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Variation in Acoustic Vowel Space in Dholuo Dialects: A Dialectical Study of KSN and B-U Dholuo Vowels of Kisumu and Siaya Counties in Kenya

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ABSTRACT

Purpose: - This linguistic study investigates the acoustic variation of Kisumu South Nyanza (KSN) and Boro Ukwala (B-U) Dholuo vowels in acoustic vowel space.

Methodology: - A combination of field recordings from ten key respondents and acoustic analysis using Praat version 6.0.43 to extract vowel duration, F1, F2 and F3 values. The researcher compared the formant frequencies from each vowel frame, ensuring vowel quality is maintained during the process of data collection. The sounds were recorded using Praat in a quiet environment in respondents' homes. The respondents produced a natural speech in the process. A carrier sentence that contained the required tokens was presented, recordings made and stored in the form of memory stick voice. The tokens were presented in CVCV structure in the environment of /h/, /t/, /p/ and /k/ voiceless sounds. The group mean formant values were normalized using Lobanov. Source Filter Theory was employed in vowel production and Dialectology Theory too to determine sounds and linguistic variations in Dholuo language.

Findings: - The researcher realized notable differences in the structure of KSN and B-U acoustic vowel space with the adjacent vowels of B-U and KSN maximally and minimally dispersed from each other. In the adjacent KSN and B-U Dholuo vowels [u,ʊ] and [o,ɔ], differences were palpable, with B-U vowel [ʊ] most back, KSN vowel [u] minimally adjusted to the centre, central KSN back vowel [o] most back with B-U central back vowel [ɔ] adjusted to the centre. Minimal differences was observed in B-U and KSN adjacent vowels [i ,I],], [e,ɛ] and [a,ɑ] with relatively low dispersion rates.

Unique Contribution to Theory, Practice and Policy: - Acoustic vowel space variation in languages including Dholuo, enhances the understanding of phonetic and phonological characteristics of Dholuo dialect. It promotes neural and cognitive processes involved in speech production and perception including an effective identification of patterns and trends that informs Dholuo evolution and development. Speakers can be able to adjust their vowel sounds to accommodate the acoustic demands of certain environments and be aware of the acoustic differences between dialects that results in varied speech. This research will undoubtedly help in developing policies that promote language diversity and inclusivity in shaping language in communication.

Keywords: *Adjacent Vowels, Carrier Sentence, Dialect, Formant, Memory stick Voice, Vowel Frame*

Introduction

Dholuo is a Nilotic language spoken in the Eastern shores of Lake Victoria in Kenya, parts of Uganda and Tanzania (Carotenuto, M. P. 2006). It has two major dialects, Kisumu South Nyanza (KSN) prevalent in Migori, Homa-Bay and Kisumu counties and Boro Ukwala (B-U) in Siaya county. Tucker (1994), is convinced that the language has ten vowel sounds, open being [i], [e], [a], [o], [u] and closed [I], [ɛ], [ɑ], [ɔ], [ʊ]). The study offered an empirical, objective and quantifiable assessment of formant characteristics of KSN and B-U in acoustic vowel space. The study was guided by the key assumption that the vowel segments of KSN and B-U have unique and distinct patterns in acoustic vowel space. Previous acoustic studies on Dholuo dialects have been auditory and perception based as a result of distinctive feature characteristics (Chomsky, & Halle, 1968). The study findings will better the understanding of Dholuo phonology and phonetics, develop Dholuo literature and inform an expanded acoustic research on other indigenous languages in Kenya and beyond. Reference was made to geographical determinants that influence formant variation in Dholuo dialects. Dholuo has been understudied acoustically using formant values and therefore the need to explore its structure in acoustic vowel space.

Literature Review

Jacobson (1980), provides Dholuo history, background and spread. Casali (2003) opines that Nilo-Saharan languages including Dholuo qualitatively distinguish their vowels by the tongue root concept (ATR), which empirically defines the variation of KSN and B-U vowel segments as open and closed respectively, with open being [i], [e], [a], [o], [u] and closed [I], [ɛ], [ɑ], [ɔ], [ʊ]). A reasonable acoustic description of vowels is realized when F1, F2 and F3 are included in vowel analysis (Ladefoged, & Disner, (2012). Oduol (1990), in his study sampled male and female respondents in identifying phonological, grammatical and lexical features of Dholuo dialects with sociolinguistic orientation playing a key element in the study. This was a key element in the study in identifying key informants for the study. Oduor (2002) investigated the effects of syllable weight on Dholuo, its relationship with tone, stress and vowel processes. The studies were impressionistic in nature. The current study is empirical in nature and similar to Oduor, (2002) but employs bi-syllabic vowel tokens, syllable weight and its effects were beyond the scope of the study. Technological speech processing was done using Praat, an open source software that acoustically analyses KSN and B-U Dholuo vowels using formant values. The discrete units of the two dialects are realized. Tucker & Brian, 1966 posit that Dholuo is a ten-vowel dialect with five being +ATR with the remaining five -ATR which identified the vowels [i], [e], [a], [o], [u] as open and KSN dialect and [I], [ɛ], [ɑ], [ɔ], [ʊ] as closed and B-U dialect. This study is similar to Kinyanjui (2019), who did a comprehensive acoustic analysis of Southern Gikuyu vowels, that compared and contrasted acoustic with auditory-perception vowel space. The study showed that the vowels are minimally and maximally dispersed to make them meaningfully contrastive. Itumo, et al., (2017), in his acoustic study purposively sampled 14 university students (7 males & 7 females). He normalized the formant values using Lobanov algorithm (Hoffman, 2011). The current study is similar to Itumo, et al., outliers were removed and the formant values normalized using Lobanov

normalization suite. Dialectology theory was used to understand how sounds, words and grammatical forms vary in Dholuo language.

Research Methodology

The study is descriptive in nature (Ruane, 2005) and integrates both qualitative and quantitative methods. Vowel segment duration and formant frequencies were measured in milliseconds and hertz respectively. The ten Dholuo vowels formed the Independent variable with the corresponding formants (F1, F2 & F3) being dependent variable. Males age range of 45-55 years was used. They seemed conservative and used the recommended Dholuo variety in daily communication. KSN informants were drawn from Kisumu County, Kisumu West constituency, Korando ward. B-U dialect was drawn from Siaya County, Alego Usonga Constituency, Usonga ward. There are marked segmental cues between the two dialects and the informants must have stayed and schooled in the regions in primary school for a continuous period of eight years. A biodata questionnaire and a Praat recorder was used to record sounds from the informants. A total of 30 word tokens were used for each vowel segment. The study culminated in 300 vowel frames. A total of 300 vowel segments of every Dholuo vowel was presented for the study. Dholuo vowel formant values were normalized using Lobanov algorithm to reduce any anatomical differences and phonemic variations. The formants are generated and recorded in an excel spreadsheet. This was done for all the ten Dholuo vowel segments. Linear Predictive Coding was used as a vital tool in locating the centrality of vowel formants.

Data Presentation and Analysis

The 30 vowel formants from each vowel segment was generated from Praat software. Removal of outliers that could negatively affect the outcome of the results was calculated using quartile 1, quartile 3, lower bound and upper bound. The calculation of the mean formant values of the 300 vowel tokens of the ten vowels segments, F1, F2 and F3 was done. The group mean values were generated using the formula.

$$\bar{x} = \frac{\sum x}{n}$$

Table 1. Text (tab-delimited) group mean formant values of B-U & KSN Vowel segments

DIALECT	VOWEL	SEGMENT	F1	F2	F3	gl1	gl2	gl3
B-U	ɑ	/ɑ/	759	1352.9	2475.966667			
B-U	ɛ	/ɛ/	494.9333333	1854.6	2452.933333			
B-U	I	/I/	304.8333333	2196.166667	2902.566667			
B-U	ɔ	/ɔ/	487.6666667	895.0333333	2427.033333			
B-U	ʊ	/ʊ/	342.2	627.2333333	2573.8			
KSN	a	/a/	789.7666667	1337.266667	2472.033333			
KSN	e	/e/	501.7	1949.733333	2521.566667			
KSN	i	/i/	311.6333333	2114.766667	2814.066667			
KSN	o	/o/	508.3333333	951.7	2354.133333			
KSN	u	/u/	397.9	918.4	2534.1			

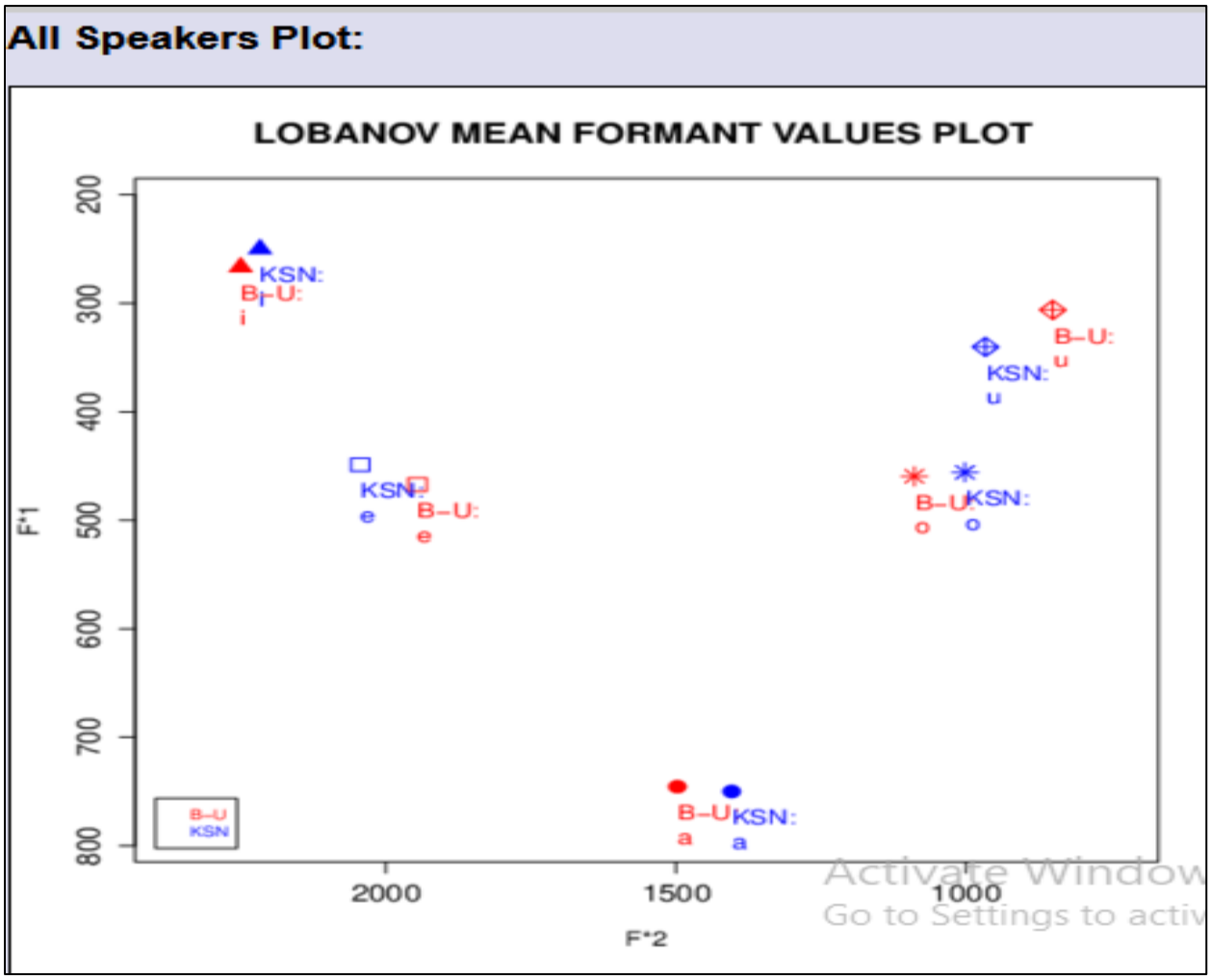

Fig 1. Lobanov All Speaker Plot

Table 2: Formant values of vowel segment /ɑ/ B-U dialect.

Dialect	Token	segment	duration	F1	F2	F3	gl1	gl2	gl3
BU	hake	/ɑ/	7.05	822	1590	2312			
BU	hake	/ɑ/	6.93	810	1599	2314			
BU	hake	/ɑ/	8.11	887	1370	3194			
BU	hako	/ɑ/	10.84	781	1432	2768			
BU	hako	/ɑ/	4.23	685	1313	2311			
BU	hako	/ɑ/	7.74	804	1451	2401			
BU	hate	/ɑ/	3.49	793	1321	2389			
BU	hate	/ɑ/	4.04	734	1443	2245			
BU	hate	/ɑ/	3.86	741	1442	2259			
BU	hato	/ɑ/	2.27	733	1360	2270			
BU	hato	/ɑ/	3.18	723	1458	2340			
BU	hato	/ɑ/	3.09	732	1429	2344			
BU	hepa	/ɑ/	8.01	673	1303	2394			
BU	hepa	/ɑ/	5.61	811	1208	2425			
BU	hepa	/ɑ/	5.6	802	1226	2418			
BU	hepa	/ɑ/	2.64	703	1283	2169			
BU	hepa	/ɑ/	3.49	699	1282	2145			
BU	hepa	/ɑ/	2.76	611	1210	2543			
BU	hepa	/ɑ/	3.48	697	1255	2336			
BU	hepa	/ɑ/	2.24	700	1260	2358			
BU	hika	/ɑ/	7.72	786	1265	2452			
BU	hika	/ɑ/	7.61	775	1279	2438			
BU	hika	/ɑ/	5.08	824	1425	2468			
BU	hika	/ɑ/	4.82	834	1416	2521			
BU	hika	/ɑ/	5.21	839	1406	2556			
BU	hika	/ɑ/	2.72	700	1260	2351			
BU	hika	/ɑ/	2.72	696	1253	2357			
BU	hika	/ɑ/	2.97	581	1223	2439			
BU	pake	/ɑ/	4.76	899	1412	3394			
BU	pake	/ɑ/	8.26	895	1413	3368			
		MEAN	5.017667	759	1352.9	2475.967			

This was done for the remaining nine vowel segments [I], [ɛ], [ɔ], [ʊ]), [i], [e], [a], [o], [u] of B-U and KSN Dholuo dialect.

Table 3 Word tokens

1. hako	hake	kepi
2. hepo	hepa	pike
3. hike	hika	hiku
4. hoto	toko	koto
5. huto	huke	kete
6. hato	hate	tepe
7. hepe	hepi	piko
8. hito	toko	kope
9. hoko	koko	kote
10. hupe	peke	Keko

Discussion

The study investigated the variation in acoustic vowel space in Dholuo dialects: a dialectical study of KSN and B-U Dholuo vowels of Kisumu and Siaya counties in Kenya. It aimed to compare the structure of the vowels in acoustic vowel space using group mean formant values. The results could widen the phonetic and phonological structure of Dholuo vowels enhancing its understanding of language and dialectical variation in different regions. The study acoustically describes the two broad Dholuo vowel systems of KSN and B-U using their group mean formant values. It results in a trapezoidal structure of the vowels with slight differences in adjacent KSN and B-U vowels in acoustic vowel space. The structure reveals and demarcates positions of front, back and central vowels.

The closed front KSN and B-U adjacent vowel segments /i/ and /ɪ/ respectively reveal B-U vowel segment /ɪ/ as minimally retracted than KSN vowel segment /i/. the relationship illustrates the vowel harmony common with adjacent KSN and B-U vowel segments. The half-closed front KSN and B-U vowel segments /e/ and /ɛ/ also appear displaced from each other but still remains adjacent. The low open front KSN and B-U vowel segments /a/ and /ɑ/ exhibit the highest group mean formant values, KSN vowel segment /a/ appear relatively more open that the partially retracted B-U vowel segment /ɑ/ in acoustic vowel space.

KSN and B-U adjacent central vowel segments /o/ and /ɔ/ appear minimally and maximally retracted to the centre respectively, with KSN vowel segment /o/ more back, with B-U vowel segment /ɔ/ minimally retracted to the centre. This marked a significant difference with back front KSN and B-U adjacent vowels /u/ and /ʊ/ that appear more contrastive than the other adjacent pairs in acoustic vowel space. The keep a maximal distance that makes them acoustically contrastive in acoustic vowel space with B-U vowel segment /ʊ/ most back and KSN vowel segment /o/ minimally adjacent to the centre, to maintain a maximal distance that makes them relatively distinct in acoustic vowel space.

The study uses mean formant values to acoustically describe the structure and vowel qualities of KSN and B-U adjacent vowel segments in acoustic vowel space. The study sought to answer the question: Describe the variation in acoustic vowel space in KSN and B-U Dholuo dialects? The

research findings place Dholuo dialects KSN and B-U as having a distinct phonemic and phonetic inventory that makes them behave differently in acoustic vowel space. The F1, F2 and F3 values were the key parameters that were used during the study. F1 is inversely correlated to vowel height, F2 is correlated to the frontness or backness of the vowel segment with F3 correlated to lip rounding. The study shows an inverse relationship in F1, F2 values in the plot as a result of the position of the tongue in the vocal tract. The higher the F1 values, the lower the tongue position and vice versa.

KSN and B-U vowel segments /i/ and /ɪ/ have the lowest F1 and highest F2 mean formant values, making the vowels most fronted. The adjacent vowel segments of KSN and B-U Dholuo dialect continue to maintain a minimum distance that creates a valuable difference needed for this study. there is a notable difference in non-adjacent vowels to adjacent pairs. The B-U back vowel segment /ʊ/ appear most back than the KSN vowel segment /u/ that is advanced to the centre. The study reflects on the contribution of empirical studies in the analysis of vowels. Previous studies have been impressionistic in nature.

The unbiased plotting of the vowel segments after creating a text (tab-delimited) format of the group mean formant values provided a sound and objective plotting of the vowels in acoustic vowel space, building on Dholuo phonetic and phonemic inventory.

The current study aligns with Jacobson (1980) and Casali (2003) in recognizing the distinction between open and closed vowels in the KSN and B-U Dholuo dialects, supporting the ATR (Advanced Tongue Root) vowel classification. It also corroborates the findings of Tucker & Brian (1966), who identified Dholuo as a ten-vowel dialect with five +ATR and five -ATR vowels. However, the findings differ from Oduol (1990) and Oduor (2002), whose studies were impressionistic and did not use detailed acoustic measurements. Oduor's focus on syllable weight and its effects on tone and stress was beyond the scope of the current study, which instead emphasized acoustic vowel space using formant values. The objective acoustic analysis in this study contrasts with the more qualitative approach of earlier works, such as Oduol (1990), and provides a clearer, data-driven understanding of vowel variation. Additionally, the study's approach to formant normalization is aligned with Itumo et al. (2017), who also used Lobanov normalization, offering consistency in the method of data processing. Similarly, it aligns with Kinyanjui (2019) in providing an empirical analysis of vowel acoustics.

Conclusion

In conclusion, the study provides an acoustic analysis of the vowel systems in the KSN and B-U Dholuo dialects from Kisumu and Siaya counties, Kenya. By comparing the group mean formant values of vowel segments, the research highlights slight but significant variations in the acoustic vowel space between the two dialects. The findings reveal distinct phonetic and phonemic differences, particularly in vowel height, frontness, and backness, with specific variations in the positioning of vowels such as /i/, /I/, /a/, and /ʊ/. This study contributes to the understanding of Dholuo dialectical variation, offering a more precise and objective method of vowel analysis compared to previous impressionistic studies.

Recommendations

Dholuo dialect analysis improves our knowledge and understanding of the phonetic and phonemic inventory of KSN and B-U Dholuo. A career sentence containing the words earmarked for the study regularized the production of the vowels, that were in consonant-vowel structure in the environment of voiceless sounds /k/, /t/, /p/ and /h/. A need for a vowel-consonant context instead of a consonant-vowel context would be recommended for an analysis of Dholuo vowel dialects, using formant values.

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