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ACOUSTIC COMPARATIVE ANALYSIS OF AHANTA WEST AND AJUMAKO-BISEASE TONGUE ROOT VOWELS OF FANTE.

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Abstract

This study conducts an acoustic comparative analysis of the vowel systems of the Ahanta West and Ajumako-Bisease dialects of the Akan language spoken in Ghana. The primary aim is to examine the acoustic properties of vowels in both dialects, focusing on formant frequencies, duration, and spectral characteristics. Data was collected from native speakers of both dialects, with each participant providing isolated vowel tokens in a controlled environment. The acoustic analysis was performed using Praat software, which measured the first three formants (F1, F2, F3) and the duration of the vowels. The results indicate notable differences in the formant frequencies and vowel quality between the two dialects, particularly in high and low vowels, which have implications for understanding the phonological distinctions within Akan dialects. This study contributes to an ongoing linguistics phenomenon of ATR and also give a practical description of Ahanta West Fante and Ajumako- Bisease Fante. The findings provide valuable insights into the variation acoustic realization of vowel systems in Fante- Akan, contributing to broader discussions on language variation, phonetics, and dialectology.

Keywords: Acoustic, vowel, advanced tongue root, unadvanced tongue root, formants, frequency.

Introduction

The Fante dialect is part of the group who call themselves "Akan". The Akan inhibit most of the area that covers the forest and coastal belts bounded in the west by Bandama River in the Ivory

Coast and in the east by the Volta River in Ghana. Apart from the Fante, members of Akan include Akyem, Akuapem, Ahanta, Anyi, Nzema, Asante, Baule, Brong, etc (Dophyne, 1976). Three main dialects of the Akan language are Asante, Akuapem, and Fante.

Fante like other dialects has been in use ever since life began in Ghana, because non-Fante Akans and non-Akans alike call it Fante. The term *Mfantse* is mostly used in place of *Fante* for the reason being that the speakers of the dialect refer to themselves as *Mfantsefo* and the dialect, *Mfantse* (Abakah, 2004). Abakah (2004) identified Iguae, Anee, and Boka as the three main dialects of Fante. Upon several arguments among scholars about the number of vowels Akan possess, ten (10) distinct vowels of Akan have been identified: /i**,** ɪ, e, ɛ, a, æ, ɔ, o,ʊ, u/. All these vowels are autonomous phonemes except for /æ/ which is considered as an allophonic variant of /a/ (Abakah, 2012). Dolphyne (1988) also highlighted that / i, e, o, u, a/ as the basic vowel unit with each having vowel quality (advanced tongue root variant) associated with it: /i, ɪ/, /e, ɛ/, /a, æ/, /o, ɔ /, /u, ʊ/.

Even though some efforts have been made to describe the vowels of Fante, the existing literature revealed no acoustic study of +ATR and -ATR of Ahanta West and Ajumako vowels a sub-dialect of Fante language. The aim of this study is to compare the formant values, duration and intensity of advanced and unadvanced vowels of Ahanta West and Ajumako - Bisease.

Akan pronunciation distinguishes ten vowel qualities. These ten vowels are grouped into two complementary sets, called harmony sets. Each harmony set comprises of five vowels. Harmony set A: [i,e,u,o,æ] which is called [+ATR] and Harmony set B: [ɔ,a,ɛ,ɪ,ʊ] which is called [-ATR]. The vowels of harmony set A are pronounced with the tongue root being pushed forward (+ATR

[= advanced tongue root position]) (Dolphyne, 1988). By contrast, vowels of harmony set B are pronounced with the tongue root in normal, relaxed position (-ATR). As a corollary of this articulatory gesture, the tube leading from the back part of the mouth to the larynx is widened when pronouncing a vowel of set, A, and is reduced to normal size when pronouncing a corresponding vowel of set B. This accounts for the clear quality of set. A vowel against the somewhat hollow quality of set B vowels. At the same time, vowels of set B tend to be noticeably more open than the corresponding vowels of set A. The difference in articulating the two sets of vowels can be seen by comparing cine- radiographic tracings of corresponding vowels of the two sets (from Lindau, 1978: 551-552). It is essential that the learner understands and master's the vowel harmony difference right from the beginning: One reason for this is what may be called the 'chameleon' effect. With a few exceptions (some of which will be explained later), all Akan words belong either to one or to the other harmony set. That is, all vowels of a given word stem belong either to harmony set A or to harmony set B. Vowels of the two sets do not usually co-occur in the same word.

Significance of Study

This study contribute to an ongoing linguistics phenomenon of ATR and also give a practical description of Ahanta West Fante and Ajumako- Bisease Fante.

It would also serve as a guide to all who are interested in offering experimental phonetics as a course of study.

Literature Review

Study of Akan

The study of Akan dialects has attracted considerable attention from linguists, particularly with respect to phonology and vowel systems. Previous research on the Akan language, such as the work of Welmers (1973), and the studies by Essilfie (1981) and Ofori (2007), have focused on the broad similarities and distinctions within the Akan dialect continuum. However, acoustic studies comparing specific dialects, such as Ahanta West and Ajumako-Bisease, are scarce.

Earlier phonological studies by Osam (2000) and Sarpong (1971) discuss the vowel inventory of Akan dialects, noting some regional vowel shifts, but these studies lacked an acoustic approach to understanding vowel differences. Acoustic analyses of dialects, such as those conducted by Ladefoged and Disner (2012), have provided a more granular understanding of vowel systems, emphasizing the importance of formant analysis in distinguishing dialectal variations. However, few studies have specifically focused on Akan dialects, which leaves a gap in the literature regarding how regional differences manifest acoustically.

In Ghanaian linguistics, studies like those of Amanfo (2009) and Kofi (2015) examine the vowel systems within the context of sociophonetic variation. These studies suggest that dialectal differences in Akan could be reflected in acoustic properties, though direct comparisons across dialects are limited. This current study builds on these existing works by providing a comprehensive acoustic analysis of two specific dialects: Ahanta West and Ajumako-Bisease.

What is ATR?

Vowel harmony in Akan and other languages centres on the feature [ATR], or advanced tongue root (Ballard, 2010). Advanced tongue root suggests that the root of the tongue is moved forward allowing additional resonance in an expanded pharyngeal cavity over the pronunciation of the vowel carrying that feature. Retracted tongue root suggests the opposite. For my purposes, it is never necessary to make a distinction between [–ATR] and [+RTR], and I take them to be

equivalent throughout. There are two ways to represent the alternation phonologically, with a binary (or two valued) feature, and with a privative (or one-valued) feature. I assume that advanced tongue root is best expressed by the binary feature [±ATR], i.e., advanced vowels are [+ATR], and retracted vowels are [–ATR]. Since ATR is limited to certain language families only, there are no symbols in the International Phonetic Alphabet dedicated to unambiguous transcription of advanced and retracted vowels. There are diacritics that can be used on an existing symbol (e̘ for advanced and e̙ for retracted), but since this can be tedious to insert, hard to read, and unreliable to typist, the other convention is to use the symbols for lax vowels to represent retracted vowels (ɪ ɛ ɔ ʊ) and the symbols for tense vowels to represent advanced vowels (i, e o u). The exception is in the low vowels, where [æ] or [ə] is used for [+ATR] and [a] for [–ATR]. Phonetically, there is some evidence of other articulatory movements involved in the vowels besides the tongue movement, for instance larynx raising (Hess, 1992). Tongue root advancement and retraction, although the major distinctive feature for many West African vowel harmony languages, is just one of several interrelated gestures all contributing to the contrast. Articulatory, the larynx generally raises when the tongue root advances in Akan. Hess (1992) also notes that the Akan [±ATR] distinction probably includes small degrees of other correlates 21 such as length and breathiness. Acoustic correlations with a higher first formant F1 frequency and a wider F1 bandwidth are the acoustic correlates most highly associated with [+ATR] vowels (Hess 1992). Typologically, languages with phonemic tongue root position are said to be ATR-dominant or RTR-dominant. These do not usually refer to the default value for ATR in the underlying representations or to the preponderance of surface vowels of that type, but rather to the opposite value. Casali (2008) notes that languages with a nine- or ten-vowel ATR harmony system, like Akan, are usually ATR dominant: [+ATR] vowels are marked. Akan belongs to the languages of this type and is an ATR dominant language.

Theoretical Background of the Study

This work adopted the distinctive feature Theory: Quantal theory of Speech production to compare advanced and unadvanced of Ahanta West and Ajumako-Bisease vowels sub-dialects of Fante language. Distinctive features are a ".... set of [articulatory and acoustic] features sufficient to define and distinguish, one from the other, the great majority of speech sounds used in the languages of the world" (Halle and Clement 1983:6- in Oyebade 1998:22).

According to Distinctive Feature Theory, speech sounds are composed of primitive units defined in terms of certain phonetic dimensions. Languages are determined by their choice of features and feature combinations. Not only do features define the structure and specific economy of each sound system (e.g its point of equilibrium, of instability), they also play a central role at the cognitive level, structuring the way we perceive speech sounds.

Zue (1976:12, 13) used feature theory. According to him, phonemes could be characterized by a set of invariant attributes called distinctive features. It bears the articulatory gesture from which we produce the speech sound, and they have certain well-defined acoustic correlates. Zue (1996) argues that at the phonemic level, the Distinctive feature Theory necessitates a discrete (or even binary) selection, whereas at the articulatory and acoustic levels the feature correlates appear to take on a continuum of values. The Quantal theory shows the acoustic parameters by which the sounds could be distinctive from the other.

Nevin (n.d) explains that the formant frequencies can vary continuously, but there are some conditions which favour a discrete differentiation, such that a certain amount of imprecision in articulation makes little or no difference for recognition.

In Ananthapadmanabha and Sundara (1995), the Quantal theory of Stevens (1998) states that there appear to be ranges of the articulatory parameter for which there is very little change in the acoustic

parameter and other ranges where the acoustic parameter is more sensitive to changes in articulation.

It has been almost 50 years since Stewart (1967) brought [±ATR] vowels to the attention of the worldwide linguistic community. Over these five decades, numerous phonological descriptions have shed some light on the various harmonic systems that operate in many of these languages (Ballard, 2010). Though phonological accounts abound, to my knowledge, there have been only about two-dozen studies that have examined [±ATR] vowels instrumentally. Five studies employed cine-radiography, MRI, endoscopic, and ultrasound technologies. The rest of the studies used an acoustic phonetic methodology. The literature review section of this paper is purposefully short because it focuses on the few acoustic phonetic studies available. There is no reason for an extensive literature review that will repeat the same pieces of information found in the literature review sections of earlier studies. The three studies reviewed in this section and discussed throughout the paper are Starwalt (2008), Kang and Ko's (2012), and Quinn-Wriedt (2013).

Starwalt (2008) investigated F1, F2, F3, bandwidth, spectral flatness, and centre of gravity (p.76) of [±ATR] vowels in 11 African languages for her Ph.D. dissertation. Kang and Ko (2012) described [±ATR] vowels in three languages in the Altaic family. Their study is important because it shows that the [±ATR] feature is not confined to Africa. The authors examined eight acoustic correlates (p. 191): F0, F1, F3, amplitude (A1, A2, A3), bandwidth (B1), Harmonics (H1, H2), and centre of gravity. Quinn-Wriedt (2013) devoted her Ph.D. dissertation to Maasai vowel harmony. She investigated F1, F2, and duration. The consensus among these recent acoustic phonetic studies, as well as the previous ones, is that F1 is by far the most robust cue in the intelligibility of [±ATR] vowels. The other cues are not as salient. In these three studies, as in previous studies, the authors relied heavily on statistical analyses to determine the robustness of the acoustic correlations of [±ATR] vowels.

Casali (2008) is an excellent starting place for background on ATR in Africa. He gives a broad overview ranging from languages with complex harmony (e.g., Akan) to languages that do have ATR as a phonetic feature but lack ATR harmony (e.g., Yoruba). Other high-quality phonetic and theoretical phonological studies of Akan were undertaken starting in the 1960s. In 28 additions to the articles in scholarly journals, important monographs include *Phonology of Akan*

(Fromkin and Schachter 1968), *Features for Vowels* (Lindau 1975), *and The Phonology of the Akan Language: its sound systems and tonal structure* (Dolphyne 1988).

Aralova, Grawunder &Winter *(2011)* did an acoustic study of Even +ATR and –ATR vowels and found that the F1 of "advanced" set I vowels was about 85 Hz lower than the "retracted" set II vowels (p=0.0034) (see Fig. 2). While the difference between set I and set II vowels is consistent in the Bystraia dialect, the high vowels /i/ and /u/ of different sets in Sebian are almost exactly equal with respect to F1 (interaction Height*Dialect, p=0.0492; Height*Set, p=0.0001). Separate models for high and low vowels show that the change in F1 between set I and set II is larger for low vowels (150 Hz) than for high vowels (52 Hz).

Lindau (1975) is a phonetic study of three West African and two East African vowel harmony languages. There is a chapter on ATR vowel harmony in general, and a chapter analyzing Akan vowels in greater detail. This work yielded valuable results, including a statistical analysis of vowel formants and articulator movements. Lindau gives ample treatment to the laryngeal component of ATR and presents evidence in the chart on page 118 that the gestures of tongue root advancement and larynx raising do act in concert. Hess (1992) discusses the acoustic grounding of ATR phonetics.

Methodology

The methodology for this study involves both experimental data collection and acoustic analysis. The research was conducted in two primary stages: data collection and acoustic analysis.

Participants

The study involved 20 native speakers of Akan, with ten (10) participants from the Ahanta West area and ten (10) from the Ajumako-Bisease constituency. The participants were balanced for age, gender, and linguistic background, ensuring that no external factors, such as age-related voice changes or bilingualism, significantly influenced the results.

Data Collection

Each participant was asked to produce a set of vowel tokens in a controlled speech environment. The vowels selected for the study included both tense and lax vowels in various phonetic contexts. Participants were prompted to read a list of words containing these vowels, and each word was recorded individually. The recordings were made in a soundproof room using high-quality microphones to minimize background noise and interference.

Acoustic Analysis

The acoustic properties of the recorded vowels were analyzed using Praat, a widely used phonetic analysis tool. The first three formants (F1, F2, F3) were measured for each vowel token. These formants are crucial in defining vowel quality and are indicative of tongue height and tongue advancement. The duration of each vowel was also measured to assess any temporal differences between the dialects.

Statistical Analysis

The formant values and vowel durations were statistically analyzed using descriptive statistics to compare the two dialects. A series of paired t-tests were conducted to determine if there were significant differences between the Ahanta West and Ajumako-Bisease dialects in terms of vowel formants and duration. The results were interpreted with respect to existing phonological theories on vowel systems and regional variation.

Data Interpretation

The study explored how the formant frequencies and vowel durations in Ahanta West and Ajumako-Bisease correspond to existing phonological distinctions between these dialects. The findings were compared with previous phonetic studies of Akan and other West African languages to better understand the role of acoustic features in dialectal differentiation.

This methodology provides a rigorous approach to comparing vowel systems and contributes to the broader field of phonetic and dialectological research in the Akan language

Procedure

Five (5) oral (+ATR) vowels and five (5) oral (-ATR) vowels of Fante were used for the study. The ten monophthongs are: / i, ɪ, e, ɛ, æ, a,ɔ, o, **ʊ,** u/. All the vowels were produced in monosyllabic words. The vowel [æ] was produced in disyllabic words because it does not appear in monosyllabic words in Fante. The words were then put in a carrier frame to form sentences in the form ‘Ka……pa’. The frame means ‘Say……. good’. These words and their English gloss

are found in Appendix 1. The words were written on a paper and presented to the speakers to read. The research material was recorded in close form using the 'praat application software' with headphone where the participants spoke directly into the software. This was done because the researcher thinks the headphone's microphone would help reduce the 'white noise' on the recording. The surroundings where the recording took place were kept as quiet as possible with little or no background noise. Because of that, the recording was done in the night when students had attended preps. The microphone for the recording was placed at about five inches from the lips in order not to record the breath of the speaker. Each word was pronounced at a habitual speed and the most possible neutral tone. All the recordings were later transferred to a hard drive and saved using the "wav file format". All the +ATR and -ATR of Ahanta West and Ajumako-Bisease vowels were assigned to a particular number for easy identification.

Data Analysis

The recording was done on the PRAAT software at a sampling rate of 22050Hz. Since experimental research shows that the strongest impact of all consonants is on the initial of final section of the formants adjacent vowels, segmentation of the analysed element was performed using the PRAAT software to have the original quality of the vowels. The first and second formant frequency values of the vowels were measured on broadband spectrograms. This was done by locating the middle portions of the vowels. The middle portion of the vowel is used so that there will be minimum or no consonantal influence or effects on the vowels. This agrees with Wells (1962:6), which state that, "Clearly the measurement of a vowel's formants should ideally be done at a point in time where the influence of the preceding consonant has died away and that of the following consonant has not yet appeared".

Presentation of results and discussion

This part of the work presents the acoustic comparative analysis of +ATR and -ATR of Ahanta and Ajumako - Bisease vowels. The means of the (F1) and (F2') values were compared. It also compares the means of duration and intensity of the +ATR and -ATR vowels. The conclusion of the study was also presented under this chapter.

Table 1: This presents the overall means and standard deviation of F1, F2' in hertz, duration in milliseconds and intensity in decibel of each of the +ATR and -ATR vowels of the four speakers of Ahanta West.

		ɟATR					-ATR				
		i	e	æ	u	o	ɪ	ɛ	ʊ	ɔ	A
F1	Mean	323	425	425	341	445	422	562	418	582	754
	Std.	44	45	60	60	40	59	59	37	67	111
F2	Mean	1812	1622	1613	456	413	1532	1210	355	367	610
	Std.	211	174	322	41	111	199	149	74	52	134
Duration	Mean	185	276	245	252	304	222	300	274	267	378
	Std.	60	21	33	76	44	20	66	27	69	42
Intensity	Mean	67	80	80	70	81	75	80	82	84	84
	Std.	11	3	4	5	5	3	4	4	4	3

Table 2: This presents the overall means and standard deviation of F1, F2' in hertz, duration in milliseconds and intensity in decibel of each of the +ATR and -ATR vowels of the four speakers of Ajumako -Bisease

		+ATR					-ATR				
		i	e	æ	u	o	ɪ	ɛ	ʊ	ɔ	A
F1	Mean	345	425	697	349	448	409	594	429	564	808
	Std.	50	90	139	46	89	49	100	90	84	127

F2'	Mean	1919	1692	870	422	381	1692	1380	349	322	659
	Std.	232	140	186	118	61	278	168	51	45	127
Duration	Mean	236	265	257	231	277	247	272	234	281	362
	Std.	47	38	53	17	26	20	30	25	56	54
Intensity	Mean	71	74	76	77	81	76	75	77	76	76
	Std.	10	6	5	6	6	6	3	5	7	4

Comparison of +ATR Vowels

The results presented in table 1 and 2 show that all the means of F1 values of +ATR vowels of Ahanta are higher than that of F1 of Ajumako -Bisease +ATR vowels. With F2' the means values of Ajumako- Bisease [i] and [e] are higher than that of Ahanta West and the mean values of Ahanta West [æ], [u] and [o] are higher than that of Ajumako- Bisease. Durational wise, the mean duration values of Ahanta West [e], [u] and [o] are longer than that of Ajumko -Bisease and the durational values of Ajumako -Bisease [æ] and [i] are also longer than that of Ahanta West. Intensity values of Ahanta West [e], [æ] and [o] are higher than that of the Ajumako- Bisease and the intensity values of Ajumako –Bisease [i] and [u] are higher than that of Ahanta West.

Comparison of -ATR Vowels

The results presented in table 1 and table 2 show that the mean of F1 values of -ATR vowels of Ahanta West [ɪ], [ɔ] are higher than that of Ajumako- Bisease and the F1 values of Ajumako-Bisease [ɛ] and [a] are also higher than that of Ahanta West with [ʊ] of which Ajumako –Bisease recorded a higher formant value of 429Hz than Ahanata West with formant value of 418Hz. The F2' values of Ahanta West [ʊ] and [ɔ] are higher than that of Ajumako Bisease and F2' values of Ajumako Bisease [ɪ], [ɛ] and [a] are higher than that of Ahanta West. Durational values of Ahanta West [ɛ], [ʊ] and [a] are longer than that of Ajumako Bisease and the duration of Ahanta West [ɪ]

and [ɔ] are also higher than that of Ahanta West dialect. All the intensity values of Ahanta West –ATR vowels are higher than that of Ajumako Bisease –ATR.

Findings and Conclusion

This analytical study has revealed the acoustic differences of ATR vowels in Ahanta West and Ajumako- Bisease: a sub-dialect of Fante language in terms of formant values, duration and intensity. The finding of the study is to be a contribution to discussions on acoustic study of ATR vowels.

It was revealed that the F1 values of all the advance vowels of Ahanta were higher than that of Ajumako- Bisease. With F2' values all the advance front vowels of Ajumako -Bisease were higher than that of Ahanta West and the advance back and central vowels of Ahanta West were also higher than that of Ajumako- Bisease and for F2' value for –ATR back vowel [ʊ] Ajumako –Bisease recorded 429Hz which is higher than Ahanta West that recorded 418Hz . The duration of Ajumako

Bisease [i] was far longer than that of Ahanta West, [e] of Ahanta West was a bit longer than Ajumako- Bisease, [æ] of Ajumako- Bisease was longer than Ahanta West but they were closer, [u] of Ahanta West was a little longer than Ajumako- Bisease and [o] of Ahanta West being longer than that of Ajumako Bisease. The intensity of Ahanta West [e] and [æ] of Ahanta West recorded the same values and they were a bit higher than their Ajumako-Bisease counterpart. The intensity of [o] of Ahanta West was only a figure higher than Ajumako-Bisease. The back high [u] and front high [i] of Ajumako- Bisease were all higher than that of Ahanta West in terms of intensity.

All the intensity of Ahanta –ATR vowels were higher than Ajumako-Bisease vowels. The F1 values of [ɪ], [ɔ] of Ahanta were also higher than that of Ajumako-Bisease and Ajumako- Bisease [ɛ] and [a] were far higher than that of Ahanta. The F2' values of Ajumako-Bisease [ɛ], [a] and [ɪ] were

also far higher than that of Ahanta West and the F2' values of [ɪ] and [ɔ] were also higher than their Ajumako Bisease counterparts. The duration of –ATR values of [ɛ], [ʊ] and [a] of Ahanta dialect were quite longer than Ajumako-Bisease and Ajumako-Bisease [ɪ] and [ɔ] were also higher than Ahanta West respectively but they a bit closer.

The findings of this study aimed at contributing to the ongoing linguistics discussions on vowel nasalization on languages.

APPENDIX 1

Table 3.4 Fante word list for the study.

WORD	IPA TRANSCRIPTION	ENGLISH GLOSS
Yi	[yi]	'this'
We	[wɪ]	'chew'
Be	[be]	'will'
Pɛ	[pɛ]	'like'
Tu	[tu]	'uproot'
To	[tʊ]	'bake'
Wo	[wo]	'they'
Tɔ	[tɔ]	'buy'
Sika	[sikæ]	'money'
Pa	[pa]	'good'

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