An areal typology of nasal vowel systems in West Africa

1. INTRODUCTION

It has been a number of decades since Greenberg’s (1959) work on “Africa as a Linguistic Area”. This important work identified a number of phonological and morphosyntactic features which broadly “characterize” African languages (p. 22-23), while also remarking on the existence of sub-areas of convergence, albeit tentatively (pg. 24). Following up on this work, Greenberg (1983) began to systematically map the geographic extent of four of these specific traits, namely labial-velar stops, labiodental flaps, ‘surpass’ comparatives, and polysemy of a term for ‘meat’/ ‘animal’ (Greenberg 1983:4). Greenberg’s study built off of large-scale African typology work in Welmers (1973) and Gregersen (1977), supporting a notion that there is a “nuclear area in Africa in which areal characteristics are most intense” around present day Eastern Nigeria/Cameroon/Central African Republic.

Later typological work in Africa sought to identify different types of African languages based on shared traits. Heine’s (1976) study based on word order facts develops an African language typology divided into 4 groups A, B, C, and D. The 4 groups also divide into a number of sub-groups based on shared properties, with skewed geographical distributions. He identifies two “areal nuclei” within West Africa where the concentration of traits of specific types is greatest: a “Mande nucleus” of type B and a “Dosso-Nikki nucleus” located “on both sides of River Niger south of Niamey”. In the French Africanist literature, typological generalizations were also made by Houis (1980), broadly classifying two African types A and B which correlate a number of phonological, lexical, and morphosyntactic features in two bundles, including nasal vowels (Houis 1980:29). In recent years, there has been something of a resurgence of areal-typological studies within Africa, e.g. the areal-typological volume of the West African Sahel (Caron & Zima 2006), as well as pan-African edited volumes in Sauzet & Zribi-Hertz (2003), Voeltz (2005), and Hieda et al. (2011). In particular work by Clements & Rialland (2006) and Güldemann (2008, 2010) have both (independently) supported demarcating Africa into a number of specific linguistic areas where shared traits cannot be uniquely and exhaustively associated with specific genetic families.

Within these areal-typological studies, contrastive nasal vowels have received substantial attention, and have additionally been discussed in varying degrees of targeted depth in Hyman (1972), Williamson (1973), Crothers (1978), Ruhlen (1978), Maddieson (1984, 2007), Clements (2000), Clements & Rialland (2006), and Hajek (2011a,b). When taken together, these studies reveal West Africa to be one of the largest nasal vowel zones in the world along with the Amazon region of South America and South Asia.

From this previous scholarship, we can identify a number of issues related to vocalic nasality which still require full explication, summarized in 1.

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1 This paper has been helped along the way by many people who are due a proper thank you: Larry Hyman, Florian Lionnet, Zach O’Hagan, Jeff Good, Keith Johnson, Roger Blench, Lev Michael, Stuart McGill, Otelemate Harry, Matt Faytak, Sophie Salffner, Jack Merrill, Hannah Sande, Erin Donnelley, Rebecca Cover, Orchid Pusey, Mercy Ansah, Anne Storch, Laura McPherson, Eric Campbell, Maria Konoshenko, and the Audience at the University of Toronto (including Keren Rice, Radu Craiovanu, Ross Godfrey, Chiara Frigeni, Elan Dresher, Peter Jurjec, Derk Denis). Jeremy Steffman acted as an undergraduate research assistant, and deserves a special thanks. All errors and weaknesses are my own.
1. Identified issues of West African vocalic nasality
   a. [1] What are the phonemic inventories of nasal vowel systems and their common gaps?
   b. [2] How can we typologize these different systems?
   c. [3] How are these types distributed areally and genetically within West Africa both compared to each other, and to surrounding nasal vowel-less languages?
   d. [4] How are nasal vowels distributed and represented within the phonological systems they occur in?
   e. [5] How do the phonetic realizations of these nasal vowels compare to their oral vowel counterparts?
   f. [6] How can we situate the nasal vowels patterns with respect to large typological and phonetic literature to help explain the patterns we see?

It is these issues which this paper addresses.

To this end, we have created a typological database of 357 languages/language clusters in West Africa. This database is the largest of its kind to date, and encodes not only the status of contrastive vowels but also the nasal vowel inventories themselves. This survey shows that contrastive nasal vowels are found nearly categorically in an expansive area stretching roughly south of the Sahel ranging from Guinea in the West to a middle area of Nigeria roughly along the Niger River. We refer to this area as the West African Nasal Vowel Zone (NVZ). Another Nasal Vowel Zone exists in Central Africa, though these areas were not targeted by the present study. This survey also shows 5 areas which do not have nasal vowels, which we refer to as West African Oral Vowel Zones (OVZ) 1-5: [1] Atlantic OVZ (Senegal/Guinea Bissau), [2] Ivoirian OVZ (Southern Ivory Coast), [3] Ghanaian OVZ (Northern Ghana, Southern Burkina Faso), [4] Upper Nigerian OVZ (Northern Nigeria, Niger), and [5] Lower Nigerian OVZ (South-Eastern Nigeria, Cameroon).

Further, we show that there are two main types of nasal vowel systems: (1) those systems which have a full set of nasal vowel counterparts, and (2) those which have nasal vowel counterparts to mid-close /e o/ missing (a fact which has been noticed by many working in West Africa previously, e.g. Hyman 1972). Those languages which lack /ẽ õ/ are found in the Nasal Vowel Zone Core, and form a continuum from Western Nigeria along the coast into Ghana, and up into the Ivory Coast and the Mande language area, cutting across language families. In contrast, languages which show a distinct presence of phonemic /ẽ õ/ (as well as other types of Nasal vowel systems) are disproportionately present in the Nasal Vowel Zone periphery where the Nasal Vowel Zone and the 5 Oral Vowel Zones meet, e.g. in the Far West region, around the Oral Vowel zone of southern Ivory Coast, in northwest Ghana, along the Ghana-Togo Mountain region, and in the central and southern-most areas of Nigeria. No other nasal vowel gap showed systematic regional patterning.

We understand this distribution of these nasal vowel types to be due to a consequence of areal convergence of specific patterns, as well as inherent phonetic pressures in the perception of nasal vowels. Firstly, we highlight a number of cases in which areal convergence is exemplified where the presence or absence of nasality is due to areal factors rather than genetic inheritance. Further, the fact that nasal vowel types which do not lack /ẽ õ/ are concentrated at the “borderlands” of the OVZs and the NVZ Core suggests that when Oral Vowel languages become Nasal Vowel languages by phonemicizing contextual nasal vowels to contrastive nasal vowels, such a process affects all vowel qualities equally at first. Only later do reductions take place via
contact-induced change in tandem with phonetic underpinnings which favor a reduced number of height contrasts for nasal vowels.

Secondly, the phonetic literature on nasal vowels shows more or less consensus that nasality affects the perception of vowels (Ohala 1975, Wright 1986, Beddor et al. 1986, Beddor 1993, Maeda 1993, among others). Nasal vowels result in Oral-Nasal acoustic coupling, which affect the first formant (F1) of a vowel, the main correlate of vowel height (a Nasal Height-Centralization Effect). This effect can lead to diachronic changes which result in gaps in nasal vowel inventories, such as the West African pattern seen throughout.

Finally, this paper situates these West African data against (1) previous large-scale cross-linguistic surveys (Ruhlen 1978, Maddieson 1984, 2007), and also to concentrated nasal vowel zones in South America and Central America. We show that although previous large-scale surveys show that nasal vowel gaps at mid-height to be common cross-linguistically, the degree and geographic extent to which a gap of /ẽ ū/ is found in West Africa is greater than when compared to South and Central America. Taken together, we conclude this paper with a final point that there is reason to suspect that we should not merely interpret these West African patterns as “phonetically determinant”, noting that the Nasal Height-Centralization Effect does not appear to affect high and low vowel pairs with multiple heights as it does with mid vowels with multiple heights.

We have taken up the present research project under what Bickel (2007) identifies as a central question of 21st century typology: What’s Where Why? In addressing the why part, the nasal vowel data presented here point to a nuanced portrait in which both areal pressures and inherent phonetic pressures shape individual languages and the larger sociolinguistic complexes to which they belong. We feel that the most balanced way to view these nasal vowel distributions is the result of low level perceptually-driven effects which have become incorporated into various grammatical systems, then subject to genetic (vertical) transmission and areal (horizontal) diffusion.

2. BACKGROUND ON PHONOLOGICAL SYSTEMS AND NASAL VOWELS WITHIN WEST AFRICA

2.1. Background on phonology

A number of linguistic traits have been identified within the West Africa, an area classified as the “(Macro) Sudan Belt” areal zone in work by Clements & Rialland (2006) and Güldemann (2008, 2010). Traits of this belt include grammatical features like serial verb constructions and certain tense/aspect systems (e.g. such as factative/performative marking), as well as phonological features such as implosives, labial-velar stops, and having more than two tone heights. Perhaps the most striking phonological feature is the regularity in the types of vowel contrasts made and the phonological activity which they show. Typical vowels systems contain 5-10 vowels, with a typical back/front symmetry. Clements & Rialland (2006) note that the high propensity of multiple heights in the high and mid vowels is disproportionately common in West Africa versus the rest of the world, and that the cross-linguistically canonical inventory /i e a o u/ is in fact relatively uncommon.

This larger inventory of vowels is due to the common distinction between two vowel types: Advanced Tongue Root [ATR]/[+ATR] versus Retracted Tongue Root [RTR]/[-ATR]. Two main transcription practices exist for marking ATR. One is using unique IPA symbols /i ɪ e ɛ ə a ɔ ʊ/ where the higher vowel represents the [ATR] value; depending on the language and description, the low series [+ATR] value is transcribed as /ɪ/ or /ɪ:/ and /ɔ/ or /ɔ:]. The second /i̘ ɪ̙ ɛ̘ ɛ̙ ə̘ ə̙ ɔ̘ ʊ̘/
ø ø ø/ using diacritics ø for [ATR] and ø for [RTR]. ATR Harmony within specific phonological domains is also very common, often both as static co-occurrence restrictions and dynamic phonological alternations.

If certain values are absent or a merger takes place, the most common cases are for /a/ to be present rather than /ø/, next followed by /i u/ to be present over /ɪʊ/. It is much less common for a distinction between oral /e e/ and /o o/ to be neutralized rather than low and high heights. Larger vowel systems with values other than those above occur in the Dan cluster of the Mande family (Vydrine 2004), Eastern Kru languages, e.g. Godie (Marchese 1978:50), and in Bantoid languages near the Cameroon/Nigeria border. Smaller vowel inventories contrasting only 5 vowels are found in Atlantic and Mande languages in far western regions, e.g. in Badyara (Kropp Dakubu 1980), Pulaar (Lacroix 1981), and Soninke (Vydrine 2004), as well as in the Jukunoid languages of Nigeria, e.g. Jukun Takum (Welmers 1968, 1973) and Kpan (Shimizu 1972).

2.2. Background on nasal vowels

Nasal vowels are remarkably common in West Africa, and perhaps can be understood as a prototypical phonological feature (Clements & Rialland 2006:8). These occur both as contextual variants of oral vowels in the context of a nasal consonant or vowel (phonetic [Ṽ]), as well as non-contextual phonemes which are not conditioned by their environment (phonemic /Ṽ/). In some languages, the analytic status of nasal vowels is clear, whereas in others it is more difficult to determine, and requires specific argumentation (see section 3.1 below).

A number of previous studies have discussed the distribution of contrastive nasal vowels in Africa. Ruhlen (1978), Maddieson (1984 [i.e. UPSID], 2007), and Hajek (2011a) [i.e. WALS] are large cross-linguistic surveys which document the cross-linguistic distribution of contrastive nasal vowels. Two other studies are Clements & Rialland (2006) and Hajek (2011b) [i.e. WALS] which specifically target nasal vowels in Africa. These studies are summarized in (2), showing the number of languages surveyed, and the percentage of nasal vowels.
2. Previous surveys of nasal vowels cross-linguistically and in (West) Africa

<table>
<thead>
<tr>
<th>Areal focus</th>
<th>Study</th>
<th>Total number of languages surveyed</th>
<th>Languages with contrastive nasal vowels</th>
<th>Percentage with nasal vowels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cross-Linguistic</td>
<td>Ruhlen (1978)</td>
<td>700</td>
<td>150</td>
<td>21.4%</td>
</tr>
<tr>
<td></td>
<td>Maddieson (1984) - UPSID&lt;sup&gt;2&lt;/sup&gt;</td>
<td>317</td>
<td>71</td>
<td>22.4%&lt;sup&gt;3&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>Maddieson (2007)</td>
<td>670</td>
<td>138</td>
<td>20.1%</td>
</tr>
<tr>
<td></td>
<td>Hajek 2011a - WALS</td>
<td>244</td>
<td>64</td>
<td>26.2%</td>
</tr>
<tr>
<td>(West) Africa</td>
<td>Clements &amp; Rialland 2006</td>
<td>150</td>
<td>African languages with nasal vowels</td>
<td>26.7%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>West African (=Sudanic Belt) languages with nasal vowels</td>
<td>34%</td>
</tr>
<tr>
<td></td>
<td>Hajek 2011b - WALS</td>
<td>40</td>
<td>20</td>
<td>50%</td>
</tr>
</tbody>
</table>

The cross-linguistic studies show that nasal vowels occur in approximately 20-26% of the world’s languages. In contrast, we see from the African studies that in West Africa, they occur to a greater degree, 34% in Clements & Rialland (2006), and 50% in Hajek (2011b).

We replicate the distribution of nasal vowels in Africa and West Africa from WALS (Hajek 2011a,b) below in (3-4).

<sup>2</sup> This intersects with Ruhlen (1976, 1978), but they are not identical.
<sup>3</sup> This database was later updated to include 451 languages, as shown at [http://www.linguistics.ucla.edu/faciliti/sales/software.htm#upsid](http://www.linguistics.ucla.edu/faciliti/sales/software.htm#upsid). Of these 451 languages, 102 were described as having contrastive nasal vowels, roughly 22.62%. This proportion is almost identical to the original 317 language sample, shown above.
3. Distribution of Nasal Vowels in Africa (Red = Has contrastive nasal vowels; White = Does not have contrastive nasal vowels)

4. Distribution of Nasal vowels in West Africa – Hajek (2011b)

These maps can be broken down (tentatively) into two major zones: (1) Sub-Saharan West Africa - Guinea to Western Nigeria, and (2) the convergence area of Southern Chad-Eastern Cameroon-Western Central African Republic. Our survey below only investigates the first, more westerly zone.

Further, Clements & Rialland’s (2006) survey shows a clear areal skewing of contrastive nasal vowels, shown in their map which we repeat in (5). The black dots represent languages with contrastive nasal vowels, whereas the white dots represent those without. Dot size roughly correlates with the number of speakers. This map consists of 150 languages, 100 of which occur in sub-Saharan West Africa: 66 from Niger-Congo, 23 from Nilo-Saharan, and 11 from Afro-asiatic (Chadic), the three major phyla of this area. Of these 100 languages, 34 have contrastive nasal vowels (34%), a figure which is both higher than the percentage of African languages
outside of the Sudanic Belt which have nasal vowels (~6%) found mostly in the Khoisan area, as well as the proportion they find of non-African languages with contrastive nasal vowels (21.2%).

5. Distribution of contrastive nasal vowels in a sample of 150 African languages (100 in Sudanic belt) – (Clements & Rialland 2006)

Within this map, the area enclosed under the dashed line contains languages which have been reported to lack distinctive nasal consonants, i.e. where nasal consonants [m n] are analyzed as contextual variants of /b d/ in the context of a nasal vowel. This type of system cuts across linguistic families, and is found in Mande (e.g. Kpelle, Dan), Kru (e.g. Klao), Gur (e.g. Buamu, Sanadi), Kwa (e.g. Abure), and Igboid (e.g. Ikwerre); see also Bole-Richard (1985:5-7).

Two further studies also identify nasal vowels as a robust feature of the West African Macro Sudan Belt. Dimmendaal (2001:374) notes that “while a contrast between oral and nasalized vowels is common in Niger-Congo, it is relatively rare in Nilo-Saharan or Afroasiatic languages”, particularly within West Africa, and conjectures controversially that a “gradual loss of nasalized vowels in Bantu languages…[is] the only plausible alternative explanation” (Dimmendaal 2001:376). Further, Güldemann (2008, 2010)’s work on establishing the Macro-Sudan Belt of West and Central Africa as an areal zone identifies a number of phonological traits, one of which is the wide geographical extent of contrastive nasal vowels. We repeat his map in 6 below.

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4 The area under the dotted line are those languages where nasal consonants are not underlying, but are contextual allophones of oral consonants, conditioned by nasal vowels in their environment.
6. **West African Areal Zone** – “Macro Sudan Belt” (III) (Güldemann 2008, 2010)

These previous surveys focused on the presence vs. absence of contrastive nasal vowels. Separately, a number of authors have commented on the exact profiles of the nasal vowel systems themselves. Within West Africa, Hyman (1972:167) was one of the first to notice that in numerous (New) Kwa and (New) Benue Congo languages, systematic restrictions exist against nasal counterparts of close-mid vowels /ẽ õ/, noting the observations in 7.

7. **Kwa/Benue-Congo restrictions on nasal vowels – Hyman (1972)**
   - Mid-high nasal vowel counterparts to oral vowels do not occur: */ẽ/, */õ/
   - [n] (and sometimes [m]) does not occur before mid vowels: *[ne] ~*[nẽ], *[no] ~*[nõ]

In particular, Hyman notes that *[ɛ̃, õ̃] “characterizes the Akan, Yoruba, Edo and Niger-Kaduna clusters...[and] a similar restriction in Grebo, a Kru language” (1972:175). Hyman puts forward the idea that the restrictions against /ẽ õ/ relate to historical original of nasal vowels in these languages, most specifically that they have developed from *CNV sequences, at least in the languages he studied.

Williamson (1973) follows up these ideas, and presents additional diachronic paths to contrastive nasal vowels across West Africa, with specific attention to Nigerian languages. She also notes the relative infrequency of /ẽ/ and /õ/ as compared with /ɛ̃/ and /ɔ̃/, though also notes numerous cases in which /ẽ ɔ̃/ are present in many West African languages, and is not sufficiently convinced of their rarity (1973:132). Unlike Hyman, she understands this as a merger of /ẽ ɔ̃/ and /ẽ ɔ̃/, rather than saying that /ẽ ɔ̃/ were never created in the first place in a proto-language. Following this early work in the 1970s, later works also commented on the lack of /ẽ ɔ̃/ across West Africa, e.g. Welmers (1973:32-33), Stewart (1983), Bole Richard (1985:13), Creissels (1994), Clements (2000:139), Vydrine (2004), and Güldemann (2010). However, in many of these works, the author is also quick to point to numerous languages which do have /ẽ ɔ̃/, particularly as originally noted by Williamson and later Capo (1985b:113). Other systematic gaps have not been identified nor a full typology of West African nasal vowel systems, and no statements have been made as to the areal distribution of these patterns, other than insofar as they correspond to genetic groups identified by Hyman above. It is to these concerns that we now turn.
3. Survey of West African Nasal Vowel Systems

This section presents a survey of vocalic nasality in 357 languages/language clusters in West Africa. These languages have been coded for (1) the absence and presence of contrastive nasal vowels, and (2) the phonemic inventory of contrastive nasal vowels within nasal vowel languages. The stated goal of this survey is to provide extensive micro-regional coverage, rather than a controlled sample of languages from separate areas. The figures presented here are subject to the availability of the data, and also may provide coverage for a number of dialects for one language (e.g. Yoruba), though less dialectical coverage for another (e.g. Akan). Therefore, the statistics should be taken as rough estimates and not necessarily as a controlled sample. Similarly, certain geographic areas are very well covered such as Southern Nigeria, whereas other areas are less so such as the Western regions of Guinea, Northern Nigeria and the Nigerian Middle Belt, and Northern Cameroon. As noted above, the present survey only investigates languages West of Cameroon, plus a handful of Cameroonian languages, and specifically has not investigated the Central African Republic area nasal vowel zone.

The quality of the linguistic data surveyed here surely varies, and will be improved upon in the future with improved documentation of these specific languages involved. Where we could, we sought confirmation of a specific language variety from more than one source, though resource and time limitations prevented us from doing so for all of varieties surveyed. All sources culled for these data are listed in the references. We note that this survey represents the largest of its kind with respect to nasal vowels in West Africa.

3.1. Evaluating contrastive nasal vowels

We should be explicit on how we evaluate whether a language contains contrastive nasal vowels. Nasal vowels refer to vowels which are phonetically realized with both oral and nasal air flow through their respective cavities. Most of the world’s languages have surface nasal vowels, often realized in the vicinity of a nasal consonant, e.g. English /mæn/ ‘man’ realized as [mæ̃n] with heavy nasalization of the underlyingly oral vowel /æ/. We understand a language to have contrastive nasal vowels if the nasality on the vowel is not conditioned by its environment. For example, Edo [bin; Benue-Congo; Nigeria] has both an oral vowel and nasal vowel series which are not conditioned by a surrounding nasal vowel, /i e a o u/ and /ĩ ẽ â õ ù/ respectively (Agheyisi 1986). In contrast, Neyo [ney; Kru; Ivory Coast] has only contrastive oral vowel, namely /i ɛ e a o o u/ (Marchese 1978:50, n.d.).

These two types belong on two poles of a spectrum of vocality nasality. For a number of languages, it is not apparent whether surface nasal vowels should be classified as contrastive phonemes or conditioned allophones. For example, as a prototypical example of this ambiguity, Williamson (1973) notes Elugbe’s (1969) study of Ika Igbo [ikk; Benue-Congo; Nigeria] in which it is not clear whether the surface nasalized vowels should be treated as underlyingly /CV/ or /CV/ clusters. For those languages in which the contrastivity status was unclear, this was noted as such. A separate issue of those languages with marginal contrastive nasal vowels is taken up below.

We typically mark nasalization with a tilde above the vowel ͏̃ , though in some cases we replicate the transcription provided for a specific language, e.g. through a tilde under the vowel ͏̧ , or through an <n>/</n> written after the vowel.

3.2. Genetic classification of West Africa

We adopt the following genetic classification for Niger-Congo languages within West Africa, taken from (Williamson 1989:21), shown in 8.
8. Genetic classification of West Africa

This classification shows that Mande and Ijoid languages are more distantly related to other Niger-Congo languages, if they belong to Niger-Congo at all. The Atlantic group as a genetic unit is highly contested, though the subgroups of Atlantic are established as genetic entities. Within the Volta-Congo family, sub-families are generally co-ordinate, and it is unclear where Dogon languages should be placed. Finally, the North Volta-Congo group here includes both Gur and Adamawa-Ubangi languages, with the Senoufo group of languages classified with Gur. Although some Bantoid languages were surveyed, Bantu languages as a whole were not surveyed (for nasal vowels in Bantu, see Maddieson 2003:20-23).

Additionally, this survey includes a small number of non-Niger-Congo languages within West Africa, including Afro-Asiatic languages (Hausa, Mina, Tamashek Tuareg, Mbuko, among others) and Nilo-Saharan (Kanuri, Songhai languages).

3.3. Summary of typological survey

In this section, we provide the results from our survey of 357 language varieties. A full list of these languages is provided in Appendix 1. In 9 below, we present the proportions of language with contrastive nasal vowels vs. languages without. This table also includes those languages where it was uncertain whether the nasal vowels were contrastive or non-contrastive (code=n~y). This table shows that approximately 56% of language varieties surveyed had contrastive nasal vowels, whereas roughly 38% did not have contrastive nasal vowels. A further 6% were ambiguous as to their analysis.
9. Proportions

<table>
<thead>
<tr>
<th>Type</th>
<th>Contrastive Nasal Vowels</th>
<th>Stats (n=357)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nasal vowel languages</td>
<td>y</td>
<td>200 (56%)</td>
</tr>
<tr>
<td>Oral vowel languages</td>
<td>n</td>
<td>134 (37.5%)</td>
</tr>
<tr>
<td>Uncertain analyses</td>
<td>n~y</td>
<td>23 (6.4%)</td>
</tr>
<tr>
<td>Total (100%)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

We were able to map the distribution of these types using Google Maps Engine Lite. These maps are shown in 10 below. A publically accessible version of map is available at [http://bit.ly/1hjmty2](http://bit.ly/1hjmty2).

10. Distribution of presence vs. absence of nasal vowels

In this map, the maroon circles represent languages with contrastive nasal vowels, yellow squares represent languages without contrastive nasal vowels, and green diamonds those whose status is unsettled. For our purposes here, we call these Nasal Vowel languages, Oral Vowel languages, and Ambiguous languages\(^5\). More detailed views of this geographic distribution are in section 4 below.

From this map, we can see a number of geographical concentrations. First, we notice a strong continuous band of Nasal Vowel languages stretching from Guinea and into Central Nigeria butting against the Niger River. In large stretches of this zone, the presence of contrastive nasal vowels is categorical. We can call this the West African Nasal Vowel Zone.

\(^5\) We acknowledge any shortcomings with whole-language typology, and use these labels for convenience of identifying appropriate areal zones.
(NVZ). We can also see that Oral Vowel languages exist mainly in 5 areas, which we identify in 11.

11. Oral Vowel language areal zones (OVZs)

a. [1] Atlantic OVZ - Senegal/Guinea Bissau
b. [2] Ivoirian OVZ - Southern Ivory Coast
e. [5] Lower Nigerian OVZ - South-Eastern Nigeria, Cameroon

The green diamonds indicating those languages whose status is unsettled are concentrated mainly where Oral and Nasal Vowel languages meet, e.g. in Sierra Leone, the Ghanaian Oral Vowel zone, and the border of the Lower Nigerian Oral Vowel zone.

Further, we can further break down the different types of Nasal and Oral Vowel languages. With respect to Nasal Vowel languages, we can first notice that oral vowels and nasal vowels typically form counterparts, e.g. a high front oral vowel /i/ corresponds to a high front nasal vowel /ĩ/. We do not find cases in which a nasal vowel occurs without an oral vowel counterpart, i.e. no situation where we find /ĩ/ but not /i/. In contrast, it is very common for a nasal counterpart to be missing. The table in 12 breaks down the number of Nasal Vowel languages which have a gap in their nasal vowel inventory opposed to those which do not. For our purposes here, we include in this number those language varieties previously classified as having an ambiguous status.

12.

<table>
<thead>
<tr>
<th>Type</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Languages with full set of counterparts</td>
<td>74/206</td>
<td>35.92%</td>
</tr>
<tr>
<td>Languages missing one or more counterparts</td>
<td>132/206</td>
<td>64.08%</td>
</tr>
</tbody>
</table>

The recurring types of gaps which are seen in nasal vowel inventories are not symmetrical. Mid-close nasal values /ẽ ź/ are most frequently absent, followed by the [+ATR] value /ə/ (counterpart of /a/), then near-high vowels and mid-open vowels. High and low vowels are least likely to be missing. This is summarized below in (13-14).

13.

<table>
<thead>
<tr>
<th>Front</th>
<th>Oral</th>
<th>Nasal</th>
<th>N</th>
<th>Proporion</th>
<th>Back</th>
<th>Oral</th>
<th>Nasal</th>
<th>N</th>
<th>Proporion</th>
<th>Low</th>
<th>Oral</th>
<th>Nasal</th>
<th>N</th>
<th>Proporion</th>
</tr>
</thead>
<tbody>
<tr>
<td>i</td>
<td>i</td>
<td>ĭ</td>
<td>197</td>
<td>15.15</td>
<td>u</td>
<td>u</td>
<td>ŭ</td>
<td>197</td>
<td>15.15</td>
<td>ə</td>
<td>ə</td>
<td>ţ</td>
<td>16</td>
<td>1.60</td>
</tr>
<tr>
<td>210</td>
<td>i</td>
<td>*î</td>
<td>13</td>
<td>2.56</td>
<td>63</td>
<td>o</td>
<td>*ô</td>
<td>17</td>
<td>2.71</td>
<td>209</td>
<td>a</td>
<td>a</td>
<td>196</td>
<td>15.08</td>
</tr>
<tr>
<td>i</td>
<td>i</td>
<td>ĭ</td>
<td>46</td>
<td>2.56</td>
<td>o</td>
<td>o</td>
<td>ô</td>
<td>46</td>
<td>2.71</td>
<td>209</td>
<td>a</td>
<td>a</td>
<td>196</td>
<td>15.08</td>
</tr>
<tr>
<td>64</td>
<td>i</td>
<td>*î</td>
<td>18</td>
<td>2.56</td>
<td>o</td>
<td>o</td>
<td>*ô</td>
<td>17</td>
<td>2.71</td>
<td>209</td>
<td>a</td>
<td>a</td>
<td>196</td>
<td>15.08</td>
</tr>
<tr>
<td>e</td>
<td>e</td>
<td>ê</td>
<td>98</td>
<td>0.89</td>
<td>o</td>
<td>o</td>
<td>ô</td>
<td>98</td>
<td>0.89</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>208</td>
<td>e</td>
<td>*ë</td>
<td>110</td>
<td></td>
<td>o</td>
<td>o</td>
<td>*ô</td>
<td>110</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>e</td>
<td>e</td>
<td>ê</td>
<td>162</td>
<td>6.75</td>
<td>o</td>
<td>o</td>
<td>ţ</td>
<td>171</td>
<td>7.77</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>186</td>
<td>e</td>
<td>*ë</td>
<td>24</td>
<td></td>
<td>193</td>
<td>o</td>
<td>*ô</td>
<td>22</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
14. Missing nasal vowel counterparts – Most likely to be absent

Mid-close  >  +ATR Low  >  Near-high  >  Mid-open  >  High & Low

*ẽ *õ  *ə̃  *ɪ̃  *ʊ̃  *ɛ̃  *ɔ̃  *ĩ *ũ *ã

This distribution supports previous observations on the widespread absence of mid-close nasal vowels (as summarized in section 2.2.), though also highlights that this is far from a universal gap, having roughly a 1:1 ratio between languages with and without phonemes /ẽ ŵ/.

We can typologize nasal vowel languages into the classification shown in the table in 16. These break down into 5 main language types:

15. Main language types
   a. [1] No Nasal V – languages without nasal vowels
   c. [3] Other Nasal V Missing – languages missing vowel other than ẽ ŵ
   d. [4] None Missing – languages with full set of nasal vowel counterparts
   e. [5] 3-Height Systems – languages with 3-height systems in system in total

These broad types are broken down into a number of different sub-types. These are coded with a specific symbol, provided in the table below.
### 16. Data point values

<table>
<thead>
<tr>
<th>Type</th>
<th>Condition</th>
<th>Symbol</th>
<th>Total</th>
<th>Meaning</th>
<th>Example language</th>
<th>Example inventory</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Nasal V (N=141)</td>
<td>-</td>
<td>🌏</td>
<td>135</td>
<td>No contrastive nasal vowels</td>
<td>Neyo</td>
<td>/ieleasou/</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Constraint against ě ɗ</td>
<td>⭐</td>
<td>6</td>
<td>Does not have contrastive nasal vowels – also has restrictions against contextual [ě ɗ]</td>
<td>Igala</td>
<td>/ieleasou/</td>
<td>Unlike other vowels, /e o/ do not become nasalized in the context of /N/</td>
</tr>
<tr>
<td>Missing ~e ~o (N=110)</td>
<td>-</td>
<td>🌏</td>
<td>102</td>
<td>Does not have contrastive nasal phonemes /ě ɗ/</td>
<td>Edo</td>
<td>/ieleasou/</td>
<td>Missing mid-close series</td>
</tr>
<tr>
<td></td>
<td>Also missing high</td>
<td>⭐</td>
<td></td>
<td></td>
<td>Ebrée</td>
<td>/ieleasou/</td>
<td>Missing additional series</td>
</tr>
<tr>
<td></td>
<td>Also missing mid-close</td>
<td>⭐</td>
<td></td>
<td></td>
<td>Ahanta</td>
<td>/ieleasou/</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Also missing low</td>
<td>⭐</td>
<td></td>
<td></td>
<td>Yoruba (Standard)</td>
<td>/ieleasou/</td>
<td></td>
</tr>
<tr>
<td>Alternative = No Nasal V</td>
<td>-</td>
<td>🌏</td>
<td>1</td>
<td>Unsettled analysis</td>
<td>Kasem</td>
<td>/ieleasou/</td>
<td>Nasal vowels rare</td>
</tr>
<tr>
<td></td>
<td>Alternative = Other Nasal V Missing</td>
<td>⚫</td>
<td>2</td>
<td>Unsettled analysis</td>
<td>Mbato</td>
<td>/ieleasou/</td>
<td>Phoneme understood as /ě ɗ/, though may be /ĩ ū/</td>
</tr>
<tr>
<td></td>
<td>Alternative = None Missing</td>
<td>🙅</td>
<td>5</td>
<td>Unsettled analysis</td>
<td>Siwu</td>
<td>/ieleasou/</td>
<td>Conflicting sources</td>
</tr>
<tr>
<td>Type</td>
<td>Condition</td>
<td>Symbol</td>
<td>Total</td>
<td>Meaning</td>
<td>Example language</td>
<td>Example inventory</td>
<td>Notes</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>----------------------------------</td>
<td>--------</td>
<td>-------</td>
<td>----------------------------------------------</td>
<td>-------------------</td>
<td>--------------------</td>
<td>--------------------------------</td>
</tr>
<tr>
<td>Other V Missing (N=18)</td>
<td>-</td>
<td>-</td>
<td>15</td>
<td>Has a V missing other than /ẽ ō/</td>
<td>Alladian</td>
<td>/i e e a şo u/</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Constraint against ē ō</td>
<td>⭐️</td>
<td>2</td>
<td>also has restrictions against /ẽ ō/</td>
<td>Grebo</td>
<td>/i e e a şo ū</td>
<td>Muffled vowels /ẽ ō not nasalized</td>
</tr>
<tr>
<td></td>
<td>Alternative = No Nasal V</td>
<td>◼️</td>
<td>1</td>
<td>Unsettled analysis</td>
<td>Basila Anii</td>
<td>/i e e a şo ū</td>
<td>Conflicting sources</td>
</tr>
<tr>
<td>None Missing (N=73)</td>
<td>-</td>
<td>-</td>
<td>47</td>
<td>Has full set of oral complements</td>
<td>Bouna Kulango</td>
<td>/i e e a şo ū</td>
<td>None missing</td>
</tr>
<tr>
<td></td>
<td>Constraint against ē ō</td>
<td>⭐️</td>
<td>20</td>
<td>Has /ẽ ō/ but shows restrictions on them</td>
<td>Fon</td>
<td>/i e e a şo ū</td>
<td>Abstract /ẽ ō/ realized as [ẽ ɔ̃]</td>
</tr>
<tr>
<td></td>
<td>Alternative = No Nasal V</td>
<td>◼️</td>
<td>6</td>
<td>Unsettled analysis</td>
<td>Dagaare</td>
<td>/i e e a şo ū</td>
<td>Conflicting sources</td>
</tr>
<tr>
<td>3-Height System (N=7)</td>
<td>-</td>
<td>-</td>
<td>6</td>
<td>Has only 3 vowel heights</td>
<td>Soninke</td>
<td>/i e a o u/</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Missing ē ō</td>
<td>⭐️</td>
<td>1</td>
<td>Does not have contrastive nasal phonemes /ẽ ō/</td>
<td>Buama</td>
<td>/i e a o u/</td>
<td></td>
</tr>
<tr>
<td>Other/No Value</td>
<td></td>
<td></td>
<td>16</td>
<td>Unknown inventory</td>
<td>Hungwerye</td>
<td>?</td>
<td>Unknown inventory</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Sekpele</td>
<td>/i e e şo u/</td>
<td>For unsettled analysis</td>
</tr>
</tbody>
</table>

6 These dots indicate are “muffled” counterparts to mid-close /e o/. See Innes (1967, 1981) and Newman (1986).
We have plotted these values on the map in 17 below, showing their geographic distribution. We further remark on this distribution in section 4.

17. Geographic distribution of typological values

3.4. Other typological issues not addressed

There are a number of typological issues related to nasal vowels which this summary does not capture and which we will not sufficiently address for this study. For example, perhaps the most influential aspect of West African nasal vowels on the wider phonological literature is the absence of underlying contrastive nasal consonants. In such languages, nasal consonants only appear in the vicinity of a nasal vowel. Clements & Rialland identify a large area where these languages occur, centered around the Ivory Coast/Ghana border, as shown in the map in 5 above.

Further, for those languages with both contrastive nasal consonants and vowels, languages differ as to whether the contrast between oral and nasal vowels is maintained in the vicinity of a nasal consonant. For example, in Kalabari [ijn; Ijoid; Nigeria] all vowels are nasalized after a nasal consonant (Harry 2003:118), whereas such vowels contrast in the vicinity of a nasal consonant in Abron [abr; Kwa; Ghana] (Timyan-Ravenhill 1983). Finally, some languages only marginally contrast nasal vowels. For example, Stauffer (1997:18) notes that in the Gao variety of Songhai, contrastive nasal vowels are extremely rare, and contrast mainly in the vicinity of /h/, presumably a type of rhyno-glottophilic effect (but also /f/7).

18. Contrastive nasal vowels only in vicinity of /h/

Gao Songhai (Stauffer 1997:18)

<table>
<thead>
<tr>
<th>Gao</th>
<th>English</th>
</tr>
</thead>
<tbody>
<tr>
<td>hũũ ‘well!’</td>
<td>husu ‘to be depraved’</td>
</tr>
<tr>
<td>hẽẽ ‘cry’</td>
<td>tee ‘to make’</td>
</tr>
<tr>
<td>sahã ‘strength’</td>
<td>waha ‘to be in a hurry’</td>
</tr>
</tbody>
</table>

7 E.g. noting fĩ ‘very black’ (likely an ideophone) with tĩfĩ ‘to grasp’ (Stauffer 1997:18).
Similar statements exist for Sherbro [bun; Mel, Atlantic; Sierra Leone] (Kropp Dakubu 1980). A larger typological survey is required to fully integrate typological values concerning these issues with nasal vowels.

4. DISCUSSION AND INTERPRETATION OF AREAL DISTRIBUTION OF THESE TYPES

In this section, we provide discussion and an interpretation of the areal distribution of the nasal vowel system types we established above. First, we can breakdown these typological values based on their genetic classification, along the major families established in section 3.2 (not at the phylum level). This is shown in 19 below. For the purposes here, the “n–y” ambiguous cases were classified with nasal vowel values. In this table, the “Other” category includes Dogon, Songhai, Adamawa-Ubangi, Chadic, and Berber languages. These families are arranged from the families with the highest ratio of Nasal Vowel languages at the top (Ijoid, Mande, and Kwa) to those with the smallest ratio (Atlantic and Other).

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Ijoid</td>
<td>8</td>
<td>7.00</td>
<td>1</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Mande</td>
<td>39</td>
<td>5.50</td>
<td>6</td>
<td>19</td>
<td>4</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Kwa</td>
<td>56</td>
<td>5.22</td>
<td>9</td>
<td>21</td>
<td>10</td>
<td>5</td>
<td>11</td>
</tr>
<tr>
<td>Kru</td>
<td>22</td>
<td>1.75</td>
<td>8</td>
<td>6</td>
<td>3</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Gur/Senoufo</td>
<td>70</td>
<td>1.69</td>
<td>26</td>
<td>25</td>
<td>16</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Benue-Congo</td>
<td>101</td>
<td>1.02</td>
<td>50</td>
<td>25</td>
<td>14</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>“Atlantic”</td>
<td>15</td>
<td>0.36</td>
<td>11</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Other</td>
<td>24</td>
<td>0.33</td>
<td>18</td>
<td>5</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

From these data, we see that no family contains only Nasal Vowel or Oral Vowel languages, and Benue-Congo in particularly is evenly split across the 101 language varieties surveyed. This suggests a role of later development of either (1) development of nasal vowels or (2) loss of nasal vowels, depending on the family. Thus there are two main avenues of explanation. The first is independent development of nasal vowel presence/absence. The second is language spread through contact and convergence.

In looking more closely at the map from ex. 17, we notice that the distribution of these typological values are not evenly spread but rather cluster in specific geographic locations. This supports a scenario of contact and convergence. We repeat this map below, and delineate specific boundaries wherein these features cluster.
20. Oral Vowel language areal zones (OVZs)
   a. [1] Atlantic OVZ
   b. [2] Ivoirian OVZ
   d. [4] Upper Nigerian OVZ
   e. [5] Lower Nigerian OVZ
In this map, we can see shaded in blue the geographically contiguous area of blue stars within the West African Nasal Vowel Zone which indicate those systems with a gap of /ẽ õ/. We can call this the Nasal Vowel Zone Core (NVZ Core). Further pockets of the lack of /ẽ õ/ also occur in the Cross River Ogoni group in southwest Nigeria, Etulo in eastern Nigeria, Bariba in northern Benin, Kusaal and Kasem in northern Ghana, and Loko in Sierra Leone. No other nasal vowel gap showed systematic regional patterning.

The yellow shaded areas represent the Oral Vowel Zones as established above and repeated in ex 20. The Atlantic Oral Vowel Zone [1] is found in the Senegal region, mainly consisting of Atlantic languages. We interpret the oral vowel languages in Sierra Leone and Guinea (Kisi, Krim, Temne, all of which are Atlantic, if such a group exists), and those languages showing an unclear interpretation of their nasal vowels (the green dots) are part of this Atlantic zone as well. The Ivoirian OVZ [2] is found in southern Ivory Coast, and is composed of Eastern Kru languages. This vowel zone is striking in being surrounded entirely by nasal vowel systems. The Ghanaian OVZ [3] is found in Northern Ghana/Togo stretching into Burkina Faso, and consists largely of Gur languages. The Upper Nigerian OVZ [4] occurs in Northern Nigeria stretching into Niger whose main languages are Fulani, Hausa, and Kanuri, and the Lower Nigerian OVZ [5] consists of Eastern Nigerian and Cameroon. Between these two Nigerian OVZs is a major is a rift of nasal vowel languages, from many different families, which we discuss below.

We also see that those systems which either (1) have a full set of nasal vowel counterparts, or (2) have a nasal vowel counterpart missing other than /ẽ õ/ are predominantly found where the NVZ Core meet the different Oral Vowel Zones 1-5, as indicated by the red arrows. We refer to these areas as the Nasal Vowel Zone Periphery (NVZ Periphery). The fact that such types are concentrated at the “borderlands” of the OVZs and the NVZ Core suggests that when Oral Vowel languages become Nasal Vowel languages by phonemicizing contextual nasal vowels to contrastive nasal vowels, and that such a process affects all vowel qualities equally at first. Later, reductions take place via contact-induced change in tandem with phonetic underpinnings which favor a reduced number of height contrasts for nasal vowels.

We discuss these patterns more closely in what follows, splitting the discussion up into four different areas: (1) Atlantic Region, (2) Burkina Faso Region, (3) Lower Ghana Region, and (4) Nigeria/Cameroon Region. These acts as references points for discussing the area only, and are not interpreted as being distinct and separate areal zones which share linguistic features to the exclusion of other areal zones. Within each of these discussions, we identify relevant cases of areal alignment.

Area 1: Atlantic Region - Mande/Atlantic/Kru languages

The Far West area consists of Mande, Atlantic, and Kru languages. A map of this area is in (21).
21. Atlantic area

A number of statements can be made about these patterns. To begin, the presence and absence of contrastive nasal vowels largely depends with one’s genetic family. Atlantic languages largely lack nasal vowels (Biafada, Bijago, Diola, Temne, Wolof, etc.), Mande languages of this area typically have contrastive nasal vowels (Susu, Mende, Kpelle, Dan), and Kru languages are split, with West Kru having contrastive nasal vowels (e.g. Grebo, Krahn, Wobe), while East Kru does not (e.g. Bete, Godie, Neyo, Kouya). The Kru isolate subgroup Aizi also appears in the southeast area of the East Kru group (Marchese 1989:126), and align with this East group in not having nasal vowels (e.g. Aproumu Aizi – Marchese 1978:52). However, certain Atlantic languages are described with contrastive nasal vowels, e.g. Badyara and Bullom So (Kropp-Dakubu 1980) and potentially Pular Fuuta and Badiaranke (Rebecca Cover, p.c.), which appear closer to Mande spheres of influence. Further, the Mande language Mandinka in Senegal/Gambia is not described with contrastive nasal vowels, which is located within a heavy Atlantic language area.

Looking closer at these data, we notice additional patterns with respect to the nasal vowel inventories. First, no clear dominate pattern emerges with respect to the type of nasal vowel system across the whole area. However, within the central part of the Ivory Coast, an areal trend occurs of languages which lack /ẽ ŵ/. This consists of a number of Mande languages (Beng, Wan, Toura, Dan), Kwa languages Baoule and Anyi, and stretches into the Senoufo area to the Northeast of Ivory Coast which also lack /ẽ ŵ/. Another strip of Kru languages which lack /ẽ ŵ/ are found to the West of this area in coastal Liberia, including Kuwaa (a Kru Isolate), and Western Kru languages Dewoin, Bassa, Klao, and Grebo.

Within this /ẽ ŵ/-less area, there is a distinct lack of nasal vowels among the Eastern Kru languages, which is highly anomalous within the Nasal Vowel Zone in that it is completely surrounded by nasal vowel languages. However, between the /ẽ ŵ/-less area and the Eastern Kru oral vowel zone, one can see a number of red and purple symbols signaling the presence of /ẽ ŵ/. These include Kru languages Krahn, Tepo Krumen, the Cedepo dialect of Grebo, Wobe, and Nyabwa (this last example being a language which lacks high /ɨ ū/, but has close-mid /ẽ ŵ/), as described in Marchese (1978) and Bearth & Link (1980) for Wobe. Mande languages adjacent

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8 However, Marchese-Zogbo (n.d./2012) later goes on to say that Western Kru languages Nyabwa, Wobe, Guere, Klao, Bassa altogether lack /ẽ ŵ/, and therefore she reconstructs Proto-Western Kru having oral */ɨ e a o o/ and nasal */ɨ ū ẽ ŵ/, but no /ẽ ŵ/. A proper analysis of Western Kru remains unsettled at present.
to this area have also been described as having /ɛ õ/, such as Liberian Kpelle (Leidenfrost and McKay 2007), and abstractly Guro and Yaure, which arguably have /ɛ õ/ nasal counterparts though whose realization is more like lower /ɛ̞  õ̞ / (Vydrine 2004). Even nearby Kwa languages Abidji and Ebrie in southeast Ivory Coast have /ɛ õ/ and do not conform to nearby patterns in larger Kwa languages Abure, Anyi, and Baoule which lack uncontroversially /ɛ õ/. What is important to take away from this micro-zone is a core oral vowel zone surrounded by nasal vowel languages with /ɛ õ/ which are then surrounded by /ɛ õ/-less languages.

Moving to the Northwest within the Atlantic area into Sierra Leone, Guinea/Guinea-Bissau, and Senegal, no clear pattern emerges. Some languages have /ɛ õ/ such as Susu and Kankan Manding, while others lack it such as Loko. In general, nasalization within this micro-area has yet to be worked out completed and is quite complex, as one might expect in a zone which appears to be between to Oral Vowel zones. The status of contrastive vocalic nasality has not yet been established in Mande languages Lele and Kankan Manding, nor in the Atlantic language Sherbro which has marginally contrastive nasal vowels after /h/ only (Kropp-Dakubu 1980).

These findings largely support previous statements of the area. Vydrine (2004:124) points to the role of areal alignment in his assessment of the phonological inventory and activity profiles of Mande, claiming that “the phonological type of a language is shown to depend much more on areal than genetic factors”. This is particularly the case in development of vowel inventories and harmony in the southern Mande-speaking regions (Vydrine 2004:116-117, citing Dwyer 1989:54), such as Dan Blossé and Dan Santa languages with large set of central vowels (e.g. /u ʌ/ ) which Vydrine attributes to influence from neighboring Kru languages Bete and Godie. Vydrine (2004:117) also previously noted that in most West Mande languages, there is a full set of nasal counterparts including /ɛ/ and /õ/, though in a number of West Mande languages (Bamana, Guinean dialects of Maninka, Vai, Mende, Soso, Jallonke), there is typically an absence or rarity of /me, mo, ne, no, nɛ, nɔ/ (Vydrine 2004:118), suggesting a restriction against [ɛ õ] to some degree in some earlier stage of the development of these languages. This historical perspective is taken up later in section 3.2.

**Area 2: Burkina Faso Region – Gur/Mande languages**

The Burkina Faso Region consists mostly of Gur/Senoufo languages, though also includes languages from Mande, Kru, and Dogon families. The exact genetic relation of Gur and Senoufo is not clear at present. Broad patterns can be identified in this Burkina Faso Region. A map is provided in (22).
22. Upper Ghana area

The large concentration of yellow circles corresponds to the Oral Vowel Zone previously identified. These mainly consist of Gur languages, e.g. Grusi languages (Sisala, Chakali), Dagbani, Mampruli, Hanga, Frafra, among others. However, within this sphere of influence, nasal vowel languages also occur, e.g. the Gur language Kusaal in far northeastern Ghana and the Grusi Gur language Kasem (though nasal vowels are found only rarely according to Kropp-Dakubu 1976:324). Along the perimeter of this Oral Vowel Zone, two Gur languages Dagaare and Vagla questionably have contrastive nasal vowels, occurring in the transitional buffer zone between the Oral and Nasal vowel zones, and this Oral vowel zone appears to extend into Central Togo (Gur languages Ntcham and Kabiye). This Oral Vowel Zone even includes the Kwa language Gonja (Williamson 1973) and also possibly Foodo (no mention of nasal vowels in Plunkett 2009), and likely the Mande language Bisa (Prost 1957, Maddieson 1984), all of which occur in language families which prototypically have nasal vowels.

Nasal vowel languages abut this Oral Vowel zone to the northwest, west, and south, consisting of other Gur languages (Deg, Moore), Mande languages (Bambara, Bobo, Samo), Kru languages (Siamou), Dogon languages to the north (Jamsay Dogon), and Senoufo languages (Cebaara dialect, Supyire, Nafaanra). What is striking is that most of these nasal vowel systems lack /ẽ õ/, though do not form a continuum. Languages with /ẽ õ/ appear without any clear pattern, e.g. Siamou, Ligbi, and Koromfe.

More concentrated studies of nasal vowels in Gur reveal distinct patterns with respect to nasal vowels. Naden (1989:154) notes that contrastive nasal vowels are “found a) in the southwest [Gur] languages…adjacent to Kwa, and b) in Gurma languages of the Ghana-Togo

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9 See Bodomo (1997), and earlier Kropp-Dakubu (1976:114; contributor E. Hall) who notes that [Ṽ] might actually be /Vm/.
10 Bisa is controversially lacking nasal vowels. Prost (1957:15) notes that they are very rare, whereas Vanhoudt (1999) notes the existence of all oral counterparts except /ẽ ū ō/, though also notes variability in the realization between oral and nasal vowels in some forms, e.g. [sǐː] ~ [sǐː] ‘calme, serein’ (p. 76). Further information on Bisa is required.
Recently, Miehe (2013) presents the most comprehensive study to date on nasal vowels in Gur, and splits them up into two large groups: type A languages with contrastive nasal vowels, and type B languages with non-contrastive, contextual nasalized vowels. Her findings reveal a striking geographical distribution in which type are “represented (without lacunae) in the west, but from a line in the east (which can be defined by the boundaries of the Moore speaking area), they do not cover a contiguous area, they are then surrounded by type B languages”, but also notes that “on the northernmost (Koromfe) as well on southernmost fringe (Baatonum) of the Gur-speaking area, we find type A languages” (Miehe 2013 (draft):6). This split happens even across sub-groups, showing areal alignment over genetic preservation, e.g. in sub-groups Western Oti-Volta, Gurunsi North, and Gurunsi West.

In terms of the types of nasal vowel systems, she finds that a lack of /ẽ õ/ characterizes most of Gur, including the following Gur groups: Oti-Volta East, Oti-Volta West, Bramu, Cermo-Curama, Baatonum, and the Senoufo group. However, she notes the presence of /ẽ õ/ in multiple different sub-groups: certain Gurunsi North languages (Lyele, Nuni, and Pana), Dyan, Dogose, Viemo, and the Kulango group (Logon, Thée, and Kulango). These do not form a single genetic sub-group, but do all appear within the confluence of the Ghana, Ivory Coast, Burkina Faso border moving from north to south, suggesting an areal rather than genetic pattern. This is particularly striking when compared to our map, as these abut Daagare, Vagla, and Ligbi, all of whom have been described with /ẽ õ/ as well. Further work is needed to clarify these matters within Gur, though it is promising. Gur in particular presents problems for diagnosing contrastive vowels, as many of its languages show synchronic [Ṽ] vs. [VN] alternations (Miehe 2013:9).

**Area 3: Lower Ghana Region – Kwa/Benue Congo languages**

The Lower Ghana area consists almost entirely of Kwa languages, which can be split up into two main sub-groups: Nyo and Left Bank (Stewart 1989:221). A map is provided in (23).

23. Lower Ghana area
These show the nearly categorical presence of nasal vowels. There are a number of cases of a Kwa language which does not have nasal vowels, e.g. Gonja (Williamson 1973), Foodo (Plunkett 2009), and Ega (Blench 2004)\(^{11}\). Gonja and Foodo are Guang Kwa languages which appear next to Oral Vowel Gur languages, which suggests areal alignment. Ega is a Kwa isolate which appears within the Oral Vowel Zone of East Kru, also suggesting areal alignment (if Ega is understood as Kwa, which is controversial\(^{12}\)).

The Ghana-Togo Mountain is a complex region, shown in 24. Along the Lake Volta region - particular on the eastern side – there is a large zone of languages which have /ẽ õ/, and either have all nasal counterparts or are missing some other vowel other than /ẽ õ/. We can compare this to the languages nearer to the ocean south of the Lake Volta region as shown in 23, where there is a distinct lack of /ẽ õ/.

24. Togo/Ghana Mountain Area

The type of nasal vowel system in this zone does not appear to conform to the two major Kwa branches Nyo and Left Bank, and are therefore not merely conservative retentions. In the /ẽ õ/-less zone in the far south, this includes both Nyo languages such as Akan/Twi, Dangme, Ga, Ahanta, Anyi, and Baoule, as well as Left Bank languages such as Avatime, and Ewe/Gbe which include Phla-Phera languages. Ewe and Fon are perhaps the most famous in this area in that they can actually be analyzed as having /ẽ/ and /õ/ phonemes abstractly, though they always surface as [ɛ̃] and [ɔ̃] (Ansre 1961:82, Capo 1981b, 1985a:20).

Within the area where /ẽ õ/ is present, these also are a mix of languages between the Nyo and Left Bank branches. The languages of this area were in the past classified as constituting a branch “Togo Remnant” within Kwa, and later Togo Ghana Mountain languages, though in a seminal statement on Kwa in Stewart (1989), he does not classify languages of this area as holding to a single genetic unit. Regardless, these languages show the presence of /ẽ õ/. For example, Basila Anii, Tetemang Lelemi, Gikyode, Ginyanga, Krache, Sekpele, and Akpafu have

\(^{11}\) A fourth potential case is Logba which has contradictory information in the two sources we have (Williamson 1973, Dorvlo 2004).

/ẽ ō/, and are classified under Stewart as belonging to the Nyo major group of Kwa languages, which are closer genetically with southwesterly located Akan and Ga. In contrast, Bowili, Nyangbo, Animere, Ahlo, and Kebu are also described as having /ẽ ō/, though are classified under the Left Bank group, which are more closely related genetically to the southeasterly located Gbe/Ewe languages. Some of these languages are described with having gaps in their nasal inventories which are not common, e.g. Basila Anii, which lacks nasal counterparts /ɪ̃ ɛ̃ ʊ̃ ɔ̃/13 /ũ/14.

However, there is reason to suspect that some Ghana-Togo Mountain languages may conform to a regional pattern of lacking /ẽ ō/ when looked at more closely. For example, although Williamson (1973) cites that Santrokofi (aka Sele) has nasal inventory /ĩ ẽ ɛ̃ ɔ̃ ũ/, Kropp-Dakubu (1980; contributor Christine Allen) notes this languages does not have /ẽ ō/ nasal counterparts, and further questions the contrastiveness of certain nasal vowels, noting only /ĩ ũ/ occur after non-nasal consonants, where all other nasal vowels occur after nasal consonants only. Further, Schuh (1995) notes that in Avatime, /ẽ/ and /õ/ are rare, and that in general among the modern generation, nasalization has all but disappeared, the nasal vowels collapsing with their oral counterparts. We leave the interpretation of these facts to a later date, and note the strong cultural influence of southerly located Akan and Ewe groups.

Finally, two Kwa languages Ebrie and Abidji should also be noted whose patterns do not conform to the Akan/Ewe type of lacking /ẽ ō/, either phonologically or phonetically. As mentioned previously, these abut the Eastern Kru zone in the Ivory Coast. Ebrie has an atypical system /i e ɛ a o u/, but only /ẽ ō/ (Ruhlen 1976:191, citing Vogler 1968), and Abidji is described in two different publications as having all nasal counterparts including /ẽ ō/ (Herault 1983:45-46; Tresbarats & Vick 1992). These two systems do not show areal alignment per se, but suggest at least that these are outside of a potential Lower Ghana areal zone.

**Area 4: Nigeria/Cameroon Region– Benue-Congo/Other**

The final area we look is Nigeria and stretching eastward into Central Africa. This area comprises of Benue-Congo languages, which abuts Chadic languages to the north and northeast, and Ijoid languages to the south. Maps of this area are provided in (25-27).

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13 I assume this is what the transcription symbol <ö> represents, as documented in Williamson (1973). Also, this language has [-ATR] /ã/.
14 These Togo-Ghana Mountain languages lack Serial Verb Constructions, as well, which also sets them apart from this wide areal pattern in West Africa (Dimmendaal 2001:385).
25. Northern Nigeria

![Map of Northern Nigeria]

26. Southern Nigeria

![Map of Southern Nigeria]
These maps show a number of patterns. First, the presence vs. absence of nasal vowels has two large borders. The first is a North/South Border, where the Kainji languages are found in Western Nigeria. The more northerly located Kainji languages abut a Hausa sphere, and do not have nasal vowels (e.g. Fakai, C’lela, Duka). In contrast, Kainji languages further to the south do have nasal vowels, which abut the Nupe & Yoruba sphere to the south and Mande languages Shanga, Boko, and Busa to the west. Such Kainji languages include Reshe, TsuVadi, and Tsishingini.

A West/East border appears to be roughly contiguous with the River Niger. Languages to the west and south of this area have nasal vowels, whereas languages to the east do not. Within the Lower Nigerian Oral Vowel Zone, there are pockets of nasal vowel languages. In southern Nigerian, these pockets include a continuous group of Igbo languages (e.g. Ezinehite, Ikwere, Ogbah, and Olu), a Cross-River group the Ogoni languages (e.g. Eleme, Ogoi, Khana, Gokana), an Ijoid language Nkoroo, and Defaka (potentially related to Ijoid). In the Central part of Nigeria, there also appears to be a (potentially) contiguous belt of nasal vowel languages from different families starting near modern day Abuja, consisting of Gwara, Mada, Lijili [all Plateau languages], Etulo [Idomoid], Jukun [Jukunoid, Benue-Platoid], and Vute [Mambiloid, Northern Bantoid]. Richards (1991) identifies nasal vowels in a Beboid language Ncane (=Nchanti, Ncanti), which is in this same region as Jukun and Vute within the Northwest Region of Cameroon near the Nigeria border (Matthew Faytak, p.c.). A West Chadic language Kofyar is also spoken in this belt near Lijili, and Kofyar, too, has been described as having nasal vowels (Bola 2011 on the Mernyang dialect). If true, this would make it quite anomalous within Chadic.

This long narrow belt of nasal vowel languages exemplifies the areal alignment nature of vocalic nasality. The more northerly located Idomoid language Etulo shows contrastive nasal vowels (Williamson 1973), whereas more southerly located Idomoid languages in the heart of the Oral Vowel Zone do not (e.g. Idoma, Igede, and Nkum Yala). Armstrong (1989:328) in fact notes that “phonemic nasal vowels do not occur in any of the Idomoid languages except Etulo, where they seem to be recent effect of nasal consonants that still occur in other related

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15 This language is a language of Kaduna state, documented by Blench (http://www.rogerblench.info/Language/Niger-Congo/BC/Plateau/Koro/Gwara%20wordlist.pdf). It is different from Gwari and Gbari.
constructions”. Within Defoid, Yoruba dialects of Southwestern Nigeria and Benin and Itsekiri all show unambiguous contrastive nasal vowels and constitute part of the Nigerian Nasal Vowel Zone. In contrast, the related Defoid language Igala exists on the other side of the Niger River some distance from Yoruba and Itsekiri, and does not have nasal vowels, showing areal alignment with the Oral Vowel Zone.\(^{16}\)

Further, areal affects are found in all other major groups of Nigeria, including Nupoid, Ijoid, Cross River, Edoid, Igbo Group, and possibly even Chadic. Nupoid languages are found at the Benue-Congo river confluence, and spread northerly/northwesterly. These are typically nasal vowel languages, as found in Nupe in our survey (but also include Asu, Dibo, Gupa, Kakanda, Kami, Kupa, Nupe Tako – Blench 1989:313). However, two Nupoid languages which abut the Oral vowel Zone – Ebira and Gade – do not have contrastive nasal vowels.\(^{17}\) Igbo Group is said to generally have nasalization, though dialects gradually lose them (Larry Hyman, p.c.). This is seen with the more northerly located Igbo Group languages Onitsha Igbo, Owka Igbo, Izi, and Ukwuani, and the very southerly located Ekpeye Igbo.

In nearby Cross River and Ijoid languages, areal alignment is also seen. The majority of Cross River languages do not have contrastive nasal vowels, and occur in the Nigerian Oral Vowel Zone, e.g. Efik (Maddieson 1984), and Lokaa (Runsewe 1988). However, the very southerly located Cross River family Ogoni (e.g. Eleme, Ogoi, Khana, Gokana) does have nasal vowels. This family occurs nearby to Igbo lects with nasal vowels, and directly next to non-Cross River languages Defaka and Nkoroo also with nasal vowels. Further, most Ijoid languages have contrastive nasal vowels, though the Ijoid language Ibani spoken on Bonny Island is said to have lost its nasal vowels due to influence of non-nasal vowel Igbo lects which are spoken directly to the north and south of it (Otelemate Harry, p.c.).

Moreover, in those languages which have contrastive nasal vowels, specific patterns are also found. Languages which have a two way-mid distinction - with nasal /ẽ õ/ present - occur in (1) Kainji and Plateau languages in the central west and moving towards the nasal band south-easterly, (2) in far south of Nigeria towards Igbo/Edo/Ejoid/Ijoid, and (3) a few languages near the Benue/Congo rivers confluence, Basa-Benue, Oko, and Ika (the latter having an unsettled genetic classification). Blue dotted areas on the map predominate elsewhere, including most of the Nigerian Nasal Vowel Zone including Defoid, Edoid, Mande, Igbo, and Nupoid languages, the Cross River Ogoni languages in the SW of Nigeria, and a few languages within the central Nigerian nasal vowel belt.

One family in which the areal alignment effect of nasal vowel systems is particularly strong is Edoid. Elugbe (1989:40) notes that nasalization on vowels is a surface feature of all Edoid language, though it is only contrastive in some. In others it is conditioned by a neighboring nasal consonant only. Geographically, Edoid is situated between Defoid (=Yoruboid) and Igbo Group languages, mainly occurring to the West of the Niger River, and situated between three-micro Zones. To the West is an almost categorical Nasal Vowel zone in which /ẽ ẽ/ are absent, e.g. in Yoruba, Itsekiri, among others. To the south are Ijo languages which typically have contrastive nasal vowels; two nearby languages Kolokuma Ije and SE Ijo (Nembe) have a full set of nasal counterparts including /ẽ ẽ/, albeit only in a limited context, e.g.

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\(^{16}\) As noted in Williamson (1973:131), some of the earliest known linguistic description of Igala found in Koelle (1854) notes dialects of Igala which did contain nasal vowels.

\(^{17}\) The value of the Nupoid language Gwari remains unsettled at this time (contradictory statements made in Blench 1989:313 and Williamson 1973).
only in ideophones (Williamson 1973, Jenewari 1989:110)\textsuperscript{18}. To the east across the Niger River is the Nigerian Oral Vowel zone.

The map below shows the Edoid family, divided into its four coordinate branches: North-West, North-Central, South-West, and Delta (the furthest south) (Elugbe 1989).

28. Distribution of nasal vowel systems in Edoid – 4 genetic subgroups divided

We see that the distribution of nasal vowels in Edoid is more subject to areal alignment than it is by genetic affiliation. In the North-West and North Central groups, those languages which are in the Yoruba sphere of influence have nasal vowel systems which lack /ẽ ő/, e.g. Ehueun and Ukue in the North-west branch, and Edo (=Bini), Esan and Owan languages in the North –Central branch. Those languages on the Eastern side of the Edoid complex that abut the Oral Vowel Zone do not have contrastive nasal vowels, e.g. Northwest Edoid languages Ibillo (=Okpamheri), Emhalhe, Uhami, Oloma; North-central Edoid languages Ghotuo, Yekhee (=Etsako), and Uneme; the Southwest Edoid language Isoko; and Delta Edoid languages Engenni and Degema. Degema occurs directly next to the Cross River language Ogbronuagum which also lacks nasal vowels. Finally, in the southern area of the Edoid complex, languages which abut the Ijoid languages have a full set of nasal vowels, including /ẽ ő/, e.g. Southwest Edoid languages Okpe, Eruwa, and Urhobo, and the Delta Edoid language Epie-Atisa.

If we look at the set of words from Edoid in example (29), we see that within those North Central Edoid languages which lack /ẽ ő/, a word with /ɛ̃/ often maps to a South West Edoid language’s /ẽ/, which suggest */ẽ/ has merged with /ɛ̃/ in these North Central Edoid languages. For example, the Edo word /èwɛ̃́/ corresponds to Urhobo /èvjẽ̀/.

\textsuperscript{18} Williamson (1983:22-23) later notes that all vowels in Ijoid can occur nasalized though [ẽ ő] are rare and are confined mainly to ideophones, or to combinations with other vowels, e.g. [ẽĩ őĩ].
29. Correspondences in Edoid

<table>
<thead>
<tr>
<th></th>
<th>Urhobo</th>
<th>Edo</th>
<th>Okpe (SW)</th>
<th>Proto-Edoid</th>
<th>Correspondence</th>
</tr>
</thead>
<tbody>
<tr>
<td>water</td>
<td>&lt;ame&gt; [amɛ]</td>
<td>&lt;ame&gt; [amɛ]</td>
<td></td>
<td></td>
<td>*A-miN</td>
</tr>
<tr>
<td>sand</td>
<td>&lt;ekpɛn&gt; [ekpɛ]</td>
<td>&lt;ekɛn&gt; [ekɛ]</td>
<td></td>
<td></td>
<td>*I-keN “earth (soil)”</td>
</tr>
<tr>
<td>eight</td>
<td>[ɛre]+[ɛ]</td>
<td>&lt;èrɛn&gt; [èrɛ]</td>
<td>&lt;èlɛnɛ&gt; [èlɛ]</td>
<td>?</td>
<td>*nhiNanhi</td>
</tr>
</tbody>
</table>

Source: Rolle (field notes); Ukere 2005 [1986]

Future work is needed to understand these diachronic developments further, as well as nasalization as a whole within Edoid19.

5. PHONETIC FOUNDATION OF NASAL VOWEL PATTERNS

We discuss here our interpretation of the role that phonetics has played in shaping the type of nasal vowel systems which exist in West Africa. We stress that this phonetic foundation should be seen as complementary to the role of areal convergence in explaining these patterns, rather than alternative. We have established in the sections above that in the Nasal Vowel Zone Core of West Africa, there is continuous and near-categorical absence of nasal counterparts for the mid-close oral series, namely a constraint against */ẽ ŏ/ (or in some case against their phonetic realization as *[ẽ ŏ], as in some Gbe languages). As we show below, this gap is predicted by phonetic theory based on both phonetic typological work and laboratory work.

Within previous phonetic work on nasal vowels, there is more or less consensus that nasality affects the perception of vowels. Nasal vowels are articulatorily distinct in that they involve systematic lowering of the velum, allowing airflow through both the oral and nasal cavities. Each of these resonance cavities is associated with its own formant/spectral profile, which results in an acoustic coupling of both the oral and nasal tract (Maeda 1993), termed “Oral-Nasal Coupling”.

This Oral-Nasal coupling results in what Johnson (2012:198) calls one of the “most complicated configuration[s] of the vocal tract” not due to articulatory reasons, but rather perceptual ones. Extensive literature has shown that Oral-Nasal Coupling results in a number of

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19 Elugbe notes that the proto */-N-/ in this table has “no segmental reflex in any known Edoid language...[and] may never have been realized except as nasalization of surrounding vowels” (Elugbe 1989: 115), speculating this may have been a velar nasal in some works. He also shows that nasalization in the NC branch can come from CVnhV sequences, and CVNV sequences (Elugbe 1989: 117), where <nh> is a lenis coronal nasal stop.
acoustic consequences which include the addition of “pole-zero pairs to the vowel spectrum and accompanying shifts in the frequencies, intensities, and bandwidths of oral formants” (Beddor 1993:172). This acoustic product feeds the perceptual input, with the coupling effects said to result in perceptual “blurring” of different vowel qualities (Ohala 1975).

This is most prominent within the first formant, the main correlate of perceived vowel height. Beddor (1993: 180) notes that nasal coupling has the effect of shifting the overall frequency of the first region (F1 region) of the total coupled spectral prominence, echoed by Kingston (2007: 417) who notes the broader bandwidth from coupling “makes it harder to detect this prominence’s center of gravity and thus to determine the vowel’s height”. The nasal formant within the acoustic product (FN) typically appears in a region between the F1 of mid oral vowels and low oral vowels, which result in “shifts in the low-frequency center of gravity due to nasalization influence perceived vowel height” (Beddor 1993: 181), which we can understand as the Nasal Height-Centralization Effect. This effect results in high and mid vowels being perceived as lower in the vowel space (e.g. /i/ as [ɪ]), and low vowels being perceived as higher (e.g. /a/ as [ɐ]).

The Nasal Height-Centralization Effect is supported by a number of experimental studies, as summarized in Wright (1986:48-49), all of which show perceptual lowering effects with high and mid vowels, and a raising effect with certain low vowels (albeit, a more complex effect which depends on the low vowel quality). Beddor et al. (1986) highlight Oral-Nasal Coupling effects on vowel perception in a series of experiments, concluding that nasalization affects vowel height in two situations: (1) when nasalization is phonetically in appropriate (e.g. too much or too little nasal coupling), and (2) when nasalization is phonologically inappropriate (in oral vowel languages). However, what is striking to note is that they also go to say that “if listeners expect nasal vowels in oral contexts” – as in contrastive nasal vowel languages – “it is hypothesized that non-contextual nasalization would have less of an effect – perhaps none – on perception of vowel height” (Beddor et al. 1986:210; italics mine).

Despite some of the subtle complexities of interpreting results from experiment study, the Nasal Height-Centralization Effect is clearly cross-linguistically supported, as well. Phonetic theory which gives a central role to listener-driven changes show that listener misperceptions can be a source of phonological change. With nasal vowels, speakers perceive differences in F1 when compared to oral counterparts, and may attribute those differences to tongue height rather than purely nasal coupling (Beddor et al. 1986:203), which in turn results in a different articulatory target when reproduced leading to diachronic change in vowel height. Such diachronic change is shown in a number of languages, e.g. those surveyed in Ruhlen’s (1978:221) cross-linguistic phonological survey. Here, he notes that in 10 languages where there exists only one oral mid vowel, the nasal mid vowel is always the same height or lower, e.g.

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20 Height-“Centralization” here does not refer to “central” as it is used in standard vowel plots, e.g. the IPA, but rather a tendency for vowels to become more mid.
21 Beddor (1983:5) cites Passy (1891), among others, as one of the earliest works to note the lowering effect of nasality on vowel height.
22 For example, refer to Wright (1975) for an excellent early study. Beddor (1993:183) also summarizes experiments which show that there less perceptual distinctness between nasal vowels as compared to perceptual measures between oral vowels.
23 The exact role which the amount of nasal coupling has on vowel perception is also highly important to vowel height perception, i.e. vowels pronounced with “heavy” vs. “light” nasalization/nasal airflow. See Ohala (1974), Wright (1975:373), Beddor et al. (1986), Hajek & Maeda (2000:4, citing Chen & Wang 1975 and Bell-Berti 1993), among others.
Chipewyan with oral values [i e a o u] but nasal values [ĩ ě ā ē ū]. Other languages which show this include Kamauni, Siona, Sango, Polish, Yuchi, Seneca, and Mezquital Otomi. In contrast, he finds no instance of the reverse in which a sole oral mid vowel is lower than the sole nasal mid vowel, e.g. a system [ɛ ě]. This is also shown later in Beddor’s (1982) cross-linguistic phonetic survey which shows strong tendencies cross-linguistically for non-contextual mid and high nasal vowels lowering, and low vowel raising (75 language sample).

These perceptual effects are understood to lead to diachronic changes in nasal vowel contrasts. This can either be chain shifts within the acoustic vowel space (e.g. famously in the history of French, *ĩ > *ẽ, ě > *ɛ̃ – Carignan 2013:142), and/or mergers of contrast resulting in the reductions in height contrast we see in many vowel inventories (Wright 1986:46, Schwartz et al. 1997:237, Kingston 2007:417). We can therefore understand the gap in [ẽ õ] as a result, in part, from the perceptual Nasal Height-Centralization Effect, with a phonological distinction between /ẽ ū/ and /ɛ̃ ū/ being perceptually unstable (as discussed in Foley 1975, Wright 1980, Maddieson 1984, also not unnoticed by Africanists, e.g. Capo 1985b:114). Because such a reduction in mid nasal vowels can be understood as “phonetically natural”, one can ask whether to situate these patterns within an areal perspective at all, given that we expect such changes to be recurring within these West African phonologies for purely perceptual reasons. In response to this, we argue below that (1) the patterns found in West Africa are not strictly replicated in other parts of the nasal zones in the world, (2) not all predictions made by a Nasal Height-Centralization Effect are borne out in the West African data, and (3) in many West African languages, there exists evidence that a constraint against ẽ œ is fully incorporated into their sound systems above and beyond any lower level phonetic effects.

6. LARGER AREAL-TYPLOGICAL COMPARISON

As shown in the description above of West African vowel systems, one of the most remarkable aspects of nasal vowels is their propensity to concentrate in specific regions, both their presence and their absence, suggesting a high susceptibility to areal alignment. This has been shown for other places of the world, as well. In Hajek’s (2011a) WALS survey, he shows that the occurrence of contrastive nasal vowels has a clear areal skew. There are 5 zones in which nasal vowels occur to a disproportionate amount compared to other areas: West African Sub-Saharan Belt, the Middle Belt of North America, North and Central South America, Northern India, and Southern Mexico. This areal distribution is also noted in Ruhlen (1978:205), Clements & Rialland (2006: 9), and Maddieson (2007). Contrastive nasal vowels are also not a feature of entire vast regions, e.g. Australia (Dixon 2004:547).

Within these different regions, however, the distribution of languages with nasal vowel gaps is not uniform. Maddieson (2007:1384) presents a ghost map visualizing the approximate geographic locations of his 670 languages surveyed, shown below in (30). This specifies [1] which languages have no nasal vowels (the small grey circles), [2] languages which have full oral and nasal counterparts (the sold black circles), and [3] languages which have a reduced number of nasal counterparts (the white-filled circles). We can see from this map that areas in

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24 Additional studies have also shown that lower vowels are more conducive to nasalization, tying in with the higher inherent sonority/intensity of low vowels.

25 This WALS maps has been expanded upon recently in the World Phonotactics Database, a phonological typological database found from Australia National University. This has over 3,000 data points, including the distribution of nasal vowels. At the time of writing this, we have not been able to adequately explore this database. This database is found at [http://phonotactics.anu.edu.au/index.php](http://phonotactics.anu.edu.au/index.php).

32
which a nasal counterpart is missing are in West Africa, Central South America, and to a less extent South-Eastern Africa, Northern North America, and a belt in Northern South Asia. In other places, it is more likely the case the there is a full nasal vowel set.

30. ‘Ghost map’ of world-wide distribution of languages with and without nasalized vowels (Maddieson 2007: 1384) – Red squares over which indicate relevant zones

Of these four regions, only the West Africa and central Amazon regions (in solid red) appear to not include a disproportionately large number of languages within their zone which do not have nasal vowels, i.e. they do not have disproportionately large number of grey dots within the region.

Further, as noted above, previous studies which have discussed the cross-linguistic distribution of nasal vowels include Ruhlen (1976, 1978), Maddieson’s (1984) UPSID, Maddieson (2007), and Hajek’s (2011a) WALS entry. In discussing patterns in his work, Ruhlen (1978:222) notes that the most common situation (“the most natural system”) is one in which all nasal vowels equal the number of oral vowels. The next most common is one in which there is a neutralization of mid vowels, or if more than one mid height, one of these mid heights. Ruhlen’s study shows that if a language lacks a nasal vowel counterpart, a mid-vowel will be the most common missing one. Of the 73 languages which he found with reduced nasal vowel inventories, 33 lacked a mid nasal counterpart (cf. high vowels, of which only 19 languages lacked a high vowel counterpart). He also notes that in larger vowel inventories (n>5), the tendency to have fewer nasal contrasts than oral contrasts becomes much more frequent. This is largely backed up by Maddieson’s (2007) study shown above, who notes that of the 138 languages surveyed, 68 (or 49.3%) had a full inventory of nasal counterparts to the oral vowels; the second most common system is one in which the nasal vowel inventory to be two less than the oral vowel inventory.
We can also look at Ruhlen’s (1978) study more closely to analyze which mid height is more often missing a nasal counterpart. As shown in Ruhlen (1978:220), of the 73 languages with nasal vowels, 28 have two oral mid vowel heights which correspond to only 1 nasal mid height, showing a mid-nasal gap, and finds that /ɛ̃ ɔ̃/ are likely to be the sole phonemes present as opposed to /ẽ ő/. However, this table includes a number of West African languages which may have skewed these findings. If we take out these languages, we are left with 14 languages, shown in the table in example (31).26


<table>
<thead>
<tr>
<th>Language</th>
<th>Family</th>
<th>Oral Mid Vowels</th>
<th>Nasal Mid Vowels</th>
<th>Nasal vowels Counterpart</th>
<th>Number of instances</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sara</td>
<td>Central Sudanic, Nilo-Saharan</td>
<td>e o o</td>
<td>e o</td>
<td>Mid-Hi</td>
<td>5</td>
</tr>
<tr>
<td>Marathi</td>
<td>Indic</td>
<td>e o o o o</td>
<td>e o o</td>
<td>5/5:</td>
<td></td>
</tr>
<tr>
<td>Lisbon Portuguese</td>
<td>Romance</td>
<td>e e o o</td>
<td>e o</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mazahua</td>
<td>Oto-Manguean</td>
<td>e e o o o o</td>
<td>e o</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yaruro</td>
<td>? [Venezuela]</td>
<td>e e o o</td>
<td>e o</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gbeya</td>
<td>Eastern Adamawa</td>
<td>e/e: e/e: o/o: o/o:</td>
<td>5/5:</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Dowayayo</td>
<td>Eastern Adamawa</td>
<td>e/e: e/e: o/o: o/o:</td>
<td>e/e: 3/5:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Haitian Creole</td>
<td>Romance creole (Fort)</td>
<td>e e o o</td>
<td>e o</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chipewyan</td>
<td>Athabaskan</td>
<td>e e: e/e: o</td>
<td>e/e:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biloxi</td>
<td>Macro-Siouan</td>
<td>e/e: e/o: o/o: o/o:</td>
<td>5/5:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tewa</td>
<td>Kiowa-Tanoan</td>
<td>e/e: e/e: o/o:</td>
<td>e/e:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Otomi (Mezquital)</td>
<td>Oto-Manguean</td>
<td>e e o o</td>
<td>e o</td>
<td>Mixed</td>
<td>3</td>
</tr>
<tr>
<td>Apinaye</td>
<td>Macro-Ge</td>
<td>e e o o o o</td>
<td>e o</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cayapo</td>
<td>Macro-Ge</td>
<td>e e o o o o</td>
<td>e o</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

This table shows 5 instances of the sole mid nasal height being mid-high /ɛ̃/ and/or /ɔ̃/, 6 instances of the sole mid nasal height being mid-low /ẽ/ and/or /ő/, and 3 instances of a mixed system. Although this sample from Ruhlen is very small, we can see from this table that there is no one clear preference for converging on a single mid nasal vowel inventory if we do not include westerly West Africa. Further, although Maddieson’s (1984) UPSID database shows that

26 I do not include in this table “repetitions” of languages which are included in his survey. For example, Ruhlen includes both Rio Portuguese and Lisbon Portuguese. I also do not include his French dialects. Further, because I do not survey the easterly Adamawa languages in this study, I leave them in the table in (31).
11 languages have /ẽ(ː)/ whereas 22 have /ɛ̃(ː)/, the same proportions do not hold for back vowels. Here, 21 languages have /õ(ː)/, whereas only 19 have /ɔ̃(ː)/.

In what follows, we look more closely at nasal vowels patterns found across the world, particularly in those languages which have two mid heights, i.e. a contrast between oral /e/ vs. /ɛ/ and/or /o/ vs. /ɔ/. We concentrate on two places in particular, in which large-scale data have been collected previously which lend itself to typological survey, namely South America and Central America. We briefly touch nasal systems in New Caledonia, South Asia, and Central Africa.

### 6.1. Case Study 1 - South American Phonological Inventory Database - SAPhon

This data suggests that South America may be a good location to explore if there are systematic restrictions against mid-high nasal vowels /ẽ õ/~[ẽ ō]/. To this end, I ran a survey of nasal vowel systems as found in South American Phonological Inventory Database (SAPhon v1.1.2)\(^{27}\). This database surveys 359 languages of South America, drawn from a number of independent sources, often of hard to find material and in languages other than English. Of the 359 languages, 158 are described as having contrastive nasal vowels, of which 68% have a full set of nasal counterparts. If a language was missing an oral counterpart, the majority case was one where a mid vowel was missing.

#### 32. SAPhon Database - Stats

<table>
<thead>
<tr>
<th>Total languages of SAPhon</th>
<th>Languages with nasal vowels</th>
<th>Languages with full nasal counterpart set</th>
<th>Languages missing a nasal counterpart</th>
</tr>
</thead>
<tbody>
<tr>
<td>359</td>
<td>158/359 (44%)</td>
<td>98/158 (62%)</td>
<td>Missing a high vowel 22/60 (37%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Missing a mid vowel 40/60 (67%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Missing a low vowel 10/60 (17%)</td>
</tr>
</tbody>
</table>

Further, we can compare the types of nasal vowels which occur in the mid vowel range and notice some striking differences when compared to West Africa. Of the 158 languages which had nasal vowels, 26 languages had more than one mid height in either the nasal or oral inventory. We only use languages for our comparison; most Amazonian languages contrast only 3 heights. As expected, reductions in the nasal inventory of mid vowels were the norm, shown in (33). However, what is striking is that there were more cases where only a mid-high nasal vowel occurred (i.e. /ẽ ō/ but not */ɛ̃ ɔ̃/), compared to those instances in which only a mid-low nasal vowel occurred (i.e. /ɛ̃ ɔ̃/ but not /ẽ ō/).

---

\(^{27}\) This is available at [http://linguistics.berkeley.edu/~saphon/en/](http://linguistics.berkeley.edu/~saphon/en/). There are some complications with using this database. It is not confirmed that the works cited in this database systematically determined whether a nasal vowel was contrastive or conditioned. Second in many South American languages, the nasalization feature itself may be understood as a property of the syllable, or the word, in which case nasal vowels have to be reinterpreted somehow. This is, of course, also an issue in Africa. For example, in the Adamawa-Ubangi family in general Boyd (1989:198) notes that “nasality is associated with morpheme structure, rather than individual segments”.
33. Types of mid nasal-vowel gaps in SAPhon\textsuperscript{28}

<table>
<thead>
<tr>
<th>Missing mid-low ɛ̃/ɔ̃</th>
<th>Missing mid-high ẽ/õ</th>
<th>Mixed (*ẽ *ɔ̃, ē ĕ)</th>
<th>Missing only /ɘ/</th>
<th>Nothing missing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apinayé</td>
<td>Canela</td>
<td>Kaingáng, São Paulo</td>
<td>Hoti</td>
<td>Cayubaba</td>
</tr>
<tr>
<td>Arára do Mato Grosso</td>
<td>Dâw</td>
<td></td>
<td></td>
<td>Kwaza</td>
</tr>
<tr>
<td>Karajá\textsuperscript{29}</td>
<td>Hup</td>
<td></td>
<td></td>
<td>Xokleng</td>
</tr>
<tr>
<td>Kuruáva</td>
<td>Krahô</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mebengokre</td>
<td>Krenak</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ofayé</td>
<td>Krinkati-Timbira</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Panará</td>
<td>Nadèb</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parkateje</td>
<td>Pumé</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suyá</td>
<td>Yuhup</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tapayuna</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Xavánte</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Xerênte</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>\textbf{12/26}</td>
<td>\textbf{9/26}</td>
<td>\textbf{1/26}</td>
<td>\textbf{1/26}</td>
<td>\textbf{3/26}</td>
</tr>
</tbody>
</table>

These data do not show the pattern that we see in West Africa. If we identify these languages on the SAPhon map, we notice both a genetic and areal skewing of this distribution. A map and table is provided in (34); red circles indicate languages having mid-high nasal vowels, whereas yellow circles indicate those with mid-low.

\textsuperscript{28} Pressing Ctrl+Left Click over a language name, this goes to the SAPhon webpage providing the phonological inventory.

\textsuperscript{29} This has /õ/, but is missing */ẽ ɛ̃ ɔ̃/.
34. Map of nasal vowel languages with a mid nasal vowel gap

![Map of nasal vowel languages](image)

35.

<table>
<thead>
<tr>
<th>Mid-High languages</th>
<th>Missing mid-low ë/õ</th>
<th>Has mid-high ë/õ</th>
<th>Family</th>
<th>Mid-Low languages</th>
<th>Missing mid-high ñ/û</th>
<th>Has mid-low ë/õ</th>
<th>Family</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apinavé</td>
<td>Macro-Ge</td>
<td></td>
<td>Canela</td>
<td>Macro-Ge</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arára do Mato Grosso</td>
<td>Isolate</td>
<td></td>
<td>Dâw</td>
<td>Nadahup</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Karajá</td>
<td>Macro-Ge</td>
<td></td>
<td>Hup</td>
<td>Nadahup</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kuruáya</td>
<td>Tupí</td>
<td></td>
<td>Krahó</td>
<td>Macro-Ge</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mebengokre</td>
<td>Macro-Ge</td>
<td></td>
<td>Krenak</td>
<td>Macro-Ge</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ofayé</td>
<td>Macro-Ge</td>
<td></td>
<td>Krinkati-Timbira</td>
<td>Macro-Ge</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Panará</td>
<td>Macro-Ge</td>
<td></td>
<td>Nadëb</td>
<td>Nadahup</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parkateje</td>
<td>Macro-Ge</td>
<td></td>
<td>Pumé</td>
<td>Isolate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suyá</td>
<td>Macro-Ge</td>
<td></td>
<td>Yuhup</td>
<td>Nadahup</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tapayuna</td>
<td>Macro-Ge</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Xavante</td>
<td>Macro-Ge</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Xerente</td>
<td>Macro-Ge</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| 12/26 Red Circles  |                     | 9/26 Yellow Circles |

We can notice two main things about this distribution. One is that there is some genetic skewing. Macro-Ge languages tend to have /ë ð/, but not */ê ɔ/. This contrasts with [1] more Easterly-located Macro-Ge languages which have /ê ɔ/, and [2] all of the Nadahup languages of
NW Brazil which also have /ɛ ɔ/. Finer genetic classifications of the languages in these families have not been researched at this time. Further, there is also a clear asymmetrical areal distribution between these two types of languages. Mid-high languages occur in the central regions of the Brazil among the Macro-Ge languages. Noteworthy are two non-Macro Ge languages Kuruáya (Tupí-Guarani) and Aráta do Mato Grosso (Isolate) which appear in the areal vicinity of the Mid-High zone, and also show that same pattern as the Macro-Ge languages. In contrast, mid-low languages occur in the eastern and southern part of the Macro-Ge region.

Although the number of languages surveyed is small, it does show that there is not a comparable areal constraint against /ɛ ɔ/ operating in South America. This may be due to the different types of nasal systems which exist in the two regions. Aikhenvald notes that in many Amazonian languages nasalization is a feature of the syllable (Hup [Makú]) or phonological word (Warao [Isolate]).

6.2. Case Study 2 - Native Central American languages

Another area which has been identical as a nasal vowel zone is Central America, referring to the area stretching from Mexico to Panama covering families Mayan, Uto-Aztecan, Oto-Manguean, Mixe-Zoquean, Totonacan, and small languages from the Arawakan family (i.e. Garífuna) and the Chibchan family (Yasugi 1995:3). Two families in Central America show a propensity of distinctive nasal vowels, Oto-Manguean and Chibchan. This is shown in the map in (36).

Yasugi (1995:45-54) compiles the phonologies of 174 Central American languages within a typological survey, and shows a majority having 6 or less contrastive vowel qualities (146/174).

---

30 This is also summarized in Ruhlen (1978:218), who speculates that the prosodic use of nasalization in South America may explain why it is common for there to be an equal number of nasal and oral vowels.

31 Suárez (1983:46) also notes that “with occasional exceptions, such as a dialect of Mam and a Zoque language (Ostuacan Zoque), nasal vowels occur only in Oto-Manguean languages”.

32 Taken from this pdf: http://ir.minpaku.ac.jp/dspace/bitstream/10502/3060/1/KH_017_4_001.pdf
~84%). The vast majority of these systems had only a 3 height contrast, therefore making comparison to West Africa more difficult. However, certain statements can be made.

First, 57/174 languages have corresponding nasal vowels, roughly 33% and higher than the 20% averages seen in samples in section 2.1 above. Of these nasal vowel languages, 12 can be described as having more than 3 vowel heights. For the purposes here, I put front /ɛ/ on a different height than that of low central /a/, even if this is not how it was presented in the typology. As one might expect, gaps in the nasal vowel inventory compared to the oral vowel inventory were common. However, the type nasal vowel gap showed no clear pattern, shown below.

37. Extrapolation of nasal vowel gaps in Central American languages with more than 3 vowel heights – Yasugi (1995)

<table>
<thead>
<tr>
<th>Language</th>
<th>Family</th>
<th>ISO</th>
<th>vowels</th>
<th>system</th>
</tr>
</thead>
<tbody>
<tr>
<td>San Pedro Amuzgo</td>
<td>Amuzgo, Oto-Manguean</td>
<td>azg</td>
<td>ie e ə o u  i ě  ā  õū</td>
<td>Missing lower mid</td>
</tr>
<tr>
<td>Xochistlahuaca</td>
<td>Amuzgo, Oto-Manguean</td>
<td>amu</td>
<td>ie æ a ə o u  ě ŋ ā ŋ řō</td>
<td>Missing high</td>
</tr>
<tr>
<td>Mazahua</td>
<td>Oto-Manguean</td>
<td>maz</td>
<td>ie ɛ i a ə o u  ĭ ě ā ŋ ř ū</td>
<td>Missing lower mid</td>
</tr>
<tr>
<td>Temoayan</td>
<td>Otomi, Oto-Manguean</td>
<td>ott</td>
<td>ie e ə a ə o u  ĭ ā ŋ ū</td>
<td>Missing all mid</td>
</tr>
<tr>
<td>Mezquital</td>
<td>Otomi, Oto-Manguean</td>
<td>ote</td>
<td>ie e a l ĭ ə o u  ĭ ě ā ŋ ū</td>
<td>Missing all mid (except /ɐ/)</td>
</tr>
<tr>
<td>Central Pame (Santa María Acapulco)</td>
<td>Pame, Oto-Manguean</td>
<td>pbs</td>
<td>ie e a o u  ĭ ě ā ŋ ū</td>
<td>Oral/nasal symmetry</td>
</tr>
<tr>
<td>Concepción Pápalo</td>
<td>Cuicatec, Oto-Manguean</td>
<td>cux</td>
<td>ie e a ə u  ĭ ě ā ŋ ŕ ū</td>
<td>Oral/nasal symmetry</td>
</tr>
<tr>
<td>Cabécar</td>
<td>Chibchan</td>
<td>cjp</td>
<td>i i e a o u  ĭ ě ā ř ū</td>
<td>Missing near-high</td>
</tr>
<tr>
<td>Bribí</td>
<td>Chibchan</td>
<td>bzd</td>
<td>i i e a o u  ĭ ě ā ŋ ū</td>
<td>Missing near-high</td>
</tr>
<tr>
<td>Térraba</td>
<td>Chibchan</td>
<td>tfr</td>
<td>i i e a ə o u  ĭ ě ā ř ū</td>
<td>Missing near-high</td>
</tr>
<tr>
<td>Teribe</td>
<td>Chibchan</td>
<td>tfr</td>
<td>i i e a ə o u  ĭ ě ā ř ū</td>
<td>Oral/nasal symmetry</td>
</tr>
</tbody>
</table>

It is actually unsettled whether this is /ẽ ɛ̃ õ ɔ̃/ missing *ĩ ũ, or /ĩ ẽ ũ ɔ̃/ missing /ɛ ɔ̃/, analyses which are based on different descriptions in different publications but using the same consultant (Yasugi 1995:191).

However, it is not clear whether /e ɛ/ actually belong to the same phoneme (Yasugi 1995:197)

Térraba and Teribe appear to be different names for different dialect zones in different countries (Panama and Costa Rica). Oakes (2001) notes that Teribe in Panama has one additional phoneme /d ŋ/, and /e ɛ/ is more like /ɛ ə/.

---

33 It is actually unsettled whether this is /ẽ ɛ̃ õ ɔ̃/ missing *ĩ ũ, or /ĩ ẽ ũ ɔ̃/ missing /ɛ ɔ̃/, analyses which are based on different descriptions in different publications but using the same consultant (Yasugi 1995:191).

34 However, it is not clear whether /e ɛ/ actually belong to the same phoneme (Yasugi 1995:197)

35 Térraba and Teribe appear to be different names for different dialect zones in different countries (Panama and Costa Rica). Oakes (2001) notes that Teribe in Panama has one additional phoneme /d ŋ/, and /e ɛ/ is more like /ɛ ə/.
This survey reveals no particular areal constraint against /õ ŭ/. Of these languages, 5 show complete or near complete oral/nasal symmetry, 1 is missing the high series /ũ ŭ/, 3 are missing the near-high series /ĩ ũ/, 2 are missing the low mid series /ẽ ɔ̃/, 1 is missing all mid /ẽ ɛ̃ ə̃ ʌ̃ ɔ̃ ũ/, and 1 is missing all mid except /ẽ/. What is striking is no clear case of a language which lacks close-mid /ẽ ŭ/ but has lower open-mid /ẽ ɔ̃/.

6.3. Other areas

Other areas show mixed similarity to the West African patterns. As shown in the chart in (38) above, New Caledonia stands out within the Oceania/Austronesia area as a zone of categorical nasal vowel presence. This is unlike the languages of even geographically proximate Loyalty Island (e.g. Iaai, Drehu, Nengone), which lack nasal vowels. Inventories of 7 New Caledonia languages have been tentatively put together. In the case of Ajië, this has two varieties which correspond to different age-based sociolinguistic classes.

38. New Caledonian languages with nasal vowels

<table>
<thead>
<tr>
<th>Language</th>
<th>Group</th>
<th>System</th>
<th>Type</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Ndrumbea/Drubea</td>
<td>Extreme Southern</td>
<td>/i e a o u/; /iː eː aː oː uː/</td>
<td>Lower mid missing (?)</td>
<td>Wikipedia (Source unknown)</td>
</tr>
<tr>
<td>2a Ajië/Houailou (Class I)</td>
<td>Southern</td>
<td>i e e w o u o c</td>
<td>Both mid heights present</td>
<td>de La Fontinelle (1976:103-118)</td>
</tr>
<tr>
<td>2b Ajië/Houailou (Class II)</td>
<td>Southern</td>
<td>i e e w o u o c</td>
<td>Lower mid missing</td>
<td>de La Fontinelle (1976:103-118); ALK</td>
</tr>
<tr>
<td>3 Xaracuu</td>
<td>Southern</td>
<td>i e e i o u o c</td>
<td>Higher mid missing</td>
<td>Lynch et al. 2002:765</td>
</tr>
<tr>
<td>4 Paicî</td>
<td>Northern</td>
<td>/i e e i o u o c/</td>
<td>Higher mid missing</td>
<td>Wikipedia; ALK</td>
</tr>
<tr>
<td>5 Cêmuhî</td>
<td>Central Northern</td>
<td>/i e e a o u/; /iː eː aː oː uː/</td>
<td>Lower mid missing</td>
<td>Lynch et al. 2002:753</td>
</tr>
</tbody>
</table>

in most contexts. Importantly, he specifically says /ĩ ŭ/ do not exist. Further, Queseda (2000:15-17) notes the absences of nasal counterparts to phonemes /ĩ o a/, and further notes that nasal vowels have a very low frequency.

36 The closest examples are Chibchan languages such as Bribrí which lack the 2nd degree height vowels /ĩ ŭ/, however. However, the phonological inventory of this language was identical in three separate publications.
These languages do not show a clear propensity of one system, though there appears to be a tendency to reduce the distinction in the nasal vowels.

Further, two other important nasal vowel zones await further exploration to compare their patterns to those found in West Africa. One is the Central African Nasal Vowel Zone, which includes Southern Chad, Eastern Cameroon, and Western Central African Republic. This is shown by Hajek (2011b), who notes the following languages with nasal vowels in this second zone area:

39. Central Africa Nasal Zone

<table>
<thead>
<tr>
<th>Sample of languages with nasal vowels</th>
<th>Family</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mbodomo</td>
<td>Gbaya, Ubangian?</td>
</tr>
<tr>
<td>Gbaya Kara</td>
<td>Gbaya, Ubangian?</td>
</tr>
<tr>
<td>Doyayo</td>
<td>Adamawa</td>
</tr>
<tr>
<td>Mbay</td>
<td>Bongo–Bagirmi</td>
</tr>
<tr>
<td>Day</td>
<td>Adamawa</td>
</tr>
<tr>
<td>Kosop</td>
<td>Mbum</td>
</tr>
<tr>
<td>Gula Iro</td>
<td>Bua, Mbum</td>
</tr>
</tbody>
</table>

Some of these languages, too, have a constraint against /ɛ̃ õ/, e.g. Doyayo has /ɛ ɛ o ɔ/ but only /ɛ ɔ/ (Wiering 1974), and Gbeya in general is also noted as having /ɛ ɛ o ɔ/ but only /ɛ ɔ/ nasal counterparts (Maddieson 1984). Further, the Bantu language Beembe (H11) is also noted as having contrastive nasalization, which is spoken near the Teke languages in Congo-Brazzaville which also have nasal vowels, e.g. Eboo-Nzikou /ɛ o ɛ/ /ɛ ɔ/ (Raharimanantsoa 2012), though this appears to be outside of the spheres of influence of West African and Central African nasal vowel zones.

Further, South Asia is a zone which shows clear nasalization as an areal feature, e.g. as argued for in Ramanujan and Masica 1973: 576)\(^{37}\). Many of these languages have more than 3

\(^{37}\text{In particular, Ramanujan and Masica (1973:576) note that “nasalization in vowels...makes a clear isogloss when we look at the map. It practically divides the southern peninsula from the northern plains. In the south, only Konkani has nasalized vowels. Telugu, Tamil, and Kodagu have them only phonetically, Parji and Ollari only marginally and mostly in loan words. In the central area, although Mundari and Kharia (except in loanwords) do not have them, the Dravidian Kurukh and Munda Juang, like the surrounding Indo-Aryan languages, have nasalized vowels. In the northeast and the northwest again, only oral vowels obtain: Balochi, Brahui, Pashto, (Persian, Burushaski also), and Garo, Khasi, Lepcha, Lushai.” In a later work, Masica (1991: 117-118) notes that nasal vowels are a prominent feature of (New) Indo-Aryan (NIA). She qualifies this, however, by noting Nasalization appears to play a prominent role in the phonology of Western NIA languages (e.g. Hindi, Punjabi, Gujarati, Rajasthan, Sindhi, “Lahnda” and Siraiki, Nepali, and Konkani), far more than in the Eastern NIA are.}
vowel heights, making them an excellent case study for comparing to the West African patterns, and preliminary analysis shows that major languages Punjabi, Hindi, and Urdu maintain a contrast in mid heights in nasal vowels, rather than reducing towards /ɛ̃ ɔ̃/. At present, it is unknown whether a large-scale inventory of phonological systems of South Asia is available.

7. A final point on interpreting the West African patterns

Having situated the West African patterns both with respect to the phonetic and areal-typological resources available on nasal vowels, we would like to make a final point on interpreting these patterns. We argue that despite these important phonetic underpinnings, there is reason to suspect that we should not merely interpret these patterns as “phonetically determinant”, but rather give space to both phonetic pressures and areal pressures of contact and convergence in the shaping of these systems.

Firstly, we should note that lowering of nasal vowels in the vowel space is neither an automatic synchronic or diachronic process. Many languages in West Africa (as other parts of the world) maintain 4 nasal vowel heights within a grammar, showing that the perceptual component of language comprehension can adequately handle F1 ambiguities in the acoustic signal (Beddor’s work goes into some detail on specific factors which lead to perceptual blurring).

Secondly, we saw from our areal-typological survey of other nasal vowel regions in section 6 that other parts of the world do not show the widespread areal ban on */ɛ̃ ɔ̃/ in West Africa, e.g. in the Amazon and Central America. These both suggest tendencies rather than fixed universals, which allows for other factors to help shape phonological systems. Even cases of mid nasal vowel raising have been documented, e.g. Portuguese *ɛ̃ ɔ̃ > ẽ õ (Schourup 1972: 21) and Scottish Irish *ɔ̃ > õ (Schourup 1972: 21, citing O’rahilly 1932) (and certain French varieties ɔ̃ > õ – Carignan 2013:147).

Thirdly, Height-Centralization effects also predict lowering of high vowels, and raising of low vowels, which would suggest certain diachronic changes, e.g. /ĩ ɪ̃ ũ ʊ̃/ merging to /ĩ ɔ̃/ and /ɔ̃ ə̃/ merging to /ɔ̃/. Both such changes are very rare in West Africa. The table in (40) presents all languages in our survey which showed both contrastive vocalic nasalization and two degrees of high vowels, e.g. an [ATR]/[RTR] distinction /i/ vs. /u/. This table shows that the majority maintain this distinction in their nasal counterparts (N =25/34), 8 languages showed only high [ATR] nasal phonemes /i ū/ with a gap in the near-high values, and only 1 showed only [RTR] nasal phonemes /i õ/ with a gap in the high values.
40. Nasal vowel languages with High [ATR]/[RTR] contrast - multiple High values

<table>
<thead>
<tr>
<th>Nasal vowel pattern type</th>
<th>Number (N=34)</th>
<th>Language(s) [Family]</th>
<th>Oral</th>
<th>Nasal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maintain distinction</td>
<td>25</td>
<td>Ahanta, Akan, Anyi, Baoule, Gikyode, Krache, Abidji, Abure, Ginyanga [Kwa]; Dagaare, Kasem, Vagla [Gur]; Epie-Atisa, Eruwa, Okpe(^{38}), Ika Igbo, Yoruba dialects (Ekiti, Ijesa, Irun, Ifaki) [Benue-Congo]; Grebo, Klao, Tepo Krumen, Krahn, (Wobe) [Kru](^{39}); Kalabari Ijo, Izon, Nembe Ijo, Kirike [Ijoid]</td>
<td>/i ɪ u o/</td>
<td>/ĩ ɪ̃ ũ o/</td>
</tr>
<tr>
<td>Lower value ([RTR]) missing</td>
<td>8</td>
<td>Basila Anii [Kwa]; Dan Santa, Guro, Toura, Yaure, Beng [Mande]; Kusaal [Gur]; Lijili [Benue-Congo](^{40})</td>
<td>/i ɪ u o/</td>
<td>/i ũ/</td>
</tr>
<tr>
<td>Higher value ([RTR]) missing</td>
<td>1</td>
<td>Deg [Gur]</td>
<td>/i ɪ u o/</td>
<td>/i ŋ/</td>
</tr>
<tr>
<td>No nasal high vowels</td>
<td>0</td>
<td>-</td>
<td>/i ɪ u o/</td>
<td>-</td>
</tr>
</tbody>
</table>

Those languages which showed gaps in the near-high values do not appear to form a clear areal pattern either.

Similar results hold for low vowels. The table in (41) presents all languages in our survey which showed both contrastive vocalic nasalization and two degrees of low vowels, e.g. an [ATR]/[RTR] distinction /a/ vs. /ã/. This table shows that the majority maintain this distinction in their nasal counterparts (N =12/18), 5 languages showed only the low [RTR] nasal phoneme /ã/, and 1 showed no nasal low vowels altogether. There were no documented instances of only the more height-central vowel /ã/ occurring to the exclusion of /ã/.

---

\(^{38}\) This refers to the South-West Edoid language Okpe, ISO-code [oke]. It does not refer to another Edoid language called Okpe, ISO-code [okx].

\(^{39}\) We do not include the Kru language Wobe here (ISO code [wob], also called Wè Northern), as sources were contradictory (Marchese n.d., Marchese 1978:51, Beath & Link, 1980, Kropp-Dakubu 1980).

\(^{40}\) Lijili does not have the phoneme /i/ (Blench 2006, citing Stoffberg 1978b).
41. Nasal vowel languages with Low [ATR]/[RTR] contrast - multiple Low values

<table>
<thead>
<tr>
<th>Nasal vowel pattern type</th>
<th>Number (N=18)</th>
<th>Language(s) [Family]</th>
<th>Oral</th>
<th>Nasal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower value ([RTR]) missing</td>
<td>0</td>
<td>-</td>
<td>/ə a/</td>
<td>/ã/</td>
</tr>
<tr>
<td>Higher value ([RTR]) missing</td>
<td>5</td>
<td>Animere [Kwa]; Deg, Kasem [Gur]; Siamou [Kru]; Lijili [Benue-Congo]</td>
<td>/ə a/</td>
<td>/ã/</td>
</tr>
<tr>
<td>No nasal low vowels</td>
<td>1</td>
<td>Etulo [Benue-Congo]</td>
<td>/ə a/</td>
<td>-</td>
</tr>
</tbody>
</table>

Concerning the Nasal Height-Centralization Effect, we might expect that these languages allow for a more crowded vowel space in the high and low height regions due to the mid vowel space having to maintain only one height distinction for many languages. However, in those cases where there is a merger in the high and low regions, there appears to be a preference for maximizing the distance of nasal vowels rather than height-centralizing them, which is not a viable strategy within the mid vowels. Whether or how this relates to Dispersion Theory is not explored here\(^{41}\).

Further, these patterns reveal that there is nothing inherent about advanced vs. retracted tongue root articulations which prefer or disprefer nasalization. Nasalization in high vowels disproportionately occurs with the [ATR] value, whereas in low vowels it occurs with the [RTR] value.

Finally, it should be emphasized that this constraint against */ẽ õ/ is robust in West Africa and has clearly been incorporated into the language-specific systems, moving beyond the phonetic underpinnings: in a sense, the perceptual difficulty of nasal vowels has taken off in West Africa and become a robust constraint against */ẽ õ/. For example, as a phonetic constraint, in some languages which do have phonological /ė ȍ/, these are realized as [ẽ ȍ] (e.g. in Gbe languages, and Ịka Igbo in Nigeria), where phonetic values have merged with lower mid values, but not phonological behavior.

To exemplify further, in many other languages of Nigeria mid-close vowels are not even contextually nasalized, e.g. in the context of another nasal segment. For instance, the East Mande language Kyanga, part of the Boko/Busa language cluster along the northern Benin/Nigeria border, lacks phonemes */ẽ ź/. On top, nasalization is said to “continue through the following adjacent vowels” from preceding nasal consonants, “except ‘o’ and ‘e’ which are never

\(^{41}\) It should be noted that cases have been noted where high vowels /i u/ which do not contrast with a [-RTR] counterpart /i u/ showing lowering effects, e.g. Hyman (1975) notes that Nupe /ĩ ũ/ are [ĭ ũ]. Beddor (1983:50) also cites three Ewe studies showing lowering of /i u/ in the context of a nasal consonant, e.g. [etm] “I am fed up with it”.

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nasalized” (Jones 2010:12). In the Benue-Congo language Igala - an Oral Vowel language - Omachonu (2000:25) notes that /e o/ do not become nasalized in the context of a nasal consonant, unlike the other 5 vowels /i e a ɔ u/. In another Benue-Congo language Edo (=Bini), in many grammatical contexts when two heteromorphemic vowels are adjacent, systematic vowel elision applies where the quality of a nasal vowel elides though its nasality remains. However, nasalization retention happens except with /e o/, which are not automatically nasalized under this vowel elision context (Aikhionbare 1989:312). Further, in the Mbe dialect Ogberia, automatic nasalization occurs with all vowel qualities after nasal consonants. However, automatic nasalization occurs before nasal consonants for all qualities except /e o/ (Chumbow 1987). Finally, Koffi (1990[2009 updated]: 94-6) notes that in Anyi notes, oral vowels /e e o ɔ/ do not have nasal phoneme counterparts, and in fact are “unasalizable” *[ẽ ɛ̃ ɔ̃]. Koffi compares vocalic nasalization after /m n/ in <mɪ̃> [mı̃́] “to swallow”, <nyan> [ɲã́] “to receive”, versus the lack of vocalic nasalization in <tɛ̀mɛ́ɛ> [tɛ̀mɛ́ɛ́] (“cooking utensil” and <mmóó> [m̀ móò] (*[m̀ mṍõ̀]) “gratitude”.

Moreover, in some cases, avoidance of /ẽ ɔ̃/ show raising rather than lowering effects, showing that not all instances of /ẽ ɔ̃/ avoidance are due to perceptual reinterpretation of tongue height position. The first case comes from Yoruboid/Defoid family [Benue-Congo: Nigeria]. Capo (1985b:106) notes that Yoruba dialects have a 7 oral vowels /i e ɛ a ɔ o u/, with a reduced number of nasal vowel correspondents. In no system does a Yoruba dialect have surface /ẽ ɔ̃/. However, in Yoruba dialects in the eastern region which abut the Edoid complex of Ondo and Edo states (e.g. in dialects Ekiti, Ijẹṣa, Irun, and Ifaki), these show a 9 vowel system, with two additional high vowels /i u/ and /i ɔ̃/. Capo (1985b) notes two particularly telling facts about these sounds. The first is that only nasal /i ɔ̃/ appear in stem final position where they contrast with /i ū/, whereas /i u/ do not appear stem-finally (Capo 1985b:110). Secondly, nasal /i/ shows regular sound correspondences to other Yoruba dialects /i/ and /i ɔ̃/, and /i ɔ̃/ likewise shows correspondence to /ū̃/, /ā/, and /ā̃/ (citing Akinkugbe 1978). Capo uses this evidence to reconstruct proto-Yoruba phonemes */ẽ ɔ̃/ which have reflexes of /i i ɛ̃/ and /i ɔ̃ ɔ̃/ in the modern dialects, counterpart to proto oral */e o/.

Other examples also exist. A similar example comes again from the Boko/Busa language cluster. These languages show a typical inventory for the region /i e ɛ a ɔ o u/ /i ẽ ā ɔ̃ ū̃/, with missing */ẽ ɔ̃/ counterparts (Jones 1998). A new variety called “New Bussa” is emerging in this area, which is highly influenced by Hausa (an unrelated Chadic lingua franca). Hausa does not have a mid contrast (specifically lacking the open-mid series), and under its influence, New Bussa is also losing this contrast. What is striking here is that oral vowels /e ɔ/ merge with higher /e o/, whereas nasal vowels /ẽ ɔ̃/ merge with perceptually dissimilar /i ū̃/ (Jones 1998:26). These do not become nasal vowels /ẽ ɔ̃/ - which could have phonetic values [ẽ ɔ̃] or [ẽ ɔ̃] as we see in Gbe – nor do they neutralize to the lower value /â/.

42 However, in contradiction, Agheyisi (1990:25) shows nasalization of /e/ [ẽ] in an elision context, and Amayo & Elugbe (1983:5) note that /e/ has “derived nasality” in the example <iyenhọ> <i-yin-ehọ/ “deafness, stubbornness”.
phonetically-driven lowering effects. Finally, Koops (1990:34) also reports that /e/ is realized as [i] in some dialects of Kutep [kub; Jukunoid; Cameroon].

8. CONCLUSION

This paper has provided a comprehensive study of nasal vowel systems within West Africa, and has shown the pervasiveness of nasal vowels in the West African phonological profile. Both the presence and absence of contrastive nasal vowels cuts across language groups and is perhaps the best example of a strong areal feature in this linguistic complex, showing a large West African Nasal Vowel Zone, and 4 distinct Oral Vowel Zones. Two main types of nasal vowel systems occur, those with /ẽ õ/ and those without it. Systems without /ẽ õ/ are shown to exist in the core of the West Africa Nasal Vowel Zone, though at the fringes of this zone, this constraint does not appear to operate. Finally, we have shown that although there is both cross-linguistic precedence and phonetic explanation for such a gap against /ẽ õ/, we do not adopt a theory of phonetic determinism, and give space to both areal and perceptual pressures to be drivers in shaping the patterns we see.

This study leaves open a number of equally interesting questions which await further exploration. Perhaps the most immediate one is how can the nasal vowel patterns be tied together with models of population and cultural movements within West Africa. Preliminary, the zone of nasal vowel systems without /ẽ õ/ which extends from Nigeria westward aligns with the extent of coastal and near-coastal inland Kingdoms before 1900 which influenced each other dramatically, e.g. among the Akan/Gbe/Ewe peoples, the Yoruba people, and the Edo (i.e. the Benin/Bini Kingdom from the 15th Century to late 19th). A strong areal spread zone here is therefore not surprising. Correlating historical information such as this with the present linguistic patterns will help address the driving 21st Century typological question “What’s Where Why?” as formulated by Bickel (2007), and provide additional insight into why we see the patterns that we do and not some other equally imaginable ones.

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**APPENDIX - WEST AFRICAN LANGUAGES SURVEYED**

This appendix provides the languages and language clusters which form the basis of this survey. For reasons of space and cleanliness, this is a reduced database of the larger one. The most important column here is “Missing Counterpart” which denotes the gaps in the nasal vowel inventory compared to the oral inventory.

<table>
<thead>
<tr>
<th>Language</th>
<th>Group</th>
<th>Sub-group</th>
<th>Nasl V?</th>
<th>Oral</th>
<th>Nasal</th>
<th>Missing Counterparts</th>
<th>Missing Nasal Height</th>
<th>Restriction on ē ō?</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abe</td>
<td>Kwa</td>
<td>Nyo</td>
<td>N</td>
<td>i i e e a u o o c/ə</td>
<td></td>
<td></td>
<td></td>
<td>*[Nẽ Nô]</td>
<td>N&quot;Guessan 1983</td>
</tr>
<tr>
<td>Abidji</td>
<td>Kwa</td>
<td>Nyo</td>
<td>Y</td>
<td>i i e e a u o o c i ɪ ɪ e e ā ū ā ŏ ŏ ŕ</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>Herault (1983:45-46); Tresbarats &amp; Vick (1992), Tresbarats 1983</td>
<td></td>
</tr>
<tr>
<td>Abron</td>
<td>Kwa</td>
<td>Tano, Potou-Tano</td>
<td>Y</td>
<td>i i e e y a u o o c</td>
<td>i i ŭ ŭ ā</td>
<td>Close Mid</td>
<td>Open Mid</td>
<td>*[ẽN õN] */ẽ ŵ/</td>
<td>Timyan-Ravenhill, Judith. 1983</td>
</tr>
<tr>
<td>Abua</td>
<td>benue-Congo</td>
<td>Cross River</td>
<td>N</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Gardner 1976; Gardner 1980</td>
</tr>
<tr>
<td>Abure</td>
<td>Kwa</td>
<td>Potou, Potou-Tano</td>
<td>y</td>
<td>i e e a u o i o c</td>
<td>ā ā i ŭ ŭ ē ŏ ŕ</td>
<td>Open Mid</td>
<td>Close Mid</td>
<td>*/ẽ ŵ/</td>
<td>Herault (1983:71), Burmeister 1983</td>
</tr>
<tr>
<td>Adangbe Ewe</td>
<td>Kwa</td>
<td>Gbe</td>
<td>y</td>
<td>i ə/ɜ a u c o</td>
<td>ũ ɜ/ɜ ā ŕ ŕ ŕ</td>
<td>None</td>
<td>None</td>
<td>/ẽ ŵ/ [ê ŕ]</td>
<td>Capo (1985:21)</td>
</tr>
<tr>
<td>Adele</td>
<td>Kwa</td>
<td>Potou-Tano</td>
<td>y</td>
<td>i e e ə/ɜ a u o o c</td>
<td>i e e ũ ŕ ŕ ə/ə</td>
<td>Mid (unspecified)</td>
<td></td>
<td>None</td>
<td>williamson 1973</td>
</tr>
<tr>
<td>Language</td>
<td>Group</td>
<td>Sub-group</td>
<td>Nasl Y?</td>
<td>Oral</td>
<td>Nasal</td>
<td>Missing Counterparts</td>
<td>Missing Nasal Height</td>
<td>Restriction on ê ô?</td>
<td>References</td>
</tr>
<tr>
<td>--------------</td>
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