# REDEFINING THE ACOUSTIC SPACE: A SPECTROGRAPHIC ANALYSIS OF THE VOWELS /a/, /i/, /u/ IN THE ASSAMESE (SECOND LANGUAGE) OF BANGLA SPEAKERS IN ASSAM



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BY

**MANALI DAS**

Under the supervision of

**PROF. VAISHNA NARANG**

**CENTRE FOR LINGUISTICS**
**SCHOOL OF LANGUAGE, LITERATURE AND CULTURE STUDIES**
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Centre for Linguistics
School of Language, Literature & Culture Studies
जवाहरलाल नेहरू विश्वविद्यालय
Jawaharlal Nehru University
New Delhi-110067 India

UC

Dated 28-07-08

# CERTIFICATE

This dissertation titled **"Redefining the Acoustic space: A Spectrographic analysis of the vowels /a/, /i/, /u/ in the Assamese (Second Language) of Bangla Speakers in Assam"** submitted by **Ms. Manali Das**, Centre for Linguistics, School of Language, Literature and Culture Studies, Jawaharlal Nehru University, New Delhi, for the award of the degree of **Master of Philosophy**, is an original work and has not been submitted so far in part or in full, for any other degree or diploma of any University or Institution.

This may be placed before the examiners for evaluation for the award of the degree of Master of Philosophy.

**(PROF. ANVITA ABBI)**
CHAIRPERSON

Prof. Anvita Abbi
Chairperson
Centre for Linguistics
School of Language, Literature & Culture Studies
Jawaharlal Nehru University, New Delhi-110067

**(PROF. VAISHNA NARANG)**
SUPERVISOR

Prof. Vaishna Narang
Centre for Linguistics
School of Language, Literature & Culture Studies
Jawaharlal Nehru University, New Delhi-110067

Dated 14-07-08

## DECLARATION BY THE CANDIDATE

This thesis titled "**Redefining the Acoustic space: A Spectrographic analysis of the vowels /a/, /i/, /u/ in the Assamese (Second Language) of Bangla Speakers in Assam**" submitted by me for the award of the degree of Master of Philosophy, is an original work and has not been submitted so far in part or in full, for any other degree or diploma of any University or Institute.


(Ms. MANALI DAS)
M.Phil student
Centre for Linguistics
SLL&CS
JNU

*Dedicated to...*

*Prabhu*

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# CHAPTER 1

# INTRODUCTION AND LITERATURE REVIEW

## 1.1 The Language situation in Assam

Assamese, the major language spoken in the North-Eastern part of the country, particularly in the Brahmaputra valley of Assam, has an old association with Bangla. Bangla is the second most important language spoken there. The three languages, Assamese, Bangla and Oriya belong to the Eastern Indic subgroup[1] which is the descendent of the earlier Eastern languages thus, making them cognate languages (Chatterji,1970:91). This explains the vast similarities that can be noticed between these three languages in terms of their structure, morphology and vocabulary.

Although the two languages, Assamese and Bangla are mutually intelligible, the primary differences between them are in terms of their pronunciation and grammar (Haldar,2007:101). The present day differences between the two languages date back to the emergence of a new literary tradition in Assam developed by the educated class of Assamese people. This literature was developed with the colloquial speech of the Sibsagar and Dibrugarh areas of Assam as the framework (Halder,2007:91). Tracing back the relationship between the two languages, we discover that there is more to it than the common bond of kinship. These two languages are tied together by a saga of language politics and a battle for supremacy in Assam.

Bangla is the language of the most important minority group in Assam thus, making it an important language in Assam. Bangla as a language has acquired such importance in the state of Assam that the significance of Assamese was once under-threat. However, owing to the untiring efforts of the Assam government and the Assamese press, Assamese as a language has regained its lost glory.

[1] The Eastern Indic is a subgroup of the modern Indo-Aryan language.

*"The 1951 census classifies Assam's population into speakers of 76 languages and dialects, and residual category consisting of 48 other languages and dialects"* (Goswami,1997:23)

Thus, the language situation in Assam is a rather interesting one given its diverse constituent racial and linguistic elements. Sandhya Goswami in the book titled *Language Politics of Assam* (1997) gives us a brief overview of the language situation in Assam highlighting the ongoing language conflict between the Assamese and Bangla communities there.

As already stated earlier, a predominant aspect of the language situation in Assam is the deep-rooted conflict between Assamese, the major language of Assam and Bangla, the language of the most important minority group in Assam. The origin of this problem can be traced back to the era of the British Raj in India (Goswami,1997:26). Assam was witness to the fall of the Ahom dynasty[2] following the annexation of the state by the British in the year 1826. This marked the end of an epoch in the history of Assam. After the declaration of Assam as a Chief Commissioner's Province in 1874, a major part of the Bangla speaking areas of Cachar and Slyhet and also Goalpara passed into the administrative supervision of the Assam government (Goswami,1997:13) .Prior to this event there was no noticeable Bengali population in Assam. Thus, this inclusion of the major Bangla-speaking areas within Assam can be said to have sowed the seeds of the still existing contention between the Assamese and the Bangla community of Assam.

The next noteworthy factor that further aggravated this problem was the influx of a large bulk of migrant laborers from the East Bengal districts, who either worked

[2] The Ahom dynasty is an off-shot of the Tai stock of the South East Asia. Assam was under the rule of the Ahom for over a century. The Ahom dynasty, however, was witness to a large amount of internal conflict and rivalry which propelled the Burmese to lead several invasions into the state and finally leading to the down fall of the Ahom dynasty.

in the tea plantations or served as peasants[3] (Goswami,1997:14). As a part of the "Divide and

Rule policy"[4], the British rulers took undue advantage of the situation to spread their imperialistic rule and created a rift between the Assamese and Bangla speakers which strangely still continues to exist.

Assamese was replaced by Bangla as the language of the courts and the administration, and it also started to be used as the medium of instruction in all the schools. Bangla as a language was patronized by the British rulers on account of its vivacity and richness (Haldar,2007:100 and Goswami,1997:15). Over and above this, Bengali people came to occupy major positions of power and authority in the government and administration of Assam. They were influential people who had a say in the decision making process of the state and thus making their services indispensable (Goswami,1997:15). This not only placed the Bengali populace at a significant position but it also directly resulted in the consolidation of the position of Bangla on the Assamese soil at the cost of the Assamese language. With time the situation only grew worse. This gradually led to the realization among the youth of Assam that their language and identity was under threat. Thus, in the wake of the situation there was deep resentment and wide spread agitation to restore the lost magnitude of the Assamese language. This unfortunate state of affairs reached its peak when Bangla was declared the state language of Assam[5].

The post-Independence period witnessed a greater influx of Hindu Bengalis to Assam in the hope of and search for better economic and social opportunities. This again led to wide spread agitation in different parts of the state. The efforts

[3] Most of the immigrants from West Bengal, Bihar and Bangladesh work as migrant laborers in the tea plantations and also as peasants in Assam and thus resulting in the largest migrant group in the state.

[4] Divide and Rule was a policy/tactic of domination that was used extensively by the British rulers. In India they created differences among the masses on the grounds of their religion, community, caste, creed, region and also language. This disunity and disharmony helped them to carve the way for widespread exploitation, both social and economic.

[5] Bangla was introduced as the language of the courts in the year 1836.

of the educated elite class of Assamese people were finally paid off when the Assam government stated, on 26th September 1947 that "Assamese is to be accepted as compulsory second language in all schools where it can not be Assamese completely" (Goswami,1997:30)

In the political sphere, organizations such as the *Assam Jatiya Mahasabha*[6] and the *Asomiya Sangha* played a pivotal role in the rejuvenation and restoration of the Assamese language. Thus during the post-Independence period the language problem rose above its stature and assumed tremendous political significance (Goswami,1997:30). And the language policy in Assam became the apple of discord between the Assamese and Bengali speaking communities.

The continuous and steady efforts of the elite educated Assamese class to restore the lost importance of the Assamese language, culminated in the Assam Education Department issuing a circular ordering the Inspectors of Schools to take the necessary action to introduce Assamese as the medium of instruction in all the schools of Assam. Sandhya Goswami (1997:30) points out that on the 19th of April, 1873, resolution stating that Assamese will be used as the medium of instruction in the entire primary and middle schools and the lower classes of high school was passed. Assamese was taught as a second language in those parts of the state where the spoken language served as the medium of instruction at the primary school level. With the gradual passage of time Assamese replaced Bangla as the medium of instruction in all those schools where Bangla was the chief medium of instruction.

The *Assam Sahitya Sabha*[7] continued unabated in its efforts to introduce Assamese as the medium of instruction in all the parts of the state including the hills. Finally, for the first time in the history of Assam, the 16th of July, 1951 was observed as the state language day by the *Assam Sahitya Sabha* (Goswami,1997: 32-34)

[6] These are two of the leading political organizations claiming to represent the Assamese speakers for the first time in history.

[7] The Assam Sahitya Sabha was established in the year 1917 AD with the chief purpose of the development and restoration of the Assamese language. It is the largest literary organization in Assam till date.

Today, Assamese is the State Official Language of Assam[8]. Assamese is used as the medium of instruction in the vernacular medium schools and it is the language of the government and administration. Even then, Bangla as a language has a strong hold in the state. This is due to the fact that it is the language of a community which is the most important minority group in the state. Assamese is the second language of these people and they have also assimilated with the culture of the Assamese people. Most of the Bangla speakers have learnt Assamese as subject at the high school level, even though they have not had formal classroom teaching of Assamese as a second language. The fact that the two languages do not have very pronounced structural differences, facilitate the learning of Assamese as a Second Language (SL) by the native Bangla speakers residing in Assam.

## 1.2 The Acoustics of Vowels

Our speech always embodies a certain message and this is what accounts for the meaningfulness of language. What has baffled speech scientists and researchers through the ages are how we, as listeners decode the underlying message that is embedded in the speech utterance. Every language consists of units which are arranged in a hierarchical manner, the most minimal unit being a phoneme[9]. Vowels serve a particular function in a language and it is on the grounds of those functions that they perform, are they determined by linguists, the most important role being that of differentiating words (Pickett,1999:6). In this sense vowels can be considered to be the building blocks of a language. Over and above this, vowels also form the nuclei of all syllables with the exception of the Syllabic Nasals/Liquids[10]. Vowels are also the carrier of prosodic information in an utterance as the stress and intonation patterns of an utterance are always marked

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[8] Assamese was declared as the State Official Language of Assam under the Official Language Act which was passed in the year 1960. The Official Language Act provided for the use of Bangla as the Associate Official Language in the Bangla dominated areas of the southern districts of Cachar, Karimganj and Hailakandi.

[9] These sound units or phonemes are further classified into consonants and vowels.

[10] Syllabic nasals and liquids are those in which have a vowel-like quality and act as syllabic nuclei. For e.g.; bird [bərd].

on the acoustic patterns of the vowel and not on the consonant (Strange,1999:153).

It is to be however borne in mind that phonemes are not defined acoustically per se, even though a word can be considered to be a string of sound patterns (Pickett,1999:6). The acoustic properties of any vowel or consonant cannot be said to be strictly associated with that particular phoneme only. This is because speech is a continuous flow of sounds and every sound that either precedes or follows another sound influence each other in terms of their acoustic properties. For e.g. if a vowel is followed by a nasal consonant such as /m/ or /n/, the vowel preceding or following it tends to get nasalized[11]. Thus, that nasalization is not the acoustic property of that particular vowel per se but rather acquires the property of being nasalized due to the phonological environment in which it occurs. It is of course true that certain vowels as well as consonants share certain similar acoustic properties. For e.g. all sibilants such as [s], [z], etc share a similar high frequency noise spectrum[12].

Vowels are defined as "*a class of pulmonic pressure sounds normally voiced, with a maintainable central oral approximant or resonant dorso-domal, or pharyngeal, articulatory channel*" (Catford, 1988:123).

The production of vowel sounds, like any other sounds involve the application of energy on the vocal tract which constitutes the "input", "excitation" or "acoustic energy" (Ashby and Maidment,2005:70). The area from the mouth to the pharynx (i.e. the oral-pharyngeal tract) that plays an important role in the production of any speech sound can be considered to be a tumbler that is filled with air. Every time we speak the pulmonic air stream (i.e. air from the lungs) pushes its way out to the oral/nasal cavity through the glottis owing to the sub-glottal pressure. This leads to the production of "glottal pulses" (Pickett,1999:23) The vibration of the vocal cords, i.e. the number of times the vocal cords open and shut within a period of a second constitutes the Fundamental Frequency which is also labeled as F0. The

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[11] Nasalization is a process of assimilatory change whereby a consonant/vowel anticipates a preceding/following nasal consonant and takes on the nasal place of articulation.

[12] In the description of sounds, we have the knowledge of the constituent frequencies and also their respective amplitudes. Such a statement is referred to a "sound spectrum".

auditory/perceptual co-relate of this being the Pitch. Thus, what we hear is the Pitch (Ball,1993:121). Over and above this, the glottal pulses (i.e. the driving system) resonates the air in the oral-pharyngeal cavity which constitute the driven system (Ball,1993:126-127). It is for this reason that over and above the Fundamental Frequency there are other high frequency vibrations that are collectively called the Harmonics. These are always the whole number multiples of the fundamental frequency. For e.g. if the fundamental frequency is 100 Hz, the harmonics will be whole number multiples such as 100 X 2, 100 X 3, etc (Catford,1988:159-160). As these sound waves generated by the vocal cords make their way through the laryngeal cavity to the oral/nasal cavity, these cavities act as filters that select certain frequencies and exclude some (Fry,1979:95).

These resonances of the vocal tract are commonly called the Formants of the vocal tract and these formants play a very crucial role in the determination of the vowel sounds (Fry,1979:76). Vowels have a number of formants which are always higher than the fundamental frequency and are numbered as F1, F2, F3, and so on. It is however to be borne in mind that there exists a difference between the Fundamental Frequency (F0) and the Formants of the vowels. Whereas Fundamental Frequency is essentially determined by the rate of the vocal fold vibrations in a second, formants on the other hand, are dependent on the overall shape and size of the cavities above the larynx (Catford,1988:160). Thus, the "articulatory target"[13] determines the F0. It is for this particular reason that the wider oral cavities have higher formant frequencies. This accounts for the high frequency formants for females and children compared to adult male speakers (Ball,1993:117 and Ashby and Maidment,2005:72). F1 for average male voices is generally ranges from 150-850 cps, whereas F2 ranges from 500-2,500 cps.

Ashby and Maidment (2005:72-74), and also Ladefoged (1962:104) point out the relation between the articulation of the vowels and their respective formant patterns. According to them, from the point of view of articulation the amount of constriction in the pharyngeal-oral cavities and also the lip-position (i.e. rounded/unrounded), the vowel height (i.e. the relationship between the highest

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[13]The posture of the vocal tract in the production of a particular vowel sound is called the Articulatory Target (Strange,1999:153).

point of the tongue and the roof of the oral cavity) and vowel location (i.e. the point of the tongue which is the most raised during the time of the vowel articulation) play a crucial role in the determination of the formants of the vowels.

There exists a direct relation between the vowel height and F1. They are inversely related. Thus, a high vowel has a low F1 as in the high vowel /i/ and /u/ whereas low vowels have higher F1 as in the low vowel /a/. Again, F2 is higher for the front vowels such as /i/ and low for the back vowels such as /u/. Similarly the amount of lip-rounding will reduce all the formant frequencies. Hence the F1, F2 and F3 of all the rounded vowels such as /u/, /o/ will be lower compared to their unrounded counterparts such as /i/, /e/) Thus, we see that there is an inverse relation between the amount of oral constriction and the first formant for vowels. In the articulation of the front vowels such as /i/, the amount of constriction in the front part of the palate is more compared to the other front vowels such as /e/, /æ/, /ɛ/ and this account for the low F1 of the front vowel /i/ (Ashby and Maidment,2005:72-74 and Ladefoged,1962:104).

On the other hand, greater constriction in the pharyngeal cavity generates higher F1 values as is found in the vowels /o/ and /a/. Greater constriction in the frontal region of the oral cavity lead to high F2 values as occurs in the vowel /i/ which has the highest front tongue constriction. Greater back tongue constriction leads to low F2 values as is found in the vowel /u/ (Pickett,1999:40-43).

Despite the fact that the formant values of the vowel phonemes have a crucial role to play in their identification, these values, however, are not absolute and constant. A large number of factors are collectively responsible for the variability in the acoustic properties of the vowel phonemes. One of those factors being the phonological environment in which the vowel sound is being uttered. Vowels are rarely used in isolation. They form a part of a string of utterance accompanied by other consonant sounds. The acoustic properties of these following and preceding consonants have an effect on the vowel sounds. Besides this, the formant values are also affected by various other factors such as the age and gender of the speaker, dialectal differences, the shape and size of the vocal tract, to name a few.

The difference in the "acoustic target"[14] of the same vowel sounds are uttered by different speakers is termed as "speaker normalization problem" (Strange, 1999:155) .It is an interesting phenomenon, however, that despite these very prominent differences, we as listeners are able to detect the same vowel sounds produced by different speakers at different times. This is because even despite the great variability in the acoustic qualities of the vowels as well as consonants as spoken by different speakers, the most essential and basic "acoustic cues"[15] remain more or less constant. (Fry,1979:129 and Strange,1999:151). For e.g. the acoustic cue for the class of the plosives such as /p/, /t/, /k/, is the interruption in the stream of sound for 40-120 ms in the flow of continuous speech and this feature remains almost constant throughout with very little variation. The identification of vowels across languages and speakers is also made possible by the fact that "the overall acoustic envelope of the different vowel phonemes of a language will remain constant across language" (Ball,1993:145).

Over and above this, in the identification of vowels, one should focus on the relation between the formants rather than focusing on the individual formant values (Strange,1999:156). For example, in the case of the high front vowel /i/, the F1 value is low, approximately 250, whereas the F2 value is very high, approximately 2500. Therefore the difference between the F1 and F2 values will be higher compared to the other vowels. In the identification of the vowel phonemes what is more important is the ratio between the values of F1 and F2 and it is this relation between these two formants that we form a "space" or rather "reference" through which we identify a particular speaker (Fry,1979:134).

In the book, *A Practical Introduction to Phonetics*, (1988:130-135) J.C Catford talks about the concepts called "vowel space" and "vowel limit". He goes on to say that the idea of the Cardinal Vowels by the renowned phonetician Daniel

[14] The formant patterns that are generally associated with a particular vowel sound are called the Acoustic Target (Strange,1999:153).

[15] In the decoding of speech/utterance we as hearers concentrate on some selected acoustic features of the sounds and discard the rest of the unnecessary acoustic information. These aspects of a sound pattern that play a significant role in the identification of the sound are collectively called Acoustic Cues. These aspects can be pertaining to the formant patterns, fundamental frequency, intensity, sonority, etc (Fry,1979:129 and Strange,1999:151).

Jones is based on the concept that the vowels are limited by vowel space/limit. In the production of a vowel, there is a certain fixed area /space within the oral-pharyngeal cavity, beyond which the vowel takes the shape of an approximate-type sound[16]. Thus, theoretically speaking, "any vowel of any language must have its tongue-position either on the vowel limit itself, or within the vowel space". For example an important characteristic of vowels is that they are all produced with the blade of the tongue maintaining a certain distance from the roof of the mouth. If the blade of the tongue is raised towards the roof of the mouth so as to cause a constriction in the oral cavity, the sound that is produced is not a vowel sound but rather what we have is a liquid such as /l/ or a proper consonant. (Chomsky and Halle,1968:302) This shows that when the articulators responsible for the production of a vowel do not remain within the bounds of the space/limit a vowel sound is not possible. For the purpose of referencing these points the two extreme vowels /i/ and /a/ have been selected as they represent the highest front and back tongue constriction respectively. It is for this particular reason that I have chosen the three vowels /i/, /u/ and /a/ in Assamese and Bangla as the subject of my study. These three vowels represent the three extreme points in the oral-pharyngeal tract. The vowel /i/ is most high close vowel with the most of the front tongue constriction; /u/ represents the most retracted high back vowel and /a/ the lowest back vowel. These three vowels are called the three "point vowels" (Pickett,1999:43). These three vowels can be said to represent the vowel space/limit/envelope in a way. It is interesting to know that in the acquisition of language, infants have a tendency to acquire these three vowels before they acquire the other vowels of the language. Winifred Strange in the article "*Perception of Vowels: Dynamics of Constancy*" (1999:157) says that "Miller (1989) proposed that vowels spoken by men, women and children can be represented unambiguously in a three dimensional "auditory perceptual space". This space is defined by F3-F2, F2-F1 and SR (i.e. sensory reference).

The formant patterns of speech are continuously changing throughout the course of a syllabus because the articulators involved in the ongoing process of speech are in constant motion and so is the vocal tract. Therefore, when we hear a vowel

[16] Sounds such as /l/, /r/ and /w/ are classified approximants.

sound, we do not perceive the formants of the vowels separately. The Fundamental Frequency and its constituent Harmonics are all heard collectively as the pitch of a particular vowel phoneme (Ball,1993:121). Therefore, the study and the analysis of the vowel sounds in terms of their Fundamental Frequency and formants (i.e. F1, F2, F3) requires us to do a spectrographic analysis which is the visual representation of a sound. The fundamental nature of a spectrograph lies in the fact that it gives us a detailed analysis of a sound wave in terms of its constituent frequencies. As has already been said that the resonance of the vocal tracts are continually undergoing change due to the continual movement of the tongue and also the other articulators, therefore the spectrograms are the representation of that sound only at that given point of time(Fry,1979:97 ).

### 1.3 The future and scope of Acoustic Phonetics

Thus, as a concluding remark, we can say that, vowel phonemes play a very important role in differentiating words (Pickett,1999:96) and the formant patterns, particularly, the relation between the F1 and F2 play a vital role in the identification of these vowels (Strange,1999:156). The analysis of phonemes in terms of their constituent frequencies have been made convenient through various interfaces and softwares such as PRAAT, Wave Surfer, GoldWave, Computerized Speech Lab(CSL) to name a few. PRAAT is software for the analysis and synthesis of speech which was written by Paul Boersma of the Department of Phonetics of the University of Amsterdam[17]. PRAAT has a variety of features which include the facility to analyze speech in terms of voice-breaking, pitch and intensity, and formant patterns to name a few. Wave Surfer is another interface which helps in the analysis of sound waves in terms of its frequency, constituent formants, and spectrographic analysis. Computerized Speech Lab (CSL) is a software as well as hardware used for speech and signal processing which was developed by STR and Kay Electrometrics Corporation[18]. In CSL, speech samples can be recorded directly and then further analyzed. For the analysis of the vowel sounds as they occur in running speech, the vowel phonemes can be separated from the adjoining consonants sounds by trimming them. This is possible through

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[17] http://www.for.hum.uva/PRAAT

[18] http://en.wikipedia.org/wiki/CSL_(speech_analysis)

the 'Trim Data Waveform' option that is available in the CSL. Through this option we are also able to erase the entire unnecessary noise disturbance that is captured from the surroundings during the course of the recording. GoldWave is digital audio editing software with various graphic visuals including spectrogram and spectrum[19]

Other Software available for the purpose of speech analysis is the Sensimetrics SpeechStation which is Windows 95 compatible and it used for standard spectrographic analysis and also for reading frequency values and time duration for sounds. The Computer Speech Research Environment developed by the Dept. of Communicative Disorders, University of Western Ontario and the Signalyse System from Macintosh computers also help perform Fourier analysis and standard spectrographic study. SPEECHLAB and SPECTO are also similar tools for speech analysis (Pickett,1999:344)

The benefits of speech analysis, spectrographic study and acoustics are extremely far reaching. This has been of tremendous help in the areas of speech pathology as well as language learning as it gives us the three-dimensional representation of speech sounds and more than hearing we can literally 'see' a sound as it is spoken at a given point in time. In the case of people suffering from language loss owing to brain injury or for the hearing impaired, speech synthesizers can convert signals into speech (Pickett and Schroeter,1999:333).

Even the forensic department applies spectrographic analysis for the purpose of speaker/speech identification. This has been so much in vogue that in the near future we will be using 'voice print' rather than 'finger print' for the identification of a person. There however is lot of ongoing controversy regarding the efficacy and credibility of the concept of voice print. This is largely to do with the fact that human voice is far from being constant as it undergoes changes with time, age and also ailment and fatigue .Besides these, our social conditioning, dialectal differences and language learning also affect the way we employ a language(Hard castle and Laver,1999:746-748). Thus, voice print cannot claim to be as precise

[19] http://en.wikipedia.org/wiki/GoldWave

and accurate as fingerprint. However, despite these shortcomings; the concept of voice print is undeniably a break through in the realm of speech technology and has revolutionized the domain of forensic sciences.

Acoustic phonetics can also contribute largely to our understanding of how speech is produced. Through acoustic analysis of speech samples, we can predict the formant values for any sort of variation in the shape and size of the vocal tract. Through our listening of sounds alone we are not able to extract the exact nature of a sound in terms of its spectral, durational and other acoustic properties. However, through the use of acoustic analysis we can study the exact acoustic properties of the sounds such as [+ acute], [-acute], [+diffuse], [-diffuse] and so on and so forth.

In it however, to be borne in mind that acoustic phonetics as a discipline cannot exist in isolation. It is in combination with the other disciplines such as speech production and speech perception that we can comprehend it better.

### 1.4 Assamese and Bangla vowels' inventory and the articulation of the vowels /a/, /i/ and /u/.

Bangla is the major language spoken in the state of West Bengal and has been included in the Constitution of India as a national language of India. The status of Bangla suffered a setback following the partition of India (Haldar,2007:106). One of the most beautiful and mellifluous languages of the country, it still continues to grow. The dialects of Bangla are named according to the districts in which they are commonly spoken for e.g. Dhaka speech (Haldar,2007:107). However it is the dialect of West Central Bengal that is considered to be the Standard Colloquial dialect. Like other Eastern Indic languages such as Assamese and Oriya, even in Bangla, the length in vowels is not of significant importance and the stress patterns are largely concentrated to the sentential level (Chatterji,1970:267 also DasGupta, 2003:355). Bangla has a vowel inventory of 7 vowels. They are [i, e, æ, a, o, u and ɔ] (Chatterji,1970:270).

As far as the articulation of the Bangla vowels is concerned we have to keep in mind that even the oral vowels have a nasal twang to it. This is due to the reason that during the articulation of the vowel sounds the soft palate is not completely raised and hence a portion of the pulmonic air escapes into the nasal cavity and thereby giving the vowels a slight hint of nasalization.

<u>Bangla vowel /i/</u>

"When the vowel is pronounced, the lips are neutral or slightly stretched aside. The tip of the tongue lies on the inner side of the lower front teeth, while the front and middle parts of the tongue rise up towards the front part of the roof of the mouth to the position for articulation of a vowel regarded as closed"(Kostic and Das,1972:9)

The front close vowel /i/ is a sound that occurs in all three word-positions: word-medially, word finally and word initially. This vowel can either be a short vowel /i/ or a long vowel /i: /. There are two graphemes in the language:

(i) ( ই ). This grapheme is written before the consonants as ( ি ).

(ii) ( ঈ ). This grapheme is written after the consonants as ( ী ).

It is however not the case that the two graphemes represent length distinction. Sometimes the grapheme ( ই ) is used to represent the long vowel /i: /. And sometimes the grapheme ( ঈ ) is used to represent the short vowel /i/. This has been illustrated in the examples below:

| IPA | Script | Word -meaning |
|---|---|---|
| /nodi/ | নদী | 'river' |
| /phoni: / | ফণী | 'snake' |
| /di:n/ | দিন | 'day' |
| /kali/ | কালি | 'ink' |

Bangla vowel /u/

"The tip of the tongue is lying behind the lower front teeth, leaning on the gum. The middle of the tongue is raised, and the back of the tongue is placed rather close to the palato-velar area, up to the position for vowels regarded as closed" (Kostic and Das,1972:30)

The back close vowel /u/ like the vowel /i/ can occur in the word final, word-initial and the word final position. It can also be either a long vowel /u: / or a short vowel /u/. It is represented by two graphemes ( উ ) and ( ঊ ). At other times it is written as either ( ু ) or ( ূ ). Some are attached with the consonants such that they cannot be separated. For e.g.

বহু /bohu/ 'Many'.

Some other examples are:

| IPA | Script | Word meaning |
|---|---|---|
| /ukil/ | উকিল | 'lawyer' |
| /cul/ | চুল | 'hair' |
| /comu/ | চমু | 'body of troops' |
| /puja/ | পুজা | 'worship' |

Bangla vowel /a/

"The tip of the tongue is lying on the inner side of the lower front teeth, or placed very slightly behind them. The middle part of the tongue is slightly raised up towards the palato-velar area with the back of the tongue being a little higher than the middle part of the tongue" (Kostic and Das,1972:20)

The back open vowel /a/ like the two vowels /i/ and /u/ discussed above also occur in the word final, word medial and word initial position. There are two variations of the two vowels. One being the short which is represented in phonetic transcription as /a/ and the long vowel as /a: /. However unlike /i/ and /u/ which are represented by two graphemes, the Bangla vowel /a/ is represented by only one grapheme ( আ ) which comes after the consonants as ( া ).

Some examples of words where this vowel phoneme occurs have been given as follows:

| IPA | Script | Word meaning |
|---|---|---|
| /taga/ | তগা | 'arm let' |
| /taka/ | টকা | 'money' |
| /am/ | আম | 'mango' |
| /aj/ | আজ | 'today' |

Assamese has an inventory of eight vowels (I, U, u, o, ɔ, E, ε and a) and twenty-three consonants[20]. An important similarity between these two languages is that, they like any other Eastern Indic languages do not possess vowel length distinction. Even though the vowels have length differences, those distinctions are only allophonic. Bani Kanta Kakoti identified two distinct dialectal groups of Assamese - Eastern Assamese and Western Assamese. The Eastern dialect is considered the Standard Colloquial variety of Assamese which acquired its current status owing to the efforts of the Christian Baptist missionaries and also due to the contribution made by the printing press (Goswami,1966:5). These two varieties of Assamese are noticeably different in terms of their vocabulary, phonology and morphology, so much so that a speaker of the Eastern variety may have difficulty in comprehending the Western variety (Goswami, 1966:5-7).

Golok Chandra Goswami in the book titled *An Introduction to Assamese* Phonology (1966:6) discusses elaborately the distinction between the Eastern and Western dialects of Assamese. In terms of the vocabulary, the words that are used for daily parlance are different. For example the word 'kua' meaning 'well' in the Eastern dialect is 'lahnda' in the Western variety.

[20] http://igitur-archieve.library.uu.nl/dissertation/2007-0620-202151/c4.pdf

The differences between the two dialects from the phonological point of view can be summed up as follows:

i. Western Assamese has a strong initial stress in place of Eastern Assamese medial stress. Thus, 'komora', "pumpkin" becomes 'kumra' etc.

ii. In the Western dialect we find more of high vowels as opposed to the higher-mid vowels and low vowels as opposed to the lower-mid vowels of the Eastern variety. For e.g., 'kapor' is 'kapur' for "cloth".

iii. In the Western variety we find the higher-low front /æ/ as opposed to the lower-mid front /ɛ/ of Eastern Assamese.

iv. There is the prevalence of aspiration in the Western variety and deaspiration in the Eastern variety. For e.g. 'bhok' is 'bhuk' for "hunger".

v. Intonation patterns are different for both of the two dialectal groups, the Eastern variety being a comparatively slower then the Western variety.(Goswami, 1966:6).

In Assamese, the vowel /i/ is a high front vowel, /a/ is a low central vowel and /u/ is a high back vowel. The front vowel /i/ is produced with the front of the tongue drawn forward towards the roof of the mouth and thus making it retracted. The width of the pharynx is enlarged owing to the forward movement of the tongue. The lips are spread. The Assamese back vowel /u/ is pronounced with the lips rounded and the body of the tongue is drawn towards the back. Like in the case of the front vowel /i/, even in /u/ there is a large space in the pharynx due to the raised body of the tongue.

There is slight difference between the vowel /a/ as it occurs in Assamese and in Bangla. In Assamese it is more central and low as compared to the low back /a/ vowel phoneme of Bangla.

In Assamese, the vowels have length distinction; however, that is only allophonic (Goswami,1966:84). The short /i/ and long /i: / and short /i/ and long /i: / can be used indiscriminately in words without affecting the sound or the meaning.

Assamese vowel /i/

The Assamese, high front unrounded vowel /i/ is represented by the graphemes ( ই ) written as ( ি ) before consonants and ( ঈ ) written as ( ী ) after consonants respectively. As in Bangla, even in Assamese it is not that the two graphemes represent length distinction always.

Following are some examples from Assamese:

| IPA | Script | Word Meaning |
|---|---|---|
| /git/ | গীত | 'song' |
| /sati/ | ছাতি | 'umbrella' |
| /xi:ma/ | সীমা | 'limit, border' |
| /xi:u/ | সিউ | ' he also' |

Assamese vowel /u/

The Assamese closed high-back vowel /u/ is represented by two graphemes ( উ ) and ( ঊ ), written as ( ু ) and ( ূ ) below consonants. The two graphemes do not represent vowel length distinction.

Following are some of the examples:

| IPA | Script | Word Meaning |
|---|---|---|
| /puθi/ | পুথি | ' a manuscript' |
| /muni/ | মুনি | 'a holy sage' |
| /pub/ | পূব | 'the east' |
| /xutra/ | সূত্ৰ | 'definition' |

Assamese vowel /a/

The Assamese central vowel /a/ is represented by the grapheme ( আ ) which is written as ( া ) after consonants. Following are some of the examples:

| IPA | Script | Word Meaning |
|---|---|---|
| /mala/ | মালা | ‘garland’ |
| /bagh/ | বাঘ | ‘tiger’ |
| /nam/ | নাম | ‘name’ |
| /xuta/ | সুত | ‘thread’ |

In Assamese and Bangla, the three vowels /a/, /i/ and /u/ are three distinct phonemes. So far as the distribution of the Assamese vowels /a/, /i/ and /u/ are concerned, there is no restriction. They occur in all the three word positions (medial, final and initial) and can be followed by any consonant or vowel or consonant cluster. (Goswami, 1966:78)

The three vowels /a/, /i/ and /u/ are considered as three distinct phonemes in Assamese as well as Bangla because the substitution of one vowel sound by the other leads us to a new word altogether.( Fromkin and Rodman,1974:71-72 and Catford,1988:198).

Following are examples from Assamese to substantiate this statement:

| IPA | Script | Word Meaning |
|---|---|---|
| /phik/ | ফিক | ‘to swell’ |
| /phak/ | ফাক | ‘gap, crack’ |
| /phuk/ | ফুক | ‘sound of blowing a musical instrument’ |

Some similar from Assamese examples are:

| IPA | Script | Word Meaning |
|---|---|---|
| /pat/ | পাত | 'leaf' |
| /pit/ | পিত | 'gall bladder' |
| /put/ | পুত | 'son' |

Following are the examples from Bangla to illustrate that the three vowels /a/, /i/ and /u/ are three distinct phonemes:

| IPA | Script | Word Meaning |
|---|---|---|
| /kal/ | কাল | ' tomorrow, time' |
| /kul/ | কুল | ' bank, a kind of fruit' |
| /kil/ | কিল | ' a way of hitting someone' |

Some similar examples from Bangla are:

| IPA | Script | Word Meaning |
|---|---|---|
| /mal/ | মাল | 'load/luggage' |
| /mul/ | মুল | 'root' |
| /mil/ | মিল | 'similarity, affinity' |

**1.5 The Acoustics of the Assamese and Bangla vowels.**

As stated already, one of the most important features of the Eastern Indic languages such as Assamese and Bangla is the absence of vowel length distinction (Chatterji,1970:269).

Bangla has a vowel inventory of 7 vowels. They are [i, e, æ, a, o, u and ɔ] (Chatterji,1970:270).

Their formant patterns have been summarized below in the following table (Kostic and Das, 1972: 5-29).

| **Vowels** | **F1** | **F2** | **F3** |
|---|---|---|---|
| /i/ | 200-300 | 2600-2700 | 3000-3100 |
| /e/ | 350-450 | 2300-2400 | 2800-2900 |
| /æ/ | 600-700 | 1700-1800 | 2700-2800 |
| /a/ | 700-800 | 1100-1200 | 2600-2700 |
| /ɔ/ | 600-700 | 900-1000 | 2700-2800 |
| /o/ | 300-400 | 800-900 | 2800-2900 |
| /u/ | 250-350 | 600-700 | 2500-2600 |

Keeping in mind that the acoustic values of that three peripheral vowels of Bangla /i/, /u/ and /a/ define the overall vowel spectra, we can conclude from the above given chart that the first formant (F1) is the lowest for the high-front vowel /i/ and gradually increases as it progresses towards the low-back vowel /a/ and again gradually decreases as it reaches the high-back vowel /u/. We also observe a very similar pattern in the case of the second formant (F2). The value of F2 is the highest for the high-front vowel /i/ and the lowest for the high-back vowel /u/.

As far as the articulation of the Bangla vowels is concerned we have to keep in mind that even the oral vowels have a nasal twang to it. This is due to the reason that during the articulation of the vowel sounds the soft palate is not completely raised and hence a portion of the pulmonic air escapes into the nasal cavity and thereby giving the vowels a slight hint of nasalization.

Similarly, the acoustic space of the formant values for the Assamese vowels has been listed below as follows[21]:

| Vowels | F1 | F2 | F3 |
|---|---|---|---|
| /I/ | 312 | 2642 | 3197 |
| /U/ | 292 | 707 | 2891 |
| /u/ | 333 | 756 | 2637 |
| /o/ | 390 | 850 | 2763 |
| /ɔ/ | 501 | 927 | 2608 |
| /E/ | 423 | 2418 | 3047 |
| /ɛ/ | 659 | 2608 | 2953 |
| /a/ | 824 | 1547 | 2766 |

**1.6 Scope and objective of the present study.**

Thus, in the light of the above discussion we can say that there is interplay between the two languages, Assamese and Bangla in Guwahati. The large Bengali populace settled in Assam makes use of Assamese as their Second Language. The fact that both the two languages are cognate languages (i.e. descendants of the same language family) also facilitates the learning of Assamese as a second language by the native Bangla speakers. The purpose of this study is to demonstrate if with time and increasing exposure to a second language (here, Assamese), the vowel space of the native Bangla speakers (with Assamese as the second language) approximate the Assamese vowel space or are they able to maintain two distinct vowel spaces –both for Assamese (SL) and for Bangla (MT). For the purpose of the current study the three peripheral vowels /a/, /i/ and /u/ in both the two languages and in all the three word positions[22] have been taken into consideration. The three vowels /a/, /i/ and /u/ have been selected for the purpose of the spectrographic study as they represent the three extreme points in

[21] http://igitur-archieve.library.uu.nl/dissertation/2007-0620-202151/c4.pdf

[22] The three word positions- initial, medial and final.

the oral – pharyngeal cavity: the vowel /i/ being the most high front close vowel, the vowel /a/ being the most low back open vowel and the vowel /u/ being the most high back vowel (Pickett,1999,43). These three vowel sounds can be said to represent the vowel space in a way. A Spectrographic Analysis of the Assamese vowels (/a/, /i/, and /u/) and also the Bangla vowels (/a/, /i/, and /u/) is carried out. As has been discussed earlier, the formants of a sound are not absolute values. Therefore, we need to focus on the ratio between the F1 and F2. The relation between the F1 and F2 of a particular vowel phoneme occupy a certain "space" in the articulation of a particular speaker (Fry,1979:134).

Thus in brief, the objective of the current study is to test if:

- The three peripheral vowels /i/, /u/ and /a/ help define the acoustic space of the vowels in the repertoire of a speaker in terms of their formant patterns.

- In the case of bilinguals, this acoustic space gets redefined as indicated by the changing formant patterns in comparison with those of the monolingual speakers.

- The hypothesis that one would like to test by means of acoustic data is that, this acoustic space is modified gradually as the learning of a second language progresses( here in the Assamese of the native Bangla speakers).

The methodology that has been followed in order to proceed with the current study has been described in details in the following second chapter.

The Spectrographic analysis of the three vowel sounds through the application of the Wave Surfer interface has been dealt with in details in the third chapter. This chapter also contains the tabulation of the formant values and their respective plotting in the Microsoft EXL sheets. The last chapter concludes this study with the observations and findings.

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# CHAPTER 2

# METHODOLOGY

During my M.Phil coursework( Speech Sciences and its Application), I wrote a term paper wherein I conducted an extensive spectrographic study of the Assamese and Bangla vowels with the focus on the three peripheral vowels /a/ , /i/ and /u/ in the Assamese (SL) of the native Bangla speakers in Guwahati, Assam. In this study, we found some interesting data. Apart from the main objective of the study, this study also gave us some interesting hypothese to explore by means of acoustic analysis. Some of the hypothese are:

- The three peripheral vowels /i/, /u/ and /a/ help define the acoustic space of the vowels in the repertoire of a speaker in terms of their formant patterns.

- In the case of bilinguals, this acoustic space gets redefined as indicated by the changing formant patterns in comparison with those of the monolingual speakers.

- The hypothesis that one would like to test by means of acoustic data is that, this acoustic space in the L1 and L2 is modified gradually as the learning of a second language progresses( here Bangla as L1 and Assamese as L2 of the native Bangla speakers)

The chapter on Methodology has the following sections:

1. The selection of subjects /informants.
2. Recording of the speech samples
3. Data elicitation.
4. Data tabulation and plotting of formants

### 1) Selection of the subjects/informants:

For the purpose of the study, 4 native Assamese speakers (2 male, 2 female) were taken as the Control Group. The target group comprised of 8 Bilingual Bangla speakers (4 male, 4 female) with Assamese as their Second Language (SL). All of these informants have Guwahati, Assam as their state of domicile. The age of the informants range between 18-25 years. Therefore, the bilingual Bangla speakers have been exposed to Assamese from 18-25 years. The educational qualification, economic status and the social strata of the informants too, is fairly uniform.

Following is the list of Bangla informants with Assamese as their Second Language (SL):

| Informant | Age ( in years) | Gender | Educational Qualification |
|---|---|---|---|
| 1 | 19 | Female | Graduation(B.Tech) |
| 2 | 24 | Male | Graduation(Engineering) |
| 3 | 21 | Female | Graduation(B.Com) |
| 4 | 18 | Male | Higher Secondary(10+2) |
| 5 | 18 | Female | Higher Secondary(10+2) |
| 6 | 20 | Male | Graduation(B.Sc) |
| 7 | 23 | Male | MBA |
| 8 | 19 | Female | Graduation(B.Sc) |

Following is the list of the Assamese informants (Control group):

| Informant | Age (in years) | Gender | Educational Qualification |
|---|---|---|---|
| 1 | 24 | Female | Graduation |
| 2 | 22 | Male | Graduation(B.Sc) |
| 3 | 23 | Male | Graduation(Engineering) |
| 4 | 18 | Female | Higher Secondary |

All the bilingual Bangla informants were born and brought up in Assam. So they have been residing in different parts of the state for at least 18 years now. Therefore, they have high levels of proficiency in Assamese. Even though they have been educated in the English medium schools, they have received formal instruction in Assamese. But it has to be kept in mind that they have learnt Assamese as a second language and also as a subject. They have learnt Assamese as a subject ranging between 2-8 years. Even though they have equal fluency in Assamese as well as Bangla, the language at home is essentially Bangla. Bangla is used to communicate with relatives as well. Assamese is used to communicate with the Assamese friends and Bangla is used to communicate with the Bangla friends. One interesting fact is that two of my bilingual Bangla female informants had an Assamese father and a Bangla mother. They used Bangla to talk to their father and Assamese to talk to their mother. They used Assamese and Bangla with a lot of code mixing and code switching.

As far as the native Assamese speakers are concerned, they have also received their school education in the English medium and have learnt Assamese as a subject for 4-6 years. Even though the native Assamese speakers do understand Bangla, they cannot speak the language nor write in it. However, the bilingual Bangla speakers can read and write in Assamese as they have had formal instruction in that language during the school years.

**2) <u>Recording of the speech samples:</u>**

The speech samples were recorded using the Sony ICD_P28 recorder. It is an IC recorder with USB PC link/ Connection with a memory of maximum 15 hours 45 mins recording time. The speech samples were then uploaded to the personal computer (PC) for further analysis via the USB cable. The speech samples get stored in the Sony Digital Voice Editor in the form of voice files.

These voice files have to be converted into WAV files in order to make them compatible with the Wave Surfer software. WAV is the short form for Waveform

Audio Format and is a file format for storing audio data. It is Microsoft and Macintosh compatible. It is extremely popular due to its simple structure and user-friendly interface. Its limitation however lies in its limited memory space which is 4 GB (Giga Byte)[23]

The software that is used extensively for the acoustic analysis of the data is Wave Surfer. It is a simple and user-friendly interface and is easily downloadable from the Internet. The Wave Surfer allows us to have a three-dimensional view of a sound. Wave Surfer comes with a variety of ready-to-use options such as Speech Analysis, Transcription, Waveform, Spectrogram, IPA transcription, etc.

### 3) <u>Data Elicitation:</u>

The purpose of the study is to study the vowel space of the three peripheral vowels /a/, /i/ and /u/ in the Assamese of native Bangla speakers. Therefore three lists of words in Assamese and Bangla with these three vowels as they occur in the word initial, word medial and word final position were prepared. The first list comprised of Assamese words with the three vowels /a/, /i/ and /u/ occurring in the word-initial, word-medial and word-final positions. The second list comprised of Bangla words with the three peripheral vowels /a/, /i/ and /u/ occurring in the word-initial, word-medial and word-final positions. The third list comprised of words which are common to both Assamese and Bangla with the three vowels /a/, /i/ and /u/ occurring in the word-initial, word-medial and word-final positions respectively. It was a little difficult finding the words which are only found in Assamese but not in Bangla and vice-versa, as the two languages are cognate languages[24].

The list of words that was prepared for the purpose of the study has been given below as follows:

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[23] http://en.wikipedia.org/wiki/WAV

[24] Assamese and Bangla are descendents of the same language family, i.e. Indo Aryan.

The list of Assamese words:

| Vowel | Word Position | IPA | Script | Word Meaning |
|---|---|---|---|---|
| /a/ | initial | /atil/ | আটিল | 'hard, tight' |
| | medial | /palət/ | পালট | 'to turn back' |
| | final | /xuta/ | সুতা | 'thread' |
| /i/ | initial | /iman/ | ইমান | 'quantifier' |
| | medial | /digh/ | দীঘ | 'length' |
| | final | /bizuli/ | বিজুলী | 'lightening' |
| /u/ | initial | /uruka/ | উৰুকা | 'harvest festival' |
| | medial | /zunuka/ | জুনুকা | 'bells, trinklets' |
| | final | /sɔku/ | চকু | 'eye' |

The list of Bangla words:

| Vowel | Word Position | IPA | Script | Word Meaning |
|---|---|---|---|---|
| /a/ | initial | /ak/ | আঁক | 'sugarcane' |
| | medial | /kak/ | কাক | 'crow' |
| | final | /baba/ | বাবা | 'father' |
| /i/ | initial | /ini/ | ইনি | 'he/she' |
| | medial | /kutil/ | কুটিল | 'plenty' |
| | final | /hosti/ | হস্তী | 'elephant' |
| /u/ | initial | /ukun/ | উকুন | 'louse' |
| | medial | /tetul/ | তেঁতুল | 'tamarind' |
| | final | /janu/ | জানু | 'knee' |

The list of words which are common to both Assamese and Bangla:

| Vowel | Word Position | IPA | Script | Word Meaning |
|---|---|---|---|---|
| /a/ | initial | /aghat/ | আঘাত | 'to injure or hurt' |
| | medial | /galagali/ | গালাগালী | 'verbal abuse' |
| | final | /mukta/ | মক্তা | 'pearl' |
| /i/ | initial | /inam/ | ইনাম | 'reward, prize' |
| | medial | /jinis/ | জিনিচ | 'thing, object' |
| | final | /jilipi/ | জিলিপি | 'a kind of sweet' |
| /u/ | initial | /ukil/ | উকিল | 'lawyer' |
| | medial | /puja/ | পুজা | 'prayer' |
| | final | /kosu/ | কচু | 'a vegetable' |

The three vowels /a/, /i/ and /u/ are considered as three distinct phonemes in Assamese as well as Bangla because the substitution of one vowel sound by the other leads us to a new word altogether. Following are examples from Assamese to substantiate this statement:

| IPA | Script | Word Meaning |
|---|---|---|
| /phik/ | ফিক | 'to swell' |
| /phak/ | ফাক | 'gap, crack' |
| /phuk/ | ফুক | 'the sound of blowing a musical instrument' |

| IPA | Script | Word Meaning |
|---|---|---|
| /pat/ | পাত | 'leaf' |
| /pit/ | পিত | 'gall bladder' |
| /put/ | পুত | 'son' |

So far as the distribution of the Assamese vowels /a/, /i/ and /u/ are concerned, there is no restriction. They occur in all the three word positions (medial, final and initial) and can be followed by any consonant or vowel or consonant cluster (Goswami,1966:78).

Following are the examples from Bangla to illustrate that the three vowels /a/, /i/ and /u/ are three distinct phonemes:

| IPA | Script | Word Meaning |
|---|---|---|
| /ka̱l/ | কাল | ' tomorrow, time' |
| /ku̱l/ | কুল | 'bank, a kind of fruit' |
| /ki̱l/ | কিল | 'a way of hitting' |

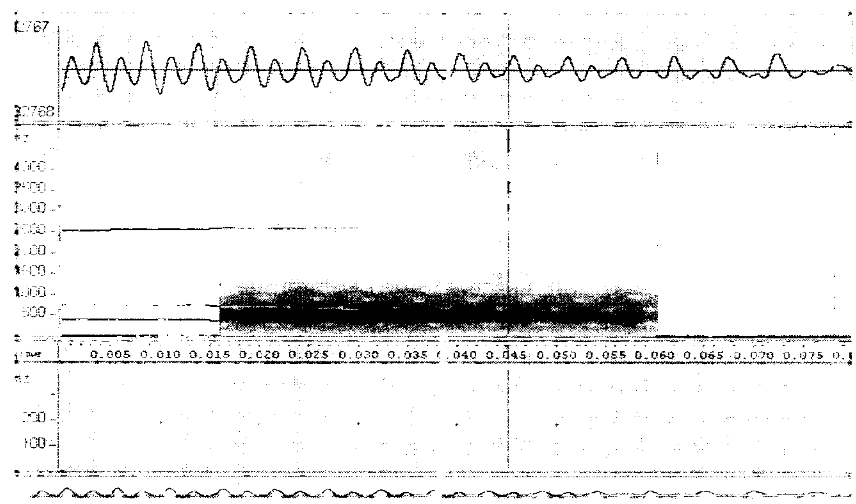
Following are some more examples:

| IPA | Script | Word Meaning |
|---|---|---|
| /ma̱l/ | মাল | 'load/luggage, alcohol' |
| /mu̱l/ | মুল | 'root' |
| /mi̱l/ | মিল | 'similarity, affinity' |

The informants/subjects were requested to read out the list of words in a natural way and on a regular pitch. The recording of the speech samples was done in an enclosed room with little noise/disturbance. The native Assamese speakers were asked to read out the list of Assamese words and the list of common words. The bilingual Bangla speakers were asked to read out all the three lists- i.e. the list of Assamese words, the list of Bangla words and the list of words common to both Assamese and Bangla.

**4) Data tabulation and plotting of formants:**

These voice samples were then opened in the Wave Surfer interface. The voice files are converted to the WAV format in the Sony Digital Recorder in order to make it compatible with the Wave Surfer interface. We select the particular vowels (i.e. /a/, /i/, /u/) from the word in which they occur either in the word-initial, word-medial or word-final position. After selecting the vowel under study, we go to the "Selection to New" option in the File menu and we arrive at the following spectrographic analysis of the vowel phoneme. A sample is given:



**Assamese word final /u/ in the Assamese informant 3(male)**

Then we 'tab'[25] the selected vowel and save it in the notepad. We arrive at a list of formant values and we select the steady state formants keeping in mind the particular vowel's formant values for Assamese and Bangla in mind.

The acoustic space occupied by the first three formants of the three peripheral vowels /a/, /i/ and /u/ in Assamese is:[26]

| Vowel | F1 | F2 | F3 |
|---|---|---|---|
| /a/ | 824 | 1547 | 2766 |
| /i/ | 312 | 2642 | 3197 |
| /u/ | 333 | 756 | 2637 |

[25] The 'Properties' option is available on the right mouse click of the selected vowel. Clicking this option leads us to the "tab" button. The 'tab' option gives us the values of the formants of a vowel and pastes them directly on a MS notepad.

[26] http://igitur-archieve.library.uu.nl/dissertation/2007-0620-202151/c4.pdf

The acoustic space occupied by the first three formants of the three peripheral vowels /a/, /i/ and /u/ in Bangla is: [27]

| Vowel | F1 | F2 | F3 |
|---|---|---|---|
| /a/ | 700-800 | 1100-1200 | 2600-2700 |
| /i/ | 200-300 | 2600-2700 | 3000-3100 |
| /u/ | 250-350 | 600-700 | 2500-2600 |

Following are the formant values for the Assamese word final /u/ in the male Assamese speaker 3 which are pasted in a Microsoft EXL sheet:

| f1 | f2 | f3 | "-f1" | "-f2" | "-(f2-f1)" |
|---|---|---|---|---|---|
| 297.8616 | 738.0002 | 2067.554 | -297.862 | -738 | -440.139 |
| 301.3861 | 747.8869 | 2070.658 | -301.386 | -747.887 | -446.501 |
| 300.1178 | 749.1684 | 2181.932 | -300.118 | -749.168 | -449.051 |
| 297.4961 | 752.0136 | 2213.544 | -297.496 | -752.014 | -454.518 |
| 296.2637 | 752.538 | 2205.22 | -296.264 | -752.538 | -456.274 |
| 295.2145 | 758.0541 | 2228.165 | -295.215 | -758.054 | -462.84 |
| 295.5164 | 768.3943 | 2246.429 | -295.516 | -768.394 | -472.878 |
| 294.6162 | 762.5256 | 2183.614 | -294.616 | -762.526 | -467.909 |
| 294.3539 | 760.6676 | 2112.957 | -294.354 | -760.668 | -466.314 |
| 295.58 | 768.1074 | 2098.632 | -295.58 | -768.107 | -472.527 |
| 294.6996 | 780.0777 | 2055.039 | -294.7 | -780.078 | -485.378 |
| 290.8585 | 779.4569 | 2450.726 | -290.859 | -779.457 | -488.598 |
| 286.7956 | 761.7944 | 2311.734 | -286.796 | -761.794 | -474.999 |
| 283.9482 | 744.0755 | 2496.293 | -283.948 | -744.076 | -460.127 |
| 285.5939 | 722.766 | 2528.802 | -285.594 | -722.766 | -437.172 |
| 291.3605 | 701.0236 | 2555.863 | -291.361 | -701.024 | -409.663 |
| 287.322 | 710.8107 | 2604.626 | -287.322 | -710.811 | -423.489 |
| 276.3772 | 718.9369 | 2638.945 | -276.377 | -718.937 | -442.56 |
| 270.0915 | 710.4191 | 2642.96 | -270.091 | -710.419 | -440.328 |
| 259.841 | 656.3555 | 2589.437 | -259.841 | -656.356 | -396.515 |
| 247.6898 | 643.4822 | 2359.166 | -247.69 | -643.482 | -395.792 |
| 231.8831 | 639.4128 | 2269.798 | -231.883 | -639.413 | -407.53 |
| 227.4756 | 616.6245 | 2358.616 | -227.476 | -616.624 | -389.149 |
| **Average** | | | **-282.711** | **-727.939** | **-445.228** |

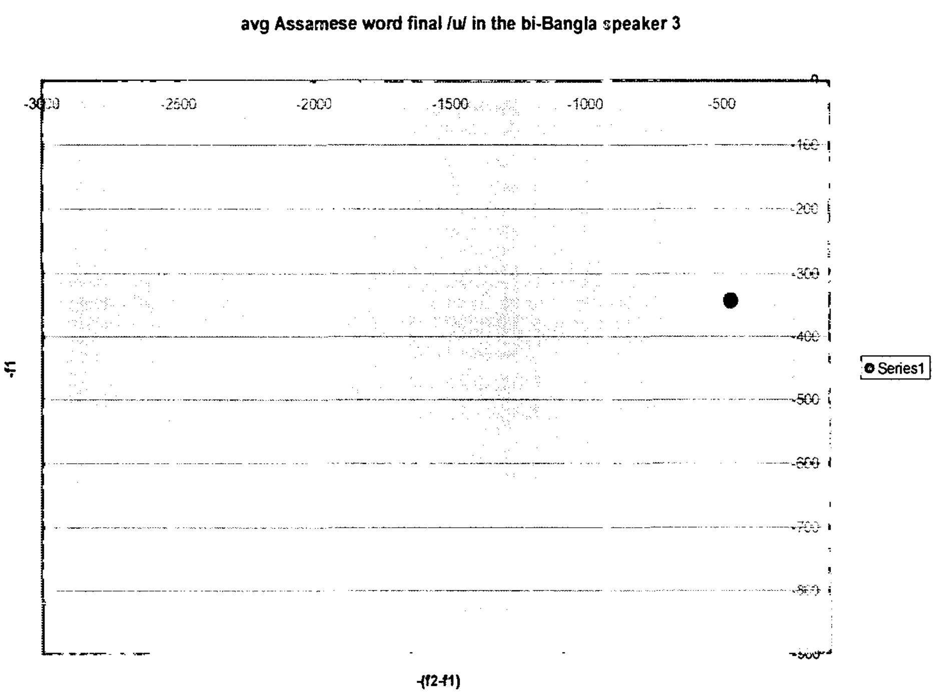
[27] Kostic, Djordje and Das, Rhea.S (1972) *A Short Outline of Bengali Phonetics*. Calcutta: Statistical Publishing Society( 8-22)

- The f1 and f2 values and also –(f2-f1) of the three vowels /a/, /i/ and /u/ in Assamese, Bangla and the words common to Assamese and Bangla, of both Assamese and Bangla speakers (both male and female) are calculated in order to study their acoustic space in the vowel chart. Three utterances of the vowels /a/, /i/ and /u/ in both the two languages as they occur in the word initial, word medial and word final position are taken for further analysis.

- The -f1 values are plotted along the Y-axis and the – (f2-f1) values are plotted along the X-axis so as to arrive at the positions of the vowels /a/, /i/ and /u/ as is given in the Cardinal Vowel Chart by Daniel Jones. The scale of the X-axis is -3000 whereas the scale of the Y-axis is fixed at -900 keeping in mind the fact that the back vowel /a/ has the highest f1 value (approx. 800 Hz) and the front vowel /i/ has the highest f2 value (approx 2600 Hz).

- The average of the word-initial, word-medial and word-final positions of each vowel for each speaker/informant is elicited in the MS EXL sheet as already shown above.

A sample of the plotting of the average values of –f1 and – (f2-f1) for the male Assamese informant 3` is given below as follows:



- The average values of the Assamese words, Bangla words and common words were plotted separately for male and female speakers and also separately for Assamese and Bilingual Bangla speakers.

The following graphs were made:

1) **Assamese vowel space for female Assamese speakers** (average of 2 speakers). The average of 6 utterances (2 utterances per word position-initial, medial, final) for each vowel, i.e. /a/, /i/ and /u/ as uttered by the two female Assamese speakers for Assamese were taken. The formant values (-f1 and – (f2-f1)) were then taken for all the three vowels in all the three word positions as uttered by the 2 female Assamese speakers (i.e. as average of 18 articulations were taken).

2) **Assamese vowel space for male Assamese speakers** (average of 2 speakers). The average of 6 utterances (2 utterances per word position-initial, medial, final) for each vowel, i.e. /a/, /i/ and /u/ as uttered by the two male Assamese speakers for the Assamese words were taken. The formant values (-f1 and – (f2-f1)) were then taken for the three vowels in all the three word positions as uttered by the 2 male Assamese speakers (i.e. as average of 18 articulations were taken).

3) **Vowel space for the common words[28] in female Assamese speakers** (average of 2 speakers).
The average of 6 utterances (2 utterances per word position-initial, medial, final) for each vowel, i.e. /a/, /i/ and /u/ as uttered by the two female Assamese speakers for the common words were taken. The formant values (-f1 and – (f2-f1)) were then taken for the three vowels in all the three word positions as uttered by the 2 female Assamese speakers (i.e. as average of 18 articulations were taken).

4) **Vowel space for the common words in male Assamese speakers** (average of 2 speakers). The average of 6 utterances (2 utterances per word position-initial, medial, final) for each vowel, i.e. /a/, /i/ and /u/ as uttered by the two male

[28] The words which are common to both Assamese and Bangla.

Assamese speakers for the common words were taken. The formant values (-f1 and – (f2-f1)) were then taken for the three vowels in all the three word positions as uttered by the 2 male Assamese speakers (i.e. as average of 18 articulations were taken).

5) **Assamese vowel space for female Bilingual Bangla speakers** (average of 4 speakers)

The average of 12 utterances (4 utterances per word position-initial, medial, final) for each vowel, i.e. /a/, /i/ and /u/ as uttered by the four female Bangla speakers for the Assamese words were taken. The formant values (-f1 and – (f2-f1)) were then taken for the three vowels in all the three word positions as uttered by the 4 female Bangla speakers (i.e. as average of 36 articulations were taken).

6) **Assamese vowel space for male Bilingual Bangla speakers** (average of 4 speakers)

The average of 12 utterances (4 utterances per word position-initial, medial, final) for each vowel, i.e. /a/, /i/ and /u/ as uttered by the four male Bangla speakers for the Assamese words were taken. The formant values (-f1 and – (f2-f1)) were then taken for the three vowels in all the three word positions as uttered by the 4 male Bangla speakers (i.e. as average of 36 articulations were taken).

7) **Bangla vowel space for female Bilingual Bangla speakers** (average of 4 speakers)

The average of 12 utterances (4 utterances per word position-initial, medial, final) for each vowel, i.e. /a/, /i/ and /u/ as uttered by the four female Bangla speakers for the Bangla words were taken. The formant values (-f1 and – (f2-f1)) were then taken for the three vowels in all the three word positions as uttered by the 4 female Bangla speakers (i.e. as average of 36 articulations were taken).

8) **Bangla vowel space in male Bilingual Bangla speakers** (average of 4 speakers)

The average of 12 utterances (4 utterances per word position-initial, medial, final) for each vowel, i.e. /a/, /i/ and /u/ as uttered by the four male Bangla speakers for the Bangla words were taken. The formant values (-f1 and – (f2-f1)) were then taken for the three vowels in all the three word positions as uttered by the 4 male Bangla speakers (i.e. as average of 36 articulations were taken).

9) **Vowel space for the common words in female Bilingual Bangla speakers** (average of 4 speakers)

The average of 12 utterances (4 utterances per word position-initial, medial, final) for each vowel, i.e. /a/, /i/ and /u/ as uttered by the four female Bangla speakers for the common words were taken. The formant values (-f1 and – (f2-f1)) were then taken for the three vowels in all the three word positions as uttered by the 4 female Bangla speakers (i.e. as average of 36 articulations were taken).

10) **Vowel space for the common words in male Bilingual Bangla speakers** (average of 4 speakers)

The average of 12 utterances (4 utterances per word position-initial, medial, final) for each vowel, i.e. /a/, /i/ and /u/ as uttered by the four male Bangla speakers for the common words were taken. The formant values (-f1 and – (f2-f1)) were then taken for the three vowels in all the three word positions as uttered by the 4 male Bangla speakers (i.e. as average of 36 articulations were taken).

In the above given graphs the three symbols that are used extensively to denote the three vowels under study are:

◊ - /a/
o - /u/
Δ - /i/

********************************

# CHAPTER 4

# CHAPTER 3

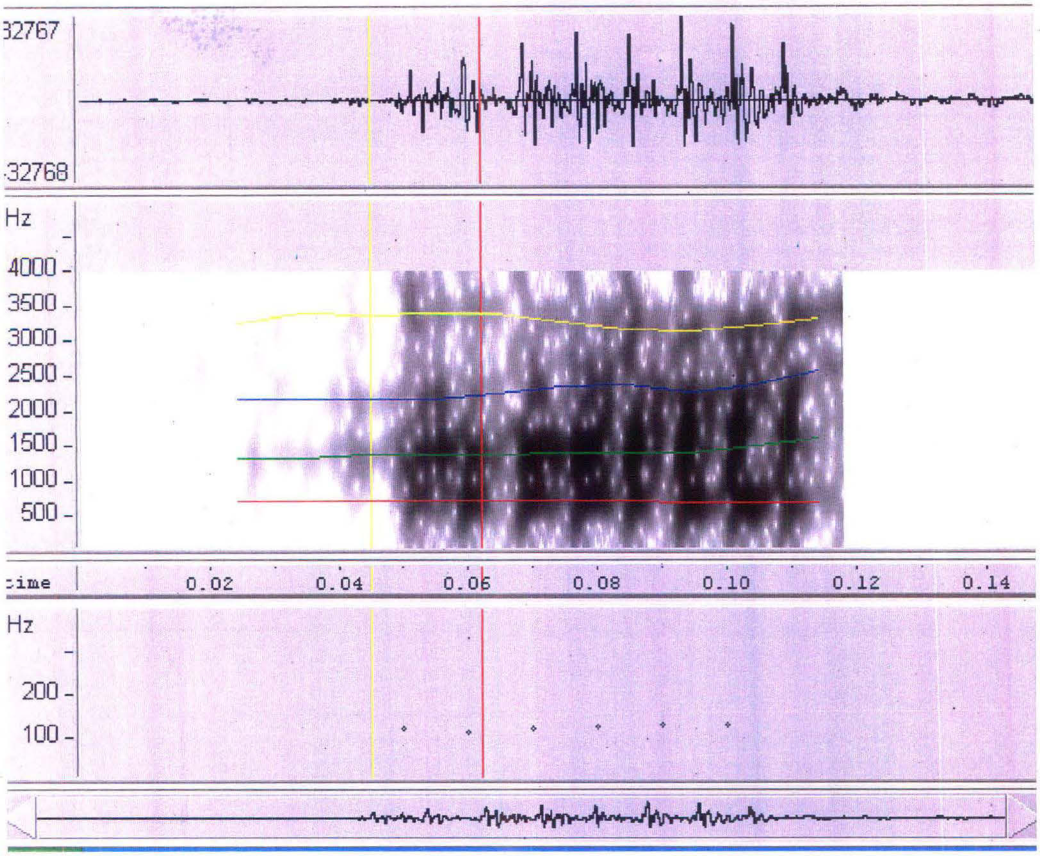
# DATA ANALYSIS

**Introduction:** Data Analysis is central to the current study as it will lead us to prove or disprove the hypothese stated initially. This chapter is devoted to the data analysis conducted in terms of the spectrographic analysis of vowels /a/, /i/ and /u/ in the Assamese speakers and also in the Bangla and Assamese (SL) of native Bangla speakers.

As a part of the current study I was required to conduct a field word in Guwahati, Assam. Two sets of speakers were selected in order to conduct the study. The first set of speakers comprised of 2 male and 2 female native Assamese speakers and the second set of speakers were 4 male and 4 female native Bangla speakers with Assamese as their Second Language. All the informants are aged between 18-25 years and are in different stages of graduation. The socio-economic status is more or less constant as they belong to middle class families. Three separate lists of words were prepared. The first consisting of Assamese words with the vowels /a/, /i/ and /u/ in the three word positions. The second consisted of Bangla words with the vowels /a/, /i/ and /u/ in the three word positions. And the third list consisted of words common to both the two languages, Assamese and Bangla with the vowels /a/, /i/ and /u/ in the three word positions. The Assamese speakers were asked to read out the list of Assamese words and common words. The Bangla speakers were asked to read out all the three lists of words. A spectrographic study of the three vowels /a/, /i/ and /u/ for every speaker is carried out using Wave Surfer software

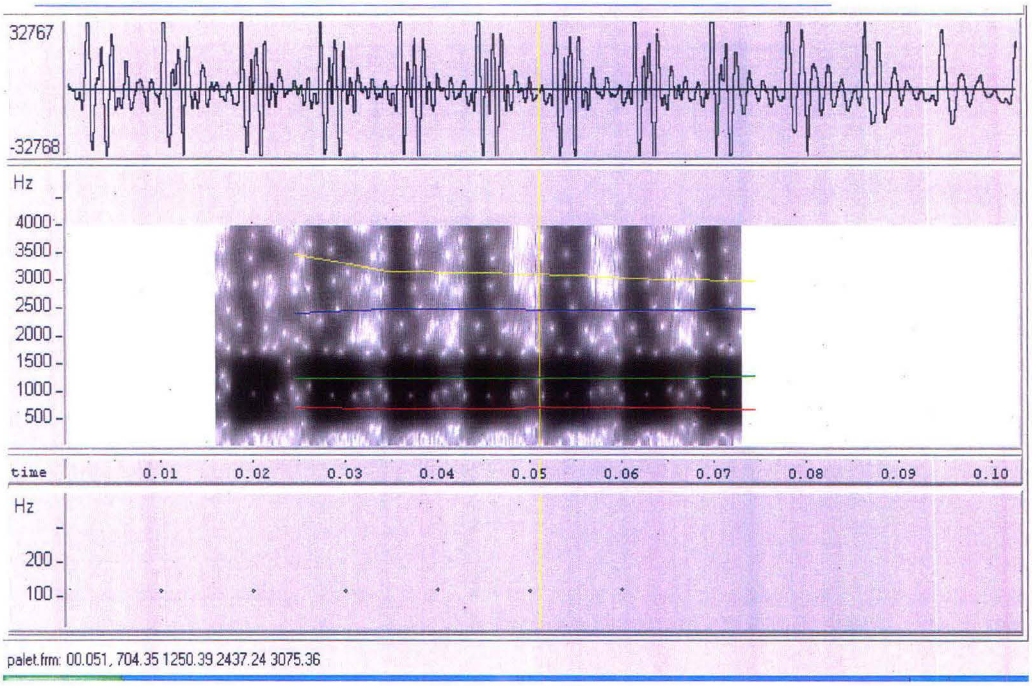
The spectrographic analysis of the vowels /a/, /i/ and /u/ of the Assamese male informant 3 has been given in details in the following section.

## Assamese word initial /a/ of the male Assamese informant 3



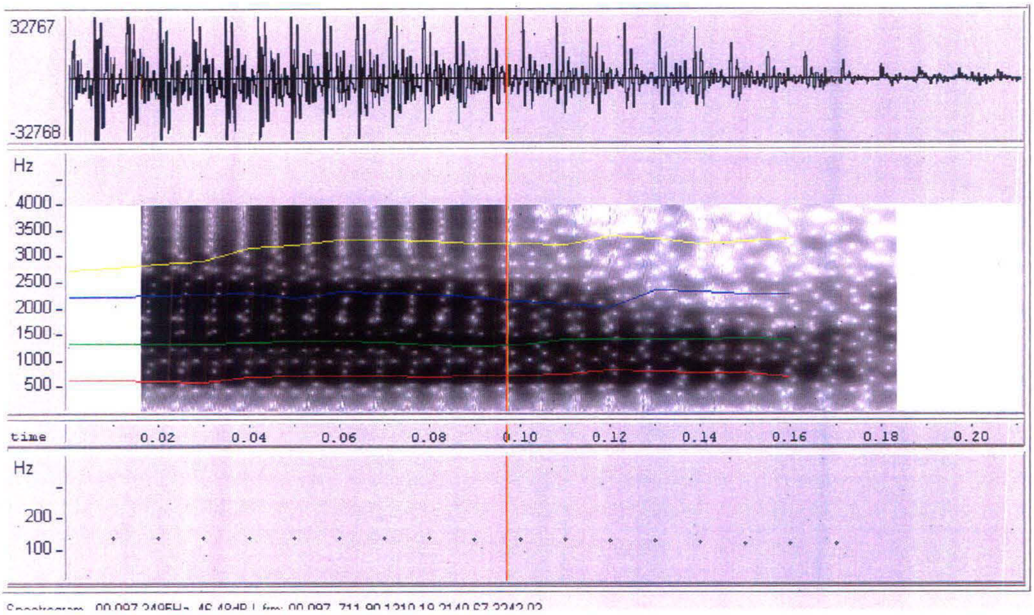

| f1 | f2 | f3 | "-f1" | "-f2" | "-(f2-f1)" |
|---|---|---|---|---|---|
| 714.0599 | 1325.02 | 2156.588 | -714.06 | -1325.02 | -610.96 |
| 711.7487 | 1338.688 | 2161.198 | -711.749 | -1338.69 | -626.94 |
| 709.2641 | 1369.745 | 2161.054 | -709.264 | -1369.74 | -660.481 |
| 702.4621 | 1381.95 | 2179.019 | -702.462 | -1381.95 | -679.488 |
| 707.2773 | 1387.739 | 2244.808 | -707.277 | -1387.74 | -680.462 |
| 723.4507 | 1390.881 | 2337.952 | -723.451 | -1390.88 | -667.431 |
| 711.767 | 1395.718 | 2362.955 | -711.767 | -1395.72 | -683.951 |
| 684.0071 | 1400.051 | 2268.278 | -684.007 | -1400.05 | -716.043 |
| 682.7162 | 1496.726 | 2368.593 | -682.716 | -1496.73 | -814.01 |
| 688.5731 | 1595.636 | 2579.528 | -688.573 | -1595.64 | -907.063 |
| **Average** | | | **-703.533** | **-1408.22** | **-704.683** |

## The Assamese word medial /a/ of the male Assamese informant 3



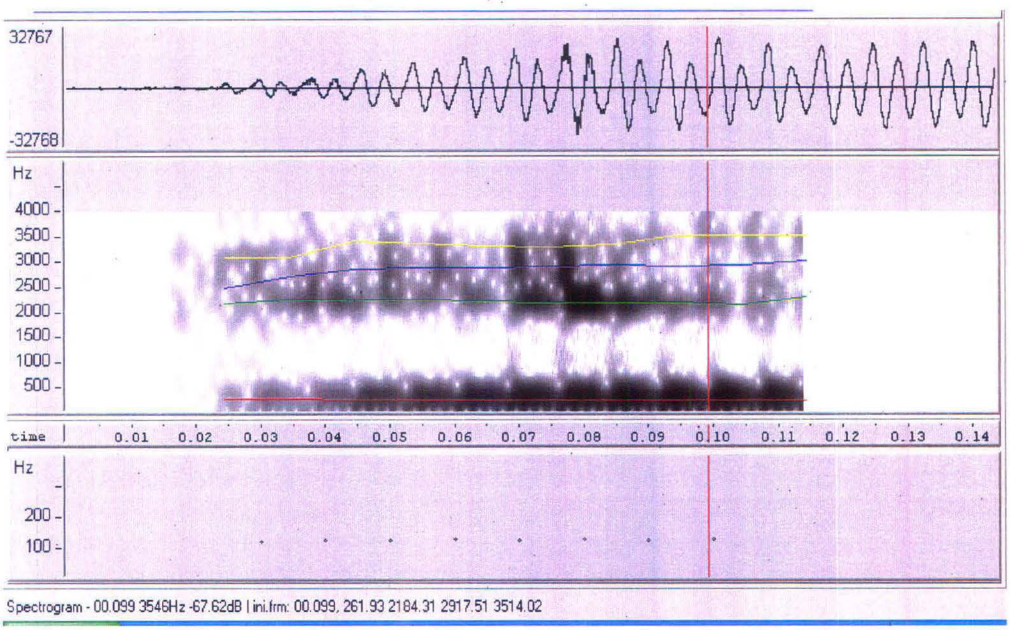

| f1 | f2 | f3 | "-f1" | "-f2" | "-(f2-f1)" |
|---|---|---|---|---|---|
| 705.6714 | 1250.865 | 2392.566 | -705.671 | -1250.86 | -545.194 |
| 696.8707 | 1250.529 | 2462.657 | -696.871 | -1250.53 | -553.658 |
| 699.4439 | 1246.399 | 2480.092 | -699.444 | -1246.4 | -546.955 |
| 704.3527 | 1250.386 | 2437.244 | -704.353 | -1250.39 | -546.033 |
| 703.8578 | 1261.16 | 2453.819 | -703.858 | -1261.16 | -557.302 |
| 699.2986 | 1275.125 | 2464.735 | -699.299 | -1275.13 | -575.827 |
| **Average** | | | **-701.583** | **-1255.74** | **-554.161** |

## Assamese word final /a/ of the male Assamese informant 3



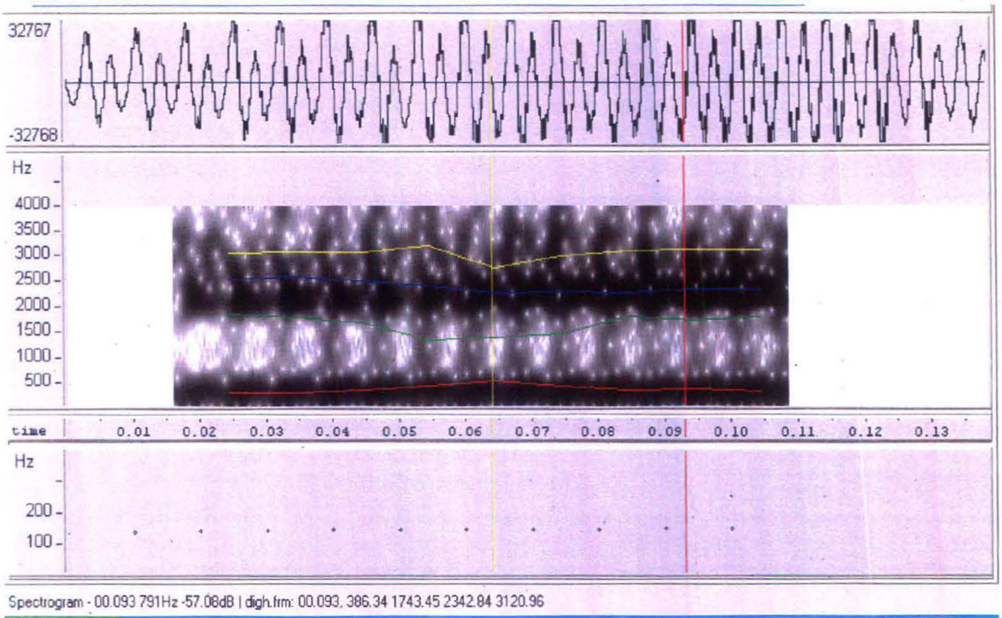

| f1 | f2 | f3 | "-f1" | "-f2" | "-(f2-f1)" |
|---|---|---|---|---|---|
| 690.4724 | 1425.436 | 2155.534 | -690.472 | -1425.44 | -734.964 |
| 651.1671 | 1341.315 | 2239.788 | -651.167 | -1341.31 | -690.147 |
| 666.1089 | 1320.196 | 2232.144 | -666.109 | -1320.2 | -654.087 |
| 638.3708 | 1329.628 | 2226.943 | -638.371 | -1329.63 | -691.257 |
| 626.8191 | 1331.677 | 2233.889 | -626.819 | -1331.68 | -704.858 |
| 630.3135 | 1324.691 | 2291.514 | -630.314 | -1324.69 | -694.377 |
| 694.9952 | 1365.103 | 2273.663 | -694.995 | -1365.1 | -670.108 |
| 710.6912 | 1373.365 | 2350.257 | -710.691 | -1373.36 | -662.674 |
| 711.1442 | 1362.589 | 2315.969 | -711.144 | -1362.59 | -651.445 |
| 700.1727 | 1333.276 | 2301.903 | -700.173 | -1333.28 | -633.104 |
| 698.5539 | 1297.666 | 2251.546 | -698.554 | -1297.67 | -599.112 |
| 704.9224 | 1290.363 | 2187.71 | -704.922 | -1290.36 | -585.441 |
| 718.9922 | 1402.939 | 2119.477 | -718.992 | -1402.94 | -683.947 |
| 779.2444 | 1410.917 | 2072.703 | -779.244 | -1410.92 | -631.672 |
| **Average** | | | **-687.283** | **-1350.65** | **-663.371** |

**Assamese word initial /i/ in the Assamese male informant 3**



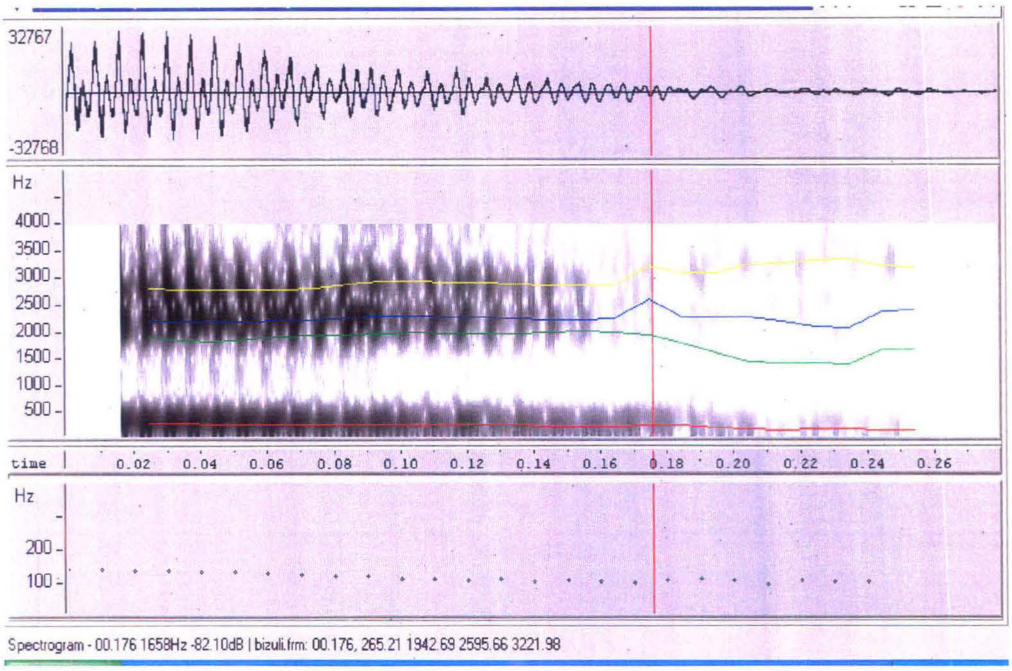

| f1 | f2 | f3 | "-f1" | "-f2" | "-(f2-f1)" |
|---|---|---|---|---|---|
| 270.8265 | 2178.926 | 2462.321 | -270.826 | -2178.93 | -1908.1 |
| 268.6817 | 2237.088 | 2699.846 | -268.682 | -2237.09 | -1968.41 |
| 263.0189 | 2239.135 | 2868.612 | -263.019 | -2239.14 | -1976.12 |
| 259.6272 | 2249.719 | 2882.428 | -259.627 | -2249.72 | -1990.09 |
| 260.2446 | 2213.72 | 2893.849 | -260.245 | -2213.72 | -1953.48 |
| 262.6832 | 2197.226 | 2908.129 | -262.683 | -2197.23 | -1934.54 |
| 263.5913 | 2188.572 | 2927.184 | -263.591 | -2188.57 | -1924.98 |
| 261.9257 | 2184.313 | 2917.511 | -261.926 | -2184.31 | -1922.39 |
| 262.3554 | 2154.321 | 2936.388 | -262.355 | -2154.32 | -1891.97 |
| 255.1312 | 2298.649 | 3000.654 | -255.131 | -2298.65 | -2043.52 |
| **Average** | | | **-262.809** | **-2214.17** | **-1951.36** |

### The Assamese word medial /i/ of the male Assamese informant 3



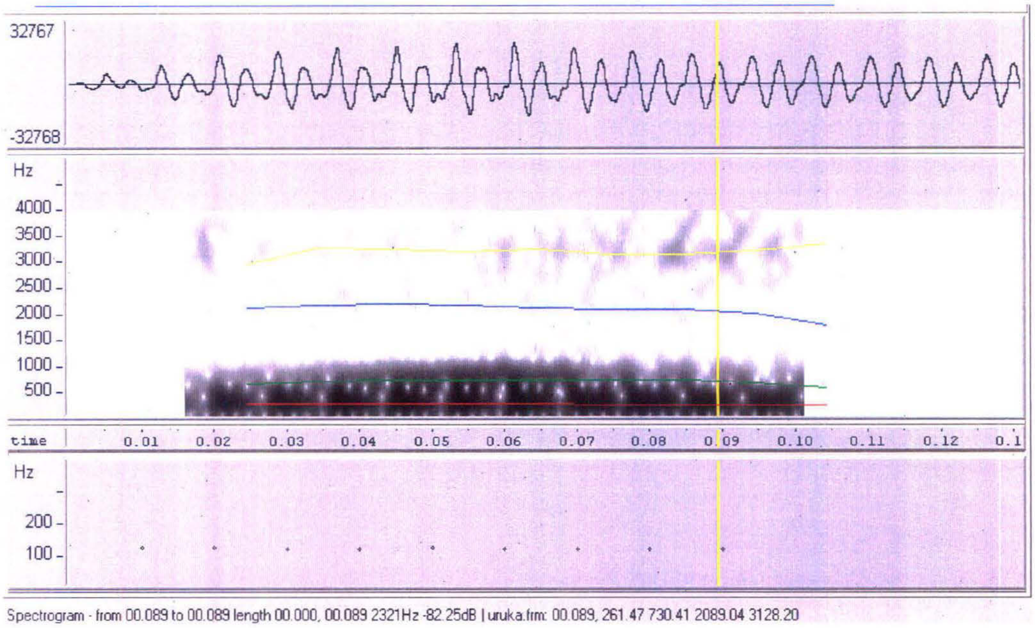

| f1 | f2 | f3 | "-f1" | "-f2" | "-(f2-f1)" |
|---|---|---|---|---|---|
| 302.0071 | 1862.958 | 2529.694 | -302.007 | -1862.96 | -1560.95 |
| 312.1414 | 1781.573 | 2564.14 | -312.141 | -1781.57 | -1469.43 |
| 349.4005 | 1683.36 | 2505.038 | -349.4 | -1683.36 | -1333.96 |
| 440.3591 | 1361.476 | 2408.933 | -440.359 | -1361.48 | -921.117 |
| 524.4802 | 1408.576 | 2270.438 | -524.48 | -1408.58 | -884.096 |
| 443.4485 | 1490.789 | 2290.101 | -443.449 | -1490.79 | -1047.34 |
| 356.6215 | 1821.386 | 2264.679 | -356.621 | -1821.39 | -1464.76 |
| 386.3358 | 1743.451 | 2342.843 | -386.336 | -1743.45 | -1357.12 |
| 337.6298 | 1801.542 | 2345.552 | -337.63 | -1801.54 | -1463.91 |
| **Average** | | | **-383.603** | **-1661.68** | **-1278.08** |

**The Assamese word final /i/ of the male Assamese informant 3**



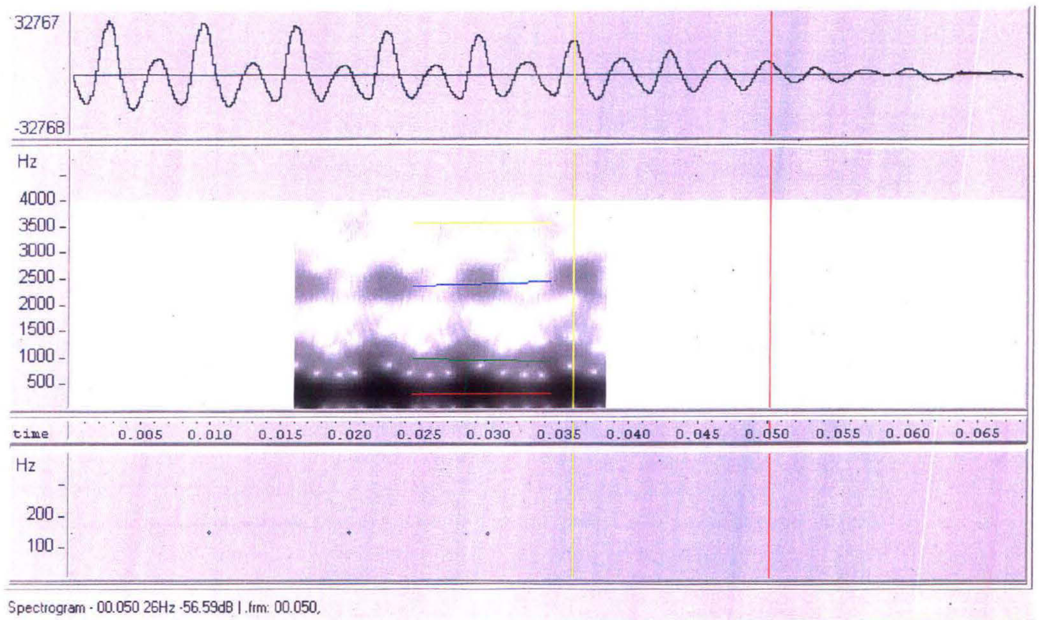

| f1 | f2 | f3 | "-f1" | "-f2" | "-(f2-f1)" |
|---|---|---|---|---|---|
| 275.3124 | 1922.484 | 2187.984 | -275.312 | -1922.48 | -1647.17 |
| 271.7987 | 1844.25 | 2194.373 | -271.799 | -1844.25 | -1572.45 |
| 267.5464 | 1808.407 | 2190.136 | -267.546 | -1808.41 | -1540.86 |
| 260.1995 | 1871.926 | 2200.968 | -260.199 | -1871.93 | -1611.73 |
| 257.6173 | 1902.65 | 2211.058 | -257.617 | -1902.65 | -1645.03 |
| 254.9589 | 1926.892 | 2225.246 | -254.959 | -1926.89 | -1671.93 |
| 251.6468 | 1948.28 | 2273.07 | -251.647 | -1948.28 | -1696.63 |
| 253.3911 | 1967.869 | 2290.377 | -253.391 | -1967.87 | -1714.48 |
| 251.8891 | 1994.496 | 2289.515 | -251.889 | -1994.5 | -1742.61 |
| 253.983 | 1976.556 | 2273.577 | -253.983 | -1976.56 | -1722.57 |
| 258.3446 | 1958.443 | 2267.131 | -258.345 | -1958.44 | -1700.1 |
| 250.7625 | 1955.463 | 2247.922 | -250.762 | -1955.46 | -1704.7 |
| 240.6425 | 1996.151 | 2223.956 | -240.642 | -1996.15 | -1755.51 |
| 230.7986 | 2022.223 | 2211.46 | -230.799 | -2022.22 | -1791.42 |
| 240.6472 | 2001.602 | 2240.796 | -240.647 | -2001.6 | -1760.96 |
| 265.2148 | 1942.695 | 2595.655 | -265.215 | -1942.69 | -1677.48 |
| **Average** | | | **-255.297** | **-1940.02** | **-1684.73** |

## The Assamese word initial /u/ of the male Assamese informant 3



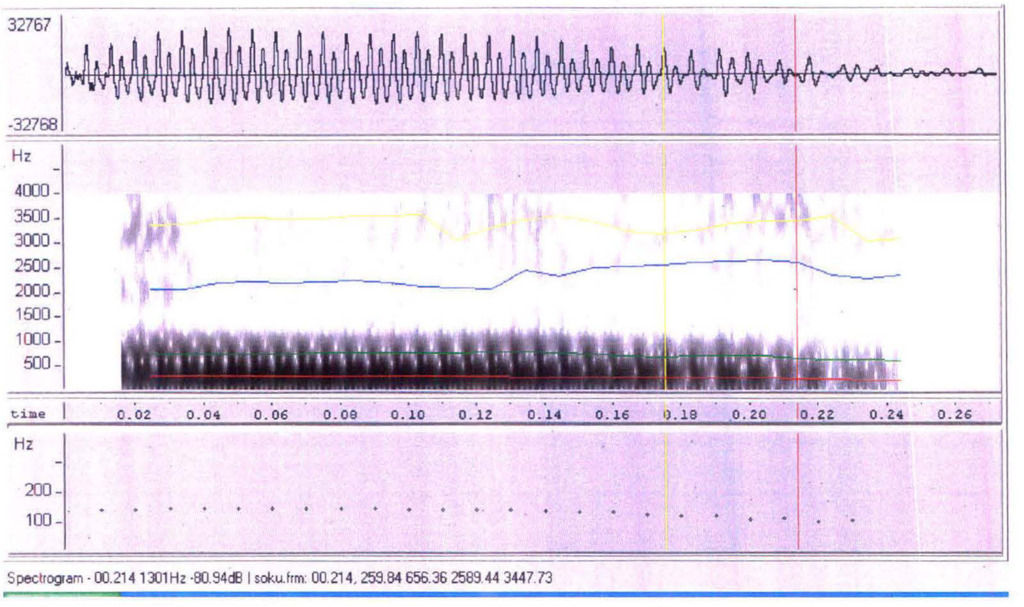

| f1 | f2 | f3 | "-f1" | "-f2" | "-(f2-f1)" |
|---|---|---|---|---|---|
| 269.3191 | 671.7221 | 2125.963 | -269.319 | -671.722 | -402.403 |
| 273 | 709.9132 | 2163.483 | -273 | -709.913 | -436.913 |
| 274.3447 | 730.0159 | 2205.543 | -274.345 | -730.016 | -455.671 |
| 273.589 | 741.7968 | 2171.099 | -273.589 | -741.797 | -468.208 |
| 268.929 | 746.0499 | 2114.983 | -268.929 | -746.05 | -477.121 |
| 263.425 | 740.7885 | 2104.56 | -263.425 | -740.789 | -477.363 |
| 261.4691 | 730.4071 | 2089.044 | -261.469 | -730.407 | -468.938 |
| 260.5 | 684.176 | 2022.675 | -260.5 | -684.176 | -423.676 |
| 256.1802 | 575.8652 | 1787.365 | -256.18 | -575.865 | -319.685 |
| **Average** | | | **-266.751** | **-703.415** | **-436.664** |

## The Assamese word medial /u/ of the male Assamese informant 3




| f1 | f2 | f3 | "-f1" | "-f2" | "-(f2-f1)" |
|---|---|---|---|---|---|
| 304.0297 | 961.4748 | 2388.655 | -304.03 | -961.475 | -657.445 |
| 298.3397 | 911.1326 | 2484.301 | -298.34 | -911.133 | -612.793 |
| 290.9234 | 839.1041 | 2498.141 | -290.923 | -839.104 | -548.181 |
| 247.1464 | 769.4366 | 2145.771 | -247.146 | -769.437 | -522.29 |
| 224.726 | 922.8834 | 2234.482 | -224.726 | -922.883 | -698.157 |
| **Average** | | | **-273.033** | **-880.806** | **-607.773** |

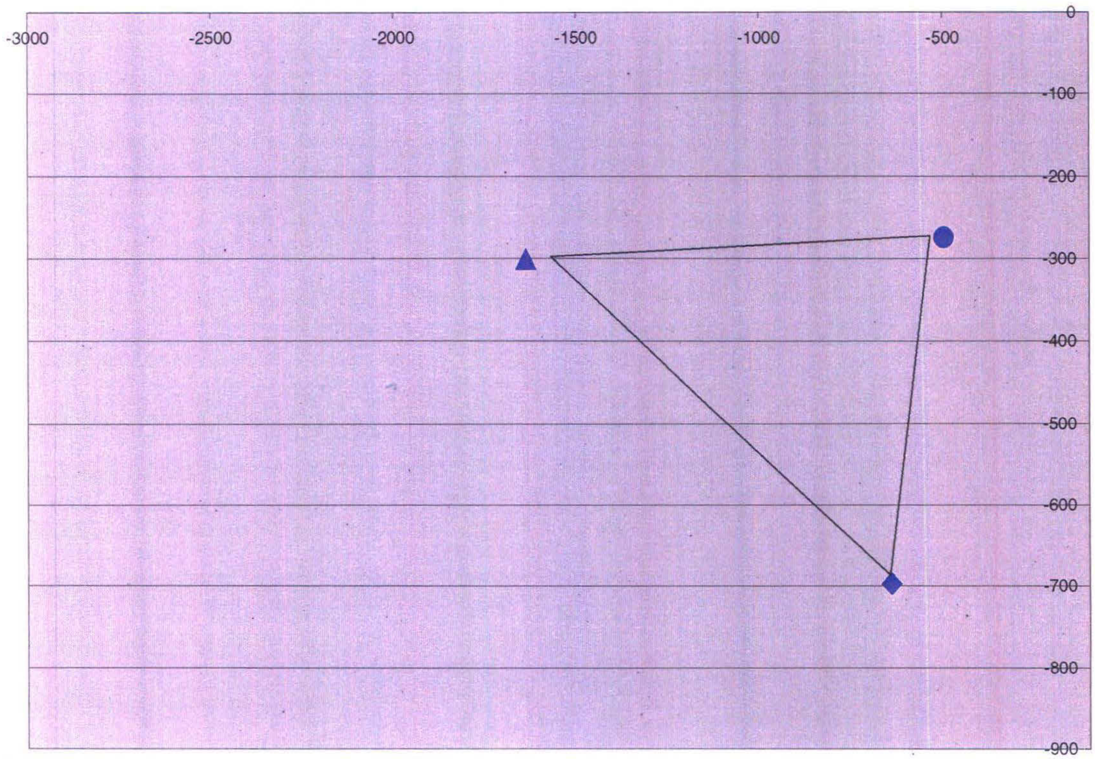
## The Assamese word final /u/ of the male Assamese informant 3




| f1 | f2 | f3 | "-f1" | "-f2" | "-(f2-f1)" |
|---|---|---|---|---|---|
| 297.8616 | 738.0002 | 2067.554 | -297.862 | -738 | -440.139 |
| 301.3861 | 747.8869 | 2070.658 | -301.386 | -747.887 | -446.501 |
| 300.1178 | 749.1684 | 2181.932 | -300.118 | -749.168 | -449.051 |
| 297.4961 | 752.0136 | 2213.544 | -297.496 | -752.014 | -454.518 |
| 296.2637 | 752.538 | 2205.22 | -296.264 | -752.538 | -456.274 |
| 295.2145 | 758.0541 | 2228.165 | -295.215 | -758.054 | -462.84 |
| 295.5164 | 768.3943 | 2246.429 | -295.516 | -768.394 | -472.878 |
| 294.6162 | 762.5256 | 2183.614 | -294.616 | -762.526 | -467.909 |
| 294.3539 | 760.6676 | 2112.957 | -294.354 | -760.668 | -466.314 |
| 295.58 | 768.1074 | 2098.632 | -295.58 | -768.107 | -472.527 |
| 294.6996 | 780.0777 | 2055.039 | -294.7 | -780.078 | -485.378 |
| 290.8585 | 779.4569 | 2450.726 | -290.859 | -779.457 | -488.598 |
| 286.7956 | 761.7944 | 2311.734 | -286.796 | -761.794 | -474.999 |
| 283.9482 | 744.0755 | 2496.293 | -283.948 | -744.076 | -460.127 |
| 285.5939 | 722.766 | 2528.802 | -285.594 | -722.766 | -437.172 |
| 291.3605 | 701.0236 | 2555.863 | -291.361 | -701.024 | -409.663 |
| 287.322 | 710.8107 | 2604.626 | -287.322 | -710.811 | -423.489 |
| 276.3772 | 718.9369 | 2638.945 | -276.377 | -718.937 | -442.56 |
| 270.0915 | 710.4191 | 2642.96 | -270.091 | -710.419 | -440.328 |
| 259.841 | 656.3555 | 2589.437 | -259.841 | -656.356 | -396.515 |
| 247.6898 | 643.4822 | 2359.166 | -247.69 | -643.482 | -395.792 |
| 231.8831 | 639.4128 | 2269.798 | -231.883 | -639.413 | -407.53 |
| 227.4756 | 616.6245 | 2358.616 | -227.476 | -616.624 | -389.149 |
| **Average** | | | **-282.711** | **-727.939** | **-445.228** |

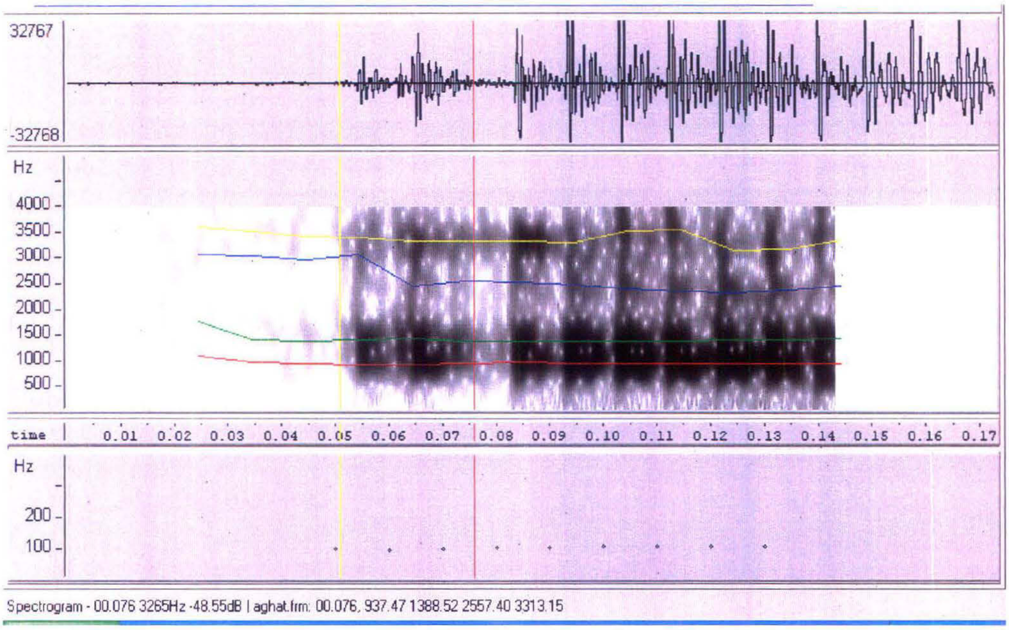
The averages of the three Assamese vowels /a/, /i/ and /u/ in all the three word positions of the male Assamese informant 3 are given below:

| Assamese | "-f1" | "-(f2-f1)" |
|---|---|---|
| **/a/** | | |
| initial | -703.533 | -704.683 |
| medial | -701.583 | -554.161 |
| final | -687.283 | -663.371 |
| **avg** | **-697.466** | **-640.738** |
| **/i/** | | |
| initial | -262.809 | -1951.36 |
| medial | -383.603 | -1278.08 |
| final | -255.297 | -1684.73 |
| **avg** | **-300.57** | **-1638.06** |
| **/u/** | | |
| initial | -266.751 | -436.664 |
| medial | -273.033 | -607.773 |
| final | -282.711 | -445.228 |
| **avg** | **-274.165** | **-496.555** |



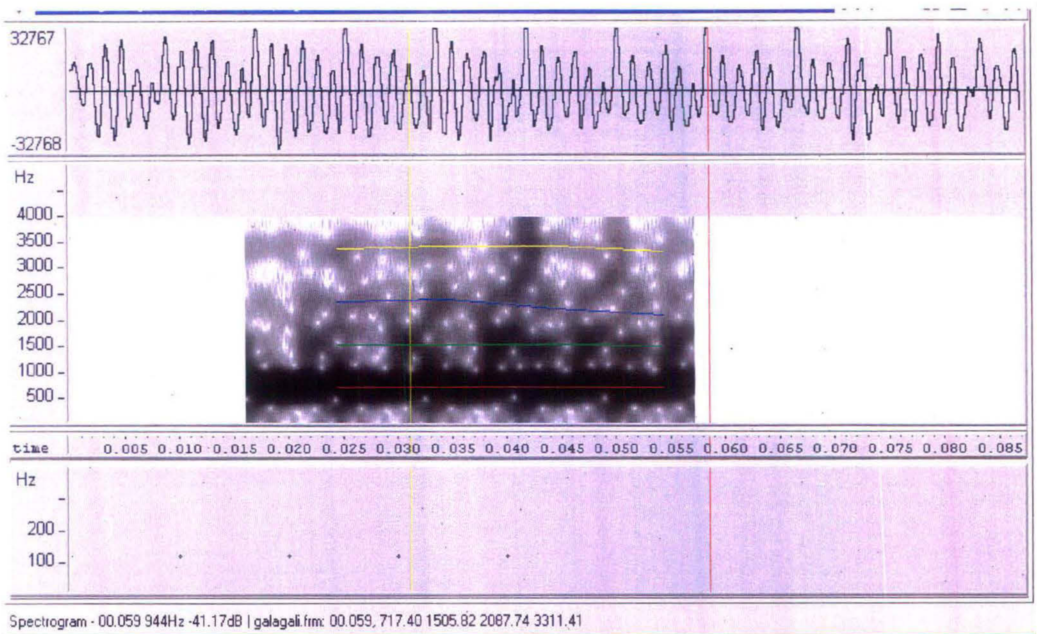

**The Assamese vowel space of the male Assamese informant 3**

**The word initial /a/ in the common word of the male Assamese informant 3**



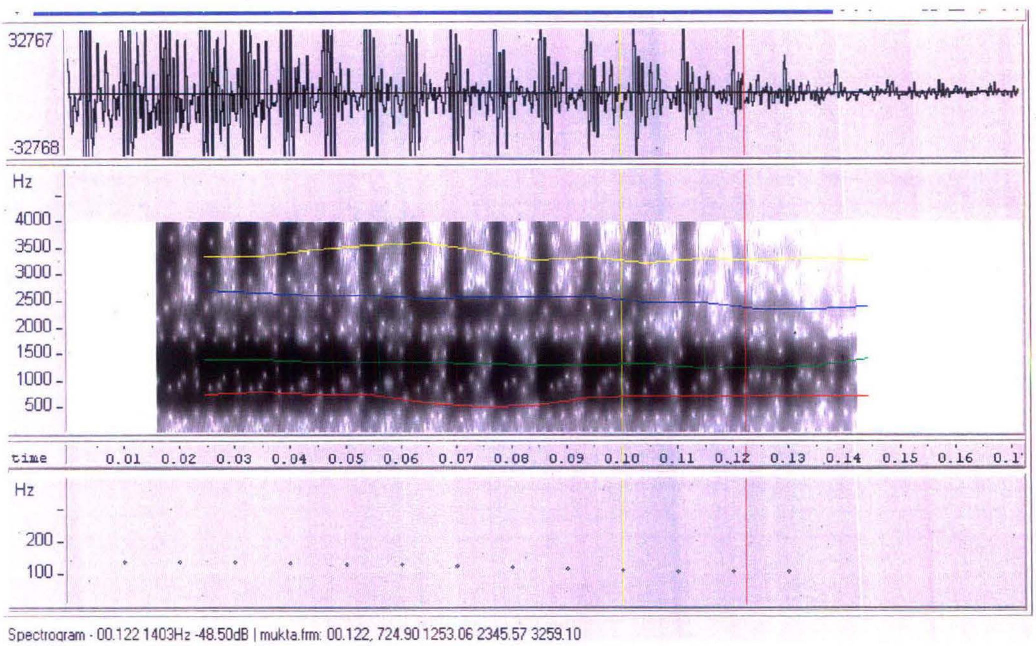

| f1 | f2 | f3 | "-f1" | "-f2" | "-(f2-f1)" |
|---|---|---|---|---|---|
| 778.9934 | 1142.395 | 1727.681 | -778.993 | -1142.39 | -363.401 |
| 739.663 | 1109.24 | 1713.711 | -739.663 | -1109.24 | -369.577 |
| 721.9778 | 1100.414 | 1715.704 | -721.978 | -1100.41 | -378.436 |
| 718.9726 | 1137.902 | 2008.718 | -718.973 | -1137.9 | -418.929 |
| **Average** | | | **-739.902** | **-1122.49** | **-382.586** |

**The word medial /a/ in the common word of the male Assamese informant 3**



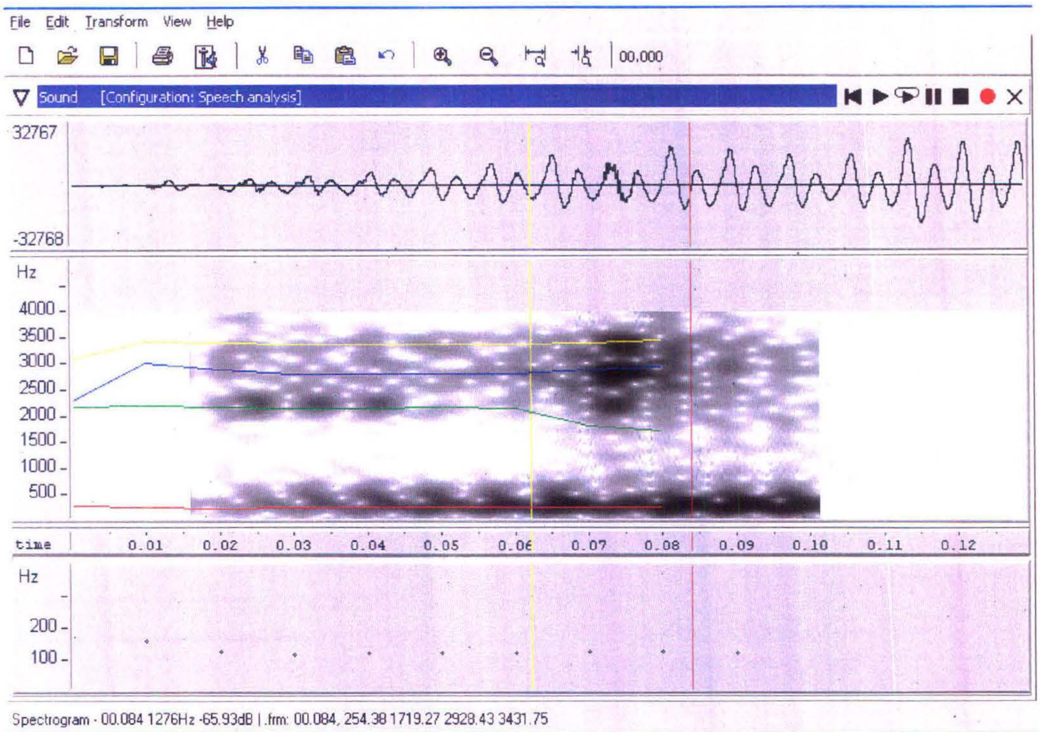

| f1 | f2 | f3 | "-f1" | "-f2" | "-(f2-f1)" |
|---|---|---|---|---|---|
| 722.6302 | 1528.631 | 2351.736 | -722.63 | -1528.63 | -806.001 |
| 720.2563 | 1530.824 | 2392.508 | -720.256 | -1530.82 | -810.568 |
| 712.4596 | 1528.805 | 2221.622 | -712.46 | -1528.8 | -816.345 |
| 717.3986 | 1505.815 | 2087.74 | -717.399 | -1505.82 | -788.417 |
| **Average** | | | **-718.186** | **-1523.52** | **-805.333** |

### The word final /a/ in the common word of the male Assamese informant 3



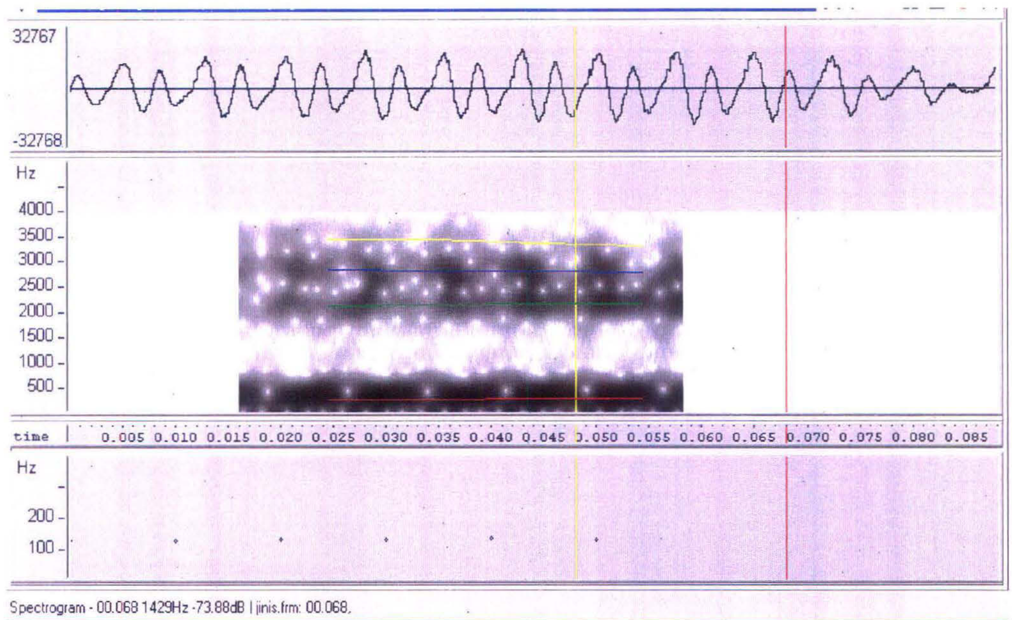

| f1 | f2 | f3 | "-f1" | "-f2" | "-(f2-f1)" |
|---|---|---|---|---|---|
| 749.7265 | 1408.789 | 2696.569 | -749.727 | -1408.79 | -659.063 |
| 786.0217 | 1399.832 | 2659.658 | -786.022 | -1399.83 | -613.81 |
| 749.2234 | 1363.241 | 2595.909 | -749.223 | -1363.24 | -614.018 |
| 742.3358 | 1355.498 | 2606.197 | -742.336 | -1355.5 | -613.163 |
| 690.9127 | 1308.882 | 2586.376 | -690.913 | -1308.88 | -617.969 |
| 701.653 | 1325.024 | 2464.541 | -701.653 | -1325.02 | -623.371 |
| 722.2703 | 1247.972 | 2463.298 | -722.27 | -1247.97 | -525.702 |
| 724.8965 | 1253.058 | 2345.566 | -724.896 | -1253.06 | -528.162 |
| 726.3504 | 1278.302 | 2341.615 | -726.35 | -1278.3 | -551.952 |
| 724.5643 | 1426.959 | 2389.345 | -724.564 | -1426.96 | -702.395 |
| **Average** | | | **-731.795** | **-1336.76** | **-604.96** |

**The word initial /i/ in the common word of the male Assamese informant 3**



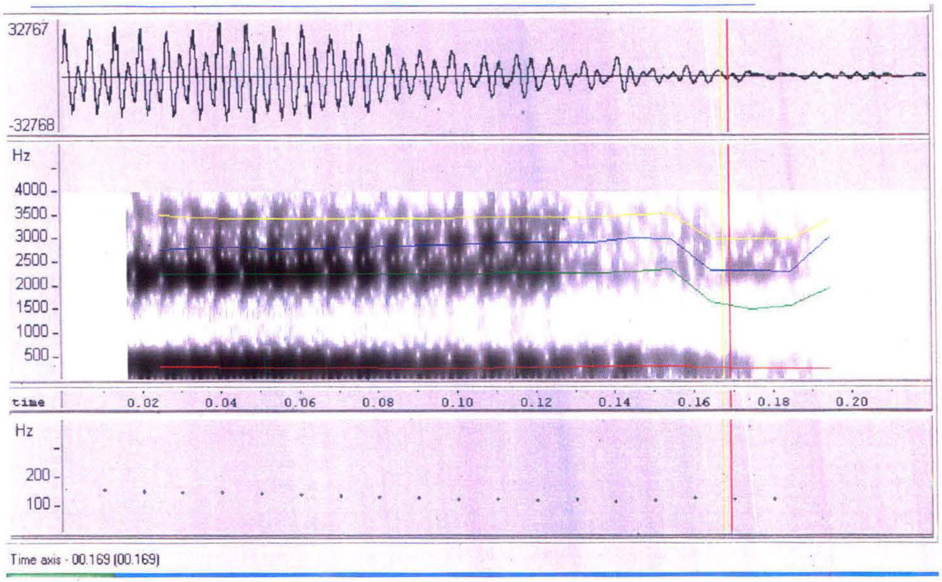

| f1 | f2 | f3 | "-f1" | "-f2" | "-(f2-f1)" |
|---|---|---|---|---|---|
| 277.8844 | 2173.243 | 2289.166 | -277.884 | -2173.24 | -1895.36 |
| 253.5895 | 2184.919 | 3007.806 | -253.59 | -2184.92 | -1931.33 |
| 242.2681 | 2179.954 | 2890.703 | -242.268 | -2179.95 | -1937.69 |
| 243.6431 | 2143.483 | 2817.181 | -243.643 | -2143.48 | -1899.84 |
| 253.7418 | 2144.705 | 2816.827 | -253.742 | -2144.7 | -1890.96 |
| 258.2392 | 2162.436 | 2814.17 | -258.239 | -2162.44 | -1904.2 |
| 264.006 | 2155.324 | 2816.391 | -264.006 | -2155.32 | -1891.32 |
| **Average** | | | **-256.196** | **-2163.44** | **-1907.24** |

**The word initial /i/ in the common word of the male Assamese informant 3**



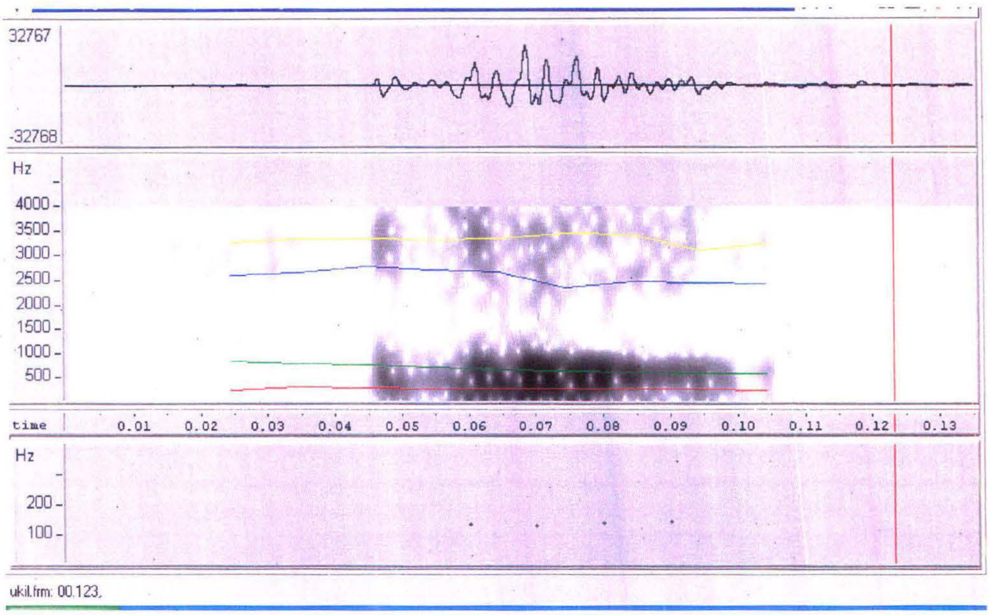

| f1 | f2 | f3 | "-f1" | "-f2" | "-(f2-f1)" |
|---|---|---|---|---|---|
| 290.4469 | 2115.645 | 2824.607 | -290.447 | -2115.65 | -1825.2 |
| 292.6907 | 2137.545 | 2800.669 | -292.691 | -2137.54 | -1844.85 |
| 297.0006 | 2155.724 | 2794.452 | -297.001 | -2155.72 | -1858.72 |
| 298.5847 | 2157.958 | 2780.625 | -298.585 | -2157.96 | -1859.37 |
| **Average** | | | **-294.681** | **-2141.72** | **-1847.04** |

**The word final /i/ in the common word of the male Assamese informant 3**



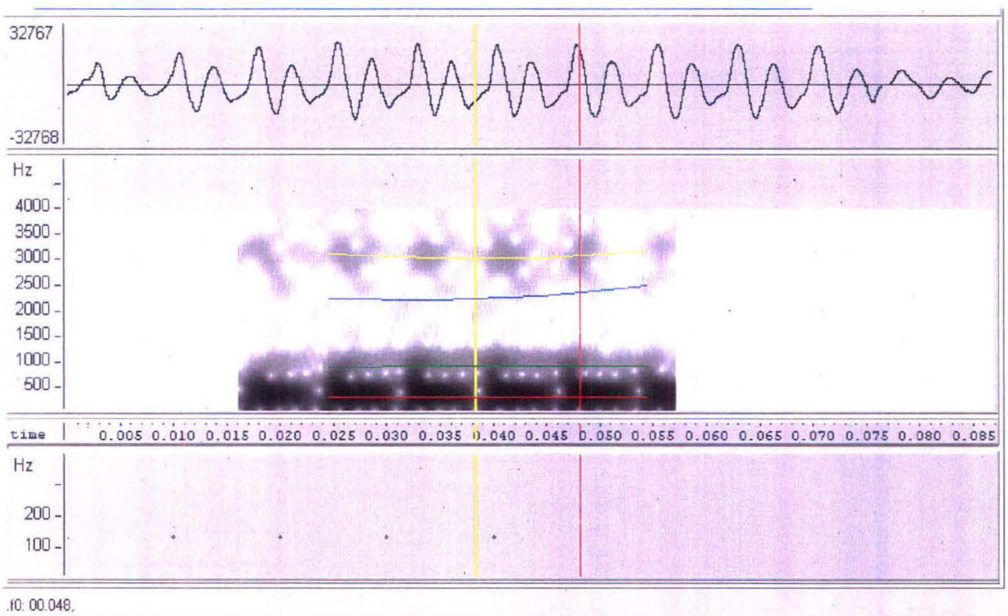

| f1 | f2 | f3 | "-f1" | "-f2" | "-(f2-f1)" |
|---|---|---|---|---|---|
| 300.2385 | 2236.889 | 2756.363 | -300.238 | -2236.89 | -1936.65 |
| 296.018 | 2242.856 | 2798.027 | -296.018 | -2242.86 | -1946.84 |
| 290.1154 | 2254.095 | 2797.942 | -290.115 | -2254.09 | -1963.98 |
| 285.906 | 2249.828 | 2792.402 | -285.906 | -2249.83 | -1963.92 |
| 280.7225 | 2238.664 | 2789.883 | -280.723 | -2238.66 | -1957.94 |
| 273.9563 | 2248.751 | 2813.207 | -273.956 | -2248.75 | -1974.79 |
| 267.0215 | 2254.059 | 2836.496 | -267.022 | -2254.06 | -1987.04 |
| 261.0181 | 2244.581 | 2868.811 | -261.018 | -2244.58 | -1983.56 |
| 265.5077 | 2252.171 | 2892.738 | -265.508 | -2252.17 | -1986.66 |
| 271.4206 | 2267.733 | 2897.486 | -271.421 | -2267.73 | -1996.31 |
| 280.2477 | 2266.624 | 2896.644 | -280.248 | -2266.62 | -1986.38 |
| 304.2842 | 2258.522 | 2915.669 | -304.284 | -2258.52 | -1954.24 |
| 315.9701 | 2296.666 | 3019.477 | -315.97 | -2296.67 | -1980.7 |
| 310.8432 | 2345.584 | 2996.322 | -310.843 | -2345.58 | -2034.74 |
| **Average** | | | **-285.948** | **-2261.22** | **-1975.27** |

**The word initial /u/ in the common word of the male Assamese informant 3**



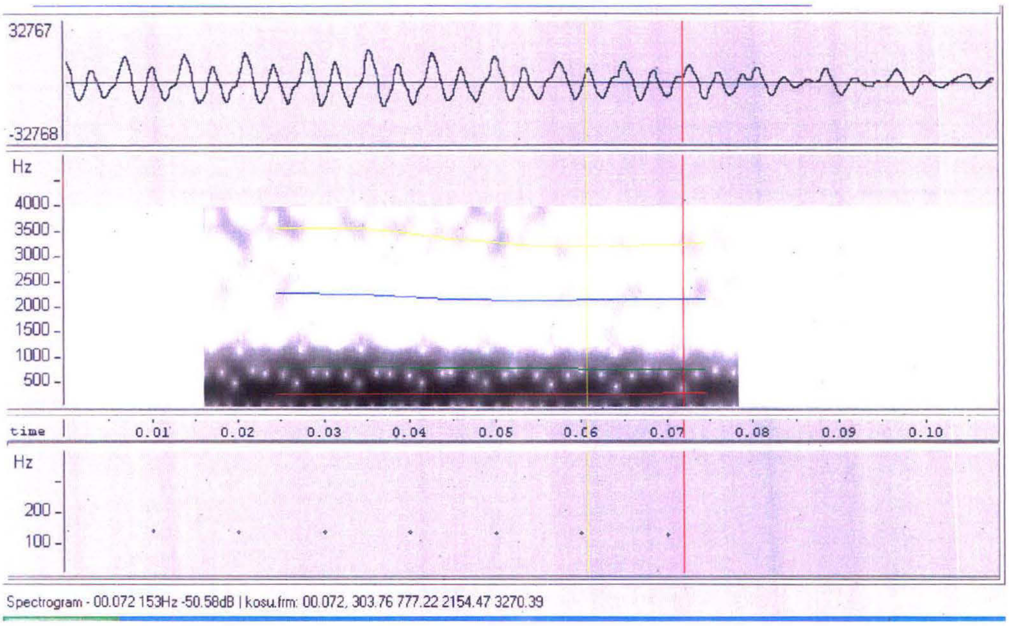

| f1 | f2 | f3 | "-f1" | "-f2" | "-(f2-f1)" |
|---|---|---|---|---|---|
| 265.6985 | 830.2153 | 2613.848 | -265.698 | -830.215 | -564.517 |
| 336.2623 | 796.6252 | 2657.901 | -336.262 | -796.625 | -460.363 |
| 313.341 | 775.6876 | 2777.296 | -313.341 | -775.688 | -462.347 |
| 276.0375 | 701.532 | 2702.688 | -276.038 | -701.532 | -425.495 |
| 274.7845 | 673.4242 | 2642.02 | -274.784 | -673.424 | -398.64 |
| 281.5488 | 650.395 | 2334.119 | -281.549 | -650.395 | -368.846 |
| 289.6259 | 618.9855 | 2443.608 | -289.626 | -618.986 | -329.36 |
| 278.4644 | 584.5139 | 2432.694 | -278.464 | -584.514 | -306.049 |
| 254.8125 | 582.1988 | 2386.683 | -254.812 | -582.199 | -327.386 |
| **Average** | | | **-285.619** | **-690.398** | **-404.778** |

**The word medial /u/ in the common word of the male Assamese informant 3**




| f1 | f2 | f3 | "-f1" | "-f2" | "-(f2-f1)" |
|---|---|---|---|---|---|
| 309.6366 | 885.4792 | 2242.897 | -309.637 | -885.479 | -575.843 |
| 312.3263 | 918.5198 | 2216.571 | -312.326 | -918.52 | -606.193 |
| 308.1188 | 921.3709 | 2296.354 | -308.119 | -921.371 | -613.252 |
| 299.8889 | 906.8972 | 2495.336 | -299.889 | -906.897 | -607.008 |
| **Average** | | | **-307.493** | **-908.067** | **-600.574** |

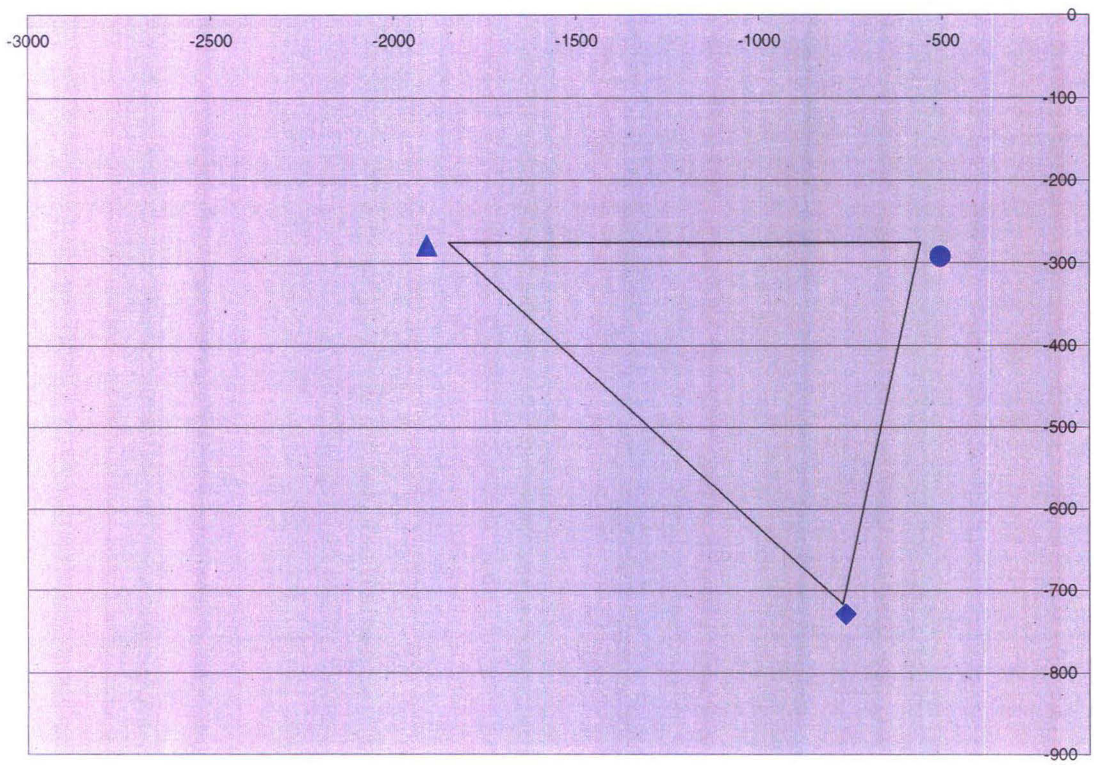
## The word final /u/ in the common word of the male Assamese informant 3




| f1 | f2 | f3 | "-f1" | "-f2" | "-(f2-f1)" |
|---|---|---|---|---|---|
| 284.2043 | 827.8775 | 2268.762 | -284.204 | -827.878 | -543.673 |
| 278.7995 | 816.9062 | 2253.904 | -278.799 | -816.906 | -538.107 |
| 275.5226 | 800.3911 | 2140.618 | -275.523 | -800.391 | -524.868 |
| 275.4498 | 783.1219 | 2104.86 | -275.45 | -783.122 | -507.672 |
| 283.6626 | 776.4235 | 2135.27 | -283.663 | -776.423 | -492.761 |
| 303.7595 | 777.2195 | 2154.466 | -303.759 | -777.219 | -473.46 |
| **Average** | | | **-283.566** | **-796.99** | **-513.424** |

The average values of the three vowels /a/, /i/ and /u/ in all the three word positions in the common words of the male Assamese speaker 3:

| Common | "-f1" | "-(f2-f1)" |
|---|---|---|
| **/a/** | | |
| initial | -739.902 | -882.586 |
| medial | -718.186 | -805.333 |
| final | -731.795 | -604.96 |
| **avg** | **-729.961** | **-764.293** |
| **/i/** | | |
| initial | -256.196 | -1907.24 |
| medial | -294.681 | -1847.04 |
| final | -285.948 | -1975.27 |
| **avg** | **-278.942** | **-1909.85** |
| **/u/** | | |
| initial | -285.619 | -404.778 |
| medial | -307.493 | -600.574 |
| final | -283.796 | -513.424 |
| **avg** | **-292.303** | **-506.259** |




**The common words' vowel space in the male Assamese informant 3**

In the way that has been shown in the last section, the spectrographic analysis is conducted for all the three vowels in all the three word positions in Assamese and common words for the Assamese speakers and, Bangla, Assamese and the common words for the Bangla informants. The average of the –f1, -f2 and – (f2-f1) values of each vowel is deduced for the male and female speakers separately, both for the Assamese and the Bangla speakers. Following are the table showing the average values (-f1,-f2 and – (f2-f1)) of the vowels /a/, /i/ and /u/ in the native Assamese speakers (male):

**Assamese vowel /a/**

| | "-f1" | "-f2" | "-(f2-f1)" |
|---|---|---|---|
| Speaker 2 | -789.38 | -1553.63 | -744.254 |
| | -817.893 | -1693.47 | -875.58 |
| | -872.45 | -1587.39 | -714.938 |
| Speaker 3 | -703.533 | -1408.22 | -704.683 |
| | -701.583 | -1255.74 | -554.161 |
| | -687.283 | -1350.65 | -663.371 |
| **Average** | **-762.02** | **-1471.5** | **-709.498** |

**Assamese vowel /i/**

| | "-f1" | "-f2" | "-(f2-f1)" |
|---|---|---|---|
| Speaker 2 | -323.596 | -1483.42 | -1159.82 |
| | -286.683 | -1812.91 | -1526.23 |
| | -294.273 | -1833.27 | -1539 |
| Speaker 3 | -262.809 | -2214.17 | -1951.36 |
| | -383.603 | -1661.68 | -1278.08 |
| | -255.297 | -1940.03 | -1684.73 |
| **Average** | **-301.044** | **-1824.25** | **-1523.2** |

### Assamese vowel /u/

| | "-f1" | "-f2" | "-(f2-f1)" |
|---|---|---|---|
| Speaker 2 | -311.941 | -789.003 | -477.062 |
| | -339.667 | -878.387 | -538.72 |
| | -389.741 | -842.684 | -452.943 |
| Speaker 3 | -266.751 | -703.415 | -436.664 |
| | -273.033 | -880.806 | -607.773 |
| | -282.711 | -727.939 | -445.228 |
| **Average** | **-310.641** | **-803.706** | **-493.065** |

Following are the tables showing the average values (-f1,-f2 and – (f2-f1)) of the vowels /a/, /i/ and /u/ in the native Assamese speakers (female):

### Assamese vowel /a/

| | "-f1" | "-f2" | "-(f2-f1)" |
|---|---|---|---|
| Speaker 4 | -1124.1 | -1791.4 | -667.3 |
| | -756.98 | -1582.48 | -825.496 |
| | -756.545 | -1325.99 | -569.443 |
| Speaker 1 | -893.508 | -1756.66 | -863.156 |
| | -706.037 | -1078.34 | -372.305 |
| | -863.464 | -1601.84 | -738.371 |
| **Average** | **-850.106** | **-1522.78** | **-672.679** |

### Assamese vowel /i/

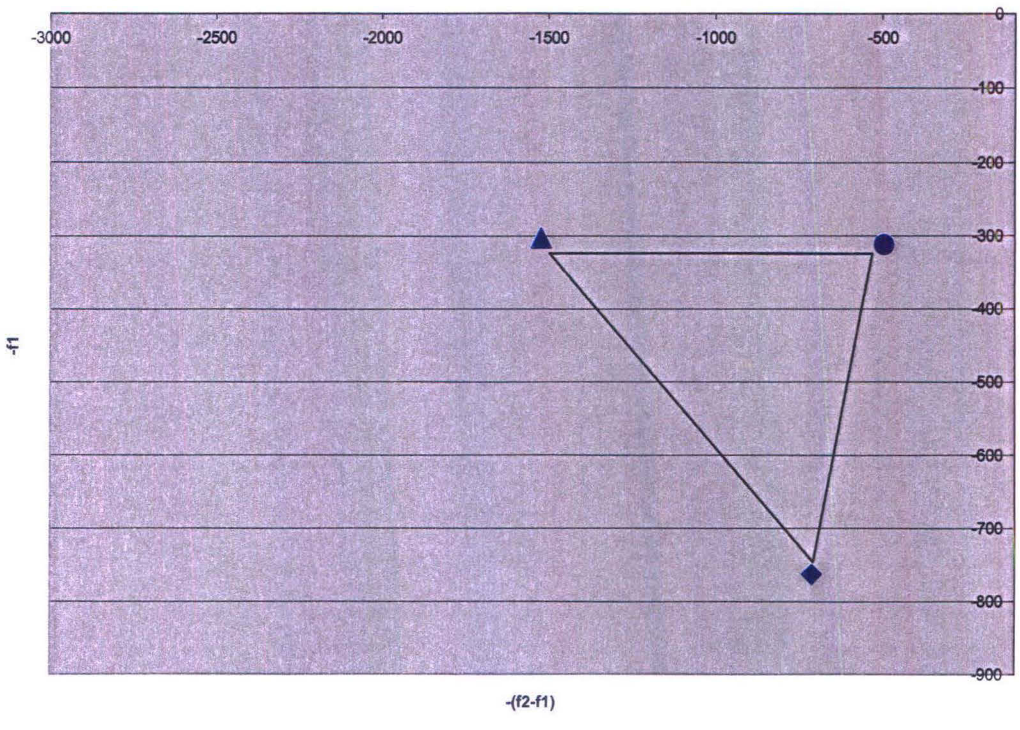
| | "-f1" | "-f2" | "-(f2-f1)" |
|---|---|---|---|
| Speaker 4 | -328.961 | -2175.48 | -1846.52 |
| | -240 | -2040.57 | -1800.57 |
| | -284.701 | -2098.31 | -1813.61 |
| Speaker 1 | -370.724 | -2367.67 | -1996.95 |
| | -347.864 | -2134.87 | -1787.01 |
| | -284.35 | -2128.82 | -1844.47 |
| **Average** | **-309.433** | **-2157.62** | **-1798.77** |

**Assamese vowel /u/**

| | "-f1" | "-f2 | "-(f2-f1)" |
|---|---|---|---|
| Speaker 4 | -358.206 | -904.996 | -546.79 |
| | -497.683 | -1170.11 | -672.428 |
| | -532.02 | -1035.84 | -503.824 |
| Speaker 1 | -331.515 | -808.896 | -477.381 |
| | -386.585 | -817.368 | -430.783 |
| | -359.83 | -764.361 | -404.531 |
| | | | |
| **Average** | **-410.973** | **-916.929** | **-505.956** |

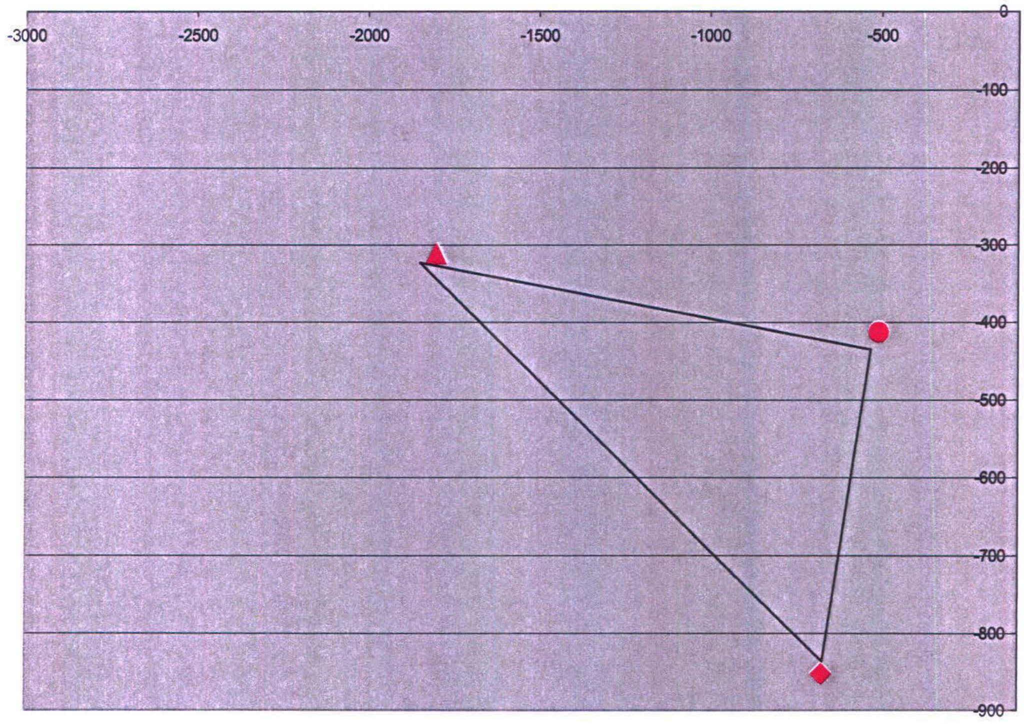
Acoustic space defined by the formant values (i.e. –f1,-f2 and – (f2-f1)) of the three peripheral vowels /a/, /i/ and /u/ in the Assamese of native Assamese male speakers.

| Vowel | -f1 | -f2 | -(f2-f1) |
|---|---|---|---|
| /a/ | -762.02 | -1471.5 | -709.498 |
| /i/ | -301.044 | -1824.25 | -1532.2 |
| /u/ | -310.641 | -803.706 | -493.065 |

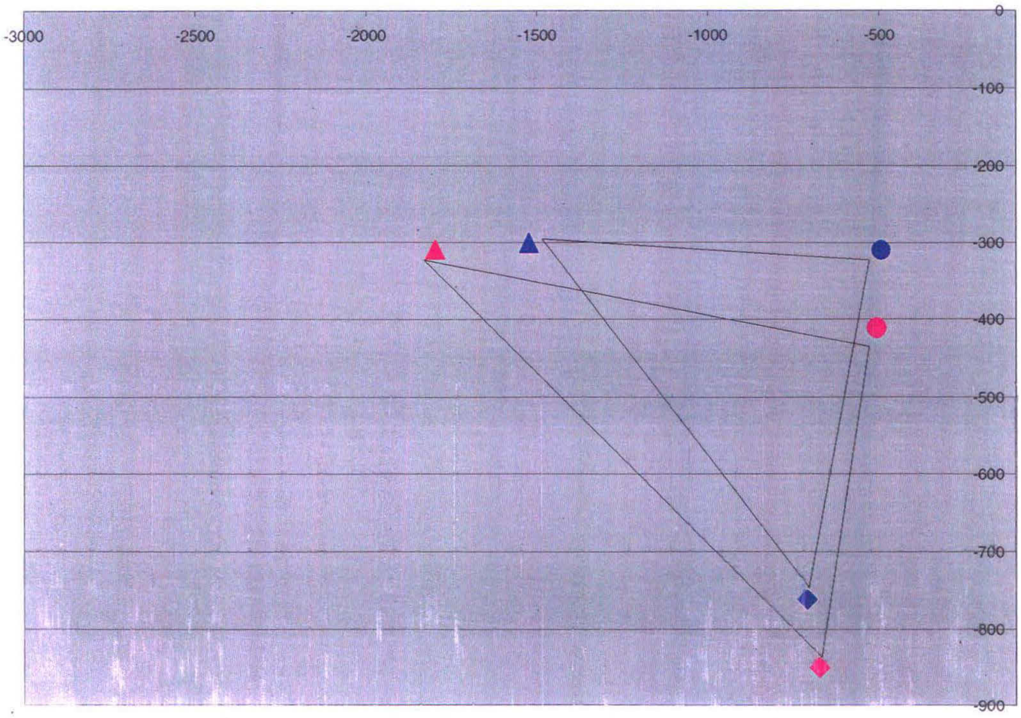


Acoustic space defined by the formant values (i.e. –f1,-f2 and – (f2-f1)) of the three peripheral vowels /a/, /i/ and /u/ in the Assamese of native Assamese female speakers.

| Vowel | -f1 | -f2 | -(f2-f1) |
|---|---|---|---|
| /a/ | -850.106 | -1522.78 | -672.679 |
| /i/ | -309.43 | -2157.62 | -1798.72 |
| /u/ | -410.973 | -916.929 | -505.956 |



**The Assamese vowel space in the Assamese speakers (male and female)**




Assamese Male Speakers ♦●▲
Assamese Female Speakers ♦●▲

## The common words' /a/ acoustic space in the male Assamese speakers:

| | "-f1" | "-f2" | "-(f2-f1)" |
|---|---|---|---|
| Speaker 2 | -829.465 | -1515.76 | -686.292 |
| | -710.293 | -1481.32 | -771.03 |
| | -848.352 | -1675.5 | -827.15 |
| Speaker 3 | -759.151 | -1319.45 | -560.301 |
| | -718.186 | -1523.52 | -805.333 |
| | -731.795 | -1336.76 | -604.96 |
| | | | |
| **Average** | **-766.207** | **-1475.38** | **-709.178** |
| | | | |

## The common words' /i/ acoustic space in male Assamese speakers:

| | "-f1" | "-f2" | "-(f2-f1)" |
|---|---|---|---|
| Speaker 2 | -293.229 | -1845.02 | -1551.79 |
| | -355 | -1900.02 | -1782.37 |
| | -341 | -1742 | -1401 |
| Speaker 3 | -256.196 | -2163.44 | -1907.24 |
| | -294.681 | -2141.72 | -1847.04 |
| | -285.948 | -2261.22 | -1975.27 |
| **Average** | **-304.342** | **-2008.9** | **-1744.12** |

## The common words' /u/ acoustic space in male Assamese speakers:

| | "-f1" | "-f2" | "-(f2-f1)" |
|---|---|---|---|
| Speaker 2 | -330.048 | -813.217 | -483.169 |
| | -197.936 | -804.375 | -606.439 |
| | -269.994 | -855.311 | -585.317 |
| Speaker 3 | -285.619 | -690.397 | -404.778 |
| | -307.493 | -908.068 | -600.575 |
| | -283.566 | -796.99 | -513.424 |
| **Average** | **-279.109** | **-811.393** | **-532.284** |

## The common words' /a/ acoustic space in female Assamese speakers:

| | "-f1" | "-f2" | "-(f2-f1)" |
|---|---|---|---|
| Speaker 1 | -876.027 | -1437.91 | -561.881 |
| | -719.746 | -1348.38 | -628.632 |
| | -733.45 | -1399.29 | -665.836 |
| Speaker 4 | -846.495 | -1419.76 | -573.266 |
| | -953.234 | -1732.99 | -779.76 |
| | -982.114 | -1523.15 | -541.034 |
| **Average** | **-851.844** | **-1476.91** | **-625.068** |

## The common words' /i/ acoustic space in female Assamese speakers:

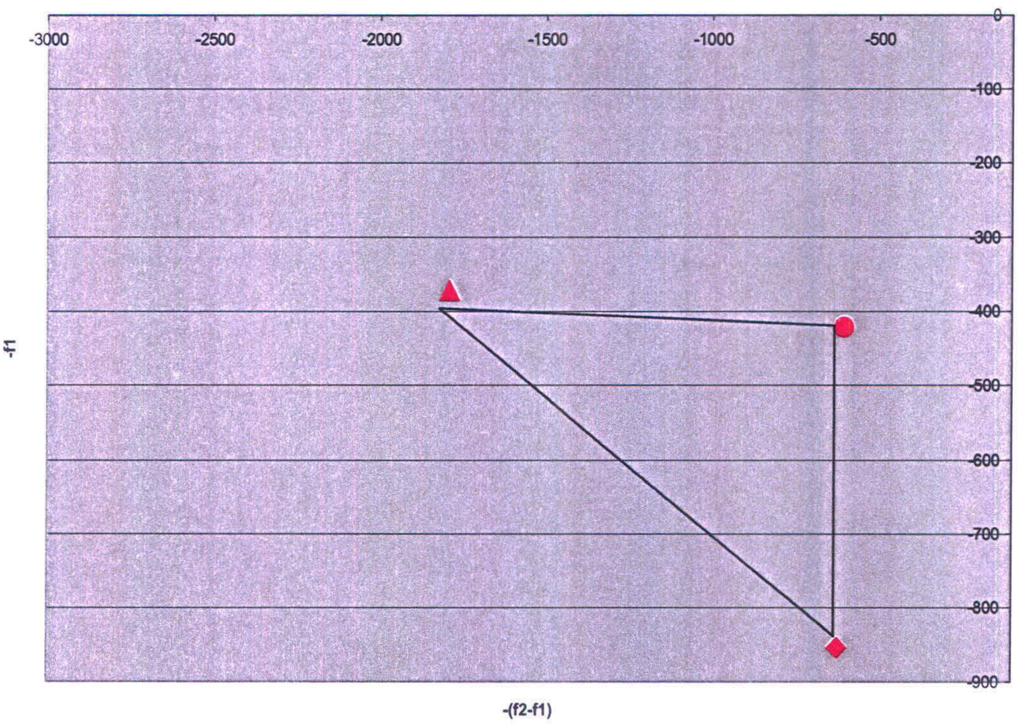
| | "-f1" | "-f2" | "-(f2-f1)" |
|---|---|---|---|
| Speaker 1 | -417.414 | -2111 | -1693.59 |
| | -355.273 | -2186.54 | -1831.27 |
| | -441.414 | -2100 | -1516.09 |
| Speaker 4 | -422.579 | -2223 | -1624.92 |
| | -327.28 | -2228.45 | -1901.17 |
| | -254.036 | -2600 | -2170.67 |
| **Average** | **-369.666** | **-2241.5** | **-1789.62** |

## The common words' /u/ acoustic space in female Assamese speakers:

| | "-f1" | "-f2" | "-(f2-f1)" |
|---|---|---|---|
| Speaker 1 | -414.194 | -1004.12 | -589.927 |
| | -308.482 | -913.354 | -604.872 |
| | -495.369 | -1211.39 | -716.018 |
| Speaker 4 | -341.908 | -841.771 | -499.863 |
| | -510.697 | -1283.34 | -772.64 |
| | -446.336 | -879.593 | -433.257 |
| **Average** | **-419.498** | **-1022.26** | **-602.763** |

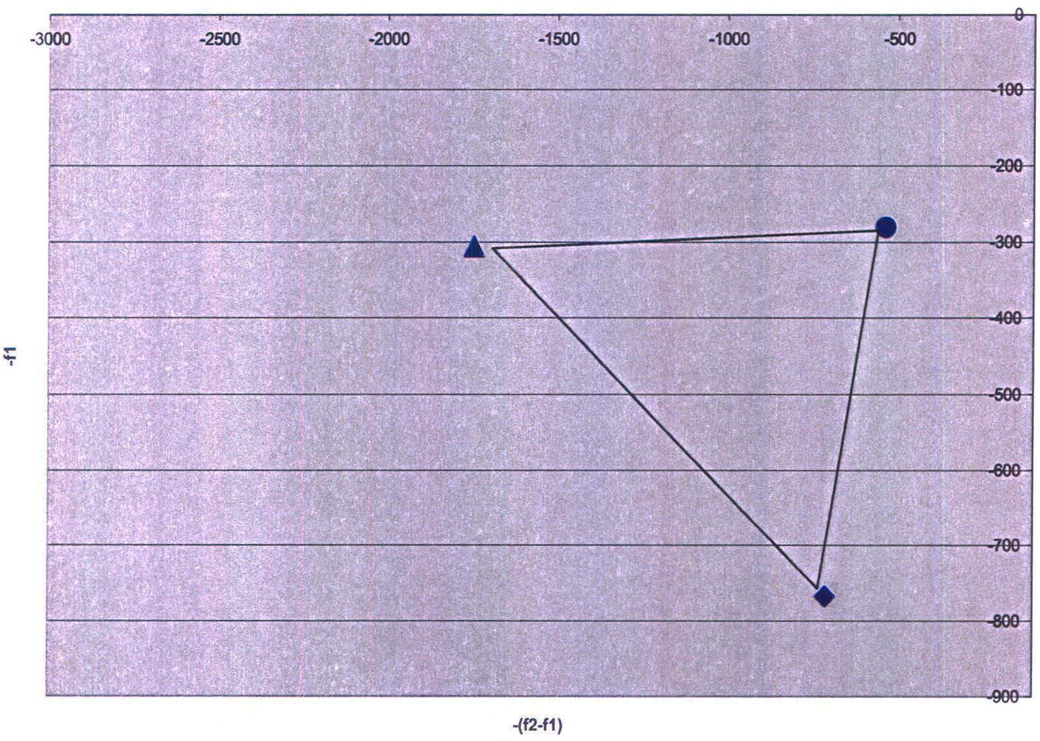
The acoustic space of the three vowels /a/, /i/ and /u/ in the common words of the female Assamese speakers:

| Vowel | -f1 | -f2 | -(f2-f1) |
|---|---|---|---|
| /a/ | -851.844 | -1476.91 | -625.068 |
| /i/ | -369.666 | -2241 | -1789.12 |
| /u/ | -419.498 | -1022 | -602.763 |

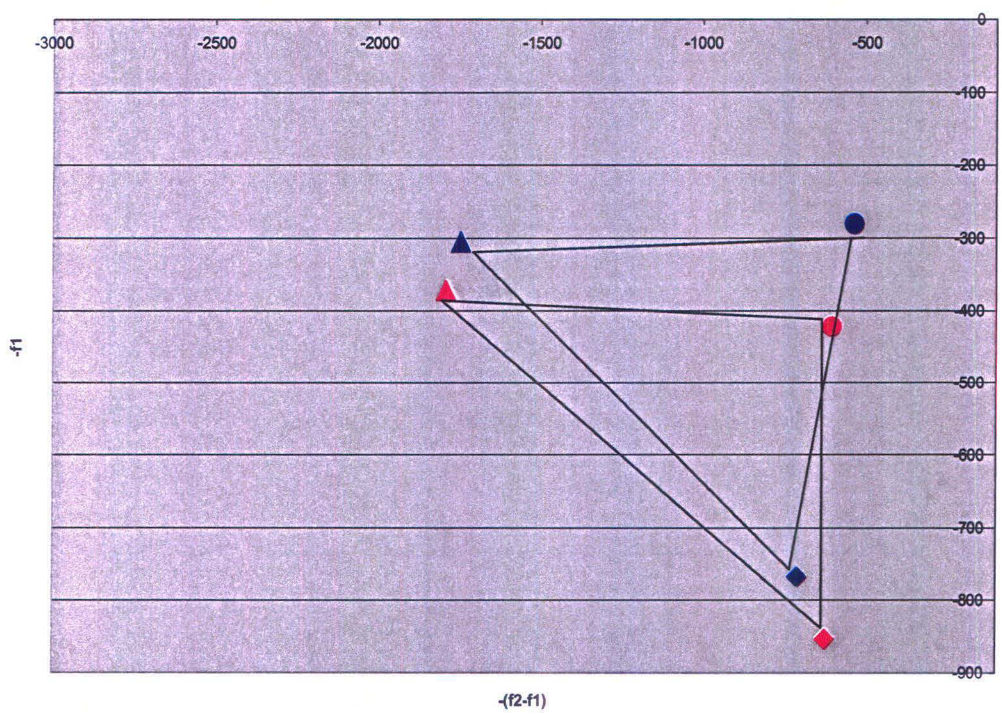


The acoustic space of common words in male Assamese speakers:

| Vowel | -f1 | -f2 | -(f2-f1) |
|---|---|---|---|
| /a/ | -766.207 | -1475.38 | -709.178 |
| /i/ | -304.342 | -2008.9 | -1744.12 |
| /u/ | -279.109 | -811.393 | -532.284 |



**The vowel space of the common words in the Assamese speakers (male and female)**




Assamese Male Speakers ♦●▲
Assamese Female Speakers ♦●▲

**Assamese /a/ acoustic space in the male Bangla speakers:**

| | "f1" | "-f2" | "-(f2-f1)" |
|---|---|---|---|
| Speaker 2 | -619.561 | -1392.96 | -773.394 |
| | -558.128 | -1372.27 | -814.144 |
| | -692.802 | -1409.8 | -717 |
| Speaker 6 | -895.716 | -1495.83 | -600.11 |
| | -792.628 | -1571.02 | -778.393 |
| | -702.738 | -1380.21 | -677.471 |
| Speaker 4 | -787.342 | -1464.27 | -676.925 |
| | -765.168 | -1263.82 | -498.65 |
| | -730.83 | -1418.39 | -687.559 |
| Speaker 7 | -848.092 | -1493.99 | -645.896 |
| | -1050.71 | -1647.41 | -596.701 |
| | -857.628 | -1482.57 | -624.944 |
| **Average** | **-775.112** | **-1449.38** | **-674.266** |

**Assamese /i/ acoustic space in the male Bangla speakers:**

| | "-f1" | "-f2" | "-(f2-f1)" |
|---|---|---|---|
| Speaker 2 | -261 | -2111 | -1850 |
| | -263 | -2074 | -1811 |
| | -207 | -1906 | -1699 |
| Speaker 6 | -296.02 | -1034.44 | -738.421 |
| | -245 | -2134.58 | -1889.58 |
| | -363.361 | -2135.48 | -1772.12 |
| Speaker 4 | -247.593 | -1520.77 | -1273.18 |
| | -294 | -2294 | -2000 |
| | -263 | -1862 | -1599 |
| Speaker 7 | -268.589 | -1135.29 | -866.7 |
| | -284.238 | -2530.82 | -2246.58 |
| | -218.412 | -1895.92 | -1677.51 |
| **Average** | **-267.601** | **-1886.19** | **-1618.59** |

## Assamese /u/ acoustic space in the male Bangla speakers:

| | "-f1" | "-f2" | "-(f2-f1)" |
|---|---|---|---|
| Speaker 2 | -368.217 | -885.589 | -517.372 |
| | -355.388 | -948.747 | -593.359 |
| | -283.915 | -741.493 | -457.578 |
| Speaker 6 | -288.945 | -929.392 | -640.447 |
| | -331.789 | -791.224 | -459.435 |
| | -259.753 | -889.695 | -629.942 |
| Speaker 4 | -333.965 | -1007.62 | -673.651 |
| | -259.696 | -917.826 | -658.13 |
| | -327.627 | -818.569 | -490.942 |
| Speaker 7 | -360.443 | -890.886 | -530.443 |
| | -234.109 | -1054.9 | -820.787 |
| | -324.022 | -805.004 | -480.982 |
| **Average** | **-310.656** | **-890.078** | **-579.422** |

## Assamese /a/ acoustic space in female Bangla speakers:

| | "-f1" | "-f2" | "-(f2-f1)" |
|---|---|---|---|
| Speaker 1 | -817.54 | -1880.25 | -1062.71 |
| | -820.301 | -1467.19 | -646.888 |
| | -862.904 | -1494.29 | -631.39 |
| Speaker 3 | -813.386 | -1913.37 | -1099.98 |
| | -834.809 | -1474.71 | -639.9 |
| | -926.857 | -1520.98 | -594.12 |
| Speaker 5 | -868.929 | -1342.72 | -473.794 |
| | -832.807 | -1564.03 | -731.227 |
| | -775.664 | -1705.94 | -930.272 |
| Speaker 8 | -893.896 | -2767.69 | -1873.8 |
| | -711.608 | -1698.52 | -986.91 |
| | -886.141 | -1774.52 | -888.376 |
| **Average** | **-837.07** | **-1717.02** | **-879.947** |

## Assamese /i/ acoustic space in female Bangla speakers:

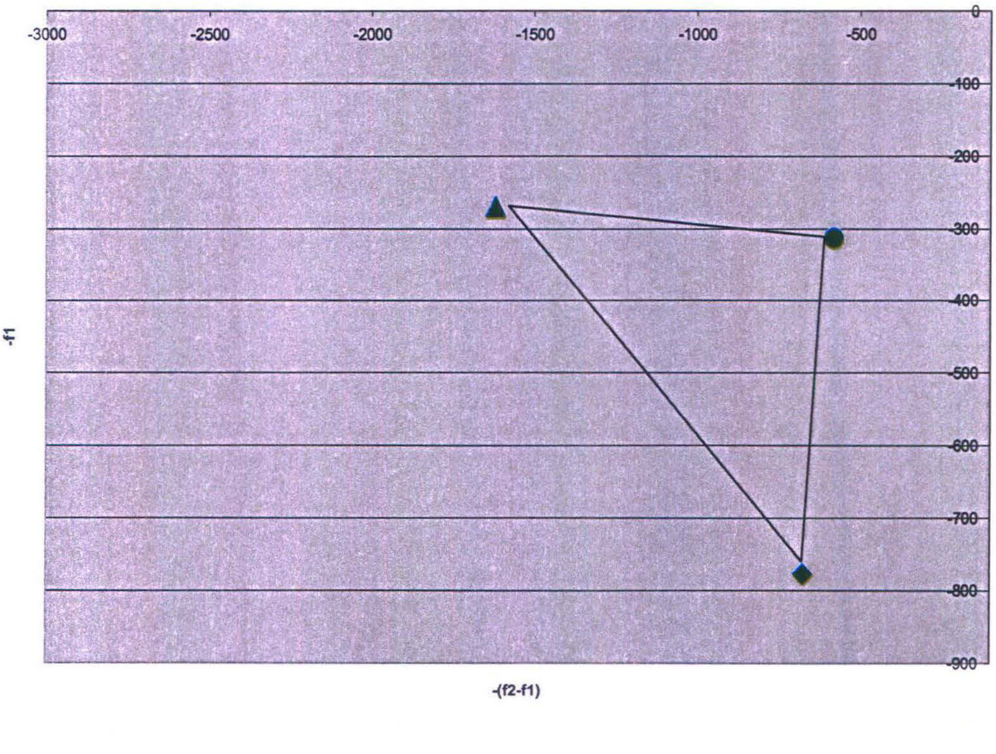
| | "-f1" | "-f2" | "-(f2-f1)" |
|---|---|---|---|
| speaker 1 | -245.512 | -2060.71 | -1815.2 |
| | -229.628 | -2422.46 | -2192.83 |
| | -261.951 | -2421.6 | -2159.65 |
| Speaker 3 | -351.612 | -1359.11 | -1007.5 |
| | -324.597 | -2240.95 | -1916.35 |
| | -329.285 | -2288.39 | -1959.1 |
| Speaker 5 | -382.658 | -1802.26 | -1419.6 |
| | -279.62 | -1801.45 | -1521.83 |
| | -285.317 | -1850.11 | -1564.79 |
| Speaker 8 | -274.741 | -1679.18 | -1404.44 |
| | -203.328 | -2268.27 | -2064.94 |
| | -248.786 | -2183.85 | -1935.06 |
| **Average** | **-284.753** | **-2031.53** | **-1746.77** |

## Assamese /u/ acoustic space in female Bangla speakers:

| | "-f1" | "-f2" | "-(f2-f1)" |
|---|---|---|---|
| Speaker 1 | -332.495 | -1666.34 | -1333.84 |
| | -281.291 | -1804.72 | -1523.43 |
| | -268.176 | -669.226 | -401.05 |
| Speaker 3 | -373.019 | -1239.55 | -866.527 |
| | -404.639 | -1401.74 | -997.099 |
| | -331.6 | -1004.11 | -672.512 |
| Speaker 5 | -380.667 | -749.926 | -369.259 |
| | -366.395 | -790.205 | -423.81 |
| | -342.376 | -747.725 | -405.349 |
| Speaker 8 | -309.63 | -918.082 | -608.452 |
| | -361.257 | -927.16 | -565.903 |
| | -291.901 | -765.255 | -473.354 |
| **Average** | **-336.954** | **-1057** | **-720.049** |

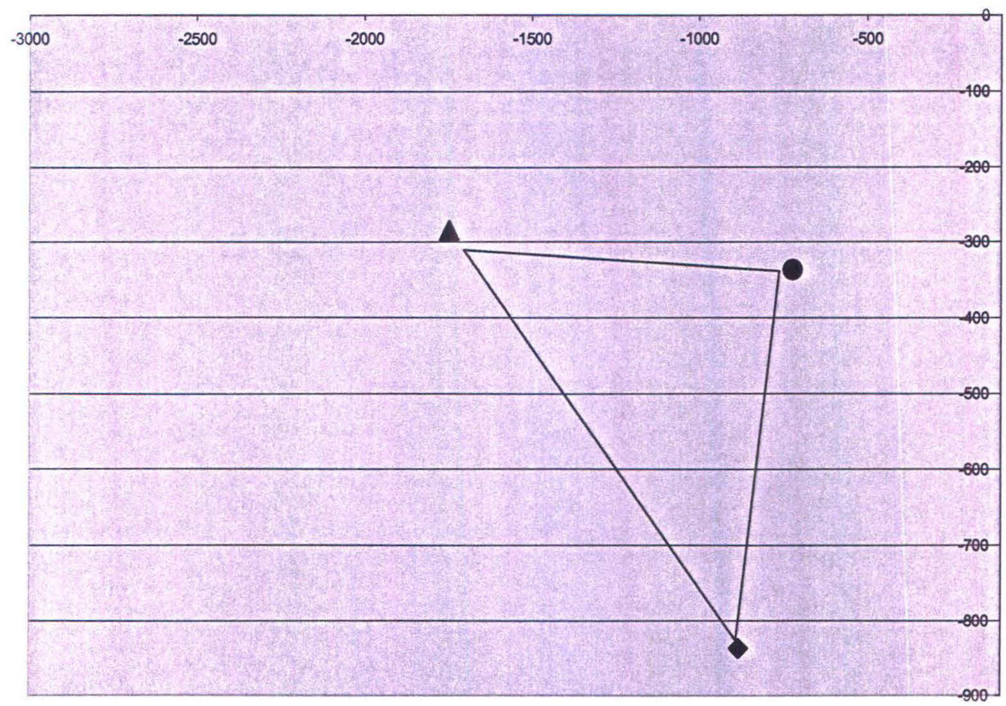
The acoustic space of the three vowels /a/, /i/ and /u/ in the Assamese of the male bilingual Bangla speakers:

| Vowel | -f1 | -f2 | -(f2-f1) |
|---|---|---|---|
| /a/ | -775.5 | -1449.266 | -674.266 |
| /i/ | -267.601 | -1886.19 | -1618.59 |
| /u/ | -310 | -890.078 | -579.922 |

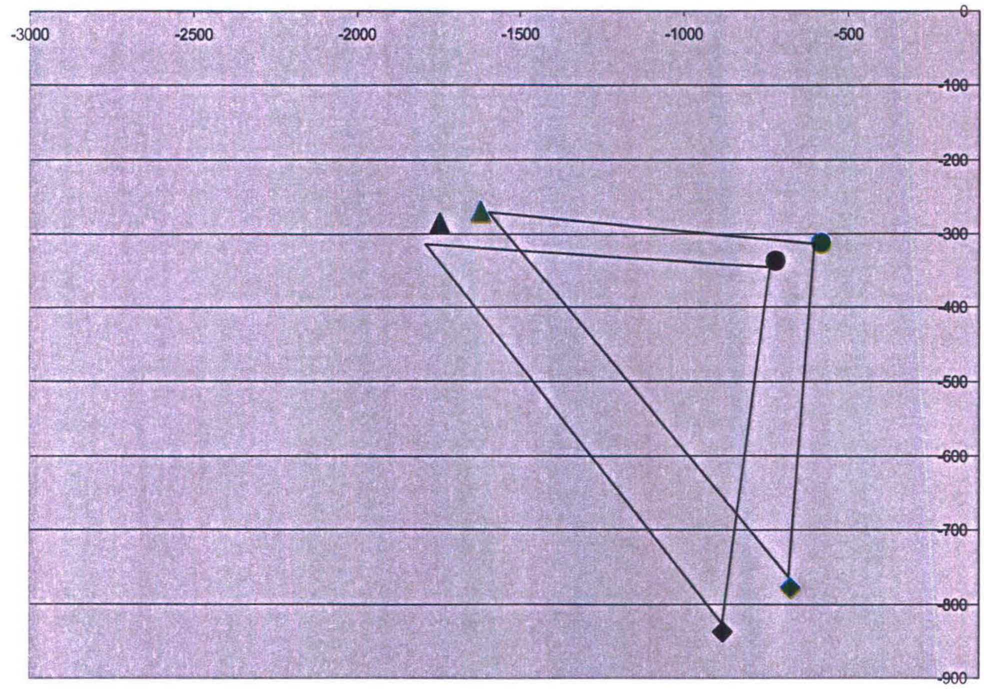


The acoustic space of the three vowels /a/, /i/ and /u/ in the Assamese of the female bilingual Bangla speakers:

| Vowel | -f1 | -f2 | -(f2-f1) |
|---|---|---|---|
| /a/ | -837.07 | -1717.02 | -879.947 |
| /i/ | -284.753 | -2031.53 | -1746.77 |
| /u/ | -336.954 | -1057 | -720.049 |



## The Assamese vowel space in the Bangla speakers (male and female)




Assamese Male Speakers ♦●▲
Assamese Female Speakers ♦●▲

The Bangla vowel formants of the native male Bangla speakers with Assamese as their second language:

**Bangla vowel /a/**

| | "-f1" | "-f2" | "-(f2-f1)" |
|---|---|---|---|
| Speaker 2 | -697.541 | -1395.42 | -697.883 |
| | -637.101 | -1376.19 | -739.086 |
| | -672.533 | -1344.14 | -671.611 |
| Speaker 6 | -664.882 | -1216.9 | -552.015 |
| | -698.394 | -1507.88 | -809.483 |
| | -665.009 | -1411.84 | -746.832 |
| Speaker 4 | -746.446 | -1349.61 | -603.162 |
| | -730.302 | -1390.01 | -659.705 |
| | -692.827 | -1322.18 | -629.355 |
| Speaker 7 | -727.199 | -1395.81 | -668.609 |
| | -703.072 | -1492.76 | -789.685 |
| | -711.514 | -1312.12 | -600.603 |
| **Average** | **-695.568** | **-1376.24** | **-680.669** |

**Bangla vowel /i/**

| | "-f1" | "-f2" | "-(f2-f1)" |
|---|---|---|---|
| Speaker 2 | -281 | -2135 | -1854 |
| | -319.544 | -2049.54 | -1730 |
| | -326 | -2178 | -1852 |
| Speaker 6 | -257.487 | -1888 | -1630.51 |
| | -256.808 | -1697.38 | -1440.57 |
| | -371.704 | -2154.34 | -1782.64 |
| Speaker 4 | -274.095 | -2047.78 | -1773.69 |
| | -317.69 | -1976.56 | -1658.87 |
| | -283.337 | -1789 | -1505.66 |
| Speaker 7 | -184 | -2165 | -1981 |
| | -271.99 | -1654.89 | -1382.9 |
| | -265 | -2247 | -1982 |
| **Average** | **-284.055** | **-1998.54** | **-1714.49** |

## Bangla vowel /u/:

| | "-f1" | "-f2" | "-(f2-f1)" |
|---|---|---|---|
| Speaker 2 | -304.791 | -712.558 | -407.767 |
| | -328.51 | -1066.24 | -737.734 |
| | -303.362 | -597.456 | -294.094 |
| Speaker 6 | -321.834 | -781.805 | -459.971 |
| | -219.784 | -963.923 | -744.139 |
| | -212.207 | -1058.83 | -846.618 |
| Speaker 4 | -393.049 | -931.106 | -538.057 |
| | -323.871 | -884 | -560.129 |
| | -304.916 | -512.837 | -207.921 |
| Speaker 7 | -269.693 | -953.586 | -683.893 |
| | -316.702 | -983.326 | -666.624 |
| | -269.693 | -953.586 | -683.893 |
| | | | |
| **Average** | **-297.368** | **-866.604** | **-569.237** |

The Bangla vowel formants of the three vowels /a/, /i/ and /u/ in the female Bangla speakers:

## Bangla vowel /a/

| | "-f1" | "-f2" | "-(f2-f1)" |
|---|---|---|---|
| Speaker 1 | -915.91 | -1486.43 | -570.519 |
| | -846.834 | -1519.14 | -672.303 |
| | -865.567 | -1643.59 | -778.024 |
| Speaker 3 | -867.388 | -1396.97 | -529.578 |
| | -1141.93 | -1783.47 | -641.541 |
| | -829.992 | -1370.02 | -540.029 |
| Speaker 5 | -847.773 | -1506.52 | -658.746 |
| | -998.315 | -1516.02 | -517.709 |
| | -865.096 | -1545.88 | -680.786 |
| Speaker 8 | 807.155 | -207.845 | -1015 |
| | -832.256 | -1592.71 | -760.458 |
| | -1133.86 | -1722.29 | -588.427 |
| | | | |
| **Average** | **-778.147** | **-1440.91** | **-662.76** |

## Bangla vowel /i/

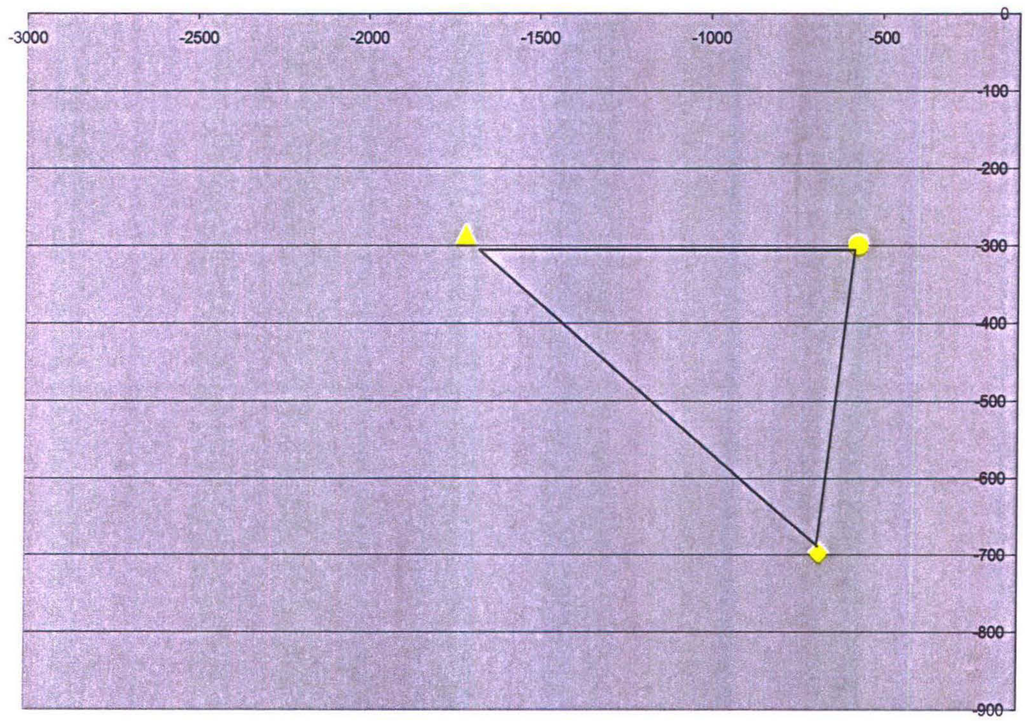
| | "-f1" | "-f2" | "-(f2-f1)" |
|---|---|---|---|
| Speaker 1 | -246.017 | -2300 | -2053.98 |
| | -472.538 | -2313.26 | -1840.72 |
| | -249.064 | -2397.18 | -2148.12 |
| Speaker 3 | -240.339 | -2450.67 | -2210.33 |
| | -326.449 | -2300 | -1632.91 |
| | -401.511 | -2225.57 | -1824.06 |
| Speaker 5 | -347.398 | -2034.92 | -1687.52 |
| | -320.04 | -2100.04 | -1562.48 |
| | -372.838 | -2188.77 | -1815.93 |
| Speaker 8 | -307.677 | -2248.75 | -1941.07 |
| | -309.906 | -2133.78 | -1823.87 |
| | -277.169 | -2300 | -2022.83 |
| **Average** | **-322.579** | **-2249.41** | **-1880.32** |

## Bangla vowel /u/

| | "-f1 | "-f2" | "-(f2-f1)" |
|---|---|---|---|
| Speaker 1 | -286.724 | -842.364 | -555.64 |
| | -318.428 | -627.256 | -308.828 |
| | -275.337 | -1261.64 | -986.306 |
| Speaker 3 | -313.307 | -1720.31 | -1407 |
| | -427.895 | -1111.59 | -683.692 |
| | -336.289 | -1161.13 | -824.841 |
| Speaker 5 | -315.646 | -763.805 | -448.159 |
| | -361.425 | -1351.98 | -990.555 |
| | -381.568 | -950.555 | -568.987 |
| Speaker 8 | -304.557 | -707.079 | -402.522 |
| | -385.466 | -1262.16 | -876.691 |
| | -250.864 | -706.659 | -455.795 |
| **Average** | **-329.792** | **-1038.88** | **-709.085** |

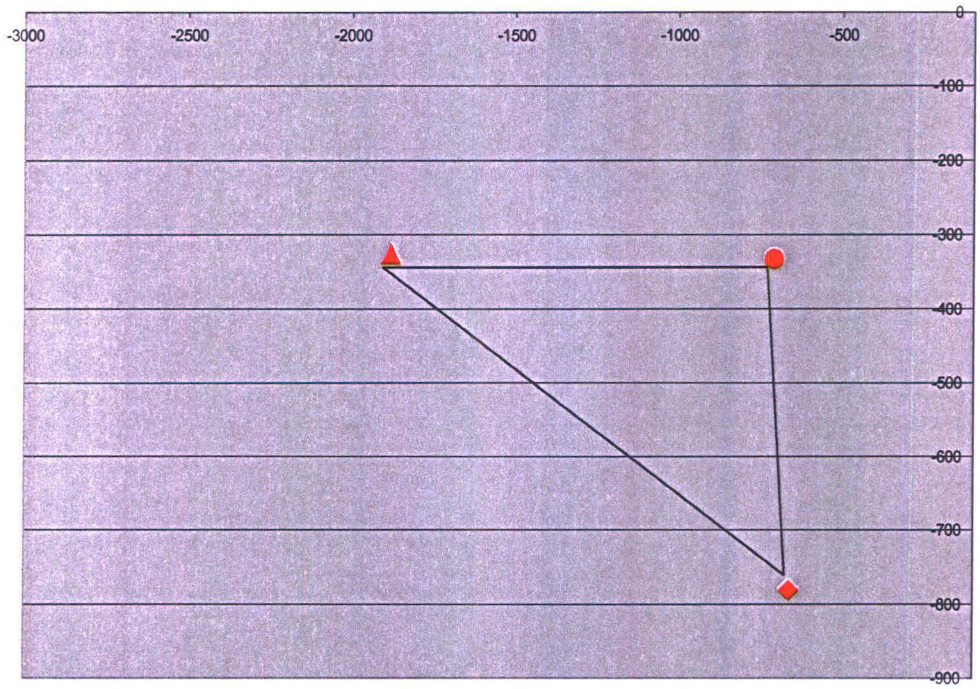
The Bangla acoustic space of the three vowels /a/, /i/ and /u/ in the bilingual Bangla speakers (male):

| Vowel | -f1 | -f2 | -(f2-f1) |
|---|---|---|---|
| /a/ | -695.568 | -1376.24 | -680.669 |
| /i/ | -284.055 | -1998.54 | -1714.49 |
| /u/ | -297.368 | -866.604 | -564.237 |

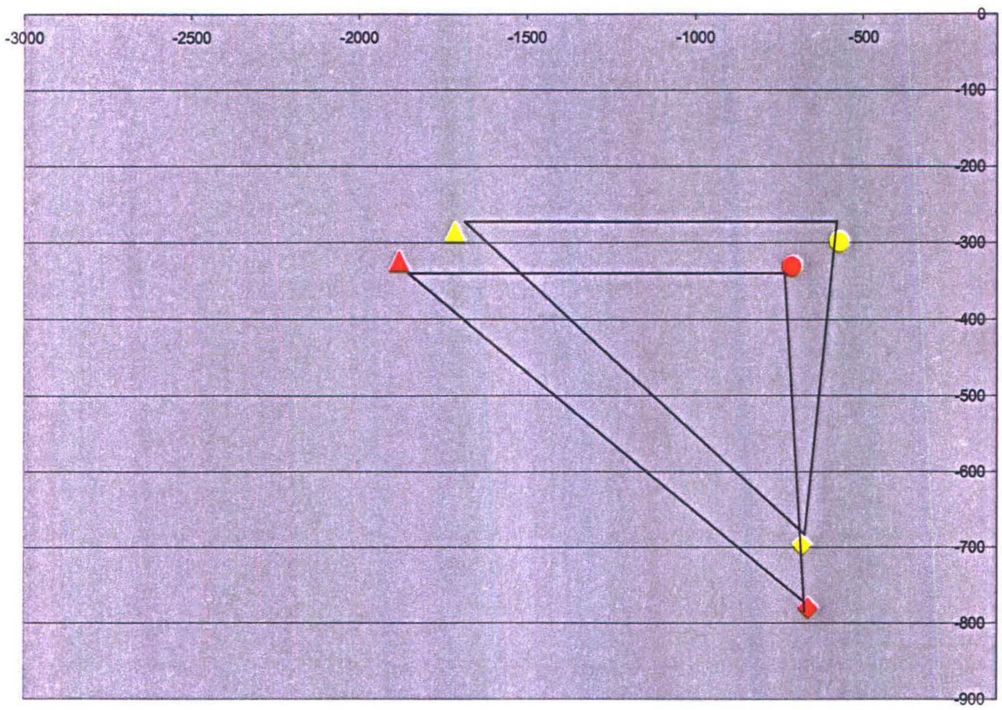


The Bangla acoustic space of the three vowels /a/, /i/ and /u/ in the bilingual Bangla speakers (female):

| Vowel | -f1 | -f2 | -(f2-f1) |
|---|---|---|---|
| /a/ | -778.147 | -1440.91 | -662.76 |
| /i/ | -322.597 | -2249 | -1880.32 |
| /u/ | -329.792 | -1038.88 | -709.085 |



**The Bangla vowel space in the Bangla speakers (male and female)**




Bangla Male Speakers
Bangla Female Speakers

The following is the acoustic space of the vowels /a/, /i/ and /u/ in the common words for the male Bangla speakers.

**<u>The common words' /a/ acoustic space</u>**

| | "-f1" | "-f2" | "-(f2-f1)" |
|---|---|---|---|
| Speaker 2 | -675.614 | -1287.1 | -611.486 |
| | -692.261 | -1416 | -723.737 |
| | -802.595 | -1329.82 | -527.224 |
| Speaker 6 | -744.454 | -1410.09 | -665.632 |
| | -733.879 | -1529.58 | -795.699 |
| | -695.065 | -1322.05 | -626.987 |
| Speaker 4 | -657.93 | -1318.46 | -660.531 |
| | -660.09 | -1373.87 | -713.784 |
| | -767.52 | -1379.53 | -612.007 |
| Speaker 7 | -834.41 | -1307.71 | -473.295 |
| | -869.28 | -1527.37 | -658.087 |
| | -797.497 | -1587.34 | -789.843 |
| **Average** | **-744.216** | **-1399.08** | **-654.859** |

**<u>The common words' /i/ acoustic space</u>**

| | "-f1" | "-f2" | "-(f2-f1)" |
|---|---|---|---|
| Speaker 2 | -292.88 | -1888.9 | -1596.02 |
| | -336.915 | -2138 | -1801.09 |
| | -273.168 | -1998.86 | -1725.69 |
| Speaker 6 | -317.857 | -1789.34 | -1471.48 |
| | -238.09 | -2100.67 | -1862.58 |
| | -368.255 | -2000.89 | -1632.64 |
| Speaker 4 | -255.84 | -1890.67 | -1634.83 |
| | -260.11 | -1789.4 | -1529.29 |
| | -268.627 | -1999.54 | -1730.91 |
| Speaker 7 | -296.622 | -1500.67 | -1204.05 |
| | -273.324 | -2127 | -1853.68 |
| | -239.27 | -2120.89 | -1881.62 |
| | | | |
| **Average** | **-285.08** | **-1945.4** | **-1660.32** |

## The common words' /u/ acoustic space

| | "-f1" | "-f2" | "-(f2-f1)" |
|---|---|---|---|
| Speaker 2 | -291.374 | -672.565 | -381.191 |
| | -302.816 | -959.53 | -656.714 |
| | -327.924 | -901.15 | -573.226 |
| Speaker 6 | -260.395 | -775.41 | -515.015 |
| | -194.676 | -884.276 | -689.6 |
| | -240.757 | -579.472 | -338.715 |
| Speaker 4 | -247.411 | -623.431 | -376.02 |
| | -293.531 | -723.437 | -429.906 |
| | -342.039 | -860.457 | -518.418 |
| Speaker 7 | -347.543 | -930.663 | -583.12 |
| | -309.947 | -803.057 | -493.11 |
| | -368.245 | -997.245 | -629 |
| **Average** | **-293.888** | **-809.224** | **-515.336** |

The following is the acoustic space of the vowels /a/, /i/ and /u/ in the common words for the female Bangla speakers

## The common words' /a/ acoustic space

| | "-f1" | "-f2" | "-(f2-f1)" |
|---|---|---|---|
| Speaker 1 | -831.094 | -1627.22 | -796.125 |
| | -863.042 | -1507.27 | -644.23 |
| | -794.574 | -1553.75 | -759.171 |
| Speaker 3 | -743.693 | -1647.69 | -903.997 |
| | -765.924 | -1659.67 | -893.744 |
| | -804.258 | -1534.33 | -730.073 |
| speaker 5 | -813.774 | -1464.48 | -650.702 |
| | -701.805 | -1580.4 | -878.59 |
| | -850.164 | -1589.73 | -739.563 |
| Speaker 8 | -865.835 | -1555.76 | -689.925 |
| | -737.599 | -1682.15 | -944.554 |
| | -843.5 | -1606.41 | -762.913 |
| **Average** | **-801.272** | **-1584.07** | **-782.799** |

**The common words' /i/ acoustic space**

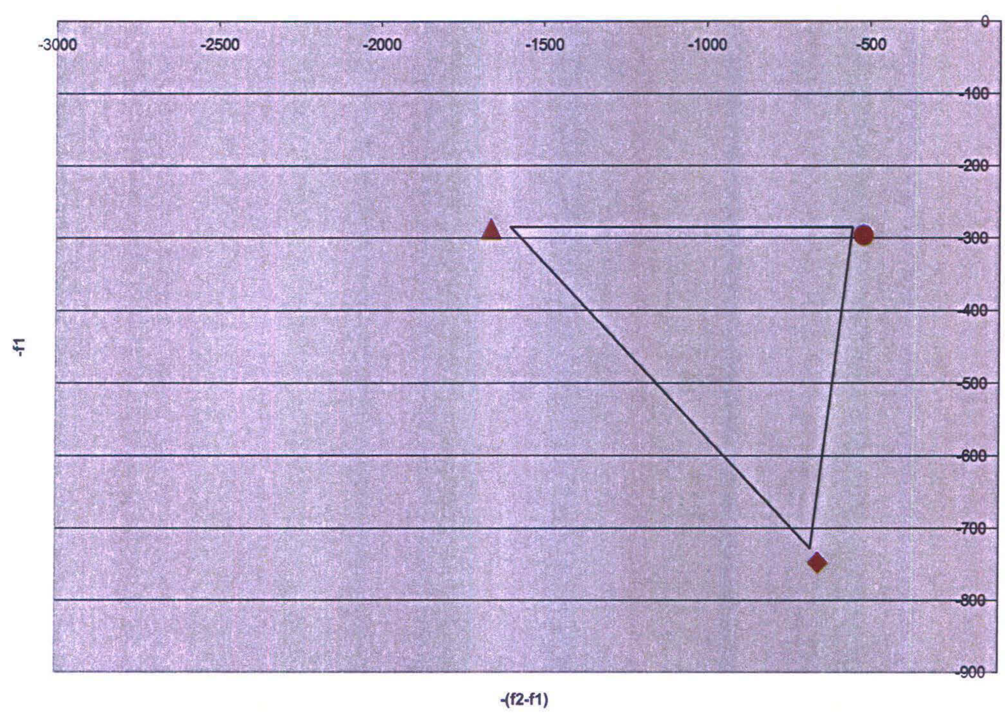
| | "-f1" | "f2" | "-(f2-f1)" |
|---|---|---|---|
| Speaker 1 | -386.692 | -2104.69 | -1718 |
| | -255.885 | -2296.41 | -2040.52 |
| | -287.646 | -2216.58 | -1928.93 |
| Speaker 3 | -332.91 | -2182.64 | -1849.73 |
| | -319.354 | -2300.9 | -1732.7 |
| | -406.273 | -2170.16 | -1763.89 |
| Speaker 5 | -429.678 | -2529.68 | -2100 |
| | -420.423 | -2385.88 | -1965.46 |
| | -309.667 | -2649.54 | -2339.87 |
| Speaker 8 | -433.84 | -2436.5 | -1643.88 |
| | -277.856 | -2105.65 | -1827.79 |
| | -240.772 | -2000 | -1327.94 |
| **Average** | **-341.75** | **-2281.55** | **-1853.23** |

**The common words' /u/ acoustic space**

| | "-f1" | "-f2" | "-(f2-f1)" |
|---|---|---|---|
| Speaker 1 | -278.96 | -926.205 | -647.245 |
| | -271.349 | -883.562 | -612.213 |
| | -271.89 | -874.871 | -602.981 |
| Speaker 3 | -411.125 | -933.177 | -522.052 |
| | -220.623 | -1044.7 | -824.079 |
| | -206.386 | -892.786 | -686.4 |
| Speaker 5 | -400 | -1185 | -785 |
| | -430.089 | -868.126 | -438.037 |
| | -387.743 | -869.541 | -481.798 |
| Speaker 8 | -249.832 | -809.72 | -559.888 |
| | -434.476 | -890.513 | -456.037 |
| | -219.514 | -983.541 | -764.027 |
| **Average** | **-315.166** | **-930.145** | **-614.98** |

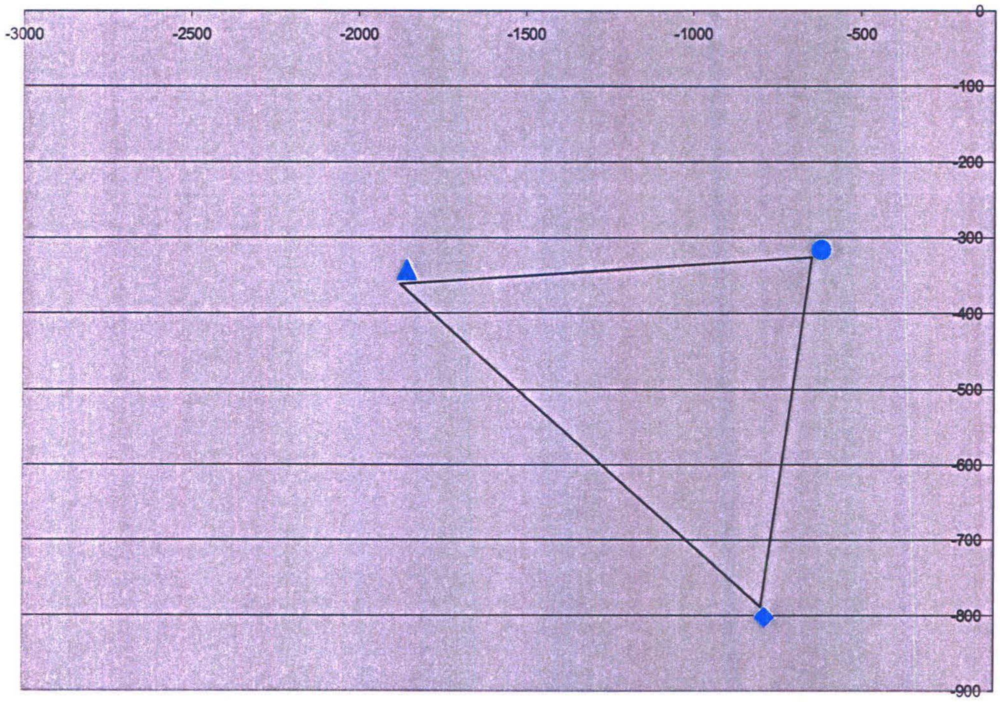
The acoustic space of the words common to Assamese and Bangla in the bilingual Bangla speakers (male):

| Vowel | -f1 | -f2 | -(f2-f1) |
|---|---|---|---|
| /a/ | -744.216 | -1399.08 | -654.859 |
| /i/ | -285.08 | -1954 | -1660.323 |
| /u/ | -293.888 | -809.224 | -515.336 |

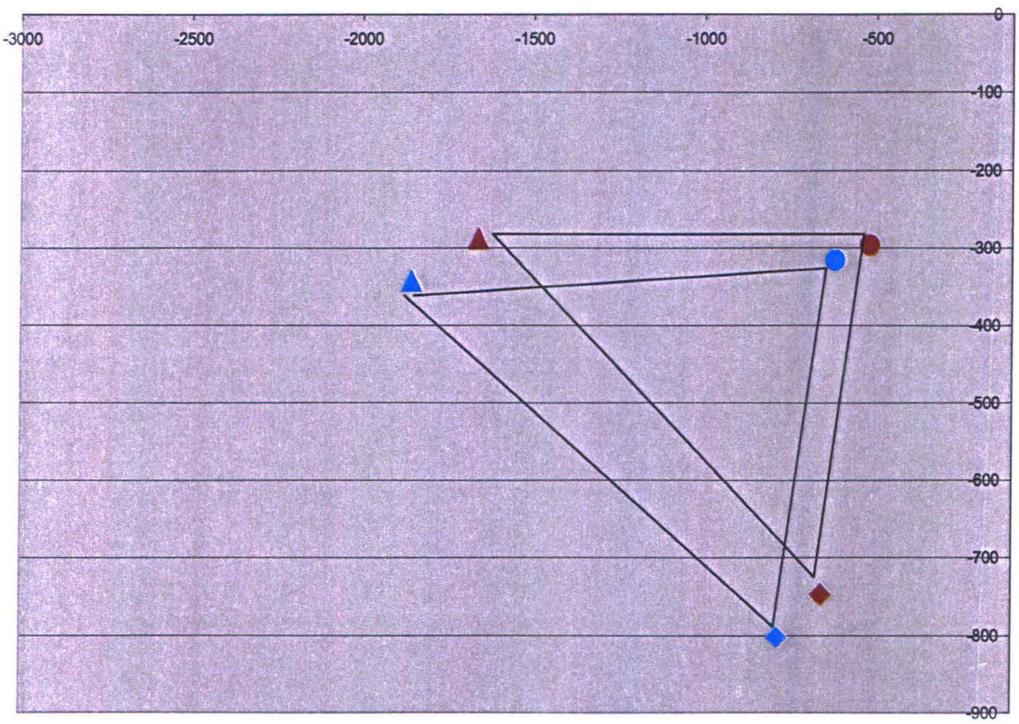


The vowel space of the words common to Assamese and Bangla in the bilingual Bangla speakers (female):

| Vowel | -f1 | -f2 | -(f2-f1) |
|---|---|---|---|
| /a/ | -801.272 | -1584.07 | -782.794 |
| /i/ | -341.75 | -2281.55 | -1853.23 |
| /u/ | -315.166 | -930.145 | -614.98 |

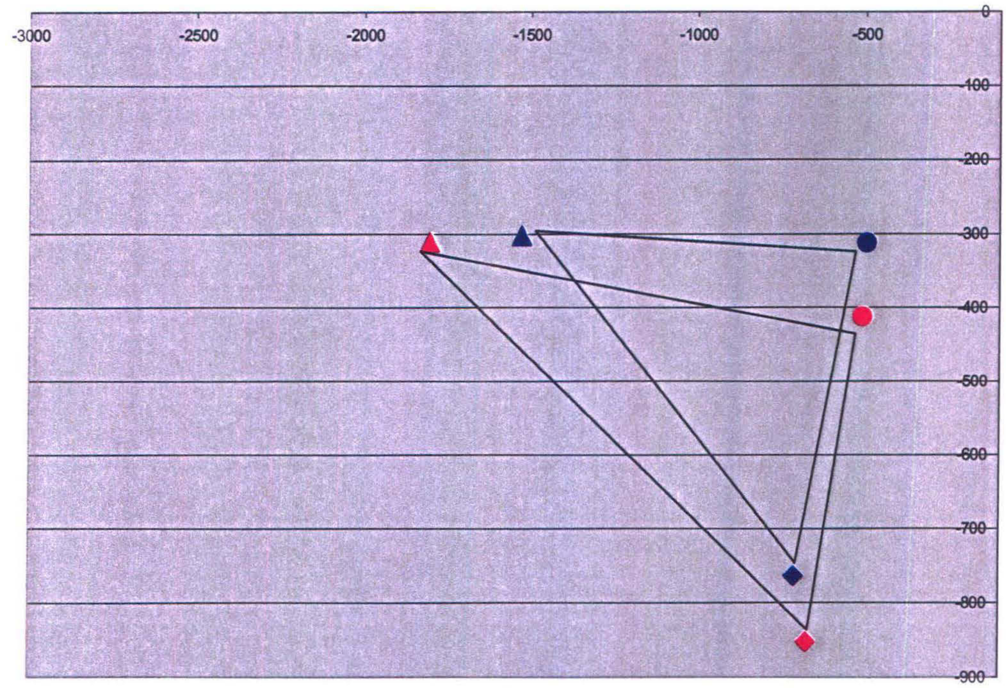


**Vowel space of the common words in the Bangla speakers (male and female)**

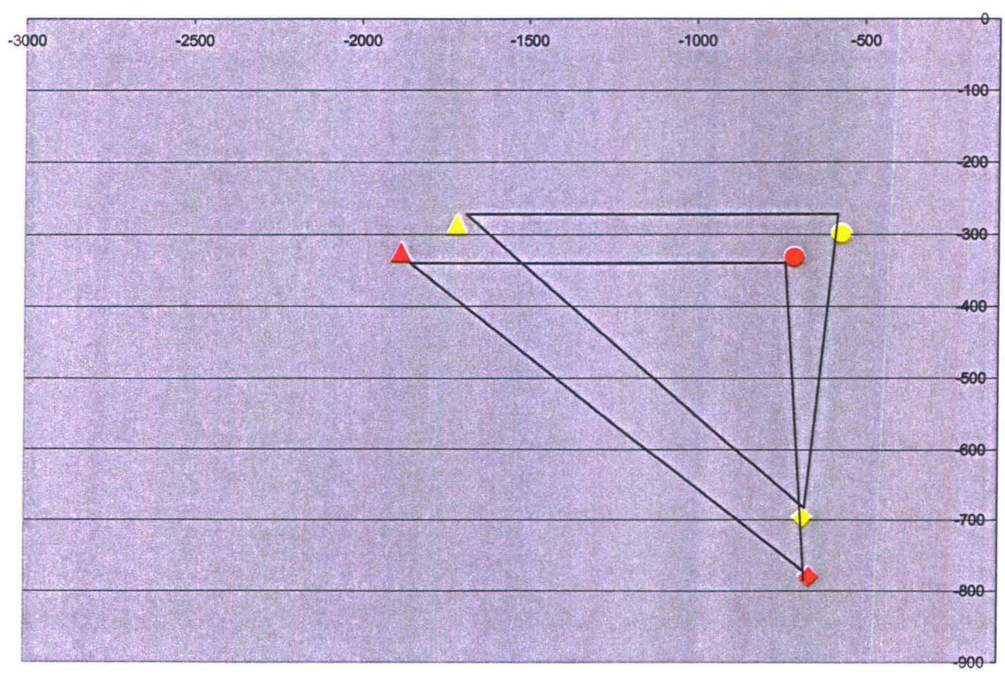



Bangla Male Speakers ♦●▲
Bangla Female Speakers ♦●▲

On the basis of the graphs discussed above we arrive at certain general observations and discussion which have been discussed in the following section.




**The native Assamese vowel space** fig (i)




**The native Bangla vowel space** fig (ii)

The graphs from fig (i) and fig (ii) lead us to the following **native Assamese and native Bangla vowel spaces:**

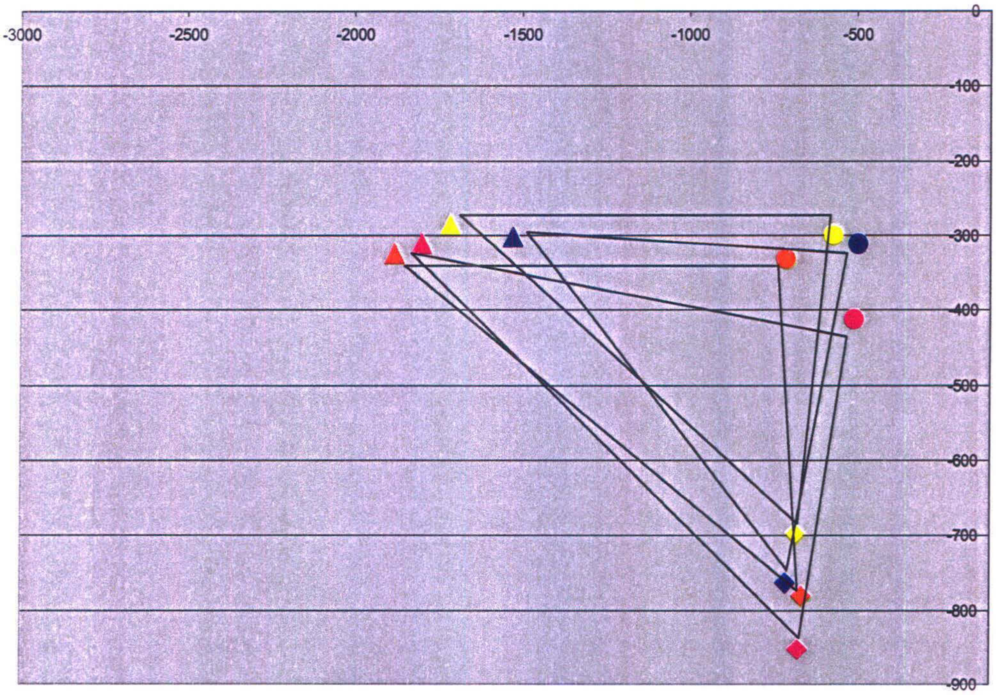



Fig (iii)

Assamese Male Speakers ♦●▲
Assamese Female Speakers ♦●▲
Bangla Male Speakers ♦●▲
Bangla Female Speakers ♦●▲

*Assamese /a/ and Bangla /a/*

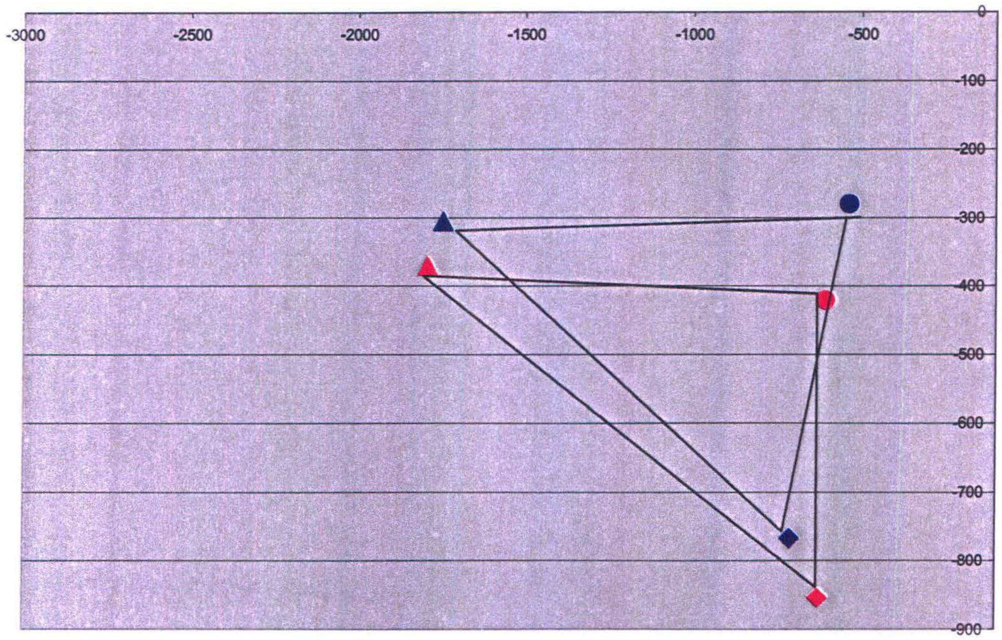
- The Assamese and the Bangla /a/ are in the same positions as far as the front-back criterion is concerned.
- The Bangla /a/ is a little higher than the Assamese /a/, which is more open than the Bangla /a/, in both male and female articulations.

*Assamese /i/ and Bangla /i/*

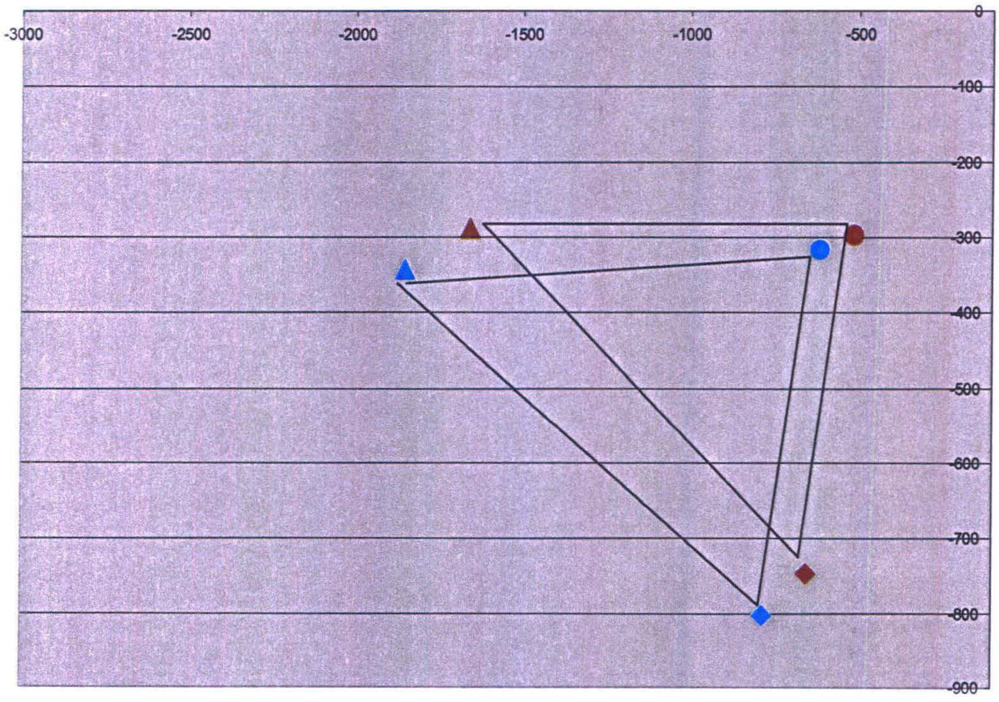
- There is not much difference between the Assamese /i/ and Bangla /i/.

*Assamese /u/ and Bangla /u/*

- Considerable difference between the Assamese and Bangla /u/
- The Bangla /u/ is more centralized especially in female articulations.
- The Assamese /u/ is lower than the Bangla /u/ in both male and female articulations.
- Male articulations are very similar.




**The common words' vowel space in native Assamese speakers** fig (iv)




**The common words' vowel space in the Bangla speakers** fig (v)

Following is the **<u>common words' vowel space</u>** in the native Assamese and Bangla speakers:

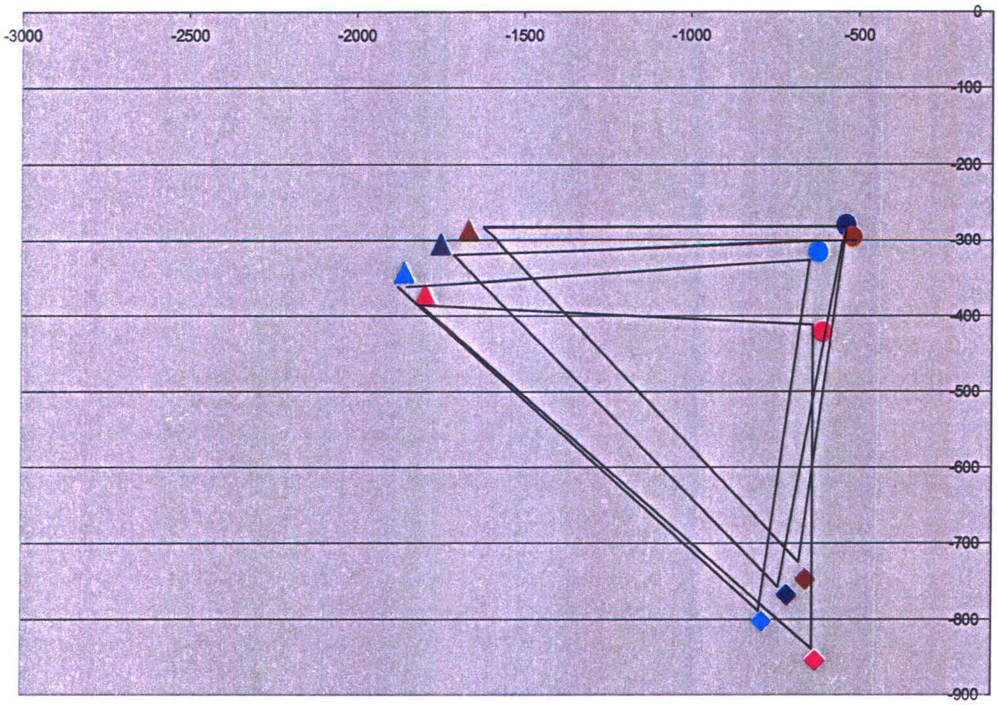



Fig (vi)

Assamese Male Speakers ♦●▲
Assamese Female Speakers ♦●▲
Bangla Male Speakers ♦●▲
Bangla Female Speakers ♦●▲

Common /a/

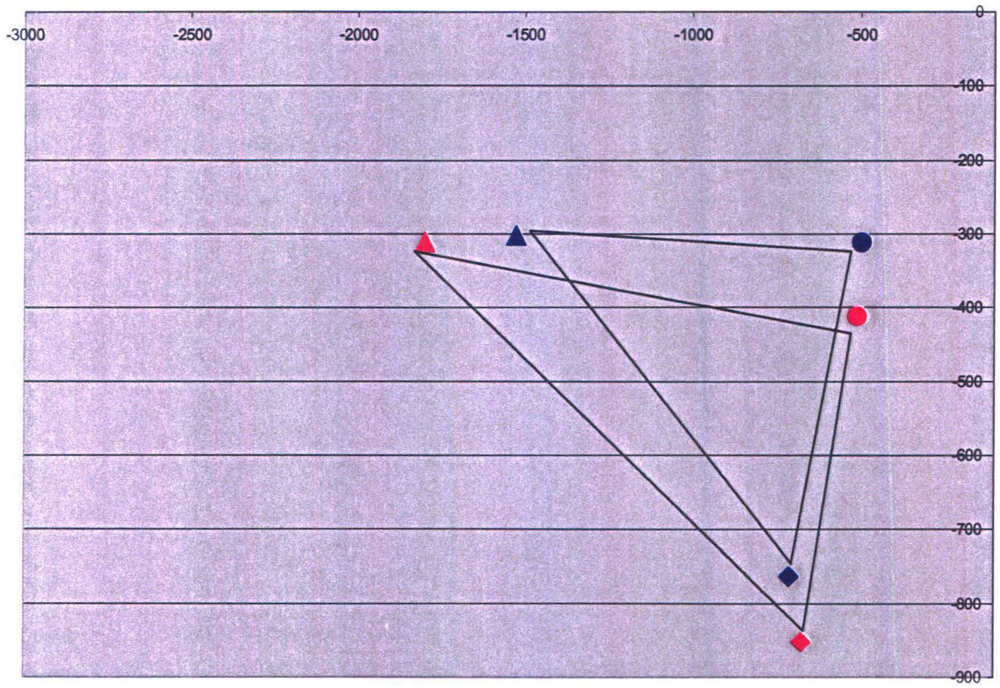
- The common /a/ of Assamese and Bangla speakers are in the same positions as far as the front-back criterion is concerned, except in Bangla females which is more centralized.

Common /i/

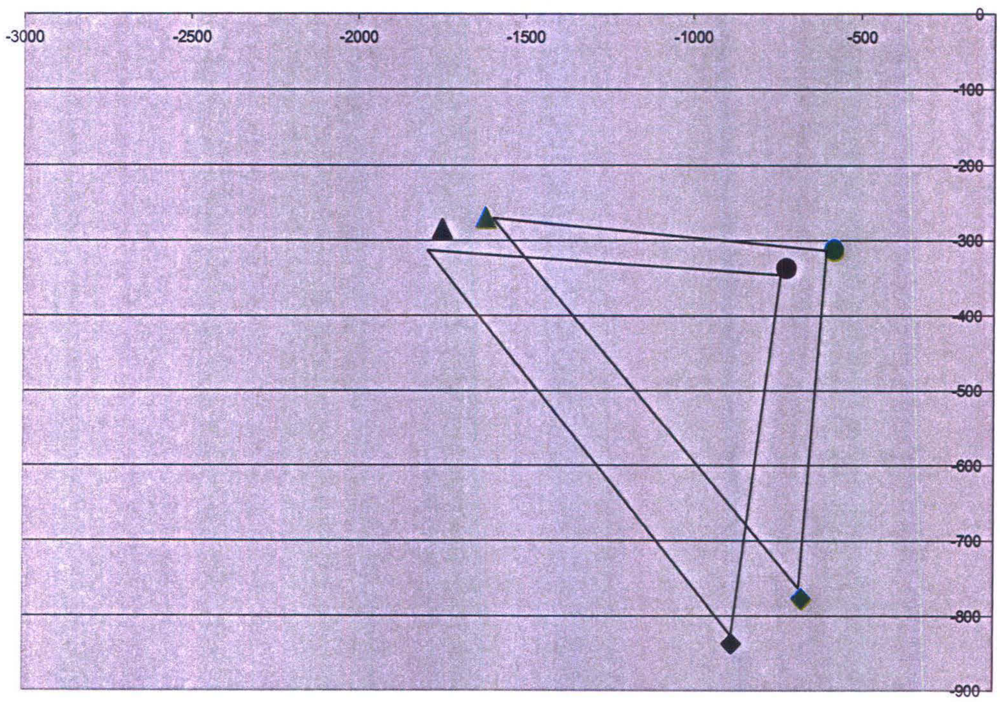
- Not much difference between the /i/ in the Bangla and Assamese speakers except in female Bangla speakers which is more front comparatively.

Common /u/

- The male articulations are almost similar.
- The female articulations are more centralized.




**The native Assamese vowel space** fig (vii)




**The Assamese L2 vowels of the Bangla speakers** fig (viii)

Following is the **Assamese vowel space** by the native Assamese speakers and the bilingual Bangla speakers:

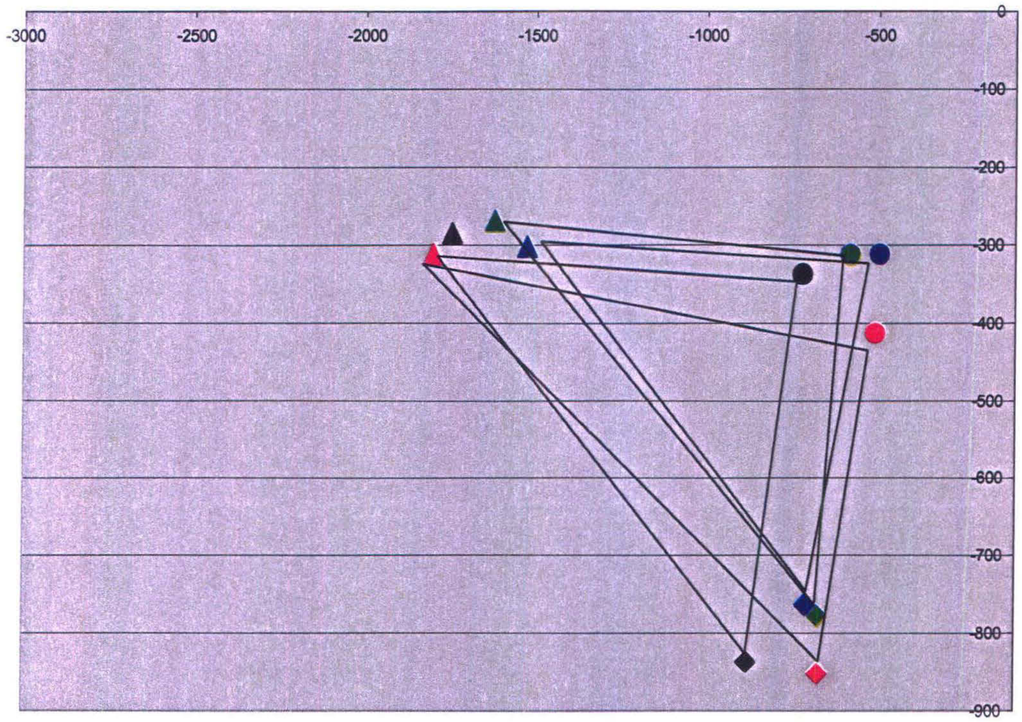



Fig (ix)

Assamese Male Speakers ♦●▲
Assamese Female Speakers ♦●▲
Bangla Male Speakers ♦●▲
Bangla Female Speakers ♦●▲

/a/ in L1 (of Assamese speakers) and L2 of Bangla speakers.

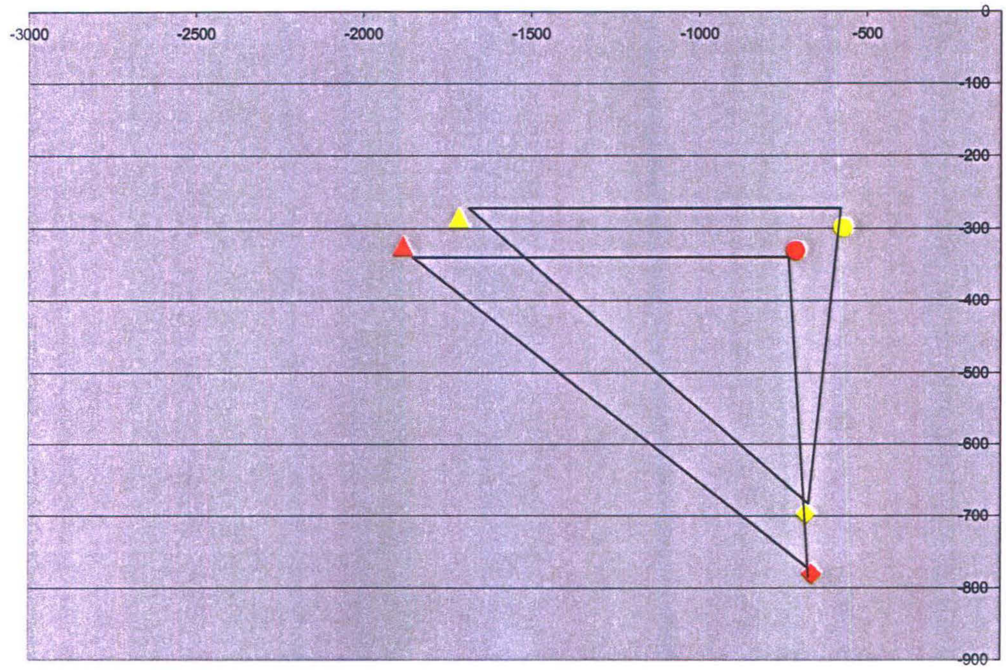
➢ The /a/ in the L1 of Assamese speakers and L2 of Bangla speakers are in the same position in terms of back-front criterion, except for the female Bangla articulation which is a little more centralized.

/i/ in L1 (of Assamese speakers) and L2 of Bangla speakers

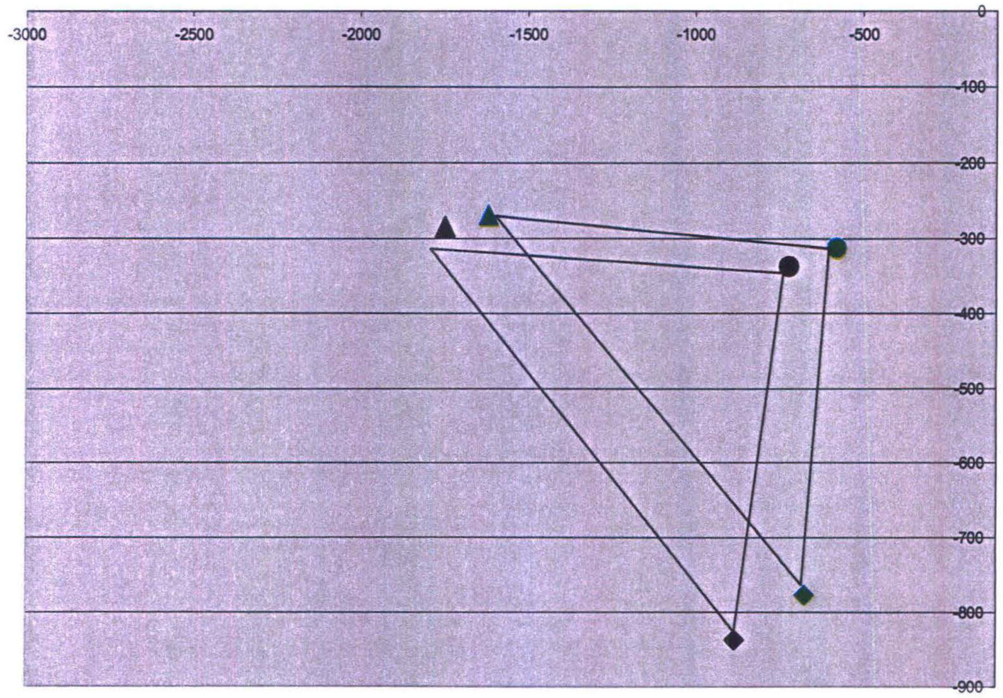
➢ /i/ in the L1 and L2 is identical both in both for male and female speakers in terms of height and backness criterion.

/u/ in L1 (of Assamese speakers) and L2 of Bangla speakers

➢ The /u/ in L2 seems to be more centralized than the L1 /u/ (please refer to fig ii where native Bangla /u/ can be seen)




**<u>Bangla (L1) vowel space of Bangla speakers</u>** fig (x)




**The Assamese (L2) vowels in Bangla speakers** Fig (xi)

**The Bangla (L1) and Assamese (L2) vowel space of Bangla speakers**

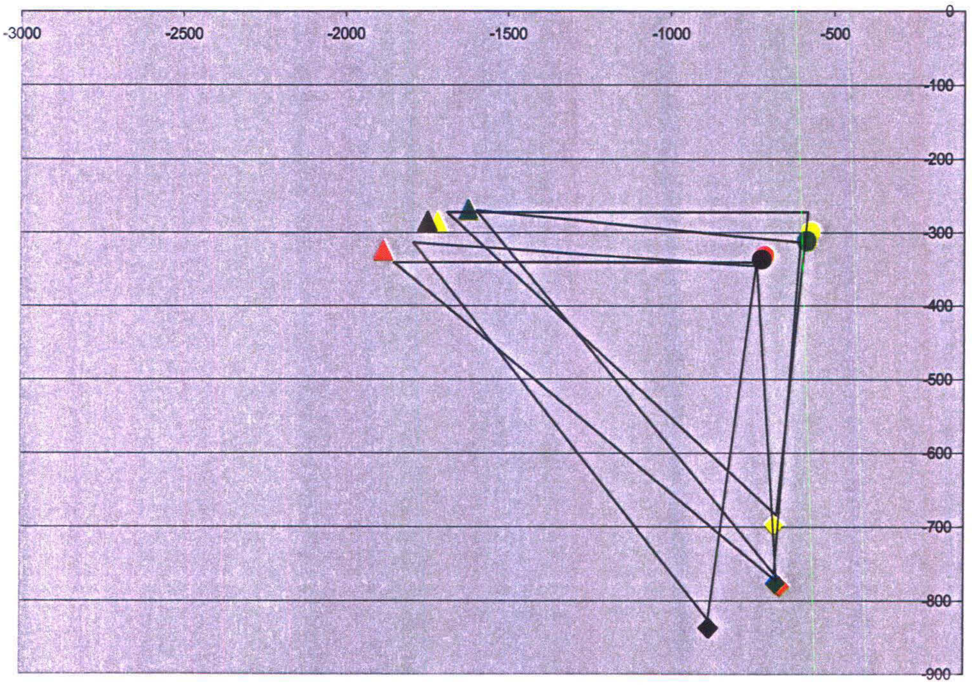



Fig (xii)

Assamese (L2) Male Bangla Speakers ♦●▲
Assamese (L2) Female Bangla Speakers ♦●▲
L1 (Bangla) Male Bangla Speakers ♦●▲
L1 (Bangla) Female Speakers ♦●▲

/a/ in Assamese (L2) and Bangla (L1) of the Bangla speakers.

- More centralized in the female Bangla articulations.
- /a/ in L2 (Assamese) and L1 (Bangla) are exactly the same.

/i/ in Assamese (L2) and Bangla (L1) of the Bangla speakers.

- /i/ in L2 (Assamese) and L1 (Bangla) are the same for both male and female speakers.

/u/ in Assamese (L2) and Bangla (L1) of the Bangla speakers

- Assamese (L2) and L1 (Bangla) of female Speakers are the same.
- Assamese (L2) and L1 (Bangla) of male Bangla Speakers are also the same. This shows that the L2 /u/ is exactly like L2 /u/ of Bangla speakers.

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## SUMMARY AND CONCLUSION

The current study was undertaken with the purpose of testing the following hypothese:

- The three peripheral vowels /i/, /u/ and /a/ help define the acoustic space of the vowels in the repertoire of a speaker in terms of their formant patterns.

- In the case of bilinguals, this acoustic space gets redefined as indicated by the changing formant patterns in comparison with those of the monolingual speakers.

- The hypothesis that one would like to test by means of acoustic data is that, this acoustic space in the L1 and L2 is modified gradually as the learning of a second language progresses( here Bangla as L1 and Assamese as L2 of the native Bangla speakers).

As a part of the current study I was required to conduct a field word in Guwahati, Assam. Two sets of speakers were selected in order to conduct the study. The first set of speakers comprised of 2 male and 2 female native Assamese speakers and the second set of speakers were 4 male and 4 female native Bangla speakers with Assamese as their Second Language. All the informants are aged between 18-25 years and are in different stages of graduation. The socio-economic status is more or less constant as they belong to middle class families. Three separate lists of words were prepared. The first consisting of Assamese words with the vowels /a/, /i/ and /u/ in the three word positions. The second consisted of Bangla words with the vowels /a/, /i/ and /u/ in the three word positions. And the third list consisted of words common to both the two languages, Assamese and Bangla with the vowels /a/, /i/ and /u/ in the three word positions. The Assamese speakers were asked to read out the list of Assamese words and common words. The Bangla speakers were asked to read out all the three lists of words. A spectrographic study of the three vowels /a/, /i/ and /u/ for every speaker is carried out using Wave Surfer software.

This spectrographic analysis helps us in deriving the formant values are every vowel (particularly f1 and f2 and the difference between these first two formants). Thus, the –f1, -f2 and – (f2-f1) values are all three vowels in all the three word positions for all the twelve informants are calculated. Then the average values of each vowel are taken out for the male and female speakers separately which helped us to arrive at the graphs that have been shown in the last chapter on data analysis.

From the graphs we arrive at the following observations:

**From fig (iii)**

*Assamese /a/ and Bangla /a/*

- The Assamese and the Bangla /a/ are in the same positions as far as the front-back criterion is concerned.
- The Bangla /a/ is a little higher than the Assamese /a/, which is more open than the Bangla /a/, in both male and female articulations.

*Assamese /i/ and Bangla /i/*

- There is not much difference between the Assamese /i/ and Bangla /i/.

*Assamese /u/ and Bangla /u/*

- Considerable difference between the Assamese and Bangla /u/
- The Bangla /u/ is more centralized especially in female articulations.
- The Assamese /u/ is lower than the Bangla /u/ in both male and female articulations.
- Male articulations are very similar.

**From fig (vi)**

Common /a/

- The common /a/ of Assamese and Bangla speakers are in the same positions as far as the front-back criterion is concerned, except in Bangla females which is more centralized.

Common /i/

- Not much difference between the /i/ in the Bangla and Assamese speakers except in female Bangla speakers which is more front comparatively.

Common /u/

- The male articulations are almost similar.
- The female articulations are more centralized.

**From fig (ix)**

/a/ in L1 (of Assamese speakers) and L2 of Bangla speakers

- The /a/ in L2 (Assamese) of the Bangla speakers are more centralized for both male and female articulations.

/i/ in L1 (of Assamese speakers) and L2 of Bangla speakers

- The /i/ in L2 seems to be identical both in male in female articulations in terms of height and back-front criterion.

/u/ in L1 (of Assamese speakers) and L2 of Bangla speakers

- The /u/ in L2 is more centralized.

**From fig (xii)**

/a/ in Assamese (L2) and Bangla (L1) of the Bangla speakers.

- More centralized in the female Bangla articulations.
- /a/ in L2 (Assamese) and L1 (Bangla) are exactly the same.

/i/ in Assamese (L2) and Bangla (L1) of the Bangla speakers.

- /i/ in L2 (Assamese) and L1 (Bangla) are almost the same.

/u/ in Assamese (L2) and Bangla (L1) of the Bangla speakers

- Assamese (L2) and L1 (Bangla) of female Speakers are the same.

- Assamese (L2) and L1 (Bangla) of male Bangla Speakers are also the same.

Thus from the above observations we can conclude that:

1) **The Bangla speakers with Assamese as their second language do not maintain a distinct vowel space for both the two languages. They merge with each other** ( as seen in fig xii)

2) **The vowel space of their second language (Assamese) shows mixed features of Bangla as well as Assamese which is indicative of the fact that there is the lack of native like competence in the second language although the speakers have been exposed to both the two languages for an equal duration of time (18-25 yrs)** (as seen in fig iii)

3) **Thus, in the case of the bilingual Bangla speakers, this acoustic space of their Assamese (second language) gets redefined as indicated by the changing formant patterns in comparison with those of the monolingual Assamese speakers.**

In my dissertation I have tried to study the acoustic space of the native Bangla speakers with Assamese as their Second Language. Given the paucity of time I could arrive at some interesting observations. However, this work can be further expanded by studying more speech samples from a larger number of speakers. The vowel duration of the Assamese and Bangla languages is another area for potential research. Even the prosodic features of both the two languages will contribute in making this an exhaustive study. I sincerely hope that my study will benefit the language teachers in Assam who are teaching Assamese as a second language to the native Bangla speakers resided there and in the long run facilitate a better quality of bilingual education in the state. I also hope that this study will lead to a better understanding of the acoustics of speech in general and of Assamese and Bangla in particular.

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