[ATR] contrast in a harmony-less language: the case of Mungbam

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Abstract

The physical parameter [ATR] has been a source of problems in the past because some of its acoustic correlates coincide with the acoustic correlates of vowel height, leading to cases where a phonologist may feel at liberty to choose either [HEIGHT] or [ATR], depending on which of the two makes an analysis more clear. In this paper data from Mungbam (Niger-Congo; Cameroon) is used to show that [ATR] may be inferred as a linguistically significant parameter on the basis of acoustic data alone in the special case where vowels cannot be said to be differentiable in terms of height. [the author(s)] argue that data from phonological processes should not be used to establish the featural identity of a segment, especially when doing so creates a false impression about the certainty of the phonetic facts.

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1 Introduction[1]

While recent work in emergent theory in phonology (Mielke, 2008) has chanelled interest towards the question of whether phonological features may or may not be innate, a more fundamental question concerns whether the notion of a phonological feature is itself internally consistent. Doubts with regard to this question have been frequently and consistently expressed in the writings of Peter Ladefoged.[2] A typical statement is as follows: "...it does not follow that the correspondence between phonological and phonetic descriptions should be largely statable in terms of features, the smallest units in each domain. This seems to me to be an improbable assumption that needs to be much more carefully argued by anyone who believes in it." (1990:404). In this paper [the author(s)] will not attempt to evaluate Ladefoged's view as a substantive theoretical claim, but will argue for a methodological convention[3] which largely respects it: that is, whether or not phonological primitives coincide with phonetic primitives should not figure into how linguistic data is collected and presented. Linguistic phonetic data, relevant to the elaboration of properties of contrast, is of a qualitatively different type than data about distributional asymmetries (i.e. phonotactics) and meaning-preserving alternations; the former type of data is phonetic in nature, and the latter type of data is determined without any phonetic considerations. [the author(s)] will present an argument for this claim in more detail in §3. The larger part of the paper, §2, is devoted to a case study concerning phonetic vowel features in the Mungbam langauge of Cameroon. On the basis of spectrographic evidence, I argue that two dialects of Mungbam exemplify an uncommon type of vowel contrast usually restricted to West African languages having [ATR]-based vowel harmony, although Mungbam contains no phonologically active class organized by the feature [ATR]. The observation that alternations in pharyngeal volume are linguistically significant in at least two of the dialects would have likely been missed under an approach where the identity of phonological and phonetic primitives was assumed.

2 Linguistic phonetic properties of Mungbam vowels

2.1 Language overview

Mungbam [mij], with approximately 2000 speakers divided between five dialects, is spoken in the Northwest province of Cameroon, one of several underdescribed Benue-Congo languages of uncertain classification in the Lower Fungom region, near the Nigerian border [reference withheld]. Despite the small area (roughly 7mi^2) over which Mungbam-speaking villages are distributed, dialectal differences are significant. As concerns the vowel system, the dialects not only differ in their basic vowel inventories, but they also conspicuously lack steady correspondences between vowels in cognate words. For this reason it will be necessary to treat the vowel system of each dialect separately, rather than attempting to uncover a single system which underlies them all. The prosodic systems of the five dialects, on the other hand, are approximately equivalent. All Mungbam varieties exhibit a word-level prominence asymmetry whereby the first stem syllable of a phonological word permits a considerably larger number of segmental and tonal contrasts than do other positions within the word [reference withheld]. Prominence of this type is culminative and obligatory, and is thus referred to as accent, following van der Hulst (2006:655), Downing (2010:382-3) and Hyman (2010:§4). [the author(s)] will use the property of accent to limit the present domain of investigation, henceforth referring only to vowels in accented syllables.

[1] Acknowledgements withheld for anonymity.
[2] See also Fudge (1967), Pierrehumbert (1990:383-4), Lodge (2009:65-9).
[3] See Botha (1971:13-4) concerning the distinction between substantive and methodological aspects of a scientific discipline.

The vowels which contrast in accented syllables are presented for each dialect in figure 1. Each plot

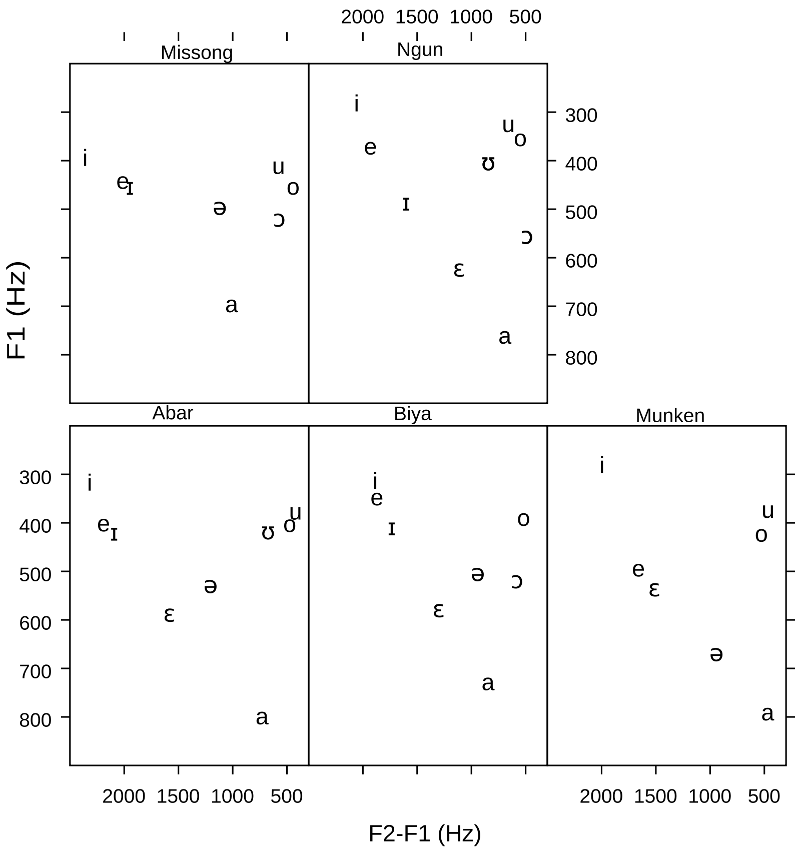

Figure 1: Average F1 x F2 values for Mungbam vowels in accented syllables, by dialect. Each chart is based on the speech of one speaker.

is based on the speech of one speaker of that dialect (data from additional Biya and Abar speakers will be considered in §2.2). Perhaps the most interesting observation to be made concerning figure 1 is that the vowel space does not appear to efficiently partitioned: with the exception of the Munken dialect, the vowels tend to be crowded in the upper part of the vowel space. While this fact by itself does not make an analysis by contrastive parameters difficult, the apparent overlap in F1 values of certain pairs of vowels does pose such a problem, since it suggest that these pairs of vowels may not actually be distinguished in terms of height alone.

Concerning the high vowels /i/ and /u/ in all five dialects, they are usually produced with friction, and are associated with spirantizing mutations in the preceding consonant.[4] In Abar, underlying

[4] See Connell (2000); Kießling (2010) for a discussion of fricative and spirantizing vowels in languages of the Cameroonian grassfields.

sequences /ɲi/ and /mu/ become syllabic nasals **ɲ** and **mm̩**, respectively, though this rule is blocked if it would create two consecutive syllables with nasal nuclei. In examples (1)-(2), /mu-/ 'class 18 prefix' and /ɲì/ 'four' are reduced to syllabic nasals when not preceded by a syllabic nasal.

(1) bə̀-mbʊ̀ŋ bə̄-ɲ̀
2-cow 2-four
"Four cows"

(2) mm̩̄-bûs mm̩̄-ɲì
18-cat 18-four
"Four cats"

That high /i/ and /u/ are produced with friction is relevant given the nearness of these vowels to mid /e/ and /o/ in F1 and F2 terms (especially for back /u/). Determining how this distinction should be represented will not be taken up in the present work. Instead, [the author(s)] will focus on the contrast between mid /e/ and /o/, and the vowels transcribed as /ɪ/ and /ʊ/, respectively. This particular type of contrast will be familiar to scholars of West African languages having cross-height vowel harmony, or [ATR] harmony (Stewart, 1971:198; Casali, 2008). As Clements (1991:52) notes, "In classical ATR-based systems, such as that of Akan, the [+high, -ATR] vowels are not well separated in first formant frequency from the [-high, +ATR] vowel." In addition to Akan (Lindau, 1978:552), "[ATR]" languages exhibiting this phenomenon include Degema (Fulop, Kari, & Ladefoged, 1998), Nawuri (Casali, 2002), Foodo (Anderson, 2007), and Igede (Armstrong, 1983:136). A consideration of the physical correlates of [ATR] contrast is made in §2.6.1. First, [the author(s)] consider the extent to which any of the pairs of contrasting vowels /e/-/ɪ/ and /o/-/ʊ/ may be said to overlap in first formant frequency for the Mungbam dialects.

2.2 Experiment design

Recordings were made for two speakers of Abar, both female, two speakers of Biya, both male, and one female Missong speaker. These three dialects were chosen because they contain contrasts which have proved difficult to perceive. The /o/-/ʊ/ contrast in Abar was only recorded for one of the two subjects, because the recording was made before [the author(s)] had learned that these two vowels were contrastive. Target words consisted of those given in table 1, though *ìtɪ̄* 'to fell a tree' was used for Abar speaker AB1 as an examplar of /ɪ/. The target words show a (near-)minimal segmental contrast between the vowels of interest. Consultants were prompted with an English gloss, and they then produced the corresponding target word in isolation. Depending on the session, a set of between 6 and 12 target words were used, with only two of these representing the vowel contrast of interest. Each word was repeated in isolation between 12 and 15 times, depending on the speaker, and tokens were presented in a randomized order. Audio was recorded outdoors on a Marantz PMD661

ABAR				BIYA		MISSONG	
íde̋	'bean'	ìfō	'to measure'	ìdē	'to cry'	ǹtsè	'to move'
ídɪ̋	'beard'	ītʊ́	'to point'	īdɪ́	'to say'	n̄dʒɪ́	'to pick up'

Table 1: Stimulus items involving questionable contrasts in Abar, Biya and Missong

solid state recorder with a Shure WH30XLR head-mounted condenser microphone. Recordings were made at a sampling rate of 44.1 kHz, at 24-bit resolution. Vowels were tagged and extracted. Sounds were then downsampled to twice the formant frequency ceiling (5 kHz for males, 5.5 kHz for females), and formants were determined via LPC analysis with 10 or 11 prediction coefficients (i.e. one per 1kHz of the new sampling rate), using Burg's method for generating prediction coefficients. Measurements for F1, F2 and F1 bandwidth (B1) were made for each vowel. B1 measurements were made from the LPC curve generated for the purpose of formant tracking. This procedure was automated using `To formant (burg)...` macro in Praat version 5.2.03 (Boersma, 2000), though it had to be carried out manually when the automatic formant tracking performed poorly. When the formant tracker produced an inaccurate measurement, the measurement was repeated by hand, in which case only F1 and F2 were measured. Inaccuracies in the formant tracker were generally only a problem for high back /u/, though two samples each of /e/ and /ɩ/ for MS1 had to be hand-corrected.

2.3 Possible limitations

The present study is based on data collected in the field as part of a larger documentation project. Though documentation of phonetic detail for each of the five dialects is a priority, the use of a large sample size characteristic of projects with a narrower focus was not entirely feasible. The small sample size makes it impossible to give any convincing explanation for the differences between speakers within a single dialect. But by using data from more two speakers for two of the dialects, this case study does not overlook the possibility of diversity in the way that a study of an idiolect may have.

Aside from the obvious factors of language, gender and age is the issue of multilingualism, which is probably the most important factor. AB2, for example, is a native speaker of Abar, and both of her parents are also natives of Abar, but she claims to be able to speak Abar, Metaʔ [mgo], Bafmen [bfm] and Pidgin English [wes], and has passive knowledge of Buu [boe]. Two demographic factors are relevant to this case: first, it is very common in Cameroon for children to spend extended periods of time living with extended family members outside of their hometown; and second, young adult populations from rural areas are quite mobile: frequent travel and relocation for employment reasons is common. A third general factor which promotes the development in rural populations of highly-multilingual individuals who do not necessarily share the same languages of competence is a high rate of exogamy, which is especially relevant for smaller communities [reference withheld]. This factor may be especially relevant for the Biya speakers. The number of Naki women who have married Biya men is such that all of the people in Biya are apparently able to understand some Naki [mff], and most speak it fluently, including both of the Biya speakers who have contributed data for this study. Although there are no categorial differences between vowels for speakers of a single Mungbam dialect, interference from other languages as a factor contributing to the low-level phonetic variation of the type shown here cannot be ruled out.

The decision to have consultants produce words in isolation rather than in a carrier phrase was motivated by the difficulty of training consultants to perform the task and the level of intermittent ambient noise, between whose lulls recordings of individual tokens were made. The use of carrier phrases is customary in recording phonetic data for several reasons, so the decision to not use them should be addressed at this point. The merits of carrier phrases are discussed in Ladefoged (2003:7-9) and Chelliah & de Reuse (2010:252-4). Carrier phrases mostly correct the problem of list intonation effects. When appropriately designed, they allow for standardized measurement of segment lengths. They can also sidestep the problem of utterance-final effects, which are generally manifested as changes in intonation and vowel length. Vowel length in Mungbam, though it has a rather low functional load as far as the number of lexical items which are distinguished only by vowel length, varies indepently of vowel quality (e.g. Abar **kwɪ́** 'enter!' vs. **kwɪ́ː** 'tie a bundle!'). List effects are irrelevant because consultants did not produce words from a list, and they were not given any indication of when the task would end until it actually ended. There are no automatic utterance-final effects on tone or vowel quality in the language, although sentence-final question and emphatic particles may be associated with a boundary tone. To summarize, the differences which arise from failure to use carrier phrases in our case either do not arise or are irrelevant to the contrast of interest.

Finally, two issues concerning the computational techniques used deserve mention. Firstly, raw formant values rather than values along a perceptual scale have been used to prepare the plots in figure 1 and for the statistical tests reported in §2.4. One motivation for transforming data before running statistical tests is when the transformed data points have a normal distribution, while the raw data points do not. In the present case, conversion to a Mel scale does not change the likelihood that the data are normally distributed, as determined by a Shapiro-Wilk normality test (Shapiro & Wilk, 1965). Furthermore, the practice of reporting formant values in Hertz is rather common in the phonetics literature (e.g. Flemming & Johnson, 2007; Mayr & Davies, 2011). The second issue concerns the accuracy of first formant bandwidth measurements. The difficulty of accurately measuring formant bandwidths from an LPC analysis based on an all-pole model (the technique used here) is well-known (Iskarous, 2010:379), especially for formants near a subglottal resonance (Atal & Hanauer, 1971:646). While it must be admitted that the possibility of inaccuracies in bandwidth measurements is real, one consolation is that the measured values do not deviate significantly from theoretical values. Figure 2 shows individual values of B1 measurements for Missong /e/ and /ɩ/ tokens, plotted together with values determined via Fant's (1972:47) model.

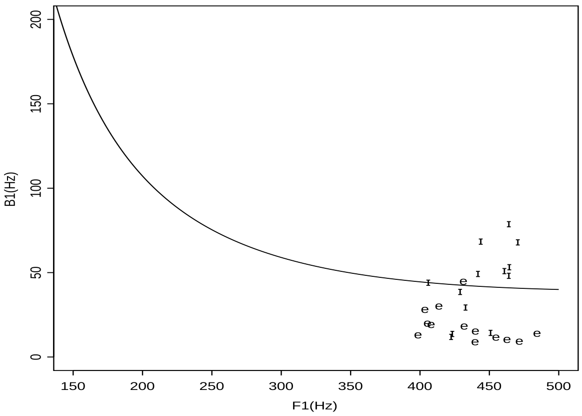

Figure 2: B1 and F1 values for tokens of Missong /e/ and /ɩ/, plotted with theoretical B1 values (Fant 1972:47).

2.4 Results

The main question is whether all of the pairs of vowels are distinct with respect to their F1 values. It will be also useful to see whether the pairs of vowels show a difference in B1, on the assumption that "lax" vowels (as they are transcribed) tend to exhibit acoustic losses at lower frequencies, signaled by an increase in B1, as has been predicted by Halle & Stevens (1969:212-3).

Table 2 shows the results of two-tailed, paired t-tests, to determine the level of significance for differences in F1, F2 and B1 for each pair of vowels. A Rom sequentially-rejective procedure was employed to control for family-type error (Rom, 1990). Because of the large number of tests, the critical value for rejecting the null hypothesis, shown in table 2, is considerably lower than the actual value of α.

For both Biya speakers, F1 is the most significant of the three parameters. F2 is significant at $\alpha = .01$ for BY2. B1 is significant at $\alpha = .05$ for BY1 and not significant at all for BY2. The two Abar speakers differ with respect to which parameter is most significant. For AB1, B1 is the most significant of the three parameters for both vowel contrasts, and F1 is the least significant of the three parameters. For AB2, F1 is the most significant parameter, and B1 is not significant at $\alpha = .05$. B1 is the most significant parameter for both pairs of vowels for AB1, significant at $\alpha = .01$ in both cases. The strongest case for overlap in F1 values is for MS1, where the difference in F1 is not significant. For the same speaker, F2 and B1 differences are significant at $\alpha = .05$, but not at $\alpha = .01$. For all of the speakers, differences in F2 are such that vowels transcribed as lax are more centralized. However, the difference in F2 found for Abar /o,ʊ/ may not be an effect independent of the tokens chosen: the consonant preceding the **ʊ** tokens is a coronal consonant, while the consonant preceding the **o** tokens is not. Coronal consonants tend to cause persistent F2 perturbations on following high back vowels (Stevens, 1998:572-3; Stevens & House, 1963).

These results may be interpreted to show that for two of the speakers, MS1 and AB1, height, as reflected by first formant frequency, is not the best parameter for characterizing the contrast between at least one pair of the vowels in question. For the remaining speakers, the contrast between the pairs of vowels in question can be satisfactorily described in terms of height, although it is not certain whether these vowels may be described as "well separated" in terms of mean F1 values.

	F1	F2	B1
AB1-/e,ɩ/	$t(12) = 2.05, p = .075$	$t(12) = 4.67, p = .0005$	$t(12) = 4.68, p = .0005$
AB1-/o,ʊ/	$t(11) = 4.28, p = .001$	$t(11) = 3.90, p = .002$	$t(11) = 5.01, p = .0004$
AB2-/e,ɩ/	$t(12) = 6.58, p < .0001$	$t(12) = 3.95, p = .002$	$t(12) = 3.53, p = .004$
BY1-/e,ɩ/	$t(11) = 5.86, p = .0001$	$t(11) = 3.68, p = .004$	$t(11) = 4.03, p = .002$
BY2-/e,ɩ/	$t(11) = 8.00, p < .0001$	$t(11) = 4.70, p = .0007$	$t(11) = 0.39, p = .70$
MS1-/e,ɩ/	$t(14) = 1.19, p = .26$	$t(14) = 4.29, p = .0007$	$t(12) = 3.74, p = .003$

Table 2: Significance levels for differences in F1, F2 and B1. Speakers AB1 & AB2 (Abar), BY1 & BY2 (Biya). Critical value for $\alpha = .05$ is $a_{1,18} = .0028$, for $\alpha = .01$, $a_{1,18} = .00056$.

2.5 The independence of B1 differences and F1 differences

We should at this point rule out the possibility that the differences in B1 measurements could be explained by differences in F1 and F2 values. To a certain degree of accuracy, B1 is expected to be affected by F1, and not by F2 (Fant, 1972:47). This issue specifically motivated the choice to compare the pair /e/-/ɩ/ rather than pairs supposedly differing only in tenseness, /i/-/ɩ/ or /e/-/ɛ/. If F1 differences between the vowels were very small, then the possibility that differences in B1 were only an artifact of differences in F1 could be disregarded. This has turned out to be the case for AB1 and for MS1: the B1 difference is obviously not explainable by differences in F1, since the F1 differences are considerably less significant than differences in B1. That B1 and F1 are not correlated is also true in a trivial way for BY2, for whom B1 differences are not at all significant. While there are correlations between F1 and B1 for AB2 and BY1, these are in opposite directions: BY1's /ɩ/ has a higher B1 than /e/ does, as is expected (following Halle & Stevens, 1969:212-3), but the opposite is true for both Abar speakers: if B1 may be considered an indication of tenseness, then the vowels transcribed as "lax" in Abar are actually more tense than the vowels transcribed as "tense." F1 and B1 cannot therefore be related in a non-language-specific way for all of the dialects.

2.6 On the appropriateness of [ATR]

Having determined in the previous section that height is not always the most appropriate feature for characterizing the contrast between pairs of vowels, I would like to consider in more detail what is known about the physical parameters characterizing [ATR] contrasts in other languages having such a contrast, in order verify that [ATR] is in fact a more appropriate way of characterizing the contrasts not characterizable by [HEIGHT]. In the remainder of this section, [the author(s)] will survey what is known about the phonetics of the tongue root contrast in languages possessing it, concluding that describing the contrast in the Missong and Abar dialects of Mungbam as involving a tongue root contrast, is in fact consistent with the way this term is used to describe vowel contrasts in other languages.

2.6.1 Phonetic properties of [ATR]

While scholars of West African languages had for some time been aware of the vowel harmony process which would eventually be termed cross-height vowel harmony, it was not until the late 1960's that a series of developments led to the discovery of a phonetic regularity in the alternation between pairs of vowels in the harmony process. Since data concerning the articulation of Mungbam vowels is not presently available, [the author(s)] will make a very brief presentation of the articulatory correlates of the [ATR] contrast, discussing what is known about the acoustic correlates of the [ATR] contrast in more detail.

2.6.1.1 Articulatory correlates Based on observations about the articulations The most precise description of the articulatory mechanism involved in [ATR] to date is given by Edmondson & Esling (2006:159,178-82) and Esling (2005:19-21). On the basis of laryngoscopic data from Akan, Kabiyé, and Somali, they describe [-ATR] vowel articulations as involving two simultaneous gestures: contraction of the hyoglossus muscle, which retracts the tongue root and raises the larynx, and contraction of the aryepiglottic and oblique arytenoid muscles (cf. Hardcastle, 1976:75-8), which causes a buckling of the aryepiglottic folds towards the epiglottis. The closure formed by the latter process is referred to as the aryepiglottic sphincter. Languages which have voice quality differences associated with [±ATR] vowels may employ additional gestures. Somali [-ATR] vowels, for example, are produced with lateral incursion of the false vocal folds, giving them their characteristic "harsh" quality (Edmondson & Esling, 2006:175-8). These findings are in line with Lindau's (1979) claim that the basic physical property which alternates in [ATR] contrasts is pharyngeal volume.

2.6.1.2 Acoustic correlates Research into the acoustic correlates of [ATR] articulations has suggested some possible measures which are useful for some vowels of some languages, but no clear correlate which applies to all cases. While variations in articulation across languages are expected to be responsible to some degree, it is expected that advances in acoustic modeling of the vocal tract may eventually lead to some refinement in the acoustic characterization of differences in pharyngeal volume.

The most general pattern involves the lowering and centralization of root retracted vowels with respect to their root advanced homologues (Halle & Stevens, 1969:211). The reported language facts generally support this prediction, though there are exceptions, as with Ikpɔsɔ (Kwa; Left Bank) /i/ and /ɩ/, which overlap with each other in F1 and F2 (Anderson, 2003:16). The tendency for overlap between adjacent [+ATR] and [-ATR] vowels, mentioned in §2.1, strongly suggests that there are acoustic correlates besides shifts in F1 and F2.

A handful of studies have sought to establish acoustic indicators of tongue root advancement or retraction beyond perturbations in F1 and F2. All of these have sought a way of measuring differences in the acoustic impedence of the pharyngeal walls due to changes in pharyngeal volume. Acoustic losses in the region of the first three formant have been modeled by Fant (1972:41-4), who proposed an empirical equation for determining formant bandwidths on the basis of Swedish data reported by Fujimura and Lindqvist (1971). Fujimura and Lindqvist's procedure, though not in itself especially invasive or expensive to perform, has not, as far as [the author(s)] can tell, been repeated on speakers of any languages other than Swedish.

Hess (1992), using data from one Akan speaker, found a reliable difference in B1 between [±ATR] vowels having similar F1 values, with root retraced vowels having higher B1 values. For pairs of vowels not having similar F1 values, she considered differences between measured B1 values and values predicted on the basis of F1 from Fant's equation. Root retracted vowels were found to show a greater divergence from Fant's equation than root advanced vowels. Hess additionally meausured spectral tilt, or the differential between the intensity of the first and second harmonics, which has been shown to be sensitive to phonation type (Gordon & Ladefoged, 2001:397-9). No correlation was found for this measure. This method was replicated by Anderson (2003), using Ikpɔsɔ data. No reliable differences were found in B1, but an effect for spectral tilt was observed.

Fulop et al. (1998), who studied [ATR] contrast in Degema vowels, used a somehwat more sophisticated procedure, employing a model which calculated a vowel's spectrum on the basis of the contribution to the overall spectrum by each formant. They computed a measure, called normalized $A_1 - A_2$, which compares the difference between the measured intensity of the harmonics nearest F1 and F2 and the theoretically calculated intensities for the same F1 and F2 values, again using Fant's (1972) model. Acoustic losses in the F1 region would be reflected by a negative normalized $A_1 - A_2$ value. Although this measure showed an overall significant effect for [ATR], it was only significant for two of the five [±ATR] pairs.

A less specific measure, which has the advantage of being easy to compute accurately, is spectral center of gravity (COG). Edmondson (2009) proposed this measure, believing that it would correlate with the perceptual quality of "flatness," as described by Kingston, Macmillan, Dickey, Thorburn, and Bartels (1997), and, using Akan and Kabiyé data, found an effect for [ATR], with root retracted vowels having higher COG. Anderson (2007) found a similar effect with data from Foodo (Kwa; Guang). Since COG necessarily takes the full spectrum into account, it is susceptible to various factors, including the value of the first three formants, and the presence of noise at higher frequencies.

With the caveat that previous studies have not been fully consistent in their findings, I will summarize by noting that [-ATR] vowels generally differ acoustically from [+ATR] vowels in one or more of the following ways: they are lower, more centralized, and/or have greater acoustic losses at low frequencies.

2.6.2 Rejecting [HEIGHT] in favor of [ATR]

Among the phonetic features for vowels proposed by Lindau (1978), The most likely ones for representing the contrast between /e/-/ɩ/ and /o/-/ʊ/ in Abar, Biya and Missong are [HEIGHT] and [ATR] (the latter of which Lindau refers to as [EXPANDED]).

The main acoustic correlate of [HEIGHT] is F1, or a mathematical function of only F1 (Lindau, 1978:545), and the usual acoustic correlates of [ATR] are F1, F2, and differences in spectral shape (see §2.6.1). One reason why it is not a simple matter to judge whether a contrast is supported by [ATR], or instead by [HEIGHT], is that [ATR] includes among its acoustic correlates an increase in F1. For this reason the choice between [HEIGHT] and [ATR] by linguists is often motivated by non-phonetic factors: e.g. a desire to reduce the number of height values, or a preference for a feature which coincides with a natural class in the language's phonology. To avoid this type of problem, [the author(s)] have chosen to examine pairs of vowels for which the height contrast is difficult to perceive. If it is not possible to show that two vowels have different steady-state F1 values, then [HEIGHT] is not a good choice for representing the contrast between them. B1, on the other hand, is expected to vary with F1 in a predictable way for vowels which contrast only for height (see §2.5); any variation which cannot be explained as being tied to F1 would be due to differences in the acoustic resistance of the vocal tract which are independent of F1. Thus, a preference for [ATR] can be grounded in the inappropriateness of [HEIGHT] for representing the physical differences.

If [ATR] is considered to be a contrast-bearing feature only in those cases where [HEIGHT] is not appropriate, then [ATR] can be taken to be contrastive in Missong and Abar, but not in Biya. This leads to the interesting situation where the front vowels of Biya and of Missong, though they sound very much alike, should be given different featural profiles, as in table 3. On the other hand, the acoustic facts concerning Biya vowels are not inconsistent with an [ATR] interpretation, they just happen to be compatible with both an [ATR] and a [HEIGHT] interpretation. Presumably, articulatory data would provide the grounds for selecting the correct interpretation.

MISSONG				BIYA			
	height	backness	expandedness		height	backness	expandedness
i	1	FRONT	[+ATR]	i	1	FRONT	—
ɩ	1	FRONT	[-ATR]	ɩ	2	FRONT	—
e	2	FRONT	[+ATR]	e	3	FRONT	—

Table 3: Possible featural decomposition for the linguistic phonetic properties of Biya and Missong front vowels

3 General Discussion

In §2 [the author(s)] have shown on the basis of acoustic data how an unusual type of vowel contrast can be interpreted in terms of commonly-used phonetic parameters. Crucially, phonological data did not enter the analysis at any point. Phonological data are relevant only to determining phonologically active classes.

To motivate this distinction, [the author(s)] will give a simple example concerning the sound system of Shupamem (Bantoid, Mbam-Nkam).[5] In order to make clear the role of of phonetic detail, [the author(s)] will hide nearly all of the phonetic facts until the end of the presentation. In Shupamem, some of the consonants which contrast in the position following a word-initial nasal are $\{a_1, a_2, a_3, a_4, a_5\}$. From this fact, we can stipulate that each a_i has a certain value for a feature [G], such that consonants having this feature value may follow a nasal. In general, data on phonotactics may be used to show that a group of segments have a feature in common. Shupamem additionally exhibits the following alternation involving the initial consonants of verb stems (b_i), when a nasal nominalizing prefix is added:

(3) $$\left\{\begin{matrix} b_1 \\ b_2 \\ b_3 \end{matrix}\right\} \longrightarrow \left\{\begin{matrix} a_1 \\ a_2 \\ a_3 \end{matrix}\right\} \quad / \text{ N } \_\_$$

From (3), we can establish paired correspondences between each b_i and a_i, stipulating that there is some feature [F] such that each b_i is [+F] and each a_i is [-F]. Generally, data from alternations may be used to show that pairs of segments have opposite values for a given feature. In both cases, no phonetic data enters into the decision to assign groups of segments to one or another phonologically active class.

Phonetic data, on the other hand, may be used to determine relationships between any two contrasting segments, without reference to their phonological behavior. Phonetic data may appear as though it can complement data about phonologically active classes. In (4), the internal organization of the set $\{a_1, a_2, a_3\}$ is neatly illustrated.

(4)

	[LABIAL]	[CORONAL]	[DORSAL]
[+VOICE]	b	d	g

Phonetic data can always fully specify a feature decomposition, such that each segment is represented by a unique feature set. Phonological data may, however, depending on the language and the segments under analysis, underspecify the decomposition, such that there may be two segments which do not differ from each other with respect to any phonologically active class, or overspecify the decomposition, such that a given segment may be distinguished from all others by more than one conjunctive combination of phonologically active classes. For this reason blending phonetic and phonological data can lead to internal conflicts in the analysis, as is the case when the phonetic details for the alternation in (3) are shaded in.

[5] Acknowledgement withheld for anonymity.

(5) $$\begin{Bmatrix} p \\ l \\ \gamma \end{Bmatrix} \longrightarrow \begin{Bmatrix} b \\ d \\ g \end{Bmatrix}$$

What has been shown in §2 is that while all contrasting segments can in principle be fully specified with reference to phonetic data, the necessary phonetic data is not always available through impressionistic observations. A careful attention to detail and more or less sophisticated instrumental analysis may be necessary. This is generally the case for the feature [ATR].[6] In these cases, the temptation may arise for the linguist to fill in gaps in the understanding of the language's phonetic system with phonological data. The converse scenario, where phonetic data masquerades as phonological evidence, being termed "substance abuse" by Hale and Reiss (2000), we might call the case where phonological data masquerades as phonetic evidence "form abuse." To take a random example of this phenomenon, consider the following remark taken from a published grammatical description:

> The vowels written e,o in Londo sound like the [+ATR] vowels usually written e,o, but they function like the [-ATR] vowels usually written ɪ,ʊ, or ɩ,ɷ. Therefore ATR is used, rather than, say, Mid. [emphasis in original] (Kuperus, 1985:58)

What can be inferred from this quote is that while there may be a fact of the matter as to whether pharyngeal volume is used linguistically in Londo, the author is not sure about the phonetic status of the vowels in question,but is willing to ignore this deficiency, since the phonological patterning of the vowels are well understood. While functional representations which are at odds with the phonetic facts are allowed for in generative phonology, provided that the "naturalness condition" is met (cf. Postal (1968:62)), the naturalness condition only functions effectively as a metatheoretical principle when the phonetic facts are known. Similarly, constraints in OT can only assign marks if there is a well-defined output which can be compared to an input for faithfulness and be evaluated as more or less well-formed (Prince & Smolensky, 2002:4). Using a label which clearly misrepresents the phonetic facts for the sake of convenience in writing generalizations about a language's phonology is permissible in some approaches to phonology under special circumstances. But using a label which represents the phonetic facts as being more certain than they actually are cannot be acceptable in any empirical approach to phonology.

4 Conclusion

Although understanding of the acoustic properties of the tongue root alternation is presently limited, [the author(s)] have made use of a rather simple technique on the basis of spectrographic data which may be considered as diagnostic of an [ATR] contrast, although it may not be used to make a valid argument that a language *lacks* an [ATR] contrast.[7] On the basis of such a technique, [the author(s)] have shown that in at least two dialects of Mungbam, [ATR] is linguistically important despite the absence of vowel harmony or any phonologically active class identifiable as [ATR]. Finally, [the author(s)] have briefly argued for viewing contrast as a phenomenon of a qualitatively different sort from other phonological effects, having motivated this claims mostly on methodological grounds.

[6] See also Clements and Osu (2002) for a phonetic study of the feature [SONORANT] in Owerri Igbo.

[7] A non-demonstrative argument of this sort has on several occasions been used by Clements (1991:52) and Clements & Hume (1995:282-3) to advocate for their multi-tiered height proposal. Clements does not, however, appear to intend that [ATR] be eliminated from the feature set entirely, as Vaux (1996:175) suggests (see the quote in §2.1.)

References

Anderson, Coleen Grace (2003). In search of an acoustic correlate to [ATR] in Ikpɔsɔ. In J. M. Mugane (Ed.), *Linguistic typology and representation of African languages* (p. 83-92). Trenton, NJ: Africa World Press, Inc.

Anderson, Coleen Grace (2007). F1 and center of gravity interplay in the maintenance of phonological height within a statistical model of a communal grammar: the case of Foodo [ATR] acoustics. *UTA Working Papers in Linguistics*, *2*, 2-29.

Armstrong, Robert G (1983). The Idomoid languages of Benue and Cross river valleys. *Journal of West African Languages*, *13*, 91-149.

Atal, Bishnu S, & Hanauer, Suzanne L (1971). Speech analysis and synthesis by linear prediction of the speech wave. *Journal of the Acoustical Society of America*, *50*(2), 637-655.

Boersma, Paul (2000). Praat, a system for doing phonetics by computer. *Glot International*, *5*(9/10), 341-345.

Botha, Rudolf P (1971). *Methodological aspects of transformational generative phonology*. The Hague: Mouton.

Casali, Roderic F (2002). Nawuri ATR harmony in typological perspective. *Journal of West African Languages*, *29*(1), 3-43.

Casali, Roderic F (2008). ATR harmony in African languages. *Language and Linguistics compass*, *2*(3), 496-549.

Chelliah, Shobhana L, & de Reuse, Willem J (2010). *Handbook of descriptive linguistic fieldwork*. Dordrecht: Springer.

Clements, George N (1991). Vowel height assimilation in Bantu languages. *Proceedings of the 17th Annual Meeting of the Berkeley Linguistics Society, special session on African language structures*, *BLS 17*, 25-64.

Clements, George N, & Hume, Elizabeth V (1995). The internal organization of speech sounds. In J. A. Goldsmith (Ed.), *The handbook of phonological theory* (p. 245-306). Oxford: Basil Blackwell.

Clements, George N, & Osu, Sylvester (2002). Explosives, implosives and nonexplosives: The linguistic function of air pressure differences in stops. In C. Gussenhoven & N. Warner (Eds.), *Laboratory phonology 7* (p. 299-350). New York: Mouton de Gruyter.

Connell, Bruce (2000). Mambila fricative vowels. In V. Carstens & F. Parkinson (Eds.), *Advances in African linguistics: Volume 4 of Trends in African linguistics* (p. 233-250). Trenton, NJ: African World Press.

Downing, Laura J (2010). Accent in African languages. In H. van der Hulst, R. Goedemans, & E. van Zanten (Eds.), *A survey of word accentual patterns in the languages of the world* (p. 381-427). Berlin: De Gruyter Mouton.

Edmondson, Jerold A. (2009). Correspondences between articulation and acoustics for the feature [ATR]: The case of two Tibeto-Burman and two African languages. In G. Fant, H. Fujisaki, & S. Jiaxuan (Eds.), *Frontiers in phonetics and speech science* (p. 179-89). Beijing: The Commercial Press.

Edmondson, Jerold A., & Esling, John H. (2006). The valves of the throat and their functioning in tone, vocal register and stress: laryngoscopic case studies. *Phonology*, *23*, 157-91.

Esling, John H. (2005). There are no back vowels: The laryngeal articulator model. *The Canadian journal of linguistics / La revue canadienne de linguistique*, *50*(1/2/3/4), 13-44.

Fant, Gunnar (1972). Vocal tract wall effects, losses and resonance bandwidths. *Speech Transmission Laboratory Quarterly progress and status report*, *13*(2-3), 28-52.

Flemming, Edward, & Johnson, Stephanie (2007). Rosa's roses: Reduced vowels in American English. *Journal of the International Phonetic Association*, *37*(1), 83-96.

Fudge, Erik C (1967). The nature of phonological primes. *Journal of Linguistics*, *3*(1), 1-36.

Fujimura, Osamu, & Lindqvist, Jan (1971). Sweep-tone measurements of vocal-tract characteristics. *Journal of the Acoustical Society of America*, *49*(2), 541-558.

Fulop, S. A., Kari, E. E., & Ladefoged, P. (1998). An acoustic study of the tongue root contrast in Degema vowels. *Phonetica*, *55*, 80-98.

Gordon, Matthew, & Ladefoged, Peter (2001). Phonation types: a cross-linguistic overview. *Journal of Phonetics*, *29*, 383-406.

Hale, Mark, & Reiss, Charles (2000). "Substance abuse" and "Dysfunctionalism": Current trends in Phonology. *Linguistic Inquiry*, *31*(1), 157-169.

Halle, Morris, & Stevens, Kenneth Noble (1969). On the feature 'advanced tongue root'. *Quarterly progress report of the research laboratory in electronics*, *94*, 209-215.

Hardcastle, W J (1976). *Physiology of speech production: An introduction for speech scientists*. London: Academic Press.

Hess, Susan (1992). Assimilatory effects in a vowel harmony system: an acoustic analysis of advanced tongue root in Akan. *Journal of Phonetics*, *20*, 475-492.

Hyman, Larry M (2010). Do all languages have word accent? or: What's so great about being universal? *UC Berkeley Phonology Lab Annual Report*, 297-315. Available from `http://linguistics.berkeley.edu/phonlab/annual_report/`

Iskarous, Khalil (2010). Vowel constrictions are recoverable from formants. *Journal of Phonetics*, *38*, 375-387.

Kießling, Roland (2010). Infix genesis and incipient initial consonant mutations in some lesser-known Benue-Congo languages. In A. R. Bachmann, C. El Mogharbel, & K. Himstedt (Eds.), *Form und struktur in der sprache: Festschrift für Elmar Ternes* (p. 187-220). Tübingen: Narr Francke Attempto Verlag GmbH.

Kingston, John, Macmillan, N. A., Dickey, L. W., Thorburn, R., & Bartels, C. (1997). Integrality in the perception of tongue root position and voice quality in vowels. *Journal of the Acoustical Society of America*, *101*(3), 1696-1709.

Kuperus, Juliana (1985). *The Londo word: Its phonological and morphological structure*. Tervuren: Musée Royal de l'Afrique Centrale.

Ladefoged, Peter (1990). On dividing phonetics and phonology: comments on the papers by Clements and by Browman and Goldstein. In J. Kingston & M. E. Beckman (Eds.), *Papers in laboratory phonology I: Between the grammar and physics of speech* (p. 398-405). Cambridge: Cambridge University Press.

Ladefoged, Peter (2003). *Phonetic data analysis: an introduction to fieldwork and instrumental techniques*. Malden, MA: Blackwell.

Lindau, Mona (1978). Vowel features. *Language*, *54*(3), 541-563.

Lindau, Mona (1979). The feature expanded. *Journal of Phonetics*, *7*, 163-176.

Lodge, Ken (2009). *Fundamental concepts in phonology: sameness and difference*. Edinburgh: Edinburgh University Press.

Mayr, Robert, & Davies, Hannah (2011). A cross-dialectal acoustic study of the monophthongs and diphthongs of Welsh. *Journal of the International Phonetic Association*, *41*(1), 1-25.

Mielke, Jeff (2008). *The emergence of distinctive features*. Oxford: Oxford University Press.

Pierrehumbert, Janet (1990). Phonological and phonetic representation. *Journal of Phonetics*, *18*, 375-394.

Postal, Paul M (1968). *Aspects of phonological theory*. New York: Harper and Row.

Prince, Alan, & Smolensky, Paul (2002). *Optimality theory: constraint interaction in generative grammar.* Rutgers Optimality Archive. Available from `roa.rutgers.edu/files/537-0802/537-0802-PRINCE-0-0.PDF`

Rom, Dror M (1990). A sequentially rejective test procedure based on a modified Bonferroni inequality. *Biometrika*, *77*(3), 663-665.

Shapiro, Samuel S, & Wilk, Martin (1965). An analysis of variance test for normality (complete samples). *Biometrika*, *52*(3/4), 591-611.

Stevens, Kenneth Noble (1998). *Acoustic phonetics*. Cambridge, MA: The MIT Press.

Stevens, Kenneth Noble, & House, Arthur S (1963). Perturbation of vowel articulations by consonantal context: An acoustical study. *Journal of Speech and Hearing Research*, *6*, 111-128.

Stewart, John Massie (1971). Niger-Congo, Kwa. In T. A. Sebeok (Ed.), *Current trends in linguistics* (Vol. 7, p. 179-212). The Hague: Mouton.

van der Hulst, Harry (2006). Word stress. In K. Brown (Ed.), *The encyclopedia of language and linguistics* (2nd ed., Vol. 13, p. 655-665). Oxford: Elsevier.

Vaux, Bert (1996). The status of ATR in feature geometry. *Linguistic Inquiry*, *27*(1), 175-182.