SPECTROGRAPHIC ANALYSIS OF DAGBANI VOWELS

FUSHEINI ABDUL-RAHMAN

ACKNOWLAGEMENT

This thesis would not exist without the help, advice, moral support, and guidance of various people. I would like to dedicate these pages to acknowledge and thank them.

Firstly, I would like to express my sincere thanks to my supervisor, Professor J. N. Akpanglo-Nartey. You introduced me to acoustic phonetics. You also helped me to become a phonetician by offering detailed suggestions and useful criticism on chapters of this thesis. Thank you for your patience and many inspiring meetings. You made a great and efficient sole supervisor.

Countless thanks to Professor Lawrence Boadi, Head of Applied Linguistics Department. Your advice and continuous encouragement served as a fatherly advice that has yielded fruits. My special thanks goes to Mrs. Valentine Bannerman, the Librarian, UEW, and her hard working staff, for all the guidance in the library. Many thanks are due Mister Thomas Tawiah for his time and guidance. He introduced me to the SPSS, the statistical device which I used throughout the analysis in this thesis.

I cannot forget my course mates in acoustic studies, Miss Rebecca Naa Atchoi Doku and Miss Nada Afi Gbegble. Our tireless efforts in the lab have not been in vain. The entire great Applied Linguistic class of UEW, I say ayekoo…

I thank John Cary and Hubert Asior for their time, and assistance in the phonetics lab. Minatu, Zuwera, Andani Azuma and Pazzack, you have been very special to me, Wuni ni yo sama!

Furthermore, I am particularly grateful to members of the Applied Linguistics Department for lessons I have had with them throughout my post graduate course.

Next, I will like to thank George Akanlig-Pare for his guidance and discussions on the topic of this thesis.

Many people in the Faculty of Languages Education have made my time here much more profitable. Thanks are due Sekyi-Baidoo J. Y., Abdulai F. B., Al-Hassan Issahaku, Mohammed H. I. Norgah, and Jakalia. Thank you for the pieces of advice on my consultations with you.

My thanks would be incomplete if I fail to thank the members of my family and friends for their support. M ba, m ma, Sana and Abdul-Kakarim, Nkpa and family, Ni yi tuma pam!

Finally, I am grateful to Carnegie Corporation grant B-7693 and TALIF grant UEWS/001/2004 for financial support. Without these grants the equipment used for this project would not have been available.

DEDICATION

I dedicate this work to the members of my family: Sana and Abdul-Karim and the ones yet to come; my sister Andaratu and the grandparents who have all passed away.

ABSTRACT

The study presents an acoustic analysis of 15 stressed short and long vowels of Dagbani with detailed formant frequency and duration characteristics of the vowels produced in the open monosyllabic (CV) phonetic context by 15 male and 15 female speakers of Nanuni, Nayahili, and Tomosili dialects of Dagbani. The aim of the study was to provide an acoustic evidence of vowel quality in Dagbani through comparison of the acoustic characteristics of the vowels produced by speakers of the three dialects of Dagbani. The voice recording of 30 speakers made up of five males and five females for each dialect was carried out. The speech data was analyzed on the Kay Elemetrics Computerized Speech Lab (CSL model 4500) software to provide frequency data and duration values for the vowels. Values for the lowest two formants (F1 and F2) for speakers' vowels were taken at the middle and the durations measured from the start to the end of the study state of each vowel.

Both frequency and statistical results indicate that no significant differences exist between the dialects of Dagbani in the CV environment. The results also reveal that Nanuni which for the first time has been studied as a dialect of Dagbani is not different from Nayahili and Tomosili on which most linguist have often based their studies as dialects of Dagbani. The position of [e] and [ɛ] across the dialects as well as gender suggests that Dagbani does not have [e] and [ɛ] distinction, at least, in CV context. Speakers did not also distinguish between the production of [i] and [□]. Further more, the results show that [a] is more of a low back vowel than a mid one. It also reveals that the sound in Dagbani labeled [ɨ] is the mid central vowel [ə] and not the mid high vowel [ɨ]. The results also confirm that two degrees of vowel length exist in Dagbani; the short vowels being about 62.4% of their longer counterparts.

CHAPTER ONE
GENERAL INTRODUCTION

1.0 INTRODUCTION

This chapter introduces the aims and objectives of the study. It further states the language family to which the language belongs and the background studies conducted on the sound system of Dagbani.

1.1 Aim and objectives

This study is an attempt to carry out an instrumental analysis to come out with a precise description of Dagbani vowels. Dagbani has been studied for a long time now; however, a few attempts have since been made by linguists to study the sound system of the language. All attempts made by linguists so far especially on Dagbani vowel description have been based on the traditional articulatory descriptions. Results of existing studies have left inconsistencies in identification and description of Dagbani vowels. Finding solution to these and other linguistic problems compels the phonetician to adopt a scientific measure that will provide a systematic and reliable description to the Dagbani vowel quality.

Spectrographic analysis involves the analysis of speech sound waves by the use of an instrument known as the acoustic spectrograph. By means of an electrical filter of variable frequency response it produces a graphic display of speech known as a spectrogram. Time is shown along one axis and frequency along the other. The amplitude at any point is indicated by the intensity of blackness at that point. A different type of display can also be produced, showing frequency along one axis and amplitude present along the other, for any moment of the sample. This second type of display is known as a section.

In order to be able to specify the vowel sounds of a language in acoustic terms, it is important to state, among other things, the frequencies of at least some of the formants characteristics of those vowel sounds. The two lowest formants, F1 and F2 were used in this study to determine vowel quality. The aim of the current study therefore is to use spectrographic analysis to come out with the vowel quality of Dagbani by comparing similarities and differences that are characteristic of the vowels of the Tomosili, Nayahili, and Nanuni dialects of Dagbani by the use of frequency data of the vowels for both men and women from the various dialects. Gender investigation is not a priority of the current study; however, a test is performed to determine the significant relationships that characterize male and female vowels of Dagbani.

1.2 The Language

Dagbani is one of the major languages spoken in the Northern Region of Ghana. The language has been classified by Bendor-Samuel (1989), and Wilson (1970a) as belonging to the Gur language family and a member of the Moore Gurma sub-group of West African languages. Naden (1988) classifies Dagbani as belonging to South Western Oti-Volta group of central Gur languages. Bodomo (1993) however, introduces an indigenous term 'Mabia' for this group of languages (Central Gur) to which Dagbani belongs. To Bodomo, the term 'Mabia' meaning 'mother's child' is more inclusive as compared to such names as Moore Gurma or Gur since it brings to light the cultural aspirations shared by the people who speak the group of languages. The other languages of this group include Dagaare, Mampruli, Kusaal. Dagbani (language under current study) is made up of two major dialects, namely Dagbani and Nanuni. The former has sub-dialects as Tomosili and Nayahili. This study involves Tomosili, Nayahili, and Nanuni as dialects of the language Dagbani.

The Tomosili dialect is spoken in and around Tamale, the central part of the Northern Region of Ghana. Outside the Tamale Metropolitan area other areas where the Tomosili dialect is spoken include Tolon-Kumbungu District to the west and Savelugu-Nanton District to the north of the Northern Region of Ghana. Nayahili can be traced to the eastern side of Tomo (the immediate environs of Tamale where Tomosili is spoken), in and around Yendi. Speakers of this dialect are also found in other areas of the Gushegu, Karaga, and Zabzugu-Tatale Districts of the Northern region of Ghana. The Nanuni dialect is spoken in the Nanumba districts, directly to the south of Nayahili. Figure 1 is the Languages Map of Ghana on which the area marked 20 indicates the Dagbani speaking area. The dialects of Dagbani have quite a large number of native speakers. The Ghana Statistical Service (March, 2002), final report of the 2000 Population and Housing Census, page 23, has the native speakers of Dagbani to be seven hundred and forty-six thousand, nine hundred and twenty-four (746,924); and native speakers of Nanuni at seventy-eight thousand eight hundred and twelve (78,812).

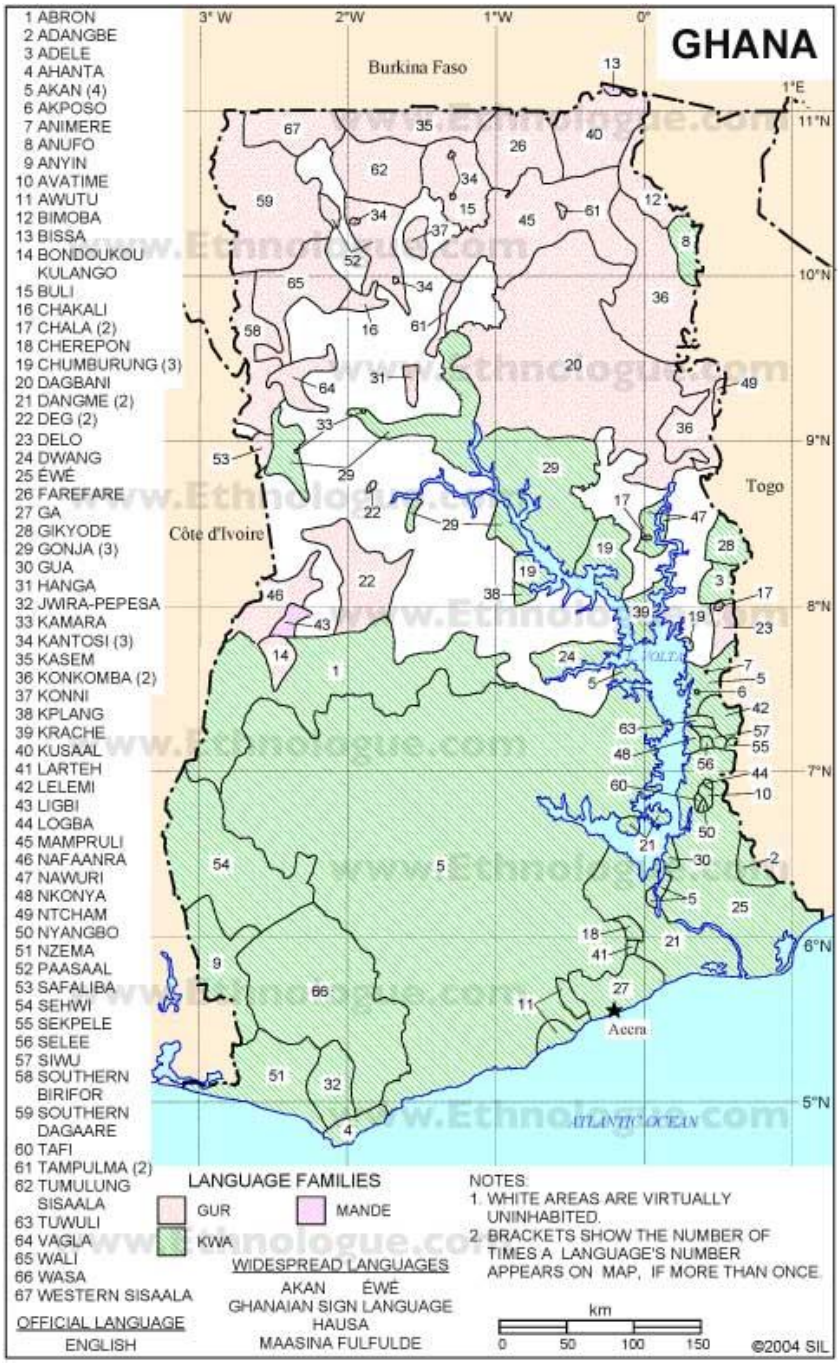

Figure 1: The Languages Map of Ghana. Source: www.Ethnofog.com.

1.3 Background to the study

Among attempts made by linguists to study the phonetic structure of Dagbani, the first attempt was Fisch (1913), based on the grammatical features of the language (Olawsky, 1999). Five vowels [i, e, a, o, u] were identified in this work. The work of Wilson & Bendor- Samuel (1965), identified six vowel phonemes of

Dagbani as [i, ɨ, e, a, o, u]. These linguists comment that it is often very difficult, either on phonetic grounds or on distributional grounds to determine which vowel sound should be grouped under one phoneme. Another known work, Wilson (1972), states that the standard way of writing the vowels of Dagbani is especially troublesome and inconsistent. He states one of his reasons for this view by the fact that the alphabet uses the letters /i, e, □, a, □, u/, however, the significant vowels in the language are [i, ɨ, u, e, a, o].

Abu-Bakari (1977) presented an articulatory description of the sound system of Dagbani. In this work, Abu-Bakari differs from the views of Fisch (1913) and Wilson (1965) for treating /ɛ/ and /ɔ/ as allophones of [e] and [o] respectively. Abu-bakari relates variation in the use of these sounds as dialectical, but did not go further to point out which dialect uses which of those sounds. Abu-Bakari's view is that [ɛ] and [ɔ] are phonemes but not allophones of [e] and [o] respectively. A newly approved Dagbani orthography dated 1998 identifies eight vowels sounds as [i, ɨ, e, ɛ, a, ɔ, o, u]. A particular problem for untrained readers of Dagbani is that the vowel **i** has up to five different phonetic representations. Part of this problem is due to the fact that in the early 1960's it was decided that seven vowels should be written, that is, [i, e, ɛ, a, ɔ, o, u] (Olawsky 1999).

A work that dealt specifically on the vowels of Dagbani is Dakubu (1997) on cross height vowel harmony. This work deals exhaustively with vowel distribution in the Dagbani word structure. Dakubu (1997) identifies the variation of vowel distribution between the Western (Tamale) and Eastern (Yendi) dialects of Dagbani referred to as Tomosili and Nayahili respectively by the current author. Dakubu asserts that the systems which display CV word structure in Dagbani seem to differ between the West and East dialects. In both dialects, [i, u, e, o, a] are said to occur in lexical stems, and [ɨ] occurs in certain grammatical particles that resemble lexical roots in that they carry word accent; and that [□] also occurs in the East. The work further states that [ɪ] occurs after palatal consonants including [ʃ] and [ʧ], but [ɨ] occurs after all others, and so they may be regarded as allophones. She states that [e] has not been realized, however [æ] seem to be usually preceded by a high off-glide on the consonant and to correspond to [ɛ] in the east. After fricatives, [ɔ] is said to be centralized and the consonant has a High off-glide. A quite recent work, Olawsky, (1999), 'Aspects of Dagbani Grammar, a phonological study of the language, identifies six vowel phonemes of Dagbani as [i, e, ə, a, o, u]. Olawsky, (1999) identifies [i] and [□] as allophones. He further state that [ɨ] appears as a variety of both [i] and [ə] in Dagbani. His work identifies /ɛ/ and /ɔ/ as allophones of the phonemes [e] and [o] respectively. The sound [ɷ] has also been identified as an allophone of the high back vowel [u]. The varying views of the various linguists calls for a systematic study into the phenomenon of vowel quality in Dagbani.

The different views held by linguist about the number of vowels in Dagbani, sums up to ten short vowels in the language as [i, □, ɨ, e, ɛ, a, ɔ, o, ɷ, u]. The qualities of these vowels in relation to tongue position (high/low versus front/back) are described in articulatory terms as high front [i, □], mid front [e, ɛ], mid central [ɨ], high back [ɷ, u], mid back [ɔ, o], and low central [a]. The writing system, however, uses **i̲** for [i], [□] and [ɨ], but **ɛ̲** is sometimes used for [ɨ] as in the word *bɛ* 'they' transcribed as [bɨ]. In fact, beginners in the language often confuse the [ɨ] sound in *bɛ* as the vowel [ɛ]. Generally, Olawsky (1999) describes the use of [ɨ] in Dagbani as one in the place the schwa [ə]. Since the IPA has [ɨ] and [ə] representing different sounds, the current writer reports that the sound in question is [ə̵] and not [ɨ].

A summary of the Dagbani vocalic system described above provides the traditional vowel map as represented in Figure 2 below.

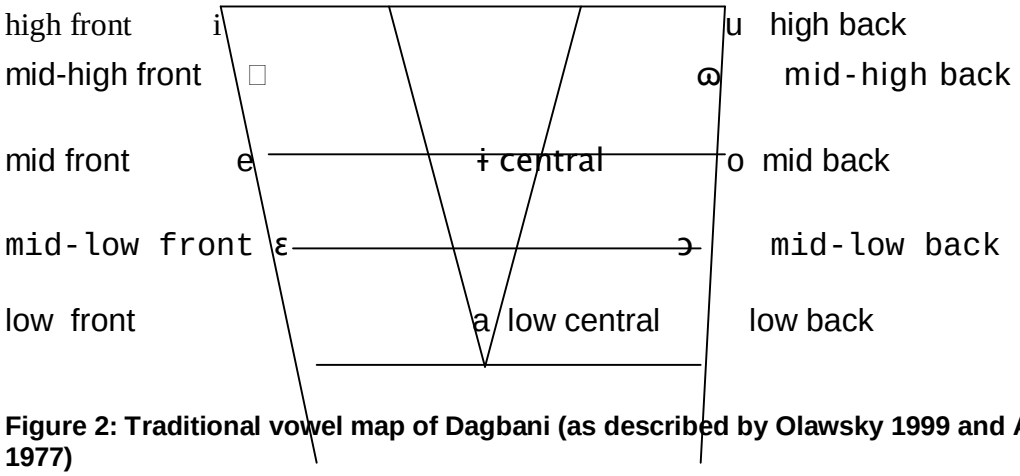

Figure 2: Traditional vowel map of Dagbani (as described by Olawsky 1999 and Abu-bakari 1977)

All attempts made by linguists to describe Dagbani vowel quality have been impressionistic; there has not been any attempt to describe them in a more sophisticated way. Articulatory description of speech sound is based on auditory impression. The disadvantage of auditory description of speech sounds is that the listener must be well trained to be able to describe perceived sounds. However, traditional articulatory description of phonetic sounds is still not very satisfactory because it is difficult to describe the tongue position of a vowel in one's own speech. For instance (Ladefoged 1993) it is not quite easy for people who know phonetics to describe where the tongue is at the beginning of the vowel in 'boy'. Very often what books tell us about the position of the tongue is a set of terms that are not really descriptive but are in fact only labels. However, Ladefoged (1993) states that it is important to note that these simple labels

describe how vowel sounds relate to one another. Jacobson (1977), a work on 'Phonetic aspects of Dholuo'; states that the traditional means of characterizing vowels, those of height, lip-rounding, and backness, are not sufficient for African languages. This hypothesis is in agreement to a previous study, by Lindau (1975), on findings with acoustic and radiographic data for eight speakers of Dholuo.

An acoustic study of the Dagbani vowel will not only give a precise and systematic description but will also add to linguistic knowledge the characteristic features of the Dagbani vowels that distinguish one dialect from another. Traditionally, vocalic phenomenon has been described in terms of tongue position in the vocal tract; such an articulatory description conceives tongue-height as playing a predominantly prominent role in the determination of vowel quality. Following this approach, depiction of vowel qualities in published literature has been made in the form of a triangular arrangement of points. The relative heights of these points are said to be a direct function of the tongue height required for a particular vowel quality. However, experimental evidence has shown that the tongue description is unsatisfactory, and has served to obscure the actual articulatory parameters involved in vowel production. Godinez (1979) suggested that vowel sounds be viewed as acoustically specifiable entities resulting from corresponding vocal tract configuration. The representation of vowels in graphic form is thought of as depicting relative differences in acoustic vowel quality and not particular tongue positions.

Spectrographic analysis of speech sounds have been done extensively in the history of speech research. Osamu and Donna (1997) cites Kent and Read (1992) among others as one of the most recent publications in which a concise account of American English characteristics can be found, in conjunction with relevant background issues of speech signal analysis. Ladefoged (1993) discuses both British and American forms of English. Another textbook by Ladefoged (1962), *Elements of Acoustic Phonetics*, deals with selected issues of acoustics and signal processing for experimental phoneticians.

By the use of spectrographic analysis, researchers have presented lots of work on the vowel quality of many languages. One such example is Godinez (1978), 'Comparative Study of some Romance vowels'. This work gives an account of features that distinguishes vowel quality between such languages as Mexican Spanish, Argentine Spanish, Peninsular Spanish, and Brazilian Portuguese. Recording of 25 male speakers of the various Romance languages was done, with 6 representing Mexican Spanish, 4 representing Argentine Spanish, 6 representing Peninsular Spanish and 9 speakers representing Brazilian Portuguese dialects. The recorded data were submitted to a spectrographic analysis. Spectrograms were made for each vowel of each speaker, and the formant frequency values F1/ F2/F3 were measured. The recorded data was also analyzed by means of a computerized LPC (Linear Predictor Coefficient) analysis to determine the formant frequency values. The study found that target areas of the vowels [o], [u] and [a] of Peninsular Spanish were seen to be positioned more closely than the other two dialects of Spanish. The latter two dialects seem to exhibit larger acoustic differences in the spacing

of the back vowels. The sound represented by [e] for Argentine Spanish seems to occupy a higher position in the vowel space than the comparable vowels of Mexican Spanish dialect. The same type of relationship seems to hold for the vowel [i] in Argentine and Peninsular Spanish. Godenez concluded that the general overall pattern seems additionally not to follow the predictions of the principle of maximal perceptual contrast discussed in Liljencrants and Lindblom (1972).

Watt and Tillotson (2001), a study of Spectrographic Analysis of Vowel fronting in Bradford English investigated why the vowel [o] in Bradford English produced by many speakers as a monophthong with a clear fronted or central quality. In their study seven speakers of Bradford English (5 males and 2 females) were recorded. Speakers' ages ranged from 17 to 75 years. Each speaker was asked to read a list of 100 isolated words plus 8 short phrases containing target phonological variables. All 7 recordings were sampled and words containing target vowels were labeled. Formant values were extracted from LPC spectral envelopes generated from the approximated midpoints of target vowels on broadband spectrograms. Formant values data of the Bradford English vowels were sampled on the form of cross-plots of F1 values against the difference between F2 and F1. Analysis showed that the target of the vowel /o/ is fronted from the peripheral to central area of vowel space in the speech of younger Bradford English speakers. The fronting process seemed most advanced among young women recorded for the project and is hence in all likelihood marked for age and gender in Bradford English.

Another article is by Shank and Wilson (2000), "An acoustic analysis of vowel formants in pharyngeal and glottal context in Nuu-chah-nulth". The study aimed primarily to document and describe precisely the acoustic effects of the glottal stop /□/ and the pharyngealised glottal stop /□/ have on adjacent vowels, with the assumption that such effects are cue to the differentiation. Data was elicited from an adult female of the Ahousa dialect of Nuu-chah-nulth. The data was elicited over a four-month period during biweekly elicitation sessions. Data was reordered using various analog cassette recorders such as the Maranz PMD 430. Data was analyzed on an imac computer sampling at 44 KHz; and an acoustic analysis performed using Praat 3.8.64. Formant averages of the three vowels ([a], [i] and [u]) in nine different contexts. The study found out that the formant values of vowels are significantly different adjacent to the plain glottal stop / □/ as compared to the pharyngealised glottal stop / □/ in Nuu-chah-nulth. The pharyngeal causes a greater rise in F1 and a more substantial drop in F3 than the glottal stop. The work concludes that there is a positive result, for the most part correlating well with the findings of researchers concentrating on Semitic and Caucausian languages.

Zee (1979), 'The interaction of tone and Vowel quality', a revised version of a paper presented at the 94th meeting of the Acoustic Society of America, investigated the effect of tone on vowel quality by using tone languages. The study explored how formant frequencies change when a vowel is pronounced with different tones in natural language produced by speakers of a tone language. In his study, five Taiwanese Chinese vowels [i], [e], [a], [ɔ]and [u] were

used for the investigation. The vowels were uttered with two contrasting tones, namely high tone and low tone. A word list containing these vowels, 10 representations for each tone class, was prepared with the test words arranged in random order and placed in a carrier frame. Recording was done on 3 male native southern Taiwanese speakers in a sound treated room. The data was analyzed by using a PDP-12 computer at UCLA Phonetic Lab. Formant frequency values were obtained from LPC spectra and fundamental frequency from the corresponding cepstrum. The averaging technique was used to obtain the formant frequencies (F1, F2, and F3). Every word associated with either high of low tone was analyzed entirely, from the beginning to the end of its waveform. The study found that formant frequencies associated with the high tone are not necessarily greater than the formant frequencies associated with the low tone for all the 3 speakers. For all 3 speakers, vowels [i], [e], [ɔ] and [u] associated with the high tone occupy areas in acoustic vowel space that are distinct from those occupied by vowels associated with the low tone. The way the formant frequency pattern associated with the high tone differs from the formant frequency pattern associated with the low tone, is unique for all 3 speakers. The value of the F0 of the high tone correlates with vowel height of all 3 speakers. No such correlation was found in vowels associated with low tone for all 3 speakers.

Umut et al. (2003) analyzed and evaluated the acoustic parameters of sustained Turkish vowels. Records had been taken from 25 volunteer adults, of who expressed that they did not demonstrate any pathologies. Volunteers uttered ‘a’, ‘e’, ‘i’, ‘o’ and ‘u’ vowels twice, where the second recordings were made approximately two weeks after the first one. Vowels were recorded and analyzed by using the Kay Elemetrics Multi- Speech (MS) analysis software. The acoustic parameters analyzed were Jitter, Shimmer, Pitch Period and HNR (Harmonic-to-Noise Ratio). The results obtained from the MS software were evaluated against normative values obtained from healthy people. After the parameter analyses, all acoustic parameters for each vowel, obtained from the same volunteer, under investigation (i.e. jitter, shimmer, pitch period, HNR) were examined for statistical significance under 95% confidence interval. The results indicated that there is no significant difference between the first and second recordings for the parameters investigated.

Bojan et al. (1996) measured the duration of stressed short and long vowels, as well as the unstressed vowels, both in open and closed syllables in order to work out general ratios between the three types of vowels in standard Slovenian. In this study, two types of text scripts were prepared for the analysis of the Standard Slovenian vowels. The first was a short word set (about 4 min/speaker), containing isolated words and (up to four) words in a short sentence. The second script was a paragraph of continuous speech (about 1 min/speaker), which was read only by two speakers (one male and one female). The study presented, only the former word set in the experimental work. Two male and two female educated speakers were recorded on a portable Digital Audio Tape recorder (Sony TCDD3). The recorded material was later analyzed using a Kay Elemetrics Computerized Speech Lab (CSL, Model 4300B). Formant trajectories within the manually segmented monophthongs of three speakers (two

male and one female) were computed using the CSL. The sample values of the first three formants were taken at the middle of the formant trajectory contour. Vowel quality analysis included the study of height (modeled by the frequency of formant one) and backness (modeled by the difference between frequencies of formant two and formant one). Vowel durations were calculated from the manually positioned boundaries in order to enable a comparative analysis with previously published results. In their results, they found out that measurements support the basic division of vowels into long stressed and short unstressed ones, while the further subdivision of stressed vowels into long and short only seems to be valid for one particular vowel, i.e., the open central vowel [a].