Journal of West African Languages

Anniversary Volume 50 (2023)

THE VOWELS OF WEST AFRICAN LANGUAGES

Fusheini Hudu
University of Ghana, Legon.
fahudu@ug.edu.gh

Abstract
For over six decades now research on the vowels of West African languages have featured prominently in typological studies of virtually every aspect of vowels, ranging from basic inventory types to feature theories. This review brings together the salient properties of vowels found in languages spoken in West Africa as well as highlight key research findings on the vowels of West African languages that have been of interest to cross-linguistic research on vowels. It traces the evolution of research on these vowels, from the early years when findings from field notes were used to analyse the genetic classification of languages, to the use of laboratory instrumental techniques in determining vowel features. It highlights key findings and debates that have taken place over the decades on vowel features and classification, vowel inventory types as well as findings from acoustic and articulatory experimental researches. The paper concludes with a look at the contribution of research on the vowels of West African languages to linguistic theory and suggestions of future directions in research on vowels of languages of West Africa.

Keywords: Vowels features, vowel inventories, language families, West Africa

Tuma kolivaai
Kamani yuumpihiyɔbu m-bɔŋɔ vihigu zaŋ jɛndi Africa Wulinluhili bala vaawulinima zaa nyɛla ŋan niŋ vɛnyɛla n-kahigi wuhi vaawulinima maa biɛhisi bala maa puuni, din wuhiri vaawuli shɛŋa ŋan be bala maa ni nti pahi sodol' shɛŋa ŋan buɣisiri vaawulinima maa nahiŋgbana. Vihigu ŋɔ nyɛla din laɣim vaawuli shɛŋa ŋan be Africa Wulinluhili bala maa ni nahiŋgbana ka lahi tiri wuhi ashi' shɛŋa ŋan yina vihisi ŋan niŋ n-jɛndi Africa Wulinluhili bala vaawulinima ni ŋa niŋbu ni mali kɔrisi shɛm n-zaŋ ti vaawulinima vihivihiriba. Di wuhila vihigu zaŋ jɛndi vaawulinima maa ni pili shɛm, n-wuhiri sahashɛli vihivihiriba ni daa pili zaŋdi lahibal' shɛŋa bɛ ni daa sabiri ka ŋa sɔŋdi ba bala woligibu polo, hali nti paai sahashɛli bɛ ni zaŋdi maʒina m-buɣisiri vaawulinima biɛhisi. Di tiriti wuhiri yɛlikpana mini naŋgbankpeeni ŋan yina vihisi ŋan niŋ yuumbɔŋ din gari maa n-jɛndi vaawulinima taɣimalisi mini ŋa pubu, vaawulinima balibu ŋan be bala puuni nti pahi vihivihiriba ni zaŋ maʒina niŋ vihisi jɛndi vaawulinima bolibu shɛm. Vihigu ŋɔ bahigu, di lahi nyɛla din tiri wuhi pahigu shɛŋa vaawulinma vihibu ni mali Africa Wulinluhili bala puuni zaŋ ti zuliya yɛltɔɣa baŋsim sodoligu, ka lahi niŋ tɔɣino jɛndi Africa Wulinluhili bala vaawulinma vihigu ni yɛn niŋ shɛm sɔhibiɛɣuni.

Bachi kpana: Vaawulinim nahingbana, vaawulunima kalinli, zuliya mabihili, Africa Wulinluhili

1. Introduction

This paper reviews research findings on the vowels of languages spoken in West Africa since the 1960s. It shows the goal and focus of research on vowels at different periods, beginning with the early 1960, when scholars engaged in analyses of field notes to analyse the genetic classification of languages, establish the segmental inventory of languages and determine the basic features of segments. Research on vowels during this period was part of the general focus on language documentation and sketches of the basic grammar of undocumented languages. This period and the decades that followed, were also characterised by debates among scholars on the exact number of vowels in the inventory of languages, vowel feature specifications and the implication of findings for the genetic relationship between languages. Several research institutions in West Africa, detailed further below, dedicated their research focus to the documentation efforts and *The Journal of West African Languages* (JWAL) was among the principal outlets that published the findings of these early researchers. Part of the goal of this review is to highlight the role of JWAL in disseminating these research findings. For this reason, an effort is made to cite every single paper in the journal that included analysis of the vowels of languages in West Africa, from the first issue of the first volume to the current issue.

Over the decades, research on the vowels of West African languages evolved and has made impact. Even if prosodic features such as syllable structure, tone and intonation are excluded, as is the case for this review, the evidence shows that the research findings on vowels have influenced our understanding of language typology, vowel features and phonological theories in general. In the past two decades in

particular, laboratory research methods and findings on the vowels of West African languages have been adopted or cited in research on non-related languages. This paper will attempt to highlight these as well as provide suggestions for future direction.

An important issue worth noting is the linguistic diversity of the West African region. In their introduction to a paper titled *Africa as a phonological area*, Clement and Rialland (2006:1) remark that "[F]rom a genetic-historical point of view, Africa contains several independent or very distantly related language groups, each of which show characteristics different from the others… For these reasons there is little reason to expect any great overall linguistic uniformity". This observation applies, to some extent, to West Africa. Even though Niger-Congo languages dominate in the region, it is also home to some languages in the Nilo Saharan and Afroasiatic families. For this reason, any discussion on the linguistic features of languages native to West Africa cannot be a discussion of a group of languages that have descended from a common ancestor. Many features that are prevalent in these languages are also shared by languages outside the region. Some of the characteristics that deserve attention may be more or less peculiar to the languages of West Africa than languages spoken outside the region. While this is the case, analyses of languages of different families within the same geographic region can shed light on the influence that these languages may have on each other in addition to its general typological relevance.

The paper is organised as follows. Section 2 looks at the issues the earliest researchers focused on in their research on the vowels of West African languages and the debates they engaged in. In Section 3, the description and features of vowels prevalent in the region are presented. This includes the basic features based on aperture and vowel quality that are used to define the acoustic space as well as the non-core features such as tongue root features, nasality, and vowel length. It also looks at the presence of diphthongs and marked feature combinations such as back unrounded and front rounded vowels as well as the feature specifications of low vowels. In Section 4, the typology of vowel inventory in the region is discussed with a focus on the distinction between symmetric and asymmetric vowel inventories. Section 5 deals with the phonetic investigations into vowels in the region while Section 6 highlights the contribution of findings on vowel research in the region to linguistic theory. The final section provides suggestions for future research directions.

2. The focus of early research on the vowels of languages of West Africa

Research focus on the vowels of West African languages has evolved over the past decades. In the 1960s, a lot of field work with descriptive grammars was conducted following the genetic classification of African languages in the 1940s and 50s. Various institutions, including the Institute of Linguistics, the Institute of African Studies at the University of Ghana, the Institute of African Studies at the University of Ibadan, and the Ghana Institute of Linguistics, Literacy and Bible Translation (GILLBT) championed these field works and documentation efforts. The two institutes of African studies at the University of Ghana, and the University of Ibadan, published a lot of descriptive grammars of languages in West Africa under the *Language Monograph* and *Collected Field Notes Series* (at the University of Ghana) and the *Occasional Publications* series (at the University of Ibadan). *The Journal of West African Languages* (JWAL) was an important outlet for peer reviewed publication of many of the descriptive grammars. In the very first volume of the journal, seven out of the nine published papers were either exclusively on or contained sketches on the phonology of various languages, with some attention to the vowels and consonants of these languages. These are Armstrong (1964), Broasnahan (1964), Bouquiaux (1964), Dustan (1964), Ladefoged (1964a), Mackay (1964), Newman (1964).

Beyond the grammatical sketches, some researches on the vowel systems of languages published in JWAL and elsewhere focused on reconstructing the sound system of proto languages. The goal was to establish the sound system that characterised the common ancestor of related languages. This led to debates, some of which continued for decades, on what the inventories of different languages were and possible changes resulting in the reduction in the number of vowels of some languages.

Notable works include Awobuluyi (1967), Bamgbose (1967), Painter (1970), Stanford & Stanford (1970), Stewart (1970, 1976, 1983), Elugbe (1983), Williamson (1983), Dolphyne (1988), Snider (1989), Adjekum et al. (1993), Casali (1995a). As discussed extensively by Casali (1995a), most of these debates relate to the claim of vowel reduction from a nine- or ten-vowel inventory in a proto-language that included the vowels /ɪ, ʊ, ʌ[1]/, to seven-vowel inventories resulting from the loss of these three vowels. The typical claim in these reductionist analyses was that, the low vowel /ʌ/, in studies that claimed a reduction from an original ten-vowel inventory, was lost through a merger with its [-ATR] variant /**a**/ while the high vowels /ɪ/ and /ʊ/ were lost through a respective merger with **/i**/ and /**u**/ or /**e**/ and /**o**/. This is the claim made about Volta-Congo languages with seven vowels (Stewart 1976, 1983, Williamson 1983), Edoid languages (Elugbe 1983), many West African languages in general (Stewart 1970). Williamson (1989) (cited in Casali 1995a) even muted the possibility that this may well have affected Niger-Congo languages in general. Similar claims on specific languages were also made, including Yoruba (Awobuluyi 1967, Bamgbose 1967, Williamson 1983), Anufɔ (Stanford & Stanford 1970), Adjekum et al. (1993), and Baule (Dolphyne 1988).

Other studies either directly or implicitly challenged claims about diachronic vowel reduction or potential vowel reduction, arguing that the number of vowels in languages that were previously claimed to have seven vowels were actually nine. Snider (1989a) argued that changes in Proto-Guan included the splitting of oral vowels resulting in a seven-vowel system becoming nine vowels in present day Guan languages. Schuh's (1995) study of Avatime shows a nine-vowel inventory, contrary to Ford's (1973) seven vowels. On Gonja, Snider (1989b) presented data which show that the language may well have been a nine-vowel language, contrary to Painter's (1970) claim that it had seven vowels. Capo (1983) also rejected Stewarts' (1971) analysis of the presence of [ɪ] and [ʊ] in Proto-Tano-Congo, a position that Stewart defended in a second publication (Stewart 1983). Cahill's (1992, 2007) analysis of Kɔnni has nine-vowels, against Naden (1986), which had seven vowels. With respect to claims about vowel reduction in Proto-Volta, Casali (1995a) doubted its level of prevalence presented in the literature. Other revisions to initial findings emerged decades later with evidence from instrumental phonetic studies, as discussed further in Section 5.

3. Vowel description and features

The phonological features that classify vowels in languages of West Africa are of two categories. In the first category are features based on aperture ([±high, ±low]) and timbre ([±back], [±round]). Those in the second category are features based on tongue root position ([±ATR], [±RTR]), vowel length ([±long]), and nasality ([±nasal]). Vowels in the first category of features constitute the core features for which vowels of every language are specified. They define the vowel space in every language, and each of them can generally combine with any feature in the second category of features. Those in the second category are key in defining the differences between the vowels of one language and another. Besides, as will be shown below, languages often impose restrictions on the combination of features within this category, which serves as another basis for comparing languages. Below, the two types of features and their prevalence in languages of West Africa are discussed in turns.

3.1. Core vowel features based on aperture and timbre

The position of height and backness as core and defining features of vowels cross-linguistically is supported by the vocalic universals below identified and discussed by Hyman (2008). These universals provide a basis for what we can expect from vowels in languages found in any region of the world.

[1] /ʌ/ is meant here as a low [+ATR] vowel. In some of these studies, it is represented differently, including /ɜ/ and /ə/, at different places in the charts. In all presentations of vowel charts, the low vowel is presented as it appears in the cited sources.

(1) Vocalic universals (Hyman 2008)
a. Every phonological system contrasts at least two degrees of aperture.
b. Every phonological system has at least one front vowel or the palatal glide /y/.
c. Every phonological system has at least one unrounded vowel.
d. Every phonological system has at least one back vowel.
e. A vowel system may be contrastive only for aperture only if its vowels acquire vowel colour from neighbouring consonants.

Descriptively, vowel height and backness each gives a maximum of three-way distinction for most languages in West Africa: low, mid, and high for height; and back, central, front for backness. For many languages, there is only one low vowel. For all languages (except some Chadic languages), there is also a minimum of two front and two back vowels. This makes a five vowel inventory the minimum for the typical language in West Africa. Other phonetic properties defining the inventory of vowels in many languages include lip rounding, which is often not distinctive from backness.

3.2. Non-core vowel features

As already noted, the vowel features that complement the core features to create a wider contrast between languages of West Africa are features based on tongue-root, length and nasality.

3.2.1. Tongue root

The position of the tongue root in vowel articulation and its role in the phonological processes is one of the distinctive properties of Niger-Congo languages, to which most languages of West Africa belong. Vowels that are distinguished by tongue root feature include **/i, ɪ/, /u, ʊ/, /e, ɛ/, /o, ɔ/, /ʌ, a/**, the first in each pair being [+ATR] and the second [-ATR] (more on this below). Niger-Congo languages differ in how they employ this cross-height feature. Clement and Rialland (2007) note that the existence of the feature [ATR] typifies non-Bantu languages, with two sets of high vowels. While many previous researchers are not clear or explicit on the phonemic status of the feature [ATR], tongue root position is shown to be distinctive in many languages (e.g. Akan, Dolphyne 1988; Safaliba, Schaefer and Schaefer 2003) creating a phonemic contrast between vowels of same height specifications. In others it is not contrastive (e.g. Dagbani; Hudu 2013, 2016). Still in some other languages, [ATR] creates contrast when applied to some, but not all vowels.

For many languages, this effect may be limited to high vowels, for others, it is limited to mid vowel vowels. For some languages, the tongue root feature applies to mid and high vowels while others have a tongue-root distinction between vowels of all height specifications. Clement and Rialland indicate that among Niger-Congo languages of West Africa, south-eastern Mande, Kru, Kwa, Gur and Ijoid languages have the most cases of high vowels distinguished by a tongue root feature. Tongue-root position ultimately has an influence on the vowel inventory of languages, as discussed further below.

Also important in defining the properties of vowels is the exact manifestation of tongue root position. In most languages, tongue root position is phonologically manifested as advancement, with [ATR] (Advanced tongue root) as a relevant feature. While the articulatory correlates of this feature is complex and may differ between languages, the basic analysis is that, in languages with [ATR] feature, the vowels are categorised into [+ATR] vowels, produced with an anterior gesture of the tongue root [**i, u, e, o, ʌ**] and [-ATR] that lack such a gesture [**ɪ, ʊ, ɛ, ɔ, a**]. However, detailed phonetic investigations, discussed further in Section 5 show that the exact distinction has more to do with the enlargement of the pharynx, with the position of the tongue root being one of several articulatory gestures that contribute to it. For this reason, and following Lindau (1975), Williamson (2004) prefers the features [expanded] and [contracted] to [ATR] and [RTR]. While this analysis is dominant for languages of West Africa, Yoruba is a well-known exception, in which tongue root distinction is shown to

be based on a retraction gesture that characterises the production of [**ɪ, ʊ, ɛ, ɔ, a**] ([+RTR] vowels) and lacking in [**i, u, e, o, ʌ**] ([-RTR] vowels).

3.2.2. Vowel length

Many West African languages lack phonemic length. Languages with phonemic vowel length are of two types with respect to the combination of length and other features. For some, length combines with vowels of all height, tongue root and nasality specifications to produce a distinction between short and long vowels among high, mid, low, nasal, oral, [+ATR] and [-ATR] vowels. Such languages include Hausa (Newman 1996), Baraïn (Lovestrand 2012), Songay languages (Heath 2011, 2014) and Fulfulde (Shehu 2015). These languages have simple inventories of five vowels, each with a phonemically long counterpart: /**i**ː**, e**ː**, a**ː**, o**ː**, u**ː/. In Safaliba, Schaefer and Schaefer (2003) indicate that there are 16 long vowels, as each oral vowel and its nasal counterpart of all height and tongue-root feature specifications receives contrastive length: /**i**ː**, ĩ**ː**, ɪ**ː**, ĩ**ː**, e**ː**, ɛ**ː**, ɛ̃**ː**, a**ː**, ã**ː**, ɔ**ː**, ɔ̃**ː**, o**ː**, u**ː**, ũ**ː**, ʊ**ː**, ʊ̃**ː/. Similarly, according to Dettweiler (2000), C'lela has eight contrastively long vowels, one for each of the short vowels in the language: /**i**ː**, ɨ**ː**, e**ː**, ɛ**ː**, a**ː**, ɔ**ː**, o**ː**, u**ː/.

In many languages, there is a systematic restriction on the combination between length and other features, resulting in much fewer long vowels. In Agoi, there are ten short oral vowels /**i, ɪ, e, ɛ, ə, a, ɔ, o, ʊ, u**/ but only seven long vowels /i: e: ɛ: a: ɔ: o: u:/, excluding non-advanced high and advanced low vowels /***ɪ, *ʊ, *ə**/ (Yul-Ifode 2003). In Dagbani, vowel length is only combined with [+ATR] non-low vowels and the only [-ATR] low vowel, producing five long vowels /**i**ː**, e**ː**, a**ː**, o**ː**, u**ː/ out of 10 short vowels [**i, ɨ, e, ɛ, a, ʌ, ɔ, o, ʊ, u**] (Olawsky 1999, Hudu 2010). In some languages like Gua (Obiri-Yeboah 2021), only oral vowels get lengthened. Vowel length may also show a limited distribution in some languages, compared to short vowels. For instance, in Bambara, long vowels do not surface in the final syllable of a dissyllabic metrical foot (Vydrin 2018). Finally, vowel length may serve as the source of contrastiveness between vowels that are non-contrastive as short vowels. Vydrine (2004) cites Bearth (1971) as having made the claim that in Tura, [**ɪ**] and [**ʊ**] are allophones of one vowel, but /**ɪ**ː**, ʊ**ː/ are separate phonemes.

3.2.3. Vowel nasality

Surface nasal vowels can be either due to an underlying contrast or nasalisation in context. When both are considered, vowel nasality is found to be more widespread among languages in West and Central Africa than elsewhere in the world, with contextual nasalisation more common than contrastive nasality (Clements and Rialland 2007). Within languages in West Africa, nasality in vowels is more common among Niger-Congo (especially Mande, Kwa, Gur/Mabia, and Adamawa-Ubangi languages) rare in Nilo-Saharan and Afroasiatic languages and unattested in Chadic languages (Clements and Riallad 2007).

Typologically, languages in West Africa can be categorised into three regarding the presence of nasal segments: those in which nasality is contrastive for vowels and consonants, those in which it is contrastive for consonants but not for vowels, and those in which it is contrastive for vowels but not for consonants. Of these, languages with contrastive nasality for only vowels would be assumed to be relatively marked. However, Clements and Rialland (2007) list 22 languages in seven countries in West Africa (Liberia, Ivory Coast, Burkina Faso, Ghana, Togo, Benin, eastern part of Nigeria) in which nasality is contrastive for vowels but not for consonants. These languages belong to different families, as shown in (2), along with one language from the Central African Republic. In these languages, nasal vowels typically nasalise adjacent sonorant consonants.

(2) Languages reported to lack distinctive nasal consonants (Clement and Railand 2007:9)

Country	Languages
Liberia	Kpelle (Mande); Grebo, Klao (Kru)
Burkina Faso	Bwamu (Gur)
Côte d'Ivoire	Dan, Guro-Yaoure, Wan-Mwan, Gban/Gagu, Tura (Mande); Senadi/Senufo (Gur); Nyabwa, Wè (Kru); Ebrié, Avikam, Abure (Kwa)
Ghana	Abron, Akan, Ewe (Kwa)
Togo, Benin	Gen, Fon (Kwa)
Nigeria	Mbaise Igbo, Ikwere (Igboid)
CAR	Yakoma (Ubangi)

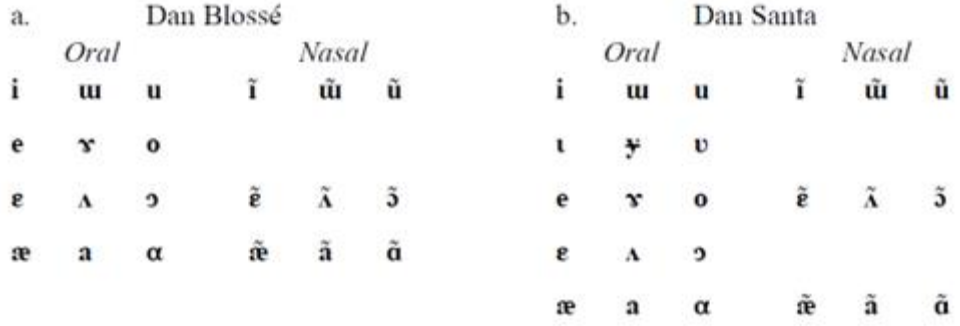
There is a further typology in the combination between contrastive nasality and other vowel features. While contrastive and contextual nasality are unrestricted in many languages (see also Aziza 2005 on Urhobo; Uguru 2010 on Degema; Storch & Koffi 2000 on Akebu etc.), in other languages nasality can be contrastive only if it combines with certain specification of the feature [ATR] and [high]. For instance, Ga (Dakubu 2002), Tuvuli (Harley 2005) and Úwù (Allison 2018) each has an inventory of seven oral vowels **/i, e, ɛ, a, ɔ, o, u**/, but only five nasals **/ĩ, ɛ̃, ũ, ɔ̃, ã**/, excluding mid [+ATR] vowels [**e, o**]. In Gua, the only vowels out of the inventory of nine vowels /**i, e, ɛ, a, o, ɔ, ʊ, ɪ, u**/ that are not nasalised are the [+high, -ATR] vowels. Thus, the language has seven nasal vowels **/ĩ, ẽ, ɛ̃, ũ, õ, ɔ̃, ã**/ (Obiri-Yeboah 2021).

The varying combination between nasality and other features has been used to distinguish languages belonging to different families, sub-groups of a proto-language, or different dialects of one language. For instance, Vydrine (2004) observes that the typical South Mande language has 9 oral vowels consisting of the [+ATR] [**i, e, u, o**] and the [-ATR]: [**ɪ. ɛ, ʊ, ɔ, a**], but only 5 [+nasal] vowels [**ĩ, ẽ, ũ, õ, ã**]. By contrast, most West Mande languages with nasal vowels have seven nasal vowels [**ĩ, ẽ, ɛ̃, ã, ɔ̃, õ, ũ**]. Similarly, Uguru (2010) argues that the Ika dialect of Igbo is unique for having nasality as a contrastive vowel feature.

3.3. Back unrounded and front rounded vowels

One typologically marked feature combination in languages of the world is [+back, -round]. In most languages of the world, it is redundant to specify vowels for both [back] and [round], as all back vowels are [+round] and front vowels are [-round]. In languages of West Africa, the only languages in which both features are contrastive appear to be Mande languages. Vydrine (2004) shows that the inventory of two dialects of the Mande language Dan includes several back unrounded vowels.

(3) Vowel inventory of Dan (Mande) (Vydrine 2004: 116)



Another language shown to have these marked vowels is Ngwe[2]. Dustan (1964) shows that this language has both front rounded and back unrounded vowels, as the inventory in (4) shows.

(4) Vowel inventory of Ngwe (Dustan 1964:39)

i	**y**		**ɯ**	**u**
e	**ø**	**ə**		**o**
ɛ	**œ**		**ɤ**	**ɔ**
æ		**a**		

3.4. The feature specification of low vowels

Most researches on West African languages appear to report only one or two low vowels, assumed to be central, and neutral to backness or rounding harmony. In many languages with only one low vowel, it is typically analysed as unspecified for the feature [ATR], as it surfaces with [+ATR] and [-ATR] vowels in harmonic domains. Thus, the only features that the low vowel is universally acknowledged to receive a specification for are the aperture features [high] and [low].

However, some scholars have argued strongly that this vowel has a specification for all other features. In languages with ten vowels or more in the inventory such as Vagla (Crouch and Smiles 1966), Akan (Stewart 1967, Dolphyne 1967, 1988), Degema (Fulop et al. 1998), Waja (Kleinewillinghöfer 1990), Sisaale (Toupin 1995), Dagaare (Saanchi 1997, Angsongna 2023), Dɛg (Crouch and Herbert 2003), Agoi (Yul-Ifode 2003), Dagbani (Hudu 2010, 2014a), Gomoa (Odoom and Adomako 2021), [**a**] is shown to pattern with [-ATR] vowels while its advanced variant [**ʌ/ə/æ**] patterns with [+ATR] vowels.

The low vowel is also subject to different analyses with respect to its specification for backness and frontness. For many early descriptive studies that lack a detailed analysis of its phonological behaviour, this vowel is regarded as a central vowel, and placed roughly midway in the vowel chart between front and back vowels. Such studies include Toupin (1995) on Sisaale which is shown to have four central vowels of different height and tongue root specifications, Schaefer (1975) on Frafra, Jordan (1980) on Nafaara, Steel and Weed (1990) on Likpakpaanl (Konkomba), and Schaefer and Schaefer (2003) on Safaliba. Other studies positing the low vowel as mid are typically more recent, and provide evidence from phonological or acoustic formant values. These studies include Cahill (2007) on Kɔnni and Ikoyo-Eweto and Ekiugbo (2017) on Uvwiẹ**.** However, some studies that have delved into the phonological patterning of the low vowel have reached a different conclusion. Akanlig-Pare (1994) analyses it as a front vowel in Buli, which, in his analysis, lacks central vowels. Thus, all [-back] vowels are front. The same analysis is given by Awedoba (2002) for the two low vowels of Kasem /**a, ə**/. By contrast, Crouch and Herbert (2003) specify the low vowel [a] as a back vowel in Deg.

Williamson (2004) argues against the position of [**a**] as a [+back] vowel in any West African Niger-Congo language. His analysis is rooted in different inventory types and the pairing between [**a**] and other vowels in various harmonic and assimilatory patterns. For instance, Williamson cites Shimizu's (1980:4, 89) analysis of Jukun to the effect that [**a**] must be a front vowel because "in a situation where front vowels become closer, /**a**/ becomes /**e**/, and in a situation where front vowels become back /**a**/ becomes /**o**/." (Williamson 2004:141).

[2] This is a language of Cameroon. Even though, it is not part of West Africa as a geopolitical unit, the paper reporting this finding was published in the *Journal of West African Languages*, as is the case with some languages spoken in neighbouring countries.

3.5. Diphthongs

Diphthongs are less common in languages of West Africa. They are prevalent in Chadic languages, including Hausa (Newman 1996); Tera (Newman 1964); and Miya (Schuh 1989), all of which are reported to have rising diphthongs. While Hausa and Miya have only two diphthongs /**ay**/ and /**aw**/, Tera has six, the same number as monophthongs in the language: **/iw, ew, aw, ay, oy, uy**/. Several Songay languages (Heath 2014) also have diphthongs. However, Shehu (2015) mention "8 possible diphthongs [**aɪ, aʊ, eɪ, eʊ, ɪʊ, ɔɪ, ɔʊ, ʊɪ**]" in Fulfulde while Onwukwe & Iwe (2021) discuss the possible emergence of diphthongs in Igbo from the borrowing of vowel-glide sequences from Anaang, in borderland areas between speakers of the two languages.

4. Inventory types

There is a fairly wide gap in the number of vowels languages in West Africa have in their inventories. The number of phonemic vowels typically range between seven and mid-twenties, with the features [ATR] and [nasal] being key determinants of the number of vowels that a language has[3]. Most Niger-Congo languages with fewer vowels tend to be those in which [ATR] does not play a role in defining the inventory. Such languages (e.g. Gwari, Hyman and Magaji 1970), have five vowels in their inventory: two vowels each in the front and back and one low vowel: /**i, e, a, o, u**/. However, as observed by Clements and Rialland (2007), systems with only five contrastive short vowels are not favoured. The typical Niger-Congo language of West Africa has four mid or high vowels, even if [ATR] is not active in the phonology. This includes the five cross-linguistically common [**i, e, a, o, u**]. In their sample of 100 languages in the Sudanic belt, (consisting mainly of most countries of West Africa with a portion of Central and East Africa), Clements and Rialland (2007) show that 74% have two high vowels or two mid vowels or both. Those with two high vowels only constitute 28%. Clements and Rialland note that this is typologically unusual given that outside Africa, such systems constitute only 2% of their sample of 345 non-African languages. The prevalence of languages with both two high and two mid vowels, which is 22% in the Sudanic belt, is even more unusual, given that only 1 out of the 345 non-African languages falls into this category.

However, further statistical evidence from Clements and Rialland's study indicates that the presence of systems with four high vowels is not uniformly spread across West Africa. They are more concentrated in south-eastern Mande, Kru, Kwa, Gur, Ijoid and Benue-Congo languages, even though within these zones, there are exceptions. Languages with this system are less frequent in the north, including northern Mande, Fulfulde, Songay, Dogon, and Chadic. Similarly, in the northeast, the Kordofanian languages Jomang and Tima and the East Sudanic languages Tama, Tabi, Nyimang and Temein are among the rare languages with four high vowels. Languages with the most vowels (e.g. Mende languages) are those that generally tend to freely combine [ATR], [nasal], [back] and [round].

One of the notable differences between languages of West Africa has to do with symmetry. Some languages have symmetric vowel inventories, with each (contrastive) vowel feature generally producing two vowels in the front-back dimension within the acoustic space. Others are asymmetric. These are discussed below.

4.1. Symmetric vowel inventories

Focusing on the vowel space by considering height, tongue root and place features at the phonetic and phonemic levels, a language with a symmetrical vowel space has the following features: (i) equal number of front and back vowels; (ii) each back vowel having a corresponding front vowel with which it differs only in the feature [back] and (iii) one or more central vowels that differ in height or tongue root feature

[3] The discussion presented here does not take into account Chadic languages, some of which have as few as two contrastive vowels (Newman 2006; Schuh 1989).

specification. Williamson (2004) refers to such systems as triangular systems, in an analysis that differs slightly from what is presented here. Examples, with different number of vowels are illustrated in (5), ranging from five to thirteen vowels.

(5) Symmetric vowel systems

a. 5 vowels

i		**u**
e		**o**
	a	

b. 6 vowels[4]

i		**u**
e	**ə**	**o**
	a	

c. 7 vowels[5]

i		**u**
e		**o**
ɛ		**ɔ**
	a	

d. 7 vowels[6]

i	**ɨ**	**u**
e	**ə**	**o**
	a	

e. 7 vowels[7]

i		**u**
ɪ		**ʊ**
e		**o**
	a	

f. 8 vowels[8]

i		**u**
e		**o**
ɛ	**ɜ**	**ɔ**
	a	

g. 8 vowels[9]

i	**ɨ**	**u**
e		**o**
ɛ		**ɔ**
	a	

h. 9 vowels[10]

i		**u**
ɪ		**ʊ**
e		**o**
ɛ		**ɔ**
	a	

i. 10 vowels[11]

i		**u**
ɪ		**ʊ**
e		**o**
ɛ	**ɜ**	**ɔ**
	a	

j. 11 vowels[12]

i		**u**
ɪ		**ʊ**
e	**ə**	**o**
ɛ	**ʌ**	**ɔ**
	a	

k. 12 vowels[13]

i	**ɨ**	**u**
ɪ	**ʉ**	**ʊ**
e	**ə**	**o**
ɛ		**ɔ**
	a	

l. 13 vowels[14]

i	**ɨ**	**u**
ɪ	**ʉ**	**ʊ**
e	**ə**	**o**
ɛ	**ʌ**	**ɔ**
	a	

While all these inventories are attested, the seven-vowel inventories show further diversity, with some more common than others. The inventory in 5e with four high vowels and two mid vowels is extremely rare in West Africa. According Casali (2003), there are only two languages in which it is attested: Kpelle, reported by Welmers (1962) and Eastern dialects of Nawdm which is reported by Nicole (1987).

[4] Example: Jju (Kaje), McKinney (1972), cited in Williamson (2004)
[5] Examples: Idoma (Williamson 2004), Ga (Dakubu 2002), Standard Yoruba (Orie 2003), Bijago (Wilson 2000)
[6] Example: Tarok (Longtau 1993), cited in Williamson (2004).
[7] Example: Kpelle (Welmers 1962), cited in Casali (2003).
[8] Example: Lokaa (Yakurr) (Iwara 1982), cited in Williamson (2004)
[9] Example: C'lela (Dettweiler 2000)
[10] Example: Ịjọ Cluster (Williamson 2004), Kusaal (Musah 2018)
[11] Example: Kpelle (Welmers 1962), cited in Casali (2003).
[12] Example: Lokaa (Yakurr) (Iwara 1982), cited in Williamson (2004)
[13] Example: C'lela (Dettweiler 2000)
[14] Example: Ịjọ Cluster (Williamson 2004), Kusaal (Musah 2018)

4.2. Asymmetric vowel inventories

A vowel system can be asymmetric for different reasons. Some languages lack one [ATR] counterpart of a vowel. For instance, Dagbani has the vowel [**ʊ**], but not [**ɪ**]. In its place is the central vowel /**ɨ**/ (Hudu 2010, 2016). While the language still ends up with an inventory of ten vowels, **[i, e, ɛ, a, ʌ, ɔ, o, ʊ, i, ɨ**], it lacks the symmetry discussed in the preceding section. Examples of asymmetric vowel systems are shown in (6).

(6) Asymmetric vowel systems

a. 6 vowels[15]

i		**u**
e		**o**
		ɔ
	a	

b. 7 vowels[16]

i		**u**
e		**o**
		ɔ
	ʌ	
	a	

c. 8 vowels[17]

i		**u**
ɪ		**ʊ**
e		**o**
		ɔ
	a	

d. 10 vowels[18]

i	**ɨ**	**u**
		ʊ
e		**o**
ɛ		**ɔ**
	ʌ	
	a	

What all these asymmetric systems have in common is the absence of a [-ATR] front vowel whose back vowel pair is present. In three of these systems, shown in 6a-c, it is [**ɛ**] that is missing, where [**ɔ**] is present. In 6d, it is [**ɪ**] that is missing, while [**ʊ**] is present in the system.

5. Phonetic investigations into the features of vowels in West Africa

Ladefoged (1964b) is one of the earliest well-known phonetic study focusing on the sounds of West African languages, even though many studies on individual languages preceded it. Instrumental methods in his study included acoustic formant charts and tracings from x-yay frames. Ladefoged focused on determining the quality of vowels common to different languages in the region as well as a discussion on vowels in harmony contexts. He presented and discussed different vowel inventories, (all of which are part of those presented in Section 4), common to languages with patterns of vowel harmony. Phonetic studies following Ladefoged have been dominated by acoustic studies investigating vowel features, the most unique being investigations on the acoustic correlates of the feature [ATR]. The major finding in these studies is that, [+ATR] vowels have a lower F1 than their [-ATR] counterparts. A sample of the dozens of studies arriving at this finding include Lindau (1978), Hess (1992), Kirkham and Nance (2017) on Akan; Ladefoged & Maddieson (1996) on Ebira; Fulop et al. (1998) for Degema; Przezdziecki (2005) for Yoruba; Hudu (2016) for Dagbani. Other recent studies have used articulatory techniques such as MRI (Tiede 1996 on Akan), and ultrasound imaging. Recent ultrasound imaging studies include Hudu (2010, 2014a) on Dagbani; Allen et. al. (2013) on Yoruba; Kirkham and Nance (2017) on Akan. There have also been perception studies, including Ozburn et. al. (2022) on Dagaare, and Rose et. al. (2023) on Akan. Findings from these studies have shed light on issues regarding vowel features and vowel inventories discussed in sections 3 and 4, provided new

[15] Examples: Konkomba (Gr/Mabia, Ghana) (Steel and Weed 1990), Tiv (Williamson 2004).
[16] Example: Ibibio (Urua 1999), cited in Akinlabi and Lee (2006).
[17] Example: Igbo (Williamson 2004).
[18] Example: Dagbani (Hudu 2010, 2016)

insights and evidence of possible diachronic changes between proto-languages and their daughter languages as well as contributed to further understanding of vowels systems and linguistic theories. The findings of a couple of these studies are highlighted below.

Przezdziecki (2005), investigated whether the differences between phonologically contrastive and non-contrastive [ATR] feature can be borne out by acoustic data. Mid vowels in each of the three dialects he investigated, Akure, Moba and Standard Yoruba, are contrastive /**e, ɛ**/ and /**o, ɔ**/, with [ATR] as the feature distinguishing each front and back pair. Akure additionally shows ATR harmony for high vowels with non-contrastive pair [**i, ɪ**] and [**u, ʊ**]. Results of his study showed that contrastive mid vowel [ATR] pairs in all dialects show no overlap in the F1 values for each pair whereas the non-contrastive high vowel [ATR] pairs in Akure showed some overlap. Przezdziecki also investigated whether vowel-to-vowel co-articulation might have been the source of [ATR] harmony in the three dialects, hypothesising that if vowel harmony originates from vowel co-articulation, then the acoustic characteristics of advanced and retracted vowels must have been present in Proto-Yoruba. This predicts that even though Moba and Standard Yoruba do not show [ATR] alternation for high vowels, /**i**/ and /**u**/ will emerge with a higher F1 preceding a [-ATR] vowel than preceding a [+ATR] vowel, even if the degree of correlation is less robust than in Akure. This prediction was borne out in results for /**i**/ and /**u**/ for Moba; and /**i**/, for Standard Yoruba, using non-words in these two dialects. The results were similar to those of the allophonic variation between the high vowels of Akure, even though the former was less robust. Przezdziecki's findings led to two major conclusions: (i) the phonological status of vowel differences correlates with the robustness of their acoustic differences and (ii) the similarity between vowel-to-vowel co-articulation in Moba and Standard Yoruba on the one hand and Akure on the other confirms the hypothesis that the co-articulatory effects existed in Proto Yoruba out of which Akure high vowel harmony developed.

Hudu (2010, 2014a) and Ozburn et al. (2018), used ultrasound imaging and vowel acoustics respectively to investigate the possibility that the low vowel [a] has a [+ATR] variant. Hudu's study investigated Dagbani, while Ozburn et al. (2008) investigated Dagaare, both languages about which earlier researchers argued to be nine-vowel languages with cross height [ATR] harmony. Like in most languages with nine vowels, the only vowel that was claimed to lack a [+ATR] variant is the low vowel. While Ozburn et al. (2018) focused solely on the low vowel, Hudu's (2010, 2014a) study investigated the tongue root position of all vowels in the language. Relevant data for this study are shown in (7).

(7) Stimuli for advanced vowels in harmonic domains (Hudu 2014: 44)

	UR (Class II) vowels		Surface form Class I harmony	
a	**/i̱/**	**/bíh-í/**	**[bíh-í]**	'child-pl.'
b.	**/ɛ/**	**/dɛ́dé/**	**[dédé]**	'exact'
c.	**/ʊ/**	**/tí-bʊ́/**	**[tí-bú]**	'give-ing'
d.	**/ɔ/**	**/dɔr-ó/**	**[dɔ́r-ó]**	'disease-sg.'
e.	**/a/**	**/gár-ó/**	**gə́r-ó**	'bed-sg.'(IZD only)
f.	**/a/**	**/tàdáb-ó/**	**tə̀də́b-ó**	'writing ink-sg.' (others)

Results of both studies showed that contrary to these claims, a [+ATR] variant of the low vowel emerges in harmonic contexts.

6. The contribution of research findings on the vowels of West African languages to linguistic theory

In their analysis of Issues at the interface between phonology and phonetics in African languages, Pulleyblank and Allen (2013) show that the findings of phonetic investigations, including acoustic and ultrasound imaging studies are instrumental in deepening our understanding of phonological phenomena, in three ways: (i) helping to verify the phonetic features of sounds whose distinctions are audible, (ii) ascertaining

the differences between sounds whose differences are difficult to perceive, and (iii) providing the only evidence for distinctions that lack phonetic correlates and cannot be audibly distinguished. Below, some of the specific details on the contributions of these phonetic studies are provided. Before that, it is worth highlighting that all but one out of the six languages whose phonological and phonetic studies were discussed in Pulleyblank and Allen's study are languages of West Africa. These languages include four Nigerian languages (Ebira, Ịjọ, Okpẹ, and Yoruba); and one language of Ghana, Dagbani. The only language in their sample of African languages that was outside of West Africa is Kinande, (Democratic Republic of the Congo). The point of this note is to show that phonetic investigations into the vowels West African languages have been at the centre of research on the phonetics-phonology interface for several decades, even when the focus is on African languages in general. Below, specific areas of phonological research on the vowels of West African languages whose findings have influenced phonological research are highlighted.

6.1. Vowel harmony

One of the phonological patterns that defines languages native to West Africa is vowel harmony, especially harmony based on the feature [ATR]. Clement and Rialland (2007) observe that [ATR] harmony is typical of languages with four high vowels, as they are largely concentrated in the Sudanic belt. It is worth mentioning that while [ATR] harmony is the most prevalent and the most widely studied, vowel harmony based on the feature [round] is also attested (e.g. Dolphyne (1988) on Fante, Casali (1995b) on Nawuri, Hudu (2014b) on Dagbani).

As far as vowel harmony is concerned, research findings on languages in West Africa have influenced theories of [ATR] harmony, as they have been at the centre of discussions on various theories of vowel harmony for the past decades. For instance, Orie (2003) uses [ATR] harmony in dialects of Ebira and Yoruba to evaluate three harmony theories: stem control theory, alignment, and licensing theory. She concludes that alignment and licensing theories were better at accounting for these harmony patterns. The findings of two of the recent acoustic and ultrasound researches (Hudu 2010, 2014a and Ozburn et al. 2018) regarding the advancement of the low vowel in harmonic contexts were also of theoretical interest. This is because some previous studies (e.g. Goad 1993) advanced a theory of harmony that precluded the possibility of low vowel advancement on the assumption that the [+low] and [+ATR] feature specifications are incompatible. Hudu (2014) concluded, based on the results, that the low vowel bears the same phonological tongue root feature specification that distinguishes [+ATR] from [-ATR].

6.2. Feature theory

Feature theories have developed and evolved over the decades using evidence from phonological systems. This section shows how research on the vowels of languages of West Africa has shaped our understanding of vowel features during the past decades.

6.2.1. The feature [ATR]

The feature Advanced Tongue Root [ATR] was first proposed by Stewart (1967) to distinguish the two vowel classes [**i, e, o, u**] (Class A) and [**ɪ, ɛ, ɔ, ʊ**] (Class B) as they exist in Akan. Vowel pairs in these two classes with identical specifications for backness ([**i, ɪ**]; [**e, ɛ**]; [**o, ɔ**]; [**u, ʊ**]) were assumed to also share same height specification and differed only in the position of the tongue root during their production. The key phonological basis supporting their phonetic analysis was the co-occurrence restrictions that ensured that only vowels in one class surfaced within a domain with more than one vowel, usually the word. This has since been termed [ATR] vowel harmony, based on Stewart's analysis. Before Stewart's proposal, different scholars had proposed different features to account for the difference between vowels in these two sets, including tongue height (Christaller, 1875), phonation types (Tucker, 1970; Berry, 1955), tenseness (Schachter and Fromkin 1968) and the term "covered" articulation

(Chomsky & Halle, 1968). The first to investigate this difference experimentally, and prior to Stewart (1967) was Ladefoged (1964b), with x-ray tracings of a speaker of Igbo. These tracings showed a wider pharynx in the production of vowels in Class I, compared to vowels of Class II.

As discussed in detail by Lindau (1979), researchers following Ladefoged and Stewart (e.g. Halle and Stevens 1969; Perkell 1971) supported the use of [ATR] as a more accurate term to describe the articulatory gesture involved in the production of these vowels. With x-ray tracings of several speakers of Akan, Lindau (1979) produced results that showed that Class I vowels had a more anterior tongue-root position than Class II vowels. This advanced tongue root position combined with a more lowered larynx, creating a more expanded pharynx compared with Class II vowels. This formed the basis for Lindau's proposal of the feature [expanded] as an alternative to [ATR] to capture the distinction between vowels in the two classes.

The impact of these findings on research on vowels in African languages and beyond was immense. At the level of phonetics, different instrumental studies were conducted to further understand the articulatory gestures involved and to ultimately motivate typological generalization on vowel features. One of these was the use of MRI by Tiede (1996), whose decision to employ a magnetic resonance imaging (MRI) was motivated by the need to undertake a study that could provide a more complete measure of pharyngeal volume by capturing both the lateral and sagittal dimension of the pharynx, unlike x-ray studies that could measure pharyngeal volume only in the sagittal dimension. Tiede's MRI study on Akan vowels in the two classes confirmed that they differed in both the sagittal and lateral dimensions. Akan Class I vowels were shown to have a larger tongue-root advancement and lower larynx height than Class II vowels in the sagittal dimension, and a larger pharyngeal airspace in the lateral dimension. The results further showed that the difference in lateral width was almost as large as that of the sagittal depth, suggesting that controls in both sagittal and lateral dimensions were equally important in producing vowel contrasts in Akan. While the term [ATR] is still widely used, there is a general understanding and acceptance of the term [expanded] as an alternative name of the feature that more accurately captures the detailed articulatory difference between vowels in the two classes.

Beyond replicating the findings of x-ray studies, Tiede also intended his study to provide results that was typologically more grounded. To achieve this, he took similar measures of English tense and lax vowels to compare the articulatory properties of vowels in the two languages and to determine if the articulatory mechanism involved in the difference between English tense and lax vowels were identical to those involved in Class I and Class II vowels of Akan. In other words, it was intended to determine if tenseness and tongue root advancement involved identical or different articulatory gestures. The results showed that tense vowels displayed properties similar to Akan [+ATR] vowels in the sagittal dimension, but same could not be said of the lateral dimension. In addition to evidence from phonological patterns such as the non-existence of vowel harmony in English, Tiede's findings provide the articulatory basis for keeping tenseness and tongue root advancement as separate phonological features.

Another type of instrumental research that has been done to investigate the feature [ATR] is ultrasound imaging. The first was conducted on Kinande, (Bantu, DRC), (Gick et al. 2015) which was followed by Hudu (2010, 2014) on Dagbani, then Allen et al. (2013) on Yoruba. Gick et al. was undertaken to test, among others, if tongue root position, as opposed to height, was indeed an articulatory correlate of the phonological [ATR] feature and to investigate a claimed transparency of low vowels to cross-height [ATR] harmony in the language. Hudu (2010, 2014), in addition to investigating similar issues also went further to test if there was a difference between phonemic [+ATR] vowels and those that surfaced in harmonic context, as well as develop and test a hypothesis known as the direct mapping hypothesis, discussed further below. The findings of all these studies, which all supported the active use of the tongue root in the articulation of vowels in the direction predicted by the impressionistic use of the ATR, have helped to strengthen the need for phonetic investigations into phonological phenomena.

Another study that compared the feature [ATR] to tenseness is Kirkham and Nance (2017), who investigated the acoustic and articulatory correlates of vowel contrasts in English-Akan bilinguals to test whether the production of [ATR] contrast by native Akan speakers had any relations with the production of the tense/lax vowel contrast in Ghanaian English. To determine this, the researchers compared the bilingual speakers' acoustic and ultrasound data with those of monolingual British English speakers. The results on the acoustic study showed that in Akan and Ghanaian English, the main acoustic correlate of [ATR] and [TENSE] contrasts is F1 whereas in British English, all the first three formants (F1, F2, F3) as well as duration played a role in [TENSE] contrasts. The results from the ultrasound imaging showed tongue root distinctions across all speakers and both languages, with additional consistent tongue height distinctions for British English. The results further revealed a very weak correlation between F1 and tongue root advancement for Akan, suggesting the existence of other measures that ensure pharyngeal cavity expansion in the articulation of the feature [ATR] in Akan vowels that are non-existent in the articulation of the feature TENSE in English vowels. In addition to supporting the general conclusions of previous studies regarding the primacy of pharyngeal cavity volume in the distinction between [+ATR] and [-ATR] vowels, these findings show that even among bilingual speakers, speakers are able to preserve the specific articulatory correlates of the feature [ATR] in Akan, distinct from [TENSE] in English.

A key motivation for the use of ultrasound technology in these studies is the advantage that it affords over acoustic and other articulatory instrumental studies. It is safe (unlike x-ray), least invasive and capable of obtaining real time data of natural language use, unlike MRI. While the use of ultrasound technology in linguistic research did not start with these studies on [ATR], the insights gained, and the techniques used have influenced subsequent articulatory studies of related phenomena in languages spoken in different parts of the world.

6.2.2. Direct Mapping Hypothesis

The final issue to discuss under this section is a hypothesis that was birthed by research intent on understanding the detailed articulatory mechanisms involved in the phonological feature [ATR]. Proposed by Hudu (2010), the Direct Mapping Hypothesis says that the phonetic displacement of articulatory organs corresponds to phonological feature specification. It was proposed to test the possibility that an anterior displacement of the tongue root confirmed in ultrasound studies of [ATR] reflects the dominant [+ATR] value of the tongue root feature in the language. To do this, Hudu made use of insights from previous studies (e.g. Honikman 1964, Laver 1978, Jenner 2001) that point to a default position for articulators specific to every language, and the conclusion by Gick et al. (2004) and Wilson (2006) that this default position is the inter-speech posture (ISP), the default posture the articulators assume between utterances. Hudu hypothesized that for a language like Dagbani with [+ATR] as the dominant value of the harmonic feature, the anterior position of the tongue root for [+ATR] vowels relative to [-ATR] vowels may not be the entire story. Rather, the dominance of the [+ATR] value should correlate with an absolute anterior position from the neutral position. The [-ATR] value, being recessive, would likely lack a unique position relative to the neutral ISP. Results of Hudu's study confirmed these predictions for Dagbani and provided a strong support for the hypothesis.

The implication for this prediction and the results for Dagbani was that, languages with [-ATR/+RTR] would show results that were the exact opposite of what was found for Dagbani: a posterior position of the tongue root from the ISP for the phonologically dominant value and a non-distinct position for the recessive feature value. Allen et al. (2013) tested this on Yoruba, a language with a dominant [-ATR/+RTR] value of the feature, and St'a´t'imcets (an Interior Salish language of British Columbia, Canada) which is known to have phonologically active retracted consonants. Results of their studies of these two languages were varied. While consonant retraction in St'a´t'imcets fully confirmed the hypothesis and its predictions, results on vowel retraction in Yoruba showed varying levels of robustness among

speakers. This hypothesis and the interesting results it generated on investigations into the feature [ATR] has since been tested on features in non-related languages such as Arabic emphatic consonants (Al-Tairi et al. 2017).

7. Future directions

To establish what deserves attention in future research on vowels in West African languages, it is important to recapitulate what the trajectory has been during the past decades. Research on African languages has travelled a fairly enviable and impactful journey from the use of vowel features to establish genetic classification in the 1960s, to instrumental investigations in the laboratory settings that are shaping phonetic, phonological and general linguistic theory in the last decade. In between them, there has been intensive research characterised by debates on the vowel inventory of languages, the nature of the vowels and vowel features as well as comparative studies between languages in West Africa and those outside the region.

Having established this impressive research history, I am of the view that in the next few decades, Africanist researchers need to focus on two main areas. One is to engage in further comparative studies of languages of different families in different parts of Africa. Comparative studies focusing on the vowels of West African languages have tended to be between dialects of one language, genetically related languages or languages spoken within one country. There remains a dearth of research that employs laboratory techniques in comparing African languages. As noted above, the impactful comparative research using laboratory techniques typically seeks to determine how similar or different African languages are from European languages, especially English. While this is impressive from a typological point of view, it is not less relevant to compare languages in West Africa to those of different genealogies within the region and other parts of the continent. In addition to its general typological relevance, such an endeavour will be useful in gaining further insights into the linguistic unity or diversity that exists within Africa.

The second area that deserves attention is external interface research such as instrumental research on the acquisition of vowels by children acquiring West African languages and the effects of various forms of language impairment (specific language impairment, aphasia etc) on vowel production and vowel quality of languages in West Africa. There is also the need for more inter disciplinary research on issues at the interface between language and artificial intelligence. For instance, Georgiou (2023) notes that during the past decade, machine learning techniques has gone beyond listeners' first language to include the prediction of listeners' non-native speech perception patterns. Conducting or replicating research conducted in other parts of the world within West Africa has a great potential to advance our understanding of the interface between language and artificial intelligence, in addition to its general impact on our overall development. Besides, as a region in which the typical language user speaks one or more foreign or local non-native languages, there is no place in the world more ideal than the West African subregion for research on machine learning and vowel perception or articulation.

References

Adjekum, G. M., Holman, E. and Holman, T. W. (1993). Phonological Processes in Anufɔ. Institute of African Studies, University of Ghana. Language Monographs, 2

Akanlig-Pare, G. (1994). Aspects of Buli phonology. Mphil thesis, University of Ghana.

Akinlabi, A., and Lee, S. J. (2006). Predicting Ibibio vowel distribution. *Journal of West African Languages* 33 (2) 43-60.

Al-Tairi, H., Brown. J., Watson, C., and Gick, B. (2017). Tongue retraction in Arabic: An ultrasound Study. In K. Jesney, C. O'Hara, C. Smith, & R. Walker. (Eds.) *Proceedings of the 654 2016 Annual Meeting on Phonology*. Los Angeles.

Allen, B., Pulleyblank, D., Ajíbóyè, O. (2013). Articulatory mapping of Yoruba vowels: an ultrasound study. Phonology 30 (2), 183--210.

Allison, I. O. (2018). Vowel harmony in Úwù. *World Scientific News* 99. 15-33

Angsongna, A. (2023). Aspects of the morphophonology of Dagaare. PhD thesis, The University of British Columbia.

Armstrong, R. G. (1964). Notes on Etulo. *Journal of West African Languages* 1(2). 57-60

Awedoba, A. K. (2002). *Studies in Kasem phonetics and phonology*. Institute of African Studies, University of Ghana. Language Monograph No. 5.
Awobuluyi, O. (1967). Vowel and consonant harmony in Yoruba. *Journal of African Linguistics*6 (1) 1-8.
Aziza, R.O. (2005). The Vowel System and Vowel Behaviour in Urhobo. A Paper presented at the 29th Conference of the Linguistic Association of Nigeria, held at University of Nigeria, Nsukka, September, 25th – 28th.
Bamgbose, A. (1967). Vowel harmony in Yoruba. *Journal of African Languages* 6, 268-273.
Bearth, T. 1971. L'énoncé toura. Norman (Oklahoma): Summer Institute of Linguistics.
Berry, J. (1955). Some notes on the phonology of the Nzema and Ahanta dialects. *Bulletin of the School of Oriental and African Studies* 17, 160-65.
Bouquiaux, L. (1964). A word list of Aten (Ganawuri). *Journal of West African Languages*. 1(2). 5-25.
Broasnahan, L. F. (1964). Outlines of the phonology of the Gokana dialect of Ogoni. *Journal of West African Languages*. 1(1). 43-48.
Cahill, M. C. (1992). *A preliminary phonology of the Kɔnni language*. Institute of African Studies, University of Ghana. Collected Language Notes No. 20.
Cahill, M. C. (2007). *Aspects of the morphology and phonology of Konni*. SIL International and the University of Texas at Arlington.
Capo, H. C. (1983). "I" et "U"en Hwe et leur place dans la reconstruction du Proto-Gbe. *Journal of West African Languages*. 13 (1). 3-18.
Casali, R. F. (1995a). On the reduction of vowel systems in Volta-Congo. *African Languages and Cultures* 8, (2). 109-121.
Casali, R. F. (1995b). Labial opacity and roundness harmony In Nawuri. *Natural Language and Linguistic Theory* 13: 649-663.
Casali, R. F. (2003). [ATR] value asymmetries and underlying vowel inventory structure in Niger-Congo and Nilo-Saharan. *Linguistic Typology* 7 (2003), 307–382.
Chris taller, J. G. (1875). *A Grammar of the A sante and Fante Language called Tshi (Chwee, Twi).*Basel: Evangelical Missionary.
Clements, G.N., Rialland, A., (2007). Africa as a phonological area. In: Heine, B., Nurse, D. (Eds.), *The Linguistic Geography of Africa*. Cambridge University Press, Cambridge, pp. 36–85. http://annierialland.free.fr/Clements_Rialland.pdf.
Crouch, M. and Herbert, P. (2003). Collected field notes on the phonology of Dɛg. Institute of African Studies, University of Ghana. Collected Field Notes No. 24.
Crouch, M. and Smiles, N. (1966). Collected field notes on the phonology of Vagla. Institute of African Studies, University of Ghana. Collected Field Notes No. 4.
Dakubu, M. E. K. (2002), *Ga Phonology*. Institute of African Studies, University of Ghana. Language Monograph No. 6.
Dettweiler, S. H. (2000). Vowel harmony and neutral vowels in C'lela. *Journal of West African Languages* 28 (1) 3-18.
Dolphyne, F. A. (1967). A phonological analysis of Twi vowels. *Journal of West African Languages* 4 (1). 83-89.
Dolphyne, F. A. (1988). *The Akan Twi-Fante language: Its sound systems and tonal structure* Accra: Ghana Universities Press.
Dustan, E. (1964). Towards a phonology of Ngwe. *Journal of West African Languages* 1(1) 39-42.
Elugbe, B. O. (1983). The vowels of proto-Edoid. *Journal of West African Languages* 13(1): 79-89.
Ford, K.C. (1973). On the loss of cross-height vowel harmony. *Research Review*, supplement 4: 50-80. Institute of African Studies, University of Ghana.
Fulop, S. A., Ethelbert, K. & Ladefoged, P. (1998). An acoustic study of the tongue root contrasts in Degema vowels. *Phonetica* 55. 80–89.
Georgiou, G.P. (2023). Comparison of the prediction accuracy of machine learning algorithms in crosslinguistic vowel classification. *Scientific Reports* **13**, 15594. https://doi.org/10.1038/s41598-023-42818-3
Gick, Bryan, Ian Wilson, Karsten Koch & Clare Cook (2004). Language-specific articulatory settings: evidence from inter-utterance rest position. Phonetica 61. 220–233.
Gick, B., Pulleyblank, D., Campbell, F., Mutaka, N., (2006). Low vowels and transparency in Kinande vowel harmony. Phonology 23 (01), 1-20.
Goad, H. (1993). *On the configuration of height features*. University of Southern California dissertation.
Halle, M. & Stevens, K. N. (1969). On the feature Advanced Tongue Root. *Quarterly Progress Report* No. 94, 209-215. Research Laboratory of Electronics, Massachussetts Institute of Technology.
Harley, M. W. (2005). *A descriptive grammar of Tuwuli, a Kwa language of Ghana*. PhD dissertation. University of London.
Heath, J. (2014). *Grammar of Humburi Senni (Songhay of Hombori, Mali)* Language Description Heritage Library Max-Planck Insstitute for Evolutionary Anthropology, Leipzig.
Heath, J. (2011). *A grammar of Koyra Chiini: the Songhay of Timbuktu*. Walter de Gruyter.
Honikman, B. (1964). Articulatory settings. In David Abercrombie, D. B. Fry, P. A. D. MacCarthy, N. C. Scott & J. L.M. Trim (eds.) In honour of Daniel Jones. London: Longmans. 73–84.
Hudu, F. (2010). Dagbani tongue-root harmony: A formal account with ultrasound investigation. Vancouver: University of British Columbia dissertation.

Hudu, F. (2013). Dagbani tongue-root harmony: triggers, targets and blockers. *Journal of African Languages and Linguistics*, 34 (1) 47-73.
Hudu, F. (2014a). [ATR] feature involves a distinct tongue root articulation: Evidence from ultrasound imaging. *Lingua* 143. 36–51.
Hudu, F. (2014b). What is a phonological word in Dagbani? A positional faithfulness account. *Ghana Journal of Linguistics* 3.1: 1–44.
Hudu, F. (2016). A phonetic inquiry into Dagbani vowel neutralisations. *Journal of African Languages and Linguistics, 37*(1), 59-89
Hyman, L. (2008). Universals in phonology. *The Linguistic Review*. 25(1-2), 83-137. https://doi.org/10.1515/TLIR.2008.003
Hyman, L. M., and Magaji, D. J. (1970). *Essentials of Gwari grammar*. Ibadan: Institute of African Studies, University of Ibadan. Occasional Publication No. 27.
Ikoyo-Eweto, E. O. and Ekiugbo, P. O. (2017). A phonetic analysis of Uvwiẹ vowels. *Journal of West African Languages* 44 (2) 1-13.
Iwara, A. U. (1982). The phonology and grammar of Loka: A preliminary analysis. M.Phil. thesis. SOAS, University of London.
Jenner, B. (2001). Genealogies of articulatory settings: genealogies of an idea. *Historiographia Linguistica* 28. 121–141.
Jordan, D. (1980). Collected Field report on Nafaara. Institute of African Studies, University of Ghana. Collected Language Note No. 17.
Kirkham, S., & Nance, C. (2017). An acoustic-articulatory study of bilingual vowel production: Advanced tongue root vowels in Twi and tense/lax vowels in Ghanaian English. *Journal of Phonetics*, 62, 65-81.
Kleinewillinghöfer, U. (1990). Aspects of vowel harmony in Waja and Tangale-Waja commo vocabulary. Frankfurter Afrikanistische Blätter (FAB) 2. 93-106
Ladefoged, P. (1964a). Igbira notes and word-list. *Journal of West African Languages* 1(1). 27-37.
Ladefoged, P. (1964b). A Phonetic Study of West African Languages. London: Cambridge University Press.
Ladefoged, P. and Maddieson, I. (1996). *The sounds of the world's languages*. Oxford & Malden, Mass.: Blackwell .
Laver, J. (1978). The concept of articulatory settings: an historical survey. *Historiographia Linguistica* 5. 1–14.
Lindau, M. (1975). [Features] for vowels. UCLA Working Papers in Phonetics.
Lindau, M. (1978). Vowel features. *Language* 54(3). 541–563.
Lindau, M. (1979). The feature expanded. Journal of Phonetics 7 (2), 163--176.
Longtau, S. R. (1993). A formal Tarok phonology. *Afrika und Übersee* 76:15–40.
Lovestrand, J. (2012). *The Linguistic Structure of Baraïn (Chadic)*. Master of Arts thesis. Graduate Institute of Applied Linguistics.
Mackay, H. D. (1964). A word list of Eloyi. *Journal of West African Languages*. 1 (1). 5-12.
Marchese, L. (1983). Atlas linguistique Kru, Abidjan: ACCT and ILA.
McKinney, N. (1972). Zizwa Jju: babbaku na Kaje: Kaje alphabet. Zaria: Institute of Linguistics.
Musah, A. A. (2018). *A Grammar of Kusaal: A Mabia (Gur) Language of Northern Ghana*. PeterLang GmbH.
Newman, P. (2006). Comparative Chadic revisited. In Newman, P. and Hyman, L. (eds.), *West African linguistics: Papers in Honor of Russell G. Schuh*, pages 188–202. Ohio State University, Columbus.
Newman, P. (1964). A word list of Tera. *Journal of West African Languages*. 1 (1). 33-50.
Newman, P. (1996). Hausa phonology. In Kaye, A. S., and Daniels, P. T. *Phonologies of Asia and Africa.* Volume 1: 537-552.
Nicole, J. (1987). Le nawdm et ses parlers locaux: Etude phonologique, synchronique et comparative d'une langue voltaïque. Thèse de doctorat d'etat, Université de Nice.
Obiri-Yeboah, M. (2021). Phonetics and Phonology of Gua. PhD dissertation. University of California San Diego.
Odoom, J. and Adomako, K. (2021). Progressive vowel harmony in Gomoa. *Ghana Journal of Linguistics* 10(2) 58-83
Onwukwe, C. and Iwe, N. (2021) Diphthongs in Igbo? Language Contact in the Igbo and Anaang Borderlands, *Language Matters*. 52:2, 96-114, DOI: 10.1080/10228195.2021.1936138
Olawsky, K. J. 1999. Aspects of Dagbani grammar – with special emphasis on phonology and morphology. München: LINCOM.
Orie, Ọ. Ọ. (2003). Two harmony theories and high vowel patterns in Ebira and Yoruba. *The Linguistic Review* 20 1–35.
Ozburn, A., Giovio Canavesi, G. F., & Akinbo, S. (2022). Perception of ATR in Dàgáárè [dàgáárì]. *Paper presented at the Annual Conference on African Linguistics 53*. UC San Diego. Ms. University of Toronto & University of Minnesota.
Painter, C. (1970). Gonja: A Phonological and Grammatical Study. Bloomington: Indiana University.
Perkell, J. (1971). Physiology of speech production: a preliminary study of two suggested revisions of the features specifying vowels. *Quarterly Progress Report* No. I 02, 123-139. Research Laboratory of Electronics, Massachussetts Institute of Technology.

Przezdziecki, Marek A. 2005. *Vowel harmony and coarticulation in three dialects of Yoruba: phonetics determining phonology*. Cornell University dissertation.
Pulleyblank, D., and Allen, B. (2013). Issues in the Phonology-Phonetics Interface in African Languages Selected Proceedings of the 43rd Annual Conference on African Linguistics, Ed. Ọ. Ọ. Orie and K. W. Sanders, 1-15. Somerville, MA: Cascadilla. Proceedings Project.
Rose, S., Obiri-Yeboah, M. & Creel, S. (2023) "Perception of ATR contrasts by Akan speakers: a case of perceptual near-merger", *Laboratory Phonology* 14(1). doi: https://doi.org/10.16995/labphon.8948
Saanchi, J. A. (1997). The vowel system of Dagaare. *Gur Papers/Cahier Voltaïques*, *2*, 129–135.
Schaefer, P. and J. Schaefer. (2003). Collected Filed notes on the phonology of Safaliba. Institute of African Studies, University of Ghana. Collected Language Note No. 25
Schaefer, R. (1975). Collected field report on Frafra. Institute of African Studies, University of Ghana. Collected Language Note No. 15
Schuh, R. G. (1995). Avatime noun classes and concord. *Studies in African Linguistics* 24 (2) 123-149.
Schuh, R. G. (1989). Long vowels and diphthongs in Miya and Hausa. In: *Current Approaches to African Linguistics* (vol. 5), ed. P. Newman and R. D. Botne, 35-43. Dordrecht: Foris Publications.
Snider, K. L. (1989a). The vowels of proto-Guang. Journal of West African Languages 19(2): 29-50.
Snider, K. L. (1989b). North Guang Comparative Word List: Chumburung, Krachi, Nawuri, Gichode, Gonja. (Comparative African Wordlists, 4). Institute of African Studies, University of Ghana.
Shehu, Ahmadu. (2015). A Comparative Study of the Rhythm of Fulfulde and Hausa. *Journal of the Linguistic Association of Nigeria*. 18.
Shimizu, Kiyoshi. 1980. A Jukun grammar. Wien: Afro-Pub.
Stanford, R. and Stanford, L. (1970). Collected field reports on the phonology and grammar of Chakosi. Institute of African Studies, University of Ghana. Collected language notes, 11.
Steel, M. and Weed, G. (1990). *Collected field reports on the phonology of Konkomba*. Collected Language Notes No. 3, Institute of African Studies, University of Ghana.
Stewart, J. M. (1967). Tongue root position in Akan vowel harmony. *Phonetica* 16, 185- 204.
Stewart, J. M. (1970). Tongue root position in the Volta-Comoe languages and its significance for the reconstruction of the original Bantu sounds. African Language Studies 11: 340-350.
Stewart, J. M. (1971). Niger-Congo, Kwa. In T. Sebok et al. *Current trends in linguistics 7: Linguistics in Sub-Saharan Africa.* 179-212. The Hague.
Stewart, J. M. (1983). The high unadvanced vowels of Proto-Tano-Congo. *Journal of West African Languages* 13 (1) 19-36.
Tiede, M. (1996). An MRI-based study of pharyngeal volume contrasts in Akan and English. *Journal of Phonetics* 24(4). 399–421.
Toupin, M. (1995). The phonology of Sisaale–Pasaale. Ghana Institute of Linguistics, Literacy and Bible Translation in Cooperation with Institute of African Studies, University of Ghana. Collected Language Notes No. 22.
Tucker, A. N. (1970). Voice quality in African languages. Paper presented at the 2nd International Conference on Language and Literature in the Sudan. December 1970, University of Khartoum.
Uguru, J. O. (2010). Nasal vowels in Ika Igbo. *Journal of West African Languages* 37 (2) 13-27
Urua, E. E. (1999). Length and Syllable Weight in Ibibio. *Studies in African Linguistics* 28: 241-266.
Vydrine, V. (2004). Areal and genetic features in West Mande and South Mande phonology: In what sense did Mande languages evolve? *Journal of West African Languages* 30 (2) 113-125.
Vydrin, V. (2018). Mande Languages. Oxford Research Encyclopedias, Linguistics.
Welmers, W. E. (1962). The phonology of Kpelle. *Journal of African Languages* 1: 13–26.
Williamson, K. (1983). Vowel merger in harmony languages. Journal of the Linguistic Association of Nigeria 2: 61-82.
Williamson, K. (1989). Niger-Congo Overview. In *The Niger-Congo Languages*, ed. Bendor-Samuel, J. 3-45. Lanham, Maryland: University Press of America.
Williamson, K. (2004). Typical vowel systems and processes in West African Niger-Congo Languages. *Journal of West African Languages* 30(2) 127-142.
Wilson, Ian L. (2006). Articulatory settings of French and English monolingual and bilingual speakers. PhD dissertation, University of British Columbia.
Wilson, W. A. A. (2000). Vowel harmony in Bijagó. *Journal of West African Languages* 28(1). 19-32.
Yul-Ifode, S. (2003). Vowel harmony and vowel merger in Agoi. *Studies in African Linguistics* 32 (1) 1-15