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Relation Between Tone and Vowel Quality in Twi

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Abstract

This study is part of a programmatic research on Twi undertaken at the laboratory of general and experimental phonetics at the *Institut de Phonétique de Strasbourg*. Twi is a register tone language spoken in Ghana, West Africa. It has a two tone system (high/low) and the downstep phenomena.

The aim of this paper is two-fold. First, some phonological aspects of Twi tones are described. Second, preliminary acoustic measurements are carried out to investigate for differences between vowel quality in the two groups. In this preliminary analysis, two adult male speakers produced a series of isolated words belonging to the two phonological classes.

The evidence from our acoustic data is for high tones to have higher fundamental frequency values than low tones. Acoustic results further show that high and low tones show sparse qualitative (F1, F2, F3 and F4) as well as sparse syllabic durational differences. However, the tendency is also for low tones to have lower F1, higher F2, higher F3 and lower F4 values than the high counterparts.

1. Introduction

The paper is divided into 3 main sections: the first part dealing with some phonological aspects of Twi vowels and Twi tonemics, the second section treats the methodology of the experimental analysis, and the last section presents observations and results of the acoustic investigations.

Twi uses tone for lexical and grammatical distinctions. It has a contrast between two pitch heights, and this occurs in words where the assigned syllable pitch is relatively higher or lower. An inventory of the phonological system of Twi shows that this language has 37 phonemically contrastive sounds: 23 consonant sounds, excluding allophones and loan phonemes (6 plosives, 4 nasals, 5 fricatives, 5 affricates, 1 trill and 2 approximants), and 14 vowel sounds: 9 oral vowels /i/, /ɪ/, /e/, /ɛ/, /a/, /ɔ/, /o/, /ʊ/, /u/ and 5 nasal vowels /ĩ/, /ɪ̃/, /ã/, /õ/ and /ũ/. It must also be noted that phonemic quantity and nasality are phonologically distinctive in Twi. Vowel quantity is used for lexical and grammatical distinctions, and nasality is used for lexical distinctions. The following examples show that there is an oral/nasal vocalic contrast in Twi, and that nasal vowels contrast with their oral counterparts after voiceless consonants: /fí/ 'to go out' vs. /fĩ́/ 'dirt, dirty', /tí/ 'head' vs. /tĩ́/'to scratch', /sí/ 'to say, to sharpen' vs. /sĩ́/ 'teeth, tooth', /ká/ 'to bite, debt', vs /kã́/ 'to say, to drive' vs, /fá/ 'to take' vs. /fã́/ 'half', /ǹ sá/ 'hand' vs. /ǹ sã́/ 'alcoholic drink'. Nasal vowels are not found before or after the approximants /j/, /w/ and voiced consonants like /b/ or /d/ in their distribution unless the vowel is followed by a nasal consonant.

All Twi vowels and syllabic consonants carry tones [6, 8, 13]. It has verbal tones, nominal tones, adjectival tones, adverbial tones and homotones.

Vowels of stem words can be divided into two categories: a class of verbs that always occurs with low tone and another class of verbs that always occurs with high tone. Continuative and stative forms of verbs carry low tones. For example sõ /sõ̀/ 'be big', wɔ /wɔ̀/ 'be located', de /dì/ 'be called', nam /nãm̀/ 'to be walking', gyina /ʤì nã̀/ 'to stand', sɛ /sɛ̀/ 'to look like', kura /kù rà/ 'to hold', hyɛ /ʃɛ̀/ 'to be wearing/put on'. All verbal paradigms except the habitual carry low tones: pɛ /pɛ̀/ 'to like', nyane /ɲã̀ nĩ̀/ 'to wake', ware /wà rɪ̀/, wa /wà/, 'to be long', yɛ /jɛ̀/ 'to be', sɛ /sɛ̀/ 'to look like', kasa /kà sà/ 'to speak' bisa /bì sà/ 'to ask'. Progressive and habitual forms of verbs carry high tones: sa /sá/ 'to dance', ka /ká/ 'to bite' dɔ /dɔ́/ 'to weed', di /dí/ 'to eat', fa /fá/ 'to take', kɔ /kɔ́/ 'to go', tɔ /tɔ́/ 'to buy'. Where there is verb serialization involving two different stems (i.e. verb plus verb constructions), the first stem carries a low tone and the second stem has a high tone: kɔ fa /kɔ̀ fá/ 'go and take', bɛ da /bɛ̀ dá/ 'come and sleep', kɔ tɔ /kɔ̀ tɔ́/ 'go and buy'. Where there is verb reduplication, the two stems carry low tones: didi /dì dì/ 'to eat' (plural form), fefe /fɪ̀ fɪ̀/ 'to suck, vomit'; (plural), bubu /bù bù/ 'to break' (plural) huhu /hù hù/ 'to blow' (plural), tete /tì tì/ 'to tear' (plural).

The following register tone patterns: (1) High-High, (2) High-Low, (3) Low-High, (4) Low-Low in bisyllabic morphemes, and (1) Low-Low-Low, (2) Low-

Low-High, (3) Low-High-High and (4) High-High-High in trisyllabic morphemes, found in other languages like Hausa and Acholi, all occur in Twi. Monosyllabic words have two possible patterns High-Low. These tone sequences have lexical and grammatical distinctions in Twi, features that are usually associated with West African languages.

1.1. Lexical contrast

Differences are made not based on absolute pitch, but on relative pitch in a word. Some examples of distinction between tone changes that are lexical are as follows: bra /brá/ 'life, existence' (noun) vs bra /brà/ 'come'(verb), dada /dá dá/ 'old' (adjective) vs dada /dà dà/ 'already' (adverb), da /dá/ 'to sleep' (verb), day' (noun) vs da /dà/ 'never' (adverb).

1.2. Lexical grammatical contrast

Tone differences distinguish the habitual from the future, the habitual from the past forms, the negative from the imperative. Typical examples of lexical grammatical contrast are: ɔwɔ /ɔ̀ wɔ́/ 'snake' vs ɔwɔ /ɔ̀ wɔ̀/ 'he/she possesses', ɔbɛfa /ɔ̀ bɛ́ fá/ 'he/she will take' vs /ɔ̀ bɛ̀ fà/ 'he/she comes to take', ɔdɔ /ɔ̀ dɔ́/ 'love' vs ɔdɔ /ɔ̀ dɔ̀/ 'he/she loves'.

1.3. Homotones

In the category of homotones are words that exhibit the same tone patterns but have different meanings. Some examples of Twi homotones involving three tone patterns are as follows. First, Low-High patterns; ɔpɛ /ɔ̀ pɛ́/ 'he/she looks for' vs ɔpɛ /ɔ̀ pɛ́/ 'Harmattan Winds', ɔyɛ /ɔ̀ jɛ́/ 'he/she is good, generous' vs ɔyɛ /ɔ̀ jɛ́/ 'he/she insults'. Second, High pattern in monosyllabic words: da /dá/ 'day' vs da /dá/ 'to sleep', ka /ká/ 'debt' vs ka /ká/ 'to bite'. Third, Low-Low patterns; ɔwɔ /ɔ̀ wɔ̀/ 'he/she possesses' vs ɔwɔ /ɔ̀ wɔ̀/ 'he/she is located', tete /tì tì/ 'to tear (plural form) vs tete /tì tì/ 'ancient times'.

In this preliminary study, formant values of the target vowels are obtained in order to verify qualitative differences between high and low tones in the second syllable of the two syllabic morphemes. Results are provided for high and low tones, with specific relative pitches assigned to them, for the front oral vowel /ɛ/ under two consonantal environments /p/ and /s/.

2. Method

The data in this work consist of acoustic tone assignments obtained from two native male speakers, with no speech or hearing impairment, producing a series of Twi minimal pairs (two pairs of words chosen to vary in tone assignment) containing high and low tones. The speakers produced the utterances at a self-selected conversational rate in two consonantal environments /p/, /s/. The randomised list of sixty-eight utterances [2] was produced at least ten times by each speaker. The selected corpus of this preliminary investigation was made up of the following bisyllabic words:

ɔpɛ /ɔ̀ pɛ́/ 'he/she looks for', (habitual),
ɔpɛ /ɔ̀ pɛ́/ 'Harmattan Winds',
ɔpɛ /ɔ̀ pɛ̀/ 'he/she likes',
ɔsɛ /ɔ̀ sɛ́/ 'he/she spreads' (habitual),
ɔsɛ /ɔ̀ sɛ̀/ 'he/she looks like'

Acoustic data were recorded in an anechoic room. First, by means of PRAAT sound editor, vowel durations were measured for the syllable CV and the target vowel. Second, FO values were calculated for the high tones and low tones, formant frequencies of vowels (F1, F2, F3, F4) were also measured for the two phonological classes. Statistical analyses (ANOVAs) were carried out on all measures obtained from the two speakers ($p \leq 0.01$).

3. Results and Discussion

The basic trend in the data, F0 and formant value measures and standard deviations for the two sets of tone assignments, reported in this paper for only one speaker, are summarized in Tables 1, 2, 3 and 4. The overall data indicate that the most important parameter for determining tone assignment contrasts, i.e. relative pitch, is highly significant ($p<0.001$). Absolute values show that the F0 for the low tone values vary between 104 Hz and 130 Hz and the high tone between 196 Hz and 251 Hz for the first pair /ɔ̀ pɛ̀/ vs /ɔ̀ pɛ́/ (see figure 1). The corresponding measurements for the second pair, /ɔ̀ sɛ̀/ vs /ɔ̀ sɛ́/, are between 110 Hz and 145 Hz for the low tone and, between 188 Hz and 224 Hz for the high tone respectively (see figure 2).

Table 1: Average F0, formant values and standard deviations for the high tone in /ɔ̀ pɛ́/ (Hz)

	F0	F1	F2	F3	F4
average	213	560	1794	2317	3603
standard deviation	14	29	66	138	208

Table 2: Average F0, formant values and standard deviations for the low tone in /ɔ̀ pɛ̀/ (Hz)

	F0	F1	F2	F3	F4
average	118	496	1858	2530	3573
standard deviation	08	19	70	207	234

Table 3: Average F0, formant values and standard deviations for the high tone in /ɔ̀ sɛ́/ (Hz)

	F0	F1	F2	F3	F4
average	211	536	1770	2418	3990
standard deviation	11	43	76	115	146

Table 4: Average F0, formant values and standard deviations for the low tone in /ɔ̀ sɛ̀/ (Hz)

	F0	F1	F2	F3	F4
average	115	461	1823	2590	3737
standard deviation	11	17	66	291	143

A close examination of formant values (F1, F2, F3 and F4) reveal that all phonological contrasts are situated around pitch heights, and that sparse differences in formant structures of a given pair are non-significant. Acoustic results show that F1, F2, F3 and F4 values for low and high tones are quite similar (p=*ns*), apart from F3 and F4 of the pair /ɔ̀ sɛ́/ and /ɔ̀ sɛ̀/. In this particular case, tone contrasts seem to be reinforced by differences in vowel quality.

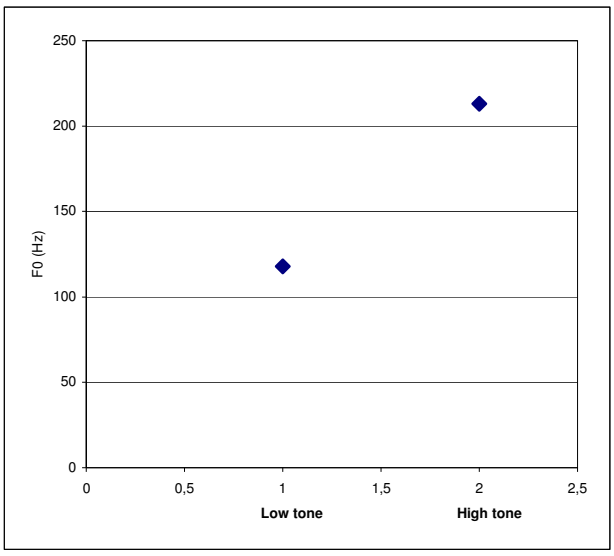

Figure 1: Average pitch (F0) values for low and high tones in */ɔ̀ pɛ̀/ vs /ɔ̀ pɛ́/* (Hz). Each point is an average of 10 tokens produced by one speaker.

3.1. /ɔ̀ pɛ̀/ and /ɔ̀ pɛ́/ contrast

Acoustic results, especially formant values, and target vowel durations furnish some indications about the low and high tone contrasts. Acoustic data of the informant illustrate that F1, F2, F3 and F4 values for low and high tones are quite similar (p=*ns*). Acoustic data also show a general tendency where the low tone has a smaller F1 formant value than the high tone. Contrary to the first formant values, the tendency is for the second and third formant values of the low tone to be greater than those of the high tone. The fourth formant values are smaller for the low tone compared to the high tone. However, it must be noted that these readings represent minor formant value differences for the two phonological classes.

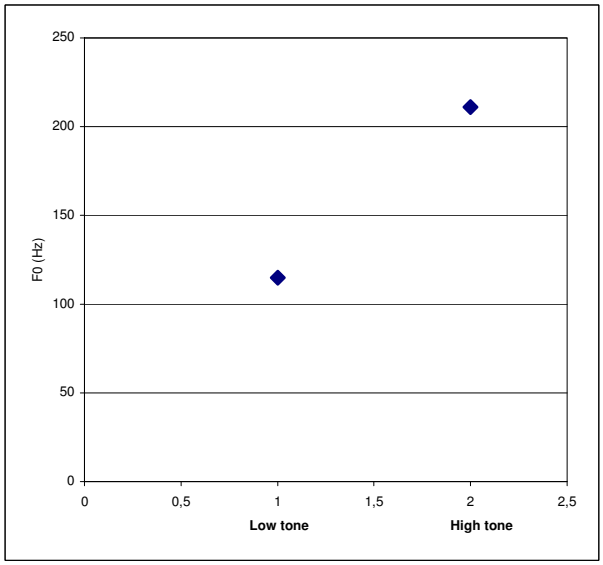

Figure 2: Average pitch (F0) values for low and high tones in */ɔ̀ sɛ̀/ vs /ɔ̀ sɛ́/* (Hz). Each point is an average of 10 tokens produced by one speaker.

Acoustic investigations also show slight duration differences between the high and low tone with the former being slightly longer than the latter. Absolute duration values of the high tone range between 142 ms and 188 ms whereas the corresponding values for the low tone range between 52 ms and 95 ms. The average values of 10 tokens is 159 ms, with a relatively small standard deviation of 12 ms for the high tone. The corresponding average value for the low tone is 68 ms with a relatively small standard deviation of 14 ms.

3.2. /ɔ̀ sɛ̀/ and /ɔ̀ sɛ́/ contrast

Formant value analysis in this contrast confirms the fact that F1, F2, F3 and F4 values for low and high tones are quite similar (p=*ns*). Formant values also confirm the tendency observed for the preceding contrast. The low tone has lower F1, higher F2, higher F3 and lower F4 values than the high tone. Like the previous category, acoustic data in this particular case show sparse syllable duration differences between the

low and high tone with the high tone having a relatively longer duration than the low counterpart. Absolute duration values of the vowel with high tone range from 107 ms to 178 ms. The corresponding values for the low tone range between 51 ms and 72 ms. The average value of 10 tokens is 144 ms, with a relatively small standard deviation of 22 ms for the high tone. The corresponding figure for the low tone is 60 ms with a relatively small standard deviation of 07 ms.

4. Conclusions

In this preliminary investigation it has been shown, on the basis of the selected corpus and evidence from our acoustic data, that pitch difference is the determining factor in distinguishing high and low tone contrasts in Twi.

Formant value analysis, undertaken to verify vowel quality for the two phonological classes, reveals sparse qualitative differences. However, thanks to the acoustic data it has been possible to show that vowel formant values could help to distinguish the two classes, the slight tendencies notwithstanding.

The low tone tends to have a smaller F1 and greater F2 values than the high tone. Low tone production (lower F1 and higher F2) could indicate an expanded or bigger pharyngal cavity than the high tone.

Formant structure comparison of the two classes indicates a more compact vowel structure for the high tone (higher F1 and lower F2) compared to that of the low tone (lower F1 and higher F2). The formant structures also suggest vowel quality that is more fronted and/or raised for the low tone compared to a vowel quality that is more retracted for the high tone.

The next step of this study is two-fold. First, to investigate formant value differences between high and low tone contrasts for the remaining oral and the nasal vowels with data based on more speakers. Second, to undertake a thorough articulatory study in order to investigate for further information on the vocal tract during the production of the two phonological contrasts.

Nevertheless, apart from formant frequencies, it should be worthwhile looking at other kinds of acoustic information like amplitudes and bandwidths.

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5. References

[1] K. Adu Manyah., 2005. Quantité et qualité vocaliques en twi : le cas des voyelles nasales. In *XVèmes Rencontres Linguistiques en Pays Rhénan*. Université Marc Bloch Strasbourg 2, Sciences Cognitives, Linguistique & Intelligence Artificiel (SCOLIA) N° 20, 9-30.

[2] K. Adu Manyah., 2004. *Étude contrastive du système phonologique en akan (twi) et du système phonologique en français en vue d'une application didactique.* Lille, Diffusion ANRT.

[3] K. Adu Manyah., 2003. Vowel quantity contrasts in Twi. In *15th International Congress of Phonetic Sciences,* Barcelona, 3185-3188.

[4] K. Adu Manyah., 2002. *Introduction à la phonétique et à la phonologie africaines. Les sons de tous les jours : le cas akan (TWI).* Paris, l'Harmattan.

[5] K. Adu Manyah & R. Sock., 2002. La quantité vocalique en twi. Quelques considérations phonologiques et analyses acoustiques préliminaires. In *XXIVèmes Journées d'Étude sur la Parole (JEP) de l'AFCP*, Nancy, 41-44.

[6] D. Creissels., 1994. *Aperçu sur les structures phonologiques des langues négro-africaines,* deuxième édition, Ellug, Université Stendhal, Grenoble.

[7] F. A. Dolphyne., 1996. *A Comprehensive Course in Twi (Asante) for the Non-Twi Learner.* Accra, Ghana Universities Press.

[8] F. A. Dolphyne., 1998. *The Akan (Twi-Fante) Language. Its Sound Systems and Tonal Structure.* Accra, Ghana Universities Press.

[9] F. A. Dolphyne., 1986. Tone and Grammar in Akan; the tone of possessive constructions in the Asante dialect In *Phonological Representation of suprasegmentals, Publications in African Languages and Linguistics,* n° 4, 35-49.

[10] F. A. Dolphyne., 1977. A classification of Akan verb systems. In *Société Linguistique de l'Afrique Occidentale. Actes du huitième Congrès International de Linguistique Africaine,* Abidjan, Université d'Abidjan, pp. 191-201.

[11] J. H. Greenberg (ed.), 1988. *Universals of Human Language,* vol. 1: *Method & Theory ;* vol. 2: *Phonology ;* vol. 3: *Word Structure ;* vol. 4: *Syntax,* Stanford, California, Stanford University Press.

[12] J. M. Stewart., 1964. *« The typology of the Twi tone system »* with comments by P. Schacter & W. E. Welmers, Legon, In *Bulletin of the Institute of African Studies,* 1.

[13] L. Y. Tufuor., 1973. *Les tons et les faits prosodiques en asante-twi (Étude instrumentale).* Thèse de 3ème cycle, Université des Sciences Humaines de Strasbourg.