language, Discourse Communication Studies*, vol. 29, no. 2, pp. 201-218, 2009.
- [18] M. Huber, "Ghanaian English: Phonology." in *Varieties of English: Africa, South and Southeast Asia*, pp. 67-92, Berlin: Mouton de Gruyter, 2008.
- [19] A. Cutler, J. Mehler, D. Norris, and J. Segui, "The syllable's differing role in the segmentation of French and English," *Journal of Memory and Language*, vol. 25, no. 4, pp. 385-400, 1986.
- [20] E. Wanner and L. R. Gleitman, *Language acquisition: The State of the Art*. Cambridge: Cambridge University Press, 1982.
- [21] K. Byers-Heinlein, T. C. Burns, and J. F. Werker, "The roots of bilingualism in newborns," *Psychological Science*, vol. 21, no. 3, pp. 343-348, 2010.
- [22] L. Bosch and N. Sebastián-Gallés, "Native language recognition abilities in 4-month-old infants from monolingual and bilingual environments," *Cognition*, vol. 65, pp. 33-59, 1997.
- [23] L. Bosch and N. Sebastián-Gallés, "Evidence of early language discrimination abilities in infants from bilingual environments," *Infancy*, vol. 2, no. 1, pp. 29-49, 2001.
- [24] M. Molnar, J. Gervain, and M. Carreiras, "Within-rhythm class native language discrimination abilities of Basque-Spanish monolingual and bilingual infants at 3.5 months of age," *Infancy*, vol. 19, no. 3, pp. 326-337, 2013.
- [25] K. E. Osam, "An Introduction to the Verbal and Multi-verbal System of Akan," in *Proceedings of the workshop on Multi-Verbal Constructions*, Trondheim Summer School, Proceedings, 2003.
- [26] M. P. Lewis, *Enthnologue: Languages of the World*. 16th edition, Dallas: SIL International, 2009.
- [27] F. A. Dolphyne and M. E. Kropp Dakubu, "The Volta-Comoé languages", in *The languages of Ghana*. London: Kegan Paul, pp. 50-90, 1988.
- [28] F. A. Dolphyne, *The Akan (Twi-Fante) Language: Its Sound System and Tonal Structure*, Accra: Ghana Universities Press, 1988.
- [29] C. Marfo and S. Yankson, "The structure of the CCV Syllable of Akan," *Concentric: Studies in Linguistics*, vol. 34, no. 2, pp. 85-100, 2008.
- [30] S. Genzel, *Lexical and post-lexical tones in Akan*, PhD Thesis, University of Potsdam, 2013.
- [31] H. F. Stahlke, *Topics in Ewe Phonology*, PhD Thesis, University of California Los Angeles, 1971.
- [32] S. A. Duthie, *Introducing Ewe linguistic patterns: A textbook of phonology, grammar and semantics*. Accra: Ghana University Press, 1996.
- [33] F. K. Ameka, *Ewe: Its Grammatical Constructions and Illocutionary Devices*. Unpublished PhD thesis, Australian National University: Australia, 1991.
- [34] P. Boersma and D. Weenink, Praat: Doing phonetics by computer (version 6.1.05) [computer program], 2019. Retrieved from <http://www.praat.org/>
- [35] J. Mehler, E. Dupoux, T. Nazzi, T. and G. Dehaene-Lambertz, "Coping with linguistic diversity: the infant's viewpoint," in *Signal to Syntax: Bootstrapping from Speech to Grammar in Early Acquisition*, 1996, pp. 101-116.
- [36] E. Grabe and E. L. Low. "Durational variability in speech and the rhythm class hypothesis," in *Papers in laboratory phonology*, vol. 7, pp. 515-546, 2002.