CAN FORMANT AMPLITUDE DIFFERENCES SERVE AS INDICATORS FOR L1-EFFECTS OF ATR IN VARIETIES OF ENGLISH IN WEST AFRICA?

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ABSTRACT

Formant amplitude differences (A1-A2) have been suggested (Fulop et al. 1998) as specific indicators for an advanced and retracted tongue root (ATR/ RTR) mechanism in vowels. Based on a consistent difference of normalized A1-A2 (Iseli & Alwan 2004), corroborating an F1 difference in ±ATR vowels in 14 (6 female / 8 male) native speakers of Ebira, a Nupoid Benue-Congo language of Nigeria, we observe higher amplitude differences in vowels with lower first formant values. Our results also show a similar distribution of A1-A2 in the Ebira-English of the same 14 speakers, dividing vowels into two groups merely comprising TENSE and LAX (but also long and short) vowels. The (British English) control group shows equivalent tendencies in some speakers (/varieties), though not as pronounced, suggesting a more gradient divide between our integration of both systems (ATR-RTR/TENSE-LAX) on the one hand, and providing an argument for incorporating and testing further acoustic dimensions on the other.

Keywords: ATR vowels, formant structure, L1/L2 influence, varieties of English, Ebira

1. INTRODUCTION

Similarities between ATR/RTR vowel systems and TENSE/LAX vowel systems have been suggested and investigated already for some time (s. e.g. [19]). Whereas in ATR/RTR vowel systems tongue height and root position are not correlated as we would observe in TENSE/LAX-systems (ibid. 303), articulatory measures by Tiede [25] would suggest for ATR-languages a higher correlation of tongue root and advancement, resulting in greater pharyngeal expansion. Acoustic comparisons between both vowel systems have been undertaken early on (e.g. [20]) and showed that formant measures typically exhibit in ATR systems a much more pronounced difference on the F1-dimension than on that of F2. However, language-specific implementations still leave room for other dimensions of the acoustic and perceptual space. In particular, the (relative) amplitude of formants had been suggested by Fulop et al. [7] as a specific indicator for an ATR-mechanism. This has since then been adopted by a number of authors when it comes to attribute ATR and RTR properties of vowel systems of similar vowel harmony (e.g. [8, 11, 16, 2]). However, earlier results are in part hard to align due to issues regarding the vowel amplitude decay [7] and its suggested necessary normalization/correction by Iseli et al. [12, 13]. Kang [16] and Aralova et al. [2] included this and found consistently higher A1-A2* differences in vowels which are interpreted as [+ATR].

1.1. Ebira and Ebira-English

The current study seeks to investigate the usefulness of the above systematics and the applied methods and parameters in the perspective of L1-influence on L2, namely Ebira (Glottocode: ebir1243), a Nupoid Benue-Congo language of Nigeria and Ebira-English, i.e. the variety of English spoken by L1-Ebira speakers. Ebira is spoken mainly in four local government areas of Kogi State, a region referred to as *Ebiraland*. Typical for this branch of Bantu languages, Ebira has a three level system (H, L, M) of lexical tone. Standard Ebira has 9 vowels, 8 of which are in ATR/RTR pairs, leaving the low central [a] as neutral [1, 11]. While other neighboring languages such as Yoruba have 7 oral vowels with no ATR contrast in high front and back positions, Ebira has /-i/ and /+ i/ & /-u/ and /+u/. In this way, a higher number of potential matching points is given for a comparison with English.

1.2. Hypotheses – L1/L2 interference

Given the various subvarieties of English in Nigeria [9, 23], our hypotheses start with the assumption that there is consistent L1-influence on L2, especially in a predominantly nonnative L2-environment, reinforcing adoption strategies akin to the *Perceptual Assimilation Model* ([4], see also [22] for a summary). In this way, we ask if and how the ATR vowel system of Ebira finds its correspondences in the reanalyzed TENSE/LAX dimensions of Ebira-English (EbEn). We acknowledge on the one hand that analogy-based adoption strategies proceed along lexical lines, but in order to describe these patterns, we follow the specific contrasts in L1 and subsequently L2. Therefore, we contrast vowel productions of L1 and L2 of one group (Ebira/EbEn) and – in addition – with L1-productions of a most likely different native group (British English). Specifically, we focus on the parameters of formant estimates with particular emphasis on spectral tilt in form of (relative) formant amplitudes (A1-A2). We expect to see a similar behavior in the L2-production of native Ebira speakers but not for speakers with a different L1-background. We are not aware of a study testing this, except [17] denying any kind of relevance of spectral tilt for vowel perception. Hence, we do not expect a spectral tilt effect for varieties of British English *per se*, but a similar, albeit less pronounced, formant amplitude difference as well as a relationship of F1 and spectral tilt, which would then include vowel duration as a partial reflex of the TENSE/LAX contrast. Tendencies in amplitude differences found so far [25, 8, 7] lead us to expect higher amplitude differences in front vowels, whereas (F1) formant differences tend to be smaller or to get neutralized (cf. [2]).

2. METHODS

2.1. Material

For this analysis we are using acoustic recordings of word lists read by 14 native speakers (8 male, 6 female; 35-56 yrs) of Ebira. The Ebira and EbEn wordlists were created to demonstrate the typical language-specific vowel contrasts in maximal extent of ATR/RTR and TENSE/LAX. The wordlist of EbEn was compiled by using the lexical sets of Wells [26] and there were three tokens per type. As a proxy for a formal speech style, these data are part of a much broader sociophonetic investigation of EbEn accent. The 14 educated speakers of standard Ebira, who all work as Civil Servants had mostly lived in *Ebiraland* until the time of data collection. The Ebira stimuli list comprised of 54 items with each vowel fixed to: tone, i.e. high, mid and low, initial and internal contexts; e.g. *isu* (mouse/house rats), *bisu* (to bait house rats), *ìsó* (nails), *hìsó* (to buy nails), *íze* (grasscutters/bushmeat), *píze* (to rear grasscutters). The EbEn word list consisted of 82 items out of 27 lexical sets. The Ebira list was repeated by all speakers four times to produce 216 tokens per speaker, whereas the EbEn list was repeated twice. Since only monophthongs had been considered, this resulted in approximately 110 items per speaker. The recordings were done with a ZOOM H4N handheld recorder with an AUDIO TECHNICA AT8531 lavalier microphone. The control corpus of English varieties of the British Isles originates from a free available source (soundcomparisons.com curated by Paul Heggarty, MPI SHH Jena). Here recordings were done by means of an OLYMPUS LS10 handheld recorder with an AUDIX HT5 headset microphone.

2.2. Acoustic Analysis

As preparation for acoustic analysis the wave signals were automatically segmented based on periodicity and amplitude. Vowel starts and endings were manually adjusted. Annotation was based either on the wordlist items (for Ebira and EbEn) or previous transcription (for British Englishes). Formant estimation was carried out by means of PRAAT[5] and the standard (Burg) algorithm adjusted for speaker sex on the first third of the vowel. Additionally a scripted implementation of the correction [12, 13] was applied. Formant estimation values were afterwards filtered for artifacts.

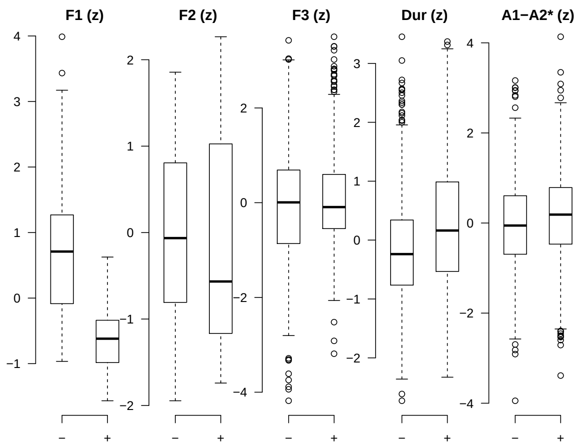

Figure 1: *Differences for 5 z-scored (by speaker) acoustic parameters of vowels in Ebira*

2.3. Statistical Analysis

Statistical analysis was carried out using the R software [21] package lme4 [3]. Collinearity was checked by means of the VIF function of the *car* package [6] applying a general linear model. Model selection for non-logit GLMMs was based on t-statistics of the parameters in the model covering all second degree interactions, and in addition, based on the Akaike Information Criterion (AIC).

3. RESULTS

3.1. Ebira

The difference in F1 serves in Ebira clearly as major feature in the distinction between [+ATR] and [-ATR] vowels, especially for high and back vowels but excluding /a/. Furthermore, we can observe that in Ebira vowels of the /E, I, O, U/-quality the ATR contrasts are for most speakers expressed by a difference of A1-A2. We fitted a binomial (logit) generalized linear mixed model by maximum likelihood (Laplace Approximation) in order to test the prediction: ± ATR categories by the measured parameters A1-A2, F0, F1, F2, F3, DUR, all z-standardized by SPEAKER. F0 is included since the items carry different tones. F1 and DUR seem to come out as the strongest (s.Table 1), whereas F2, F3 and A1-A2 show minor impact.

Table 1: Logistic model estimates for z-standardized acoustic parameters in Ebira vowels

	Estim	StErr	z	P(> | z |)	2.5%	97.5%
(I)	-0.80	0.20	-3.92	0.00	-1.24	-0.38
$A1A2_z$	0.19	0.07	2.60	0.01	0.05	0.33
$F0_z$	0.43	0.12	3.64	0.00	0.20	0.66
$F1_z$	-4.57	0.22	-21.05	0.00	-5.01	-4.16
$F2_z$	-0.15	0.07	-2.01	0.04	-0.29	-0.00
$F3_z$	-0.37	0.11	-3.38	0.00	-0.59	-0.16
Dur_z	1.12	0.10	11.83	0.00	0.94	1.31

The logistic model for ±ATR already indicates a negative correlation of F1 and A1-A2, i.e. we observe higher amplitude differences with lower first formant values. This follows the well-pronounced divide in the high vowels /I/ and /U/.

An alternative generalized linear model with A1-A2* as response and F1, F2, F0, DUR and SPEAKER as predictor variables with possible interactions shows likewise only a strong dependency of F1 and F2 but not F0. F3 and F2 exhibit a relatively strong correlation (r=0.53 t=30.5 $p < 0.0001$) for this area.

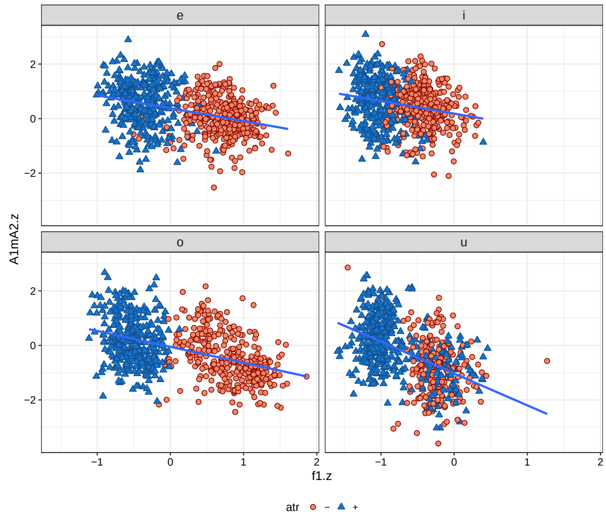

Figure 2: *Ebira: A1-A2* vs F1 per vowel category*

3.2. Ebira-English

Based on a prior analysis with regard to the behavior of particular lexical set vowels in EbEn [15, 14] a divide for the lexical sets was carried out (s. Table 2), bearing in mind that the BATH and TRAP vowels are considered as neutral [14] along with PALM, START, LETTER and COMMA. However, with regard to A1-A2(*), these vowels group with those corresponding to [-ATR], i.e. showing lower A1-A2* values than average (Fig. 3).

Table 2: A1-A2 for tokens in Ebira-English according to gross categories of vowel quality

Exp	i	e	ɐ	o	u
high A1-A2 '+ATR'	heat fleece Chelsea	share tape death	goat though both	cloth strut duck	tooth good goose
low A1-A2 '-ATR'	near shit filth	self air girl	assume comma Ghana	horse sought soil	foot spook sure

There is only a faint negative correlation of A1-A2 and DUR (r = -0.08, p=0.002), so that we do not expect a link with these parameters. F3, although correlating (r=0.37 t=17.8 $p < 0.0001$) with F2, seems to have no significance and is therefore left out subsequently.

The token realizations appear not as consistent as one would expect if these would follow the lexical sets (cf. [15]). We observe here inter-individual variability to be at play which needs to be further investigated, as well as the trends on the word level with respect to a possible model. However, a split for a particular subgroup (gender) is not apparent and therefore not explored further at this point. Al-

Table 3: Logistic model estimates for z-standardized acoustic parameters in Ebira-English vowels

	Esti	SE	z	P(>|z|)	2.5 %	97.5 %
(I)	1.80	0.09	19.67	0.00	1.63	1.99
$A1A2_z$	0.07	0.07	1.12	0.26	-0.06	0.21
$F1_z$	1.41	0.10	13.97	0.00	1.22	1.62
$F2_z$	-0.20	0.06	-3.10	0.00	-0.32	-0.07
Dur_z	-0.52	0.07	-7.23	0.00	-0.66	-0.38

though we observe a general small trend (r = 0.24, t = 10.1, $p < 0.0001$), i.e. an overall point-biserial correlation of the uncorrected A1-A2 and 'ATR' correspondence category, the applied binomial (logit) LMM reveals again (Table 3) only a dependency of F1, but not for amplitude difference.

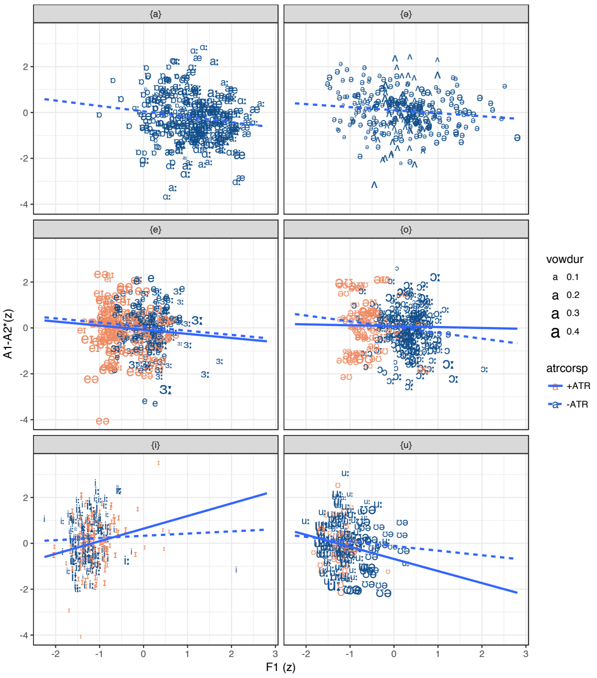

Figure 3: Ebira-English: standardized F1 vs A1-A2* values per gross vowel category

3.3. British English varieties

With respect to the relationship of A1-A2* and F1 we do observe all possible trends (Fig. 4) including those where there seems to be none. However, this reflects only the overall trend in the pooled (and standardized) samples.

4. DISCUSSION & CONCLUSION

The results for Ebira are comparable with previous research on ATR/RTR vowel systems, where high vowels had been described as categories which tend to be neutralized ([2] for Even; [24] for Yoruba). Apart from that, we can report a small but clear trend

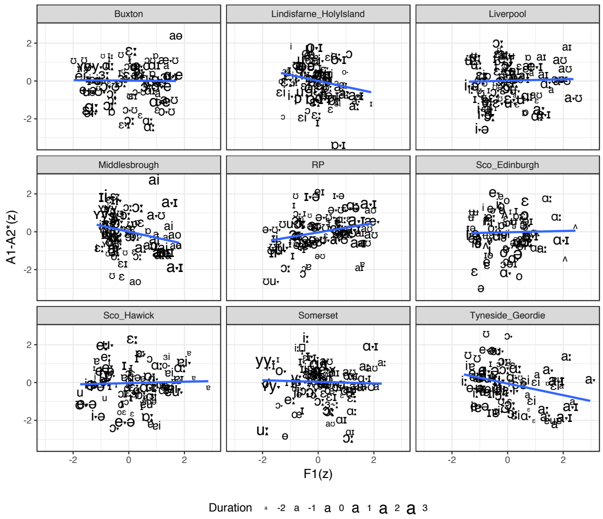

Figure 4: A1-A2*(z) vs F1(z) plot with three examples per trend; displayed are the token vowels

of lower A1-A2 values in [-ATR] vowels. It needs to be noted that the natural trend of higher formant amplitudes being more effected (cf. [7]) by the natural decay of harmonic magnitudes and its suggested corrections by Hanson [10] and Iseli [12] were primarily based on theoretical models. Although we can confirm the previously described corroboration of F1 and amplitude difference for ATR vowel contrast in Ebira, when projected onto EbEn, our current data show similar tendencies comprising higher A1-A2 values with lower F1 measures. Nonetheless, these come out not as sharp in our data so that we are not yet able to confirm our hypotheses (1.2). The (BE) control group shows in some speakers equivalent tendencies though not as clearly, suggesting at most a more gradient divide between both systems at the one hand and a need for integrating further acoustic dimensions on the other. We suspect that additional formant characteristics other than their center frequency relation contribute to the vowel category attribution. Other spectral parameters like the normalized bandwidth of the first formant (B1*) or center of gravity were suggested in the past [18, 24]. At the end, the amplitude difference may be not just an epiphenomenon (cf. e.g. [17]), but also a stronger corroboration with other dimensions in the acoustic space. As in other places, the correction of the amplitude differences neutralizes the beforehand clear differences and needs to be therefore under scrutiny.

5. ACKNOWLEDGEMENTS

We would like to thank all our Ebira participants, as well as Prof. Schmied (TU Chemnitz), Natasha Aralova, Benjanim Rosenbaum, Dan and Laurel (all MPI EVA), and Frank Lorenz (U Erfurt).

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