UNIVERSITY OF EDUCATION, WINNEBA

ACOUSTIC CHARACTERISTICS OF FRICATIVES IN ASANTE, BONO AND DENKYIRA DIALECTS OF AKAN

AKUAMAH ABDULAI

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A THESIS IN THE DEPARTMENT OF APPLIED LINGUISTICS, FACULTY OF FOREIGN LANGUAGES EDUCATION AND COMMUNICATION SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES, UNIVERSITY OF EDUCATION, WINNEBA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE MASTER OF PHILOSOPHY (APPLIED LINGUISTICS) DEGREE.

DECEMBER, 2015

DECLARATION

STUDENT‟S DECLARATION

I, AKUMAH ABDULAI declare that this thesis, with the exception of quotations and references contained in published works which have all been identified and duly acknowledged, is entirely my own original work, and it has not been submitted, either in part or whole, for another degree elsewhere.

SIGNATURE: …………………………

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SUPERVISOR‟S DECLARATION

I hereby declare that the preparation of this work was supervised in accordance with the guidelines for supervision of thesis laid down by the University of Education, Winneba.

NAME OF SUPERVISOR:

…………………………………………………………………..

SIGNATURE: ……………………………………….

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"A diligent and grateful heart prompts me to sing thy praise. Thy love and mercies from the start have blessed me all my days" (The SDA Hymnal 639).

On this note I ascribe all my gratitude and appreciations to the Lord Almighty for making this dream a reality. No amount of adjectives can perfectly describe how grateful I am to the Creator for how far He has brought me.

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DEDICATION

I dedicate this Thesis to my parents: Mr. George Nyantakyi Akuamah (father) and Mrs. Margaret Adu Akuamah (mother).

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ABSTRACT

This study investigated the fricatives of Asante, Bono and Denkyira with the aim of establishing the acoustic properties of the fricatives. Three fricatives [f], [s] and [ç] of Asante, Bono and Denkyira were examined in [a, ɛ, ɪ] vowel contexts. Fifteen (15) male and fifteen (15) female speakers between the ages of 20-35 years were recruited for the study. All the fricative consonants were within the scope of prevocalic and intervocalic using CV and CVC syllables respectively. Three parameters were used: Spectral peak location, duration and F2 transition. Various statistical analyses were also carried out to determine the differences and similarities that existed among the fricatives as well as the dialects. The results indicated that the spectral peak location and F2 transition were able to differentiate all the fricatives at their various places of articulation. [f] had the highest spectral peak location frequency, followed by [s] and [ç] respectively. For F2 transition, [f] had the lowest F2 value, followed by [s] and [ç] respectively. Also, the duration of [f] was significantly different from both [s] and [ç] but [s] and [ç] were not significantly different. Duration was not robust in differentiating the fricatives. However, the duration of [f] was significantly different from both [s] and [ç] but [s] and [ç] were not significantly different. The study also discovered that, whenever [s] and [ç] occurred at word-initial position, the Asante speakers produced them with shorter durations than Bono and Denkyira speakers. Again, it was discovered that only the duration of [ç] at word initial position differs in term of gender. Another finding of the study is that males and females differ significantly in the production of the fricatives with females having higher spectral peak location frequency values than their male counterparts.

CHAPTER ONE

INTRODUCTION

1.0 Introduction

This chapter of the thesis presents a brief account of the Akan language, the background to the study, statement of the problem, purpose of the study, research questions, limitations, delimitation and the significance of the study.

1.1 Background to the Study

In majority of the world‟s languages, consonants are combined with vowels in making meaningful utterances. Consonants can be distinguished from one another by the manner in which they are produced. These consonant sounds in one way or the other are characterized by audible hisses, buzzes or clicks. Over the decades, linguists have adopted various techniques in their research with the aim of finding features that differentiate between naturally produced speech sounds. A good number of such researches have paid attention to acoustic signals of how these sounds are produced and transmitted to the hearer. This notwithstanding, the descriptions of the mechanism involved in sound production, especially fricatives, still remains a complex phenomenon to describe (Al- Khairy, 2005).

Fricatives are produced with the generation of audible frication or turbulence in the vocal tract either within a narrow constriction, or when the jet of air created by a constriction impinges on some downstream obstacles, or both. (Nartey, 1982; Fromkin and Rodman, 1983; Ladefoged, 2006; Jones and Nolans, 2007; Lodge, 2009). As a matter of fact, the International Phonetic Alphabets (IPA) provides a larger set of symbols that represent fricatives than other manners of articulation, however, fewer places of articulation are found in many languages than other consonants. According to Maddieson (2005), the Phonological Segment Inventory

Database (UPSID) Survey of the phonological systems of 317 languages revealed that 296 languages, representing 93.4% of the sample, have at least one fricative. Sixty-two (62) languages representing 19.6% languages have pattern models within the UPSID sample to distinguish only two fricatives.

The production of speech articulatory sounds particularly fricatives, are influenced by both intrinsic and extrinsic factors. The intrinsic factors resulting in inconsistency in the acoustic properties of fricatives involve the shape of the vocal tract and the rate of the air movement (Tjaden and Tumer 1997). While their extrinsic factors also include age, vocal tract size, speaking rate and linguistic context (Tabain 2001), a combination of one or more of these factors also gives rise to inconsistency (Al- Khairy, 2005).

In view of the variability in the production of fricatives a number of studies have been conducted with the aim of conducting cross linguistic analyses (Nartey 1982; Gordon, Barthmaier and Sands) and within the same language (Al-Khairy 2005; Padgett and Zygis, 2007; Jones and Nolan 2007, and Nigeriaaki, Botinis and Fourakis, 2013). These works have been successful using some consistent parameters in carrying out appropriate analyses. In general, these studies have recognized acoustic differences between the sibilant [s, z] and non-sibilant [f, v] fricatives, which involve spectrum, amplitude, and duration of the frication noise.

Most acoustic studies on fricatives were done with reference to other languages, especially in English, with few in some Ghanaian languages. Even though there have been efforts to give articulatory and acoustic description of Akan consonants, there is no acoustic study on Akan fricatives. Previous research work generally focused on Akan phonology, morphology and syntax with few studies carried out on acoustics of Akan consonants (see Bosiwah 2008 and Ntiriwa, 2011).

However, many linguists have conducted studies on acoustic structures of fricatives worldwide. Most of the research works like Al-Khairy (2005), Gordon et al (2000) Jongman, Wayland and Wong (1998) and Jongman, Wayland and Wong (2000) examined the acoustic (physical) properties of fricatives at the word-initial and word-medial positions. These studies have concentrated on measurements-noise duration, spectral shapes, spectral peak location, amplitude and second formant transition from the fricative into the following vowel. The measurements were successful in describing the physical properties of the fricatives at the various places of articulation at various rates, for example, 83.5% rate for Al-Khairy (2005). Generally, these acoustic analyses revealed that spectral peak location frequencies were higher for labiodentals and interdentals but decreased as the place of articulation moved backwards. Again, the results showed that the physical properties of duration distinguished the fricatives. The acoustic properties also revealed that non-sibilants, generally, had shorter duration than the sibilants. These studies further suggested that F2 transition properties at vowel onset increased in frequencies as the place of articulation moves further back.

The present study investigates the acoustic structures of Asante, Bono and Denkyira fricative consonant sound produced in both word-initial and medial-positions. The measurements - spectral peak location, duration and Second formant (F2) transition used in determining the acoustic properties were taken at three different locations of the fricative consonants. In addition to this, the acoustic properties of the fricatives were compared with reference to gender. Finally, the fricatives of the three dialects, Asante, Bono and Denkyira were compared to find out the similarities and differences (variation) between their acoustic properties.

1.2 The Akan Language

Akan is a Kwa language of Niger- Congo family group spoken predominantly in Ghana and Cote d'Ivoire with over million speakers in Ghana alone (Guerini, 2016). Geographically, Akan is a language spoken by people located between Lake Volta in Ghana and River Bandama in Côte d'Ivoire (Atlas on Regional Integration in West Africa, 2006). The language is made up of many dialects, which are distinct in terms of accent but are mutually intelligible. In a broader sense, these dialects are classified into the Fante and Twi dialects (Abakah, 2005 and Boadi, 2009). Fante dialect, according to (Boadi, 2009), is spoken along the coast between Sekondi-Takoradi in the Western Region and Accra in the Greater Accra Region of Ghana. The sub-dialects that make up the Fante variety include Gomoa, Ekumfi, Nkusukum, Iguae, Breman and Agona. The Twi variety, on the other hand, is made up of such dialects as the Asante, Akuapem, Wasa, Akyem, Kwahu, Assin and Bono (Bosiwah, 2008). Some ethnic groups such as the Aowin, Sehwi, Nzema, Ahanta and Guans like the Effutu, Awutu, Anum, Kyerepong and Larteh use Akan as their second language (Abakah, 2004; Bosiwah, 2008 and Dolphyne, 1988). See appendix A for the language map of Ghana.

The 2010 population and housing census by the Ghana Statistical Service put the percentage of native Akan speakers alone at 47.5%. Aside this, many non-native speakers use the Akan language as their second language, making it the most spoken indigenous language in Ghana. According to the 2000 population and housing census, Asante constitutes 14.8% of the entire population of Ghana as against Fante, 9.9%, Bono 4.6%, Akyem 3.4% , Akuapem 2.9%, Kwahu 1.9, Wasa 1.4%, Ahafo 1.1%, Assin 0.8 and Denkyira 0.5%.

Asante, Akuapem and Fante are the main dialects that have acquired literary status. Literatures are available in these dialects which are studied as core subjects at the primary school and the Junior High School levels, and as elective subjects at Senior High School and tertiary levels.

In recent times, Akan has been the leading language that is used in most of the electronic media houses, especially FM stations in Ghana. Akan, particularly the Twi dialect, serves as a language for trade in most parts of Ghana, and "several million people use it as a second language" (Bendor-Samuel, 2012, p.1).

1.3 Statement of the Problem

A lot of progress has been made in the study of Akan language, especially in the field of Phonology, Morphology, Syntax, Semantics and Sociolinguistics. Nonetheless, there has been a lacuna in the field of acoustic phonetics as compared to articulatory description of sounds of the language. The acoustic description of Asante, Bono and Denkyira (Twi) fricatives are relevant because any systematic difference between any two language groups or even a dialect within the same language must be essential for the language teacher (Akpanglo-Nartey, 2008). Bosiwah (2008) carried out experiments, in this field of phonetics by examining acoustic analyses on Akan nasals. Ntiriwa (2011) also followed their footsteps by comparing Akan stops to Gadangme and Ewe stops using their acoustic properties. Despite these moves, much work needs to be done in the acoustic description and investigation of the language. For this reason, the researcher saw it as a challenge and decided to examine the acoustic characteristics of fricatives in Asante, Bono and Denkyira dialects of Akan in order to support the efforts of linguists towards the development of the language by providing alternative ways of describing the facts of articulation.

1.4 Purpose of the Study

The purpose of the study was to give an acoustic description of Twi fricative consonants within the scope of prevocalic and intervocalic using CV and VCV syllables. The purpose of this method was to examine by means of spectrographic analyses the spectral peak location, duration and second formant transition to define the acoustic properties of [f, s, ç] as used in Twi.

1.5 Research Questions

This study was guided by the research questions below.

1. What are the acoustic characteristics of the fricatives [f, s, ç] of Asante, Bono and Denkyira?
2. What are the dialectal similarities and differences in the acoustic properties of the fricatives in Asante, Bono and Denkyira?
3. What are the gender differences in the production of fricatives?

1.6 Limitation

The major challenge which militated against the study was that some of the participants were not co-operative. This was addressed by explaining the motive behind the study. In some instances, some participants were paid for the services they rendered. Also, it was difficult getting a soundproof environment to carry out the recordings.

1.7 Delimitation

The study was centred on the acoustic characteristics of Akan fricatives [f, s, ç] in relation to their different places of articulation. The phoneme /h/ was not considered in this study partly because most studies exclude it since it is classified as a "voiceless counterpart of abutting vowel." Jongman, Wayland and Wong (2000, p. 1252). Linguists such as Ali, Spiegel and Mueller (2001), Jongman, Wayland and Wong (1998) and Ladgofed (2006) also excluded it from their studies on fricatives citing the similar reason. At the preliminary stage of the study, the spectrogram for /h/ was seen not to be stable across the word position. At the word-initial position, it was realised as voiceless. However, when it occurred at the word-medial position, /h/ was often realised as breathy voice. It was also observed that there was no voicing bar for /h/ on the spectrogram. Actually, /h/ tends to take the spectral characteristics of the surrounding vowels making it difficult to be identified on the spectrogram. These observations supported the claims made by the some phoneticians that /h/ is a voiceless form of the surrounding vowels.

The spectral shapes, spectral peak location, frication duration and F2 vowel transitions will be used for this study. These cues are chosen because they have been proved to be effective in distinguishing voiceless places of articulation in other languages.

Also, the study only considered three dialects of Akan, namely: Asante, Bono and Denkyira. Therefore, the general name Twi used in the study is a cover name referring only to Asante, Bono and Denkyira. These dialects were selected because it was anticipated that the speakers in such communities use the fricatives sounds appropriately as required for the research.

1.8 Significance of the Study

The outcome of this study will be useful as far as the documentation of Twi dialect of Akan language in linguistics is concerned. In addition, it would serve as a reference for further studies on issues related to acoustic study of fricatives of Akan and other speech work in the language. Thus, it will serve as a source of written material for teachers, students and linguists in general. Finally, it is anticipated that this study will provide alternative ways of describing Twi consonants, particularly fricatives.

1.9 Organization of the Study

The study is organized into five chapters. The first chapter introduced the study, the Akan language, aims and objectives of the study. The chapter further presented the statement of the problem, purpose of the entire work, limitation, delimitation and organization of the chapters of the work. The second chapter reviewed relevant literature to the study. This review included the theory underpinning the study of fricatives. This same chapter discussed gender and speech production. The third chapter discussed methods used for the data collection and analyses. The fourth chapter also presented the data and the results of the study. The chapter 5, which is the final chapter, provided the summary of the study which is treated under the following sub-headings: summary of findings, discoveries, recommendation and conclusion.

1.10 Conclusion

This chapter discussed the general overview of the study. It provided information about the background of the study, the statement of the problem, a brief background of Akan and the objectives of the study. It also looked at the research questions that guided the study, delimitation and limitations of the study.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter discusses the review of related Literature within the scope of language study. It also reviewed the acoustic studies on fricatives in other languages specifically relevant to the present study.

2.1 Theoretical Framework

This study is based on the source-filter theory of speech production. Al-Khairy (2005) posits that fricative production is best described within this theoretical framework. The theory was propounded by Gunnar Fant in 1960:

> The source-filter theory hypothesizes that an acoustic speech signal can be seen as a *source* signal (the glottal source, or noise generated at a constriction in the vocal tract), *filtered* with the resonances in the cavities of the vocal tract downstream from the glottis or the constriction (p.12)

This implies that in the production of speech sounds two independent stages and processes are involved. The sound source is either glottal source or noise generated at the narrowing point in the vocal tract. The filter also gives indication of the resonance in the cavities of the vocal tract downstream from the glottis or the constrictions produced by the gestures of the lips, the tip and the body of the tongue or the velum.

In most instances, the filtering of a source spectrum is done by the part of the vocal tract which is in front of the sound source. In other cases such as glottal sources, the filter is the entire supra-glottal vocal tract. Filtering in the vocal tract usually involves some parts of the vocal cavity and occasionally, the nasal cavity, depending on the state of the velum (Mannell, 2008).

A filter is anything that can selectively allow some things to pass through and block others (Mannell, 2008). There are three different kinds of filters (Fry, 1979). A low pass filter permits only frequency components below a specified frequency (cut-off frequency) to pass and reduces or blocks completely frequency components above the cut-off frequency. Also, a high pass filter permits only frequency components above a cut-off frequency to pass unattenuated. A band pass filter is a combination of low pass and high pass filters: it permits frequency components between two cut-off frequencies to pass unattenuated.

Shadle (1990) claims that there are at least two sources in the production of fricative sounds which can be classified as having distinctive spectra. These he identified as wall or surface source and obstacle source. *Wall or Surface source* arises when the pulmonic air impinges on the surface which is almost parallel to its direction, the processes involved in the production of [x] as in "xɔma" *soil* in Toda and [χ] as in "maχar" *he sold* in Hebrew are typical examples. Spectrum of a surface source is characterized by a broad spectrum. *Obstacle source*, on the other hand, results when the airflow is directed against an obstacle that is approximately perpendicular to its direction. For example, the tongue may be grooved to rapt the pulmonic air against upper or lower teeth. This source is used when producing sibilant fricatives; examples are [s], [ʃ], [z] and [ʒ].

The filter-source theory shows articulatory-acoustics relationships. In the production of speech sounds, three main kinds of sound sources are involved. These are quasi-periodic laryngeal voicing source, continuous aperiodic turbulent source and transient aperiodic noise source (Johnson, 2003). Sources which originate from quasi-periodic laryngeal sources are characterized by the vibration of the vocal folds. Examples are vowels, nasals and approximants. Continuous aperiodic turbulent source is also produced at some point along the vocal tract. Majority of sounds produced from this source are voiceless fricatives. The last source which is transient aperiodic noise source is produced at some point along the vocal tract which causes the release burst in voiceless stops (Johnson, 2003).

In the production of voiced fricative consonants, however, both periodic laryngeal source and aperiodic noise generated in the vocal tract are combined (Johnson 2003 and Tserdanelis 2004). Whether it is alone or in combination, these sources act as input for the vocal tract (filter) which modifies the input into different frequency components of the source that passed through the filter. As stated earlier, the source and the filter are assumed to be independent. The implication is that you can modify the output of the vocal folds without changing the vocal tract and the vice-versa.

Fricatives are characterized by turbulence (Heinz, 2011). The turbulent noise sources which characterize the production of fricatives emanate when airflow passing through a narrow channel hits the inert outside air (either in a wider channel or in open space), and begins to move chaotically. When air passes through the constriction, particles of air begin to move irregularly resulting in random fluctuation called aperiodic wave. This aperiodic source is then filtered by the vocal tract.

The theory is designed to describe all factors that are relevant in understanding the production of fricatives. Shadle (1990) suggested that the mechanisms involved in production of sound eventually affect the physical properties of the sound. Therefore, the physical structures (properties) of speech sounds, to large extent, are determined by the processes they go through before their production. Although human beings are not capable of producing carbon copies of their utterances, and again, fricative sounds as we know are the most complex of all the speech sounds (Jesus, 2000), most studies carried out using the source-filter have achieved some levels of consistency in their findings.

2.2 Effects of the Filter in the Production of Sound

The major difference that exists between filter function of a vowel and fricative consonants is attributed to the presence of anti-formants or zeros. Johnson (2003) defines zeros as "frequencies that are not transmitted by the vocal tract but are instead trapped in the back cavity." In other words, the energy trough produced is as a result of the stoppage in vocal cavity which causes the acoustic energy to reduce. Hence "the energy that is diverted „bounces back‟, as it were, into the energy in the airstream" (Lodge 2006, p. 216). This results in an energy valley rather than energy peak. It happens because of the radical narrowing which occurs in the production of fricatives.

No matter the source, the turbulence is modulated by the vocal tract. The front cavity is seen as a half–open tube which acts as the main fitter. Al-Khairy (2005) noted that the spectrum which is the product of filter that displays the effect of the transfer function of the vocal tract depends on the following factors:

> (a) the natural frequencies of the cavity anterior to constriction (poles), (b) the radiation characteristics of the sound leaving the mouth and (c) the resonant frequency of the posterior cavity (zeros) (p.6).

This implies that the transfer function of vocal tract for fricatives mostly depends on the resonances of the anterior cavity. Again, filtering function and poles of high frequency are defined by the length and the size of the vocal tract. Longer anterior cavity always results in lower frequencies. However, constriction which occurs more forward in the mouth generates shorter front cavity that has high resonances.

In the light of the above, Heinz (2011) stated that energy peak for alveolar sounds is approximately around 7500Hz and occasionally, minor energy peak may be located at about 4500Hz. He further posits that post-alveolar fricatives also have energy peak located around 3500-4000Hz. Therefore, pharyngeal fricatives are expected to have a low frequency than their velar counterparts. In like manner, velar fricatives have lower frequencies as compared to the palatal counterparts. Consequently, the further back in the vocal tract constriction occurs, the lower the frequency. In producing glottal fricative [h] there is no constriction in the vocal tract hence, the filtering effect is similar to that of vowel resonant structure.

Sounds which are made with the obstruction taking place in the front of the mouth, like dentals, labio-dental and bilabials, exhibit flatter spectra because there is almost no vocal tract in front of the constriction to filter the sound (Heinz 2011).

2.3 Acoustic Cues to Fricative Place of Articulation

Some related studies are reviewed in relation to the cues adopted for the study namely; spectral peak location, duration and second (F2) transition.

2.3.1 Spectral Peak Location

Jongman, Wayland and Wong (1998) carried out an investigation of the characteristics of English fricatives. Their aim was to find acoustic parameters which would be effective for classifying place of articulation in fricatives. The dimensions used were duration, spectral peak location and amplitude. The participants involved 10 females and 10 males from Cornell University. The eight fricatives of English [f, v, θ, ð, s, z, ʃ, ʒ] were embedded in the carrier frame "say……..again."" The fricatives in the initial position were each followed by the vowels [ɪ, e]. Each CVC token was repeated three times, resulting in a total of 144 tokens per participant. A Bonferroni post-hoc tests revealed that the spectral peak location for alveo-palatal [ʃ, ʒ] were significantly different from that of the other places namely; labiodentals [f, v], inter-dentals [θ, ð] and alveolar [s, z]. Again the results indicated that [s] and [z] were significantly different from that of [f, v] and [θ, ð]. Lastly, the labiodental [f, v] were not significant from the interdental [θ, ð]. Their corresponding frequencies were as follows; labiodental [f, v] 7678Hz, interdentals [θ, ð] 7503 Hz, alveolar [s, z] 6882 Hz and alveo-palatals [ʃ, ʒ] 3712Hz.

On gender, the study discovered that the mean spectral peak location was significantly higher for females at 6809Hz than for males at 6066Hz. The findings suggest that the properties of the spectral peak can provide reliable information about all the four places of articulation for English fricatives despite variations in speakers and vowel contexts.

In a similar study, Jongman et al (2000) investigated English fricatives with the aim of establishing the acoustic properties of the fricatives. They found that all the twenty speakers (ten males and ten females) recorded in vowel contexts showed that all the four places of articulation in English were clearly distinct from one another in terms of spectral peak location. Not only did the spectral peak location differentiate among different places of articulation, but also effective in contrasting those produced at the same place of articulation [ɵ] and [ð] and between [f] and [v]. It was noted that spectral peak location for the labiodentals was 7733 Hz, for dentals 7470 Hz, for alveolars 6839 Hz, and for palato-alveolars 3820 Hz. Spectral peak location thus decreases in frequency as place of articulation moves further back in the oral cavity. Within the spectral peak location it was noted that the mean spectral peak location was significantly higher for female speakers around 6800Hz than for male speakers around 6122Hz. Nonetheless, there was no difference between /s/ and /z/ and between [ʃ] and [ʒ], the differences in spectral peak between [f] and [v] (832Hz) and between [f] and [v] (340 Hz) were significant.

In a study that addresses the acoustic characteristics of American Fricatives, Ali et al (2001) further demonstrated that the spectrum and the intensity of frication are reliable techniques for the identification of the place of articulation of fricative consonants. The study discovered that /s/ has a high –frequency spectral peak and that the lowest spectral peak is located at 4000Hz in approximation.

In a related study, Al-Khairy (2005) noted that one of the earliest attempts to relate the fricative place of articulation to the frequency location of energy maximum in the frication noise was carried out by Hughes and Halles in 1986. In that study, a gated 50ms window of the frication was used in producing English fricatives /f, v, s, z, ʃ, ʒ/. The study showed that for some of the speakers there was a strong energy component situated at a frequency level below 700Hz for voiced fricative spectrums. However, such energy concentrations were completely absent at the same regions for the voiceless fricatives. On the other hand, the differences in places of articulation were found to be correlated "to a certain extent, to the location of the most prominent spectral peak." (Al-Khairy, 2005; p.15)

Reetz and Jogman (2010) state that modern findings suggest labio-dentals [f,v] have higher spectral peak frequencies close to 8000Hz than interdentals [θ, ð]. Also, alveolars exhibit spectral peak between 4000Hz to 7000Hz. Alveo-palatals, on the other hand, show a mid-spectral peak frequency around 2300Hz to 3500Hz. This further buttresses the point that constrictions which occur at the anterior positions have higher spectral peak frequencies than longer posterior positions such as velar, uvular and pharyngeal fricatives.

Commenting on spectral peak, Adam (2012) stated that literature available on acoustic phonetics show that the voiceless alveolar fricative /s/ displays most frequency peaks within 3500-5000Hz range and 2500-3500Hz. He discovered through a research on the difference in acoustic patterns between Broca aphasics and normal speakers that, spectral peak for alveolar /s/ was lower for the aphasic participants than for the control participants. The spectral peak location for the aphasic subject was located between 480-1090Hz while that of the normal participants was approximately between 4680-8000Hz.

Furthermore, Lee (2011) investigated sibilant fricatives of Mandarin Chinese. Fricatives [s̺, ş, ç] were examined in the vowel contexts /a, i, u/. The findings indicated that /s/ had the longest spectral peak and amplitude at higher frequencies, followed by / ç/ and /s̺/ being the lowest.

In a nutshell, Johnson (2003) suggests that when a change occurs in the frequency of a fricative with regards to the place of articulation, the variation in the frequency is attributed to changes in the filtering effect of the vocal tract, more importantly, changes in the length of the front cavity of the vocal tract. This is the reason why shorter front cavity produces higher frequency of low spectral peak with the exception of those fricatives without front cavity. Moreover, when the front cavity is very short, its lowest resonance frequency is also too high to offer any significant shaping of the noise energy. Accordingly, the spectrum for such fricatives is flat or diffused, without having prominent peaks or valleys (Kent and Read, 1992). Again, spectral peak location for back fricatives shows a formant-like structure similar to the preceding vowel. This general assumption can be accounted for by the source filter theory. Since spectral peak is promising in this regard, the researcher found it helpful for the study.

2.3.2 Duration

Fricatives inherently differ in duration (Akpanglo-Nartey, 1982). Most studies which used this cue indicated that different fricatives have distinct duration. Painter (1970) carried out a study on phonology and grammar in Gonja (a Gur language spoken in the northern part of Ghana). The study revealed that [f] and [s] have longer duration when compared with other consonants. The outcome was in agreement with the generalization that [f] and [s] are almost equal in terms of duration, with [s] relatively longer (Akpanglo-Nartey, 1982).

Duration distinguishes sibilant from non-sibilant fricatives. The findings by Jongman et al (2000) indicated that labiodental [f, v] was 123ms, interdental [θ, ð] was 126ms, alveolar [f, s] was 148ms and palate-alveolar [ʃ, ʒ] was 150ms. A Bonforroni post-hoc test indicated that duration of the sibilant fricatives was significantly longer than that of the sibilant fricatives. There was no significant difference between male and female speakers. However, the gender results that fricatives produced by female speakers (around 139ms) were slightly longer than those produced by the male speakers (around 135).

In the same development, Pincas and Jackson (2004) studied acoustic effects of source interaction in fricative speech sounds. Two speakers (one male and female) with British accents were recorded. The stimuli were put in a carrier frame "What does / / mean?" The eight English fricatives were elicited from the vowel contexts /a, i, u/. Each word was repeated nine times. In all, 2166 tokens were obtained. Recording was done using Beyer-dynamic M59 dynamics microphone linked directly to PC with a Creative Labs Audigy Sound card. Audio captured in mono was sampled at 44.1kHz. Measurements on duration demonstrated that frication duration for voiceless fricatives were longer than the voiced ones. When the trends across place of articulation and the vowel contexts were compared, it revealed a high degree of correlation for all participants for voiceless fricatives. Time for /a/ was appreciably shorter than /i/ and /u/. Also, when labiodental and dental fricatives were compared with alveolar and post-alveolar fricatives, it was obvious that the latter showed significantly longer mean duration.

Jones and Nolan (2007) carried out a study on voiceless fricative of Welsh (a Celtic language spoken in Wales). The study investigated the acoustic characteristics of the six voiceless fricatives place contrasts namely /f, θ, s, ʃ ,ɬ, χ / as produced by native speakers of northern Welsh dialect. Five participants; two males and three females were recorded. The participants were between 15-60 years. The target words were put in a carrier frame /DywadaX hefyd/ "say X also." The results also indicated that / ʃ / and / θ / tend to be the longest fricatives in terms of duration, whereas / ɬ / and /f / had the shortest duration which was in conformity to the average of the group ranking duration.

Gordon, Barthmair and Sands (2008) sought to conduct a cross-linguistic study of voiceless fricatives in seven languages which are considered to be endangered language. The study examined the duration of the fricatives. Duration was measured for [s, ç, ɬ, x, χ, ɬ, f, fʲ, s, ʃ, x, θ] in Gaelic, Aleut, Apache, Chickasaw, Scottish Gaelic, Montana Slish and Toda. Duration was measured for Gaelic fricatives [f, fʲ, s, ʃ, ç, x]. Nine speakers, three females and six males were recorded. The targeted fricatives occurred word initially, preceded by the vowel [a]. It was established that the duration of [s] was relatively longer as compared to other fricatives while [f] had shorter duration relative to the other fricatives.

However, duration was not useful in the identification of acoustic place of location in Chickasaw. In the same experiment, data was collected for fricatives [f, s, ʃ, ɬ] among natives of Chickasaw speakers (7 females and 5 males). The targeted fricatives appeared in either a disyllabic or trisyllabic word following unstressed [i] and stressed [a]. Duration was seen not to be a reliable cue for fricatives at the various places of articulation. However, it was significant in differentiating fricatives produced by the female participants from that of the male participants. It was discovered that the female speakers had a longer duration as compared to their male counterparts. For Western Apache, the fricatives [s, ʃ, ɬ, x] were examined. The findings indicated that duration did not distinguish the fricatives. This was revealed through the pairwise comparison test that was conducted on the results. However, gender difference was significant as female speakers showed longer duration than male speakers.

In Aleut, the fricatives investigated by Gordon et al (2008) were [s], [ɬ], [ç], [x] and [χ]. The outcome suggested that durations of the fricatives differed significantly. Alveolar [s] emerged as having longer duration than [ɬ], [ç], [x] and [χ]. On the other hand, [ɬ] and [ç] had the shorter duration. The study further demonstrated that there was no significant difference between fricatives at word-initial and word-final positions. Again, duration for place of articulation showed [s] at word-final position was significant from [χ] at the same word position. There was no gender difference in the duration of Aleut fricatives. In the fricatives of Montana Salish, however, duration served as a poor differentiator in both places of articulation and gender. In all the fricatives [s, ɬ, x^w, χ, $χ^w$] examined, gender did not affect duration. Within place of articulation, the differences in the fricatives were not significant. The findings in Hupa fricatives, unlike Montana Salish, revealed that [s] had the longest duration in female speakers than their male counterparts.

In Toda, the postalveolar fricative [ʃ] was relatively longer than all the other fricatives. Also, pairwise comparison showed that [f] and [x] were significantly different on the basis of place of articulation. Labiodental [f] and interdental [θ] recorded the shortest durations. Male and female speakers showed equivalence in duration for [f] and [θ]. However, female speakers" duration for [f] was shorter than all the other fricatives.

Patil and Rao (2008) also investigated the acoustic cues for the classification of unvoiced obstructs in Marathi (an Indo-Aryan language spoken by the Marathi people of western and central India). The obstruents were classified as affricates, stops and fricatives. Affricates frication duration was found to be shorter than that of fricatives but longer than that of the stops. Frication duration was identified as an effective cue that can be used to differentiate among the three unaspirated obstruent classes.

Furthermore, Reetz and Jogman (2010) postulate that duration is also an effective technique for distinguishing sibilant from non-sibilant frequencies. They argue that alveolar and alveo-palatal sounds [s, ʃ, ʒ] have longer duration than labiodentals and interdentals [f, v, θ, ð]. He further stated that voiced fricatives have shorter duration than their voiceless counterparts.

Roengpitya (2011), on his part, conducted a comparative acoustic study of English and Thai fricatives to find out the acoustic characteristics of eight English fricatives and two fricatives produced by Thai native speakers. Sixty–seven English and ten Thai words were used. The target words were elicited in framed sentences /phûutkhamwâa….sɔɔkrá/ meaning "say the word that ………two times". In all, 924 tokens were elicited from three female native-Thai speakers in a state university in Thailand. The study revealed that duration which was one of the acoustic parameters used for native-Thai speakers, who were acquiring English as L2, was effective alongside F0 values and the voicing state. He pointed out that the frication duration highly affected the shapes and the heights of the amplitude of fricatives.

In a related study, Kuzla, Chao and Ernestus (2013) sought to address prosodic effects on the duration of and amount of glottal vibration in German word-initial fricatives /f, v, z/ in assimilatory and non-assimilatory devoicing contexts. Fricative duration emerged as a major cue for fortis-lenis distinction in fricatives. Fortis fricatives were longer than lenis ones in German. They postulate that the main phonetic correlate of the fortis-lenis opposition in fricatives is frication noise.

Nirgaianaki, Botinis and Fourakis (2013) also studied perception of the voice distinction in Greek fricatives across different places of articulation. Ten female speakers aged between 20-35 were recruited for the experiment. The six Greek fricatives /f. v, s, z, x, ɣ/ were recorded in real words of the structure CVCV in the context of the vowel / a /. The words were placed in a carrier frame [`pa….ksa `na] (I said ….again). Duration measurements of each fricative and vowel that followed them were taken. The result revealed that noise duration has a significant effect on the fricative. The studies concluded that duration is also crucial in determining voice or voiceless fricatives.

Salgado, Slavic and Zhao (2013) carried out a study on aspirated and unaspirated fricatives of Sgaw Karen (a language in Myanmar and Thailand) to find out how they are produced. They discovered that the duration of the fricatives was longer after high vowel /u/ than after low vowel /i/. Again, they discovered that duration has shown to be significantly higher for stops than fricatives. Finally, the study also revealed that the aspirated fricative has shorter aspirated duration than the aspirated stop. The stimuli which comprises /s, s^h/ had aspirated and unaspirated stops

/p, t, k p^h, t^h, k^h/ as a control stimuli. They were presented in three vowel contexts /a, o, u/. These stimuli were then embedded in the sentence frame, X [ʔime lə-p^hla], where X is the target word for absolute initial while word-medial position [ɟasɔkɔmɔ] X [ʔi me lə-p^hla]. A total of 74 tokens were recorded using a digital recorder which was later uploaded onto PRAAT (5.3.32) for analysis at the sample rate of 22kHz.

In their latest work, Schötz, Nolan and Asu (2014) conducted an acoustic study of the Estonian Swedish lateral [ɬ]. The aim was to unearth whether [ɬ] is a fricative in Estonian Swedish or an [sl] cluster. PRAAT was used for the analysis. In this study too duration was useful since it clearly demonstrated that [ɬ] is more similar to the duration of [s] than that of [l]. This means that in terms of duration, [ɬ] may be considered some form of lateral [s] and this was the basis of distinction between these sounds.

In conclusion, most of the studies have found duration parameter as an important cue in distinguishing between places of articulation of fricatives. The researcher therefore adopted this cue to carry out the acoustic studies on Twi fricatives.

2.3.3 F2 Vowel Transition Cue

Fricatives are sensitive to vowel context. Thus, fricatives tend to differ in their transition in relation to the adjacent vowel sound. F2 transition frequency, according to Ali (2008), refers to the second format frequency taken at the onset of the following vowel, and is considered to correlate negatively with the length of the back cavity immediately after the release of a coronal constriction. This is because the narrowest constrictions starting at the alveo-palatal position anterior to where the lower front cavity resonance crosses the lowest back cavity resonance.

According to Wilde (1995), the size and length of the oral/front cavity are the main factors determining second formant frequency (F2). Furthermore, F2 is connected with the front-back dimension: front vowels have high F2 while back vowels have low F2 (Akpanglo-Nartey 1982, Al-Khairy 2005 and Gordon et al 2008). The formant frequencies decrease through the cardinal vowels (Johnson 2003). The works of Akpanglo-Nartey (1982) and Al-Khairy (2005) demonstrated that the relationship is not straightforward because of the possible effects of lip rounding, which always lowers all frequencies; thus [ɑ] is "backer" than [u] but has higher F2.

In a cross linguistic study of fricatives, Akpanglo-Nartey (1982) revealed that the distinction between /v/ and /ð/ depends on the Second Formant (F2) frequency of /u/, / i/, and / ɛ /. A study also carried on Avatime fricatives also indicates that the vowels following the bilabial fricatives have slightly how F2 values as compare to those that follow the labiodental ones (Nartey 1982). The implication is that in vowel contexts, the transitions of vowel formants are possible cues in identifying fricatives. As Akpaglo-Nartey (1982; p 7) puts it "the farther forward a front fricative is, the low its F2 onset will be". Scholars like Al-Khairy (2005), Gordon et al (2008) and Jongman et al (2000) among others have studied acoustics of fricatives using this cue and have proved to be effective.

Wilde (1995) carried out a study on the analysis and synthesis of fricative consonants. The study focused on the acoustic consequences of fricative production. The data collected were intended to examine acoustic characteristics of fricatives in front, back and unrounded vowel contexts. Three participants recorded were American English speakers comprising of a male and two females. Fricatives targeted were elicited from "CVCV̋CVC nonsense syllables. Eight English fricatives consisting of /f, v, θ, ð, s, z, ʃ, ʒ / and stressed vowels / i, ɛ, ʌ, a, o, u / were used. The speech was recorded using an Altec Omnidirectional and microphone (Model 684A) feeding a Nakamichi tape recorder (Model LXY5). The recording was sampled at 16kHz. F1 onset, F2 onset and F3 onset were used. The results showed the range for F2 onset, was seen to show solid or robust group differences according to vowel context, place of articulation and fricative-vowel interaction. The study demonstrated that F2 onset values were lowest for labio-dentals and successively higher for dentals, alveolars and palate- alveolars. It was observed that the F2 range for the back vowel was consistent with the second resonance being associated with "the cavity behind the primary constriction" (Wilde, 1995, p47).

Jongman et al (2000) also provides similar results suggesting that F2 transition alone at fricative-vowel boundary changes systematically as a function of place of articulation. In a study conducted with the aim of describing acoustic characteristics of English fricatives, the findings indicated that the F2 onset values increased as the place of articulation moved further back in the vocal tract. A post-hoc test showed that the differences between [θ, ð] and [s, z] were not significant. The F2 onset values were obtained as 2334Hz in the context of [i], 1820Hz before [e], 2010Hz before [a], 1710Hz before [u], 1526Hz before [o] and 1512Hz before [a]. Also, F2 onset was significantly higher for [ʒ] which was around 2040Hz than for [ʃ] which was around 1925Hz. F2 onset was higher for females at 1967Hz than males at 1689Hz.

Again, formant transition served as a useful technique in distinguishing between velar and uvular fricatives (see Gordon et al, 2008). The study found that rounded velar [x^w] and uvular [χ^w] in Hupa and Montana Salish have lower F1 and F2 values in their vowel transitions than unrounded uvulars. Also, in Toda, formant transitions were useful in differentiating non-sibilant fricatives [f] and [θ]. The F2 transition values were higher in the vowel preceding [θ] than in the vowel before [f]. However, the difference did not extend to the female speakers. Furthermore, F2 transition values proved to distinguish [ʃ] from other coronal sibilant fricatives in Toda.

Li (2008) examined the phonetic development of voiceless sibilant fricatives in English, Japanese and Mandarin Chinese. The study suggested that onset F2 frequencies vary more according to the context of the vowel. Front vowels /i/ and /e/ have higher frequency values than the back vowels /a/ and /o/. It demonstrated that the F2 onset measures indexes of the length of the back cavity. This according to the research emanated from the fact that the F2 values are taken at the end of the frication and the onset of the vowel, which was largely influenced by the tongue advancement of the vowel. However, F2 transition for /u/ was higher than anticipated, which indicated that the American English /u/ is highly fronted. He concluded that M1 and F2 transition significantly correlated with the tongue posture distinction, with the F2 transition playing more important role than M1 in terms of contrasting palatalization in Mandarin. That is, the palatalization distinction between /s/, /ṣ/ and /ç/. In a related development, Japanese listeners were able to distinguish between /s/ and /ç/. The researcher used this as well as other cues to determine the acoustic characteristics of fricative places of articulation in Twi.

2.3.4 Summary

In nutshell, acoustic studies focusing on fricatives of different languages have shown that cues of duration, second formant (F2) transition and spectral peak location can all serve to distinguish fricatives. They have demonstrated to differentiate sibilants [s, ç, ʃ, ʒ] and non-sibilants [f, v, x, θ, ð,] fricatives. Within the fricatives, male speakers have exhibited lower spectral peak location frequencies than their female counterparts. In addition, [f] was found to be shortest in duration than all other fricatives. No single cue, however, seems enough to distinguish all the fricatives.

Therefore, the present study combines these cues to do acoustic description of Asante, Bono and Denkyira fricatives.

2.4 Gender and Speech Production

The human voice is highly sexually dimorphic (Cartei, Wind, Heidi, and David, 2012). This stems from the level of the vocal tract length adjustments when speaking. The possible articulatory gestures assumed in the production of sounds can be attributed to this phenomenon. Titze (1989) states that "comparison is drawn between male and female larynges on the basis of overall size, vocal fold membranous length, elastic properties of tissue, and prephonatory glottal shape" (p. 1). The female glottis appears to converge more linearly (from bottom to top) than the male glottis, primarily because of medial surface bulging of the male vocal folds. Klatt and Klatt (1990) also associated phonation type with the speaker"s gender: female voices are often considered more breathy than male voices. This subsequently affects the physical (i.e. acoustic) properties of produced sound.

Heine and Narrog (2015) postulate that when the same sound (vowel or consonant) is produced by different speakers, different acoustic realisations emerge due to speaker differences in age, gender, dialect, articulatory setting and other specific characteristics. They further stressed that one factor which contributes to "variable acoustic realization is that speakers differ in the size and shape of their vocal tracts." (p. 2). This tends to affect the resonating cavities that determine the acoustic output due to its size.

Gender differences in male and female voices are connected with complex and multidisciplinary issues. According to Pepiot (2015), not only are they linked with acoustic and perceptual measurements, but to anatomy and physiology, sociology and philosophy as well. Acoustically mean fundamental frequency, which is associated with the perceptual notion of pitch, is mostly considered as the main difference between male and female voices (Pepiot, 2015). Males appear to have lower F0 frequency as compared to their female counterparts. The study also revealed that, vowel formats of females tend to be higher than those of their male counterparts.

Johnson (2003) posits that when different studies on acoustics are compared with format frequencies it would be noticed that cross-gender differences differ from one language to the other. For example, male-female differences are relatively small in Danish but appear much higher in Russian. Also, in a Chinese dialect mean F0 is almost the same for both male and female speakers.

As indicated earlier, differences in human voice have roots in biological sex differences. According to Pepoit (2015), with the onset of puberty, the male larynx is enlarged and vocal folds increase in length and in thickness, resulting in a decrease in frequency (Hz) of vocal fold vibration and thus a lowering of voice pitch. However, he postulates that biologically, females experience about a one-half octave average drop in voice pitch with puberty. Biologically, males tend to experience a full octave average drop in pitch, with the result being that adult male voices tend to operate within a lower frequency range than female voices. Nonetheless, according to him, gendered constructions of the human voice vary widely over time and place.

2.5 Conclusion

This thesis is within the theoretical framework of the filter-source theory of speech production developed by Grunnar Fant in 1960. The theory describes speech production as a two stage process comprising the generation of a sound source, with its own spectral structure which is afterward shaped or filtered by the natural frequencies of the vocal tract. Hence fricatives are produced with narrow constrictions.

From the review, it was revealed that spectral peak location was effective in differentiating the fricatives at the various places of articulation. Additionally, it was obvious that the fricatives that were produced at the interior parts of the vocal tract tend to have higher frequencies as compared to those produced at the posterior parts. Labiodentals [f, v] have higher frequencies than alveolar [s] and alveo-palatal [ʃ]. Duration also tends to increase as the place of articulation moves backwards with the sibilants having higher frequencies than the non-sibilants. This can be attributed to the longer constrictions which normally characterize these sounds. On the other hand, F2 transition is inversely proportional to the spectral peak location as the frequency values increase as the places of articulation move backwards.

The literature also acknowledged the differences in gender as far as the speech is concerned. Females have higher voice pitch than males. This is generally attributed to the fact that males have longer vocal tracts as compared to females.

CHAPTER THREE

METHODOLOGY

3.0 Introduction

This section of the study takes a look at the systematic procedures that were used to collect data. The section discusses the participants, speech stimuli, data collection, data analyses tools (spectrographical and statistical analysis) of the various measurements which were taken.

3.1 Participants

The researcher recorded 30 participants, 15 males and 15 females, who were indigenous speakers of Twi. Ten participants, five males and five females each were recruited from Asante, Bono, and Denkyira dialects of Akan since they fairly represent the majority groups of Twi-speaking Akans. Again, Asante, Bono and Denkyira speakers study Asante Twi as a core subject at the basic level of education. Participants whose ages fall between 20-35 years were recorded because they were the people who were accessible for the recording. The researcher used purposive sampling technique to select the participants since they possessed the information which was elicited for the study. The selection of the participants was done through interview.

Both males and females were selected because of the assumption that there are sex-related phonetic differences. All the participants, with the exception of the ten participants from Denkyira, were undergraduate students from the University of Education, Winneba who have lived in their native places for almost all their lives and have used their indigenous tongue regularly with their parents, siblings and colleagues. This was to ensure that the data collected were truly Twi since their language would not be much influenced by other languages. For the sake of accuracy in the phonetic data, the researcher ensured that the participants did not have any unusual voice or hearing disorder of any kind such as apraxia, dysarthria cluttering, hearing loss among others. This is necessary because any person with some amount of hearing impairment would have some level of speech impairment (Gadagbui, 1998). This was done by asking the participants some few questions on their background before the recordings were done.

3.2 Research Design

This research is quantitative. Quantitative research is grounded on quantity numbers. Citing Creswell (2009) Owu-Ewie (2012), defines quantitative research as; "testing objective theories by examining the relationship among variables. It requires the varying perspective at which numbers are assigned." (p. 3). The definition indicates that, quantitative research deals with theories that need to be tested and proven based on numerical facts.

3.3 Data Design

Speech data of fricatives were designed for Asante, Bono and Denkyira. The targeted sounds (fricatives) were used in monosyllabic and disyllabic words. The targeted sounds occurred at word-initial positions in monosyllabic words. The targeted sounds in the disyllabic words on the other hand were put at word-medial positions. The fricatives at the initial positions were followed by the vowels [a, ɛ, ɪ]. These vowels were selected because of the distribution of [ç]. It only occurs before front vowels. Though such limitation does not affect [f] and [s], using the back vowels would bring about a lot of nonsense words in the production of [ç] which would have been difficult for the participants to read. Also, those fricative consonants at the intervocalic position were put in similar vowel environment [a-a] and [ɛ-ɛ] to ensure consistency. The wordlists comprised real words and "nonsense words." The nonce word was used to check the validity of the real words.

The stimuli which were used in monosyllabic words structured CV and disyllabic words structured VCV, where V is always a vowel [a, ɛ, ɪ] and C represents fricative consonants [f, s, ç]. The assistance of native speakers with linguistic background was sought in the preparation of the speech data of the selected dialects. The English gloss of each target-word was given to guide the participants to elicit the target-word appropriately. Different wordlists were prepared in the selected dialects because of slight pronunciation differences in some of the targeted words, especially that of Bono.

Each of the words was put in a carrier frame. The participants were presented with the prepared words in a carrier sentence, "Ka [key word] bio." (Say [………] again), which were recorded. Sentences containing the stimuli of the Twi fricative consonants were written on a rectangular cardboard for participants to read.

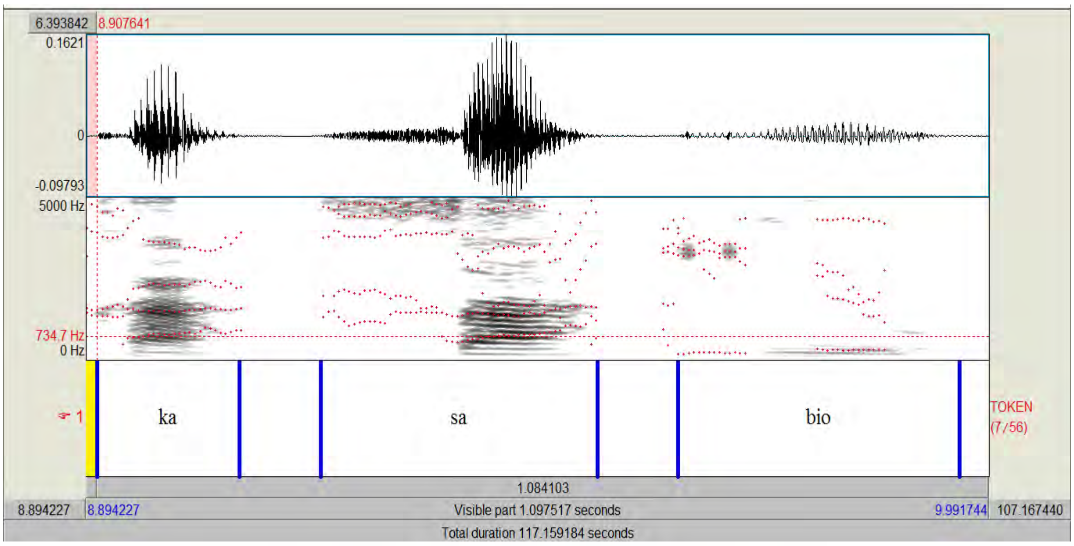
The carrier frame "Ka………bio" in the various dialects is to ensure that, the participants elicit the targeted speech data as it is produced in their dialect accurately. The fricatives were also placed in between vowels for easy and accurate measurement of the frication duration.

3.4 Data Collection

The recordings were done using Window sound recorder with an external microphone to record the audio signal of the words as the participants read from the carrier frames. A Johnstar headphone was connected to Acer Aspire /V5 with screen resolution of 64 bit. Before the recording process began, the researcher explained the motive of the work and the procedures to the participants for them to be informed about the whole process. At least ten minutes were given to each subject to rehearse and familiarize themselves with the stimuli. It was intended to reduce errors and also speed up the recording process. Also, appliances such as fans, air conditions and computers in the laboratory were put off to prevent the microphone from picking ambience sounds.

Afterwards, the participants were made to read out the sentences for recording. In order to reduce if not to eliminate breath of the speaker, the microphone of the headphone was adjusted at a convenient angle position from the month. This was to avoid turbulence from direct airflow striking the microphone. Three filler stimuli were added at the beginning and end of the list to avoid "beginning" and "ending" effects (Akpanglo-Nartey, 2006; Bosiwah, 2008; Salgado, Slacvic and Zhao, 2013). The recordings for Asante and Bono took place at the Centre for Hearing and Speech Services (CHSS), University of Education, Winneba South Campus and for Denkyira at the Statistics Office of the Upper Denkyira West Directorate of the Ghana Education Service, Diaso. The recording procedure was highly monitored to ensure that the production of the tokens elicited were the acceptable version.

The audio speech signals of the participants were then saved and later uploaded, processed and segmented in PRAAT (version 5.4.0.1_win64). A sampling rate of 441000 Hz was used for the analyses. PRAAT was developed by Paul Boersma and David Weenink of the University of Amsterdam. It is a free computer software programme use to analyze, synthesize and manipulate speech into sound wave. PRAAT is a useful linguistic tool that has the basic measurement technique for acoustics of speech signal. This produces a graphic display of a speech sound conventionally called spectrogram (Bosiwah, 2008).



by Figure 1 A waveform (top) and a wideband spectrogram (bottom) of the token "kasa bio" produced Asante male speaker at the word initial position.

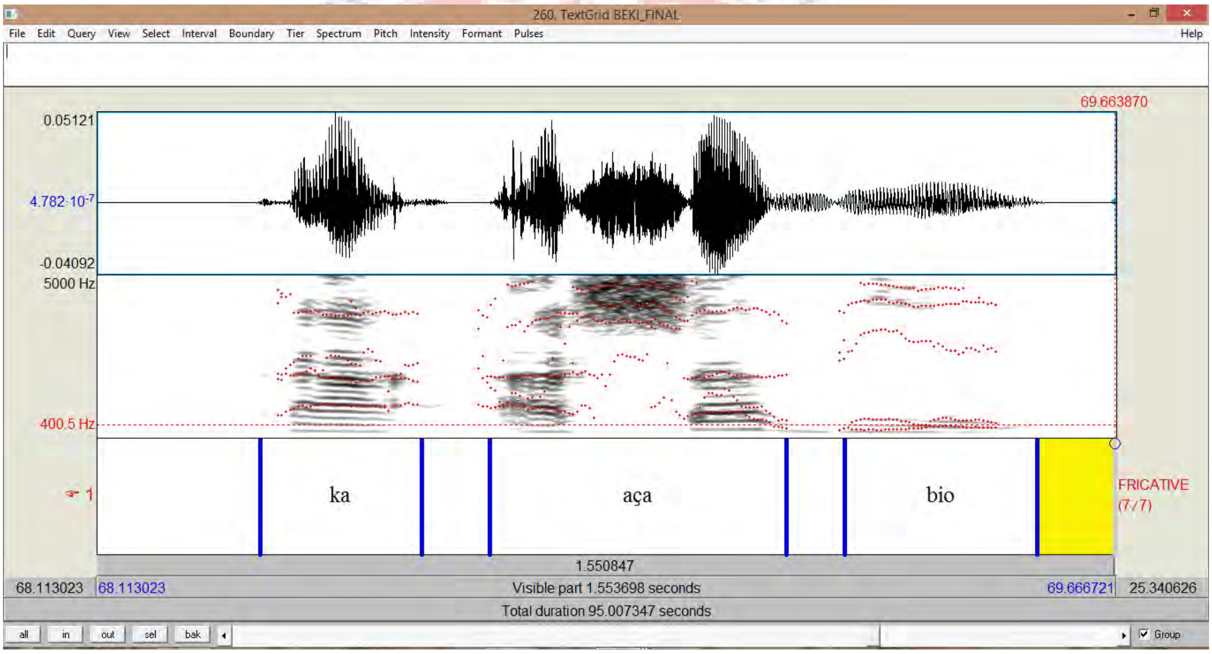


Figure 2 A waveform (top) and a wideband spectrogram (bottom) of the token "ka ahya bio" produced by Bono female speaker at medial postion.

3.5 Acoustic Analysis

All the measurements were done using PRAAT (version 5.4.0.1_win64). Fricatives segmentation took into account both waveform and wideband spectrogram at the same time. For all the fricatives, the onset and the offset were selected. The onset is defined "as the point at which high frequency energy first appeared on the spectrogram and/ or the point at which the zero crossings rapidly increased" (Jongman et al, 2000, p. 873). Offset is also defined "as the intensity minimum immediately preceding the onset of the vowel periodicity" (Jongman et al, 2000, p. 873). The constriction was determined by analyzing the onset and offset of the fricatives noise in the acoustic signal. In cases where it was difficult to identify the onset and the offset of a sound, it was copied into a Microsoft office word and subsequently artistic effect "glow edge" was used to make it more visible and easy to read.

Measurements which were adopted include; Spectral properties spectral peak location, frication duration and F2 vowel transition.

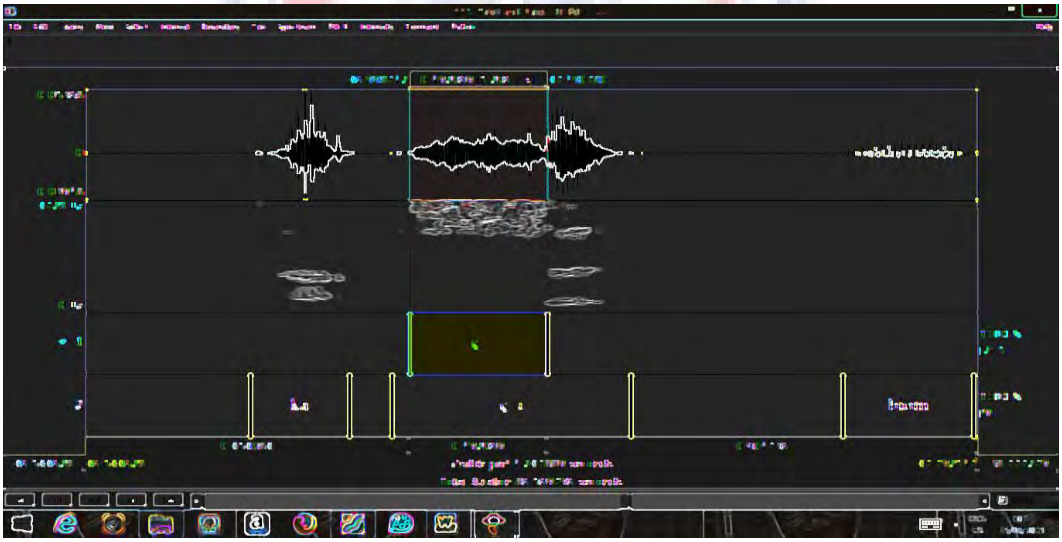


Figure 3 „Glow edges‟ in the Microsoft word used to enhance visibility.

3.5.1 Spectral Peak Location

This study adopts the definition by Jongman et al (2000, p. 1255) of spectral peak which is defined as "the highest-amplitude peak of the FFT spectrum." The peak of each of the fricatives was measured in each of the vowel contexts. The spectrogram was set to display frequency up to 9,000Hz (Morrison, 2006; Bird & Qian, 2009). The

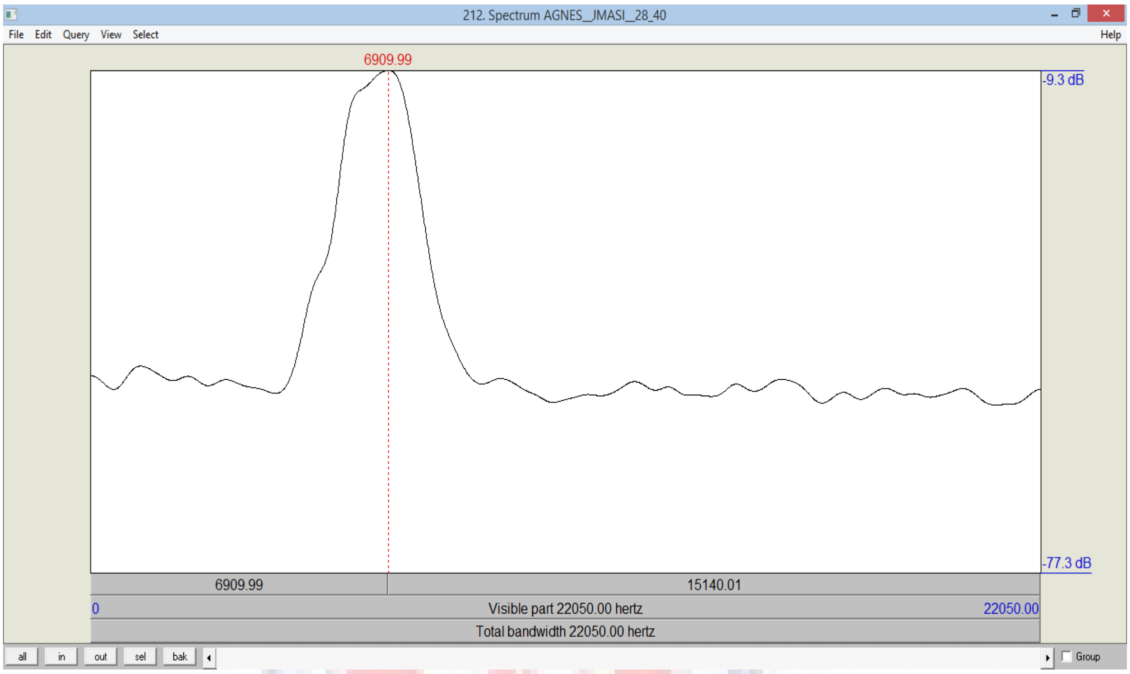


Figure 3.2 showing a ceptrum smoothing of Twi fricative [s] as produced by female speaker and how the frequency values for spectral peaks were taken.

3.5.2. Duration

Duration is defined as the interval between fricative onset and the offset. The measurements were extracted, by enveloping the portion between the onset and offset of the fricatives. The duration was then read and recorded from the bar along the bottom of the Editor window of PRAAT. Figures given in seconds were recorded and later converted to milliseconds for analyses.

3.5.3 F2 Transition

The F2 values of the vowel that comes after each of the fricatives were taken. This was done by segmenting the vowel portions in each of the target words. In order to ensure that F2 values measured were only in target vowel sounds and not in non-target sounds, each vowel segment were manually marked at the onset and offset based on the waveform and wideband spectrogram patterns. After this was done the cursor was placed at the offset of the fricative and onset of the proceeding vowel. Before the recording of the figures, each sound was played back and listened in order to ensure the actual sound was measured.

The second formant transitions of the vowels were used because the vowel phase is sustained through the frication giving an "indication of the position of tongue contact on front-back axis."(Lodge, 2009, p. 191).

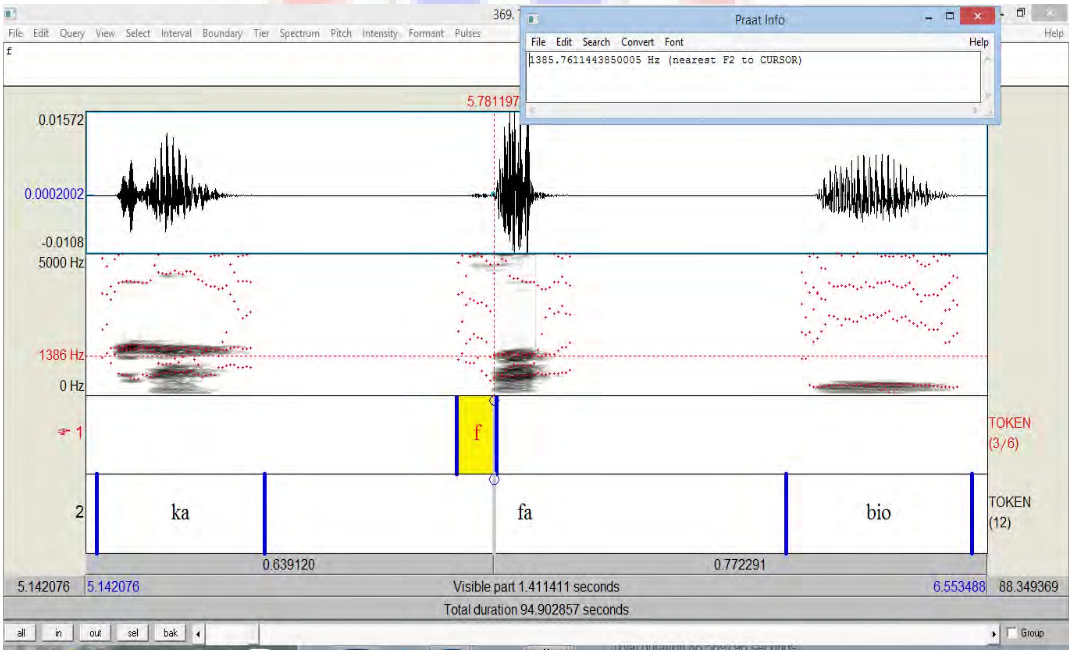


Figure 3.5 A snapshot of spectrogram showing how measurements of F2 were taken

3.6 Statistical Analysis

The researcher used two different statistical tools in analyzing the figures recorded in the study. For the acoustic cues mentioned above, measurements of the significant differences between different places of articulation for these measurements were attained by performing one-way Analysis of Variance (ANOVA) method using Statistical Product and Service Solutions (SPSS). This was to discover the significant relationship between fricatives of the different dialects at different places of articulation as produced at the initial and medial positions respectively. Means of the results were compared to ascertain the similarities and the differences existing among the fricatives of the different dialects.

Also, T-test procedure was used to determine whether the level of differences between the fricatives [f, s, ç] within a particular dialect is statistically significant. It compared the means of the variables for each dialect.

Spectral peak location, duration and F2 transition were analyzed within the parameters of place of articulation, dialect and gender.

3.7 Conclusion

This chapter presented the procedures of the study which comprised the selection of participants, data collection, acoustic analysis of data as well as statistical analysis of spectral peak location, duration and F2 transition. In all three dialects comprising Asante, Bono and Denkyira were selected since these dialects use the fricatives sounds appropriately as needed for the study. The speech data were put in a carrier frame and were recorded from the selected participants and analysed using PRAAT software and SPSS statistical tools. The results of the analyses are presented in chapter four.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.0 Introduction

This chapter presents and discusses all the results of the spectrographic and statistical analyses of Twi fricatives. The findings of the spectral peak location, duration and second formant transition values are presented in tables. Analysis of Variance (ANOVA) tests and Sample T-Tests of the mean values were also analysed and presented in tables.

4.1 Asante Twi

Ten participants, five males and five females (residents of Kumasi) produced prevocalic and intervocalic fricatives in the Asante dialect of Akan. Spectral peak location was measured in order to describe the acoustic properties (structures) of the fricatives [f, s, ç] of Asante. The speakers were between the ages of 22 and 35 years who are native speakers and have lived almost all their lives in Kumasi and could read simple sentences in their language. They were recorded and subsequently analysed using PRAAT and SPSS. The researcher used both tables and figures (bar charts) to present the data. This is because tables summarize the numerical data whiles the bar charts allow the reader to visualize patterns and trends more easily. See Tables 4.1.1-4.1.12 for the results from the analyses and Appendix C for the raw data.

4.1.1 Asante Spectral Peak Location Mean Values

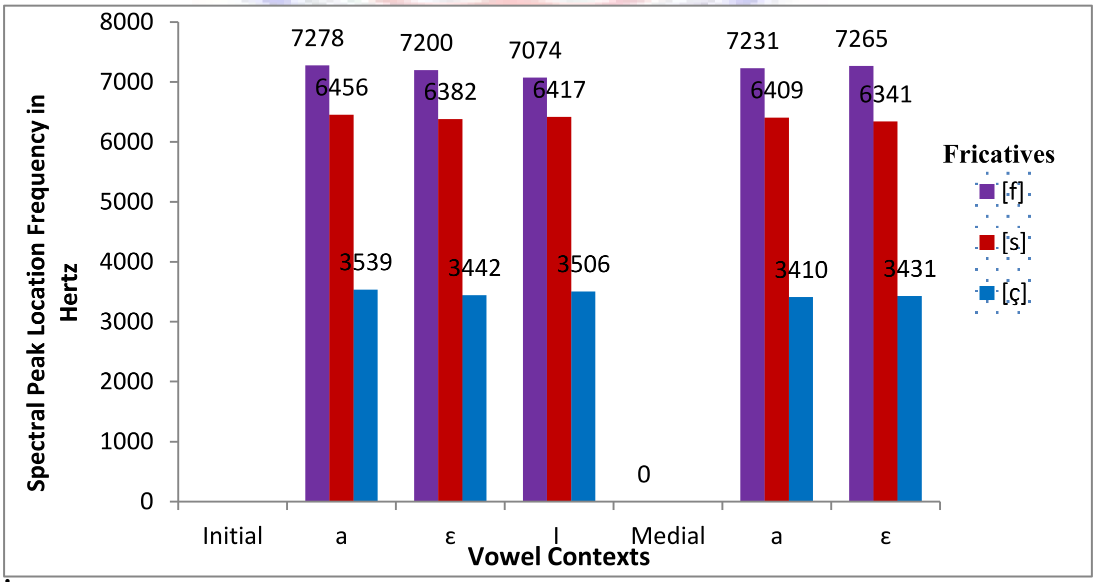
The mean values of spectral peak location recorded for word-initial position in Asante were presented as [f] 7278Hz, [s] 6456Hz and [ç] 3539Hz in the context of [a]. On the other hand, in the context of [ɪ] the values were [f] 7200Hz, [s] 6382Hz and [ç] 3442Hz. Also, [f] was 7074Hz, [s] was 6417Hz and [ç] was 3506Hz in the context of [ɛ]. At the word medial, [f] has 7231Hz, [s] has 6409Hz and [ç] has 3410Hz in the [a] vowel environment. In the [ɛ] vowel context, the results were presented as follows [f] 7265Hz, [s] 6341Hz and [ç] 3431Hz.

When the results were compared it was discovered that [f] had the highest mean values of spectral peak location than [s] and [ç] in all the vowel contexts namely [a], [ɪ] and [ɛ] at both initial and medial positions. This is followed by [s] and [ç] in that order. See Table 4.1.1 and Figure 4.1.1 for the summary of the results and Appendix C for the raw data.

Table 4.1.1 Mean Values of Spectral Peak Location for Asante Speakers at Different Word Positions

			f	s	ç
Asante	Initial	a	7278	6456	3539
		ɪ	7200	6382	3442
		ɛ	7074	6417	3506
	Medial	a	7231	6409	3410
		ɛ	7265	6341	3431

n = 10. Source: Field Data, 201



4.1.1 Bar Charts showing Mean Values of Spectral Peak Location for Asante Speakers at Different Word Positions

4.1.2 Gender Characteristics of Asante Fricatives Using Spectral Peak Location

Spectral peak location mean values of male and female speakers of Asante were computed and analysed (see Table 4.1.2, Figure 4.1.2 and Appendix C for the raw data). The results showed the males‟ spectral peak location of the fricatives for the various vowel contexts at the word initial position. In the environment of [a], the males [f] was 6882Hz, [s] was 6188Hz and [ç] was 3144Hz. Also, in [ɪ]-vowel context, [f] was 6923Hz, [s] was 5810Hz and [ç] was 3051Hz. Again, in the [ɛ] vowel environment the result stood as [f] 6902Hz, [s] 6193Hz and [ç] 3140Hz. At word medial position the results were as follows [f] 6885Hz, [s] 6104Hz and [ç] 3018Hz in the context of [a]. Also, [f] was 6897Hz, [s] was 6140Hz and [ç] was 3008Hz in the context of [ɛ] for males. The female results also indicated that [f] 7675Hz, [s] 6724Hz and [ç] 3934Hz in context of [a]. Also, [f] was 7476Hz, [s] was 6754Hz, [ç] was 3934Hz in the environment of [ɪ]. In the [ɛ] vowel context [f] was 7247Hz, [s] was 6641Hz whilst [ç] was 3872Hz at word-medial position.

The results revealed that the spectral peak location frequency values for Asante males were lower than the females in the initial and medial word positions.

Table 4.1.2 Mean Values of Spectral Peak Location of Male and Female Speakers of Asante at Different Word Positions

			f		s		ç	
Asante			**Male**	**Female**	**Male**	**Female**	**Male**	**Female**
	Initial	a	6882	7675	6188	6724	3144	3934
		ɪ	6923	7476	5810	6754	3051	3832
		ɛ	6902	7247	6193	6641	3140	3872
	Medial	a	6885	7577	6104	6714	3018	3802
		ɛ	6897	7632	6140	6563	3008	3854

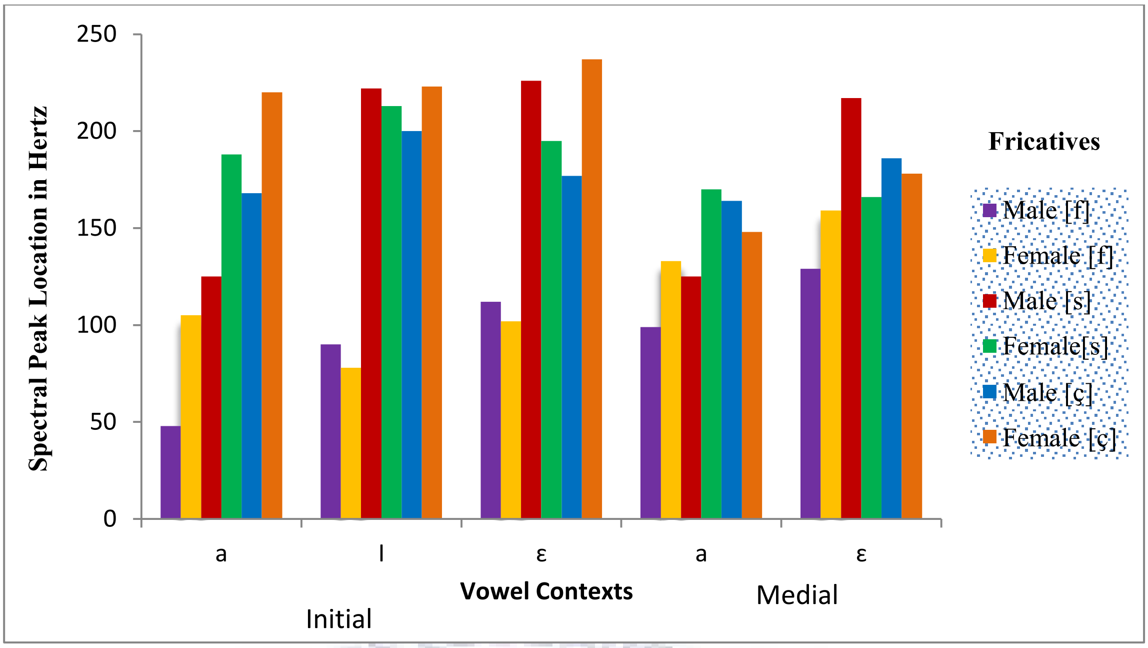


Figure 4.1.2 Bar charts showing Mean Values of Spectral Peak Location for Asante Speakers at Different Word Positions

The spectral peak location values were analysed to ascertain the similarities and differences in terms of gender. A One-way ANOVA was conducted with the significant level set at $p<0.05$. Table 4.1.3 and Figure 4.1.3 gives the detailed results. The results were presented at the initial position as [f] $p<0.00$ (F-value, 60.86), [s] $p<0.00$ (F-value, 30.65) and [ç] $p<0.00$ (F-value, 40.96) in [a] context. [f] $p<0.00$ (F-value, 12.39), [s] $p<0.02$ (F-value, 9.25) and [ç] $p<0.00$ (F-value 51.73) in the [ɪ] context. Also, [f] was $p<0.22$ (F-value, 82.29) in the environment of [ɛ]. At the word medial position the results were also presented as [f] $p<0.00$ (F-value, 87.57), [s] $p<0.00$ (F-value, 13.31) and [ç] $p<0.00$ (F-value, 124.37) in the [a]-vowel context. In the context of [ɛ], the result stood at [f] $p<0.00$ (F-value, 755.84), [s] $p<0.00$ (F-value 27.43) and [ç] $p<0.00$ (F-value 111.48).

The results showed that at the word initial position there was a significant difference between males and females in the production of the fricatives [s] and [ç] with p<0.00 significant level. Nevertheless, males and females did not differ in the production of [f] even though the females had frequencies slightly higher than the males. Moreover, all fricatives [f], [s] and [ç] were significantly different in both male and female speakers in word medial position at significant level of P<0.00.

Table 4.1.3 Differences and Similarities between Male and Female Speakers of Asante

			f		s		ç	
			F. ratio	**p. value**	**F. ratio**	**p. value**	**F. ratio**	**p. value**
Asante	Initial	a	60.86	0.00	30.65	0.00	40.96	0.00
		ɪ	12.39	0.00	9.25	0.02	51.73	0.00
		ɛ	1.78	0.22	21.65	0.00	82.79	0.00
	Medial	a	87.57	0.00	13.31	0.00	124.37	0.00
		ɛ	75.84	0.00	27.43	0.00	111.48	0.00

n = 10. Source: Field Data, 2014

4.1.3 Asante Fricatives at Different Place of Articulation using Spectral Peak Location

In order to determine whether there are similarities or differences in the fricatives of Asante as far as their various places of articulation are concerned, a paired Sample T-Test was carried out. [f-s], [f-ç] and [s-ç] were compared. The level of significance stood at [f-s] p<0.00, (T-value, 13.49), [f- ç] p<0.00 (T-value, 49.08) and [s-ç] p<0.00, (T-value, 47.69) for word-initial position. At word-medial position, the significance level stands at [f-s] p<0.00 (T-value, 13.97), [f-ç] p<0.00 (T-value, 81.19) and [s-ç] p<0.00 (T-value, 36.81).

The results indicated that all the three fricatives were distinct from one another since they were statistically significant at both initial and medial positions. It was found that the labiodental [f] had the highest frequency. The alveolar [s] was also higher than the palatal [ç] at both initial and medial positions. At the initial and medial word positions, [ç] had the lowest frequency.

Table 4.1.4 Paired Sample T-Test on Spectral Peak Location for Asante Speakers

		Fricatives	T- value	p. value
	Initial	[f-s]	13.49	0.00
		[f- ç]	49.08	0.00
Asante		[s- ç]	47.67	0.00
	Medial	[f-s]	13.97	0.00
		[f- ç]	81.19	0.00
		[s- ç]	36.81	0.00

4.1.4 Fricative Duration Mean Values of Asante Dialect

In addition to the Spectral Peak location and Second Format (F2) transition, duration of Asante fricatives at different word positions, as well as gender was analysed. Table 4.1.5 and Figure 4.1.3 showed the results of fricative duration of Asante Twi measured in milliseconds (ms) at different word positions. Refer to Appendix C for the raw data. It was found that at the word initial position, [f] was 112ms, [s] was 165ms and [ç] was 196ms in the context of [a]. In [ɪ] environment [f] was 107ms, [s] was 179ms and [ç] was 219ms, while in the context of [ɛ], [f] was 111ms, [s] was 179ms and [ç] was 189ms. At word medial, [f] was 141ms and [s] was 161ms and [ç] was 171ms in [a] context. Finally, [f] was 152ms, [s] was 172ms and [ç] was 184ms in the environment of [ɛ].

The results also indicated that [ç] had longest duration followed by [s]. Meanwhile, [f] had the shortest duration in Asante. These were the trend for both initial and medial positions.

Table 4.1.5 Mean Values of Duration of Male and Female Speakers of Asante at Different Word Positions

			f	s	ç
	Initial	a	122	165	196
		ɪ	107	179	219
Asante		ɛ	111	179	189
	Medial	a	141	161	171
		ɛ	152	172	184

n = 10. Source: Field Data, 2014.

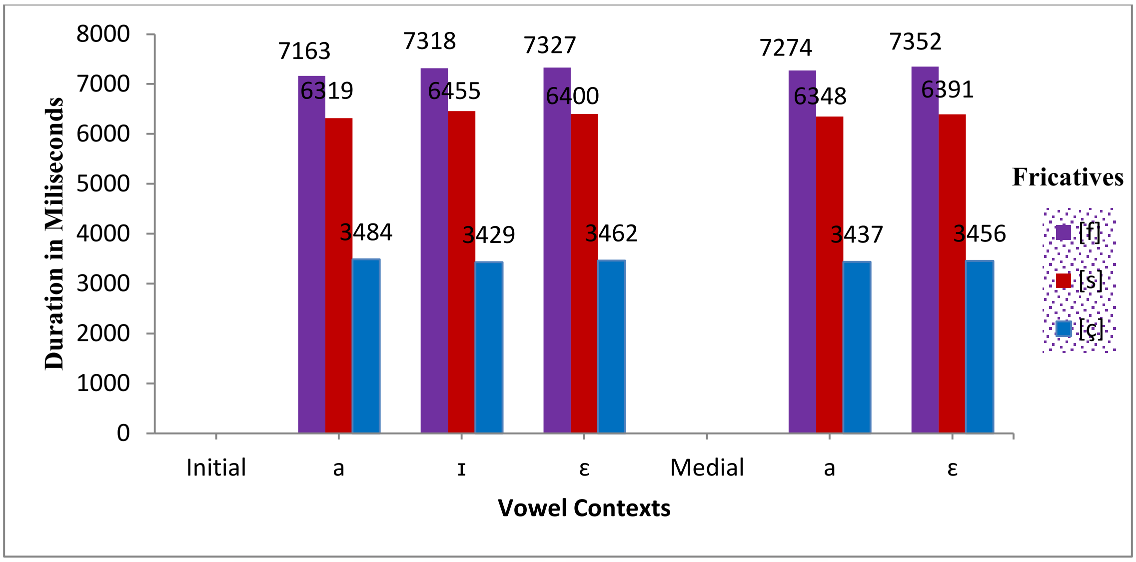


Figure 4.1.3 Bar Charts showing Mean Values of Duration of Male and Female Speakers of Asante at Different Word Positions

4.1.5 Gender Characteristics of Asante using Fricative Duration

The duration of the fricatives were also compared for male and female speakers. For the males, the outcome for word initial shows that [f] was 135ms, [s] was 158ms and [ç] was 224ms in the environment of [a]. Furthermore, the results showed that [f] was 138ms, [s] was 181ms and [ç] was 239ms in [ɪ] vowel context. Still on the initials, [f] was 138ms; [s] was 161ms and [ç] was 201ms for [ɛ] context. At the medial position, [f] was 159ms, [s] 157ms and [ç] 178ms whilst [f] was 172ms, [s] was 158ms and [ç] was 182ms for [a] and [ɛ] respectively.

At the word initial the female results stood as [f] 109ms, [s] 172ms and [ç] 168ms in the context of [a]. Also in the [ɪ] context, the results revealed [f] was 16ms, [s] was 178ms and [ç] was 200ms whiles in the context of [ɛ], [f] was 85ms, [s] was 192ms and [ç] was 177ms. Again, at the word medial position the males had [f] 123ms, [s] 164ms and [ç] 164ms for [a] and [f] 132ms, [s] 186ms and [ç] for 186ms for [ɛ] context. See Table 4.1.7 and Figure 4.1.4 below for the summary and Appendix C for the raw data.

Table 4.1.6 Mean Values of Fricative Duration for Male and Female Speakers of Asante at different Word Positions

			f		s		ç	
			Male	**Female**	**Male**	**Female**	**Male**	**Female**
Asante	Initial	a	135	109	158	172	224	168
		ɪ	138	16	181	178	239	200
		ɛ	138	85	167	192	201	177
	Medial	a	159	123	157	164	178	164
		ɛ	172	132	158	186	182	186

n = 10. Source: Field Data, 2014.

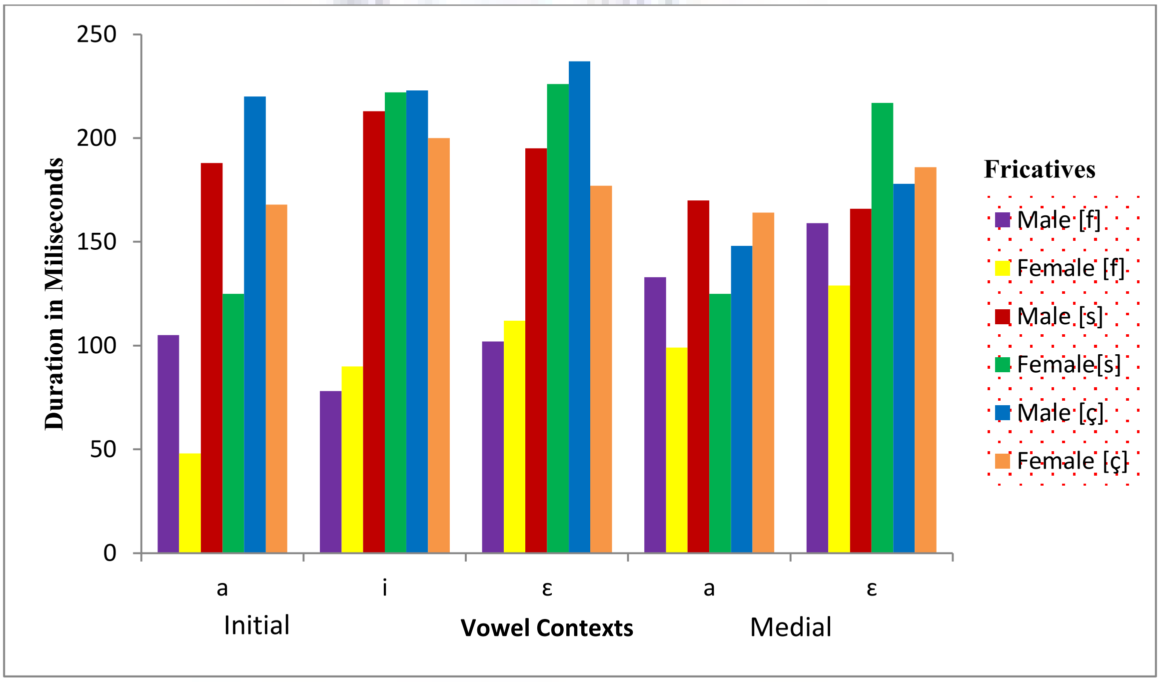


Figure 4.1.4 Bar Charts of Mean Values of Fricative Duration for Male and Female Speakers of Asante at Different Word Positions

Furthermore, the male speakers of Asante Twi were compared to their female counterparts to find out if there were similarities or differences. The results from One-way ANOVA test conducted are presented in table 4.1.8 as follows; initial, [f] was [p<0.05 (F-ratio 5.58); p<0.05 (F-ratio 5.35); p<0.12 (F-ratio3.06)], [s] was [p<0.28 (F-ratio 0.32); p<0.08 (F-ratio 0.06); p<0.05 (F-ratio 5.09)] and [ç] was [p<0.00 (F-ratio 17.04); p<0.00 (F-ratio 14.99); p< 0.10 (F-ratio 3.57)] for [a], [ɛ] and [ɪ] context respectfully. Also, at word medial, [f] was [p<0.33(F-ratio 1.09); p< 0.82 (F-ratio 0.6)], [s] was [p<0.65 (F-ratio 0.22); p< 0.55 (F-ratio 0.09)] and [ç] was [p<0.04 (F-ratio 0.74; p<0.77 (F-ratio 0.09) for [a] and [ɛ] respectively in each fricative.

At the word medial position, duration measures were not found to differentiate the three fricatives of Asante reliably. A one-ANOVA (fricative and gender) pooled over all speakers indicated no significant effect of the fricative on duration measurements at the medial position. However, at word initial both [f] and [ç] did not reach significant level of p<0.05 in the context of [ɛ] for both sexes but they were significant in [a] and [ɪ] vowel contexts. Also, [s] was not significantly different in the environment of [a] and [ɪ] but [ɛ] for males and females.

Table 4.1.7 Differences and Similarities between Males and Females of Asante

	Fricative		**f**		**s**		**ç**	
			F. ratio	p. value	F. ratio	p. value	F. ratio	p. value
	Initial	a	5.58	0.05	0.32	0.28	17.04	0.00*
Asante		ɪ	5.35	0.05*	0.06	0.82	14.99	0.00*
		ɛ	3.06	0.12	5.09	0.05	3.57	0.10
	Medial	a	1.09	0.33	0.22	0.65	0.74	0.42
		ɛ	0.06	0.82	5.30	0.55	0.09	0.77

*p< 0.05. n = 10. Source: Field Data, 2014.

4.1.6 Duration of Asante Fricatives at Different Places of Articulation

Table 4.1.8 presents the result of a Sample T-Test conducted to find out whether the different fricatives differ or not in their duration. This was the detailed results [f-s] p<0.00 (T-value -5.74), [f- ç] p<0.00 (T-value -5.45) [s- ç] p<0.00 (T-value -2.93) for word initial and [f-s] p<0.10 (T-value 1.183), [f- ç] p<0.10 (T-value -1.210) [s- ç] p<0.12 (T-value -1.72) for word medial position.

It was realized that all the fricatives [f], [s] and [ç] had significantly different durations at word initial position with the significant level of p<0.00. Meanwhile the Asante fricatives did not differ at the word medial position for duration. See Table 4.1.8 for the level of significance. It discovered that [ç] had the longest duration in Asante dialect followed by [f] and [s] respectively.

Table 4.1.8 Paired Sample T-Test on Duration for Asante Speakers

		Fricatives	T- value	p. value
	Initial	f-s	-5.74	0.00
		f- ç	-5.45	0.00
Asante		s- ç	-2.93	0.02
	Medial	f-s	-1.183	0.10
		f- ç	-1.210	0.10
		s- ç	-1.72	0.12

4.1.7 Second Formant (F2) Vowel Transition Mean Values of Asante

Table 4.1.10 and Figure 4.1.5 below present the mean values of second formant (F2) transition for Asante speakers. See Appendix C for the raw data. In the monosyllabic words the results showed that the transition from [f, s, ç] into [a] environment as 1427Hz, 1523Hz and 1651Hz respectively. Again, [f, s, ç] into [ɪ] context was 1906Hz, 1904Hz and 1948Hz in that order. Also, the transition from [f, s, ç] into [ɛ] was 1709Hz, 1741Hz and 1766Hz respectively. Moreover, in disyllabic words, [f, s, ç] at the point of transition into [a] environment was 1442Hz, 1568Hz and 1634Hz respectively. Finally, [f, s, ç] into [ɛ] was 1741Hz, 1760Hz and 1771Hz accordingly.

It was discovered that both males and females of Asante dialect displayed F2 onset values that were lowest for labiodental [f] and successively higher for alveolar [s] and alveopalatal [ç] (See Akpaglo-Nartey, 1982 and Wilde, 1995).

Table 4.1.9 Mean Values of F2 Vowel Transition of Male and Female Speakers of Asante at Different Word Positions

			f	s	ç
	Initial	a	1427	1523	1651
Asante		ɪ	1904	1906	1948
		ɛ	1709	1741	1766
	Medial	a	1442	1568	1634
		ɛ	1741	1760	1771

n=10 Source: Field Data, 2014.

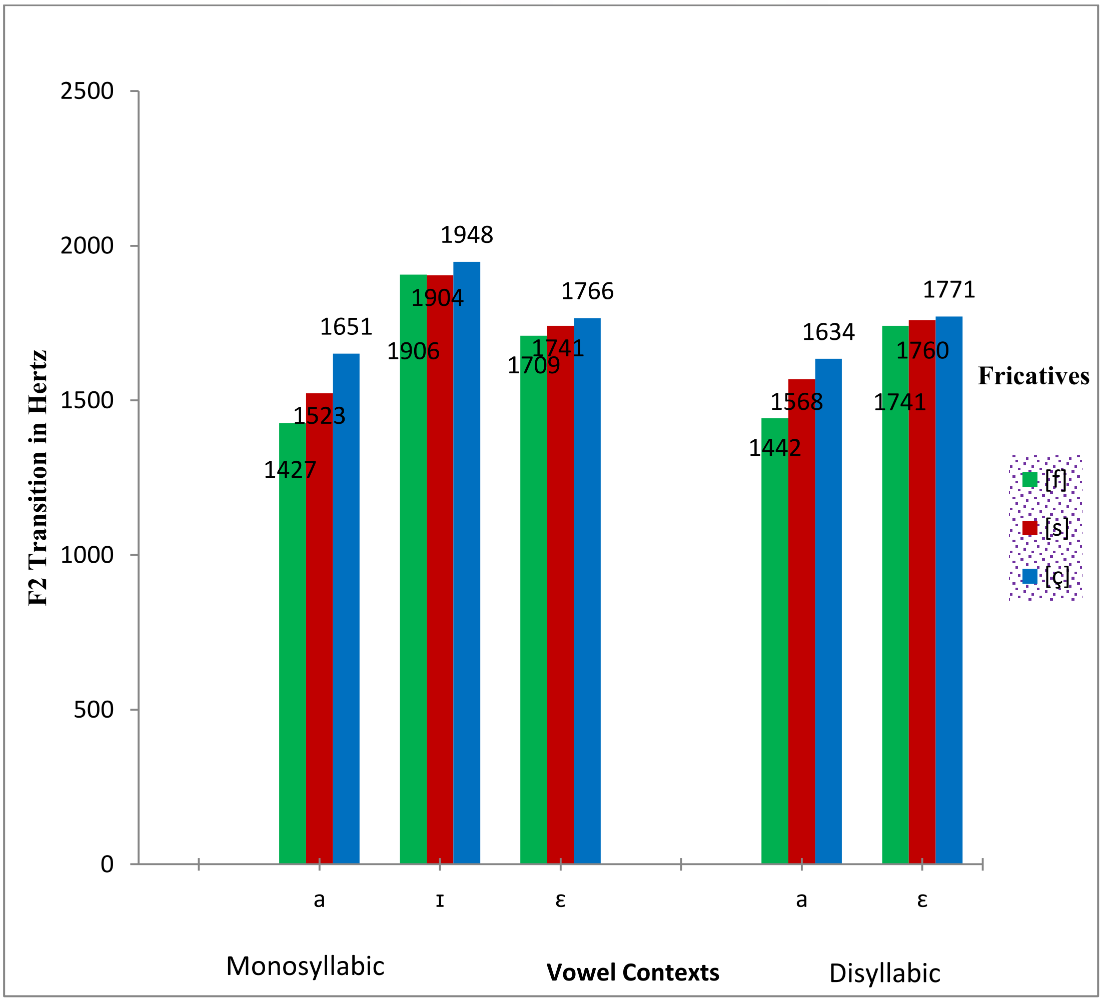


Figure 4.1.5 Bar Charts showing Mean Values of Second Formant Transitions for Speakers of Asante in Monosyllabic and Disyllabic Words

4.1.8 Gender Characteristics of Asante Fricatives Using F2 Vowel Transition

F2 transition values were computed and analysed to determine the gender differences or similarities (See Table 4.3.2, Figure 4.1.6 and Appendix C for the raw data). In the monosyllabic words the results for males were as follows; [f] 1435Hz, [s] 1514Hz and [ç] 1643Hz into [a] environment. In [ɪ] environment also, [f] is 1897Hz, [s] is 1889Hz and [ç] was 1965Hz. Furthermore, [f] is 1674Hz, [s] was 1740Hz and [ç] was 1767Hz in the environment of [ɛ]. Meanwhile, the results for the transition was [f] 1449Hz, [s] 1576Hz and [ç] 1657Hz into [a] environment. In the same way [f] was 1752Hz, [s] was 1540 Hz and [ç] was 1517Hz in the transition into [ɛ].

The mean values for F2 transition from fricatives into the vowels of Asante female speakers were also recorded as [f] 1420Hz, [s] 1532Hz and [ç] 1659Hz in the environment of [a]. [f] was 1915Hz, [s] was 1919Hz and [ç] 19 32Hz in the context of [ɪ]. Again, [f] was 1745Hz, [s] 1743Hz and [ç] 1765Hz at the point of transition into [a]. In the disyllabic words the F2 result was [f] 1434Hz; [s] 1580Hz and [ç] 1610Hz. Additionally, [f] was 1730Hz, [s] 17870Hz and [ç] was 1778Hz in the context [ɛ].

Table 4.1.10 Mean Values of Second Formant Transitions for Male and Female Speakers of Asante in Monosyllabic and Disyllabic Words

			f		s		ç	
			Male	**Female**	**Male**	**Female**	**Male**	**Female**
	Initial	a	1435	1420	1514	1532	1643	1659
Asante		ɪ	1897	1915	1889	1919	1965	1932
		ɛ	1674	1745	1740	1743	1767	1765
	Medial	a	1449	1434	1576	1580	1657	1610
		ɛ	1752	1730	1740	1780	1517	1778

n=10. Source: Field Data, 2014.

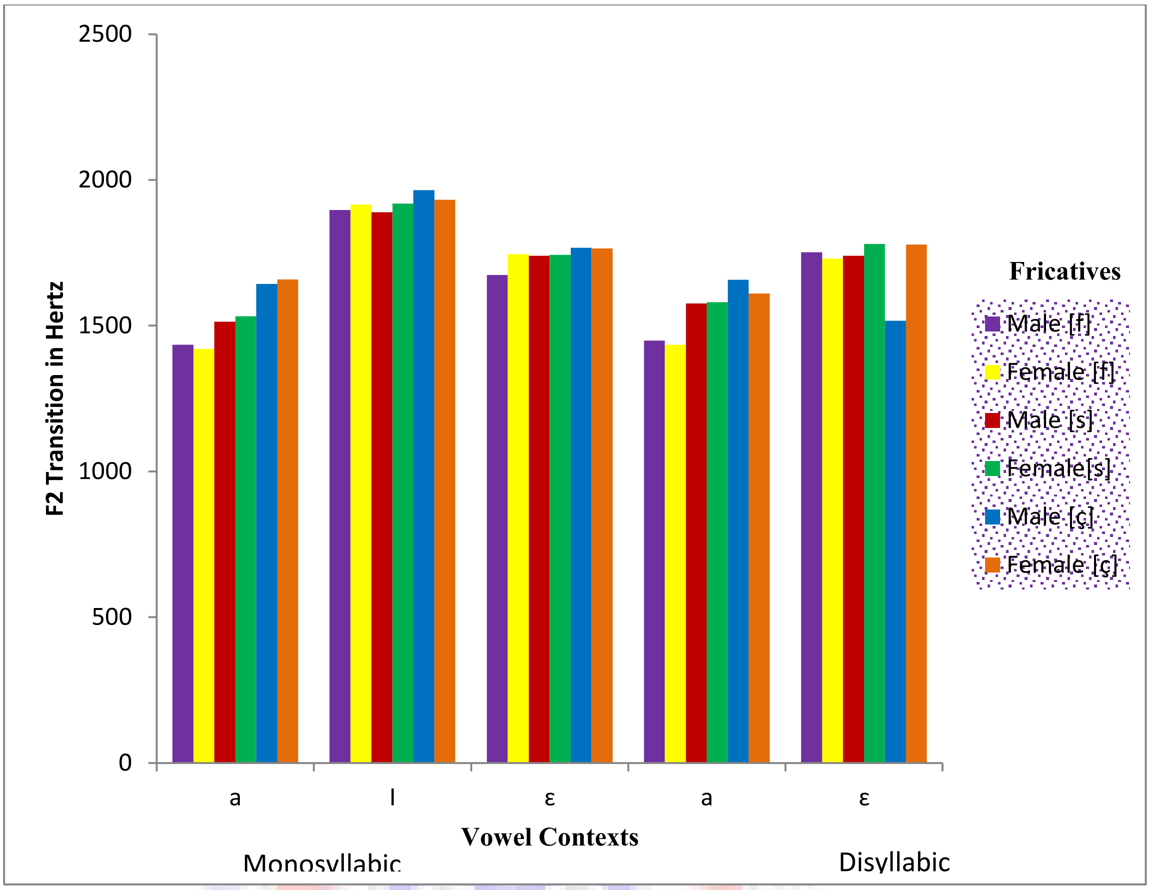


Figure 4.1.6 Bar Charts showing Mean Values of Second Formant Transitions for Male and Female Speakers of Asante in Monosyllabic and Disyllabic Words

Using SPSS, a one-way Analysis of Variance (ANOVA) conducted to ascertain if there were significant differences and similarities between male and female speakers of Asante dialect of Akan in respect to F2 transition of the adjacent vowel (after the fricatives). Table 4.3.3 displays the outcome after the significant level set at $p<0.05$. In monosyllabic words, the outcome stood as [a] $p<0.68$ (F-ratio 0.18); $p<0.61$ (F-ratio 0.29); $p<0.55$ (F-ratio 0.39), [ɪ] $p<0.20$ (F-ratio 1.94); $p<0.61$ (F-ratio 0.29); $p<0.01$ (F-ratio 10.06) and [ɛ] $p<0.08$ (F-ratio 4.03); $p<0.87$ (F-ratio 0.03); $p<0.91$ (F-ratio 0.01) for [f, s, ç] correspondingly . Disyllabic words analysis also show [a] $p<0.77$ (F-ratio 0.09), $p<0.90$ (F-ratio 0.02); $p<0.17$ (F-ratio 2.26) and [ɛ] p<0.28 (F-ratio 1.33); p<0.29(F-ratio 1.23); p<0.41 (F-ratio 0.76) for [f, s, ç] respectively.

The results demonstrated that among Asante speakers there were no significant differences between males and females at the point of transition from the fricatives into the vowels in monosyllabic and disyllabic words. Meaning the F2 transition values were not different for male and females in Asante Twi. See table 4.1.11 below for the summarized results.

Table 4.1.11 Differences and Similarities in Transition between Male and Female Speakers of Asante using One-Way ANOVA

			f		s		ç	
			F. ratio	p. value	F. ratio	p. value	F. ratio	p. value
Asante	Monosyllabic	a	0.18	0.68	0.29	0.61	0.39	0.55
		ɪ	1.94	0.20	0.29	0.61	0.06	0.10
		ɛ	4.03	0.08	0.03	0.87	0.01	0.91
	Disyllabic	a	0.09	0.77	0.02	0.90	2.26	0.17
		ɛ	1.33	0.28	1.23	0.29	0.76	0.41

n = 10. Source: Field Data, 2014.

4.1.9 F2 Transition of Asante Fricatives at various Places of Articulation

Sample T-test was conducted on the mean values of Asante speakers to find out the similarities and differences among the three fricatives being examined in reference to the F2 values of the adjacent vowels. The significant level stands at [f-s] p<0.03 (T-value -2.49), [f-ç] p<0.00 (T-value -9.09), and [s- ç] p<0.00 (T-value 5.44) for word-initial position for the word-medial position, the result also stands at [f-s] p<0.00 (T-value -3.94), [f- ç] p<0.00 (T-value -7.47) and [s- ç] p<0.05 (T-value -2.89).

The results revealed that the fricatives were distinct from each other as far as F2 transition values were concerned because they were all significantly different.

Refer to Table 4.1.12 for the significant levels. It was also demonstrated that the F2 value increases as the place of articulation goes backwards. Hence the F2 transition values of the voiceless labiodental fricative [f] had the lowest F2 values as compared to [s] and [ç] in both monosyllabic and disyllabic words. Meanwhile, [ç] had the highest F2 transition value followed by [s]. The finding was consistent with Wilde, (1995).

Table 4.1.12 Paired Sample T-Test on F2 Transition for Asante Speakers

		Fricatives	T- value	p. value
	Initial	f-s	-2.49	0.03
Asante		f- ç	-9.09	0.00
		s- ç	-5.44	0.00
	Medial	f-s	-3.94	0.00
		f- ç	-7.47	0.00
		s- ç	-2.27	0.05

4.2 BONO DIALECT

Ten native speakers of Bono from Dormaa Ahenkro in the Bono Ahafo region were recorded for the study. They were five males and five females. The participants were between the ages of 22 and 35 years, who had lived in the town for most of their life time and could read simple sentences in their dialect. The participants were selected through interviews. It was anticipated that the language community uses the fricatives needed for the researcher appropriately. The spectral peak location, duration and F2 transition mean values of the sounds were recorded and subsequently analysed. The measurements were taken at word-initial and medial-positions. However, data were only collected and analysed for the fricatives at word-final position because fricatives [f, s, ç] of Twi do not occur at the word-final position of words in Twi. The researcher used both tables and figures (bar charts) to present the data. This is because tables summarize the numerical data whiles the bar charts allow the reader to visualize patterns and trends more easily. Tables 4.2.1-4.2.12, Figures 4.2.1-4.2.6 and Appendix D present the results of the analyses.

4.2.1 Bono Spectral Peak Location Mean Values

The mean values of spectral peak location recorded for Bono speakers at word-initial position were [f] 7163Hz, [s] 6319Hz and [ç] 3484Hz for [a] environment. Also, [f] was 7318Hz, [s] was 6455Hz and [ç] was 3429Hz for [ɪ] environment. [f] was 7327Hz, [s] was 6348Hz and [ç] was 3462Hz in the environment of [ɛ]. In the medial position, the results were [f] 7274Hz, [s] 6348Hz and [ç] 3437Hz for [a] environment. Also, in [ɛ] context [f] was 7352Hz, [s] was 6391Hz, was 3456Hz.

The results revealed that [f] had the highest spectral peak location values followed [s] and [ç] respectively. See Table 4.2.1, Figure 4.2.1 and at Appendix D for the raw data.

Table 4.2.1 Mean Values of Spectral Peak Location for Bono Speakers at Different Word Positions

n =				f	s	ç
	Bono	Initial	**a**	7163	6319	3484
			ɪ	7318	6455	3429
			ɛ	7327	6400	3462
		Medial	**a**	7274	6348	3437
			ɛ	7352	6391	3456

n=10. Source: Field Data, 2014.

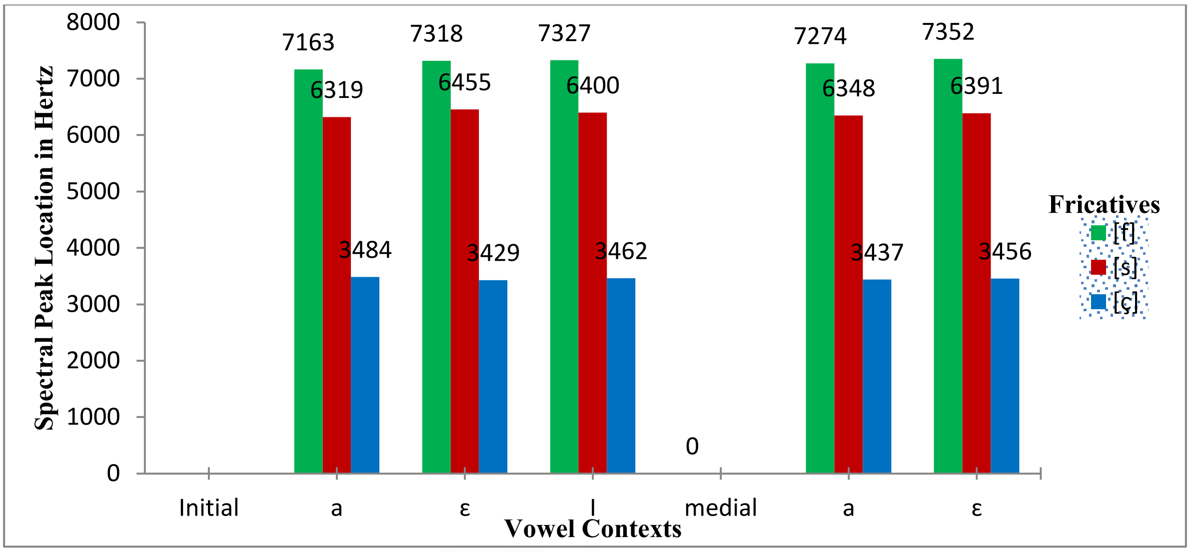


Figure 4.2.1 Bar Charts showing Mean Values of Spectral Peak Location for Speakers of Bono at Different Word Positions

4.2.2 Gender Characteristics of Bono Fricatives Using Spectral Peak Location

The raw data were collected and computed in SPSS for analysis. The mean values of both males and females were calculated and consequently used for the analysis. The mean values for the male speakers in the various vowel contexts were presented for the word-initial as [f] 6682Hz, [s] 5926Hz and [ç] 3093Hz in the context of [a]. In [ɪ] vowel context, [f] 6950Hz, [s] 6148Hz and [ç] 3093Hz whilst [f] was 7022Hz, [s] was 6037Hz and [ç] 3159Hz in the environment of [ɛ]. At word medial position, [f] was 7073Hz, [s] was 6091Hz and [ç] is 3075Hz for [a] vowel context. One the other hand, [f] is 6976Hz, [s] was 5985Hz and [ç] is 3059Hz in the context of [ɛ].

Meanwhile, the spectral peak location for the female speakers of Bono also showed mean values for word-initial position as [f] 764Hz, [s] 6712Hz and [ç] 3875Hz for [a] contexts. For [ɪ] contexts, the results were depicted as [f] 7687Hz, [s] 6762Hz and [ç] 3765Hz. [f] 7632Hz, [s] 6763Hz and [ç] 3765Hz for [ɛ] vowel environment. At the medial position, the results were as follows [f] 7474Hz, [s] 6606Hz and [ç] 3799Hz in the context of [a]. Lastly, [f] was 7727Hz, [s] was 679Hz and [ç] was 3792Hz in the context of [ɛ].

From the above data, it could be observed that males had lower spectral peak location frequencies compared to their female counterparts. See Table 4.2.2 and Figure 4.2.2 for the summary of the results as well as Appendix D for the raw data.

Table 4.2.2 Mean Values of Fricative Spectral Peak Location for Male and Female Speakers of Bono at Different Word Positions

			f		s		ç	
			Male	Female	Male	Female	Male	Female
Bono	Initial	a	6682	7643	5926	6712	3093	3875
		i	6950	7687	6148	6762	3093	3765
		ɛ	7022	7632	6037	6763	3159	3765
	Medial	a	7073	7474	6091	6606	3075	3799
		ɛ	6976	7727	5985	6798	3059	3792

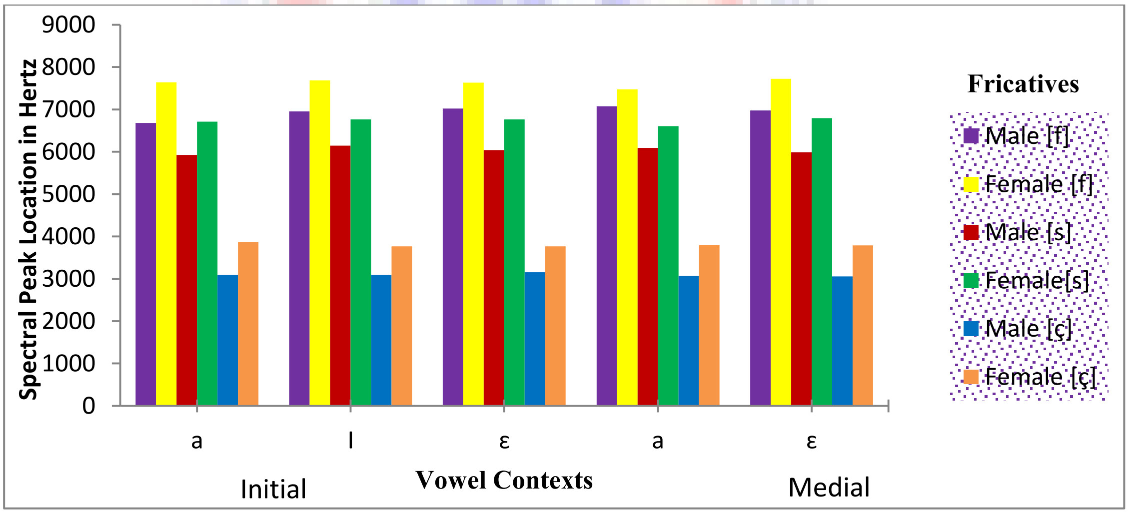


Figure 4.2.2 Bar Charts showing Mean Values of Fricative Spectral Peak Location for Male and Female Speakers of Bono at Different Word Positions

A One-way ANOVA was conducted for both sexes to find out the similarities or differences. The outcome is presented at the initial position as [f] p<0.00 (F-value, 19.02), [s] p<0.00 (F-value, 30.65) and [ç] p<0.00 (F-value, 40.96) in [a] context. [f] p<0.00 (F-value, 6.29), [s] p<0.03 (F-value 6.56,) and [ç] p<0.00 (F-value 86.13) in the [ɪ] context. Also results recorded as, [f] p<0.00 (F-value, 64.28), [s] p<0.00 (F-ratio 53.39) and [ç] p<0.00 (F-ratio 75.19) in the environment of [ɛ]. At the word medial position the results were also presented as [f] p<0.00 (F-value, 11.96), [s] p<0.00 (F-value, 37.57) and [ç] p<0.00 (F-value, 44.91) in the [a]-vowel context. In the context of [ɛ], the results were [f] p<0.00 (F-value, 66.78), [s] p<0.00 (F-value 316.55) and [ç] p<0.00 (F-value 94.76).

According to the outcome displayed, fricatives produced by male and female speakers were significantly different. See table 4.2.3 for the significance level. This feature was particularly evident for the female speaker, as they recorded frequency values higher than their male counterparts. This finding was similar to Jongman et al, (1998).

Table 4.2.3 Differences and Similarities between Male and Female Speakers of Bono

			f		**s**		**ç**	
			F. ratio	p. value	F. ratio	p. value	F. ratio	p. value
	Initial	a	19.02	0.00	51.18	0.00	193.19	0.00
Bono		ɪ	6.29	0.00	6.56	0.03	86.13	0.00
		ɛ	64.28	0.00	53.39	0.00	75.19	0.00
	Medial	a	11.96	0.00	37.57	0.00	44.91	0.00
		ɛ	66.78	0.00	316.55	0.00	94.76	0.00

n = 10. Source: Field Data, 2014.

4.2.3 Spectral Peak Location of Bono Fricatives at various Places of Articulation

A Sample T-Test was run to ascertain the similarities or differences of the Bono fricatives produced at the various places of articulation. The outcomes were presented as [f-s] p<0.00 (10.14), [f-ç] p<0.00 (67.08) and [s] p<0.00 (T-value 43.64) for word initial and [f-s] p<0.00 (T-value 27.28), [f-ç] p<0.00 (T-value 73.48) and [s-ç] p<0.00 (T-value 78.26) for the word medial fricatives.

The results suggested that the acoustic properties of the three fricatives were significantly different in the spectral peak location measurements. In simple terms, labiodental [f] and alveolar [s] and palatal [ç] were distinct from each another. Labiodental [f] had the highest frequency value followed by alveolar [s] and palatal [ç]. See the Table 4.2.4 below for the significant level.

Table 4.2.4 Paired Sample T-Test on Spectral Peak Location for Bono Speakers

		Fricative	**T- value**	**p. value**
Bono	Initial	[f-s]	10.14	0.00
		[f- ç]	67.08	0.00
		[s- ç]	43.64	0.00
	Medial	[f-s]	27.28	0.00
		[f- ç]	73.48	0.00
		[s- ç]	78.26	0.00

4.2.4 Fricative Duration Mean for Bono Dialect Speakers

The results for fricatives produced at word initials in Bono was presented as [f] 77ms, and [s] 157ms and [ç] 219ms for the [a] vowel context. Again, in the [ɪ] context, [f] is 84ms, [s] 218ms and [ç] 227ms. Also, in the context of [ɛ] the results stand as [f] 71ms, [s] 211ms and [ç] 227ms. At the word medial, [f] was 77ms, [s] was 116ms and [ç] was 147ms and [f] was 144ms, [s] was 192ms and [ç] was173ms in [a] and [ɛ] environment respectively. Table 4.2.5, Figure 4.2.3 and Appendix C show the result of the analyses.

The results showed that Bono [f] had the shortest duration with [ç] having the longest duration in word initial position. In addition, it could be seen that the duration of [s] was in between [f] and [ç]. In medial position the duration pattern was similar to that of the initial fricatives in the [a] environment. Nonetheless, [s] tends to have the longest duration followed by [ç] and [f] respectively in [ɛ] vowel context.

Table 4.2.5 Fricative Duration mean values of Bono

			f	s	ç
	Initial	a	77	157	219
		ɪ	84	218	227
Bono		ɛ	71	211	227
	Medial	a	116	147	175
		ɛ	144	192	173

n = 10. Source: Field Data, 2014.

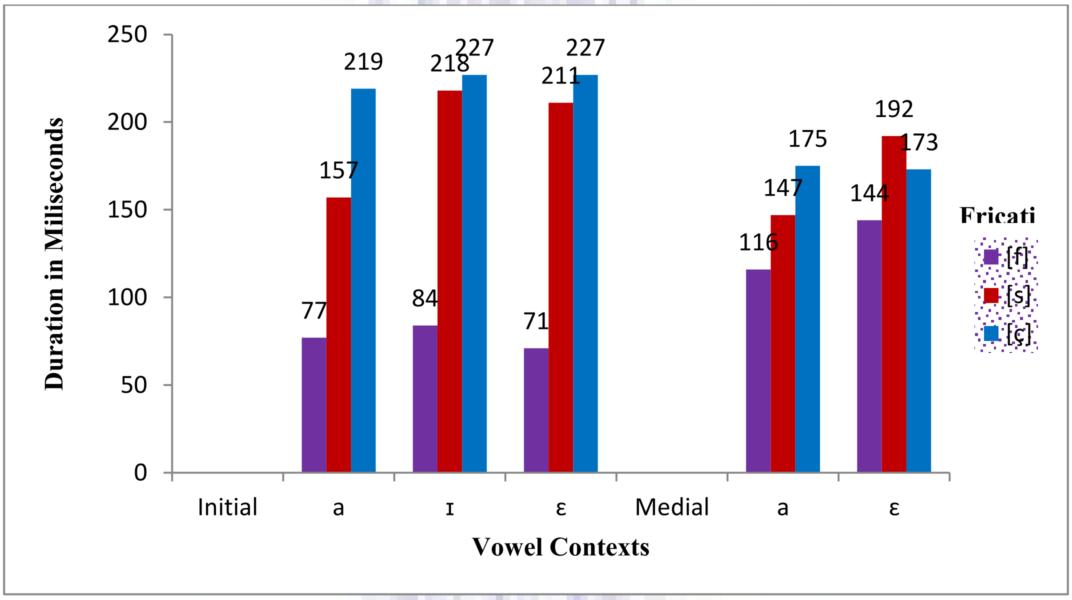


Figure 4.2.3 Bar Charts showing Mean Values of Fricative Duration for Bono Dialect Speakers at Different Word Positions

4.2.5 Gender Characteristics of Bono Fricative using Duration

Bono fricatives were also compared in terms of gender. The rationale was to determine the similarities and differences between male and female speakers in Bono. The summary of the results are displayed in Table 4.2.7 and Figure 4.2.4. The results for the male were: [f] 105ms, 78ms and 102ms, [s] 188ms 213ms and 195ms, as well as [ç] 220ms, 223ms, 237ms in [a, ɪ, ɛ] contexts respectively for each fricative at word initial position. At word medial position, [f] is 133ms, 159ms; [s] 170ms, 160ms; [ç] 148ms, 178ms in the contexts of [a, ɪ, ɛ] accordingly in each fricative. The fricative duration values for the female speakers at word initial are: [f] 48ms, 90ms and 112ms; [s] 125ms, 222ms, 226ms and [ç] 168ms, 200ms and 177ms in [a, ɪ, ɛ] environments respectively in each case. At word medial position, [f] was 99ms and 129ms, [s] was 125ms and 217ms as [ç] was 164ms and 186ms for [a] and [ɛ] respectively in each fricative.

Table 4.2.6 Mean Values of Fricative Duration for Male and Female Speakers of Bono at Different Word Positions

			f		s		ç	
			Male	**Female**	**Male**	**Female**	**Male**	**Female**
Bon	Initial	a	105	48	188	125	220	168
		i	78	90	213	222	223	200
		ɛ	102	112	195	226	237	177
	Medial	a	133	099	170	125	148	164
		ɛ	159	129	166	217	178	186

n=10. Source: Field Data, 2014.

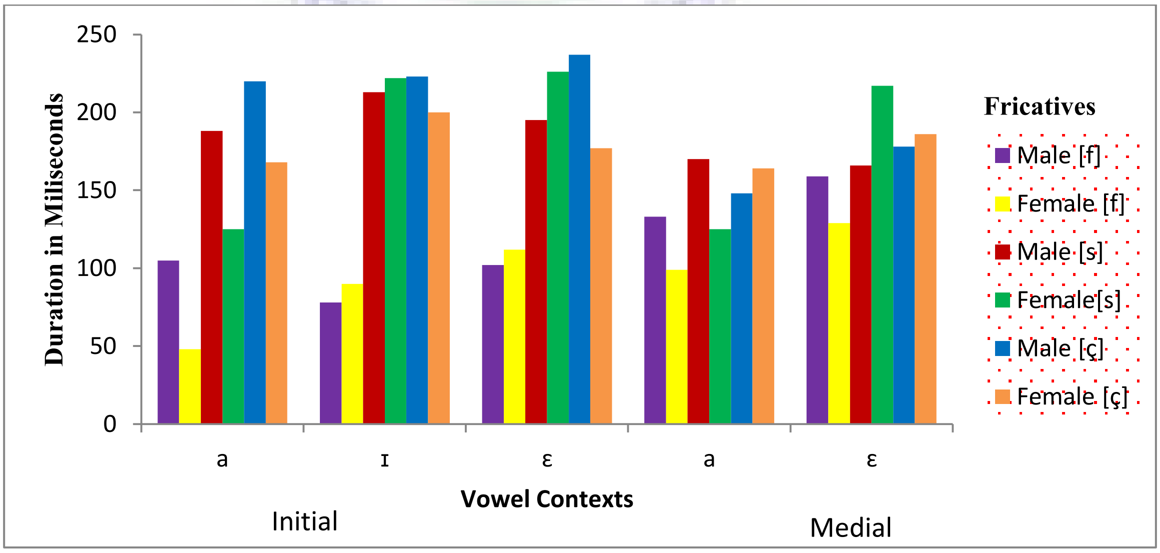


Figure 4.2.4 Bar Charts showing Mean Values of Fricative Duration for Male and Female Speakers of Asante Dialect at Different Word Positions

The One-way ANOVA results for gender was presented for the three fricatives examined in reference to [a, ɪ, ɛ] in that order were; [f] [p<0.03 (F-ratio 7.61); p< 0.67(F-ratio 0.20); p<0.71 (F-ratio 0.15)], [s] was [p< 0.00 (F-ratio 22.89); p<0.64 (F-ratio 0.24); p<0.18 (F-ratio 0.17)] and [ç] was [p<0.86 (F-ratio 0.03); p< 0.40 (F-ratio 0.78), p< 0.18 (F-ratio 0.210]. At the word-medial position, [f] was [p< 0.18 (F-ratio 2.13); p< 0.00 (F-ratio 15.00)], [s] is [p< 0.03 (F-ratio 6.91); p< 0.06 (F-ratio 4.61)] and [ç] was [p< 0.68 (F-ratio 0.18); p< 0.53 (F-ratio 0.43)] for the respective vowel context [a, ɛ] in each fricative. See Table 4.2.8 for the summary of the results.

The results indicated that in terms of gender, there were significant differences in [f] produced initially in the context of [a] and medially in the context of [ɛ] in terms of gender. [s] was also significantly different for male and female initially and medially in the environment of [a]. In the contexts of [ɪ] and [ɛ] were not significant for both [f] and [s]. However, [ç] was significant in all the vowel contexts for gender.

Table 4.2.7 Differences and Similarities between Male and Female Bono Dialect Speakers

			f		**s**		**ç**	
			F. ratio	**p. value**	**F. ratio**	**p. value**	**F. ratio**	**p. value**
	Initial	a	7.61	0.03	22.89	0.00	0.03	0.86
Bono		ɪ	0.20	0.67	0.24	0.64	0.78	0.40
		ɛ	0.15	0.71	0.17	0.18	0.21	0.18
	Medial	a	2.13	0.18	6.91	0.03	0.18	0.68
		ɛ	15.00	0.00	4.61	0.06	0.43	0.53

4.2.6 Duration of Bono Fricatives at Different Places of Articulation

In addition to gender, the fricatives were also juxtaposed to see if they differ in their places of articulation. This is the result for initials [f-s] p<0.00 (T-value -11.22), [f- ç] p<0.00 (T-value -17.77) and [s- ç] p<0.00 (T-value -3.84). In word medial position, the results stood as [f-s] p<0.01(T-value -3.84), [f- ç] p<0.00 (T-value -3.79) and [s- ç] p<0.45 (T-value -0.79).

The sample T-test results demonstrated that all the fricatives [f, s, ç] were significantly different from one another at the word initial position. [ç] was longer than [f] and [s] in terms of duration while [s] was longer than [f] but shorter than [ç] with [f] being the shortest in duration. See the Table 4.2.9 below for the detailed results. At word medial position, [s] and [ç] were not significantly different.

Table 4.2.8 Paired Sample T-Test on Fricative Duration for Bono Speakers

		Fricatives	**T- value**	**p. value**
Bono	Initial	f-s	-11.22	0.00
		f- ç	-17.77	0.00
		s- ç	-3.84	0.00
	Medial	f-s	-3.84	0.01
		f- ç	-3.79	0.00
		s- ç	-0.79	0.45

4.2.7 Second Formant (F2) Vowel Transition Mean Values of Bono

Ten speakers of Bono dialect of Akan were used for this analysis. These included five males and five females. The F2 transition into the vowels were taken and analysed accordingly. The mean values of the F2 transition in monosyllabic words were given as [a] 1522Hz, 1476Hz and 1544Hz for [f, s, ç] respectively. The results stood as [ɪ] 1914, 1901Hz and 1952Hz while [ɛ] was 1797 Hz; 1739Hz and 1769Hz for [f, s, ç] respectively. Also, in disyllabic words the results were presented as [a] 1422Hz, 1529Hz and 1613Hz respectively for [f, s, ç]. Finally, [ɛ] was 1706Hz, 1713Hz and 1769 Hz for [f, s, ç] respectively.

The results showed that in the dissyllabic words the F2 transition increases progressively as the place of articulation moves backwards. However, this was not the case with monosyllabic words. [f] was higher than [s] but lower than [ç] in the context of [a] and [ɪ]. Furthermore, [f] had the highest F2 transition frequency followed by [ç] and [s] accordingly. The results were summarized in Table 4.2.9 and Figure 4.2.5 below.

Table 4.2.9 Mean Values of Second Formant Transitions for Bono Dialect Speakers in Monosyllabic and Disyllabic Words Syllabic words

			f	s	ç
Bono	Monosyllabic	a	1522	1476	1544
		ɪ	1914	1901	1952
		ɛ	1797	1739	1769
	Disyllabic	a	1420	1529	1613
		ɛ	1706	1710	1769

n = 30. Source: Field Data, 2014.

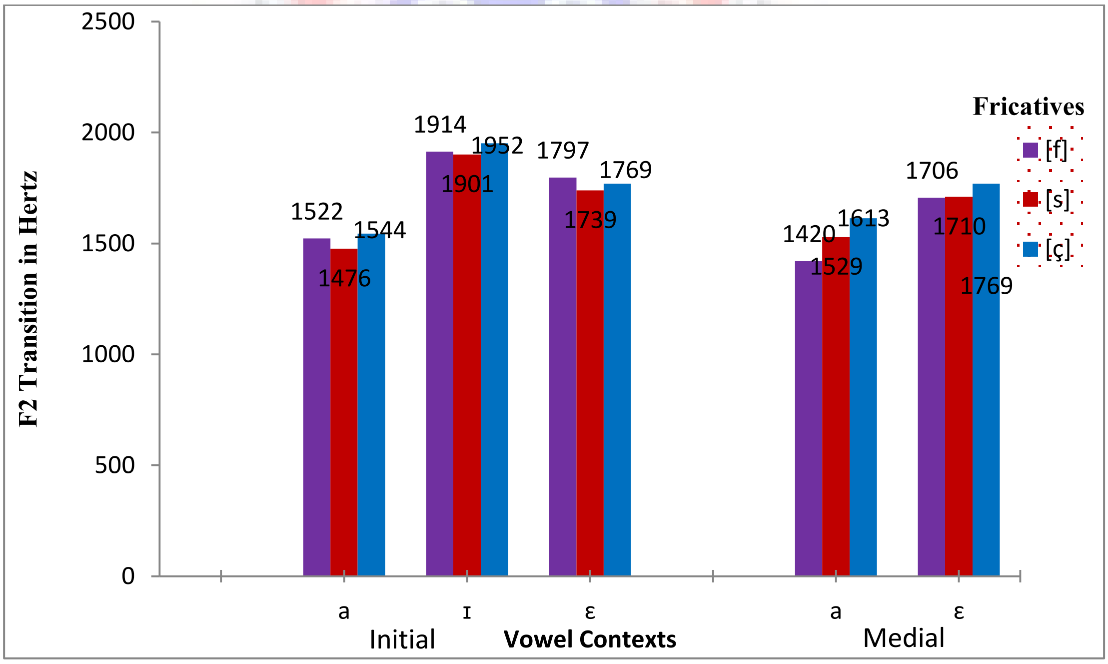


Figure 4.2.5 Bar Charts showing Mean Values of Second Formant Transitions for Bono Dialect Speakers in Monosyllabic and Disyllabic Work

4.2.8 Gender Characteristics of Bono Fricatives Using F2 Vowel Transition

Table 4.2.10 and Figure 4.2.5 display the F2 transition into the vowels with reference to gender. Also see appendix D for the raw data. In monosyllabic words the results for the males were: [f] 1458Hz, [s] 1514Hz and [ç] 1505 in the environment of [a]. [f] was 1901Hz, [s] was 1889Hz and [ç] was 1932Hz for [ɪ] environment whereas [f] was 1707Hz, [s] was 1740Hz and [ç] was 1964Hz for [ɛ] context. Again, [f] was 1524Hz, [s] 1576Hz and [ç] 1649Hz in [a] environment whilst [f] was 1707Hz, [s] was 1740Hz and [ç] was 1767Hz in the environment of [ɛ]. Furthermore, the disyllabic words stand as [f] 1524Hz, [s] 1576Hz and [ç] 1649Hz for [a] while transition of [f, s, ç] into [ɛ] was 1707Hz, 1740Hz and 1767Hz respectively.

For females F2 transition into [a] in the monosyllabic words, the results were: [f] 1393Hz, [s] 1469Hz and [ç] 1583Hz. Also, [f, s, ç] transition into [ɪ] at 1903 Hz, 1914 Hz and 1973 Hz whereas [f] was 1740Hz, [s] was 1743Hz and [ç] was 1774Hz for [ɛ]. Finally, the F2 transition in the disyllabic words reveals [f, s, ç] respectively transition into [a] at 1315Hz, 1509Hz and 1577Hz respectively. [f] was 1704Hz, [s] was 1723Hz and [ç] was 1771Hz for [ɛ] environment.

Table 4.2.10 Mean Values of Second Formant Transitions for Male and Female Speakers of Bono in Different Syllabic Words

			f		s		ç	
	Gender		**Male**	**Female**	**Male**	**Female**	**Male**	**Female**
	Monosyllabic	a	1458	1393	1514	1469	1505	1583
		ɪ	1901	1903	1889	1914	1932	1973
Bono		ɛ	1707	1740	1740	1743	1964	1774
	Disyllabic	a	1524	1315	1576	1509	1649	1577
		ɛ	1707	1704	1740	1723	1767	1771

n = 10. Source: Field Data, 2014.

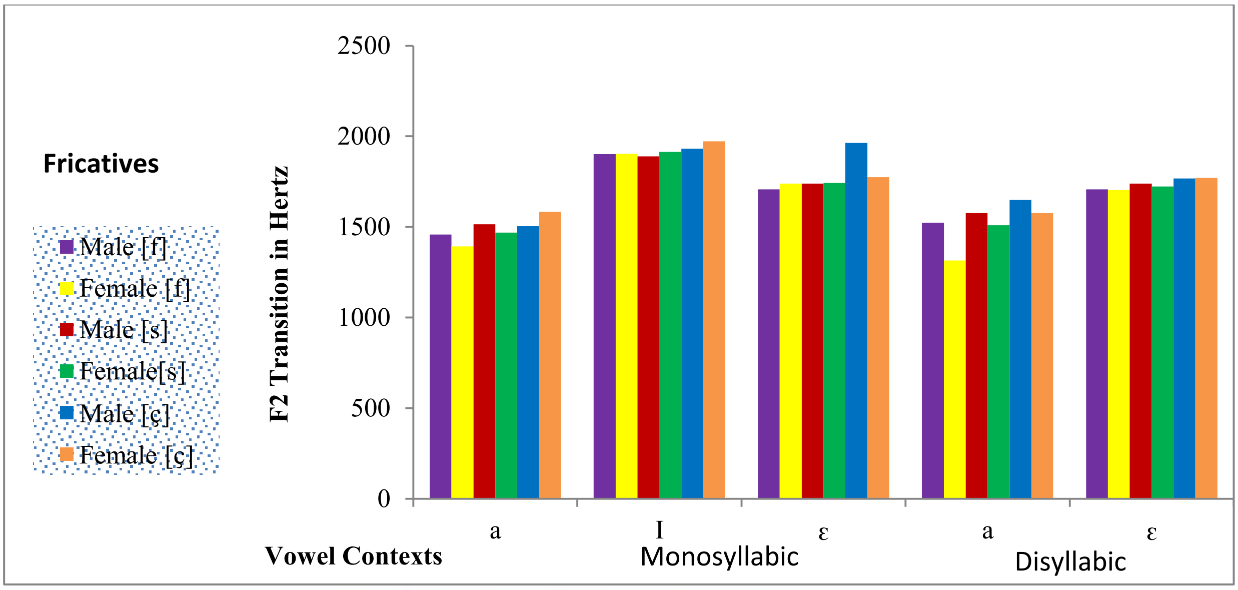


Figure 4.2.6 Bar Charts showing Mean Values of Second Formant Transitions for Male and Female Speakers of Bono in Monosyllabic and Disyllabic Words

Again, One-way ANOVA was conducted and results showed [f] p<0.16 (F-ratio 2.46), [s] p<0.86 (F-ratio 0.03) and [ç] p<0.01 (F-ratio 9.88) in [a] context. The transition into [ɪ] also showed [f] p<0.76 (F-ratio 0.10), [s] p<0.43 (F-ratio 0.70) and [ç] p<0.05 (F-ratio 5.30). Also, transition into [ɛ] was [f] p<0.10 (F-ratio 3.60), [s] p<0.44 (F-ratio 0.39) and [ç] p<0.23 (F-ratio 0.44). In the disyllabic words the results was presented as [f] p<0.00 (F-ratio 37.49), [s] p<0.59 (F-ratio 0.31) and [ç] p<0.17 (F-ratio 2.30) while the transition into [ɛ] was [f] p<0.94 (F-ratio 0.01), [s] p<0.50 (F-ratio 0.51) and [ç] p<0.82 (F-ratio 0.06). Table 4.2.11 displays the summary of the results.

Male and female speakers results showed that both sexes differ in the production of [ç] in [a] and [ɪ] environments at initial position. This notwithstanding, [f] and [s] were not significant in all the vowel contexts. Also, at the medial position males and females [f] were statistically significant in context of [a]. Meaning there was difference between males and females [f] in [a] vowel environment. However, [s] and [ç] did not differ in terms gender in the same vowel environment. Lastly, all the fricatives did not differ in males and females in the environment of [ɛ].

Table 4.2.11 Differences and Similarities in Transition between Male and Female Speakers of Bono

			f		s		ç	
			F. ratio	p. value	F. ratio	p. value	F. ratio	p. value
Bono	Monosyllabic	a	2.46	0.16	0.03	0.86	9.88	0.01
		ɪ	0.10	0.76	0.70	0.43	5.30	0.05
		ɛ	3.60	0.10	0.39	0.55	0.44	0.23
	Disyllabic	a	37.49	0.00	0.31	0.59	2.30	0.17
		ɛ	0.01	0.94	0.51	0.50	0.06	0.82

n= 10. Source: Field Data, 2014.

4.2.9 F2 Transition of Bono Fricatives at Different Places of Articulation.

In order to find out whether similarities or differences exist among the three fricatives being investigated in respect to places of articulation, a Sample T-Test was carried out. Using SPSS computer software, the significant level was set at p<0.05. The result revealed [f-s] as p<0.18 (T-value -1.45), [f-ç] as p<0.00 (T-value -6.39) and [s-ç] as p<0.02(T-value -2.96) in monosyllabic words. These were the results when F2 values of the preceding vowels were compared in the disyllabic words [f-s] p<0.07 (T-value -2.11), [f- ç] p<0.00 (T-value -6.58) and [s- ç] p<0.02 (T-value -2.89).

It was revealed that there was no significant difference between the labiodental [f] and alveolar [s]. Hence, the palatal [ç] was higher than both [f] and [s].

Table 4.2.12 Paired Sample T-Test on F2 Transition for Bono Speakers

		Fricatives	T- value	p. value
Bono	Monosyllabic	f-s	-1.45	0.18
		f- ç	-6.39	0.00
		s- ç	-2.96	0.02
	Disyllabic	f-s	-2.11	0.07
		f- ç	-6.58	0.00
		s- ç	-2.89	0.02

4.3 Denkyira Dialect

Ten participants who are native of Denkyira (from Diaso in the Central Region of Ghana) comprising five males and five females were recorded. They were between the ages of 20 and 35 who have being living in the communities for most part of their lives and could read at least simple sentences in Asante Twi. This was done through interviews. The community was selected because the researcher anticipated that the speakers in the community use the fricative sounds needed for the research. The researcher used both tables and figures (bar charts) to present the data. The reasons being that tables summarize the numerical data whiles the bar charts allow the reader to visualize patterns and trends more easily.

4.3.1 Spectral Peak Location Mean for Denkyira Speakers

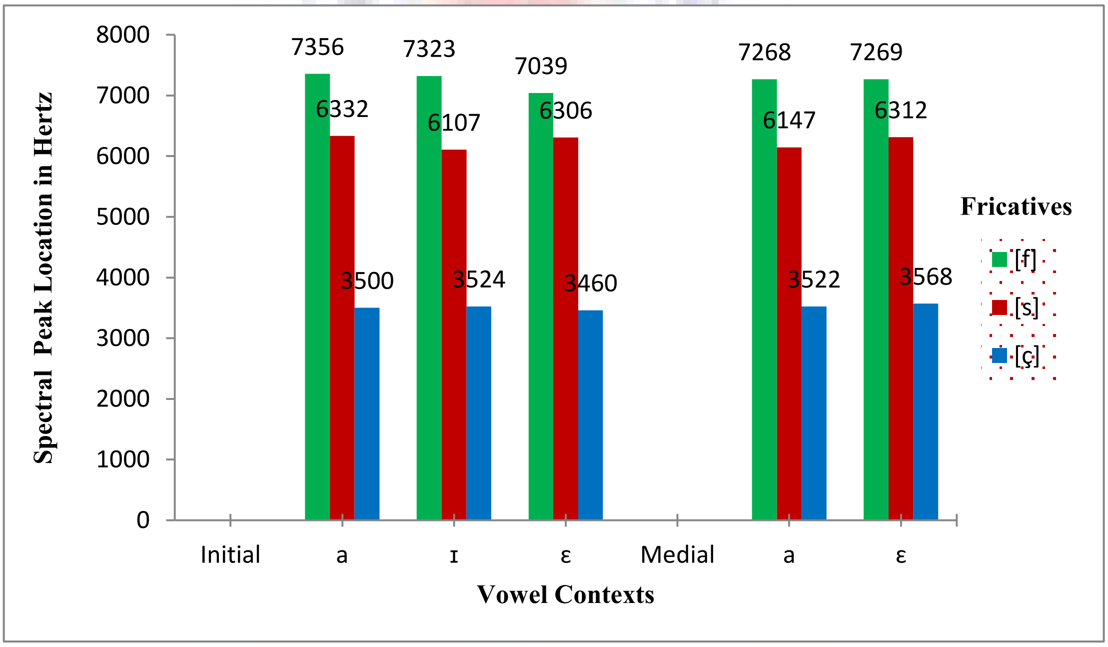
The results of spectral peak location for Denkyira speakers at the word initial position were presented as [f] 7356Hz , [s] 6332Hz and [ç] 3500Hz in the context of [a]. In the environment of [ɪ] the results were as follows [f] 7323Hz, [s] 6107Hz and [ç] 3524Hz. Whilst that of [ɛ] displayed [f] 7039H, [s] 6306Hz and [ç] 3460Hz. The results for the word medial position were also presented as [f] 7268Hz, [s] 6147Hz and [ç] 3522Hz for [a] vowel context. Also, in [a] context [f] was 7269Hz, [s] was 6312 Hz and [ç] was 3568Hz. The results are summarized in the Table 4. 3.1 and Figure 4.3.1 below.

It can be observed that at both initial and medial positions the labiodental [f] had the highest spectral peak location frequency, followed by alveolar [s] and palatal [ç] respectively.

Table 4.3.1 Mean Values of Spectral Peak Location for Denkyira at Different Word Positions

			f	s	ç
Denkyira	Initial	a	7356	6332	3500
		ɪ	7323	6107	3524
		ɛ	7039	6306	3460
	Medial	a	7268	6147	3522
		ɛ	7269	6312	3568

n=10. Source: Field Data, 2014.



4.3.1 Bar Charts showing Mean Values of Spectral Peak Location for Denkyira Speakers at Different Word Positions

4.3.2 Gender Characteristics of Denkyira Fricatives using Spectral Peak Location

Ten Denkyira speakers comprising of five males and five females were recorded and subsequently used for this analysis using SPSS. The mean values for males at word initial position were as follows; [f] 7033Hz, [s] 5935Hz and [ç] 3083Hz all in the contexts of [a]. [f] was 7001Hz, [s] was 5687 Hz and [ç] was 3218 Hz in the context of [ɪ]. That of [ɛ] vowel environment resulted in [f] 6559Hz, [s] 5813 Hz and [ç] 3157 Hz. At word medial position, the male speakers had [f] 6847Hz, [s] 5941Hz and [ç] 3146 Hz in the context of [a] while in [ɛ] environment, [f] 6961Hz, [s] 6030Hz and [ç] 3238 Hz. In the same vein the female speakers displayed the following results at word initial position [f] 7679Hz, [s] 6729Hz and [ç] 3917Hz in the context of [a]. [f] 7645, [s] 6252 Hz and [ç] 3829Hz all in the context of [ɪ] while in the [ɛ] vowel position, the results were, [f] 7519 Hz, [s] 6800 Hz and [ç] 3763Hz. At the word medial position, the results were reported as [f] 7689, [s] 6353Hz and [ç] 3898 Hz in the context of [a]. Finally, in the [ɛ] context [f] was 7566, [s] was 6963 Hz and [ç] was 3897Hz. See Table 4.3.2 and Figure 4.3.2 for the summary of the results.

The spectral peak location values for the fricative consonants showed that [f] at word-initial and word-medial positions were higher for female speakers as compared to the male speakers. The results for [s] and [ç] were no exception as the females exhibited higher values at both word-initial and word-medial positions than their male counterparts.

Table 4.3.2 Mean Spectral Peak Location for Male and Female Speakers of Denkyira at Different Word Positions

			f		s		ç	
	Gender		**Male**	**Female**	**Male**	**Female**	**Male**	**Female**
	Initial	a	7033	7679	5935	6729	3083	3917
Denkyira		ɪ	7001	7645	5687	6527	3218	3829
		ɛ	6559	7519	5813	6800	3157	3763
	Medial	a	6847	7689	5941	6353	3146	3898
		ɛ	6961	7566	6030	6963	3238	3897

n = 10. Source: Field Data, 2014.

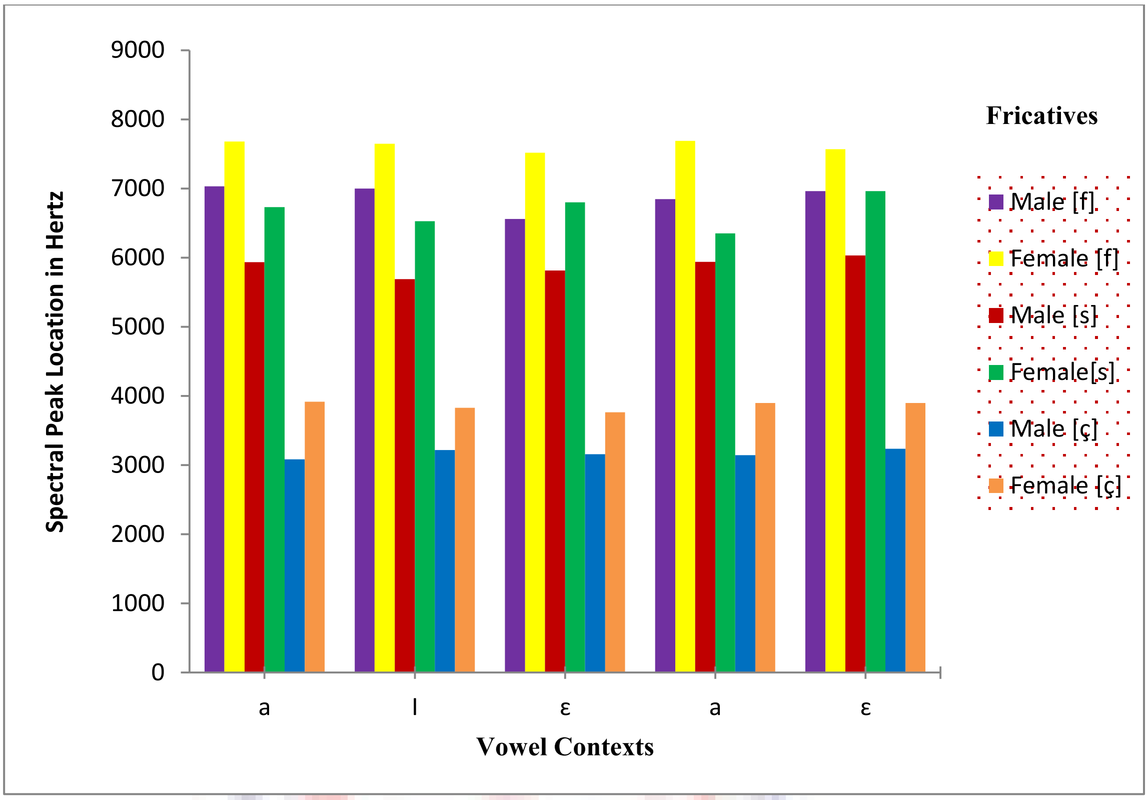


Figure 4.3.2 showing Mean Values of Spectral Peak Location for Male and Female Speakers of Denkyira at Different Word Positions

Table 4.3.3 presents the One-way ANOVA results as [f] p<0.00 (F-ratio 71.82); p<0.00 (F-ratio 87.40); p<0.00 (F-ratio 19.62), [s] p<0.00 (F-ratio51.15); p<0.00 (F-ratio 12.35); p<0.00 (F-ratio 422.01) and [ç] p<0.00 (F-ratio 161.27); p<0.00 (F-ratio 40.78); p<0.00 (F-ratio); p<0.00 (F-ratio 52.22) in word initial for the vowels [a, ɪ, ɛ] in each case for the fricatives. At the word-medial position, the results of the fricative consonants is presented in their respective vowel environments [a, ɛ] with [f] p<0.00 (F-ratio 33.98); p<0.00 (F-ratio110.21), [s] p<0.04 (F-ratio 6.47); p<0.00 (F-ratio 31.61) and [ç] p<0.00 (F-ratio 168.70); p<0.00 (F-ratio 183.07).

It was discovered from the results that female speakers differ significantly from their male counterparts in their acoustic properties as far as spectral peak location was concerned. The females had higher frequencies values than males.

4.3.3 Differences and Similarities between Male and Female Speakers

			f		s		ç	
			F. ratio	p. value	F. ratio	p. value	F. ratio	p. value
		a	71.82	0.00	51.15	0.00	161.27	0.00
Denkyira	**Initial**	ɪ	87.40	0.00	12.35	0.00	40.78	0.00
		ɛ	19.62	0.00	422.01	0.00	52.22	0.00
		a	33.98	0.00	6.47	0.04	168.70	0.00
	Medial	ɛ	110.21	0.00	31.61	0.00	183.07	0.00

n = 10. Source: Field Data, 2014.

4.3.3 Spectral Peak Location of Denkyira Fricatives at Different Place of Articulation

In addition, a Sample T-Test was carried out on the fricatives of Denkyira to find out the significant levels of the three fricatives [f, s, ç] produced in all the vowel contexts. Table 4.3.4 below gives the details as [f-s] p<0.00 (T-value 15.45), [f- ç] p<0.00 (T-value 17.48) and [s-ç] p<0.00(T-value 48.22). At medial position [f-s] was p<0.00 (T-value 12.29), [f- ç] was p<0.00 (T-value 113.93) and [s-ç] is p<0.00 (T-value 34.72).

All the three fricatives were significantly different. This implied that there were differences among the fricatives both at the initial and medial positions. The results revealed that [f] was higher than [s] and [ç]. It was followed by [s] which was also higher than [ç]. Again, [ç] had the lowest frequency as far as spectral peak location was concerned in Denkyira. These characteristics shown by the fricatives were similar to Jongman et al (1998) findings on English fricatives.

Table 4.3.4 Paired Sample T-Test on Spectral Peak Location for Denkyira Speakers

		Fricatives	T- value	p. value
	Initial	f-s	15.45	0.00
		f- ç	76.48	0.00
Denkyira		s- ç	48.32	0.00
	Medial	f-s	12.29	0.00
		f- ç	113.93	0.00
		s- ç	43.72	0.00

4.3.4 Fricative Duration Mean Values of Denkyira

Table 4.3.5 and Figure 4.3.3 below display the results of fricative duration in Denkyira dialects. At word initial position, the mean values for [f] were 37ms, 110ms and 92ms for [a, ɪ, ɛ] contexts respectively. Values recorded for [s] were 154ms, 179ms and 196ms for the respective vowels [a, ɪ, ɛ] contexts. Also, [ç] values were 197ms, 205ms and 231ms. At the word-medial, [f] had 112ms and 139ms, [s] had 159ms and 168ms as [ç] had 172ms and 165ms respectively for the vowel [a, ɪ, ɛ] environments.

The results revealed that in all the vowel contexts at word initial, [f] had the shortest duration. It can also be noticed that [ç] had the longest duration with [s] being the intermediate. The values recorded for the fricatives at word-medial position also indicated that [f] recorded the lowest values in duration than both [s] and [ç] in all environments. Meanwhile, [s] had lower value recorded for the duration following the vowel [a] than [ç]. However, [s] and [ç] were of equivalent duration at the word-medial position in [ɛ] context as [s] was slightly ahead in terms of value recorded with three points interval.

Table 4.3.5 Mean Values of Duration for Denkyira Speakers at Different Word Positions

	Duration		f	s	ç
	Initial	a	37	154	197
		ɪ	110	179	205
Denkyira		ɛ	92	196	231
	Medial	a	112	159	172
		ɛ	139	168	165

n = 5. Source: Field Data, 2014.

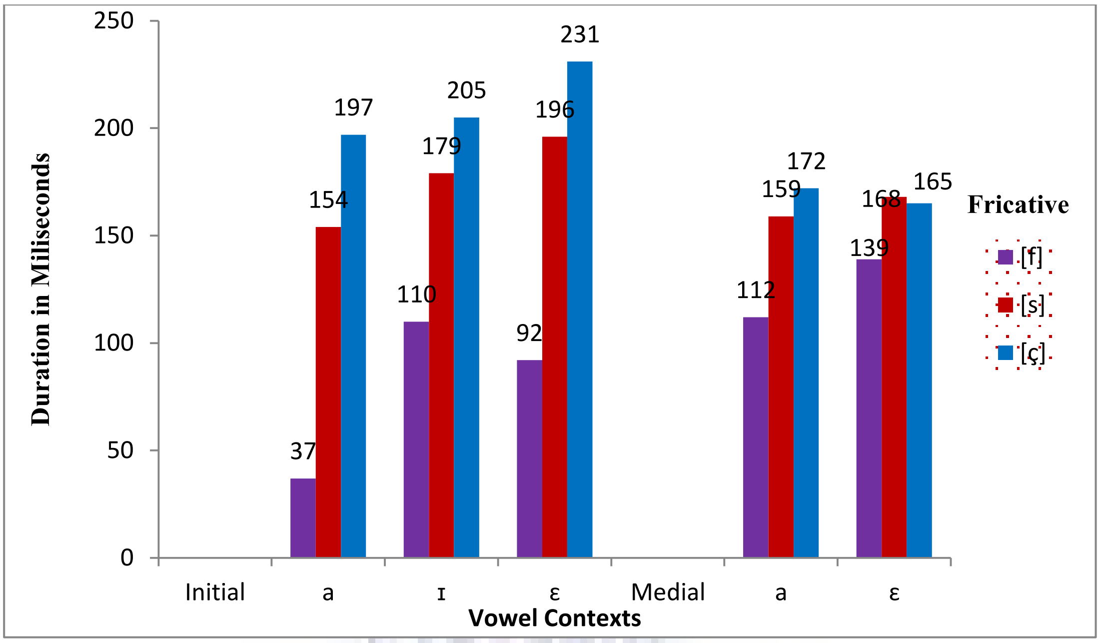


Figure 4.3.3 Bar Charts showing Mean Values of Duration for Denkyira Speakers at Different Word Positions

4.3.5 Gender Characteristics of Denkyira using Fricative Duration

The results for the males displayed alongside their female counterparts in Table 4.3.6 and Figure 4.3.4 below. At the word initial position for males in the [a, ɪ, ɛ] vowel environment respectively, [f] was 121ms, 124ms and 99ms; [s] was 142ms, 180ms and 202ms; [ç] was 225ms, 220ms and 229ms. At the word medial position, in [a] and [ɪ] vowel environment [f] was 112ms, 148ms. [s] was 147ms and 160ms and [ç] was 173ms and 162ms.

The results of the females duration presented at the initial position in the vowel contexts [a, ɪ, ɛ] were [f] 86ms, 86ms and 84ms; [s] 167ms, 171ms and 201ms and [ç] 169ms, 189ms, 233ms. At the word medial position, in the context [a, ɛ], [f] was 111ms and 130ms whereas [s] was 172ms and 176ms and [ç] was 172ms and 168ms.

Results recorded for [f] indicated that female speakers had lower duration than their male counterparts at the word initial-position. Again, at word-medial position, male and female speakers" values were almost the same though the male speakers" values were only one point higher than the female speakers in the context of [a]. However, at the word-medial position the males had higher values of duration than the females in the context of the vowel [ɛ]. Similar trends were discovered in the values recorded for [s] and [ç] at the word-initial position. Males recorded higher values for duration than females. But the opposite was the case at word-medial as the female speakers showed higher values for duration than their male counterparts. The findings were unique in Denkyira speakers; meaning male speakers relatively produced fricatives with longer duration than female speakers at the word-initial position and the vice-versa at word-medial position.

Table 4.3.6 Mean Values of Fricative Duration for Male and Female Speakers of Denkyira at Different Word Positions

			f		s		ç	
	Gender		**Male**	**Female**	**Male**	**Female**	**Male**	**Female**
Denkyira		a	121	086	142	167	225	169
	Initial	ɪ	124	096	188	171	220	189
		ɛ	099	084	202	201	229	233
	Medial	a	112	111	147	172	173	172
		ɛ	148	130	160	176	162	168

n = 10. Source: Field Data, 2014.

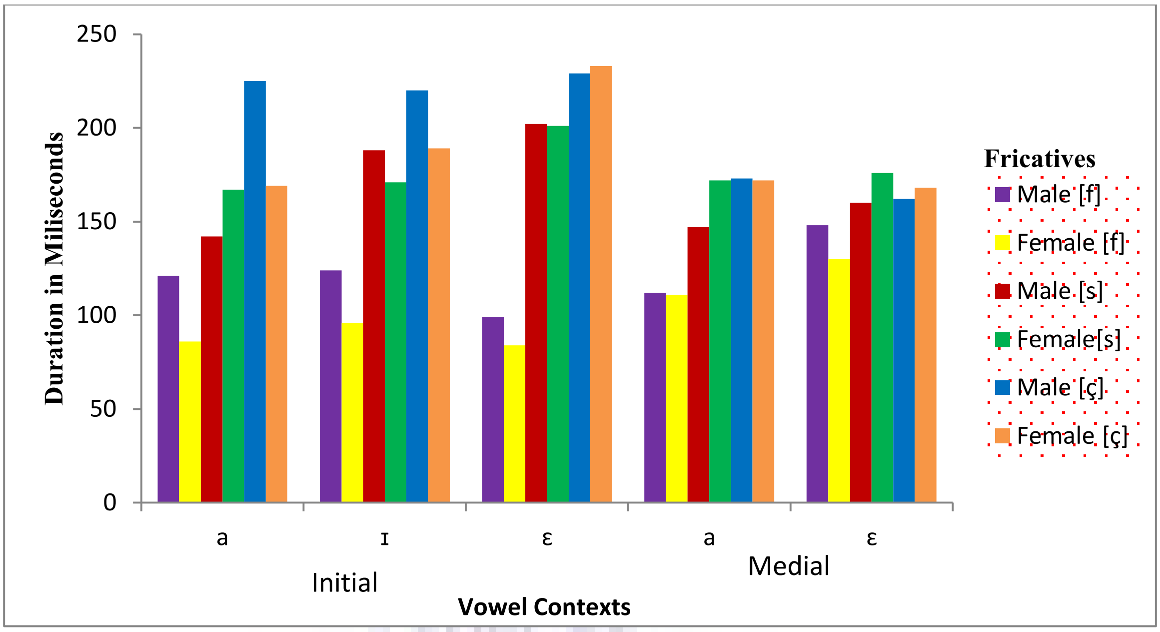


Figure 4.3.4 Bar Charts showing Mean Values of Fricative Duration for Male and Female Speakers of Denkyira at Different Word Positions

Table 4.3.7 below gives the details of the One- way ANOVA test carried out to determine the similarities and differences between male and female Denkyira speakers. It was reported in each fricative sound according to the arrangement of the vowels [a], [ɪ] and [ɛ] in whose context they were examined. At the word initial position, the results revealed that [f] was [p<0.27 (F-ratio 1.42); p<0.31 (F-ratio 1.18); p<0.61 (F-ratio 0.28)], [s] was [p<0.48 (F-ratio 0.55); p<0.66 (F-ratio 0.61); p<0.29 (F-ratio 0.30)] and [ç] is [p<0.00 (F-ratio 41.22), p< 0.04 (F-ratio 6.24); p<0.73 (F-ratio 0.13)]. At the word medial position too, fricatives were presented accordingly in their respective vowel contexts namely; [a] and [ɛ]. [f] was [p<0.97 (F-ratio 0.00); p<0.28 (F-ratio 0.32)] [s] was [p<0.07(F-ratio 4.28); p<0.33 (F-ratio 1.08)] and [ç] was [p<0.93(F-ratio 0.01); p<0.68 (F-ratio 0.04)].

The results showed that [ç] was significantly different for both males and females at the initial position in the environment of [a] and [ɪ] but was not significant in [ɛ] context. At the word medial, males and females did not differ because there were no significant differences between them.

Table 4.3.7 Differences and Similarities in Duration between Male and Female Speakers of Denkyira

			f		s		ç	
	Duration		F. ratio	p. value	F. ratio	p. value	F. ratio	p. value
		a	1.42	0.27	0.55	0.48	41.22	0.00
	Initial	**ɪ**	1.18	0.31	0.21	0.66	6.24	0.04
Bono		**ɛ**	0.28	0.61	1.30	0.29	0.13	0.73
		a	0.00	0.97	4.28	0.07	0.01	0.93
	Medial	**ɛ**	0.32	0.28	1.08	0.33	0.04	0.68

4.3.6 Duration of Denkyira Fricatives at Different Places of Articulation

Table 4.3.8 below displays results obtained from a Sample T-Test to find the similarities or the differences that exist among the three fricative consonants. The results were as follows; initially, [f-s] p<0.00 (T-value -6.68), [f- ç] p<0.00 (T-value -10.03) and [s- ç] p<0.00 (T-value -3.96). At word medial position, the results were reported as [f-s] p<0.00 (T-value -4.04), [f- ç] p<0.00 (T-value -3.70) and [s- ç] p<0.00 (T-value -0.60).

The T-sample test showed that at word initial position [ç] was longer than [f] and [s]. At the same time, [s] was longer than [f] but shorter than [ç]. Meanwhile, at the medial position, [ç] was longer than [f] but not [s]. That is to say that both [ç] and [s] are the same in duration.

Table 4.3.8 Paired Sample T-Test on Fricative Duration for Denkyira Speakers

		Fricatives	T- value	p. value
Denkyira	Initial	f-s	-6.68	0.00
		f- ç	-10.03	0.00
		s- ç	-3.96	0.00
	Medial	f-s	-4.04	0.00
		f- ç	-3.70	0.00
		s- ç	-0.60	0.56

4.3.7 Second Formant (F2) Transition Mean for Denkyira Dialect Speakers

F2 transition was measured for Denkyira vowels which come immediately after the fricative sounds in both monosyllabic and disyllabic words. In the monosyllabic words the results show [f, s, ç] transition into [a] as 1493Hz, 1450Hz, and 1526Hz respectively. Also, the outcome of [f, s, ç] into [ɪ] shows 1943Hz, 1909Hz and 1945Hz whilst [f, s, ç] into [ɛ] was 1731Hz, 1686Hz and 1704Hz in the environments of [f], [s] and [ç] in that order. The F2 transition values in the disyllabic words displayed [f, s, ç] into [a] as 1416Hz, 1524Hz and 1589Hz and [ɛ]; 1629Hz, 1661Hz and 1589Hz in [f], [s] and [ç] accordingly. See the Table 4.1.9, Figure 4.3.5 and Appendix C.

Table 4.1.9 Mean Second of Formant Transitions for Denkyira Speakers at Different Word Positions

			f	**s**	**ç**
Denkyira	Monosyllabic	a	1493	1450	1526
		ɪ	1943	1909	1945
		ɛ	1731	1686	1704
	Disyllabic	a	1416	1524	1589
		ɛ	1629	1661	1692

n = 10. Source: Field Data, 2014.

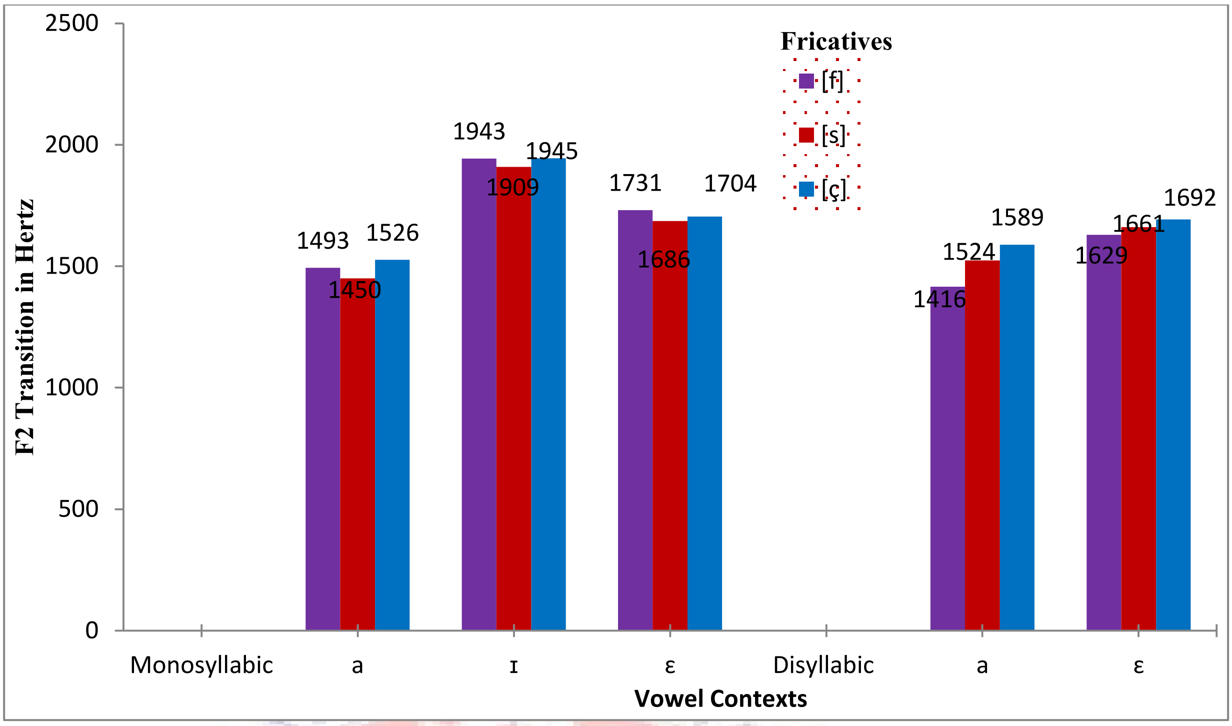


Figure 4.3.5 Bar Charts showing Mean Values of Second Formant Transitions for Denkyira Speakers in Monosyllabic and Disyllabic Words.

4.3.8 Gender Characteristics of Denkyira Fricatives Using F2 Vowel Transition

F2 transition values were computed and analysed for speakers of Denkyira with respect to gender (See Table 4.3.2 and Appendix E for the raw data). In the monosyllabic words the results for males were as follows; in the context of [a], [f] was 1435Hz, [s] was 1467Hz and [ç] was 1486Hz. In [ɪ] environment it occurred as [f] 1890Hz, [s] 1911Hz and [ç] 1925Hz respectively. Meanwhile the transition into [ɛ] was 1615Hz, 1626Hz and 1646Hz for [f], [s] and [ç] respectively. The disyllabic words were also reported [f] transition into [a] as 1496Hz, [s] into [a] as 1588Hz, and [ç] transition into [a] as 1584Hz. while [f,] transition into [ɛ] was 1567Hz, [s] transition into [ɛ] was 1541Hz and [ç] into [ɛ] was 1629Hz.

The F2 transition mean values of Asante female speakers were presented for the monosyllabic words at word in the context [a] as [f] 1334Hz, [s] 1432Hz and [ç] 1566Hz. In the environment of fricatives transition into [ɛ] the values were; [f]

1712Hz, [s] 1746Hz and 1761Hz. In [ɪ] also [f] was 1920Hz, [s] 1908Hz and 1965Hz.

The F2 values were recorded for the context of [a] as [f] 1336Hz, [s] 1460Hz and [ç] 1594Hz. Moreover, fricatives transition into [ɛ] presented as [f] 1722Hz, [s] 1781Hz and [ç] 1756Hz.

Table 4.3.10 Mean Values of Second Formant Transitions for Male and Female for Speakers of Denkyira in Monosyllabic and Disyllabic Words

			f		**s**		**ç**	
	Gender		**Male**	**Female**	**Male**	**Female**	**Male**	**Female**
Denkyira		a	1435	1334	1467	1432	1486	1566
	Monosyllabic	ɪ	1890	1920	1911	1908	1925	1965
		ɛ	1615	1712	1626	1746	1646	1761
	Disyllabic	a	1496	1336	1588	1460	1584	1594
		ɛ	1567	1722	1541	1781	1629	1756

n = 10. Source: Field Data, 2014.

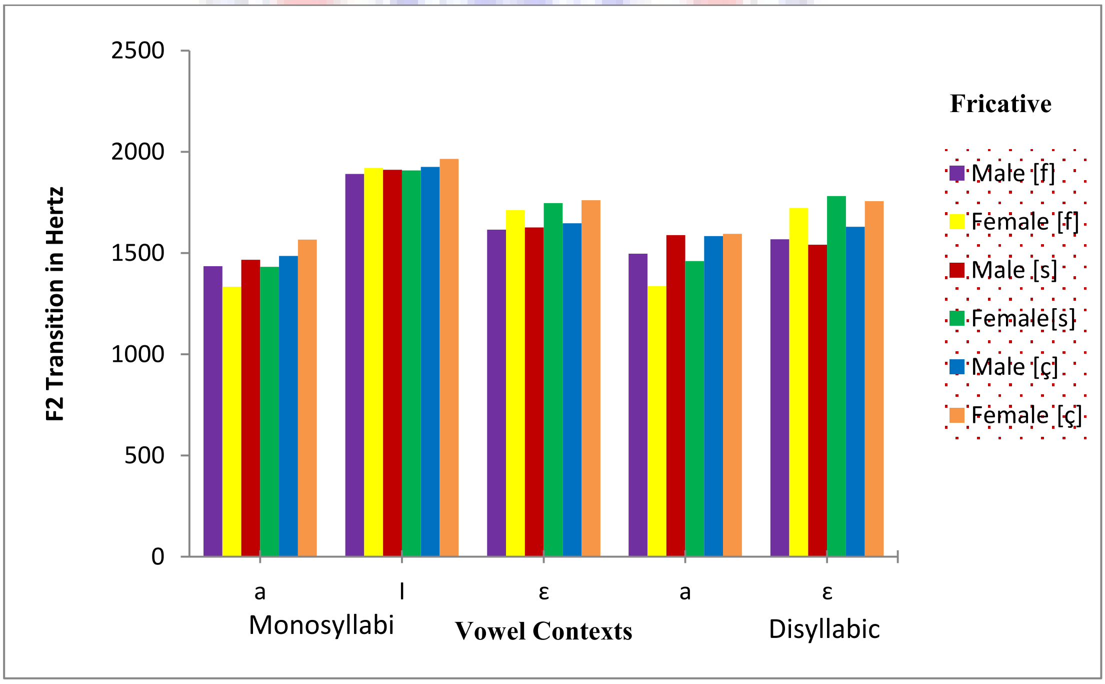


Figure 4.3.6 Bar Charts showing Mean Values of Second Formant Transitions for Male and Female for Speakers of Denkyira in Monosyllabic and Disyllabic Words

One-way Analysis of Variance was carried out to find the significance differences between males and females. In the monosyllabic words, transition into [a] is [p<00.2 (T-value 0.02; p<0.35 (T-value 0.97); p<0.04 (T-value 6.45)], [ɪ] is [p<0.07(T-value 4.28); p<0.93 (T-value 0.01); p<0.16 (T-value 2.46)] and [ɛ] p<0.00 (T-value 22.85); p<0.00 (T-value 65.17); p<0.00 (T-value 58.57)] for [f, s, ç] respectively. In the disyllabic words the detailed result shows transition into [a] as [p<0.06 (T-value 4.94); [p<0.00 (T-value 1747); [p<0.83 (T-value 0.05)] whereas transition into [ɛ] is [p<0.00 (T-value 30.56); [p<0.00 (T-value 45.05); [p<0.00 (T-value 24.30)] for their respective fricative environments [f, s, ç].

The results revealed that F2 transition into [ɛ] was significantly different for males and females in both monosyllabic and disyllabic words for the fricatives examined in Denkyira. However, [ɪ] was not significant in males and females in the monosyllabic words. On the other hand, second formant transition into [a] was significant in both sexes for the fricative [f] and [ç] but not [s] in monosyllabic words. Also, in the disyllabic words transition into [a] was significant in both sexes for [s] and [ç] environments but was not significantly different in [f] when occurred after [a] in disyllabic words.

Table 4.3.11 Differences and Similarities in Transition between Male and Female Speakers of Denkyira

			f		s		ç	
			F. ratio	p. value	F. ratio	p. value	F. ratio	p. value
Denkyira	Monosyllabic	a	8.01	0.02	0.97	0.35	6.45	0.04
		ɪ	4.28	0.07	0.01	0.93	2.46	0.16
		ɛ	22.85	0.00	65.17	0.00	58.57	0.00
	Disyllabic	a	4.94	0.06	17.47	0.00	0.05	0.83
		ɛ	30.56	0.00	45.04	0.00	24.30	0.00

n = 10. Source: Field Data, 2014.

4.3.9 Second Formant (F2) Transition of Denkyira at Different Places of Articulation

A Sample T-Test was examined to determine whether the fricatives are the same or different in terms of their places of articulation. The F2 transition of [f], [s] and [ç] into the vowels [a], [ɛ] and [ɪ] in monosyllabic and disyllabic words were compared. Table 4.3.3 below gives the details as [f-s] $p<0.00$ (T-value -2.06), [f- ç] $p<0.00$ (T-value -4.93) and [s- ç] $p<0.02$ (T-value -2.91) for monosyllabic words. Also, for the disyllabic words [f-s] is $p<0.00$ (T-value -4.10), [f- ç] is $p<0.00$ (T-value -5.26) and [s- ç] is $p<0.00$ (T-value –2.50).

The Sample T-Test demonstrated that there were significant differences between the fricatives compared. Thus, [ç] transition into the vowels has the highest F2 values followed by [s] and [f] respectively in both monosyllabic and disyllabic words.

Table 4.3.12 Paired Sample T-Test on F2 Transition for Denkyira Speakers

		Fricatives	**T- value**	**p. value**
Denkyira	Monosyllabic	f-s	-2.06	0.00
		f- ç	-4.93	0.00
		s- ç	-2.91	0.02
	Disyllabic	f-s	-4.10	0.00
		f- ç	-5.26	0.00
		s- ç	-2.50	0.00

4.4 Twi Speakers

The results obtained from the 30 participants of Asante, Bono and Denkyira were subsequently put together to draw conclusion for three dialects of Akan. The results attained from the various analyses are displayed in Tables 4.4.1-4.4.15.

4.4.1 Mean Values of Spectral Peak Location for Twi

The spectral peak location values for word-initial position were [f] 7231Hz, [s] 6342 Hz and [ç] 3483Hz respectively. At the word-medial position the results were [f] 7276Hz, [s] 6345Hz and [ç] 3466Hz. See table 4.4.1and figure 4.4.1 for the summary of the results.

The results revealed that spectral peak location mean values of Twi showed [f] was higher than [s] and [ç]. [s] had a higher spectral peak location frequency values than [ç] and lower than [f]. [ç] had the lowest spectral peak location value in three dialects examined. The outcome was similar for both initial and medial positions.

Table 4.4.1 Spectral Peak Location Means in Hz for Twi Speakers

	Position	f	s	ç
Twi	Initial	7231	6342	3483
	Medial	7276	6345	3466

n = 30. Source: Field Data, 2014.

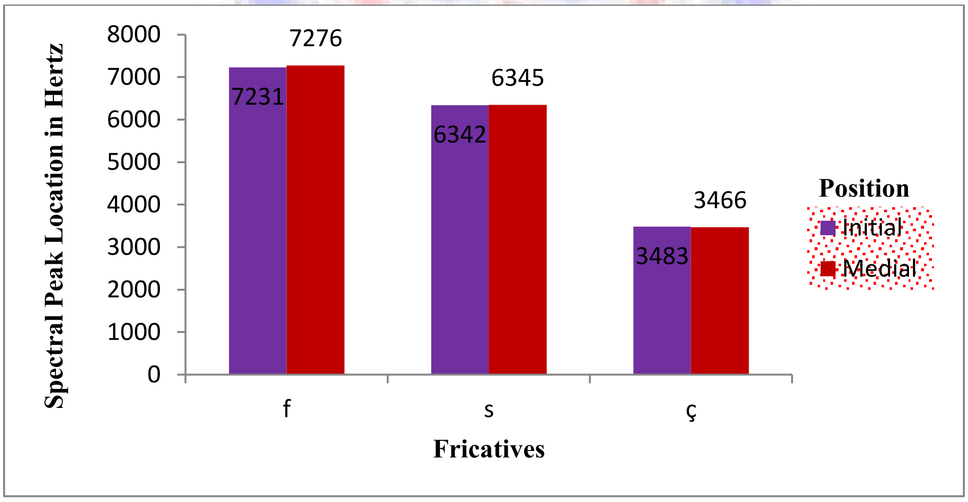


Figure 4.4.1 Bar Chart of Spectral peak Location Mean Values for Twi

4.4.2 Gender Characteristics of Twi Fricatives for Spectral Peak Location

Male and female spectral peak location mean values of fricative consonants were computed for all the three dialects of Akan namely Asante, Bono and Denkyira. The mean with their corresponding positions are presented. At the word-initial position male [f] was 6884Hz, [s] was 5971 Hz and [ç] was 3126Hz. In the word-medial position, [f] was 6942Hz, [s] was 6049 Hz and [ç] was 3091Hz. In the females at word-initial position, [f] was 7568Hz, [s] was 6712Hz and [ç] was 3834Hz whilst [f] was 7611Hz, [s] 6601 Hz and [ç] 3840Hz for word medial position (see table 4.4.2 and figure 4.4.2).

Throughout the analysis it was discovered that the female speakers have higher frequency spectral peak locations than their male counterparts.

Table 4.4.2 Mean Values of Spectral Peak Location for Male and Female Speakers of Twi

			f	s	ç
	Gender				
Twi	**Male**	Initial	6884	5971	3126
		Medial	6942	6049	3091
	Female	Initial	7568	6712	3839
		Medial	7611	6601	3840

n = 30. Source: Field Data,

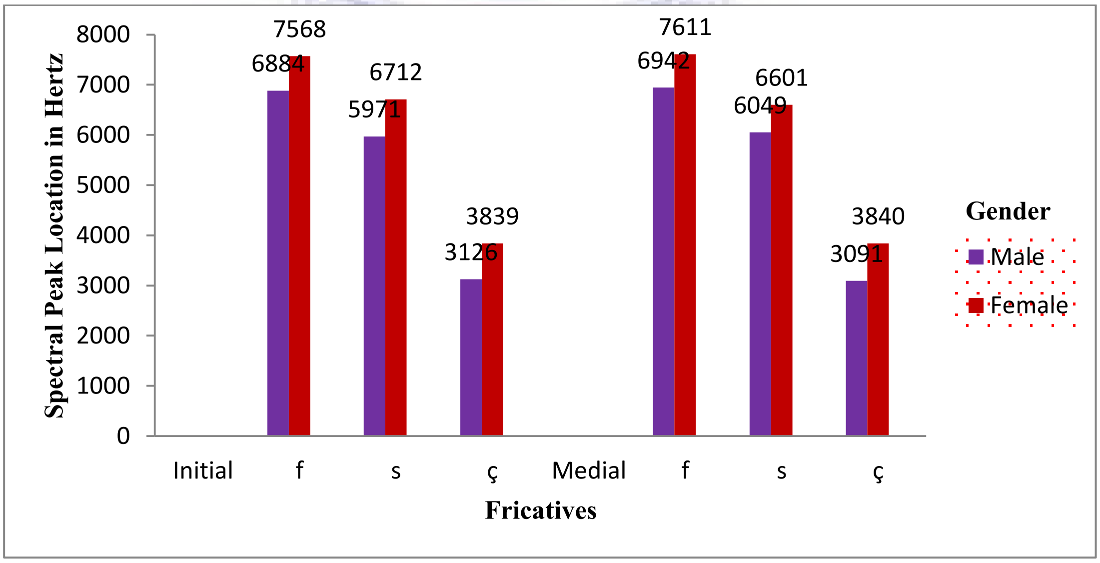


Figure 4.4.2 Bar Chart Fricatives of Male and Female Speakers of Twi

Spectral peak location mean values of male and female speakers of Twi were calculated to ascertain the differences between the two groups. On the basis of this, a One-way analysis of variance (ANOVA) was conducted with p<0.05 significant level. The results were [f] p<0.05 (F-ratio 114.92), [s] p<0.00 (F-ratio 127.49) and [ç] p<0.00 (F-ratio 588.16) for word-initial position. At the word medial position, [f] is p<0.00 (F-ratio 340.92), [s] is p<0.00 (F-ratio 101.04) and [ç] is p<0.00 (F-ratio 426.12).

The results indicated that the differences between male and female speakers of Twi were statistically significant. This feature was particularly evident for the female speaker, because the frequency values of male speakers were lower than their female counterparts in Twi for all the fricatives examined. The results are shown in Table 4.2.3 below.

Table 4.4.3 Differences and Similarities in Male and Female Spectral Peak Location Values for Twi Speakers

Twi		f		s		ç	
	Position	F. ratio	p. value	F. ratio	p. value	F. ratio	p. value
	Initial	114.85	0.00	127.49	0.00	588.16	0.00
	Medial	340.92	0.00	101.04	0.00	426.12	0.00

p < 0.05. n = 30. Source: Field Data, 2014.

4.4.3 Spectral Peak Location of Twi Fricatives at Different Places of Articulation

In an attempt to ascertain the distinctiveness of Akan fricative consonants [f,], [s] and [ç], a sample T-Test was conducted using SPSS. The significant level was set at p<0.05. The results were presented as [f-s] p<0.00 (F-ratio 21.09), [f-ç] p<0.00 (F-ratio 105.90) and [s-ç] p<0.00 (f-ratio 76.99) at the word initial position. Also, at the word medial position, the results showed that [f-s] was p<0.00 (F-ratio 25.20), [f-ç] was p<0.00 (F-ratio 136.74) and [s-ç] was p<0.00 (F-ratio 68.76). Table 4.4.4 displays the summarized results.

From the results it was clear that the fricatives produced at the various places of articulation are distinct because they were statistically different from one another in terms of spectral peak location. [f] had higher spectral peak location frequency as compare to [s] and [ç]. In the same vein, [s] was also higher in spectral peak location frequency than [ç] but lower than [f]. This suggests that in Twi [f] had higher spectral peak location frequency value followed by [s] and [ç] respectively.

Table 4.4.4 Paired Sample T-Test on Spectral Peak Location for Twi Speakers

		fricatives	T- value	p. value
	Initial	f-s	21.09	0.00
		f- ç	105.90	0.00
Twi		s- ç	76.99	0.00
	Medial	f-s	25.20	0.00
		f- ç	136.74	0.00
		s- ç	68.76	0.00

4.4.4 Spectral Peak Location of Asante, Bono and Denkyira Fricatives

Table 4.4.5 below presents at the differences of Twi fricatives produced by speakers of Asante, Bono and Denkyira at both word-initial and word-medial positions. This was done using one-way ANOVA with the significant level at p<0.05.The main purpose is to determine whether the fricatives are different as regard the three dialects being experimented. The results below indicated that [f] was p<0.89 (F-value 0.12), [s] was p<0.70 (F-value 0.36) and [ç] was p<0.07 (F-value 0.03) at word-initial position. On the other hand, [f] was p<0.92 (F-value 0.08), [s] was p<0.53 (F-value 0.66) and [ç] was p<0.07 (F-value 0.03) for word-medial positions.

The results indicated that in Twi there were no significant differences between same fricatives produced at different word positions by Asante, Bono and Denkyira speakers. It implies that fricatives produced by Asante, Bono and Denkyira speakers at both initial and medial are not different from one other.

Table 4.4.5 Differences in the Spectral Peak Location of fricatives of Asante, Bono and Denkyira

		f		s		ç	
	Position	F. ratio	P. value	F. ratio	p. value	F. ratio	p. value
Twi	Initial	0.12	0.89	0.36	0.70	0.03	0.97
	Medial	0.08	0.92	0.66	0.53	0.29	0.75

$p > 0.05$. n = 30. Source: Field Data, 2014.

4.4.5 Mean Duration of Twi Fricatives

Table 4.4.6 and Figure 4.4.3 below indicates duration mean values of Twi fricatives. The duration mean value for [f] was 100ms, [s] was 182ms and [ç] was 212ms for word-initial. At the word-medial position the values for [f] was 134ms, [s] was 167ms and [ç] was 173. The result shows that [f] relatively had the shortest duration value followed by [s] and [ç]. Hence in Twi [ç] had the longest duration, followed by [s] and [f] respectively.

Table 4.4.6 Duration Mean of Fricatives for Twi Speakers

	Position	f	s	ç
Twi	Initial	100	182	212
	Medial	134	167	173

n = 30. Source: Field Data, 2014.

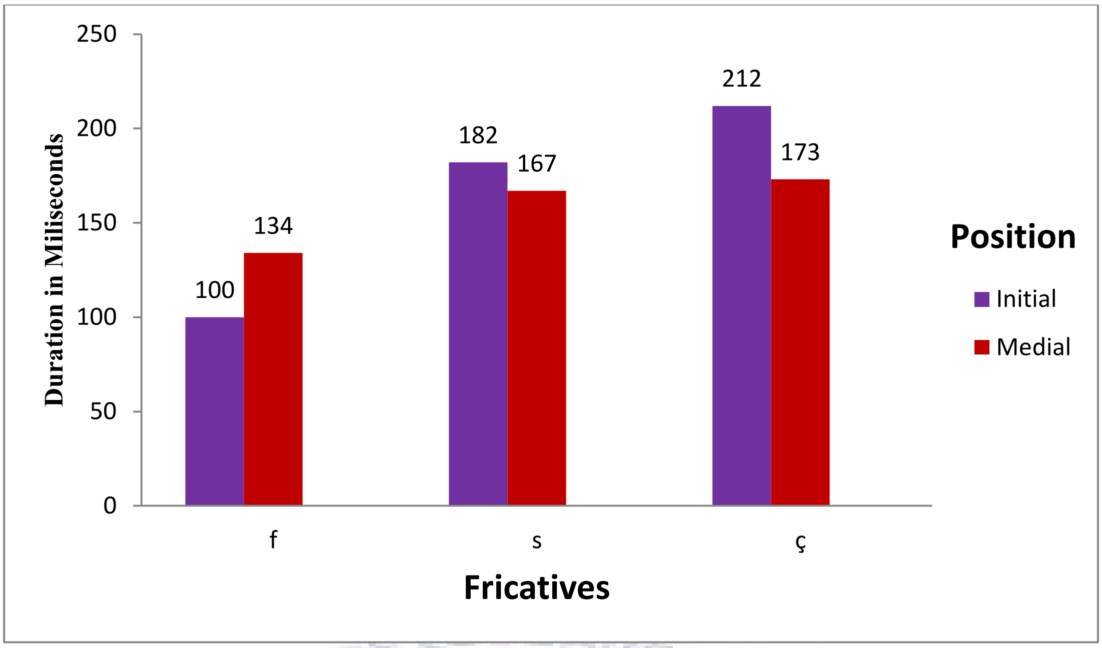


Figure 4.4.3 Bar Chart of Duration Mean of Fricatives for Twi Speakers

4.4.6 Gender Characteristics of Twi Fricatives Using Duration

Duration values for male and female speakers of Twi were calculated to ascertain the similarities and differences between the two sexes. In tables 4.7.1 and 4.4.2 the results for duration mean values of males are presented as [f] 99ms [s] 173ms and [ç] 223ms for word-initial. Again, [f] was 131ms, [s] is 160ms and [ç] was 173ms in the word-medial position. For the female speakers the duration mean values were: [f] 102ms, [s] 184ms, and [ç] 202ms at the word initial position. Again, for female speakers in the word medial position the result stands as [s] 137ms, [s] 180ms and [ç] 174ms.

Table 4.4.7 Mean Duration Fricatives for Male and Female Speakers of Twi in Milliseconds

	Duration		f	s	ç
	Male	Initial	102	184	223
		Medial	131	160	173
Twi					
	Female	Initial	99	174	202
		Medial	137	180	174

n = 30. Source: Field Data, 2014

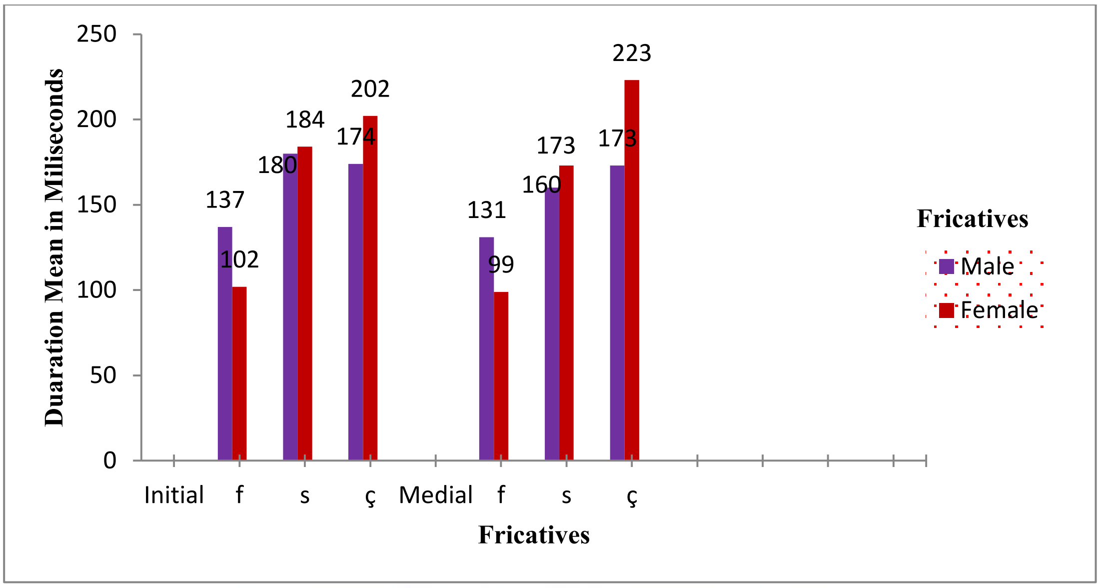


Figure 4.4.4 Mean Duration Fricatives for Male and Female Speakers of Twi in Milliseconds

In table 4.4.8, the results showed the One-way Analysis of Variance (ANOVA) carried out to determine the distinctiveness of male and female speakers of Akan as [f] p<0.78 (F-ratio 0.08), [s] p<0.64 (F-ratio 0.22) and [ç] p<0.00 (F-ratio 11.72) for word initial. Finally, the result for word-medial reveals [f] is p<0.65(F-ratio 0.21), [s] is p<0.05(F-ratio 4.27) and [ç] is p<0.80(F-ratio 0.07) at the word medial position.

The results indicated that with the exception of [ç] at the word-initial position which is significantly different for Asante, Bono and Denkyira, there were no significant differences between male and female speakers in respect to duration. However, the [f] as produced by males was relatively higher than the females while the female [s] and [ç] were slightly higher than that of their male counterparts. Lastly, males and females do not differ since there are no significant between them at the word medial position.

Table 4.4.8 Differences and Similarities in Male and Female Duration for Twi Speakers

		f		s		ç	
Twi	Position	F. ratio	p. value	F. ratio	p. value	F. ratio	p. value
	Initial	0.08	0.78	0.22	0.64	11.72	0.00*
	Medial	0.21	0.65	4.07	0.06	0.07	0.80

*p < 0.05. n = 30. Source: Field Data, 2014.

4.4.7 Duration of Fricatives of Twi at Different Places of Articulation

Using SPSS computer software, a sample T-Test was conducted on the various fricatives being investigated. This was carried out to find out whether these fricatives produced at different places of articulation are similar or different from one another. The three fricatives [f], [s] and [ç] were analysed. See table .4.8.7 for the summary of the result. The outcome were presented as [f-s] p<0.00 (f-ratio -12.10), [f-ç] p<0.00 (F-ratio -14.65) and [s-ç] p<0.00 (F-ratio -6.30) for the word initial position. In the medial position the results were as follows: [f-s] p<0.00 (F-ratio -5.15), [f-ç] p<0.00 (F-ratio -9.82) and [s-ç] p<0.00 (F-ratio -1.78).

The results revealed that all the fricatives [f, s, ç] of Twi were significantly different in terms of duration at the word-initial position. At the word medial position, there were significant differences between [f-s] and [f-ç]. However, [s-ç] were not statistically significant.

Table 4.4.9 Paired Sample T-Test on Fricative for Twi Speakers

		Fricatives	T- value	p. value
Twi	Initial	f-s	-12.10	0.00
		f- ç	-14.65	0.00
		s- ç	-6.30	0.00
	Medial	f-s	-5.15	0.00
		f- ç	-9.82	0.00
		s- ç	-1.78	0.09*

*p < 0.05. n = 30. Source: Field Data, 2014.

4.4.8 Duration of Asante, Bono and Denkyira Fricatives

One-way Analysis of Variance was calculated using SPSS with the significant level at p<0.05. The results were presented in table 4.4.9 as [f] p<0.38 (F- ratio 1.00), [s] p<0.03 (F-ratio 3.96) and [ç] p<0.03 (F-ratio 4.26) for word initial. Meanwhile, [f] is p<0.30 (F-ratio 1.28), [s] was p<0.811 (F-ratio 0.22) and [ç] is p<0.56 (F-ratio 0.59) at word-medial position.

Table 4.4.10 Differences in Duration of Fricative of Asante, Bono and Denkyira Dialects of Twi

Twi	Position	f		s		ç	
		F. ratio	P. value	F. ratio	p. value	F. ratio	p. value
	Initial	1.00	0.38	3.96	0.03*	4.26	0.03*
	Medial	1.28	0.30	0.22	0.81	0.59	0.56

*p < 0.05. n = 30. Source: Field Data, 2014.

At the word medial position, the result revealed that there were no differences among Asante, Bono and Denkyira fricatives in respect to duration at the medial-position for all fricatives examined. In the same manner, [f] at the word initial position do not differ in among the three dialects. Nevertheless, [s] and [ç] were statistically significant among all the three dialects of Akan at the word-initial position. Therefore there was the need to carry out further test to see which dialect was different from the other.

Hence, a Levene‟s homogeneity of variance test was conducted. The test results showed that the three Akan dialect groups used in the study were not different p<0.51 (F ratio 0.70). Therefore equal variance was assumed for the duration fricatives for initial [s]. It was against this backdrop that One-Way ANOVA Bonferroni Post-Hoc multiple comparisons were computed to test the differences that existed in the duration of fricatives of initial [s] for the three Akan dialects. The results indicated that, the duration of fricative for [s] of Asante dialect was significantly different from that of the Bono dialect ($p<0.05$). However, the duration of fricative for initial [s] for the Denkyira dialect was not significant with both Asante ($p < 1.00$) and Bono ($p < 0.09$) dialects. This implies that the duration for initial [s] for the Denkyira dialect was not statistically different from the duration of initial [s] of Asante and Bono dialects.

Again, a Levene‟s homogeneity of variance test computed, the results showed that the three Akan dialects used in the study were significantly different at $p< 0.00$ (F ratio 4.42). Therefore, equal variance was not assumed for the duration of fricatives for initial [ç]. One-Way ANOVA Dunnett‟s T3 Post-Hoc multiple comparison was computed to test the differences that exist in the frication duration for initial [ç] of the three Akan dialects. The results indicated that the duration of fricative [ç] of Asante Twi dialect was significantly different from that of the Bono dialect ($p<0.00$). However, the duration fricative for initial [ç] for the Denkyira dialect is not significant with both Asante ($p< 0.65$) and Bono ($p<0.13$) dialects. This implies that the duration for initial [ç] for the Denkyira dialect was not statistically different from the duration for initial [ç] of Asante and Bono dialects.

4.4.9. Mean of Second Formant (F2) Transition for Twi

Table 4.4.1 presents F2 vowel transition mean values for male and female Speakers of Twi. The results in the monosyllabic words were[f] 1672Hz, [s] 1703Hz and [ç] 1756Hz. In the disyllabic words, the results were presented as [f] 1559Hz, [s] 1628 Hz and [ç] 1678Hz respectively. It was observed that the F2 transition mean tend to increase as the place of articulation moves backwards. Relatively [ç] was higher than [f] and [s]. Meanwhile [s] was higher [f] but lower than [ç].

Table 4.4.11 Second Formant (F2) Transition Mean Values for Twi in Hertz

	Position	f	s	ç
Twi	Initial	1672	1703	1756
	Medial	1559	1628	1678

n = 30. Source: Field Data, 2014.

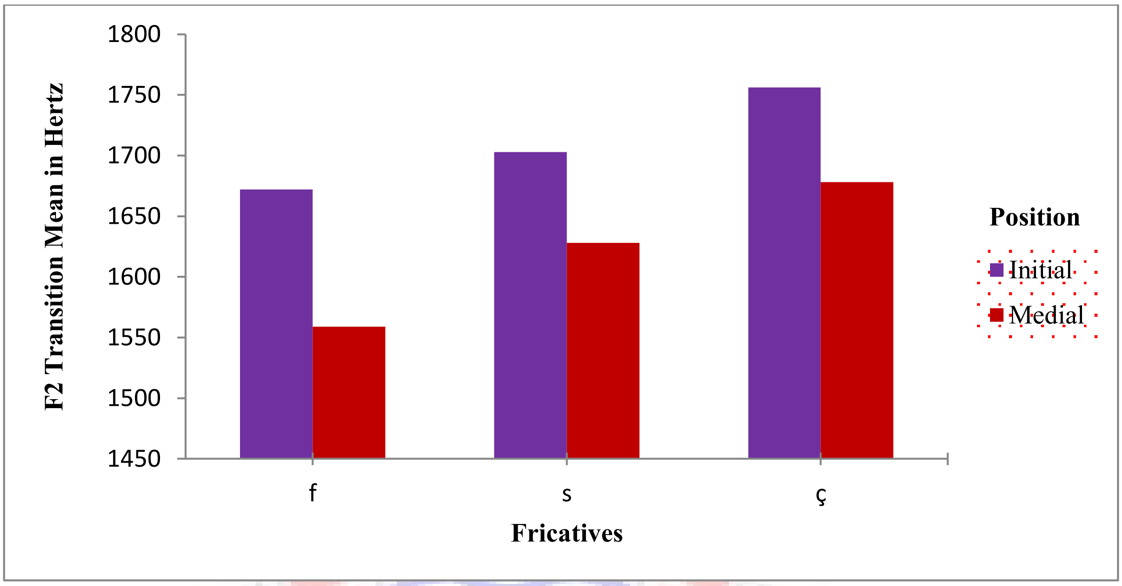


Figure 4.4.5 Bar Chart of F2 Transition Mean of Fricatives for Twi Speakers

4.4.10 Gender Characteristics of Twi Fricatives using F2 Transition

Table 4.4.12 shows the F2 transition mean values of male and female speakers of Twi. The results were presented for the male speakers as [f] 1668Hz, [s] 1695Hz and [ç] 1737Hz in the monosyllabic words, and [f] 1578Hz, [s] 1616Hz and [ç] 1675Hz in the disyllabic words. In the same vein, female speakers showed [f] 1679Hz, [s] 1712Hz and [ç] 1775Hz as F2 transition mean values for monosyllabic words. In the disyllabic word, the female F2 mean values showed [f] as 1540Hz, [s] 1639Hz and [ç] 1681Hz.

Table 4.4.12 F2 Transition Mean Values in Hertz for Male and Female Speakers of Twi

Fricatives			f	s	ç
	Male	Initial	1668	1695	1737
		Medial	1578	1616	1675
Twi	Female	Initial	1676	1712	1775
		Medial	1540	1639	1681

n = 15. Source: Field Data, 2014.

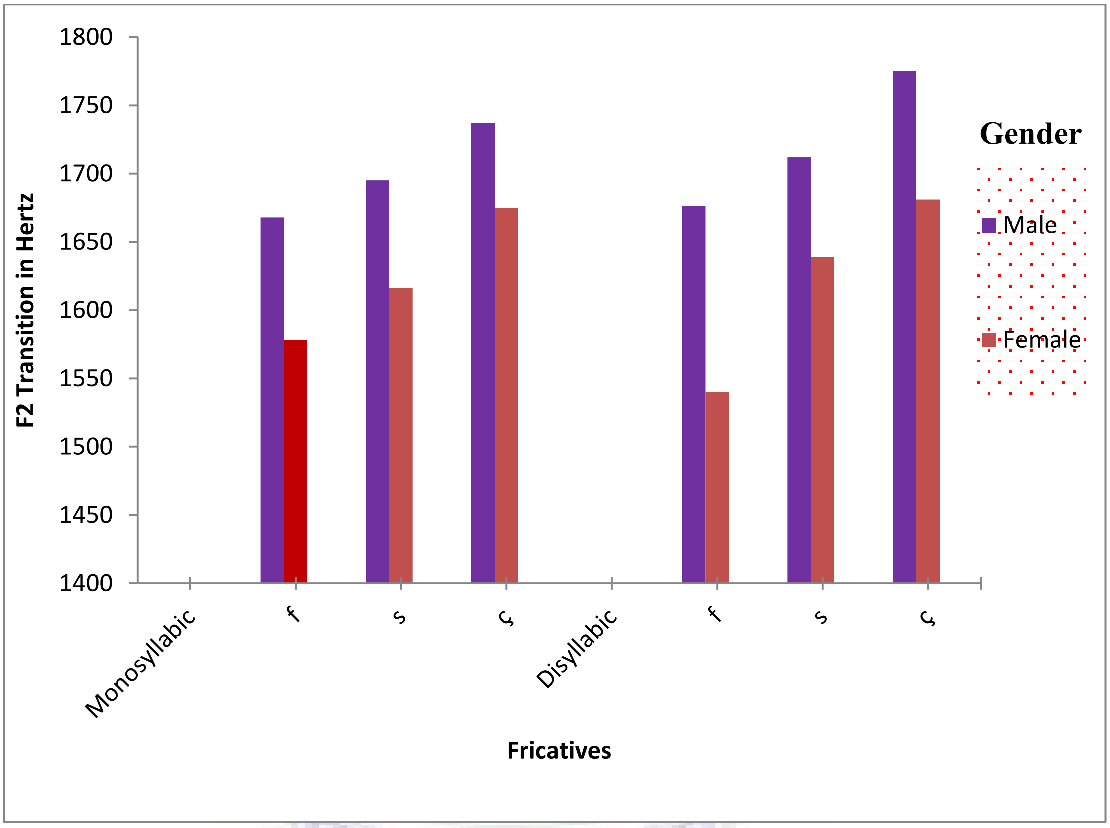


Figure 4.4.6 F2 Transition for Male and Female Speakers of Twi At Different Word Positions

4.4.11 Gender Characteristics of Twi Fricatives

In order to ascertain if there are similarities or differences between male and female speakers of Twi is respect to F2 transition, one-way ANOVA test was conducted. Using SPSS software, the significant level was set at $p<0.05$. The findings are shown in table 4.8.4 as [f] $p<0.51$ (F-ratio 0.45), [s] $p<0.26$ (F-ratio 1.33) and [ç] $p<0.28$ (F-ratio 1.46) for word-initial position. In the same development [f] $p<0.07$ (F-ratio 0.38), [s] $p<0.28$ (F-ratio 1.24) and [ç] $p<0.78$ (F-ratio 0.08)

The results revealed that at the word-initial position, there are no significant differences between males and females. At word medial position, [f], [s] and [ç] are not significantly different as far as gender is concern. This is because the values for the females are not significantly different from males at word initial positions. Also, F2 transitions into the vowel are not statistically significant at word-medial position. It implies that there are no differences between how males and females produce fricatives in Twi. See the Table 4.4.13 below for the results summary.

Table 4.4.13 F2 Transition in Hertz for Male and Female for Twi Speakers

		f		s		ç	
Twi	Position	F. ratio	p. value	F. ratio	p. value	F. ratio	p. value
	Initial	0.45	0.51	1.33	0.26	1.46	0.28
	Medial	0.38	0.07	1.24	0.28	0.08	0.78

$p < 0.05$. n = 30. Source: Field Data, 2014.

4.4.12 F2 Transition of Twi Fricatives at Different Place of Articulation

The three fricatives of Twi were compared to determine whether they are similar or different in Asante, Bono and Denkyira. This was done using SPSS with the significant level set at $p<0.05$. A sample T-Test was carried to ascertain whether the fricatives were similar or different. The results were shown as follows [f] $p<0.00$ (T-value -3.56), [s] $p<0.00$ (T-value -10.89) and [ç] $p<0.00$ (T-value -6.30) for word initial position. The word-medial position also showed [f] $p<0.00$ (t value -5.57), [s] $p<0.00$ (T-value -11.06) and [ç] $p<0.00$ (T-value -4.44) see Table 4.8.5.

The results revealed that [f] has lowest F2 value as compared to [s] and [ç]. On the other hand [s] was higher than [f] but lower than [ç]. In effect [ç] has the highest F2 value as compare to the other fricative consonants. The results were tabulated in T 4.4.14.

Table 4.4.14 Paired Sample T-Test on F2 Transition mean for Fricatives of Twi

		Fricative	T- value	P. Value
Twi	Initial	[f-s]	-3.56	0.00
		[f- ç]	-10.89	0.00
		[s- ç]	-6.31	0.00
	Medial	[f-s]	-5.57	0.00
		[f- ç]	-11.06	0.00
		[s- ç]	-4.44	0.00

*p<0.05. n = 10. Source: Field Data, 2014

4.4.13 F2 Transition of Asante, Bono and Denkyira Fricatives

Levene‟s homogeneity of variance test showed that F2 transition for [s] in the context of [ɛ] assumed equal variance at P<0.17 (F-ratio 1.90). Subsequently, a One-way ANOVA Boniferroni Post-Hoc conducted. The outcome indicated that F2 transition of [s] into [ɛ] in Asante dialect was significantly different from Denkyira (p<0.02) but not significant with Bono dialect (p <0.00). However, Bono was significantly different from Denkyira (p <0.00). This implies the F2 transition of Denkyira dialect vowel [ɛ] after the [s] was significantly different from Bono and Asante.

In the same vein, a Levene‟s test run for F2 transition of [ç] indicated that equal variance was assumed for the transition into [ɛ] was at p< 0.20 (F-ratio 1.72). Afterwards, a One-way ANOVA Bonniferroni Post-Hoc test was carried out to ascertain the level of significant. The result showed the F2 transition of [ɛ] which comes after [ç] in Asante was significantly different with Bono and Denkyira at (p< 0.00). Meanwhile, Bono was significant with Asante (p <0.00) but not significant with Denkyira (p< 1.00).

Finally, equal variance was assumed for [ɛ] in the environment of [ç] as p< 0.09 (F-ratio 9.91) when Levene‟s homogeneity test was conducted. Again, a Post-Hoc test conducted showed that Denkyira [ç] was significantly different from Asante dialect in terms of F2 Transition of [a] at (p < 0.00) and Bono also at (p <0.00). However, the Asante dialect was not significantly different from the Bono dialect as the result revealed (p <1.00). This implies that Asante and Bono would always be the same in this regard. Find the summary in Table 4.4.15 below.

Table 4.4.15 Comparison of Asante, Bono and Asante Fricatives base on F2 Transition

Fricatives		f		s		ç	
	Vowels	F. ratio	P. value	F. ratio	p. value	F. ratio	p. value
Twi	a	1.31	0.29	4.91	0.17	16.26	0.00*
	ɪ	0.10	0.90	0.04	0.96	1.12	0.90
	ɛ	2.42	0.50	5.35	0.01*	7.83	0.00*

*p > 0.05. n = 30. Source: Field Data, 2014.

4.5 Summary and Conclusion

This chapter discussed the result of the analyses within the framework of spectral peak location, duration and the second formant (F2) transition in different vowel contexts. Various tests were conducted on gender similarities and differences as well as fricatives place of articulation in each of the dialects used. The statistical tools employed included One-way ANOVA and a Sample T-Test.

It was revealed that [f] has the highest frequency when compared with [s] and [ç]. Alveolar [s] was also higher than [ç] in parameters of spectral peak location. The females have higher spectral peak location frequencies than the males. Comparing the duration it was detected that [s] was the shorter than [ç], but longer than [f]. Relatively, [ç] had the longest duration in Twi. At the F2 transition level, palatal [ç] was the highest followed by [s] and [f] respectively. The monosyllabic words had higher F2 transition frequency values than the disyllabic words.

Fricatives examined on the basis of previous studies showed relatively a substantial variation in their production. The current study in the same vein revealed fricatives of Asante, Bono and Denkyira showed considerable variation in their acoustic properties at the various places of articulation. Interestingly, the study also discovered that fricatives [s] and [ç] of Asante Bono and Denkyira served as the greatest source of variation in the three dialects. However, [f] was similar in all three dialects. This supported the fact that [s] is known to differ significantly from language to language and speaker to speaker in their acoustic properties (Gordon et el, 2008). This suggests cross-dialect and inter-speaker differences at the point of constriction, length of constriction and front-back movement of the tongue (Al-Kairy, 2005 and Gordon et el, 2008).

CHAPTER FIVE

CONCLUSION

5.0 Introduction

The primary aim of this study was to give an acoustic description of fricative consonants of the Twi dialect using spectrographical analysis in order to classify them accordingly. The spectrographical analyses were done alongside statistical analyses. This section, therefore, discusses the main findings of the study and also seeks to answer the research questions.

5.1 Summary of Results

The fricative consonants of Twi were investigated using three main cues namely: spectral peak location, duration and second formant (F2) transition. The spectrographical analyses were done alongside statistical analyses.

5.1.1 Summary of Spectral Peak Location Results

There was generally a considerable uniformity across the speakers and dialects examined in the spectral peak location characteristics of the fricatives [f], [s] and [ç]. The findings were similar for all the fricatives in Asante, Bono and Denkyira speakers. The findings conformed to the assumption made by the filter-source theory. Thus, the spectral frequency values correlated with the backness of the fricatives.

Spectral peak location of fricatives was in conformity with other previous studies (Jongman et al, 1998; Jongman et al, 2000, Al-khairy, 2005; Jongman, 2000) in that the frequency decreases as the place of articulation moves backwards in the vocal tract. This finding is further supported by Johnson (2000) that changes occur in the length of the oral vocal tract. This is why shorter cavities tend to have higher frequencies than longer cavities. Averagely, in Twi, [f] had the highest spectral peak location (around 7231Hz and 7276Hz) followed by [s] (around 6342Hz and 6345Hz) and [ç] (ranged between 3466Hz and 3483Hz) in that order. The results were consistent at both initial and medial positions. This means fricatives produced at word-initial or word-medial exhibited the same acoustic characteristics. Also, spectral peak location confirmed that all the fricatives are different from one another in respect to the places of articulation as suggested by (Jongman et al, 1998). The T-Test results showed that the three fricatives [f, s, ç] mutually exclusive in relation to their place of articulation.

Furthermore, the findings revealed that spectral peak location was significantly higher for females than for male speakers. The females had higher frequencies than their male counterparts which is consistent with (Jongman et al, 1998). The findings suggested that female speakers of Twi have an average spectral peak location mean around 7568Hz and 7611Hz for [f], 660Hz and 6712Hz for [s] and; 3839Hz and 3840Hz for [ç]. Their male counterparts also had an average spectral peak location of 6884Hz; 6942Hz for [f], 5971Hz; 3126Hz for [s] and 3126Hz; 3091Hz for [ç]. The differences can be linked to the fact that human voice is sexually dimorphic (Cartei et al, 2012). This stems from the fact that females have shorter vocal tract than males. Therefore, females are likely to generate higher values than males.

The spectral peak location properties suggested that the dialects examined: Asante, Bono and Denkyira are similar. Thus, there were no significant differences in the dialects investigated. This was revealed by an ANOVA test which was carried for the three dialects.

5.1.2 Summary of Duration Results

The study revealed that the duration of the sibilant fricatives [s] and [ç] were both longer than the non-sibilant [f]. The mean value of Twi non-sibilant [f] was 134ms, whilst the sibilants [s] and [ç] had 167ms and 173ms respectively. The findings were in agreement with Al-Khairy (2005). The longer duration of the sibilants can be attributed to the articulatory efforts needed to force air through the narrow channel required for the sibilant articulation. It was also in agreement with Akpanglo-Nartey (1982) assumption that fricatives inherently differ in duration. Again, [f] was found to have the shortest duration when compared to the other fricatives (Jogman et al, 1998; Gordon et al, 2008; Jones and Nolan (2007) and Reetz and Jongman, (2009). Subsequently, in Twi, the alveo-palatal [ç] had the longest duration followed by the alveolar [s] and the labiodental [f] having the shortest duration noise.

The study further showed that only alveo-palatal [ç] at word initial position was significant between male and female. Apart from this, there was no significant difference between males and females as regards duration at both word initial and medial positions in Twi. This notwithstanding, [f] was higher in males than females whilst [s] and [ç] were also relatively higher in females than in males.

Moreover, the Sample T-test on fricative place of articulation revealed that the duration of Twi fricatives examined [f, s, ç] are distinct at word-initial position. Meanwhile, that was not the case for [ç] and [s] at word-medial position since it was established that there are no differences in this regard. Furthermore, the study showed that there were no differences among the three dialects at word-medial. However, at the initial position, Asante [s] was different from both Bono and Denkyira. This means that Bono and Denkyira fricatives are of equivalent duration. Again, [ç] at the initial position as produced by Asante was different from Bono but not Denkyira. Fricative [ç] of Denkyira was not significant with that of Asante and Bono.

In spite of the minor differences that existed among the three dialects of Akan, these differences do not affect their intelligibility.

5.1.3 Summary of Second Formant (F2) Transition Results

Furthermore, second formant (F2) at transition was also robust in distinguishing the fricatives. The findings showed that in Twi [f], [s], and [ç] were significantly different at the various places of articulation. The measurement obtained showed that the F2 frequencies tend to increase as the place of articulation moves backwards (Wilde, 1995; Al- Khairy, 2005). This is because F2 frequency is considered to correlate inversely "with the length of the back cavity immediately after the release of the coronal constriction" Li (2008, p25). Hence in Twi, [f] had the lowest F2 transition (1672Hz), followed by [s] with 1703Hz and [ç] with1756Hz being the highest in the three vowel-contexts analysed. In all, [f], [s] and [ç] were significantly different from one another as regards their places of articulation.

Both sexes did not differ significantly in F2 transition for Asante, Bono and Denkyira. This was not different in word position too (males and females were not statistically significant from each other).

This study also showed that at F2 transition level, [s] as produced by Denkyira speakers was significantly different from Bono and Asante in the context of [ɛ]. Meanwhile, for [ç] in the context of [ɛ], Asante was different from Denkyira and Bono but Bono and Denkyira speakers did not differ in their F2 values. Finally, the fricative-vowel boundary transition for [ç] into the vowel [a] showed that Denkyira fricative [ç] was significantly different from that of Asante and Bono.

5.2 Discoveries/Findings

The study discovered that alveolar [s] and alveopalatal [ç] of Asante speakers differed at word-initial position from Bono and Denkyira speakers in duration. Whenever [s] and [ç] occurred at word-initial position, the Asante speakers produced them with shorter durations than Bono and Denkyira speakers, though that was not the case at word-medial position since [s] and [ç] were of equivalent durations in all the three dialects.

Another remarkable discovery was that when mid-low front vowel [ɛ] followed [s] and [ç], the F2 values of Asante speakers differ significantly from Bono and Denkyira speakers but in Bono and Denkyira there were equivalent F2 values. However, Denkyira fricative [ç] always differs from Asante and Bono speakers in the environment of [a].

It is expected that the findings will go a long way to provide an alternative means of describing Twi fricatives. It is hoped that these characteristics identified will enable both teachers and learners to ascertain the possible areas of similarities and differences. This is because Akpanglo-Nartey (2006) posits that the concern of every language teacher is to present the structure of language at all levels of grammar comprising phonetics, phonology, morphology, syntax and semantics.

5.3 Implications for Future Study

The research was conducted in only three dialects of Akan. Therefore, findings may not be generalized to the whole Akan communities. Further research could, therefore, be conducted in a wider scope to include all the communities. Again, study investigated Twi fricatives using three cues with the aim of describing the acoustic characteristics of the fricatives. It is recommended that there must be comparative studies into all the other dialects of Akan using Spectral Peak Location, F2 transition and duration as well as other relevant techniques such as centre of gravity, amplitude, intensity, locus, spectral movement among others. This is because these cues have also been discovered to be robust in classifying fricatives.

Also, the scope of the phonetic environment should be broadened to cater for back vowels Akan and close disyllabic (CVC) contexts as contexts are known to affect sound production.

Finally, a closer attention should be paid to [s] and [ç] of Akan by collecting more data across the various dialects of Akan to support these findings. This is because they served as the greatest source of variation in all the three dialects investigated.

5.4 Recommendations

It must be noted that; no two utterances are the same even the one made by same speaker (Lodge, 2009). This is why it is impossible for an individual to produce carbon copies of utterances made. Again, utterances are influenced by both internal and external factors (Al-Khairy, 2005). If that is the case, then, one can appreciate that acoustic characteristics of any linguistic sound may vary from one speaker to another as well, for the fact that acoustic properties are determined by physical characteristics of the speaker (Lodge, 2005). In view of this and in order to highlight the importance of acoustic study in Akan language, the researcher would like to recommend the study of acoustic phonetics alongside articulatory phonetics in our schools in future since it provides an alternative means of describing sounds. Furthermore, there should be a research into the acoustic study of the Akan approximates in the near future to balance the equation in the linguistic field of the study of our language.

The researcher would also like to recommend that, there should be a study on the differences and similarities between Twi and Fante fricatives since the two are dialects of Akan. It has been proved that [f, s, ç] are distinct fricative consonants (Dolphyne 1988). This recommendation, if considered, would be a step in the right direction to broaden the scope and knowledge base of the linguistic investigations within the study of the Ghanaian languages, particularly Akan, to give acoustic phonetics a strong place in the field of linguistic studies in Ghana.

5.5 Conclusion

The three fricatives of Twi examined namely: [f, s, ç] are distinct. Apart from [s-ç] which did not differ in duration, the parameters used for the study were robust in classifying all the fricatives examined according to their places of articulation. Obviously, using spectral peak location, duration and F2 transition are promising methods in distinguishing fricatives with a language. Future research should concentrate on the perceptual realities of the acoustic parameters adopted in this study and how changes in the acoustic cue will influence the fricative place of articulation.

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APPENDIX A

Language Map of Ghana

Appendix B

Wordlist of Asante, Bono and Denkyira Containing the Fricatives

Word	Transcription	English Gloss
[a]		
fa	[fá]	"take"
sa	[sá]	"dance"
hya	[çá]	"nonse word"
[ɪ]		
fe	[fɪ́]	"vomit"
se	[sɪ́]	"sharpen"
hye	[çɪ́]	"burn"
[ɛ]		
fɛ	[fɛ́]	"squeeze"
sɛ	[sɛ́]	"lay"
hyɛ	[çɛ́]	"wear"
	VCV	
[a-a]		
afa	[àfá]	"succeeded"
asa	[àsá]	"dance"
ahya	[àçá]	"nonce word"
[ɛ-ɛ]		
ɛfɛ	[ɛ̀fɛ́]	"it squeezes"
ɛsɛ	[ɛ̀sɛ́]	"it resembles"
ɛhyɛ	[ɛ̀çɛ́]	"it wears"

APPENDIX C

Raw Data of Asante Dialect

1. Spectral Peak Location of Asante [f] in Hertz

	Initial			Medial	
Sex	**a**	**ɪ**	**ɛ**	**a**	**ɛ**
Female 1	7899	7655	7012	7636	7788
Female 2	7602	6903	7049	7355	7568
Female 3	7811	7500	7579	7700	7507
Female 4	7412	7785	7426	7603	7499
Female 5	7649	7537	7168	7592	7800
Male 1	6993	6878	7201	6744	7001
Male 2	7000	6906	6010	6827	6977
Male 3	6901	7032	7331	6994	6709
Male 4	6707	6804	7066	6905	6899
Male 5	6808	6995	6900	6956	6900

2. Spectral Peak Location of Asante [s] in Hertz

	Initial			Medial	
SEX	a	ɪ	ɛ	a	ɛ
Female 1	6767	6606	6463	6974	6559
Female 2	6954	6785	6471	6978	6471
Female 3	6654	6925	6559	6219	6463
Female 4	6677	6775	6895	6733	6654
Female 5	6566	6677	6817	6668	6566
MALE 1	6398	5023	6099	6094	6304
MALE 2	6077	5235	6307	6048	5935
MALE 3	6308	6709	6190	5805	6064
MALE 4	6026	6011	6173	6198	6120
MALE 5	6132	6072	6198	6375	6276

3. Spectral Peak Location of Asante [ç] in Hertz

	Initial			Medial	
SEX	a	ɪ	ɛ	a	ɛ
Female1	3999	4503	4800	4785	3942
Female2	4964	4010	4024	4905	3908
Female3	4874	4711	4991	4931	3978
Female4	4385	3924	4723	3667	3882
Female5	3949	4517	3824	3720	3561
Male 1	4005	3891	3305	3069	3049
Male 2	3832	4290	3566	3705	3080
Male 3	4341	3504	3198	3083	2955
Male 4	4031	3063	3012	2837	2932
Male 5	3611	3207	3017	3098	3025

4. Duration of Asante [f] in seconds

	Initial			Medial	
SEX	a	ɪ	ɛ	a	ɛ
Female 1	0.1192	0.1699	0.1670	0.1283	0.1670
Female 2	0.1422	0.0590	0.0519	0.1192	0.1919
Female 3	0.1437	0.1448	0.1755	0.1953	0.1710
Female 4	0.1174	0.1563	0.1488	0.1365	0.1530
Female 5	0.1520	0.1618	0.1464	0.2159	0.1755
Male 1	0.0952	0.0163	0.1414	0.0240	0.1308
Male 2	0.0946	0.0562	0.0386	0.1631	0.1200
Male 3	0.0951	0.1069	0.1012	0.0954	0.1488
Male 4	0.1364	0.0894	0.1071	0.1496	0.1607
Male 5	0.1217	0.1112	0.0377	0.1821	0.1012

5. Duration of Asante [s] in seconds

	Initial			Medial	
SEX	a	ɪ	ɛ	a	ɛ
Female 1	0.1283	0.1992	0.1661	0.1661	0.1661
Female 2	0.1808	0.1761	0.1491	0.1491	0.1419
Female 3	0.1747	0.1417	0.1738	0.1738	0.1721
Female 4	0.1333	0.1946	0.1729	0.1577	0.1564
Female 5	0.1711	0.1946	0.1741	0.1395	0.1589
Male 1	0.1743	0.1481	0.1586	0.1686	0.1749
Male 2	0.1690	0.1547	0.1833	0.1518	0.1786
Male 3	0.1898	0.1849	0.2115	0.1213	0.1576
Male 4	0.1769	0.2020	0.2088	0.1816	0.1999
Male 5	0.1513	0.1984	0.1952	0.1967	0.2168

6. Duration of Asante [ç] in seconds

	Initial			Medial	
SEX	a	ɪ	ɛ	a	ɛ
Female	0.2380	0.2656	0.2100	0.1671	0.1825
Female 2	0.2439	0.2150	0.1943	0.2066	0.2074
Female 3	0.1996	0.2470	0.1640	0.1735	0.2023
Female 4	0.1934	0.2434	0.2185	0.1654	0.1569
Female 5	0.2436	0.2225	0.2190	0.1792	0.1584
Male 1	0.1520	0.2044	0.1520	0.1526	0.1723
Male 2	0.1645	0.1911	0.1645	0.1273	0.2038
Male 3	0.1960	0.1903	0.1960	0.1444	0.1509
Male 4	0.1689	0.2016	0.1839	0.2046	0.2033
Male 5	0.1575	0.2127	0.1862	0.1923	0.1991

7. F2 Transition of Asante [f] in Hertz

	Initial			Medial	
SEX	a	ɪ	ɛ	a	ɛ
Female 1	1403	1920	1713	1319	1689
Female 2	1380	1890	1720	1446	1737
Female 3	1509	19070	1792	1372	1718
Female 4	1412	1952	1709	1442	1742
Female 5	1395	1905	1792	1593	1763
Male 1	1400	1920	1678	1447	1700
Male 2	1355	1880	1557	1492	1746
Male 3	1495	1882	1701	1401	1757
Male 4	1429	1900	1709	1499	1787
Male 5	1496	1903	1723	1408	1770

8. F2 Transition of Asante [s] in Hertz

	Initial			Medial	
SEX	a	ɪ	ɛ	a	ɛ
Female 1	1466	1911	1759	1539	1896
Female 2	1535	1921	1742	1565	1778
Female 3	1493	1919	1734	1631	1715
Female 4	1574	1917	1754	1524	1738
Female 5	1590	1929	1727	1641	1774
Male 1	1600	1927	1756	1562	1756
Male 2	1513	1967	1701	1618	1701
Male 3	1477	1660	1780	1623	1780
Male 4	1481	1932	1761	1570	1761
Male 5	1500	1957	1704	1507	1704

9. F2 Transition of Asante [ç] in Hertz

	Initial			Medial	
SEX	a	ɪ	ɛ	a	ɛ
Female1	1692	1937	1776	1626	1759
Female2	1584	1910	1774	1608	1782
Female3	1645	1955	1783	1669	1758
Female4	1688	1932	1720	1504	1791
Female5	1684	1924	1774	1641	1798
Male 1	1594	1977	1777	1631	1763
Male 2	1666	1960	1762	1670	1800
Male 3	1641	1968	1754	1615	1726
Male 4	1671	1939	1792	1681	1763
Male 5	1644	1982	1750	1690	177

APPENDIX D

RAW DATA OF BONO DIALECT

1. **Spectral Peak Location of Bono [f] in Hertz**

	Initial			Medial	
SEX	A	ɪ	Ɛ	A	Ɛ
Female 1	7752	7950	7859	7166	7843
Female 2	7560	7573	7503	7507	7676
Female 3	7604	7611	7690	7589	7903
Female 4	7687	7500	7507	7609	7707
Female 5	7612	7802	7599	7499	7505
Male 1	6066	6805	7004	7226	6934
Male 2	6245	6908	6909	6984	6945
Male 3	7000	7051	6899	7307	6912
Male 4	7101	6997	7200	6852	7212
Male 5	6999	6988	7098	6996	6879

2. **Spectral Peak Location of Bono [s] in Hertz**

	Initial			Medial	
SEX	a	ɪ	ɛ	a	ɛ
Female 1	6892	6878	6859	6634	6884
Female 2	6994	6930	6947	6555	6806
Female 3	6691	6375	6799	6602	6777
Female 4	6550	6656	6542	6705	6845
Female 5	6431	6971	6666	6532	6676
Male 1	5920	6988	6275	6397	6062
Male 2	5829	5920	5909	6039	5939
Male 3	6012	5829	6091	5979	6022
Male 4	5992	6012	5904	6060	5901
Male 5	5877	5992	6006	5979	6001

3. Spectral Peak Location of Bono e [ç] in Hertz

	Initial			Medial	
SEX	a	ɪ	ɛ	a	ɛ
Female1	3841	3835	3835	3894	3900
Female2	3781	3643	3643	3684	3835
Female3	4021	3957	3957	3496	3916
Female4	3933	3701	3701	3914	3580
Female5	3798	3691	3691	4009	3730
Male 1	3103	3200	3019	3187	3034
Male 2	3202	3020	3222	3178	3227
Male 3	3511	3011	3123	3039	3009
Male 4	3545	3201	3207	3090	3020
Male 5	3703	3033	3225	2881	3005

4. Duration of Bono [f] in Seconds

	Initial			Medial	
SEX	a	ɪ	ɛ	a	ɛ
Female 1	0.1777	0.1529	0.1390	0.1315	0.1638
Female 2	0.1051	0.0189	0.0622	0.1125	0.1428
Female 3	0.0940	0.0532	0.0582	0.1257	0.1495
Female 4	0.0628	0.0939	0.1233	0.1489	0.1805
Female 5	0.0870	0.0722	0.1260	0.1472	0.1564
Male 1	0.0566	0.1323	0.1589	0.0127	0.1147
Male 2	0.0549	0.0620	0.0940	0.1296	0.1270
Male 3	0.0215	0.0643	0.1666	0.1252	0.1335
Male 4	0.0622	0.0988	0.0669	0.1284	0.1282
Male 5	0.0465	0.0914	0.0744	0.1000	0.1400

5. Duration of Bono [s] in Seconds

	Initial			Medial	
SEX	a	ɪ	ɛ	a	ɛ
Female 1	0.2002	0.2375	0.2304	0.2087	0.1735
Female 2	0.1826	0.2557	0.1870	0.1685	0.1532
Female 3	0.2011	0.2059	0.2045	0.1529	0.1517
Female 4	0.1767	0.1822	0.1329	0.1793	0.1763
Female 5	0.1789	0.1857	0.2210	0.1389	0.1748
Male 1	0.1328	0.2288	0.2350	0.1328	0.2733
Male 2	0.1330	0.2587	0.2658	0.1330	0.2247
Male 3	0.0826	0.2252	0.2242	0.0826	0.2542
Male 4	0.1219	0.2019	0.2045	0.1219	0.1448
Male 5	0.1557	0.1970	0.2003	0.1557	0.1882

6. Duration of Bono [ç] in Seconds

	Initial			Medial	
SEX	a	ɪ	ɛ	a	ɛ
Female 1	0.2002	0.2375	0.2304	0.2087	0.1735
Female 2	0.1826	0.2557 0	0.1870	0.1685	0.1532
Female 3	0.2011	0.2059	0.2045	0.1529	0.1517
Female 4	0.1767	0.1822	0.1329	0.1793	0.1763
Female 5	0.1789	0.1857	0.2210	0.1389	0.1748
Male 1	0.1328	0.2288	0.2350	0.1328	0.2733
Male 2	0.1330	0.2587	0.2658	0.1330	0.2247
Male 3	0.0826	0.2252	0.2242	0.0826	0.2542
Male 4	0.1219	0.2019	0.2045	0.1219	0.1448
Male 5	0.1557	0.1970	0.2003	0.1557	0.1882

7. F2 Transition of Bono [f] in Hertz

	Initial			Medial	
SEX	a	ɪ	ɛ	a	ɛ
Female 1	1329	1914	1728	1307	1703
Female 2	1294	1907	1755	1326	1720
Female 3	1471	1895	1703	1361	1710
Female 4	1423	1889	1797	1204	1694
Female 5	1447	1910	1715	1378	1695
Male 1	1444	1897	17080	1554	1697
Male 2	1500	1911	1697	1497	1753
Male 3	1403	1901	1700	1545	1637
Male 4	1522	1909	1724	1478	1799
Male 5	1420	1887	1704	1547	1648

8. F2 Transition of Bono [s] in Hertz

	Initial			Medial	
SEX	a	ɪ	ɛ	a	ɛ
Female 1	1140	1904	1752	1381	1718
Female 2	1564	1929	1786	1404	1707
Female 3	1610	1911	1719	1677	1745
Female 4	1500	1902	1733	1598	1733
Female 5	1529	1926	1726	1487	1711
Male 1	1478	1767	1713	1692	1700
Male 2	1481	1922	1730	1437	1610
Male 3	1517	1916	1750	1500	1702
Male 4	1472	1930	1733	1566	1744
Male 5	1473	1907	1747	1549	1761

9. F2 Transition of Bono [ç] in Hertz

	Initial			Medial	
SEX	a	ɪ	ɛ	a	ɛ
Female1	1601	1955	1780	1689	1797
Female2	1589	2012	1737	1493	1767
Female3	1503	1996	1749	1687	1788
Female4	1580	1970	1807	1504	1787
Female5	1641	1933	1799	1511	1717
Male 1	1511	1917	1749	1613	1747
Male 2	1478	1931	1783	1663	1762
Male 3	1487	1927	1777	1670	1769
Male 4	1531	1974	1740	1683	1773
Male 5	1520	1909	1770	1617	1786

APPENDIX E

RAW DATA OF DENKYIRA DIALECT

1. Spectral Peak Location of Asante [f] in Hertz

	Initial			Medial	
SEX	a	ɪ	ɛ	a	ɛ
Female 1	7567	7505	7663	7803	7596
Female 2	7700	7567	7426	7774	7602
Female 3	7697	7873	7504	7801	7630
Female 4	7865	7676	7499	7500	7599
Female 5	7567	7603	7503	7567	7404
Male 1	6999	6908	6910	6806	7109
Male 2	7212	7040	6087	6376	7005
Male 3	7000	7003	6987	7112	6910
Male 4	6890	6990	5997	6901	6898
MALE 5	7065	7065	6813	7040	6934

2. Spectral Peak Location of Denkyira [s] in Hertz

	Initial			Medial	
SEX	a	ɪ	ɛ	a	ɛ
Female 1	6655	5877	6776	6118	6471
Female 2	6845	6660	6895	6201	6559
Female 3	6798	6899	6817	61150	6693
Female 4	6747	6590	6785	6654	6698
Female 5	6599	6607	6725	6677	6546
MALE 1	6308	6021	5820	5718	6212
MALE 2	5768	5778	5895	5990	6278
MALE 3	5830	5806	5668	5743	5847
MALE 4	5872	5783	5863	6255	5868
MALE 5	5899	5047	5818	6001	5947

3. **Spectral Peak Location of Denkyira [ç] in Hertz**

	Initial			Medial	
SEX	a	ɪ	ɛ	a	ɛ
Female1	3841	3835	3835	3894	3900
Female2	3781	3643	3643	3684	3835
Female3	4021	3957	3957	3496	3916
Female4	3933	3701	3701	3914	3580
Female5	3798	3691	3691	4009	3730
Male 1	3103	3200	3019	3187	3034
Male 2	3202	3020	3222	3178	3227
Male 3	3511	3011	3123	3039	3009
Male 4	3545	3201	3207	3090	3020
Male 5	3703	3033	3225	2881	3005

6. Duration of Denkyira [f] in Seconds

	Initial			Medial	
SEX	a	ɪ	ɛ	a	ɛ
Female 1	0.0453	0.0613	0.1375	0.1329	0.1779
Female 2	0.1744	0.1618	0.1333	0.0400	0.1395
Female 3	0.0946	0.1261	0.0780	0.1401	0.1530
Female 4	0.1411	0.1046	0.0851	0.1283	0.1670
Female 5	0.1505	0.1654	0.0622	0.1192	0.1012
Male 1	0.0794	0.0732	0.1780	0.0866	0.1454
Male 2	0.0842	0.1106	0.0696	0.1882	0.1198
Male 3	0.0566	0.0894	0.0420	0.1434	0.1365
Male 4	0.0549	0.0525	0.0444	0.0853	0.1448

6. Duration of Denkyira [s] in Seconds

	Initial			Medial	
SEX	a	ɪ	ɛ	a	ɛ
Female 1	0.0271	0.2142	0.1729	0.1776	0.1801
Female	0.1693	0.1741	0.1908	0.1377	0.1395
Female	0.1662	0.1943	0.2085	0.1589	0.1577
Female	0.1397	0.1583	0.2142	0.1283	0.1491
Female	0.2072	0.1992	0.1646	0.1333	0.1738
Male 1	0.1898	0.2125	0.2045	0.1662	0.2199
Male	0.2084	0.0238	0.2003	0.1507	0.1925
Male 3	0.1564	0.1972	0.1987	0.1644	0.1705
Male 4	0 0.1439	0.2218	0.1999	0.1863	0.1587
Male 5	0.1353	0.1973	0.2029	0.1900	0.1403

6. Duration of Denkyira [ç] in Seconds

	Initial			Medial	
SEX	a	ɪ	ɛ	a	ɛ
Female 1	0.2356	0.2371	0.2205	0.1760	0.1476
Female 2	0.2436	0.2302	0.2128	0.1583	0.1437
Female 3	0.1934	0.2145	0.2604	0.1554	0.1341
Female 4	0.2307	0.1979	0.2265	0.1681	0.1759
Female 5	0.2234	0.2225	0.2243	0.2066	0.2074
Male 1	0.1715	0.1912	0.2100	0.1735	0.1518
Male 2	0.1697	0.1488	0.2443	0.1602	0.1681
Male 3	0.1720	0.2051	0.2542	0.1512	0.1691
Male 4	0.1685	0.2100	0.2444	0.1905	0.1860
Male 5	0.1643	0.1881	0.2135	0.1836	0.1648

7. F2 Transition of Denkyira [f] in Hertz

	Initial			Medial	
SEX	a	ɪ	ɛ	a	ɛ
Female 1	1304	1904	1695	1211	1792
Female 2	1386	1901	1731	1207	1764
Female 3	1347	1938	1701	1300	1719
Female 4	1309	1916	1728	1372	1691
Female 5	1324	1943	1704	1592	1644
MALE 1	1399	1889	1590	1542	1618
MALE 2	1476	1892	1680	1481	1517
MALE 3	1481	1911	1609	1479	1529
MALE 4	1493	1912	1589	1490	1499
MALE 5	1324	1847	1608	1488	1521

8. F2 Transition of Denkyira [s] in Hertz

	Initial			Medial	
SEX	a	ɪ	ɛ	a	ɛ
Female 1	1473	1922	1767	1461	1714
Female 2	1320	1926	1723	1344	1894
Female 3	1411	1900	1748	1491	1772
Female 4	1455	2002	1772	1507	1779
Female 5	1499	1789	1719	1496	1748
Male 1	1504	1912	1617	1569	1520
Male 2	1473	1931	1600	1592	1477
Male 3	1421	1889	1643	1588	1563
Male 4	1430	1924	1613	1611	1571
Male 5	1509	1899	1655	1581	1576

9. F2 Transition of Denkyira [ç] in Hertz

	Initial			Medial	
SEX	a	ɪ	ɛ	a	ɛ
Female1	1526	1943	1754	1578	1770
Female2	1532	1949	1782	1691	1800
Female3	1552	2064	1780	1599	1704
Female4	1611	1927	1722	1504	1714
Female5	1609	1944	1769	1597	1790
Male 1	1444	1947	1616	1573	1623
Male 2	1467	1933	1666	1667	1691
Male 3	1438	1906	1640	1588	1618
Male 4	1577	1920	1672	1490	1621
Male 5	1504	1918	1636	1604	1592