On Quantity and Quality of Oral and Nasal Vowels in Twi

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Abstract

In both the oral and written contexts Twi, a tone language of the Kwa group (Niger Congo) spoken in Ghana, West Africa, has two contrasting lengths in words. Quantity is used for lexical and grammatical distinctions where the oral or nasal vowel is either short or long. This study reports observations and results of an experimental research on short and long oral/nasal vowels. Evidence from our acoustic data, based on the production of oral and nasal vowels belonging to the two phonological categories by two adult native speakers, shows that vowel duration is the determining factor in distinguishing the two classes. Acoustic results further indicate that short and long vowels are distinguished not only by vowel duration but also by post-vocalic consonant duration: phonologically short vowels are followed by phonetically long consonants in both the oral and nasal categories. Acoustic investigations also show that phonologically long vowels are followed by phonetically short vowels in the nasal category. Relative values also make clear and indeed confirm the robustness of the feature in Twi. The control of vowel quality between the two phonological classes indicates sparse formant or qualitative differences in both the oral and nasal contexts.

1. Introduction

An inventory of the phonological system of Twi shows that this language has 9 oral vowels /i/, /ɪ/, /e/, /ɛ/, /a/, /ɔ/, /o/, /ʊ/, /u/ and 5 nasal vowels /ĩ/, /ɪ̃/, /ã/, /õ/ et /ũ/. Quantity contrasts affect the entire vocalic system of the Twi language. Quantity is used for lexical and grammatical distinctions where the oral or nasal vowel is either short or long. Differences in quantity distinguish the present progressive, the present habitual, the present perfect, the simple future and the immediate future from the past forms of the verb. Lexical-grammatical distinctions: verb-noun, verb-adjective, verb-adverb, noun-adjective, noun-adverb and adjective-adverb are also made through differences in vowel length (e.g. /akura/ 'mouse' *vs.* /akuraa/ 'village', /pɛ/ 'like, desire, same' *vs.* /pɛɛ/ 'liked, desired', /pi/ 'thicken' *vs*. /pii/ 'thickened, plenty'; /kɔ/ 'go' *vs*. /kɔɔ/ 'went, red').

2. Method

The data in this study consist of acoustic durations obtained from two native male speakers producing a series of Twi minimal pairs containing long and short vowels embedded in a carrier sentence: "Kã sɛ__Kofi", meaning "Say__Kofi". The speakers produced the utterances at a self-selected conversational rate in three consonantal environments /p/, /t/, /k/. The randomized list of utterances was produced at least ten times. Acoustic data were recorded in an anechoic room. By means of a Praat Sound Editor, vowel durations, and formant frequencies of vowels (F1, F2, F3 and F4) as well as consonant durations were measured for the following: the target vowel, the post-vocalic consonant and the syllable V+C. Statistical analyses (ANOVAs) were carried out on all measures obtained from both speakers ($p \leq 0.01$).

3. Results and discussion

The overall data indicate that the most important parameter for determining vowel quantity contrasts, i.e. vowel duration, is highly significant ($p<0.001$). For Speaker 1, absolute values show that the duration of short oral vowels vary between 61 ms and 105 ms and long vowels between 138 ms and 275 ms. The corresponding measurements for Speaker 2 are 58 ms and 93 ms for the short vowels and 124 ms and 254 ms for the long vowels, respectively. For Speaker 1, values for short nasal vowels are between 107 ms and 146 ms. The corresponding data for Speaker 2 are 78 ms and 118 ms. The lowest value recorded for Speaker 1 is

259 ms for the long nasal vowels whereas the highest value is 308 ms. The corresponding values for Speaker 2 are 179 ms and 214 ms respectively.

Absolute duration measures indicate the relevance of both vowel and consonant durations in distinguishing the two phonological classes. In the VC domain, when the vowel is phonologically short, the subsequent consonant is phonetically long. Thus concomitant consonantal differences seem to reinforce vowel quantity contrasts in Twi, where phonologically short vowels, are followed by phonetically long consonants. The ratio is between 0.21 and 0.28 for the first speaker and between 0.19 and 0.32 for the second speaker for the oral vowels. The corresponding data for the nasal vowels are between 0.31 and 0.38 for the first speaker and between 0.33 and 0.49 for the second speaker respectively. To sum up, differences in consonant duration between long and short vowels are significant ($p>0.001$).

However, acoustic observations suggest that consonant durations of the longer counterparts are not as clear-cut as the short vowels. In other words, for the long vowels, no coherent compensatory behaviour between vowel and consonant durations is observed. In fact, when the vowel is phonologically long, the subsequent consonant may either be slightly longer than the vowel, equally long, or slightly shorter than the vowel. Contrary to the oral vowels, post-vocalic consonant durations are systematically slightly shorter than the long nasal vowels for the two speakers. In this category of long vowels, consonant duration values are generally close to vowel values. The slight difference between the two average values are not statistically significant *(p=ns)*. An overall comparison of absolute values reveals that Speaker 1 has longer values than Speaker 2: vowel, consonant and total durations are systematically longer for Speaker 1 compared with those for Speaker 2. The differences in segment durations for the two could be explained by differences in speaking rate of the two speakers. (See tables 1 and 2).

Differences in consonant duration between long and short vowels have also been attested for Modern Swedish [10]. The authors further posit that there is a complementarity pattern whereby the long vowel+consonant (V:C) sequences have the tendency of possessing almost the same duration as the short vowel+consonant (VC:) sequences. According to this study the VC: types are in general slightly shorter in total duration than the V:C sequences. This phenomenon seems to be observed for all oral and nasal vowels produced by the first Twi speaker (67% of all cases), where the VC: sequences are in general slightly shorter than the V:C counterparts. However, in the case of the second speaker, the complementarity pattern seems to apply partially, without reference to the vowel duration. Indeed, the tendency is verified in only 39% of the cases in both the oral and nasal contexts.

Comparing the data of only the nasal vowels, it can be observed that this trend applies to the two front vowels /ĩ/, /ɪ̃/ and the open vowel /ɑ̃/ but not to the 2 back vowels /õ/ and /ũ/, for speaker 1. The short vowel /ɪ̃/ + consonant sequence has an average duration of 473 ms as compared to 502 ms for the long vowel /ɪ̃ɪ̃/ + consonant type. The average is 395 ms and 526 ms for the pair short /ɪ̃/ + consonant and long /ɪ̃ɪ̃/ + consonant, and 502 ms compared to 517 ms for short /ɑ̃/ + consonant and long /ɑ̃ɑ̃/ + consonant. Concerning the two nasal back vowels /õ/ and /ũ/, the average values are 524 ms and 543 ms respectively for the category of short vowel + consonant and 520 ms and 524 ms for the category of long vowel + consonant.

For the second speaker, the short /ɪ̃/ + consonant (238 ms) *vs*. long /ɪ̃ɪ̃/ + consonant (308 ms), short /ɑ̃/ + consonant (378 ms) *vs* long /ɑ̃ɑ̃/ + consonant (405 ms) and /ũ/ + consonant (316 ms) *vs* /ũũ/ + consonant (341 ms) series, conform to the model. Concerning the other two nasal vowels, it is rather short /ĩ/ and /ũ/ + consonants (350 ms and 372 ms) that are longer than /ɪ̃ɪ̃/ and /ũũ/ + consonants (343 ms and 333 ms). (See tables 1 and 2 again). Thus, the observation on the complementarity pattern is in accordance with results obtained for Bolognese where it is shown that the phenomenon is only partially applicable [7].

Two remarks can be made to conclude this section. First, the findings of this study on phonological durational contrasts and the contribution of the post-vocalic consonant to distinguish the two phonological classes have already been documented on studies in Thai [9] and Bolognese [7]. Second, in the group of long vowels, tables 1 and 2 clearly show that post-vocalic consonant durational values are close to vowel durations. The difference between the two average values are not statistically significant *(p=ns)*.

After this overview on absolute and relative durational values for the two phonological classes, let's now continue our investigations on quality differences between the two categories of vowels in both the oral and nasal contexts. The study of quantity in a language cannot be based solely on observations of absolute duration values, since these segmental values cannot wholly be representative of a phenomenon as elastic as speech. Relative values must be taken into consideration in order to be able

to rationalise differences obtained in absolute segmental values. The VC domain, according to previous investigations [8] seems to be an efficient temporal span where quantity contrasts are clearly exemplified. A close look at the proportion of time taken by vowel duration in the VC syllable duration will therefore further clarify our observations.

For Speaker 1, short oral vowels represent, on average, 17 % to 22 % of the VC syllable durations, whereas long vowels represent an average of 37 % to 55 % of this syllable. For Speaker 2, short oral vowels represent 16 % to 24 % of the VC domain and the long vowels represent between 44 % and 59 % of this VC domain.

Table 1. Nasal vowel and post-vocalic consonant durations and standard deviations (in ms) for Speaker 1

vowel	short	standard deviation	long	standard deviation
ĩ	113	14	279	23
consonant	360	51	223	31
ɪ̃	107	16	308	34
consonant	288	72	218	98
ɑ̃	139	22	259	35
consonant	363	46	258	81
ɔ̃	127	14	300	36
consonant	397	71	220	21
ũ	146	24	293	36
consonant	397	98	231	53

Table 2. Nasal vowel and post-vocalic consonant durations and standard deviations (in ms) for Speaker 2

vowel	short	standard deviation	long	standard deviation
ĩ	87	09	195	25
consonant	263	44	148	27
ɪ̃	78	10	186	17
consonant	160	09	122	20
ɑ̃	118	08	214	23
consonant	260	40	191	34
ɔ̃	106	15	179	22
consonant	266	52	154	30
ũ	87	13	198	38
consonant	229	28	143	20

The proportion of time taken by short nasal vowels varies between 22 % and 25 % of the VC syllable duration for Speaker 1 and between 22 % and 33 % for Speaker 2. For Speaker 1, long nasal vowels represent an average of 45 % to 54 % of the VC syllable duration whereas the corresponding figures for Speaker 2 are 48 % and 60 % respectively. By comparing data for the oral and nasal vowels one can observe that it is the same scenario for our two informants. Similar conclusions have been obtained for Italian dialects spoken in Northern Italy [13] [14] and Bolognese [7].

Vowel data comparison also reveals that the nasal vowels are systematically longer than the oral counterparts in both short and long contexts, for both subjects. Moreover, the present investigation also suggests that vowel quantity contrasts emerge distinctly in this VC acoustic domain, regardless of expansion or compression of the speech signal.

Even though the two speakers have different absolute values for vowel and consonant durations, which can be explained by individual speaking rates, we observe, thanks to relative data analysis, that it is basically the same strategy that is adopted by the two speakers to preserve phonological contrasts and distinguish between the two phonological classes. Both speakers maintain the proportion of the vowel relatively stable within the VC syllable domain: a difference of around 10 % separates the two phonological classes in both the oral and nasal contexts. Such results have previously been reported for unrelated languages like Swedish and Wolof [12].

A close examination of formant values of the target vowels (F1, F2, F3 and F4) reveal that all phonological contrasts are indeed durational in nature, and that sparse differences in formant structures of a given pair are non-significant. (See Figures 1 and 2). With the exception of the following pairs of back vowels: short /ʊ/ and long /ʊː/ and short /u/ and long /uː/ in the oral category, and the pair short /ɔ̃/ and long /ɔ̃ː/ in the nasal context, where vowel quantity contrasts seem to be reinforced by differences in vowel quality, figures 1 and 2 clearly show that F1, F2, F3 and F4 values for short and long oral and nasal vowels are quite similar *(p=ns)*.

4. Conclusion

Evidence from our acoustic shows that vowel duration is the most important parameter to distinguish the two phonological classes of short and long vowels in both the oral and nasal contexts in Twi. Indeed, the study of absolute and relative values confirms the relevance of vowel duration in vowel quantity distinction. Acoustic results also show that post-vocalic consonants could help distinguish the two phonological categories. Phonologically short vowels are followed by

phonetically long consonants. However, with the exception of the nasal category of vowels, phonologically long vowels are not necessarily followed by phonetically short consonants. Acoustic investigations also reveal that nasal vowels have longer durational values than oral vowels in both the short and long contexts. Acoustic evidence of the two phonological categories indicates sparse formant or qualitative differences in both the oral and nasal contexts. Quantity contrast which affects the entire vocalic system (oral and nasal) of the Twi language seems indeed to be a robust phonological feature.

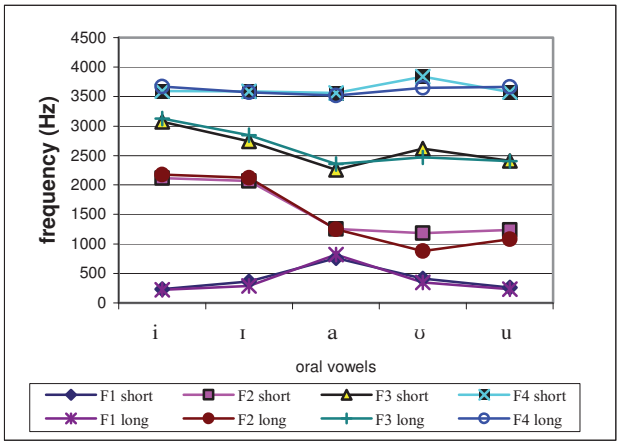

Figure 1. Comparison of formant values (in Hz) for short & long oral vowels for speaker 2

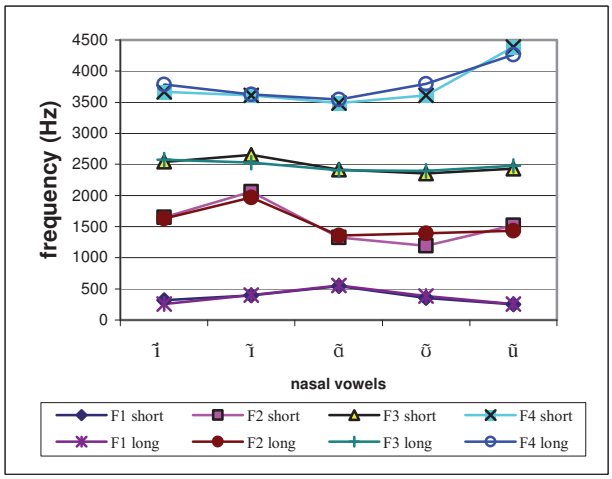

Figure 2. Comparison of formant values (in Hz) for short & long nasal vowels for speaker 2

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