UNIVERSITY OF CAPE COAST

AN ACOUSTIC INVESTIGATION OF VOWEL QUALITY AND LENGTH IN GHANAIAN ENGLISH

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BY

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DECLARATION

Candidate's Declaration

I hereby declare that this thesis is the result of my own original research and that no part of it has been presented for another degree in this university or elsewhere.

Candidate's Signature ……. Date ……..

Name: Christopher Ankomah

Supervisors' Declaration

We hereby declare that the preparation and presentation of the thesis were supervised in accordance with the guidelines on supervision of thesis laid down by the University of Cape Coast.

Principal Supervisor's Signature ……. Date ……

Name: Professor Lawrence K. Owusu-Ansah

Co-Supervisor's Signature …… Date ……

Name: Dr Kwabena Sarfo Sarfo-Kantankah

ABSTRACT

Discourse on the existence of Ghanaian English (GhE) has provided several works on the description of GhE pronunciations, especially vowels (for example, Bobda, 2000; Huber, 2008; Lomotey, 2010; Ofori, Duah & Mintah, 2014). But the major challenge is that most of these studies, impressionistically, have provided different numbers of the English monophthongal vowels used in the Ghanaian context and often deny the existence of any long vowel or certain English vowels like /ʊ ʌ ə ɜ: ɔ:/ in GhE. Another alternative to the study of vowels is through instrumental perspective which appears more objective than the auditory approach. Consequently, the present study makes another attempt through the lenses of acoustic approach to investigate the English pure vowels employed by Ghanaians in their spoken English. The vowels were studied within three different contextual realisations: in citation, in sentences and in spontaneous speech. Forty educated Ghanaian speakers provided the data for the study. The results of Praat acoustic measurements in relation to formant frequencies (F1/F2) and vowel length indicated that Ghanaian speakers of English realise the RP vowels /i:, ɪ, e, a, a:, ɒ, ɔ:, ʊ, u: ʌ, ə/, except /ɜ:/ which is fronted and /æ/ which is rendered /a/. It must be emphasised that some of the vowels did not occur in the expected environments (words) and subsequently some also alternated with other vowels in the same words. Length was not a major issue in the identification of GhE vowels. Based on these findings, the study recommends that Ghanaians should consider the codification of GhE for pedagogical purposes and for official use instead of using the RP as the norm.

KEY WORDS

Acoustics

Vowel quality

Vowel length

Ghanaian English

Educated Ghanaian

Formant frequencies

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DEDICATION

To my parents,

Mr Daniel Mensah and Mrs Georgina Konamah

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INTRODUCTION

> *A term such as **the English language** comprises all linguistic varieties that owe their basic resources to the historical tradition known as English. That language is no longer an exclusive possession of the English, or even of the English and the Americans—there are perhaps more users of English in the Third World (just as there are more Christians), and they have their own rights to its resources and future.*
>
> *Hymes (1966, p. 31)*

It has become crucial that non-native varieties such as Ghanaian English (GhE) are studied in their own right due to the fact that L2 speakers of English religiously use English as their working language which is mostly characterised by certain nativised forms. Kachru (1992) affirms these modifications that English undergoes reincarnations once it is adopted in a new geographical space. These modifications are caused by local linguistic and cultural settings. In the case of GhE, these marked features are pervasively observed from the pronunciations, especially the vowel components. Although certain studies have described Ghanaian English vowels (e.g., Bobda, 2000; Huber, 2008; Ofori, Duah & Mintah, 2014), one challenge is that most of them employed auditory approach which appears more subjective than objective. Another challenge is that the outcomes of these studies deny the existence of certain English vowels like /ʊ ʌ ə ɜ: ɔ:/ in GhE.

Resolving these problems might be very significant in adding to the voices (example, Gyasi, 1997; Lomotey, 2010; Quarcoo, 1994) calling for the official codification and usage of the Ghanaian variety of English in place of RP

(Received Pronunciation), so that Ghanaians would be able to talk about the English they use very well. It is therefore in the light of these challenges that the current study makes another attempt to investigate the pure vowels of GhE from the lenses of acoustic phonetics.

Background to the Study

The increasing role of English in the world has drawn different scholars and linguists from various parts of the world to delve into the different varieties of this same language. As a result of this, English has attracted a lot of names and terminologies such as *world English* or *global English*, *English* as *de facto* or *de jury* (e.g. B. Kachru, Y. Kachru & Nelson, 2006; Kachru, 1992). Mesthrie (2004) observes that Africans and other parts of the world got in contact with English as a result of several historical events such as Christianity, colonisation, slavery or trade, as well as other influence from the US. With little option in selecting an official language for the nation after colonisation and independence, the affected countries adopted English as a working language of their lands. English has been used as a tool to unify such nations and to establish boundaries (Kachru, 1992). Gyasi (1997, p. 65) reiterates this point that in Ghana "English unites the people because no other language is used in every part of the country or by as many people for communication beyond the local level".

In such countries where English is used as their second language (such as Nigeria, Ghana, Zambia, Singapore or Malaysia), English has been seen as the language of the colonial masters (Kachru, 1992; Morris, 1998). Instead of such countries conceiving English as a colonial phenomenon, it has gone

beyond that and has been given a special place in social life, politics, education and cross-cultural communication (Kachru, 1992) in these colonial countries. Consequently, these contact situations have given birth to different types of English (Mesthrie, 2004) around the globe. Gut (2009) adds that all over the world English is spoken in different national, regional and even social varieties. Although they share common phonemes, the phonemic inventory of, say, Jamaican English and Scottish English differ significantly.

In Ghana, the picture is not different, as English is used as an official language in all domains of the country's life: education, governance, law, commerce, media, etc. In Sey's (1973, p. 10) assessment of English in Ghana, he remarks that English is "considered indispensable, because by purely historical accident, it has become the most convenient medium of education and the only effective link with the rest of the world." It is difficult to agree with Sey on his claim on describing Ghanaian contact with English as a "purely historical accident". In actual fact, the main reason behind the historic contact between Britain and Ghana was a planned one. That notwithstanding, what Sey means is that English language has become an effective tool for people from different parts of the world and of different linguistic background to bridge the gap of language barriers. Generally, in multilingual Ghana, English is used to serve as a link language between people of different mother tongue backgrounds (Sarfo, 2011).

In education, for instance, Ghanaian schools persistently use English as the official language and medium of instruction; yet the English we speak, although intelligible to other speakers of English, appears to be different from the native speakers' English. Mesthrie (2004) states that the differences between

Ghanaian English and British English are largely observed in the spoken form than the written form. Based on the spoken English alone, most users of the English language are able to distinguish, for instance, a Ghanaian speaker from, say, a Nigerian. It can be observed that the English spoken in Ghana has not been officially recognised as such let alone its codification. In Lomotey's (2010) view, since Ghanaian English has not been codified, it will be difficult to describe exactly the kind of English Ghanaian use.

Interestingly, the kinds of disparity that exist between native and non-native varieties have been treated as deviations and errors. However, Owusu-Ansah (2012, p. 9) asserts that there has been "a paradigm shift in the study of non-native varieties" from the perspective of analysing them as error-driven to a new image of achieving their communicative functions. It is also important to note that there are a lot of varieties of English within Great Britain, the United States or elsewhere which are not even mutually intelligible (Hymes, 1966). These arguments have probably served as the main motivation behind different studies into non-native varieties of English around the world. In the case of Ghana, the existence of the Ghanaian variety of English has become a major area of study by many scholars to ascertain the reality of its existence (e.g. Bobda, 2000; Huber, 2008; Ngula, 2011; Ofori, Duah & Mintah, 2014; Owusu-Ansah, 1997; 2012). Moreover, English as a global language is today spoken in different accents and one of the main differences in the pronunciation of English lies in the realisation of vowels in different varieties of English (e.g., Maxwell & Fletcher, 2009; Mutonya, 2008). Using educated Ghanaian English as an example, this study sets out to explore the ways in which Ghanaian speakers of English articulate the English vowels, drawing on acoustic empirical analysis.

Statement of the Problem

Based on Received Pronunciation (RP) as a model, the teaching of English sounds has been clearly spelt out in all English syllabuses from the pre-tertiary schools up to the tertiary level in Ghana. But the doubt in people's mind is the extent to which Ghanaians have been able to approximate the sounds of RP, particularly the vowel sounds. In fact, I share the same view with Ngula (2011) and Owusu-Ansah (1991; 1997) that Ghanaians only pretend to be teaching and speaking RP. Meanwhile, it has been claimed that areas in the world where English is used as a second or foreign language, there will be a set of characteristic deviations from the "Authentic English", which is usually as a result of transfer from the mother tongue onto L2 (Lanham states in Schmied, 1991, p. 123). But then Tsukada (2001) states that second or foreign language learners have the assumption that their main goal is to attain communicative competence in the target language, but mutual intelligibility becomes ultimately desired. Owusu-Ansah and Tortor (2013, p. 69) posit that "for most parents in Ghana, the purpose of schooling is to learn and be proficient in the English language." But Kachru (1992) argues that people learn English because it opens doors in trade, diplomacy, science and technology.

Moreover, it can be argued that some scholars have attempted to describe the Ghanaian variety of English phonologically (e.g., Bobda, 2000; Huber, 2008; Ofori, Duah & Mintah, 2014) but it appears that much attention has not been given to the study of the vowel sounds acoustically. What this means is that most of the studies that have described the GhE vowels have done so subjectively. One major issue that needs further improvement in respect of the description of the vowel sounds is the impressionistic approach employed.

This is not to say that auditory analysis is not useful. However, some researchers (for example, Deterding, 1997; Gut, 2009; Watt & Fabricius, 2002) contend that new technology and the possibilities of analysis of acoustic properties of speech sounds have reliably improved the description of some sounds, particularly vowels. Essentially, Gut (2009, p. 138) adds that "an acoustic study of speech recordings reveals many properties of speech that cannot be heard even by trained listeners".

What this implies is that it would be much more desirable if the descriptions of GhE vowels were done acoustically to resolve the issue of subjectivity. This study, therefore, takes a cue from the preceding argument to find out, acoustically, how Ghanaians articulate the vowel sounds of English based on the RP model, and also to fill the gap in the literature. Another important problem is about the findings of the studies that have already described GhE sounds, specifically the vowel component. There are certain sounds that have been discounted in GhE, for instance, English vowels /ʊ ʌ ə/ as in ***foo****tball*, *c**u**p* and ***a****gain* respectively. It is also evidently clear from the literature that there seems to be no consensus on the number of vowels in the Ghanaian English. For instance, Huber (2008) identifies a five-pure vowel inventory in GhE while Ofori, Duah and Mintah (2014) identify eight pure vowels. The final point worth investigation is the claim that Ghanaians do not discriminate between certain minimal pairs or short and long vowels (e.g., /e/ - /ɜ:/), or that some long vowels like /ɜ:/ as in *thirty* or /ɔ:/ in *forty* do not exist at all in Ghanaian English (e.g., Bobda, 2000; Ofori, Duah & Mintah, 2014).

Purpose of the Study

The main purpose of this study is to carry out an acoustic investigation into vowel quality and length in Ghanaian spoken English, in order to establish the Ghanaian English vowel inventory through acoustic means. For Lomotey (2010), Ghanaian speakers of English must be conscious of the kind of English they speak in order to effectively describe and explain its structures and system. Again, as already indicated, this study has the aim of coming out with a finding that will either confirm or disconfirm what is already in the literature about the description of the Ghanaian English vowels. This is as a result of the fact that almost all the studies that have described the vowels of Ghanaian English have discounted the existence of certain vowels, specifically long vowels, in this variety of English.

Research Questions

Since this study investigates the pure vowel inventory of GhE, the following research questions have been posed to guide the study:

1. Which English monophthongal vowels are produced by Ghanaian speakers?
2. What are the acoustic characteristics of the English monophthongal vowels articulated by Ghanaian speakers?
3. To what extent do GhE monophthongal vowels exhibit length contrast between vowel pairs?

Significance of the Study

The results of this study are expected to be very beneficial in different ways. Firstly, it is believed that this study will demonstrate how Ghanaians articulate their variety of the English vowels, as a way of identifying the Ghanaian English vowel inventory. This is due to the fact that certain studies have revealed that some African countries, including Ghana, mostly front the central vowel /ɜ:/ to /e/ (Bobda, 2000; Mutonya, 2008; Schmied, 1991). Again, Bobda (2000, p. 187) observes that a Ghanaian speaker that "Ghanaians generally boast that their pronunciation is nearer that of RP [sic] than that of other non-native users of English in the former British colonies in Africa, especially in West Africa". After this study, this notion will be clarified, through the results, as to whether or not Ghanaian English exhibits different phonological forms from the other West African varieties of the same colonial experiences, as claimed by some studies (e.g., Bobda, 2000; Mutonya, 2008).

It will also make a dialogic contribution to the on-going research on the existence of Ghanaian English and the emergence of varieties of English in Africa (Huber, 2008) and world Englishes. Finally, the study is also intended to make a significant contribution to the acceptance and codification of Ghanaian English for official use and pedagogical purposes in Ghana.

Delimitation

The Received Pronunciation (RP) is said to be a twelve-vowel system (e.g. Roach, 1998), plus diphthongs and sometimes triphthongs. This research concentrates on pure vowels in the exploration of the Ghanaian variety of English; thus, consonants, diphthongs, triphthongs and specific prosodic

features are not considered due to the focus and constraint of time for the study. Again, the study is delimited to acoustic approach, which concentrates on vowel quality and length because acoustic properties of vowels seem to be more objectively identified than auditory perception approach.

In terms of whom to study, this research targeted educated Ghanaians who have acquired higher level of education up to the tertiary level. For Trudgill and Hannah (2013) point out that, in places where there is a continuum of social dialects, the top variety like the Standard English is identified as the acrolect; the base or the "bottom" variety is classified as the basilect; while the intermediate variety is considered the mesolect. However, Mesthrie (2004) makes an essential point that the terms basilect, mesolect and acrolect are mostly connected to the studies of Creole, but have been borrowed in the study of varieties of English. To Mesthrie, the suitable terms should have been *basilang*, *mesolang* and *acrolang* which are more related to interlanguage studies to refer to the levels of competence of the individual. Mesthrie agrees that, in spite of the varied terms, most authors still adopt the Creole-based terms without any serious damage with respect to understanding. It means that many writers find the Creole-based terms more comfortable and prefer them to the interlanguage terms in the study of varieties of English, especially, in the ESL contexts.

Moreover, it is important to note that the subtypes of English spoken in a country have been mainly categorised based on certain social variables such as education and other issues like internal acceptability and international intelligibility. The variety of English spoken in Ghana is considered to have sub-varieties in approximation towards the standard variety (RP) (Boadi, 1971;

Ngula & Nartey, 2014; Sey, 1973), depending on the speaker's educational background or exposure. It should be noted, however, that high proficiency level of using English does not automatically correspond to advanced education (Bamgbose, 1992; Sey, 1973). In categorising the sub-varieties, Ngula and Nartey (2014) juxtapose the sociolinguistic varieties of basilect, mesolect and acrolect of the English spoken in Ghana to Boadi's three main classifications of the sub-varieties in Ghana. According to these scholars, the first category of speakers acquires some basic level of English, through their contact with some speakers of English in their environment or has attained little education up to the elementary level, thus the basilectal variety. The middle variety (the mesolect) is by the second group of speakers who have attained some secondary level of education. The third variety is described as the highly-educated variety (Boadi, 1971) spoken by Ghanaians who have acquired proficiency of English up to the university level, which is seen as the acrolectal variety. It is within the third variety that Ngula and Nartey (2014, p. 85) define Ghanaian English as "the English produced by educated Ghanaians who have been brought up and schooled up to the university level in Ghana, and who are using English for major communicative purposes". They refer to this variety as the "local Ghanaian standard variety of English".

Other important issues in the identification of these subtypes are the notions of acceptability and intelligibility pointed out by Banjo (1971, as cited in Bamgbose, 1992). Banjo regards standard varieties of English to be associated with these two factors, in addition to educational background of speakers. Bamgbose, like Banjo, argues that the standard of other varieties of English should be based on what is locally acceptable and internationally

intelligible. But these writers basically regard the variety of those with university education background as more acceptable by the local speech community and also intelligible to outsiders. This is usually associated with higher education because speakers of that variety are thought of as having been exposed to the British standard variety as they climb the academic ladder.

It can be observed that different scholars have different views on the classification system for the continuum varieties. It is quite clear that what is mostly considered standard in most L2 contexts is the variety which moves gradually toward the line of higher education but of local acceptability and international intelligibility. It means that most writers still define the variety spoken by people with university education as high standard.

Subsequently, in line with the definition of the educated Ghanaian variety of English above, this research focuses on the English produced by highly educated Ghanaians, which is considered both locally acceptable and internationally intelligible. Ngula and Nartey (2014) suggest that Ghanaians should promote the highly-educated variety as the local standard variety which can replace the RP in order to promote the institutionalised variety in Ghana. On what we use as the norm in Ghana, Gut (2009) points out that it is the British Isles standard variety popularly called the BBC variety or RP which originated from speakers of middle-class or upper-class with a high level of educational background. Gut (ibid) indicates that the RP is spoken by about 5% of the British Isles population and it is more of social dialect than regional. It is not surprising that the highly-educated variety is insistently being promoted to be the standard in Ghana. This choice is also reinforced by the fact that the

institutionalised variety is already in use in the state institutions and education in Ghana.

However, the focus is on teachers who are impressionistically thought as the major distributors of GhE most Ghanaians speak, especially, in the formal settings. It is also important to note that, generally, it is through formal education that literacy in English is acquired in Ghana (Gyasi, 1997; Owusu-Ansah & Torto, 2013; Sey, 1973). Consequently, teachers at the senior high schools are central to the study and are used to represent Ghanaian speakers of English. This is the level where the teachers possess at least a first degree certificate, unlike the basic school where some have secondary education certificate. In other words, not all basic school teachers might possess tertiary certificate. The idea is that the expectation of English proficiency exposure at the first-degree level is higher, although not always the case. However, it is crucial to add that educated Ghanaians who have acquired native-like accent, such as suggested by Sey (1973), will not be part of the study because such accent will not demonstrate typical Ghanaian way of speaking. By using their background information and also how they speak, the researcher could figure them out.

Since the entire nation could not be covered within the stipulated time for the programme, the research site for this study was confined to Mim Senior High School: it means that other teachers beyond the confines of Mim Senior High School in the municipality were ignored. Teachers at Mim Senior High School constitute a heterogeneous group of varied ethnic background and sex (Mim Senior High School, 2017), which is a relatively good representation of educated Ghanaians. They are also considered to have acquired fairly higher

level of English proficiency with their university background. The researcher's proximity to the site too informed this choice in order to create a good rapport for easy collection of data and opportunity for the study to be completed in time.

Limitation

The research was confronted with a number of challenges. Finance was part of the challenges in carrying out this study. One issue was purchasing the instruments needed for the study, for example, digital audio recorder for the collection of the data. This delayed the time for the data collection for the study.

Some participants were unwilling to open up for the data collection, but demanded some amount of money to sustain their interest to contribute their part to the study. Some harboured the fear that their voices could go viral or public. These attitudes delayed the collection of the data. They were, however, assured of confidentiality as voices would be used for academic exercise only and nothing else, which was also supported by informed consent forms signed by the informants and the researcher.

Certain factors, such as environmental noise, place of recording and unexpected events, during data collection became a bit challenging to the data collection process. Since there was no specific designated room or laboratory for the data collection, the process demanded visiting informants in their homes, mostly in the evening. At some point in time of the data collection, certain unexpected external noise affected the process of recordings. In such instances, the recordings were stopped and taken again in order not to affect the analysis. Even on occasions where some level of noise was recorded, such portions were not used for the analysis. Those who got visitors too were allowed to see them

before continuing with them so that they would be in their natural sense or state to participate. Because of these circumstances, I recorded more data than expected, so as to replace the affected and unwanted ones.

In short, participants' unwillingness to involve themselves in the study, finance and unexpected situations were issues that affected the data collection and to some extent the data for the study; the researcher, however, made sure that these challenges were controlled and minimised so that they would not affect the validity of the data for the analysis. For instance, the researcher recorded 45 participants instead of 40 for the study, in order to replace the data with noise. The five extra participants were recorded from the majority group, Brong Ahafo, in the site for the study, but only one was replaced in that same group due to noise that affected the data. Participants were also assured of the security of their voices in the work and personal identity.

Organisation of the Thesis

This thesis is organised into five chapters. The introduction of the study constitutes chapter one. Chapter two reviews literature on the concepts and theoretical frameworks used in the study, as well as relevant empirical studies. Chapter three presents the methodology, which involves the research design, population, sample and sampling procedure for the data collection and analysis of the data. Results and discussion constitute chapter four. The last chapter, chapter five, presents the summary, conclusions and recommendations of the study.

CHAPTER TWO

REVIEW OF LITERATURE

Introduction

This study aims at identifying the inventory of Ghanaian English (GhE) vowels. As a result of that, this chapter has been devoted to the review of literature related to the topic under study in order to explore the key concepts and theories around which this research is developed. It means that what exists already will disclose how far the topic under consideration and discussion has travelled in order to make a meaningful contribution. Reviewing the existing literature relevant to this study will enable me to bring to the fore the state of current knowledge in order to ascertain already existing knowledge on the topic. This section therefore deals with two fundamental frameworks: the conceptual framework and the theoretical framework. Here, concepts related to the vowels being studied are reviewed and then also the state of Ghanaian English. Again, this study reviews the theories for vowel identification and GhE. It also pays attention to some relevant empirical works related to the topic for the study. It is therefore relevant to note that this review of literature generally defines the confines and perspectives of the work.

Conceptual Framework

The study is underpinned by certain concepts which shape the work. In this case, speech production and concepts related to vowels will be in focus. Another important issue that cannot be overlooked in this study is the debate about the existence of Ghanaian English. This emanates from the fact that certain marked features related to the way Ghanaians speak the English have

been classified as deviations or errors, which have also been strongly disagreed with (for example, see Ahulu, 1994; Dako, 2003; Gyasi, 1990; Nimako, 2004; Owusu-Ansah, 2012; Sey, 1973). These issues will critically constitute the conceptual framework. The conceptual framework provides the study with the broader perspectives through which the work takes its forms. This particular section begins with the production of speech sounds in general and narrows down to the conceptualisation of vowels.

Speech production and vowel quality

In the production of different speech sounds, we use the tongue, lips and other vocal organs (Ladefoged, 1996). Before any sound is produced, energy is required; the basic source of the energy is the respiratory system pushing air out of the lungs (Cruttenden, 2008; Gimson, 1970; Ladefoged, 1996; Ladefoged & Johnson, 2011; Roach, 1998). Gimson (1970) indicates that there are important modifications that happen to the airstream from the lungs to give the sound quality of a speech. The vocal folds are adjusted in a way that only a narrow passage is allowed for airstream from the lungs to pass through to produce voiced sounds; the vocal folds can also be apart to produce voiceless sounds. For the purpose of this study and the description of speech sounds, much more attention is given to vowel production than consonants.

Davenport and Hannahs (2005) maintain that two different forms of vibrations are caused: periodic vibrations and aperiodic vibrations. The periodic vibrations are regular and usually associated with vowels and sonorants, whereas the aperiodic vibrations are non-regular which characterise obstruents. In the same way, Cruttenden (2008) adds that these vibrations can be complex

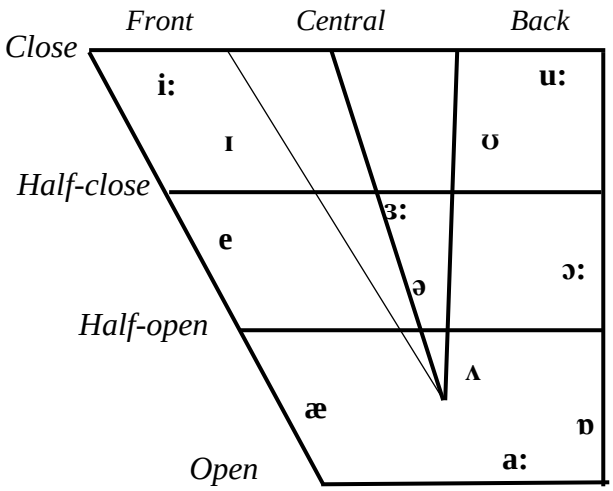
but regular to produce *tones* to result in a vowel sound production; the vibrations may also be irregular to produce *noise* resulting in some consonants such as /s/, or can be the presence of both regular and irregular leading to a sound like /z/. On the contrary, Johnson (2003) shares a slightly different view on the two sound waves: periodic and aperiodic. To Johnson, the periodic sounds have regular pattern intervals but come in two forms: simple and complex. The simple periodic waves are also known as sine waves, which emerge from motion of simple harmonics. Simple periodic waves are very rare in speech and it is only children who come close in the production. Complex sound waves are described in terms of the combination of the sine waves with additional sound wave component.

Cruttenden (2008) indicates that, normally in vowel production, the vocal folds provide the vibrator but in the case of consonant articulations, the air disturbance source is provided by constriction above the larynx, with or without vocal fold accompaniment. Unlike the usual descriptions of consonants based on the place of articulation, manner of articulation and voicing, the vowel sounds are, however, very difficult to pin down since the articulators do not make contact in their production (Davenport & Hannahs, 2005). Ladefoged and Johnson (2011) suggest that we can therefore describe some sounds, especially vowels, better by describing their acoustic structures because certain sounds become confused with one another. It is argued that vowels can be distinguished from one another by the two characteristic vocal tract pitches or formant frequencies (formant one and formant two) associated with their overtones (Ashby, 2011; Gut, 2009; Ladefoged, 1996; Ladefoged & Johnson, 2011). They explain that, apart from the pitch at which the vowel is articulated, depending on

the pulse produced by the vocal folds, the shape of the resonating cavities produces some overtone pitches and it is these which give the distinctive quality of the vowel. Ladefoged (1996) explains that the movement of the tongue, the lips and the soft palate cause variations in the shaping of the vocal tract. This action damps series of waves in the vocal tract to determine the quality of vowels. For instance, the vocal organs can assume a position to leave a series of waves in the vocal tract to determine the quality of a vowel like [i:] as in see; but another position will damp different series of waves for a sound like [e] as in set. Ashby (2011, p. 84), therefore, refers to vowel quality as "the nature of the sound that we hear". This sound comes about as a result of auditory effect from the combination of three core parameters: the Backness-Openness-Rounding.

Generally, vowel sounds can be described roughly in terms of the part of the tongue raised, the degree of height or tongue raising and the shape of the lips. In simple terms, the vowels can be described based on three factors (Cruttenden, 2008; Gut, 2009; Ladefoged & Johnson, 2011; Roach, 1998): the height of the body of the tongue; the part of the tongue which is raised (front-back position); and the degree of lips rounding. Cruttenden asserts that out of these three factors, it is only the lip position which can be easily described. Figure 1 below illustrates, simply, the relative description of the traditional English vowel chart:

Figure 1: The English vowel chart: The pure vowels



Source: Gimson (1970)

Vowel duration and length

Vowel duration and length are two terms that are often used interchangeably to refer to how long the vowel lasts in its articulation (e.g., Davenport & Hannahs, 2005; McMahon, 2002). However, Cruttenden (2008) and Lodge (2009) argue that it is important to distinguish between vowel length and vowel duration. Cruttenden holds the view that, in acoustic terms, the variation of duration may not correspond to our linguistic perception of length, as the latter may refer to English long and short vowels as in *word* /wɜ:d/ and *wed* /wed/ respectively. Moreover, it is difficult to refer to absolute duration values because, in connected speech, the duration of all vowels will change considerably from utterance to utterance, which are dependent on factors such as whether the utterance is spoken quickly or slowly, whether the syllable is accented or not, and whether the vowel is followed by voiced or voiceless consonant (Cruttenden, 2008; Lodge, 2009; Skandera & Burleigh, 2005). Therefore, the length relationships between these pairs of vowels are complicated, as the environment of the vowel determines its length, whether

short or long. Usually, vowels followed by voiced consonant sounds are longer than those followed by voiceless consonant sounds. For instance, Lodge (2009) explains that, under the same stress condition, the /ɒ/ in *pot* is shorter than in *pod* and the latter can be longer than /ɔ:/ in say *sport*, due to the effect of the consonants following them—the voiced consonants make the preceding vowels longer than voiceless consonants. Again, when nothing follows, there is greater vocoid duration too, for example, *sort* /sɔ:t/, *sword* /sɔ:d/ and *saw* /sɔ:/. Here, the /ɔ:/ in *saw* is longer than the ones in *sword* and *sort*. The one in *sword* is also perceived to be longer than the /ɔ:/ in *sort*.

In addition to the auditory impression of vowel quality, vowel sounds may appear to be of different length to the listener (Cruttenden, 2008; McMahon, 2002). Skandera and Burleigh (2005) point out that duration is usually a phonetic construct whereas length is often restricted to phonology. They consider length as a phonological concept because the difference in length (short and long) has different functions in English sound system—it can bring a difference in meaning. So, by vowel length, two groups of English pure vowels can be established as short and long vowels. It must, however, be noted that there can be two different contextual realisations of the short and the long vowels. In the following vowel pairs, it is argued that the vowels in the first words in each case are expected to be longer than those in the second vowels, in the phonetic contexts. But in the second set of words (phonemic context), the pairs of vowels are expected to be relatively the same in terms of length. The arrangement of the vowels is not in any special order.

Phonetic contexts of vowels

/ɪ/	bid ~ bit	/i:/	heed ~ heat
/æ/	cad ~ cat	/a:/	card ~ cart
/e/	bed ~ bet	/ɜ:/	heard ~ hurt
/ɒ/	cod ~ cot	/ɔ:/	cord ~ court
/u:/	food ~ Luke	/ʊ/	hood ~ hook

Phonemic context of vowels

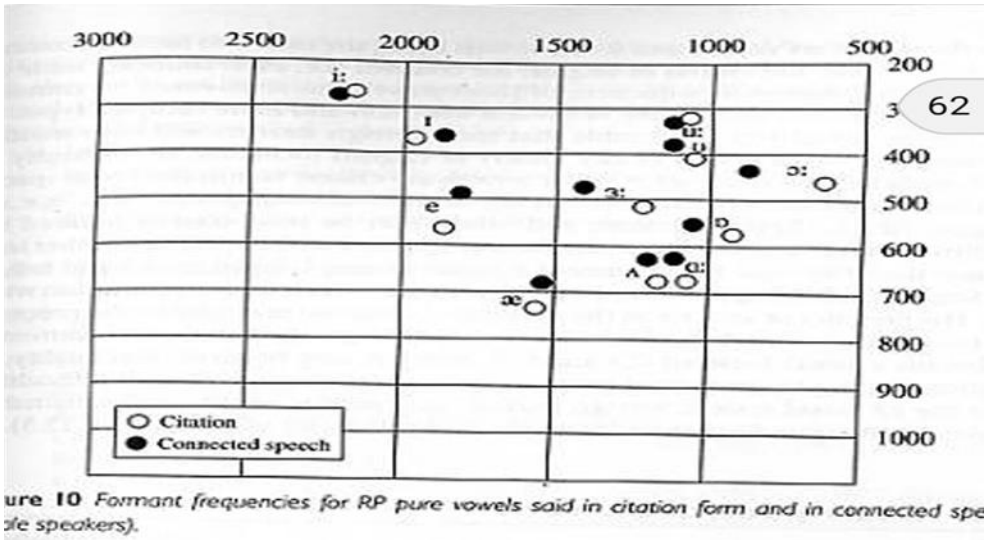
/i:/	seat ~ feat	/ɒ/	spot ~ stop
/ɪ/	fit ~ sit	/ɔ:/	caught ~ taught
/e/	head ~ said	/ɜ:/	fir ~ fur
/æ/	pad ~ lad	/a:/	hart ~ harp

Skandera and Burleigh (2005) observe that the difference in vowels is not just brought about by length but, more importantly, the quality. As part of investigative contribution to the study of Ghanaian English, this current study therefore adopts the length relationship to establish the English long and short vowels, and duration is used for the contextual variation of these vowels, thus their phonetic realisations. But the analysis of the data will use the term duration in a different sense to represent the time on the acoustic instrument for the purpose of identifying vowel length in this work. The two terms are distinguished in the discussion of the results and findings of the work.

Acoustics characteristics of vowels

Stevens and Hanson (2010) suggest that vocal tract sounds can be described through different acoustic distinguishing features. In acoustics, the

essential spectral features of speech sounds are usually deposited and captured on spectrogram for speech recognition (Ellis, 2010). Within the spectrogram, short fragments of overlapping speech are segmented. We can therefore find the display and reflection of vocal tract configurations for describing vowels, especially. This information is used to describe the status and nature of the vocal tract of speakers used in sound production in terms of formant frequencies, pitch, intensity, and pulse. The quality of a vowel is usually carried by its formant frequencies. In the recognition of vowel quality, Formant one is associated with vowel height (openness) and Formant two corresponds to front-back dimension in describing vowels acoustically, as well as the shape assumed by the lips (Ashby, 2011; Gut, 2009; Harrington, 2010; Kpodo, 2013; Ogdens, 2009; Watt & Fabricius, 2002). Watt and Fabricius indicate that open vowels mostly record higher F1 values compared with close vowels. In terms of F2, front vowels have higher values than back vowels, and mostly become higher if the back vowels are rounded too. We can see samples of vowel placement in Figure 2.



ure 10 Formant frequencies for RP pure vowels said in citation form and in connected spe
ale speakers).

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Figure 2. RP (males) pure vowels plot (adapted from Cruttenden, 2008, p. 103)

Figure 2 is a demonstration of the vowel quadrilateral based on 16 RP male and female speakers (taken from Cruttenden, 2008, p. 103) to show the relative disparity between the traditional vowel chart (in Figure 1) and acoustic vowel plotting. The data for the plotting were extracted from speech in citation form and spontaneous speech. We can see how the /ɔ:/ vowel, for instance, appears more peripheral than all the back vowels due to the spectral feature representing the vocal configuration. This is an indication that the drawing of many traditional vowel chart seems to be oversimplification of the configuration of vowel sounds in the vocal tract.

Theoretical Frameworks

This section of the study describes the theoretical lenses through which the phenomena of vowels and the place of GhE can be defined. Due to that, there are different frameworks which are discussed under two levels in this work. The first level is about the phonological theory that underpins the description of the vowels under study, specifically the phonological Source/Filter theory. The second level is a multi-level approach within which Ghanaian English is measured or identified. Such theories include the "Three Concentric Circles" provided by Kachru (1996) on the spread of English, Schneider's (2007) "Dynamic Model" and the "Unified Classification of World Englishes model" by Owusu-Ansah, Sarfo-Adu and Ahiale (2016). The discussion starts with the Source/Filter model.

The Source/Filter Theory

According to Ashby (2011) and Ladefoged and Johnson (2011), the Source/Filter is an acoustic theory of speech production. It is a phonetic theory

that is used to distinguish one vowel from another. Johnson (2003) indicates that this theory can be traced back to Fant (1960). Ashby indicates that the theory constitutes two main components: the sound source and the filter which is acted on by the vocal tract. The theory demonstrates that a vowel sound is concurrently made up of a number of different pitches. The pitches are produced when the air in the vocal tract acts like the air in the organ pipe. The vocal folds act like the source of sound energy and cause the sound to travel to the lips. Most of the sound energy spread out at the lips for listeners to hear but some reflect back into the vocal tract. The reflected sound energy's addition will cause amplification of energy at some frequencies and leave energy at the resonators, depending on the shape and length of the vocal tract. Due to the interruption of the sound waves reflection in it, the vocal tract becomes a frequency filter to alter the timbre of the vocal fold sound. In other words, the voicing waveform would be changed into a complex periodic waveform by the vocal tract functioning as a filter. Consequently, there are different overtone pitches produced and these are called *formant frequencies* or simply *formants* (F1, F2, F3, F4, or F5; the lowest three formants are usually used). The frequency denotes the repetition of sinusoidal patterns per unit time, simply put, it is the number of times the sine waves occur in a second. Frequency is expressed as cycles per second, which is usually referred to as Hertz (Hz). It is these formants, measured in Hertz, which will distinguish one vowel from another, in order to establish a vowel quality. Acoustically, vowels are basically distinguished by their first two formant frequencies (F1 & F2). Gut (2009) indicates that Formant 1 corresponds to vowel height: the lower the F1 the higher the vowel, and the higher the F1 the lower the vowel. Formant 2 also

corresponds to the front-back dimension: the higher the F2 the more front the vowel, but the lower the F2 the more back the vowel.

This theory is preferred to other phonological theories such as the Distinctive Feature Theory (DFT) because it is suitable in the distinction of vowels by way of providing acoustic cues of vowels. The source/filter theory provides the parameters that define the quality and other vital characteristics of the vowel. This theory seems to allow for objective description of individual vowels by using peaks of energy in the airstream deposited in the resonators. The researcher, therefore, finds this theory more suitable to provide the right framework for the study, as it tends to examine vowels and how they are distinguished from one another in respect of their formant values.

World Englishes

The phenomenon of World Englishes has existed as a result of the transplantation and the spread of English across different regions and cultures, and how varied users have appropriated English language to suit their own contexts. The major proponent behind the notion of World Englishes is Kachru (1996). As a result of the spread of English, Kachru (1996) identifies three concentric circles: The Inner Circle, The Outer Circle and The Expanding Circle. The first, the Inner Circle, comprises countries where English is used as a native language, such as the United Kingdom, the United States of America, Australia, Canada, and New Zealand. The Outer Circle, which is the second category, consists of countries where English is an institutionalised variety. English is used as an official language in such countries and these countries include former British colonies like India, Nigeria, Ghana, Zambia, etc. The

third group is categorised as the Expanding Circle consisting of countries where English is a foreign language, largely as a result of globalisation, trade and commerce. Some of these countries include China, Japan, Argentina, Rwanda, etc.

Most discussions on World Englishes have largely focused on the Outer Circle which indicate that Englishes in such countries have undergone some nativisation and acculturation. Kachru (1986) holds the view that as scholars study the linguistic characteristics of the varieties of English in such contexts, it will be able to establish how similar, and at the same time, how each variety differs from one another; of which the Ghanaian variety can be described as a unique variety from others like Indian, Nigerian or Kenyan English. This current study intends to dwell on this notion to examine the unique linguistic features that typify Ghanaian variety from the RP.

Critique of the Three Concentric Circles

However, Kachru's classification model has suffered a number of criticisms. For instance, Schneider (2007) points out that Kachru's categorisation of English speaking countries into Inner Circle, Outer Circle and Expanding Circle does not generally clarify the exact criteria for inclusion into these categories because some non-native speakers, for example, have developed English as their first language. The three circles seem to still correspond to the initial classification of English speaking countries into ENL-ESL-EFL distinctions. Schneider, therefore, proposes his dynamic model to appropriate these countries.

Schneider's Dynamic Model

Schneider's dynamic model (2007) is basically a diachronic approach which provides a framework for defining and identifying different varieties of English, especially in the postcolonial settings. Schneider sees new varieties of English as products of going through the process of revolution which is related to colonial and postcolonial history. The model presents a new variety of English as emerging from a sequence of five different phases: *foundation, exonormative stabilization, nativisation, endonormative stabilisation* and *differentiation*. These phases are characterised by distinctive features.

The first phase, Foundation, is marked as the starting point of linguistic modifications. It is the initial stage where English is transplanted from the source country, mostly England, to a new territory (colonies) by a group of settlers. At this point, both the settlers and the indigenous group see themselves distinctively different from the other. Contact situation operates at two levels: within the settlers and between the settlers and the indigenous groups. Within the settlers' community, a complex dialect or "interdialect" emerges towards linguistic homogeneity as a result of the speakers' regional and social dialects. Different purposes such as trade, negotiation and obligations bring a cross-cultural communication, leading to a lingua franca and starting point of bilingualism, especially on the part of the indigenes. Pidginisation becomes an option. Indigenous languages do not mostly affect the spoken English except the area of toponymy—there is much borrowing of place names in the spoken English of the settlers.

The second phase is the "Exornormative Stabilisation" stage which is characterised by socio-political stabilisation of the settlers and mostly their dominance over the colonies. English becomes official language of administration, education, or law and it is widely spoken in this new environment. At this stage, children of British decent and of mixed races are born. We observe the beginning of the elitism segregation among the indigenous community due to their knowledge of English—paving way for relatively higher social status. As a result of education and more contact with English, bilingualism also increases among the indigenous strand as schools are established to train local people to assist the British in ruling and maintaining their dominance over the colonies. In education, the British standard is used as reference norm in teaching the indigenes but linguistic correctness is not so much of interest. The local environment begins to insidiously modify the nature of the spoken English of the settlers. More importantly, there is some observable phonological transformation as a result of L1 interference within the indigenous group. Linguistically, this stage marks the beginning of structural nativisation, as emerging variety, and paves way for the next phase.

Nativisation is the third phase of the dynamic model which constitutes political and sociocultural transformation—typically marked by political and economic independence—as well as, more importantly, linguistic changes. Acculturation becomes very crucial at this stage and the number of English speakers increases, shaping the acquisition of second language—the presence of English is appreciated to perform important functions in the new environment. Local conservative language observers show frequent concern for adequacy of linguistic usage that people should stick to the norms of the English language.

The indigenous usage of the English language is at the centre of the birth of new distinct postcolonial English because this stage sees the heaviest effects on the restructuring of the English language; often shaped by the language of the indigenous environment. Here, the indigenous speakers become active participants in the on-going changes.

Linguistically, one important aspect and typical feature of this phase is phonology. The indigenous speakers of English consistently show features of local accent due to the effect of the 'pool' of the mother tongue interference. There may exist a variety of sociolinguistic accents but a relatively common pronunciation will widely be adopted which will begin to gradually develop into a local form which might not necessarily be a formally acceptable form. Schneider (2007) describes this phase of the model as a very important stage that sets the stage for the next phase to consider codification of the emergence of the new variety.

Phase 4 is the Endonormative Stabilisation which still occurs in the era of political independence. One typical feature of this phase is the acceptance of a local linguistic norm of English in formal contexts, which reflect, more importantly, cultural self-reliance of the construction of the new identity. The language, at this stage, has achieved much homogeneity. This new language formed is now positively evaluated and recognised, the initial stigma almost fades away, and only minority conservatives will still retain the previous norms. It now becomes the target language in education, oral usage and in other formal domains. This new language is now labelled "X English" replacing the old symbolic expression "English in X". One other trait of this phase is codification

of the new variety, essentially, production of a dictionary of the language and later by other linguistic structures.

Differentiation is phase 5 and the last stage of Schneider's model. At this stage, there is now room for internal differentiation. There is increased internal sociolinguistic diversification. The pattern of internal interactions will demonstrate accommodation of internal linguistic selection by group memberships. It provides space for dialectal birth in relation to ethnic, social and regional variation. This new English variety may exist alongside the indigenous languages and in some cases alone producing L1 or L2 situations.

In short, Ghana can now be identified within the general characteristics of the fourth phase (Endonormative Stabilisation) and at the same time the Differentiation phase of Schneider's dynamic model. More precisely, Ghana exhibits some characteristics of phase 5. It means that Ghana has developed an endonorm which is relatively stable. What is left is for Ghana to now pay attention to the features of this stage of the Ghanaian variety of English, by way of preparing for its codification and acceptance for formal usage.

Critique of the Dynamic Model

Although the Dynamic Model of Postcolonial Englishes has shown the importance of sociolinguistic and sociocultural significance of emerging varieties of new Englishes, it has some shortcomings. For example, Owusu-Ansah, Sarfo-Adu and Ahiale (2016) note that this model ignores the varieties of English within the Expanding Circle proposed by Kachru (1996). Another problem is that it rates the varieties of Inner Circle speakers of English as the highest varieties. One other weakness is that the five phases of the model show

progression of the development of a new English towards Standard English and native-like competence. There is also the challenge of progression of countries through the five stages, which appear to demonstrate non-linearity. For instance, in tracing the development of the Ghanaian English through Schneider's dynamic model, Owusu-Ansah et al. (2016) point out that Ghanaian English's progression through the five phases has not been lineal. This is because Ghana's sociolinguistic history has exhibited some elements of all the five phases. Meanwhile, Ghana is now entering the fourth phase, endormative stabilisation. Out of the weaknesses of Kachru's three concentric circles and Schneider's dynamic model, Owusu-Ansah et al. (ibid) propose a new model for the classification of Englishes around the world, thus, *The Unified Classification of World Englishes Model*.

The Unified Classification of World Englishes Model

This new model of classifying world Englishes was conceived by Owusu-Ansah, Sarfo-Adu and Ahiale (2016) from the amalgamation of Kachru's Three Concentric Circles and Schneider's Dynamic Model, in order to resolve their weaknesses. This model looks at world Englishes as belonging to blocks: The Native Speaker Block, The Post-Colonial Englishes Block and The Rest of the World. It does not necessarily mean that the blocks must form continuous geographical groups. The model shares similar features with Kachru's Inner Circle, Outer Circle and Expanding Circle with a new feature of interlocking triad. The new model arranges those countries that use English as their first language as belonging to one block without privileging the so-called Inner Circle speakers. The interlocking nature of the unified classification model resolves the problem of not accounting for cases like Jamaica which

finds itself in more than one circle. What this means is that some speakers with post-colonial experience or variety can progress to the block or region of the preconceived native speakers of English or to another zone.

In relation to the ownership of English, the model aims at crediting ownership to all users of English in different degrees. The model looks at the speakers in the three blocks as belonging to "one global community". They are all participants and stakeholders in shaping or modifying the resources of the language. It suggests that modified features in one zone can affect the language use of other zones.

This new model introduces three arrows with two heads each, which form a triangle or a pyramid. The arrows represent the kind of interactions that exist between the speakers of the various blocks. Two types of interactions are identified: historical and contemporary. Historical interaction has allowed the language to borrow vocabularies from other blocks' varieties. For instance, words like 'mango', 'pyjamas' and 'bungalow' from Hindi while 'banana', 'juju' and 'kwashiorkor' are originally African words. The pointed arrows explain that there are Englishization and nativization effects; meaning that English affects other languages and vice versa. In other words, English and other languages like African languages contribute to the repertoire of each other. The model therefore describes this relationship as a kind of give-and-take affair.

This phenomenon replaces the old notion of native variety always giving to the non-native varieties without receiving. The aspect of 'contemporary interaction' basically explains the variation that happens when speakers of English from different blocks interact. There are some elements of adjustment

and linguistic accommodation. For instance, a post-colonial block speaker who resides in the environment of native speaker consciously or unconsciously imitates the other block speakers. Figure 3 below demonstrates a simple pictorial view of The Unified Classification of World Englishes Model.

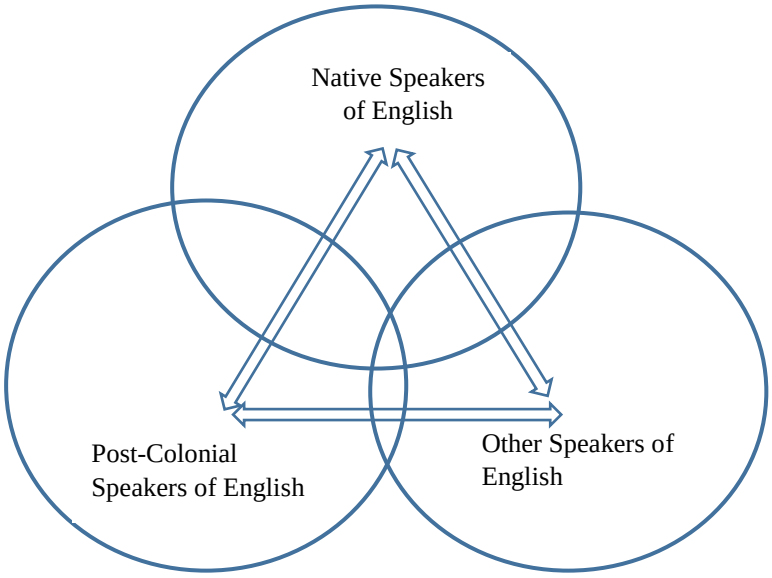

Figure 3: The Unified Classification of World Englishes Model

One advantage of this model is that there are intersections of the circles which can place countries of multiple identities or other in respect of language use in different locations, depending on the focus of the group of speakers. For instance, some L2 speakers use English alongside other local languages, whereas there are other identified groups within the same context who use English as their first language. Such situations can be found in Ghana and other post-colonial settings. Aside from this, as a result of migration and other determinant factors, there are other users of English from Post-colonial and Other Speakers' blocks who reside permanently or so in the so-called native speakers' environment like United Kingdom and the United States of America.

Usually, these speakers acquire some accents which are neither typical of post-colonial speakers and nor native speakers—more or less, a mixture of the two. Basically, the model seems promising for identification of language dialects and varieties within this framework.

However, this new model seems to talk about only three blocks of speakers: The Native Speaker Block, The Post-Colonial Englishes Block and The Rest of the World; but there are more than three blocks represented on the model. We can see various intersections of the model but have not been catered for in the description and the explanation of the model. Obviously, not all the intersections of the model account for specific speakers of English. For instance, the intersection of Post-Colonial Speakers of English and Other Speakers seems to remain redundant. Again, the authors of the model do not give names of countries which are located in the specific and various regions of the blocks for purposes of illustration.

Although the model appears to have few windows for criticism, it is still very useful in resolving most challenges of Kachru's Three Concentric Circles and Schneider's Dynamic Model. From the perspective and purpose of studying Ghanaian English in this context, Ghana can be located in the Post-Colonial Speakers of English block.

English in Ghana versus Ghanaian English: Status

The transplantation of English from the native land (Britain) to non-native environments, like Ghana, has raised concern about whether Ghanaians have the right to the language's resources or not (Owusu-Ansah, 2012). Historically, it has been noted that Ghana's contact with English can be traced

back to the second half of the 15th century, due to the English quest to trade in gold and spices (Sey, 1973; Spencer, 1971). To Boadi (1971), the English language was imposed on Ghana by the colonialists for their administrative purposes. To do this, the British started schools around the coast to train Ghanaian children to meet their demands by the 18th century. Considered as the official language of Ghana, English became the standard language of education, media and governance among the multilingual situations in the country. Mesthrie (2004) asserts that the full force of English was much felt in Africa-Asia in the formal colonisation in the nineteenth century. Some Ghanaians and other African children were sent to Britain to acquire British education for administrative purposes.

Sey (1973) indicates that the educated Ghanaian invariably aimed at proficiency in using British Standard English. This goal remained the major focus of those trying to be proficient in English and the English syllabus for education in Ghana. People acquired varying degrees of English, ranging from a sub-basic variety to the most sophisticated variety of the highly-educated Ghanaian. The ways Ghanaians articulate the English sounds have drawn the attention of many scholars to investigate the extent to which they depart from the British Standard pronunciation, which has served as the model since the beginning of the language's use by Ghanaians. The significant issue here is that the English spoken in Ghana has been looked at as either deviant usage or nativized forms. It is to this end that Spencer's (1971, p. 4) question: "What kind of English are we discussing?" becomes relevant.

As a matter of fact, different scholars and linguists have different positions on the existence of Ghanaian English. This is because Owusu-Ansah

(2012) posits that after Sey's (1973) publication of his work that denied the existence of GhE, the aftermath of it has remained a matter of debate. And even, currently, a significant number of Ghanaian academics will remain puzzled to answer the question of whether or not there is anything like Ghanaian English. Owusu-Ansah (ibid) also intimates that there have been many direct or indirect refusals to accept the existence of Ghanaian English. For the purpose of this work, it is very crucial to put things in perspective in order to establish the status of the English spoken in Ghana.

We can think of the expressions *English in Ghana* and *Ghanaian English* as two terms with different connotations. Schneider (2007) claims that when English language lands in a new environment for different contextual socio-political and economic reasons, the language is labelled as "English in X", where "X" stands for the new locality, for instance, English in Ghana or English in Nigeria. The indigenous people are often sceptical about this new language and see it as the "visitors' language". But when this new language travels far and beyond its primary purpose for which it was brought for it to be positively adapted as official language by the local people or the country, it gradually graduates to become "X English", for instance, Ghanaian English, Indian English or Nigerian English. Regular use of this language by the local people modifies it and shapes its linguistic forms towards a specific homogeneity. Outsiders and insiders are able to identify the new speakers of this new variety with specific linguistic forms and changes that have occurred as a result of acculturation and indigenisation. Some scholars (for example, Sey, 1973, Ahulu, 1994) see the new changes as deviations and errors while others consider them as the gradual development of a new variety of the language. This current

work, therefore, borrows Schneider's two terms, *English in X* and *X English* to discuss whether there is English in Ghana or there exists Ghanaian English.

English in Ghana

Some scholars (for instance, Ahulu, 1994; Dako, 2003; Gyasi, 1990; Nimako, 2004; Sey, 1973) have strongly contested the existence of *Ghanaian English* and rather classified it as *English in Ghana*. Just like Sey, Dako describes the English Ghanaians speak as *Ghanaianisms*. In the view of most scholars, any modification to the native norm should be regarded as a deviation or an error. This view to language seems to take its strength from ideas that favour the maintenance of the status quo—only the native norm should be preserved. One key figure in this school of thought is Sey (1973). In Sey's opinion, what earlier scholars have attempted to describe as a Ghanaian English should be treated trivially. He argues that educated Ghanaians cherish the British Standard English (usually known as RP) than being told of sounding Ghanaian. He states that educated Ghanaians would guard using RP in order to protect their social prestige rather than accepting anything considered linguistic innovation. He takes this as preoccupation, precisely, because of the international prestige attached to English language. To him, it is this basic attitude of Ghanaians that militates against the so-called Ghanaian English. Besides, the number of Ghanaians who were engaged in the regular use of English was few.

Additionally, Sey advances his argument that there is not much difference between Ghanaian standard variety and the British standard. In other words, people's impression about the existence of the Ghanaian standard variety

of English is "nothing more than British standard with an injection of vocabulary items of Ghanaian origin or English words with peculiar Ghanaian usage" (Sey, 1973 p. 9). He contends that people are only preoccupied with this Ghanaian English and describes it as "impure" or unguarded linguistic habits. On the same issue, Ahulu (1994) views Ghanaian English as a variety which is similar to other non-native varieties, such as Kenyan English, Nigerian English or Singaporean English, because they all share certain peculiar characteristics. Due to this, we cannot boast of any autonomous variety as Ghanaian English.

Unfortunately, Sey and his followers' intuition about the whole matter seriously ignores the significant marked features of a distinctive variety of the language heavily affected by mother tongue interference and localised forms of pronunciation. Owusu-Ansah (2012) adds that their arguments fail to account for dialects and language identifications. Besides, Adika (2012) points out that the use of English in Ghana has massively expanded ever since its implantation within its multilingual contexts. Notwithstanding, Sey invariably maintains his stance in the end that the variety of English in Ghana is nothing more than British Standard English.

Ghanaian English

On the contrary, many other scholars hold a different position to language "deviance" by L2 speakers or foreign speakers. This other view to language study describes a language from the descriptive point of view. Scholars from this school of thought usually argue that it is crucial to think of the functional usage of a language to achieve its communicative purposes. There are a lot of major proponents of Ghanaian English (for example, Adika, 2012;

Adjaye, 2005; Appartaim, 2009; Bobda, 2000; Huber, 2004, 2008; Lomotey, 2010; Ngula, 2011; Ofori, Duah & Mintah, 2014; Owusu-Ansah, 1997, 2012; Quarcoo, 1994). They believe that there have been several decades ever since Sey conducted his research to disprove the existence of Ghanaian English, even the population of Ghana as of that time was around 8.5 million. And as time passed by major changes have occurred historically and sociologically. Currently, the population of Ghana stands around 28 million (Ghana Statistical Service, 2016). So, Adika (2012) has maintained that the English spoken in Ghana has experienced innovation, adaptation and standard maintenance over the years. It is therefore important to maintain the firm stand, just like Adika (2012) and Quarcoo (1994) put it, that definitely, there is a distinctive Ghanaian variety of English.

Besides, more scholars have called for the maintenance and sustainability of GhE to retain the Ghanaian identity because language reflects peculiarities of cultures. The way a language is spoken and used represents the people and their environment (Bodomo, 1996). Crystal (1987) adds that the localised varieties of English spoken in different parts of the world are used as symbols of their identity. For instance, Gyasi (1997) reports that some Ghanaians make a case that the users of English in Ghana should speak English to reflect their culture and abolish the Native way of speaking the English language. Due to this, those who use English find it easy to accommodate the 'Ghanaianness' of speaking the English language. He argues that imitating foreign culture could lead to the loss of African culture. In this way, an important element of language is the use of it to express the world-view of its speakers (Bodomo, 1996). This language becomes the bearer of the indigenous

system of beliefs and practices of its people in the area of socio-culture, economics, politics and technology.

Beyond this, Quarcoo (1994) strengthens the ownership point that the English Ghanaians speak cannot be described as neither a pure international dialect nor pure British Standard English. It is an indication that it will be uneasy for one to describe the English variety Ghanaians speak as the RP model. It is not surprising for Quarcoo (1994, p. 331) to conclude that:

> We have watched the mouths of Ghanaian speakers of English and come to the firm conclusion that after the language has been with them for over 150 years, the Ghanaian speakers of English have done a few things to it to enable us to label their English a "Ghanaian artefact".

This comment from Quarcoo is, indeed, a confirmation of what Dell Hymes (1966) has already espoused about non-native varieties of English of having right and access to their resources.

Another important document which sounds convincing about the existence of GhE is Owusu-Ansah's (2012) work on the *Three Proofs of the Existence of Ghanaian English*. This work presents three fundamental and cogent arguments that provide readers with thought provoking issues to think about, in order to agree with the supporters of the Ghanaian variety of English. The first issue raised by Owusu-Ansah is about the fact that Ghanaians are very much aware that their way of speaking English is quite typical of Ghanaians than their neighbours with the same sociolinguistic history in the same continent or region. The second point is that Ghanaians' emotional attachment to the way

they speak English is an undeniable fact, unlike Sey's claims. It shows how they have accommodated their local style of using English. Thus, Ghanaians usually expect their compatriots to speak English in a way which is characteristic of Ghanaians—a view shared by Gyasi (1997). The last argument firmly stands on the fact that Ghanaians' way of pronouncing English has provided enough evidence to demonstrate contextual systematic variation and stability. This has led to some form of institutionalised variety in Ghana, which gives the signal of the existence of Ghanaian English.

So far, the two schools of thought about the existence of the Ghanaian English have demonstrated substantial skewness to one side: Ghanaian English. Significantly, what we need to note is that Ghanaians invariably know that they speak English like Ghanaians and that is what seems to be the case. This provides the firm stance that Ghanaian English already exists; it is a matter of accepting it in good faith for its use. Owusu-Ansah (2012, p. 1) was right when he vehemently stated that "neither Sey's work nor any of the writings that purport to describe the phenomenon has been able to convince readers of the existence of Ghanaian English." It is obvious from the preceding arguments that it is an undeniable fact that Ghanaian English exists. It will therefore be misleading for people to refute the existence of the Ghanaian variety of English. It is crucial to stress that this study endorses the sect that supports the existence of Ghanaian English.

Related Empirical Studies

Since the inception of English as an official language in Ghana, some localised forms of the language have drawn some scholastic works to delve into

the description of such characteristic features. We can point at a number of works in the literature. This section discusses some of these studies which have already taken a close look at the state of Ghanaian spoken English, especially those relating to vowel identification and description. This gives empirical picture of the current state of GhE, in order to serve as a guide to the current work. Some of the studies include Ofori, Duah and Mintah (2014), Ngula (2011), Bobda (2000), Huber, 2008, Sey (1973) and others.

Ofori, Duah and Mintah (2014) did a study on Ghanaian English phonology and the study explored the feasibility of a proposed Ghanaian English pronunciation standard (GhEPS). The main focus of their study was to ascertain an earlier claim on the same topic by Koranteng (2006). Their study investigated all possible phonemes that could be used as standard for GhE, but only the outcome of the vowels will be reviewed here for the purpose of the current study. Their research studied twenty final year pupils of basic schools (both public and private) in the Greater Accra Region. All the 20 respondents read 60 sentences containing all English vowels and consonants, which were recorded. The transcription of the data was done impressionistically. After the analysis, it was realised that the English twelve vowels were reduced to eight /i, ɪ, ɛ, a, ɔ, u, e, o/. The last two vowels (/e, o/) emerged from the monophthongisation of the RP diphthongs /eɪ/ and /əʊ/ and that there was no long vowel realised. The outcome of the study seems to affirm the findings of some earlier studies conducted by scholars like Bobda (2000), Huber (2008) and others, who claim that there are no long vowels and other vowels like /ʌ, ə, ʊ/ in Ghanaian English. It also brings readers' attention to the nature of English spoken by L2 elementary learners in Ghana.

The data collection method of putting the vowels and consonants in sentences for respondents to read seems to be praised by many researchers to provide good environment for collecting naturally occurring data of such kind. However, it is very crucial to note that continuous reading of sentences is likely to produce data in phonetic context instead of phonological realisation. The analysis was basically done on auditory approach which sometimes can be very illusive in vowel descriptions, unlike consonants. Again, the informants for such a study of this nature appears not to give the general reflection of reality, in my view, because the English language proficiency level of most junior high school pupils in Ghana is a bit questionable to represent the way Ghanaians speak; even using them as a supporting model to promote the acceptability of Ghanaian English pronunciation standard might raise some questions in people's minds since they are mostly amateur L2 speakers. Moreover, samples of words containing the studied vowels were not provided. Again, the claim that there is no English long vowel detected tends to suggest, just like earlier works, that Ghanaians are likely to reduce, for instance, words such as *s**aw***, *f**ore**father*, *f**our*** and ***or*** to short vowels, which seems a bit doubtful in my mind. It is against these arguments that the current study gains considerable strength and grounds.

The study therefore focuses on the basilectal variety of GhE, but provides a basis for my work to either confirm or disconfirm the outcomes. This study is similar to my study in that their study investigated GhE vowel inventory, which my work also investigates. The difference is that the focus on the participants and analytical approaches are different: while their research studied basic school pupils and used auditory analytical approach, my work

studies senior high school teachers with university education and employs acoustic approach to analyse the data.

Another work which relates to the current study is Ngula (2011) on Ghanaian English, focusing on spelling and pronunciation. His main aim was to prove that Ghanaians pronounce English words based on one-to-one correspondence between spelling and sounds, which is seen as a typical feature of GhE. In his study, he recorded 50 selected words put in sentences which were read by 60 graduate students (English major students were not part of the speakers) of University of Cape Coast. Auditory perception approach was used to analyse the data. In the end, his study affirmed his assumption that the educated Ghanaian pronunciation diverged from the RP model as its standard, which is unmarked feature of typical GhE. The study attributed the difference to the English spelling and pronunciation gap and then also the influence of different indigenous languages spoken in the country. This paper is another piece of scholarly work that excites the reader on the typical characteristics of Ghanaian English.

This study is worth noting because the sample size and the number of participants with their rich educational background of post-graduate studies suggest that, really, the study employed informants with background of higher level of English proficiency to represent educated Ghanaians and, essentially, GhE. It gives good basis for the validity of his subjects' selection. However, the auditory approach used in the study appears to be a little bit unreliable, as he himself accepted in his work that he was aware of scientific and objective instrumental approach. Sometimes, it is difficult for our auditory organs to perceive some speech sounds clearly, especially vowels quality, as compared to

subjecting them to instrumental analysis. That notwithstanding, the results actually reflect many assumptions people have on Ghanaian English.

This study is related to my current study because the focus of my study is on how educated Ghanaians (the same as Ngula) articulate the English vowels, and most of the words in Ngula's study focused largely on vowels; implicitly, measuring how Ghanaians read the standard pronunciation of RP. However, the current study departs from Ngula's study in terms of approaches used in the data analysis. Ngula employed auditory perception approach whereas the current study dwells on acoustic instrumental analysis. In spite of the different approaches, Ngula's work gives some kind of support to the current study in terms of the state of GhE.

A work which is closely related to my study is Bobda (2000). He investigated the distinctiveness of the Ghanaian variety of English in relation to West African countries, with similar sociolinguistic background and identical colonial experiences. Bobda's work seems to hinge on impressionistic view. The paper shows that Ghana presents a national English accent which is noticeably distinct, although with some similar pronunciations, from its neighbouring countries. The study basically looked at the pronunciation of English in Ghana, particularly vowel restructuring. It was revealed that Ghanaian English demonstrates restructuring of the RP /ʌ/ to /a/ or /o/, while other West African countries typically mark it as /ɔ/. Unlike other West African speakers of English, Ghanaians mostly front the central vowel /ɜ:/ to only /ɛ/ across the board which makes Ghanaians quite unique in West Africa, whereas the /ə/ is rendered /a/ or /e/. Bobda explains that the uniqueness of Ghanaian English is probably as a result of Ghana's longest contact and intimacy with the

English expatriates. The paper also attributes it to the fact that there have been some recent or ongoing sound changes in GhE.

However, it is crucial to note that Ghana's long contact with the expatriates was shorter (17th century-1957, see Huber, 2004) than other West African countries like Nigeria, which contact situation dates back from 16th century to 1963 (Gut, 2004). It simply means that long contact situation might not be a major issue in accounting for Ghanaians fronting of the central vowel /ɜ:/ than other West African countries but there might be other factors like English regional or social dialects exposed to Ghana. It might also be about the influence of the local linguistic situation in Ghana.

In the end, Bobda's (2000) findings and arguments maintain that English sounds such as /ʌ, ə, ɜ:/ are reduced to different forms in Ghanaian English, suggesting that they are not realised at all. It is quite interesting to note, on the contrary, that the sound /ə/ whose existence is discounted in Ghanaian English, has been invariably used in the transcription of how Ghanaians pronounce specific words such as *struggle* /stragəl/, *trouble* /trɔbəl/ and *double* /dɔbəl/ by Bobda himself. In such contradictory situations, the outcome of the paper becomes doubtful. On the whole, Bobda's work invokes in readers some sense of reflection on why Ghanaian pronunciations are unique by concentrating on some vowels which distinguish Ghanaian speakers of English from other West African English-speaking countries. Its relatedness to this work is shown by the fact that this current study is also interested in finding out the reality of GhE vowels but from the perspective of instrumental analysis.

Sey (1973) is a related work which has described the nature of how educated Ghanaians pronounce English. In Sey's bid to explore the Ghanaian variety of English, he paid some attention to the pronunciation of Educated Ghanaian English (E.G.E). Sey recognised that there were certain marked features of the English spoken by the educated Ghanaian but described them as deviant usage. He discussed some deviations in respect of grammar, semantics and rarely pronunciation in his work. Most relevant to this current work is the pronunciation aspect, particularly vowels. Sey's impression of educated Ghanaian English showed that the educated Ghanaian would articulate the RP vowels in the following fashion:

1) RP /æ, a:, ə/ > EGE /a/
2) RP /ʌ, ɔ/ > EGE /ɔ/
3) RP /u:, u/ > EGE /u:/
4) RP /ə:/ > EGE /ɛ:/
5) RP /i:, ɪ/ > EGE /i:/

This work is quite interesting in giving the linguist or the reader a historical view of how English vowels were articulated in the early and middle stages of the history of the English spoken in Ghana. What Sey brings to readers' notice is that Ghanaians would not pronounce the RP vowels /æ, a:, ɪ, ʊ, ʌ ə/, which almost correlates to some current studies (e.g., Bobda, 2000, Ofori, Duah & Mintah, 2014). We can agree with Sey on the examples of words (*put, push, cushion, wolf, woman, Wolsey, Wolseley, book, good, cook* and *look*) he provided for the testing of the /ʊ/ vowel in educated Ghanaian English, which are typically pronounced with the vowel /u:/. This assertion by Sey is true and commonly found in the spoken English of educated Ghanaians even today.

However, it is clear from his examples that these observations were made without recourse to words such as caref*u*l, awf*u*l, f*oo*t and f*oo*tball which are normally articulated with the /ʊ/ vowel in the spoken English of Ghanaians.

Sey (1973) emphasised that native speakers, such as preachers, traders, administrators and teachers, who actively brought the English language to Ghana, were not only speakers of RP but also other dialects. Again, Sey treated these modifications as deviations emanating from the mother tongue interferences. In his view, it should not be misconstrued as a new variety.

One interesting study about the description of Ghanaian English pronunciation, which is related to the current study, is Huber's (2004; 2008) work. Huber's work takes an impressionistic look at the phonological features of the Ghanaian variety of English, by describing the vowels and consonants that occur in GhE, as well as suprasegmental features. For the purpose of the current study, attention has been given to vowels. The words which contained the vowels for his study included *kit, dress, trap, lot, strut, foot, bath, cloth, nurse, fleece, face, palm, thought, goat/goal, goose, price, choice, force, cure, happy, letter, horse* and *comma*. The work revealed that the RP pure vowels were reduced to 7 instead of 12, thus /i ɛ a ɔ u e o/, where the last two resulted from the monophthongisation of the RP diphthongs /eɪ/ and /əʊ/. Huber indicates in the study that vowel length is not a feature of Ghanaian English possibly because most indigenous languages in Ghana do not have this phonological feature. He attributes the reduction of monophthongs to the absence of central vowels in most of West African languages. Conclusively, Huber regarded the difference between the RP and Ghanaian English as influence from L1.

What this work suggests is that the vowels /ɪ æ a: ɔ: ʊ ʌ ɜ: ə/ do not exist in Ghanaian English. It is quite surprising to find some vowels, particularly /ɪ ʊ/, as not part of Ghanaian spoken English, because one can easily perceive these vowels in words like *kit* and *foot* respectively. Meanwhile, these two words were used by the author in his attempt to explore the vowels in Ghanaian English.

"Ghanaians' realisation of [ə] and its implication for English teachers" by Lomotey (2010) is a study which was devoted to finding out exclusively whether or not English vowel 12 existed in Ghanaian English. The work studied 66 University of Education, Winneba, first year students. English words containing the sound /ə/ at the initial, medial and final positions were given to the speakers to read. Some of these words included *about*/*against*, *backward*/*cupboard* and *bitter*/*sofa*. The words were kept in carrier frames or sentences. Key Elemetrics Computerised Speech Laboratory software was used in the analysis. In the end, Lomotey, just like Sey (1973) and Bobda (2000), concluded that Ghanaians typically did not realise the articulation of /ə/ in their spoken English.

Just like other studies on Ghanaian spoken English, this work provides another result to deny the existence of /ə/, because Ghanaians do pronounce syllables and words in unaccented manner (Lomotey, 2010). It is interesting and surprising for studies like this and others to come out with such findings because the authors themselves are aware that some Ghanaian languages like Ewe and Dagbani have the schwa sound as part of their phonological inventories and yet they do not realise them in GhE. It means that some of the participants involved as speakers for the work were native speakers of Ewe and

Dagbani. Even these languages are described as tone languages and, for that matter, syllable-timed. It is no wonder that Lomotey calls for further investigation into the same sound in Ghanaian spoken English. This work really motivates the current work in searching for the vowel inventory of Ghanaian English.

Adjaye's (2005) work also provides, principally, impressionistic detailed description of Ghanaian English pronunciation, focusing on speakers of Akan, Ewe and Ga with good educational and social background. The work aimed at describing the vowels and consonants as well as prosodic features of Ghanaian English, which did not occur much in free speech. The main goal was to fill the gaps which were created by earlier research works on Ghanaian English description. What is of utmost importance to this present study is the monophthongal vowel component of her work. Her findings revealed a continuum of vowel systems. Broadly, Adjaye identifies four short monophthongs /ɪ ɛ a ɔ/ and occasional realisation of four long vowels /i: a: u: ɔ:/. This means that Ghanaian speakers of English generally do not pronounce the RP vowels /æ ʌ ɒ ʊ ə ɜ:/, only that they were realised in some few individuals' speech. Consequently, Adjaye points out that there are very few Ghanaians who make attempt to aim at the realisation of all the RP vowels.

It is important to note that, the work does not oversimplify GhE but is able to point at certain short and long vowels like /ɪ ʌ ʊ u: ə ɔ: ɜ:/ which are usually denied by most works in the literature about the spoken English of most Ghanaians. It is crucial to note something about Adjaye's findings about some RP vowels, that some RP vowels were either merged or realised differently. For instance, the work indicates that there is some merging of some vowels—

/ʌ/~/æ/ to /a/, /ɒ/ to /ɔ/, /ʊ/~/u:/ to /u/. Her results provide motivation for the present study to do acoustic assessment to either confirm or refute them.

Chapter Summary

The related literature reviewed so far indicates that there is some evidence to support the claim that Ghanaian English shows some distinct features, phonologically, which makes it different from any other variety of English, though they are mutual intelligible. On the whole, it has been observed that these works seem to reveal closely related findings of non-existence of certain vowels in Ghanaian English, most especially English long vowels and central vowels. The empirical evidence clearly reveals that the studies heavily used auditory perception as the major approach, but this present study employs acoustic analytical approach which appears to be more scientific and objective in describing vowels. To identify the block or region where Ghanaian English can be located, multi-level theoretical frameworks have been employed. The study also hinges on the Source/Filter Theory in identifying the vowel quality.

CHAPTER THREE

METHODOLOGY

Introduction

This thesis chiefly aims at identifying the pure vowel inventory of the Ghanaian variety of English acoustically. In order to address the research questions, the processes the data went through before the analysis was done are discussed in this chapter. It is necessary to give the details of the kind of data used in this research so that readers can appreciate the findings of the work from the fundamentals underlying the data and the analysis. Specifically, this chapter of the thesis deals with the methodology employed in the data collection, transcription, and the analysis of the spoken data that served as the basis for the findings in this study. The main focus of the chapter, primarily, covers the research design, population and study site, sample size, sampling procedure and data analysis procedure.

The Research Design

The research design employed in this research is a mixed method of quantitative and qualitative approaches. The preference for this mixed method is reinforced by Johnson, Onwuegbuzie and Turner's (2007) assertion that this combination is necessary in data collection and analysis to yield better interpretation and understanding. The qualitative aspect of the design covers obtaining information regarding the subjects, and the application of descriptive tools like mean, percentage and standard deviation in describing the details of the vowel sounds. It also covers the process and technique used in the data collection. Thus, the study employed unstructured or informal interview to elicit

the targeted vowels. This is also in line with the descriptive approach of research which observes and describes natural phenomena, conditions and behaviour that exist without influencing them in any way (Best & Kahn, 1998). Since the study sought to describe the pronunciation of the English monophthongs in a Ghanaian context, the quantitative approach was also employed to help in the acoustic analysis of the data in respect of using Praat as the main instrument. The quantitative aspect of this work also focuses on the use of inferential statistics (t-test) to test for significant variance in the analysis of the data in terms of formant frequencies and durational values of the vowels in focus to describe the vowel length in the Ghanaian situation.

The Population and Study Site

Since the study focuses on educated Ghanaian variety of English, the population for the study comprises educated Ghanaians who have attained a university degree. Here, teachers, who are considerably assumed to be the focal points or distributors of the kind of English many Ghanaians speak, are studied as the target population. It is common knowledge that Ghana is largely an English L2 speaking nation and the kind of English spoken is mostly acquired through formal education. What this suggests is that teachers in Ghana can be regarded as being in the front lines of planting English in Ghana. Quite apart from that, teachers are generally considered to have heterogeneous background: from different ethnic groups and sexes, who have been distributed across the country in order to educate the youth to acquire proficiency in English language and attain higher level of knowledge so as to develop the nation.

However, the site of the study is located at the Mim Senior High School in the Asunafo North Municipality in the Brong Ahafo Region, where the researcher could be actively engaged with the participants to produce naturally occurring data in a conducive environment. The accessible population of the teachers was 82 (Mim Senior High School, 2017), who were between the ages of 25-55. Moreover, I had the strong conviction that my closeness to the intended participants and the phenomenon being studied would provide quality data. The simple reason was that I could determine who was trying to contrive the data for the study. This assertion is also confirmed by Marshall and Rossman (2011) that a realistic site is where entry is possible; there is high probability of mix process, people, programmes, interactions and structures of interest being present. Again, the researcher is able to build trusting relationships with the participants, etc.

It is, again, argued that the researcher's familiarity with where he has worked before helps him to create rapport with the participants, which can lead to more accurate interpretation of data. My closeness to the selected site, therefore, helped me to build good relationship with the participants to collect reliable data with ease and to finish the research on time. One other advantage is that my familiarity with the speakers helped me to determine whom to select to be part of the study with respect to the data collection so that it would not affect the main focus of the study.

The Sample Size

Since acoustic analysis and research are quite demanding, the researcher could not study all the accessible population of 82 but to select 40 participants

to be involved in the study. The subjects consisted of 30 males and 10 females. The ages of the speakers ranged from 25-51 years with an average age of 35.5 years. The number involved was 40 because each participant was given 38 word lists containing the targeted vowels being studied to read. The wordlists comprised carefully selected words containing English short and long vowels for the participants to pronounce them. The list of words generated tokens of at least 1,520. It is also important to note that these individual words were in carrier frames, specifically sentences, to be read. There were sixteen sentences made up of 123 words which generated 4,920 tokens of words. In all, there were 6,440 tokens of words generated.

The choice was also justified by Marshall and Rossman's (2011) assertion that it is important to select samples for a study, depending on a number of factors – ranging from a case study to the purpose of the study. The sample can also range from one participant or organisation to a huge number. Therefore, I selected 40 participants to conveniently study them for the purpose of this research. In relation to their qualifications, five of these speakers had master's degree while thirty-five had first degree.

The Sampling Procedure

This study employed a non-probability technique of quota sampling in the selection of the informants for the data collection. The quota sampling encompasses selecting sub-groups by virtue of their association and using convenient sampling technique in the selection of the samples. To investigate how educated Ghanaians speak English, I selected participants who, more or less, represented different ethnic background and varied sexes for this work.

One demerit of non-probability sampling is that not every element has equal chance of being selected.

However, the quota sampling seems to be an improved technique in giving quotas to represent groups, although representation is not the fundamental hallmark of a qualitative technique. Notwithstanding, this was done so as to avoid the possibility of selecting participants from the same cultural background; possibly because they might have some special deficiency or some specific way of articulating the vowels, as the study was not about just a specific ethnic group.

Since the teachers from Brong Ahafo constituted the highest number in the school, I selected participants, firstly, from the other groups (for example Upper West, Central Region, Western Region or Greater Accra) which were considered minority in the school. What this means is that all the speakers from the minority groups were selected and those who were not born or bred within their respective speech communities were ignored. The simple reason is that such speakers might not speak English with their native accent and varied accents were useful in this study. Trochim (2006) refers to this sampling technique as nonproportional quota sampling which considers and selects the small number available to represent a group for data collection. It must be emphasised that there was no representation of speakers from the Northern Region of Ghana because no one from the region was teaching in the school. This exclusion could not have any significant effect on the study since there was diversity of speakers involved.

Therefore, I carefully selected speakers to represent nine out of the ten regions of Ghana to constitute 40, who are currently teaching at Mim Senior High School. The 40 participants were thought appropriate because of the time frame for the study, and also acoustic analysis of speech sounds demands a lot of time. The number of male and female speakers selected to be part of this study to produce the spoken data was determined by the number present in the school. So the number of males and females, as well as the number of subjects from different regions were not for the specific purpose of equal representation. However, the researcher did not find it useful to represent only speakers from the same speech community, possibly, due to the likelihood effect of a specific indigenous vowel system on the results or the findings. The selected speakers did not exhibit any form of speech impairment. For the purpose of easy reading and identification, the various regions from which the speakers were selected have been shortened, for instance, Brong Ahafo (BA), Eastern Region (ER), Volta Region (VR), Ashanti Region (AR), Greater Accra (GA), Central Region (CR), Western Region (WR), Upper East (UE), and Upper West (UW). Table 1 is the distribution of the speakers selected from each group.

Region	**BA**	**ER**	**VR**	**AR**	**GA**	**CR**	**WR**	**UE**	**UW**	**Total**
Males	6	2	5	5	2	3	1	4	2	**30**
Females	4	1	1	2	1	-	-	-	1	**10**

Table 1: Distribution of male and female speakers with their region

In terms of educational level, three of the participants had second degree and thirty-seven had first degree from various academic fields. Moreover, the study was interested in including speakers from different ethnic background, so I used the file containing the background information of the teachers in Mim

Senior High School (2017) to select those who had stayed in the study site for less than nine years. There was only one participant who had stayed in the study site (Brong Ahafo Mim) for ten years but was included (see Appendix C for details). The choice for nine years was determined by the available least number of years got from the school file, in order to select 40 participants for the study. They spoke their respective indigenous languages. For example, those from Brong spoke Brong; those in Eastern region and Ashanti spoke Twi; Gas spoke Ga and Voltarians spoke Ewe (see Appendix C for others and details). It was believed that the participants' stay outside their indigenous land had not affected their speech.

Stimuli/Material

The term "stimuli" describes the speech material used in eliciting the vowels under study. The speech material used in this study comprised 38 wordlists and 16 sentences which were used to extract the formant frequencies and duration required for the description of the vowels. In terms of the word lists, 30 of them were monosyllabic words with CVC structure of 12 monophthongs in *hVd/hVt*, *sVt/sVd*, *fVt/fVd*, CVp and *dVk* environments. The word list was randomly constituted to avoid using intentionally taught knowledge to read the words, especially the vowel pairs. CVC context provides natural environment for the production of quality of vowel sounds—without producing unstressed syllables to cause vowel reduction. Fricatives chosen were all voiceless with no significant effect on the quality of the vowels they preceded in the monosyllabic words. Besides, fricatives chosen as part of the onsets of the syllables provided good pictures in the spectrograms and waveforms of the sounds for the study, for easy identification of the targeted

vowels. For instance, the picture frame provided in Figure 4 clarifies the use of a fricative /s/ as the onset of *saw*.

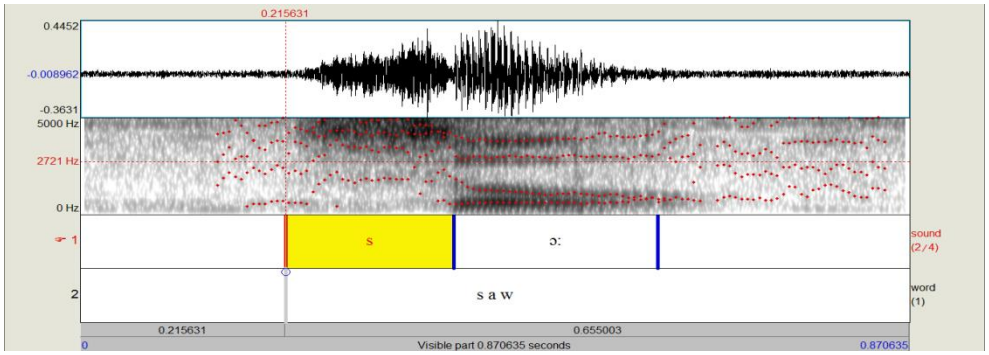

Figure 4: A female speaker's articulation of *saw*

Other structures that contained some of the monophthongs included the *CV*, *VCV*, and *CVCV*. The disyllabic context *VCV* was chosen to test for the English vowel /ə/ whose existence in Ghanaian English has been discounted (for instance, Bobda, 2000; Huber, 2004; 2008; Lomotey, 2010; Ofori, Duah & Mintah, 2014). Table 2 demonstrates the 12 pure vowels and the contexts within which they were contained.

Vowels	***CVC***	***VCV***	***CV***	***CVCV***
i:	H<u>ee</u>d/Heat			
ɪ	H<u>i</u>d/H<u>i</u>t			
e	H<u>ea</u>d/S<u>e</u>t			
æ	H<u>a</u>d/H<u>a</u>t			
a:	H<u>ar</u>d/C<u>al</u>m		C<u>ar</u>	
ɒ	H<u>o</u>d/H<u>o</u>t			
ɔ:	S<u>wor</u>d		S<u>aw</u>	F<u>or</u>ty
ʊ	F<u>oo</u>t/H<u>oo</u>d			
u:	F<u>oo</u>d/H<u>oo</u>t			
ʌ	C<u>u</u>p/D<u>u</u>ck			
ɜ:	H<u>ur</u>t/H<u>ear</u>d			Th<u>ir</u>ty
ə	-	<u>a</u>go		

Table 2: The environments of the pure vowels and examples of words

Some of the vowels' environments used in this study seem to contradict the common context (*hVd*) within which many acoustic studies have been conducted to identify the nature of vowel quality and length (for example, Hillenbrand, Getty, Clark & Wheeler, 1995; Maryam, 2015; Watson et al., 1998; Wells, 1982). Most of these works have featured the words: *heed, hid, hayed, head, had, hod, hawed, hoed, hood, who'd, hud, heard, hoyed, hide, hewed* and *how'd* in the attempt to evaluate the quality of vowels. It is argued that the onset of the syllable structure (usually *h*) is considered voiceless which has no effect on the following vowel. It does not also create a situation of coarticulation to affect the vowel.

It must be noted, here, that this "common" context is useful in doing research in native speakers' situation but not always the case in the L2 context. These days, students are taught how to produce long and short vowels but do not usually read and speak the same way. It is likely, therefore, for speakers to read words in citation form, even in the context /*hVd*/, with such taught pronunciations in mind to produce artificial data for a study which might affect the reliability of the results. The emphasis, however, in selecting words and environment for studying a vowel quality or length should be put on determination to explore the existence of vowel qualities in L2 context and not constraining ourselves to the so-called common environment alone. After all, other contexts containing long vowels, such as *CV* as in car /kaː/ or saw /sɔː/, and short vowels can be found in English language and dictionaries. Besides, other scholars (for example, Adank et al., 2004; Deterding, 1997; Huber, 2008; Maxwell & Fletcher, 2009; Watson et al., 1998) have used varied contexts such as CCVC (e.g., *fleece* or *trap*) or CVCV (e.g., *comma*) to study the vowels of

other varieties of English like Ghanaian English, Austrian English and Indian English.

So, going by Deterding's (1997) advice, tokens of vowels that occurred after approximants /j/, /w/ and /r/ were avoided because such approximants can largely have coarticulatory effects on the environment of the formant frequencies of vowels.

Data Collection Procedure

The data for this study were spoken data which were collected through recordings using DAT (Digital Audio Tape) IC recorder (Sony ICD-PX333). The choice for the IC recorder was based on the fact that it can record very clear sounds with very minimal noise. It has a component that deals with noise reduction in sound recording. More importantly, this recorder records sounds in the default WAV format which is required of Praat in acoustic analysis. Other instruments for recording sounds such as the mobile phone might not record the sound in this format for Praat analysis unless it is converted to WAV format using ITunes (Styler, 2016). The conversion might lead to loss of quality of data, although not always the case.

Following Adank et al. (2004) and Easton and Bauer (2000), the recordings were done at any convenient place that could be useful in avoiding noise from the background in order not to affect the data for the analysis—an appropriate way to provide quality speech samples for the analysis (Maryam, 2015). This is strongly supported by Ladefoged's (2001) view that a good environment is a requirement for recording acoustic data. This is to say that most of the recordings were done in the homes of the speakers and in some

cases any convenient room found in the school because there was no appropriate designated room or laboratory for the recording. This decision was to motivate the speakers to be part of the study, as most of them found it inconvenient to move to any far destination for the recording. Even with my familiarity with them, most participants wanted to find excuses to avoid being part of the speakers for the study. Any recording or data that contained noise from the recorded surrounding, that was adjudged to affect the data, was rejected.

After seeking the consent of the informants, the procedure and the work were explained to each subject. As already indicated above (in the sample size), there were 38 word lists which were read in isolation and 16 sentences containing the vowels under study. The sentences provided environments for the words containing the vowels to be produced in connected speech. The participants were, therefore, given enough time to familiarise themselves with the word lists and the sentences before recording their readings and each word or sentence was repeated at least twice for certainty. The recording of the data was done at the convenience of the speakers. Some of the words were also given to the participants to use them freely in order to record data for naturally spontaneous speech. In the course of the recording, the process was paused for the speakers to attend to their immediate needs and personal issues which were unavoidable. Those who also wanted to re-read the task given were given the chance to do so.

To avoid unwanted noise from the surroundings, the volume of the Sony IC recorder was lowered to the volume level of four or five and the 'Noise Cut' button of the recorder was switched on in a relaxed and informal atmosphere. Another strategy of avoiding unwanted noise was to do the recordings in the

evenings where most animals like birds and human activities were subsided in terms of noise making in the environment. Following Leung et al. (2016), I placed the digital recorder about 45^0, 4 centimetres away from their mouth for clearer sounds. Each informant spent about five to ten minutes. The data collection lasted for five weeks.

Method of Data Analysis

This particular section deals with how I interacted with the data collected in order to come out with the findings of this study. An acoustic instrument was used to analyse the data scientifically because Ladefoged and Johnson (2011) argue that we can describe better the acoustic structures of some sounds, especially vowels, rather than by describing the involved articulatory movements. They further state that it is important for linguists to describe the acoustic structures of speech due to the fact that certain vowel sounds become confused with one another, and acoustic analysis eliminates this confusion.

Acoustic instrument

In acoustic phonetics, using power spectra to analyse vowels becomes problematic because time is not represented (Johnson, 2003). The power spectrum might take a snapshot signal of the frequency within a specific period of time, but our idea and understanding of what takes place before and after the snapshot remain hidden to us. The sound spectrograph provides a remedy to this challenge. Some software for speech analysis contain this component of corresponding time. Consequently, the acoustic instrument that was used for the data analysis was Praat computer programme (version 6.0.28), a software written and maintained by Paul Boersma and David Weenink (Styler, 2016).

It is a free software for the analysis and reconstruction of acoustic speech signals. It displays the sound's waveform on the top and a spectrogram on the bottom with menu for further manipulation and analysis of a sound file. A broadband spectrogram displays the spectral energy of sounds over time. Styler (2016) indicates that one might be interested in spectrum visibility range from 0-5000 or 6000 for speech. "Praat defaults to showing a broadband spectrogram, which is excellent for viewing the temporal structure of the sound and for seeing vowel formants" (p. 15). This software can analyse, synthesise, manipulate and create high quality picture for research work. Van Lieshout (2003) indicates that Praat tool is quite flexible to analyse speech sound. It can give a wide range of standard and non-standard procedures. Praat can be downloaded from the website: http://praat.org. Praat has, frequently, been used worldwide in acoustic studies by several researchers (for example, Gut, 2009; Leung et al., 2016; Manya, 2011; Maryam, 2015; Maxwell & Fletcher, 2009; Wissing & Pienaar, 2014; Yang & Whalen, 2015).

Analysing the Recordings using Praat

Analysing the data for the work involves the processes used in handling the data recorded from different phonetic contexts in order to measure and extract formant frequencies and duration for descriptive analysis. It basically comprised dealing with annotation and measurement of formants and phonetic durations.

Annotation of the recordings

There are two different forms of transcription—the raw words transcription and annotation of speech sounds in the Praat. The latter deals with

annotating the speech sound by using *tiers* in the Praat. Sound annotation means linking a transcription with a recording or assigning labels to the recorded sounds. After opening a sound file, I selected *annotate* and next is *to TextGrid* where a window popped up to be continued by selecting the tiers and the interval tiers to type in the names needed (Styler, 2016). Sample names can be seen in the extreme right sides of the white and yellow sections in Figure 5:

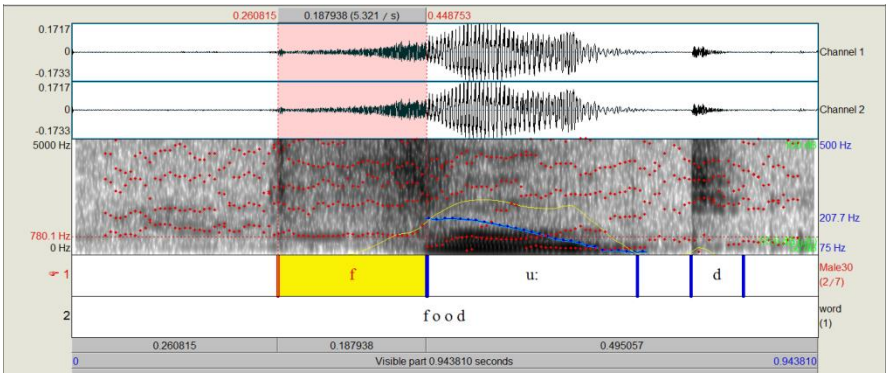

Figure 5: Annotation of a male speaker articulating *food*

After this, a TextGrid of the sound appears at where the original sound file is located on the Praat Objects window for the assigning of words or symbols for transcription to correlate with the energy concentration of the waveform or spectrogram of the sound produced. A clear illustration can be seen in the white and yellow sections of Figure 5.

Acoustic Measurements

Maryam (2015) indicates that formant frequencies, durations and F0 are the reliable acoustic properties of vowels, but F1 and F2 are most useful in vowel quality. The focus of the study is to acoustically establish vowel quality and length in the spoken English of educated Ghanaians in order to identify the vowel inventory of Ghanaian English. Basically, two of the formant frequencies were considered, for Cruttenden (2008) and Gut (2009) argue that the first two

formant frequencies, or at most three, would be sufficient to identify vowels. Therefore, F1 and F2 values, measured in Hertz (Hz), of the vowels were taken from the data with the help of Praat to ascertain the quality of the vowels being studied (Davenport & Hannahs, 2005; Ledafoged & Johnson, 2011), usually determined on the F1/F2 space. Tokens were taken from the data for the analysis of formant frequencies and duration.

Harrington (2010) reports that ever since Essner and Joos (in 1947 and 1948 respectively) demonstrated plotting of F1 on x-axis and F2 on the y-axis to resemble the articulatory vowel quadrilateral, the F1 and F2 plane has been conceived as another standard way of identifying vowel quality in linguistic phonetics. At some point, F1 can be plotted against F2-prime (F2') or the "effective upper formant" (Harrington, 2010, p. 84). In Watt & Fabricius' (2002) view, this adopted vowel classification method allows for greater objectivity in dealing with individual vowel than impressionist approach. Consequently, the formant values identified were used to plot the vowels on a grid to identify the vowel quality produced by the informants. After that the duration (measured in milliseconds) of the vowels were measured so as to establish the long and short vowels in terms of vowel length. In terms of any challenge or difficulty in using the acoustic instrument, I consulted an acoustician, Mr. Lawrence Bosiwah, who has been using Praat at the Ghanaian Languages and Linguistic Department, UCC, for assistance.

Formant frequencies

Formant frequencies play a key role in the identification and description of vowel qualities. The quality of a vowel is captured in a sound wave. Praat

displays a series of red dots to represent the peaks of the formant frequencies in the spectrogram (Styler, 2016) as can be seen in Figure 6. In Figure 6, four red lines of little dots can be seen in the spectrogram (the second box from top), which represent the peak of energies of the sound or simply the harmonics. In the spectrogram, the lowest dotted line (reading from the bottom) represents F1, the second F2, and the third and fourth for F3 and F4 respectively.

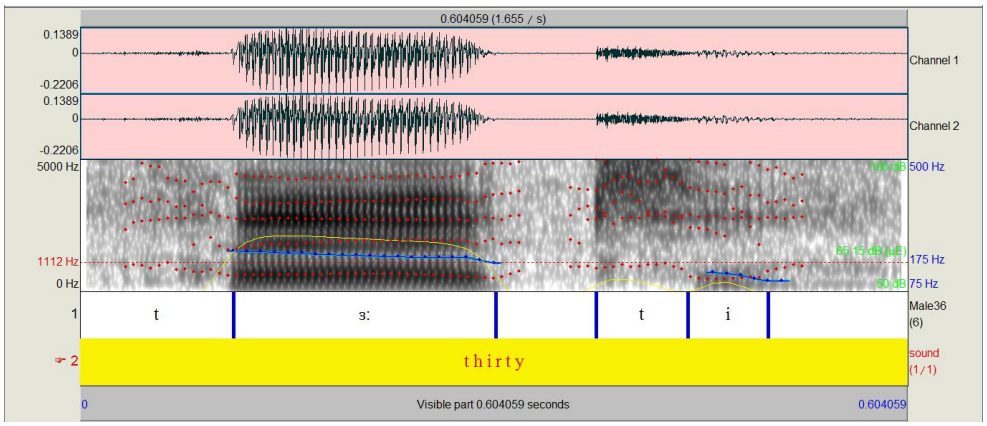

Figure 6: The display of formant frequencies in red dots (in the spectrogram)

According to Styler (2016), Praat provides different methods of taking formant measurements. Styler contends that finding the correct formant peaks can be tricky. To him, using the cursor to locate the approximate formant frequencies by looking at a broadband spectrogram becomes easy to measure the formant heights. However, this method of "eyeballing it" consumes time and can lead to providing inaccurate values of the formants. To Ellis (2010), the Linear Prediction model provides one essential means through which unwanted spectral details can be avoided. Consequently, Praat offers a built-in tool called Linear Predictive Coding (LPC) algorithm to calculate and display the vowel formant frequencies easily. Johnson (2003) also agrees that, in speech spectrum, LPC analysis automatically provides a relevant way and common technique for identifying the location and broad peak widths.

Styler (2016) suggests that it is also important to note that formant settings can be adjusted to improve the result of formant findings. The default number of formants Praat has is five in 500 Hz often in speech research. We can lower the number of formants to five if we are interested in looking at few formants. Therefore, after opening a sound file in the Praat Object Window to start workflows, the vowel quality, based on F1 and F2 values, were identified using the inbuilt Praat LPC. Again, Johnson (2003) suggests that paying attention to sampling rate is crucial because sampling the signal captures all the relevant information useful for listeners in sound analysis. According to Styler (2016), the default sampling frequency for most purposes for Praat is 44100Hz and that was what this work utilised for the Praat acoustic analysis.

Following Watson et al. (1998), the formant tracks for the acoustic vowels were extracted from the point where there was strong vertical striation in the spectrogram and also guided by the onset waveform periodicity. The vowel offset was also marked at the closure of a stop consonant or at a point where there was a significant amplitude reduction in the waveform. The acoustic targeted vowel was therefore marked by a regular periodicity cessation. On the whole, the onset and offset of acoustic target vowel were marked as single time point.

Vowel normalization is a research too used by researchers, mostly in sociophonetics, to deal with differences in vowel placement on vowel space area by different speakers as a result of different physiological effects (Watt & Fabricius, 2002; Watt, Fabricius & Ezra, 2009). By this, it is claimed to reduce the speakers' effects of different formant frequencies. Very much aware of the reduction effects of speakers on formant frequencies, this study did not consider

performing any vowel normalisation because Disner (as cited in Watson et al., 1998) contends that this process can, at the same time, unpredictably distort the data. In Watt & Fabricius' (2002) view, some of the transformed measurements, for instance Bark, do not entirely remove vocal tract length effect of disparities between multiple speakers' vowels spaces.

Vowel duration

It has been argued that not only do vowels differentiate themselves from one another through formant frequencies but also duration, specifically in terms of vowel length (Klatt, 1976; Ladefoged & Maddieson, 1990; Lindau, 1975; Maryam, 2015). Vowel length is mostly established by the use of phonemic vowel duration (Tsukada, 2009). Maryam (2015), however, claims that this differentiation method is not absolute, especially in the prosodic context. In the present study, vowel duration taken from phonetic context has been used to measure vowel length in order to establish vowel pairs in GhE. The wide-band spectrograms and time domain waveforms provide the onset and the offset of the vowel tokens (Tsukada, 2009).

The onsets of the vowel tokens were, therefore, measured from the vertical striations which were strong in the spectrogram and the waveform periodicity, following the criteria of Leung et al. (2016). The higher energy frequency cessation of the vowel tokens was considered the vowel offset. To examine the duration in simple terms, the cursor was used to select the vowels being investigated and the durations were taken in milliseconds (ms), which were contrasted with their pair counterparts in order to establish their respective lengths.

Ethical Issues

As it has always been the case, researchers who are interested in collecting certain types of data which are not in the public domain have the obligation to deal with ethical issues such as accessibility, privacy, confidentiality and informed consent. These ethical issues in research must be given the necessary recognition in order to respect and protect participants' rights. It is almost always required of a researcher, during data collection, to seek the consent of the participants for their involvement. Consequently, I applied for ethical clearance from the Institutional Review Board (IRB), UCC, through the Department of English before embarking on the data collection. The department gave a clearance letter to that effect. Again, the informed consent forms which educated informants on their rights, obligations and the objectives of the study were showed to and signed by the participants prior to the recording of their speeches. This helped me to acquire the trust and confidence of my participants to assist in the collection of the data and to clear any doubt on the use and purpose of the data being collected from them. The names of the informants were not used publicly but coded, for instance, *female one* or *male one* in that order in my work for the purpose of confidentiality and demonstration.

Chapter Summary

This particular chapter has so far discussed the nature and the source of data involved in this study and the approach, as well as the process the researcher used in engaging with the data in order to come out with the findings. In order to analyse the data exhaustively, the study considered the pragmatic

approach as being relevant in studying the data. To get the data for the study, this work employed the quota sampling technique to select 40 teachers from Mim Senior High School in the Brong Ahafo Region of Ghana to represent educated Ghanaians, since the work focused on the spoken English of educated Ghanaians. The speakers produced the English pure vowels in three different contexts: citation, sentence and an interview section; so as to describe the kind of RP vowels produced by Ghanaian speakers. Noise became the main concern to the data because the recordings were done at any place considered appropriate, but more than forty recordings were done in order to replace the affected ones. The five extra came from the majority group, Brong Ahafo.

To talk about the central issues of vowel quality and length and the processes involved in this study, the acoustic instrument, Praat, was useful in the extraction of the first two formants and durational values. The chapter has also discussed how ethical issues were resolved because the participants' rights needed to be protected, by means of using informed consent form and authority note from the Department of English.

CHAPTER FOUR

RESULTS AND DISCUSSION

Introduction

The main purpose of this study was to examine the vowel inventory of Ghanaian English, especially monophthongs, through acoustic means. The main task of the study was to answer three basic research questions: (1) Which English monophthongal vowels are produced by Ghanaian speakers? (2) What are the acoustic characteristics of the English monophthongs articulated by Ghanaian speakers? (3) To what extent do GhE monophthongs exhibit length contrast between vowel pairs? To answer these questions, this chapter presents and interprets the results of the analysis of the data which were produced by the 40 educated Ghanaian speakers of English (30 males and 10 females aged between 25-51 years.

The principal focus of this section of the study is on formant frequencies (F1/F2) and length of the twelve English vowels, of which the former addresses the research question one and the latter addresses the research question three. Some characteristic features of research questions one will be used to address the research question two. The Source/Filter theory was relevant in providing the sound spectral energies of the speech sounds provided by the speakers for this study. Praat (Boersma & Weenink, 2016) displayed the visual representation of the acoustic cues of the vowels into waveform and spectrogram. Within the spectrogram, the F1 and F2 of the vowels were extracted for vowel qualities; duration was taken for vowel length. The results have been presented according to the research questions formulated in Chapter

One by looking at the formant frequencies of the vowels to determine the quality of the vowels before considering the vowel length using duration.

To be sure of any suspected close vowels (in relation to formant frequencies and length) in this study, the study employed statistical analysis using Paired-Sample t-test to further compute the data results to establish significant differences. This analysis was done using the SPSS (version 16.0.0). Following Chang (2008), the confidence interval was set at 0.05 (95% confidence interval of difference). It must, therefore, be noted that if the calculated p-value is below the 0.05 significance threshold, then we can claim that the two vowels involved differ in terms of F1 and F2 or duration. Alternatively, if the calculated p-value is above the 0.05 significance level, then we can conveniently claim that there is no statistically significant difference in the vowels in question.

Formant frequencies

The first two formant frequencies (F1 & F2) of the targeted vowels produced by the speakers are the main focus of this section to establish the quality of the vowels. In this study, three different contextual realisations of English monophthongs were tested: words in citation, in sentences and in an interview section. The mean and standard deviation for F1 and F2 values of the targeted vowels were measured and the results are presented in Tables 3-5 below. The results from the analysis of the data focus on the twelve English monophthongs produced by the Ghanaian speakers of English for this study.

The F1 and F2 values for the vowels were further subjected to t-test analysis using the Paired Sample t-test to find out whether there was a

statistically significant variation in the production of some vowel pairs in the Ghanaian English, for instance, comparing the F1s alone and F2s alone of the English vowel pairs.

Monophthongs in citation form

In an attempt to explore phonemic inventory of monophthongs used in GhE, the study employed words containing the twelve English vowels. The subjects read the words in a citation form. The results for the first two formant frequencies (F1/F2) extracted from the vowels have been presented in tables and figures below. Figure 7 demonstrates the ellipse plot of all the twelve English vowels produced by the Ghanaian speakers of English and Table 3 also displays the mean F1 and F2 frequencies. The plotting was done using F1 on the y-axis against F2' (F2-F1) on the x-axis on the plane.

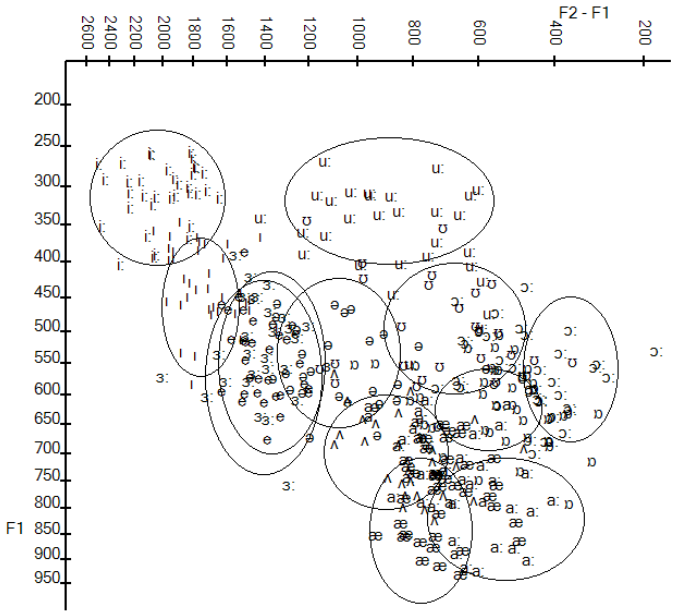

Figure 7. The ellipse plot of the twelve English monophthongs in citation

Figure 7 is the ellipse plot of the English twelve vowels which were produced by the Ghanaian speakers of English in citation form. It can be closely observed that there are some vowels which overlap in the way they have been scattered. It can be seen again that the front vowel /e/ and central vowel /ɜ:/ largely overlap. Another close observation can be made in relation to the three vowels /æ/, /a:/ and /ʌ/ which also seem to occur, generally, within the same vowel space on the plane. This is an indication that such vowels seem to be identical in vowel quality. The scatter plot of such vowels in pairs in a section below gives details about such overlapping for further contrast and discussion. It is also important to note that there are some individual vowels which lie outside the ellipses, giving the general sense that the speakers' vowels were produced separately due to different physiological configurations of their vocal tracts. This means that different speakers possess different shapes and sizes of vocal tracts and usually can affect the way speech sounds are produced.

Table 3 displays the results of the mean F1 and F2 values used in the production of the twelve English vowels which were read in word list form by the Ghanaian speakers. It can be observed that there were contrasts in most of the vowels produced. The closest front vowel /i:/ was produced using an average F1 of 306Hz and F2 of 2280Hz followed by the /ɪ/ vowel with 427Hz (F1) and 2133Hz (F2). The vowel /i:/ is the closest vowel because the space between the front part of the tongue and the palate was very small (306Hz) and it is also the highest front vowel. In terms of the back vowels, the one closest to the roof of the mouth was the /u:/ vowel produced with the mean F1 of 362Hz and F2 of 1238Hz but the one which was the most back vowel was the /ɔ:/ vowel produced with the least F2 frequency (1043Hz, see Table 3) and the next

to this vowel is the vowel /ɒ/ (F2 of 1152Hz). In respect of the open vowels, the /æ/ vowel recorded the highest F1 frequency of 773Hz, making it the most open vowel in terms of space in the mouth allowed by the tongue, which is closely followed by the vowel /a:/ (F1 of 744Hz). Table 3 gives the rest of the mean values for F1/F2 with their respective standard deviations in Hz.

	/i:/	**/ɪ/**	**/e/**	**/ɜ:/**	**/æ/**	**/a:/**	**/ɒ/**	**/ɔ:/**	**/ʊ/**	**/u:/**	**/ ʌ/**	**/ə/**
F1	306	427	540	532	773	744	615	569	507	362	697	549
SD	46	56	63	74	86	90	66	63	76	66	68	61
F2	2280	2133	1931	1941	1486	1408	1152	1043	1204	1238	1511	1612
SD	234	164	129	187	140	121	148	130	76	215	133	199

Table 3. Mean F1 and F2 (in Hz) of monophthong vowels in citation form

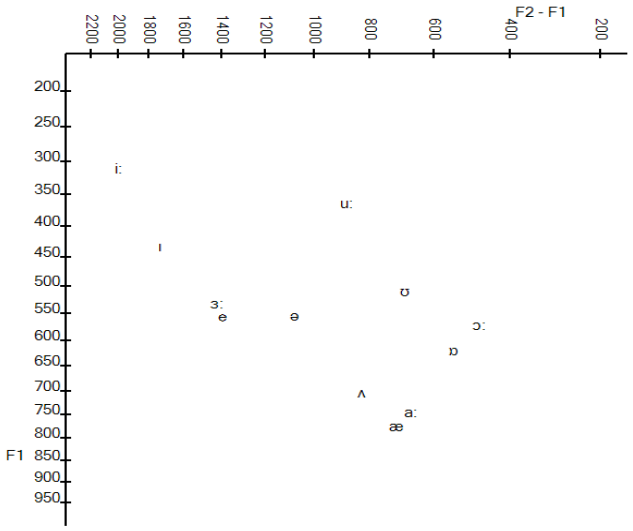

Figure 8. Mean F1/F2 plot of the 12 monophthongs produced by the speakers

Figure 8 is a demonstration of the plot of the mean F1/F2 plot of the twelve vowels produced by the speakers. It can be seen that the /e/ and the /ɜ:/ vowels clearly overlap. The next closest vowels in terms of vowel space are the /a:/ and /æ/. The /ɒ/ and the /ɔ:/ also seem close to each other. The next section

pays very close attention to the variations between the vowel pairs to establish the number of monophthongal vowels realised by the Ghanaian speakers of English. It must be emphasised that the words which were read by the speakers did not occur as minimal pairs or the order in which they are arranged below.

The /i:/~/ɪ/ vowels

The English words HEED /hi:d/ and HIT /hɪt/ were read in citation form in an attempt to explore the occurrence of /i:/ and /ɪ/ in the Ghanaian context in terms of their formant frequencies. The results of the data revealed that the Ghanaian speakers of English made a distinction between the two vowels. It is evident from Table 3 that all the speakers (100%) used the average F1 of 306Hz and F2 of 2280Hz in producing the vowel /i:/ in the word HEED whereas the F1 mean of 427Hz and F2 of 2133Hz were used by 90% of them in the production of /ɪ/ in HIT. The 10% of them realised the /ɪ/ vowel as /i:/. Close observation indicates that there are differences in both F1 and F2 frequencies of the two vowels. The results of the paired sample t-test revealed that there was a highly significant contrast between the /i:/~/ɪ/ vowels in terms of F1, /i:/ (M = 3.0551E2, SD = 40.62, N = 35); /ɪ/ (M = 4.2683E2, SD = 56.33), t (34) = -12.429, p = .001. The F2 frequencies of the two vowels also showed high statistical variation, /i:/ (M = 2.2800E3, SD = 233.91, N = 35); /ɪ/, (M = 2.1332E3, SD = 163.78), t (34) = 3.703, p = .001. We can see that the p-value for comparing the F1 values of the two vowels is 0.001 which seems far less than the threshold mark of 0.05, suggesting that the difference is statistically significant. In terms of the F2 frequencies, the p-value (0.001) also indicates that there was a highly significant difference between the two vowels.

The average difference between the F1 frequencies (121Hz) of the two vowels indicated that there was enough distance between them. In other words, the F1 (306Hz) of /i:/ suggests that, physiologically, the tongues of the speakers were closer to the roof of the mouth than the /ɪ/ vowel (F1 of 427Hz) in their production. With respect to the F2 frequencies of the two vowels, the mean difference of 147Hz (usually in thousands unlike F1 in hundreds) between the two vowels tells us that the front part of the tongue which was used in articulating the /i:/ (2280Hz) vowel was almost the same as that of /ɪ/ (2133Hz). But the most crucial thing is that they are classified as vowels of different qualities.

The /e/~/ɜ:/ vowels

The two words HEAD /hed/ and THIRTY /θɜ:ti/ were given to the participants for the study to read in citation form so as to find out whether Ghanaian speakers of English discriminate between the /e/ and the /ɜ:/ vowels. The acoustic results indicated that the two vowels were produced with almost the same formant frequencies and that there seems not to be any clear-cut difference between them. In the articulation of the /e/~/ɜ:/ vowels in H*EA*D and TH*IR*TY respectively, almost all the speakers used the average F1 of 540Hz in producing the former and a mean of 532Hz in articulating the latter. Statistically, there was no significant variation between the F1 frequencies of the two vowels, /e/ (M = 5.3988E2, SD = 63.27, N = 34); /ɜ:/ (M = 5.3238E2, SD = 73.56), t (33) = .451, p = .655. The t-test report obviously shows that there was no significant difference between the F1 of the two vowels because the p-value (.655) was far larger than the 0.05 threshold mark.

In respect of the F2 frequencies, the speakers employed a mean of 1931Hz in producing the vowel /e/ while a mean of 1941Hz was used to produce the vowel /ɜ:/. Again, the results of the t-test revealed that there was no significant variation between the two vowels in terms of their F2 frequencies, /e/ (*M* = 1.9309E3, *SD* = 128.53, *N* = 34); /ɜ:/ (*M* = 1.9405E3, *SD* = 187.12), *t* (33) = -.279, *p* = .782. The very high p-value (.782) of the two vowels is an indication that the F2 frequencies of the vowels did not demonstrate any contrast and that they occurred within the same region on the plane. The statistical report of the F1/F2 has suggested that the Ghanaian speakers for the study did not discriminate between the /e/~/ɜ:/ vowels. It must however be noted that only three of the speakers, representing 7.5%, of the speakers appeared to produce THIRTY with F1 of 482Hz and F2 of 1670Hz, possibly suggesting the realisation of the vowel /ɜ:/.

Figure 9 demonstrates in detail the scatter plot of the two vowels /e/~/ɜ:/ produced by the Ghanaian speakers in citation form. It reinforces the numerical data presented on the distinction between /e/ and /ɜ:/ vowels. It can be observed that only three of the /ɜ:/ vowel shifted towards the central part of the plane, suggesting that the three could be possible realisation of the central vowel. Quite apart from these, the rest of the /ɜ:/ and the /e/ vowels appeared to be overlapping within the same vowel space of the front vowel /e/. It shows that the part of the tongue which was raised in the articulation of the two vowels occurred within the same vowel space.

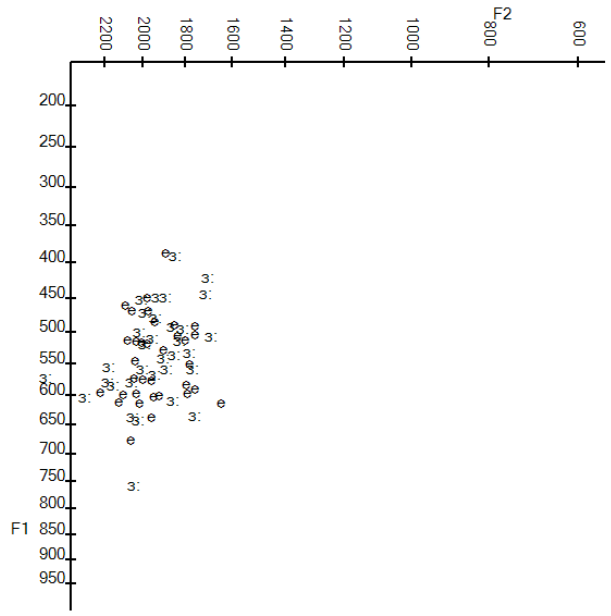

Figure 9. **The scatter plot of /e/~/ɜ:/ vowels produced by the speakers**

The /æ/~/a:/ vowels

The /æ/ and /a:/ vowels were explored within the English words HAD /hæd/ and CALM /ka:m/ respectively in the first context (citation form). The data results disclosed that there was some variation between the two vowels. We can observe from Table 3 that the speakers used the average F1 frequency of 773Hz and 744Hz in the production of /æ/ and /a:/ vowels respectively. We can see that they are very close. However, the paired sample t-test report showed that there was some level of significant variation between the two vowels in respect of their F1 values, /æ/ (M = 7.7270E2, SD = 85.97, N = 40); /a:/ (M = 7.4370E2, SD = 90.29), t (39) = 2.083, p = .044. It means that there was mean difference of 29Hz between the two vowels. The statistical results suggest that the two vowels were close in their F1 frequencies due to the fact that the p-value (0.044) was closer to the 0.05 threshold mark. It also means that in terms of the

height of the tongue to the palate, the /æ/ was a little bit far away from the palate than the /a:/ did.

When it comes to their F2 values, we can note that there was a variation between the two vowels. In the articulation of the two vowels, the speakers used an average F2 of 1486Hz in articulating the /æ/ vowel whereas average of 1408Hz (see Table 3) was used in the production of the /a:/ vowel. Interestingly, the averages of the two vowels appear close from observation, but statistical analysis indicated that the F2 of /æ/ in the production of HAD was highly significantly different from /a:/ in CALM, /æ/ (M = 1.4861E3, SD = 139.55, N = 40); /a:/ (M = 1.4080E3, SD = 120.70), t (39) = 2.083, p = .001. The p-value of 0.001 which is far less than the threshold mark 0.05 suggests that the speakers showed contrast between the two vowels /æ/ and /a:/ in the word list reading.

Figure 10 is the scatter plot of the /æ/ and /a:/ vowels produced by the speakers for further details. It provides pictorial view about how the individual speakers articulated the two vowels in citation form. It is crucial to note that, although there were overlapping vowels, most of the /æ/ vowels occurred at the lower side of the plane whereas most of the /a:/ vowels occurred a bit higher above where some appear overlapping.

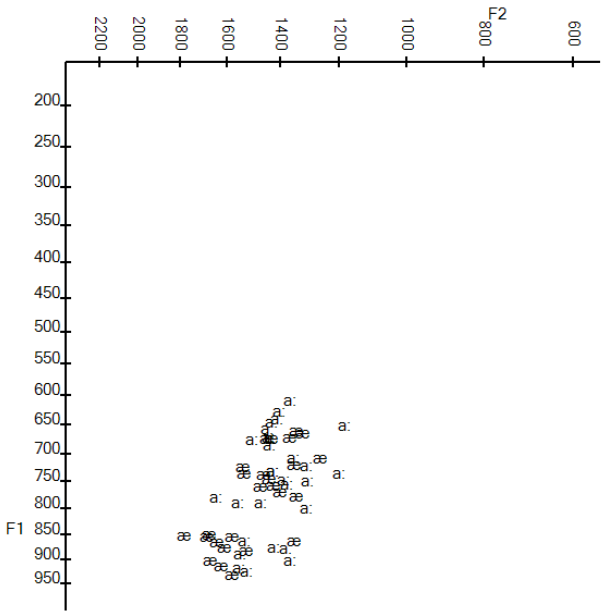

Figure 10. Scatter plot of the /æ/ and /a:/ vowels produced by the speakers

The /ɒ/~/ɔ:/ vowels

To assess the occurrence of the /ɒ/~/ɔ:/ vowels in GhE, the words HOT /hɒt/ and SAW /sɔ:/ were given to the participants to read in isolation. As indicated in Table 3, we can see that the speakers used a mean F1 of 615Hz in articulating the /ɒ/ vowel while an average F1 of 569Hz was used to produce the /ɔ:/ vowel. This is an indication that the two vowels exhibited some variation in their F1. The results of the paired sample t-test confirmed that the two vowels were different in their F1 frequencies, /ɒ/ (*M* = 6.1508E2, *SD* = 65.73, *N* = 40); /ɔ:/ (*M* = 5.6922E2, *SD* = 62.94), *t* (39) = 3.309, *p* = .002. It is important to note that the p-value of 0.002 is far less than the 0.05 threshold mark and, therefore, suggests a statistical contrast between the F1 values of the two vowels. What this means is that the two vowels were articulated with different heights in raising the tongue to the roof of the mouth. In other words, the height of the

tongue raised in the production of /ɔ:/ vowel (569Hz) in S*AW* was a bit closer to the palate than the /ɒ/ vowel (615Hz) in H*O*T. This is also clearly demonstrated in Figure 8.

The data results also indicated that there was a contrast between the F2 frequencies of /ɒ/~/ɔ:/ vowels. We can read from Table 3 that the speakers used F2 averages of 1152Hz and 1043Hz in producing the /ɒ/~/ɔ:/ vowels respectively. The statistical results revealed that the two vowels were significantly different in respect of their F2 frequencies, /ɒ/ (*M* = 1.1515E3, *SD* = 147.89, *N* = 40); /ɔ:/ (*M* = 1.0426E3, *SD* = 129.72), *t* (39) = 3.494, *p* = .001. The p-value (.001) in this case shows high level of significant contrast between the two vowels, indicating that the speakers did discriminate between them in reading the words in isolation. The mean F2 values of the two vowels show that they are back vowels. It also means that the /ɔ:/ (1043Hz) was articulated more back than the /ɒ/ (1152Hz) in the first context.

The /ʊ/~/u:/ vowels

In testing for the existence of the vowels /ʊ/ and /u:/ in the Ghanaian spoken English, the study explored the words F*OO*T and H*OO*T. After reading the words in citation form by the Ghanaian speakers, the results (see Table 3) showed that all the speakers used average F1 of 507Hz and 362Hz in reading the vowels in the words FOOT and HOOT respectively. In terms of the F2 for the two vowels, the mean 1204Hz and 1238Hz were used respectively. The F1 and F2 results give an indication of vowel contrast between the two vowels articulated by the speakers. Statistically, the paired sample t-test report revealed that there was a highly significant difference between the two back vowels with

respect to their F1 frequencies, /ʊ/ (*M* = 5.0673E2, *SD* = 75.75, *N* = 30); /u:/ (*M* = 3.6243E2, *SD* = 66.08), *t* (29) = 8.323, *p* = .001. A close observation of the p-value (.001) indicates that it is smaller than the threshold mark (0.05) compared. It, therefore, suggests that the speakers sustained a highly significant contrast between the two vowels /ʊ/ and /u:/ in the articulation of the words FOOT and HOOT respectively in terms of their F1 in reading the word list. This also means that the closeness of the part of the tongue to the palate was closer in the production of /u:/ vowel than that of the /ʊ/ vowel in their production.

With regard to the F2 frequencies extracted from the results of the speakers' reading, it was recorded that the speakers did not show any significant contrast between the two vowels. It can be seen that the speakers used a mean F2 of 1204Hz to produce the vowel /ʊ/ while mean F2 of 1238Hz was employed in producing /u:/ (see Table 3). After the computation of the frequencies of the two vowels, the paired sample t-test report indicated that there was no significant contrast between the F2 frequencies of the two vowels, /ʊ/ (*M* = 1.2039E3, *SD* = 213.88, *N* = 30); /u:/ (*M* = 1.2383E3, *SD* = 215.05), *t* (29) = -.683, *p* = .500. The p-value calculated (.500) appears far larger than the threshold point (0.05), suggesting that there was no significant variation. It also points out that the speakers pronounced the two vowels with almost the same part of the tongue raised.

Although there was a clear case of no significant difference between the F2 of /ʊ/ and /u:/, this does not also validate the fact that the two vowels are the same. However, the most crucial issue here is that their first formant frequencies were relevant in bringing a significant contrast between the two vowels. In other words, while the F1 showed some important level of variation, the F2 did not.

This is an indication that the back part of the tongue which was raised in the production of the vowel /ʊ/ in FOOT was approximately employed by the speakers in articulating the /u:/ vowel in HOOT.

The /ə/~/e/ vowels

In the exploration of the existence of the unaccented vowel /ə/ in GhE, the English word *A*GO was given to the speakers to read in citation form and the acoustic result was compared to the /e/ vowel in H*EA*D. The results indicated that there was a variation in the two vowels, although there was some observed overlapping. The F1 mean frequency of 549Hz (65% of the speakers) was recorded as against 540Hz in the articulation of the /ə/~/e/ vowels respectively. The difference appears to suggest that there was no significant variation between the two vowels. Statistically, it was true that the two vowels did not show any significant variation in their F1 frequencies, /ə/ (M = 5.4873E2, SD = 61.14, N = 26); /e/ (M = 5.4800E2, SD = 66.41), t (25) = .040, p = .969. The extremely high level of the p-value suggests that the Ghanaian speakers produced the F1 frequencies of the two vowels within the same height. In other words, the height of the tongue which was used in the production of the two vowels was almost the same in terms of F1.

It is also important to note that the results of the mean frequencies of the F2 for the two vowels /ə/~/e/ revealed that there was some difference in the production of these vowels. It can be read from Table 3 that a mean F2 of 1612Hz was used to articulate the /ə/ vowel in *A*GO and average F2 of 1931Hz was employed in producing /e/ in H*EA*D. The paired sample t-test results also indicated that there was a highly significant variation between the vowels /ə/~/e/

in their F2, /ə/ (*M* = 1.6117E3, *SD* = 198.88, *N* = 26); /e/ (*M* = 1.9295E3, *SD* = 139.25), *t* (25) = 7.053, *p* = .001. The p-value (0.001 is less than the 0.05) has shown that the two vowels belong to different vowel qualities in terms of F2. It is an indication that the front part of the tongue was used in producing the vowel /e/ (1939Hz) whereas the /ə/ (1612Hz) vowel shifted towards the central part of the tongue (see Figure 8). It must be quickly added that 35% of the rest of the speakers who articulated the first vowel of AGO demonstrated the use of /e/ vowel instead of /ə/.

Interestingly, whereas the F1 frequencies exhibited no significant variation in the production of /ə/~/e/ vowels, the F2 did indicate such a difference to suggest a distinction between the two vowels.

Summary of vowel quality in the citation form

The following summaries are drawn from the analysis of the vowel quality based on the F1 and F2 produced by the speakers in the first context:

1. There was a highly significant difference between the /i:/~/ɪ/ vowel pair in relation to both F1 and F2.
2. Statistically, there was a highly insignificant variation between the two vowels /e/~/ɜ/ in terms of both F1 and F2.
3. Generally, there was a significant difference between /æ/~/a:/ vowels. While the F1 showed some significance difference or some level of closeness in terms of height, the F2 showed a highly significant difference.
4. There was a significant distinction between /ɒ/~/ɔ:/ vowels in terms of both F1 and F2. The F2 was highly different in /ɔ:/ than the /ɒ/ vowel.

5. Largely, there was a highly significant contrast between the /ʊ/~/u:/ vowels. Unlike their F2, the F1 showed a highly significant variation.
6. There was a general distinction between /ə/~/e/ vowels. There was no significant contrast in terms of their F1 but the F2 showed a high level of significant difference.

Vowels in sentences

The second context which was used in the exploration of the English monophthongal vowels in GhE was their occurrence in sentences. All the twelve English monophthongs were placed in the environments of sentences for the participants to read, of which the F1 and F2 of the vowels were extracted from the targeted words. This was to find out whether the vowels would exhibit the same quality in different contexts. The mean results of the data are presented in Table 4 and Figure 11 for further observation.

	/i:/	**/ɪ/**	**/e/**	**/ɜ:/**	**/æ/**	**/a:/**	**/ɒ/**	**/ɔ:/**	**/ʊ/**	**/u:/**	**/ʌ/**	**/ə/**
F1	326	400	531	505	744	742	596	544	499	395	635	473
SD	43	74	70	78	69	101	62	46	58	55	27	83
F2	2250	2015	1939	1913	1613	1387	1315	1060	1368	1159	1480	1767
SD	231	163	193	141	95	141	112	173	282	318	87	212

Table 4. Mean F1 and F2 (in Hz) of monophthong vowels in sentence

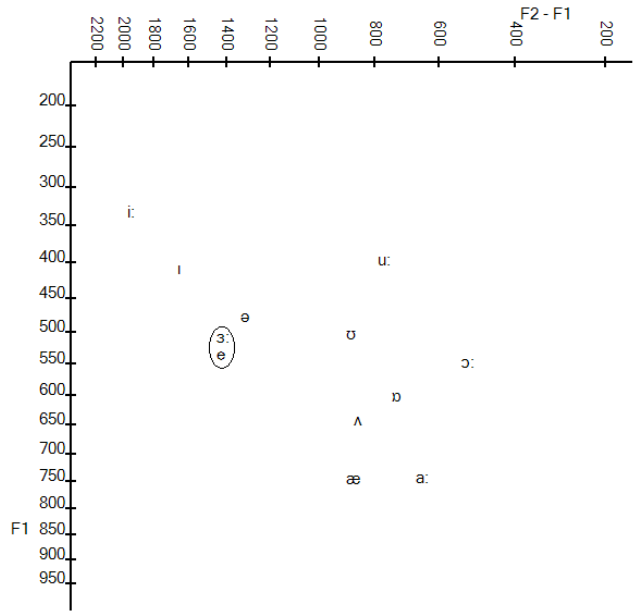

Figure 11. F1/F2 plot of the monophthongs read in sentences

The results from the articulation of the English monophthongal vowels in the context of sentences revealed that the pronunciation of some of the twelve vowels overlap in the Ghanaian speakers' speech. We can observe from Figure 11 that two of these vowels closely overlap. We can see the English front short vowel /e/ overlapping with the central vowel /ɜ:/. However, the rest of the monophthongs seem to occur at different positions on the plane, suggesting that they could be identified as separate vowels with their specific qualities.

Figure 12 illustrates the ellipses plot of the vowels articulated by the speakers in the second context, indicating how the individual vowels occurred on the F1/F2 plane (in Hz). There are, of course, overlapping vowels on the plane. To ascertain the qualities of the vowels produced by the speakers, the study gives a detailed report on the twelve English vowels concentrating on

their average values for the first two formant frequencies. The presentation is done in pairs and it begins with the /i:/~/ɪ/ vowels.

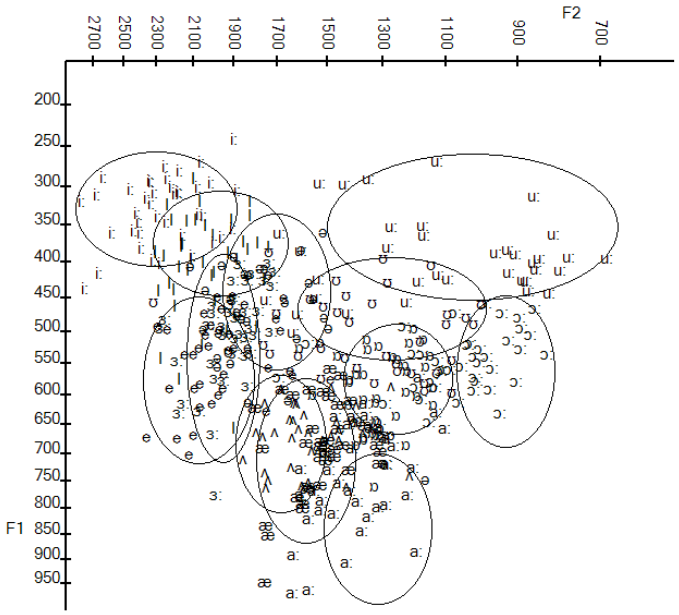

Figure 12. The ellipses of the twelve English monophthongs in sentences

The /i:/~/ɪ/ vowels

The two vowels /i:/~/ɪ/ were contained in the words H*EA*T /hi:t/ and S*I*T /sɪt/ respectively, which were placed in sentences for the Ghanaian speakers to read. This was to determine whether Ghanaian speakers of English realise the two vowels in the environment of a sentence. The results indicated that the two vowels were of different vowel qualities based on their F1 and F2 average values. From Table 4, we can see that all the speakers used the mean F1 of 326Hz and mean F2 of 2250Hz in producing the vowel /i:/ in the word HEAT. It is also realised that the speakers used average F1 of 400Hz and mean F2 of 2015Hz in articulating the /ɪ/ vowel in SIT. It was obvious from the paired sample t-test results that the two vowels were significantly different. The two F1

frequencies showed a highly significant statistical variation, /i:/ (*M* = 3.2550E2, *SD* = 43.35, *N* = 40); /ɪ/ (*M* = 3.9958E2, *SD* = 74.08), *t* (39) = -6.113, *p* = .001. The F2 frequencies of the two vowels also demonstrated a highly significant contrast, /i:/ (*M* = 2.2500E3, *SD* = 230.96, *N* = 40); /ɪ/ (*M* = 2.0153E3, *SD* = 162.99), *t* (39) = 5.688, *p* = .001. In terms of the F1 values for the two vowels, the p-value (.001) falls below the threshold mark of 0.05, suggesting confidence of significant contrast in their F1 values. The p-value (.001) of the F2 values also indicates that the two vowels were pronounced independently of the other.

What the F1 and F2 results suggest is that the part of the tongue that was raised in the production of /i:/ (326Hz) was closer to the palate or a bit higher than the part used in producing vowel /ɪ/ (400Hz), because the smaller the F1 value the closer the part of the tongue to the roof of the mouth. The F2 values also suggested that the two vowels were produced with the front part of the tongue but the /ɪ/ (2015Hz) vowel was a little central than the /i:/ (2250Hz) vowel. The small F2 difference of 235Hz means that they were relatively close in terms of "frontness".

The /e/~/ɜ:/ vowels

To verify whether the two vowels /e/~/ɜ:/exist independently in GhE, the words HEAD /hed/ and THIRTY /θɜ:ti/ were put in sentences for the participants to read. The results of the two vowels appear to show no significant contrast. We can see from Table 4 that the speakers used an average F1 of 531Hz in producing the /e/ vowel in HEAD whereas a mean F1 of 505Hz was used in the case of the /ɜ:/ vowel. There was an indication from the paired sample t-test report that the two vowels showed no significant contrast in terms

of their F1, /e/ (*M* = 5.3138E2, *SD* = 69.68, *N* = 40); /ɜ:/ (*M* = 5.0485E2, *SD* = 78.02), *t* (39) = 1.668, *p* = .103. Obviously, the p-value of 0.103 suggests that no significant difference was observed statistically and that the speakers did not discriminate between the /e/~/ɜ:/ vowels in the second context. In other words, the speakers used relatively the same closeness of the tongue's height in articulating the two vowels.

Undoubtedly, the F2 of the two vowels also demonstrated no important variation to classify them as independent of each other. It is clear that the speakers used the mean F2 of 1939Hz and an average of 1913Hz in the production of the /e/~/ɜ:/ respectively (see Table 4). There was also evidence from the statistical analysis that no significant contrast was observed between the two vowels, /e/ (*M* = 1.9390E3, *SD* = 192.46, *N* = 40); /ɜ:/ (*M* = 1.9132E3, *SD* = 140.99), *t* (39) = .909, *p* = .369. The most essential element in the computation (*p* = .369) shows that the speakers did not sustain any meaningful difference between the vowels in question. It is evident that the speakers raised the same region of the tongue (front) to produce the two vowels in the context of sentences. It is therefore clear that the speakers produced the /e/~/ɜ:/ vowels within the same vowel space in the second context to probably suggest that the Ghanaian speakers of English did not pronounce the central vowel /ɜ:/.

The /æ/~/ʌ/ vowels

A close observation and also literature on GhE tend to suggest that Ghanaians are not likely to pronounce the English vowels /æ/~/ʌ/. Because of this, the /æ/ and /ʌ/ vowels were explored between the English words S*A*T /sæt/ and D*U*CKS /dʌks/ in the second context. From the acoustic results, 52.5% of

the speakers appeared to use the two vowels interchangeably in the words D*U*CKS and S*A*T. This is due to the fact that, relatively, the /ʌ/ vowel seems to occupy a large portion of the vowel space of the half-open area, while the supposed /æ/ vowel occupies the large area of most open vowel space in the centre (see Figure 12). The choice of concentrating on the interchangeability of the two vowels is reinforced by Cruttenden's (2008) assertion that some vowels are interchanged in RP. Cruttenden (ibid) reports that there are a number of instances where, for example, both /æ/ and /a:/ are heard in words like *lather, transfer* or *elastic*.

Consequently, the F1/F2 values in Table 4 shows the results of 21 (52.5%) speakers out of the 40, in the production of both /æ/ and /ʌ/ vowels. From Table 4, we can see that the /æ/ vowel was produced with the F1 mean of 744Hz whereas the /ʌ/ vowel recorded 635Hz in its production. It was clear from the paired sample t-test results that there was a highly significant difference in the F1 values, /æ/ (M = 7.4371E2, SD = 69.40, N = 21); /ʌ/ (M = 6.3524E2, SD = 21.43), t (20) = 1.670, p = .001. The small value of the p-value (.001, compared to the threshold mark of .05) confirms that the difference between the two vowels, in terms of their F1, was strong enough to identify them separately. It means that the /ʌ/ vowel was produced relatively closer to the roof of the mouth than the /æ/ vowel.

The F2 of these same vowels also suggested a significant difference between them. It can be read from Table 4 that the speakers articulated the two vowels with the mean F2 frequencies of 1613Hz for vowel /æ/ as against 1480Hz for vowel /ʌ/. It was also reported from the statistical lenses that a highly significant difference was shown by the speakers with respect to the F2

values of the two vowels, /æ/ (*M* = 1.6129E3, *SD* = 95.05, *N* = 21); /ʌ/ (*M* = 1.4800E3, *SD* = 87.31), *t* (20) = -16.026, *p* = .001. Again, the p-value here is too small to determine sameness of vowels, suggesting that the speakers articulated the two vowels independently.

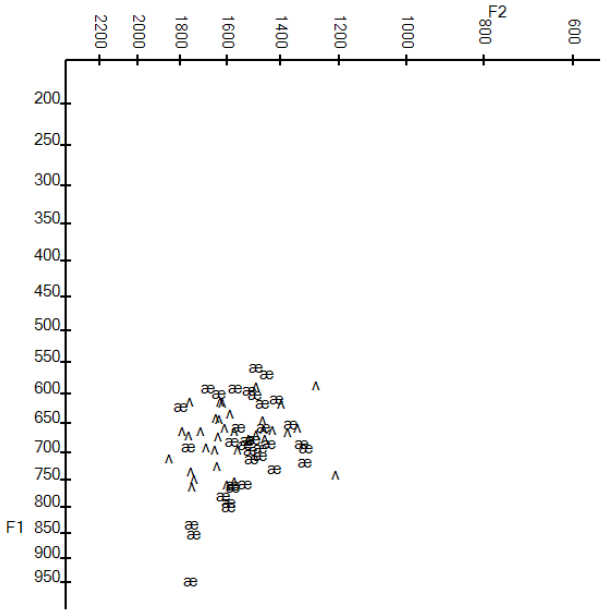

Figure 13. Scatter plot of /æ/~/ʌ/ vowels produced by the speakers

Figure 13 demonstrates the scatter plot of the two vowels /æ/ and /ʌ/, showing certain areas of strong overlapping and those without. It is an indication that some of the speakers (47.5%) possibly pronounced the two expected vowels in their right environments. However, from the position of the articulated vowel in SAT /æ/ which appears more central than the RP /æ/, we tend to suggest the /a/ vowel instead.

The /ɒ/~/ɔ:/ vowels

The words SH*O*T /ʃɒt/ and F*AU*LTY /f*ɔ:*lti/ were put in the context of a sentence for the speakers to read in order to evaluate the occurrence of the two vowels /ɒ/~/ɔ:/ in Ghanaian spoken English. Evidence from the data analysis revealed that the two vowels were pronounced differently in terms of their F1. Table 4 illustrates that the average F1 which was used in the production of /ɒ/ was 596Hz whereas F1 mean of 544Hz was used to pronounce /ɔ:/. Although close observation of the difference of the two means appears similar, the statistical results indicated that the vowels were of different F1 frequencies, /ɒ/ (*M* = 5.9602E2, *SD* = 61.88, *N* = 40); /ɔ:/ (*M* = 5.4402E2, *SD* = 46.00), *t* (39) = 5.357, *p* = .001. In this case, the p-value of 0.001 is small enough to claim that there was a variation maintained by the speakers in the production of the F1 values. The meaning of this is that the height of the tongue which was raised to the roof of the mouth was closer in pronouncing /ɔ:/ while it was a bit open in the case of /ɒ/ in the second environment of the vowels.

We can also see more evidence from the F2 frequencies of the two vowels. The difference was that the speakers pronounced the /ɒ/ vowel with the F2 mean of 1315Hz and /ɔ:/ with the average of 1060Hz. Further statistical analysis that was done suggested that the two vowels were pronounced independently of each other, /ɒ/ (*M* = 1.3152E3, *SD* = 112.35, *N* = 40); /ɔ:/ (*M* = 1.0606E3, *SD* = 172.61), *t* (39) = 9.743, *p* = .001. The small p-value (.001) in this instance suggests that there was a highly significant contrast between the two vowels produced by the speakers. What the results indicate is that, physiologically, the part of the tongue which was raised in pronouncing the /ɒ/

vowel (1315Hz) was relatively central than the /ɔ:/ vowel produced with the far back (1060Hz) of the tongue.

The /ʊ/~/u:/ vowels

Due to an attempt to verify the existence of the vowel /ʊ/ in GhE, the study selected the word FOOT /fʊt/ and placed it in a context of a sentence and the result was compared with the /u:/ vowel contained in the word WHO /hu:/ in a sentence. The results of the acoustic analysis pointed out that the speakers discriminated between the /ʊ/~/u:/ vowels. This is evident from Table 4 that the speakers used F1 average of 499Hz in producing the /ʊ/ vowel as against the /u:/ vowel with F1 mean of 395Hz. It can be deduced from the two values that there was a large difference. The paired sample t-test results supported the claim that a significant variation existed between the production of /ʊ/~/u:/ vowels in respect of their F1 values, /ʊ/ (M = 4.9905E2, SD = 57.87, N = 37); /u:/ (M = 3.9532E2, SD = 54.67), t (36) = 7.509, p = .001. The calculated p-value of 0.001 (less than the 0.05) is evidence that there was a highly significant contrast between the two vowels. The difference in the F1 mean of the two vowels shows that the /u:/ vowel was produced closer to the palate than the /ʊ/ vowel.

In relation to the F2 frequencies of the /ʊ/~/u:/ vowels, the data results revealed a contrast between the two vowels produced by the speakers. It was recorded that the speakers used an average frequency of 1368Hz as against 1159Hz (see Table 4) in the articulation of the two vowels /ʊ/~/u:/ respectively. The evidence from the paired sample t-test also confirmed that the speakers maintained a significant difference between the vowels in question, /ʊ/ (M = 1.3682E3, SD = 282.45, N = 37); /u:/ (M = 1.1588E3, SD = 317.80), t (36) =

3.389, p = .002. From the perspective of the p-value (0.002 was far less than the 0.05 threshold mark), there was enough statistical evidence that the speakers pronounced the two vowels separately. It also means that the part of the tongue which was raised during the production of the two vowels was the back, but the /ʊ/ vowel (1368Hz) looked a bit central than the /u:/ (1159Hz) vowel.

The /ə/~/e/ vowels

The word *A*GO /əgəʊ/ served as the lenses in the exploration of the /ə/ vowel which was compared with the /e/ vowel in H*EA*D /hed/ in the second context in the GhE pronunciations. After the acoustic analysis, the results revealed that the /ə/ vowel (53.3%) was produced differently from the /e/ vowel and the remaining 46.7% were the same as /e/. It means that while the speakers used the F1 mean of 475Hz in producing the /ə/ in *A*GO (see Table 4), the F1 average of 531Hz was employed by the same speakers to pronounce the /e/ in H*EA*D. The individual F1s of the speakers were subjected to paired sample t-test and the results indicated that the two vowels were statistically different, /ə/ (M = 4.7268E2, SD = 83.36, N = 28); /e/ (M = 5.4568E2, SD = 75.98), t (27) = 3.629, p = .001. A highly significant difference is illustrated by the small value of the p (.001), showing that the height of the tongue within which the /ə/ vowel was articulated was closer to the roof of the mouth than the /e/ vowel.

From the outcome of the F2 frequencies produced by the speakers, it was also disclosed that the two vowels showed a large variation. It is clear from Table 4 that the F2 average (1767Hz) which was used in producing /ə/ was different from the F2 mean (1939Hz) used in the production of the /e/ vowel in the second context. Statistically, the two vowels showed a highly significant

variation in their productions, /ə/ (*M* = 1.7670E3, *SD* = 212.07, *N* = 27); /e/ (*M* = 1.9821E3, *SD* = 164.53), *t* (27) = 4.040, *p* = .001. We can see that the p-value value in this case is far less than 0.05, giving us the indication that the speakers maintained a highly significant contrast in the pronunciation of the /ə/~/e/ vowels. The difference that existed between the two vowels gives the clue that different parts of the tongue were employed—central for /ə/ and front for /e/. Interestingly, both F1 and F2 could exhibit a significant variation in the production of /ə/~/e/ vowels unlike the first context.

Summary of vowel quality in the sentence context

Based on the realisations of the monophthongs in sentences, the following summaries are drawn from the F1/F2 of the data to identify the vowel quality.

1. The difference between /i:/~/ɪ/ vowel pair in terms of both F1 and F2 was highly significant.
2. The variation between the two vowels /e/~/ɜ/ in terms of both F1 and F2 was highly insignificant.
3. Generally, there was a significant difference between the /æ/~/ʌ/ vowels. Both F1 and F2 showed highly significant variations, but there was alternation between the two vowels.
4. There was a highly significant distinction between /ɒ/~/ɔ:/ vowels in terms of both F1 and F2, suggesting that /ɔ:/ appeared more back than /ɒ/.
5. Both F1 and F2 displayed a highly significant contrast between /ʊ/~/u:/ vowels. The /u:/ vowel appeared more back than the /ʊ/ vowel.

6. Generally, there was a highly significant distinction between the /ə/~/e/ vowels in respect of both F1 and F2 by 53.3% of the speakers. However, 46.7% did not show any significant difference between them.

Vowels in the interview section

The third context within which the twelve English monophthongs were examined was an interview section with the speakers. The speakers were asked to use the words which were provided by the researcher and contained all the twelve vowels in free speech. This was to allow for spontaneous usage of the vowels under study and also to find out the realisations of the English twelve vowels. The results of the production of the monophthongs in terms of F1 and F2 mean (in Hz) in this last environment, by the Ghanaian speakers, are tabulated in Table 5 below and again demonstrated in Figure 14 for easy identification and description.

	/iː/	**/ɪ/**	**/e/**	**/ɜː/**	**/æ/**	**/aː/**	**/ɒ/**	**/ɔː/**	**/ʊ/**	**/uː/**	**/ʌ/**	**/ə/**
F1	317	418	530	474	839	699	566	518	450	335	692	450
SD	32	48	64	35	100	99	112	56	41	38	57	69
F2	2322	1887	1971	1942	1615	1408	1189	1018	1245	1129	1482	1631
SD	202	222	260	338	134	99	153	98	144	157	86	178

Table 5. Mean F1 and F2 (in Hz) of monophthong vowels in interview section

The mean F1 and the F2 frequencies of the twelve monophthongs were recorded in Table 5 and these values were used in plotting the twelve vowels in Figure 14 below. A section below gives a general description of the occurrence of the vowels on the plane, followed by a detailed report about them.

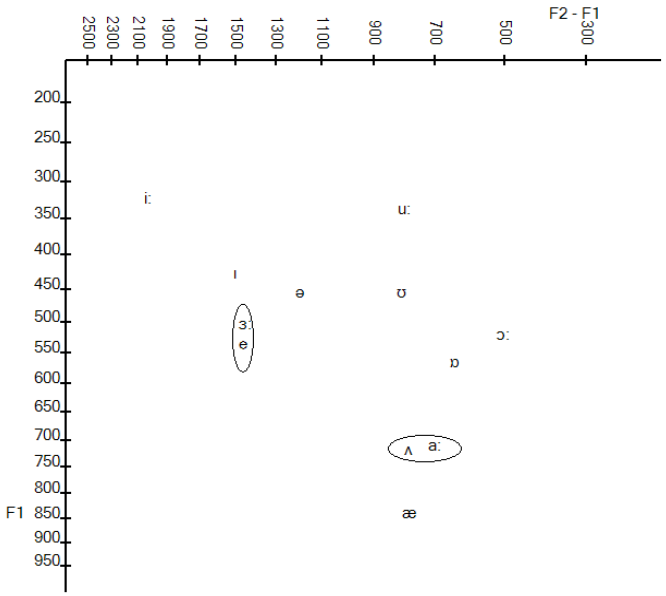

Figure 14. Mean plot (F1/F2) of the twelve vowels produced by the speakers

We can observe from the plane (Figure 14) that the closest vowel to the roof of the mouth is the /i:/ while the /æ/ vowel remains the lowest vowel on the plane. The next vowel which is close to the palate is the back vowel /u:/. This indicates that the speakers' tongues were closer to the palate in the articulation of the front vowel /i:/ than the back vowel /u:/. It can also be seen that the vowel space of the /æ/ also shows how low the tongues of the speakers were in its production compared to the rest of the vowels. It appears that the /e/ and /ɜ:/ vowels show up in the same vowel space and also the vowel spaces for the /ʌ/ and /a:/ appear to be similar. The /ɔ:/ vowel still maintains the most back position than the rest of the vowels in this last context.

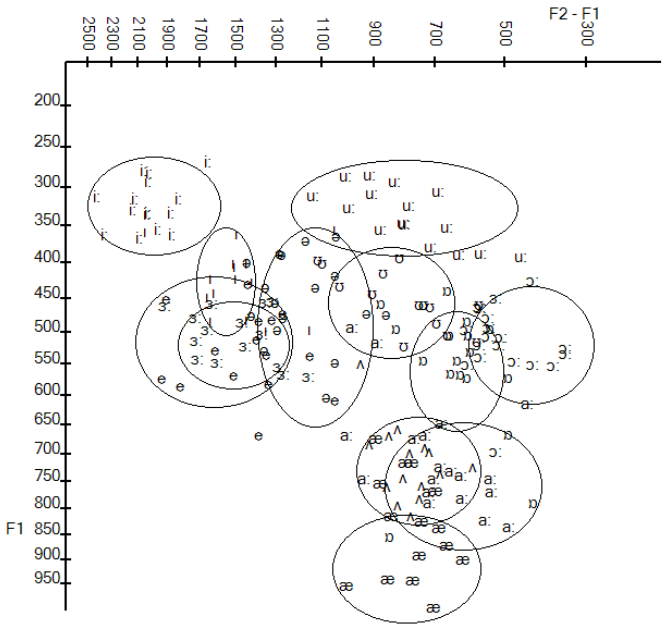

Figure 15. Ellipses plot of the twelve monophthongs produced by the speakers

Figure 15 displays the ellipses plot of the twelve English monophthongs produced by the individual speakers. The distribution of the vowels shows certain instances of overlapping, particularly the /e/~/ɜ:/ vowels. We can also point at certain portions of /ɒ/ and /ɔ:/ indicating overlapping as well as the /ʌ/ and /a:/ showing a high degree of overlap. These overlapping vowels seem to suggest sameness of vowel qualities. However, the comparison of the pairs of the vowels below will ascertain the degree to which they overlap and will be chiefly confirmed by the results of the paired sample t-test. Again, it appears that the /ə/ and the /u:/ vowels occupy very large vowel spaces in terms of the way the vowels are scattered on the plane (see Figure 15). The /u:/ vowel displays its occurrence as close back vowel which scatters from the back towards the central part of the plane. Relatively, we can also see the schwa vowel occupying the central part of the plane and moving towards the lower

section of the plane, indicating its versatile nature across the central region. The /i:/ vowel has again showed that it was produced at the very front part of the tongue (with highest F2 of 2322Hz) and the most back of the tongue was used to produce the /ɔ:/ with lowest F2 value of 1018Hz.

The following section deals with the comparisons of the pairs of the vowels produced by the speakers in the interview section. The mean values for F1 and F2 of each vowel articulated were used in the assessment of the independence of the vowels.

The /i:/~/ɪ/ vowels

The third contextual realisation of the /i:/ and the /ɪ/ vowels constituted the use of HEAT and HIT respectively in the interview section. After the extraction of the F1 and F2 frequencies from the targeted vowels, it was realised that the speakers made a distinction between the two vowels. In terms of the F1 values, the speakers recorded mean frequencies of 317Hz for the /i:/ vowel and 418Hz for the /ɪ/ vowel (see Table 5). The report of the statistical analysis confirmed a highly significant difference in relation to their F1 values, /i:/ (M = 3.1707E2, SD = 31.89, N = 15); /ɪ/ (M = 4.1813E2, SD = 48.34), t (14) = -5.431, p = .001. It is obvious that the p-value of 0.001 is far less than the 0.05 threshold mark, suggesting that the two vowels were significantly different in terms of vowel height. This translates into the fact that the /i:/ with the F1 value of 317Hz was closer to the palate than the 418Hz of the /ɪ/ vowel.

With respect to the F2 of the two vowels, we can still observe a variation between them. It can be read from Table 5 that the speakers recorded F2 frequencies of 2322Hz and 1887Hz in pronouncing the /i:/ and the /ɪ/ vowels

respectively. The results of the paired sample t-test gave enough evidence to support that the F2 values of the two vowels were significantly different, /i:/ (*M* = 2.3222E3, *SD* = 202.01, *N* = 15); /ɪ/, (*M* = 1.8836E3, *SD* = 221.84), *t* (14) = 3.703, *p* = .001. In this case, we can see that the p-value is extremely smaller than 0.05. This confirms that the speakers articulated the two vowels with different vowel spaces. The /i:/ was produced with the very front part of the tongue than the /ɪ/ which appeared more central.

The /e/~/ɜ:/ vowels

We can, again, observe the use of the target words H*EA*D and TH*IR*TY in the interview section for assessing the realisation of the /e/ and the /ɜ:/ vowels respectively by the Ghanaian speakers of English for the study. The results of the two formant frequencies showed that the two vowels appeared to occur within the same vowel space, just like the first two contexts. From Table 5, it can be seen that the F1 average frequencies of 530Hz was used for the production of the /e/ vowel in HEAD and 474Hz in the articulation of the /ɜ:/ in THIRTY. After the computation of the F1 values using the paired sample t-test, it was realised that there was statistical variation between the two vowels, /e/ (*M* = 5.2987E2, *SD* = 64.25, *N* = 15); /ɜ:/ (*M* = 4.7140E2, *SD* = 34.45), *t* (14) = 3.291, *p* = .005. The p-value of 0.005 shows that there was a significant difference because it is considered smaller than 0.05 threshold mark. It points to the fact that the heights of the two vowels were not the same—that the /ɜ:/ vowel was relatively closer to the roof of the tongue than the /e/ vowel.

However, the F2 results of the two vowels seem to suggest that the vowels showed no variation in their production. It is clear from Table 5 that the

F2 average frequencies used by the speakers in the production of /e/~/ɜ:/ vowels were 1971Hz and 1942Hz respectively. The results of the paired sample t-test indicated that there was no significant distinction between the two vowels in terms of their F2 values, /e/ (*M* = 1.9708E3, *SD* = 259.62, *N* = 15); /ɜ:/ (*M* = 1.9401E3, *SD* = 337.62), *t* (14) = .255, *p* = .802. We can see that the p-value is extremely higher than the 0.05 threshold mark set, confirming that the speakers did not vary in F2 frequencies used in articulating the two vowels. In other words, the speakers for the study employed the same part of the tongue (front) to produce the two sounds. We can conclusively state that the two vowels were not independently pronounced, only that their height showed marginal variation.

The /æ/~/a:/ vowels

The /æ/ and /a:/ vowels were explored between the English words HAT /hæt/ and CALM /ka:m/ in the third context, where the speakers used the words freely in their speech. The data results indicated that there was variation between the two vowels. From Table 5, it can be seen that the speakers used F1 average frequencies of 839Hz to articulate the /æ/ vowel and 699Hz for the /a:/ vowel. Statistically, the paired sample results proved that there was a significant difference in the F1 values of the two vowels, /æ/ (*M* = 8.3847E2, *SD* = 100.04, *N* = 15); /a:/ (*M* = 6.9847E2, *SD* = 99.95, *N* = 15), *t* (14) = 3.420, *p* = .004. The p-value in this situation is conceived as being less than the threshold mark. This is an indication that the two vowels differed from each other in relation to the F1 frequencies. Physiologically, the height of the tongue to the palate was relatively more open in the production of /æ/ than /a:/.

With respect to their F2 frequencies, it was observed that differences still persisted. The speakers used 1615Hz and 1394Hz as the mean values (see Table 5) for the F2 in the production of /æ/ and /a:/ vowels respectively. It was statistically proven that the two vowels were realised independently in relation to their F2 frequencies, /æ/ (M = 1.6146E3, SD = 133.82, N = 15); /a:/ (M = 1.3535E3, SD = 99.29), t (14) = 6.106, p = .001. It can be seen that the value for the p is .001, which is far less than the mark set for the threshold (0.05). What this means is that the significant difference that existed between the two vowels was very high which made the /æ/ more central and the /a:/ relatively more back. The results of the data seem to suggest that the /æ/ vowel was produced as a more central and lowest vowel, unlike the RP. It can, therefore, be identified within the vowel space of the cardinal vowel /a/, and the one which usually occurs in the indigenous languages of Ghana.

The /a:/~/ʌ/ vowels

In the third context, the two vowels /a:/~/ʌ/ were compared in the words CALM and DUCK to see whether there was any significant variation between them. The scatter plot of these two vowels was specifically separated from the rest of the vowels for clearer observation and clarification because they seem close in their distribution on the plane. We can see from Figure 16 that there are sections where both /a:/ and /ʌ/ vowels overlap. There are other portions where we can observe them as separately distributed. Some also appear moving far and beyond the common concentrated areas. Specifically, 40% of the two vowels overlapped while 60% of them did not.

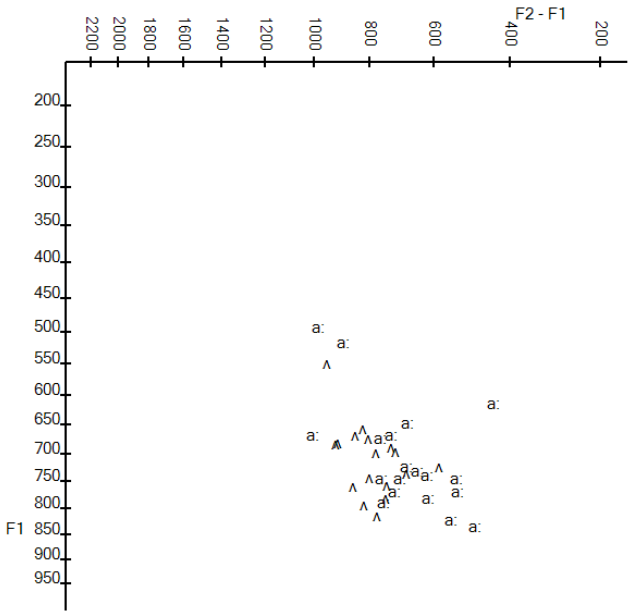

Figure 16. The scatter plot of /ʌ/~/a:/ produced in an interview section

After computing for the mean frequency values, the results appeared to point out some distinction in one of the formant frequencies for the two vowels. From Table 5, we read that the majority of the speakers used the average F1 frequency of 699Hz as against 693Hz in the articulation of the two vowels respectively. The paired sample t-test results revealed that the two vowels did not show any significant contrast in their F1 frequencies, /a:/ (*M* = 6.9847E2, *SD* = 99.95, *N* = 15); /ʌ/ (*M* = 6.9253, *SD* = 57.30), *t* (14) = .202, *p* = .843. It is clear from the p-value (extremely higher than 0.05) that the speakers exhibited no statistical variation between the F1 frequencies. This is an indication that, in terms of vowel height, the two vowels maintained the same openness in their articulation by the Ghanaian speakers.

On the contrary, the F2 values of the two vowels recorded some significant variation between them. It was recorded that the speakers used the

average F2 values of 1393Hz for the production of /a:/ vowel and 1482Hz in producing the vowel /ʌ/. After the paired sample t-test computation, the report indicated that the two vowels differed significantly in their F2 frequencies, /a:/ (*M* = 1.3925E3, *SD* = 99.29, *N* = 15); /ʌ/ (*M* = 1.4820E3, *SD* = 85.85), *t* (14) = 3.400, *p* = .004. Unlike the p-value for the F1, the p-value for the F2 frequencies showed that the two vowels were significantly pronounced differently in respect of their F2. The difference in the F2, physiologically, suggests that the /ʌ/ vowel was articulated a bit central but the /a:/ vowel appeared more back, in spite of the fact that their F1 did not show any significant variation.

The /ɒ/~/ɔ:/ vowels

In the third context, the study compared the occurrence of HOT and SAW/FAULTY to test for the /ɒ/ and /ɔ:/ vowels in the Ghanaian spoken English, beginning with HOT~SAW. The HOT and SAW results indicated that the two vowels were not significantly discriminated. From Table 5, it can be seen that the speakers used average values (F1) of 567Hz to produce the /ɒ/ vowel in HOT and 534Hz for /ɔ:/ in SAW. No significant difference was also observed in the F2. The report of the paired sample t-test suggested that there was no significant variation between the two vowels in terms of their F1 and F2, F1 /ɒ/ (*M* = 5.6733E2, *SD* = 115.29, *N* = 15); /ɔ:/ (*M* = 5.3360E2, *SD* = 78.22), *t* (14) = 1.235, *p* = .237. F2 /ɒ/ (*M* = 1.2063E3, *SD* = 154.24, *N* = 15); /ɔ:/ (*M* = 1.1433E3, *SD* = 165.84), *t* (14) = 1.243, *p* = .234. In each case, the p-value is higher than the 0.05 threshold mark, indicating that the two vowels were pronounced within the same vowel space by the speakers.

For the purpose of certainty, the word HOT was compared with FAULTY to test for a variation between the /ɒ/~/ɔ:/ vowels. The result revealed that the two vowels (/ɒ/~/ɔ:/) appeared differently pronounced by the speakers. As the speakers used F1 mean value of 566Hz to articulate the vowel /ɒ/ in HOT, the F1 mean of 518Hz was used in the production of the /ɔ:/ vowel in F*AU*LTY. Statistical analysis showed that there was no significant difference in their F1 values, /ɒ/ (*M* = 5.6617E2, *SD* = 111.53, *N* = 15); /ɔ:/ (*M* = 5.1778E2, *SD* = 55.77), *t* (14) = 1.512, *p* = .149. This is an indication that the tongue of the speakers was raised within the same height towards the palate. However, the F2 values showed some significant different values in the production of the two vowels. The results of the paired sample t-test confirmed the difference in the F2 values, /ɒ/ (*M* = 1.1889E3, *SD* = 152.99, *N* = 15); /ɔ:/ (*M* = 1.0170E3, *SD* = 98.35), *t* (14) = 4.794, *p* = .001. What the results mean is that the speakers showed a highly significant distinction between the two vowels by producing the /ɒ/ more central than the /ɔ:/ vowel.

The /ʊ/~/u:/ vowels

In testing for the existence of the vowels /ʊ/ and /u:/ in the Ghanaian English, the study considered the exploration of the words F*OO*T and H*OO*T in the third context. After extracting the F1 and F2 values of the two vowels pronounced by the Ghanaian speakers, the results from Table 5 showed that the speakers used average F1 of 450Hz and 335Hz in reading the vowels in the words FOOT and HOOT respectively. Statistically, the paired sample t-test report revealed that there was a highly significant difference between the two back vowels in their F1 values, /ʊ/ (*M* = 4.4987E2, *SD* = 41.28, *N* = 15); /u:/ (*M* = 3.3457E2, *SD* = 156.70), *t* (14) = 8.805, *p* = .001. A close observation of the

p-value (.001) indicates that it is smaller than the 0.05 threshold mark compared. It therefore suggests that the speakers maintained a highly significant contrast between the two vowels /ʊ/ and /u:/ in the last context.

In terms of the F2 for the two vowels, the mean values appeared to show a marginal variation. We can see from Table 5 that the speakers used average frequencies of 1245Hz and 1129Hz in producing the respective /ʊ/ and /u:/ vowels. After their F2 frequencies were subjected to statistical analysis, the results, however, disclosed that the difference was not significant enough, /ʊ/ (M = 1.2448E3, SD = 143.96, N = 15); /u:/ (M = 1.1294E3, SD = 156.70), t (14) = 2.139, p = .051. In this situation, the p-value calculated (.051) is marginally bigger than the threshold point (0.05), suggesting that there was no significant contrast between the two vowels in the third context.

Interestingly, whereas the F1 showed significant variation in the production of the /ʊ/~/u:/ vowels, the F2 did not indicate such difference—we see no significant difference between the F2 frequencies of /ʊ/ and /u:/. However, this does not suggest that the two vowels are the same. What is significant is that their first formant frequencies were very crucial in bringing a contrast between the two vowels, because the F1 showed some high level of variation between the two vowels. Physiologically, it is an indication that the back part of the tongue which was raised in the production of the vowel /ʊ/ in FOOT was almost the same as the part (back of the tongue) employed by the speakers in articulating the /u:/ vowel in HOOT, but then the height of the tongue to the palate was closer in /u:/ than /ʊ/. We can, conclusively, suggest that there was enough evidence to give an indication of vowel contrast between the two vowels articulated by the Ghanaian speakers in the interview section.

The /ə/~/e/ vowels

In order to assess the realisation of the /ə/ vowel in GhE, the two words *A*GO and H*EA*D were given to the participants in the interview section for them to use them as much as they wanted. It was realised that the majority (65%) of the speakers produced the first vowel as the /ə/ vowel in *A*GO and the remaining 35% realising it as the vowel /e/. The data results gave an indication that there was a significant contrast between the /ə/ and /e/ vowels. With regard to the F1 value for the /e/ vowel, the speakers used an average of 530Hz, whereas 450Hz was used to produce the vowel /ə/ (see Table 5). The statistical results confirmed that there was a significant difference between the F1 frequencies for the two vowels, /e/ (M = 5.2987E2, SD = 64.25, N = 15); /ə/ (M = 4.4980E2, SD = 68.97), t (14) = 3.266, p = .006. It is important to note that the p-value in this situation is less than the 0.05 mark, which stresses the fact that the two vowels were not produced at the same height of the tongue. Simply put, the space between the tongue and the palate in the articulation of the two vowels meant that the /e/ vowel was more open than the /ə/ vowel.

Again, an observation of the mean F2 results for the two vowels suggests that there was a high distinction between them. It is also obvious from Table 5 that the speakers employed different F2 values, 1971Hz and 1631Hz in the articulation of /e/ and /ə/ vowels respectively. Statistically, the paired sample t-test results pointed out that, indeed, the two vowels exhibited a high significant variation, /e/ (M = 1.9708E3, SD = 259.62, N = 15); /ə/ (M = 1.6126E3, SD = 178.43), t (14) = 4.996, p = .001. Here, the calculated p-value is too small to make a claim for equality of the two vowels.

It is also significant to state that the remaining 35% of the speakers articulated (as already indicated above) the first vowel of *A*GO within the same vowel space of the /e/ vowel signalling that the speakers used /e/ vowel in place of the schwa in that context.

Summary of vowel quality in the interview section

After the analysis of the monophthongs in the third context, the following findings were drawn from the outcome of the F1/F2 produced by the speakers.

1. The distinction between the vowel pair /i:/~/ɪ/ in relation to both F1 and F2 was highly significant. The /ɪ/ looked relatively more central than the /i:/ vowel.
2. Generally, there was a highly insignificant variation between the two vowels /e/~/ɜ/. However, the F1 indicated some marginal variation unlike the F2 which indicated no variation, making them front vowels.
3. There was a significant difference between /æ/~/a:/. While F1 showed a significant difference in terms of height of the tongue, the F2 showed highly significant difference.
4. The was 60% significant difference between the vowels /a:/~/ʌ/, but 40% overlapped. The F2 was highly insignificant but F1 indicated significant difference, suggesting some level of sameness in terms of height but the /ʌ/ vowel was more central than the /a:/ vowel.
5. There was, generally, a significant distinction between /ɒ/~/ɔ:/ in terms of F2 for the vowels in H*O*T/F*AU*LTY. There was no significant difference in their F1, identifying them with almost the same height.

But there was insignificant difference between the vowels in H*O*T/S*AW* in terms of both F1 and F2.

6. There was a highly significant contrast between the /ʊ/~/u:/ vowels. But while the F1 showed highly significant difference, the F2 indicated marginally insignificant difference. It means that the parts of the tongue raised were relatively the same but of different heights.
7. There was 65% distinction between /ə/~/e/ vowels in terms of both F1/F2, but 35% indicated no difference. The F2 indicated a high level of significant difference whereas the F1 showed slight significant difference.

In addition to the identification of the /ə/ vowel in all the three contexts, the analysis of this vowel below, in relation to fundamental frequency (F0) and intensity, throws more light on whether or not the /ə/ vowel exhibited accented pattern in the data produced by the Ghanaian speakers of English in this study.

The /ə/ vowel: F0 and Intensity

The /ə/ vowel was subjected to further scrutiny relative to its F0 (fundamental frequency) and intensity employed by the speakers to find out whether Ghanaian speakers of English realise this vowel in their speech. In other words, the goal was to investigate the realisation of vowel reduction, apart from vowel quality and duration, in the spoken English of the Ghanaian speakers. Berreta (2003) indicates that there are exhibitions of different acoustic properties of vowel reduction. Firstly, the unstressed vowel is characterised by reduced acoustic energy with decreased amplitude. Secondly, the duration of the vowel reduces; sometimes native speakers appear to skip it. As a result of that

the /ə/ vowel was tested using the English words *A*GAIN /ə' geɪn/ and *A*GO /ə' gəʊ/.

Table 6 demonstrates the results of the measurement of the data in relation to pitch (in Hertz/Hz) and intensity (in decibel/dB) used by the speakers in the production of the words *Again* and *Ago*. These disyllabic words with the VCV(C) structure have been split into two parts so as to illustrate the pitch and acoustic energy used in the production of the vowels in the two syllables in each case to ascertain whether or not there was an accented syllable and for that matter vowel reduction in the data gathered.

	Pitch (Hz)				**Intensity (dB)**			
	a-	**-gain**	**a-**	**-go**	**a-**	**-gain**	**a-**	**-go**
In Citation	158	191	158	185	55	69	60	69
In sentence	135	160	113	152	54	62	60	65
Interview	150	158	141	170	69	77	72	80

Table 6: Pitch and Intensity in the production of the VCV syllable

It can be seen from Table 6 that the first syllables of the two words recorded smaller values than the nuclei of the second syllables. It is clear from Table 6 that the word *again* which was read in citation showed lower pitch in the production of the first syllable V (a-) with the mean of 158Hz as against the mean pitch of 191Hz for the second vowel in CVC (-gain). In its use in sentences, the word *A*GAIN recorded the mean pitch of 135Hz used in articulating the first syllable V (a-) as against 160Hz in the nucleus of the second syllable CVC (-gain). The word *A*GO also demonstrated the same pattern as that of *AGAIN* in the two different environments as can be observed in Table 6. The same pattern for the first two contexts has been exhibited by the third context, the interview section (see Table 6). Surprisingly, the two words

used showed some significant differences in pitch with respect to their first and second syllables in all the three environments, suggesting that the first syllables in each case have a lower pitch than their second syllables.

Interestingly, the level of force used by the speakers in the production of the words *again* and *ago* in all the three different contexts illustrated the same pattern like the pitch employed. The speakers used a mean intensity of 55dB as against 69dB in the production of the two syllables V (a-) and CVC (-gain) respectively of the word *again* in the wordlist reading (see Table a). In terms of the word *ago*, it can be noted that the speakers used an average intensity of 60dB in the articulation of *a-* as against intensity of 69dB for the vowel in *go* (ago) in citation form. We can see similar pattern in the second and the third contexts (see Table 6), pointing out that there appears to be a vowel reduction in the data collected from the Ghanaian speakers' speech.

Comparison of vowel quality in the three contexts

The F1/F2 results for the three contexts used in this study to identify the vowel quality have been compared in Table 7 (in Hz) below; Figure 17 represents the plots of the vowels in each context. Summaries of observations drawn from Table 7 and the plots are also given below.

General observations

1. In all the three groups each of the vowels in terms of their contextual realisations seem to occupy separate vowel spaces except the case of /e/~/ɜ:/ vowels.

2. Almost all the realisation of the vowels /e/ and /ɜ:/ overlapped within the same front vowel space in the position of the /e/ vowel in all the three contexts.
3. Generally, the /i:/ and /e/ vowels were the only vowels that appeared to cluster most by occupying the same vowel space than the others, followed by the /a:/ vowel in all the three contexts.
4. On the other hand, the schwa vowel occupied the largest vowel space, but the /ə/ in the first context appeared to be more open in terms of the height to the palate than the second and the third contexts.
5. The shortest distance between the vowel pairs was recorded between the /æ/~/a:/ vowels in the first context, which was closely followed by the /ʌ/~/a:/ in the third contexts.
6. In terms of similar vowels occurring closely together in the three contexts compared, the common pattern was that four vowels (/ɪ/ /ɒ/ /ɔ:/ /ʊ/ and /ə/) were very close in contexts two and three than context one.

	Citation		Sentence		Interview	
	F1	**F2**	**F1**	**F2**	**F1**	**F2**
i:	306	2280	326	2250	317	2322
ɪ	427	2133	400	2015	418	1887
e	540	1931	531	1939	530	1971
ɜ:	532	1941	505	1913	474	1942
æ	773	1486	744	1613	839	1615
a:	744	1408	742	1387	699	1408
ɒ	615	1152	596	1315	566	1189
ɔ:	569	1043	544	1060	518	1018
ʊ	507	1204	499	1368	450	1245
u:	362	1238	395	1159	335	1129
ʌ	697	1511	635	1480	692	1482
ə	549	1612	473	1767	450	1631

Table 7. Comparison of the mean F1/F2 of the vowels in the three contexts

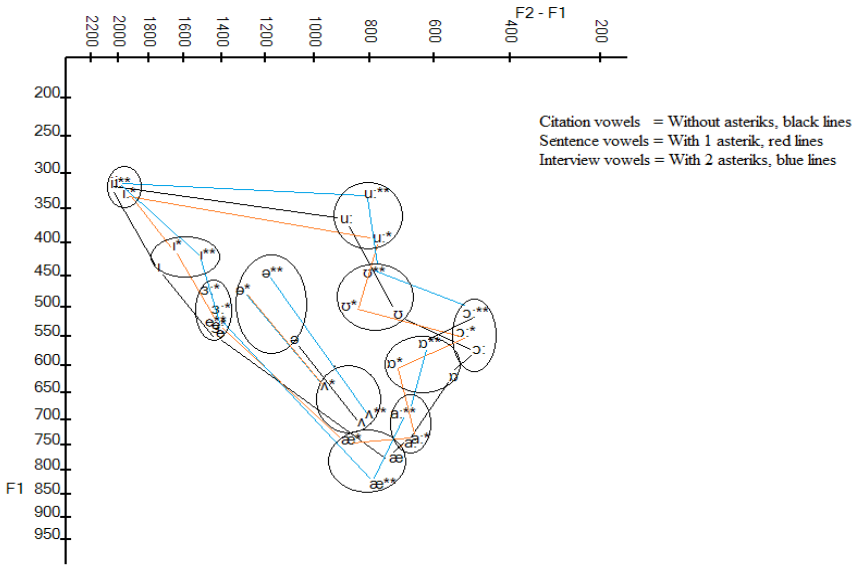

Figure 17. Mean F1/F2 plots of the vowels in the three contexts

Vowel length

Another dimension of English vowel identification is length. In order to establish the length of a vowel, durational measurements were taken acoustically. In this study, the spectrogram and waveform provided the means through which the vowel durations for the tokens containing the targeted vowels were measured. The mean and the standard deviation (SD) of each vowel were calculated for descriptive analysis. The durational values for the vowels were further subjected to a statistical analysis using the paired sample t-test to test for significant contrast between tense and lax vowels for length distinctions.

This section therefore reports the results of the measurement of the durations of the monophthongal vowels realised by the Ghanaian speakers of English in the three different contexts: in citation form, in sentence and in spontaneous speech. Table 8-10 presents the results of the three contextual

durations (in milliseconds or ms) used by the speakers. The analysis was done in terms of the mean durations of the vowels and their respective standard deviations (*SD*).

	/i:/ ~ /ɪ/		**/e/ ~ /ɜ:/**		**/ʌ/ ~ /a:/**		**/ɒ/ ~ /ɔ:/**		**/ʊ/ ~ /u:/**		**/ə/**
Duration	152	115	121	202	109	173	122	185	122	162	91
SD	36	34	26	41	23	31	28	42	36	42	28

Table 8. Mean durations (ms) of monophthongal vowels in citation form

We can observe from the results of Table 8-10 that the Ghanaian speakers of English generally showed some contrast in length in the production of almost all the 12 monophthongs in all the three different contexts. In the reading of the words in isolation (see Table 8), the least time that was used in articulating the vowels was 91ms in producing the vowel /ə/ in the word *A*GO and the highest duration was recorded as 202ms in producing the English vowel /ɜ:/ in the word TH*IR*TY. The closest duration (difference 37ms) used was between the production of /i:/ (152ms) and the /ɪ/ (115ms) vowels. In the second context, the /ə/ vowel, again, recorded the least average time (82ms) in the production of the 12 vowels (see Table 9). The same pattern was used in the third context as the speakers used a mean duration of 80ms for the same /ə/. The highest average duration (208ms) was used to produce the vowel /ɔ:/ in the word FAULTY. The shortest difference in duration (3ms) was recorded between /e/~/ɜ:/ (121ms-118ms) in the words S*E*T and TH*IR*TY respectively.

For the purpose of clarity and close observation of the vowel contrast realisation in terms of durational (length) measurements in the English spoken by the Ghanaians, the vowels are paired below. The results are based on the

three different environments upon which the vowels were placed and produced. It begins with the comparison of /i:/ and the /ɪ/ pair in citation form.

Monophthongs in citation form

The /i:/~/ɪ/ vowels

In terms of duration, the results from Table 8 indicate that all the speakers maintained a significant difference between the H*EA*T /hi:t/ and H*I*T /hɪt/ vowels in reading the word list. It can be seen from Table 8 that the average duration used by the speakers in the production of the vowel /i:/ was 152ms whereas the mean duration of 115ms was used to produce the vowel /ɪ/ in the word HIT. Statistically, the results of the paired sample t-test conducted showed that there was a highly significant variation between the mean durations used in the production of the two vowels /i:/~/ɪ/. The paired sample t-test revealed that the speakers used more duration in producing the vowel /i:/ (*M* = 1.5182E2, *SD* = 36.08, *N* = 39) than /ɪ/ (*M* = 1.1451E2, *SD* = 33.86), *t* (38) = 7.198, *p* = .001. This means that there was a significant mean difference of 3.7307E (generated from the SPSS) between the vowels of HEAT and HIT. The positive mean difference (3.7307E or 37ms) indicates that the /i:/ had more duration than the /ɪ/ in the order of /i:/~/ɪ/ occurrence, suggesting that the Ghanaian speakers used more time in producing the former than the latter. It is therefore obvious that the speakers made a highly significant durational contrast between the two vowels /i:/~/ɪ/ in their production in the citation form.

The /e/~/ɜ:/ vowels

In assessing the durational difference that exists between the /e/ and /ɜ:/ vowels, the study explored the words S*E*T and TH*IR*TY respectively. The

results from the analysis (see Table 8) indicated that the speakers used the average duration of 121ms to produce /e/ in the word S*E*T and mean duration of 202ms in producing the vowel /ɜ:/ in TH*IR*TY. We can see some substantial variation between the durations used in articulating the two vowels. The paired sample t-test revealed that the speakers used more duration in producing the vowel /ɜ:/ (*M* = 2.0242E2, *SD* = 41.03, *N* = 40) than /e/ (*M* = 1.2125E2, *SD* = 26.26), *t* (39) = 12.465, *p* = .001. This indicates that there is a mean difference of 8.1175E1 (81ms) between the vowels /e/ and /ɜ:/. The mean difference led to the generation of small p-value (.001) which is less than the threshold mark (.05). This means that there was enough evidence to claim that a highly significant distinction was made between the two vowels /e/ and /ɜ:/ in the first context.

The /ʌ/~/a:/ vowels

C*U*P and C*AL*M constituted the two words used as stimuli to elicit the durations of the vowels /ʌ/~/a:/ in the word list reading. The results from Table 8 demonstrate that the mean duration (173ms) used in the production of /a:/ in the word C*AL*M by the speakers was significantly higher than the mean duration (109ms) used in articulating the vowel /ʌ/ in the word C*U*P. After the statistical analysis was conducted, the paired sample t-test indicated that the speakers used significantly more duration in producing the vowel /a:/ (*M* = 1.7336E2, *SD* = 31.20, *N* = 39) than /ʌ/ (*M* = 1.0859E2, *SD* = 22.76), *t* (38) = 14.366, *p* = .001. Out of the two means, we can observe a significant mean difference of 6.4769E between the vowels in C*AL*M and C*U*P.

The /ɒ/~/ɔ:/ vowels

H*O*T and F*OR*TY were the words that were used in the measurement of the duration of the /ɒ/~/ɔ:/ vowels. The results from the analysis of the data shown in Table 8 suggest that there exists some variation between the vowel pair /ɒ/ and /ɔ:/. It is observable from Table 8 that the speakers used the average duration of 185ms as against 122ms in the production of the vowels /ɔ:/ and /ɒ/ in the words H*O*T and F*OR*TY respectively. It can be observed that the speakers used more time to articulate /ɔ:/ vowel than /ɒ/. The paired sample t-test which was conducted to evaluate whether the difference that existed between the two vowels was significant confirmed that the speakers used more duration in producing the vowel /ɔ:/ (*M* = 1.8515E2, *SD* = 42.31, *N* = 40) than /ɒ/ (*M* = 1.2200E2, *SD* = 27.97), *t* (39) = 9.295, *p* = .001. This is clear that the significant mean difference between the two vowels /ɔ:/ and /ɒ/ was 6.3150E1 (63ms).

The /ʊ/~/u:/ vowels

The two words that were used as stimuli to measure the duration of the /ʊ/ and /u:/ vowels in the citation form comprised F*OO*T and H*OO*T respectively. The results from Table 8 revealed that a variation existed between the duration of the vowels /u:/ (with a mean duration of 162ms) in the word H*OO*T and /ʊ/ (with a mean duration of 124ms) in the word F*OO*T. After a statistical analysis was conducted to determine the significant difference between the two vowels, the paired sample t-test report revealed that the speakers used more duration in producing the vowel /u:/ (*M* = 1.6151E2, *SD* = 41.81, *N* = 37) than /ʊ/ (*M* = 1.2370E2, *SD* = 36.74), *t* (36) = 4.981, *p* = .001. This shows that there was a highly significant mean difference of 3.7810E1

(38ms) between the vowels /u:/~/ʊ/. What is significant is that the speakers maintained a contrast between the two vowels in the citation form because the p-value (.001) is less than the confidence interval of difference (.05).

The /ə/~/e/ vowels

The word *A*GO was used to measure the duration of the vowel /ə/. It can be seen from Table 8 that the /ə/ vowel recorded the least duration (91ms) compared to the rest of the vowels in citation produced by the Ghanaian speakers. The mean duration of this vowel was compared to the /e/ vowel in SET (which measures the second least duration in citation and also closer to /ə/ in terms of vowel space). A paired sample t-test was further conducted to evaluate whether, statistically, there was a significant difference between the mean durations of the vowel in the word S*E*T and the first vowel in *A*GO. The assessment of the statistical analysis indicated that, significantly, the speakers used more duration in producing the vowel /e/ (M = 1.2149E2, SD = 26.56, N = 39) than the /ə/ (M = 91.4872, SD = 27.81), t (38) = 5.620, p = .001. It is obvious that the significant mean difference between the two vowels /e/ and /ə/ is 3.0000E1, suggesting that more time was used to produce the /e/ than the /ə/.

Summary of vowel duration in the citation form

1. The /i:/ vowel was significantly different from the /ɪ/ vowel in terms of length, suggesting that the /i:/ vowel was longer than vowel /ɪ/.
2. There was a highly significant distinction between /ɜ:/~/e/ vowel pair. The /ɜ:/ vowel was produced longer than the /e/ vowel.
3. There was a highly significant length difference between the /ʌ/~/a:/ vowels, indicating that the /a:/ vowel was longer than vowel /ʌ/.

4. The durational difference between the /ɒ/~/ɔ:/ vowel pair was highly significant. The former was shorter than the latter.
5. The length difference between the vowel pair /ʊ/~/u:/ was highly significant. The /ʊ/ vowel was shorter than the /u:/ vowel.
6. The length difference between the vowel pair /ə/~/e/ was highly significant. The /e/ vowel was longer than the vowel /ə/.

Vowels in sentences

The results of the mean durations used by the 40 speakers for the study are presented in Table 9. They have been displayed in terms of vowel pairs for easy reading and interpretations.

	/i:/ ~ /ɪ/		**/e/~/ɜ:/**		**/ʌ/ ~ /a:/**		**/ɒ/ ~ /ɔ:/**		**/ʊ/ ~ /u:/**		**/ə/**
Duration	124	91	104	118	112	191	130	194	97	100	82
SD	47	21	25	41	34	40	24	42	21	20	13

Table 9. Mean durations (ms) of the monophthongs used in sentences

The /i:/~/ɪ/ vowels

In a different context (vowels used in sentences) of reading the two vowels, the results of the speakers' reading of the vowels have shown that the speakers still maintained a significant difference between the duration used in producing the vowels /i:/ and /ɪ/. The results from Table 9 indicate that all the speakers used an average duration mean of 124ms in producing the vowel /i:/ in the word S*EA*T /si:t/ as against the mean duration of 91ms for vowel /ɪ/ in the word S*I*T /sɪt/. Statistical analysis showed that the speakers employed more time in articulating the vowel /i:/ than /ɪ/, /i:/ (M = 1.2430E2, SD = 46.94, N = 40) than the /ɪ/, /ɪ/ (M = 90.5500, SD = 20.96), t (39) = 4.217, p = .001. The mean difference (3.3750E1 or 34ms) that was statistically derived between the two

vowels suggests that the speakers used a highly significant difference of duration in producing the two vowels (/i:/~/ɪ/). More importantly, the p-value is considered very smaller than the 0.05 threshold mark. It is therefore obvious that statistically the participants used more duration in producing the close front vowel /i:/ than the /ɪ/ vowel.

The /e/~/ɜ:/ vowels

In the second context (sentence form), we can see some variation between the duration used in the production of the two vowels /e/ and /ɜ:/. It can be seen from Table 9 that the speakers used an average mean of 117ms in the articulation of the vowel /ɜ:/ in the word TH*IR*TY and average mean of 104ms in producing the vowel /e/ in the word S*E*T. The results of the paired sampled t-test showed that the speakers employed different durations which were close in the articulation of the vowels /ɜ:/ and /e/, /ɜ:/ (M = 1.1748E2, SD = 40.97, N = 40) and /e/, (M = 1.0408, SD = 24.99), t (39) = 2.117, p = .041. The mean difference of 1.3400E1 and the probability value (p = .041 is close to the threshold mark of 0.05) suggesting that the two different significant durations used in the production of the two vowels were very close.

The /a:/~/ʌ/ vowels

Again, in the second environment in which the two vowels (/a:/~/ʌ/) were placed for reading, it was realised that the speakers showed a large duration variation between the articulation of the vowels /a:/ in C*AL*M and /ʌ/ in C*U*P. The results of the data (see Table 9) indicate that the speakers used the mean duration of 191ms in producing vowel /a:/ and mean duration of 112ms in producing vowel /ʌ/. Statistically, the results of the paired sampled t-test

suggested that the duration between the two vowels was highly significant, /a:/ (*M* = 1.9068E2, *SD* = 39.97, *N* = 40) and /ʌ/ (*M* = 1.1202E2, *SD* = 33.61), *t* (39) = 9.387, *p* = .001. The mean difference between the two vowels was recorded as 7.8650E which is quite large in favour of the vowel /a:/. The p-value is also small to claim equality in vowel duration.

The /ɒ/~/ɔ:/ vowels

Again, the two words F*AUL*TY /fɔ:ti/ and H*O*T /hɒt/ were placed in the context of sentences which were read by the Ghanaian speakers to measure whether there was any significant difference in the duration used in producing the vowels /ɔ:/ and /ɒ/ respectively. From the data analysis report, it was observed that the speakers used a mean duration of 194ms as against 108ms in producing the vowels /ɔ:/ and /ɒ/ respectively (see Table 9). This is an indication that there was a significant variation of duration in articulating the two vowels. The statistical reports also confirmed that the speakers used more time in producing the vowel /ɔ:/ than /ɒ/, /ɔ:/ (*M* = 1.9440E2, *SD* = 32.39, *N* = 40) and /ɒ/, (*M* = 1.0768E2, *SD* = 23.88), *t* (39) = 15.877, *p* = .001. The confirmation of the durational contrast is exhibited by the small p-value. What this means is that the mean difference that was realised was 8.6725E1 in favour of the first vowel (/ɔ:/) in F*AUL*TY.

The /ʊ/~/u:/ vowels

In order to assess whether there was a variation between the duration used in producing the vowel pair /u:/ and /ʊ/ in sentences, the two words "P*U*T" and F*OO*T containing the respective vowels were explored. P*U*T was used because it contained the /u:/ vowel instead of the /ʊ/ vowel—all the Ghanaian

speakers realised it as /u:/. "P*U*T" also provided natural or phonemic environment for the long vowel /u:/ to test for vowel length. It is clear from Table 9 that the difference of duration that was used by the Ghanaian speakers was not strong enough to bring a significant difference. An average duration of 100ms was used in producing the vowel /u:/ in "PUT" whereas an average duration of 97ms was used to produce /ʊ/ in FOOT. The statistical test for significance of the variation of time used in articulating the two vowels revealed that there was no strong significant difference between the two vowels in the environment of sentences, /u:/ (M = 99.4500, SD = 20.43, N = 40) as against /ʊ/, (M = 97.1500, SD = 21.17), t (39) = 0.048, p = .631. The duration of 2.30000 was realised as the mean difference between the duration used in articulating the two vowels, which is not significant enough to demonstrate any significant variation. Again, the compared calculated probability value (0.631) is above the threshold value of 0.05 (the 95% confidence interval of the difference). This therefore suggests that the durations used in producing the two vowels /u:/ and /ʊ/ by the speakers in sentences remained within the same time domain.

The /ə/~/e/ vowel

The /ə/ vowel was again explored in a different context to find out whether Ghanaian speakers of English use duration to discriminate this vowel from other vowels in the environment of a sentence. The first vowel in *A*GAIN /ə'gein/ was explored in relation to the vowel /e/ in the word SET /set/ /. Table 9 indicates that the speakers used an average duration of 104ms in producing the vowel /e/ in the word S*E*T whereas an average duration of 82ms was used to produce /ə/ in the word *A*GAIN. The paired sampled t-test report revealed that the difference in duration between the two words was statistically significant, /e/

(*M* = 1.0408E2, *SD* = 24.97, *N* = 40) is more than /ə/ *(M* = 82.0000, *SD* = 13.35), *t* (39) = 5.299, *p* = .001. With the mean difference of 2.2075E1 (22ms), the SET vowel can be said to contain more time than the /ə/ in *A*GAIN.

Summary of vowel duration in the context of sentences

1. The /i:/ vowel was significantly different from the /ɪ/ vowel in terms of length, suggesting that /i:/ was longer than /ɪ/.
2. The duration between /ɜ:/~/e/ vowel pair was significant but was relatively close. The /ɜ:/ vowel was produced a little bit longer than /e/.
3. There was a highly significant length difference between /a:/~/ʌ/, indicating that /a:/ was longer than /ʌ/.
4. The difference between /ɒ/~/ɔ:/ vowel pair was highly significant. The former was shorter than the latter.
5. The length between the vowel pair /ʊ/~/u:/ was highly insignificant. Both vowels relatively used the same duration.
6. There was a highly significant length difference between the vowel pair /ə/~/e/. The /e/ was longer than the /ə/.

Vowels in interview section

The results of the 12 monophthongs produced by the 40 Ghanaian speakers in terms of duration have been presented in tabular form as can be seen from Table 10 for easy comparison and analysis.

	/i:/ ~ /ɪ/		**/e/~/ɜ:/**		**/ʌ/ ~ /a:/**		**/ɒ/ ~ /ɔ:/**		**/ʊ/ ~ /u:/**		**/ə/**
Duration	119	93	118	139	106	179	117	208	104	125	80
SD	35	12	22	40	24	37	17	37	13	29	14

Table 10. Mean durations (ms) of monophthong vowels in interview section

The /i:/~/ɪ/ vowels

The third context witnessed the use of SEAT and SIT to measure the duration used in the articulation of the /i:/ and /ɪ/ vowels respectively. The results of the duration showed that the speakers recognised a contrast between the two vowels. It is obvious from Table 10 that the mean durations of 119ms and 93ms were employed by the speakers to produce the respective /i:/ and /ɪ/ vowels. Statistically, there was a highly significant variation between the two vowels because the duration for /i:/ (M = 1.1912E2, SD = 34.80, N = 16) was more than the /ɪ/ (M = 92.7500, SD = 12.28), t (15) = 4.217, p = .001. It is evident that the p-value of .001 is far less than the threshold 0.05 mark. We can also observe the mean difference of 2.6375E1 (26ms) between the two vowels, which appears small, but it, importantly, suggests that the vowel /i:/ was longer in duration than the /ɪ/ in the third situation.

The /e/~/ɜ:/ vowels

In the course of exploring the duration contrast between the /e/~/ɜ:/ vowels, the words S*E*T and TH*IR*TY were again given to the participants in an interview section to use freely in their speech. The results of the duration used in the pronunciation of /e/ and /ɜ:/ in the respective words S*E*T and TH*IR*TY suggested that the speakers recognised some variation. We can clearly see from Table 10 that the production of /e/ and /ɜ:/ lasted for the average periods of 118ms and 139ms respectively. However, it was reported by the paired sample t-test that the two vowels did not show any significant difference, /ɜ:/ (M = 1.3925E2, SD = 38.59, N = 16) compared to /e/ (M = 1.1844E2, SD = 22.19), t (15) = .151, p = .151. Since the p-value (.151) here is much higher than the

threshold mark (0.05), we can say that there is evidence to claim that the difference in duration was not significant enough to point at a durational variation between the two vowels. In very simple terms, the Ghanaian speakers produced the two vowels within the same time frame.

The /ʌ/~/a:/ vowels

The same words (CALM/CUP) used in the first two contexts were again tested in the last context to evaluate the duration used in the production of /a:/ and /ʌ/ in GhE. The data results from Table 10 indicate that the speakers showed some contrast in the duration they used to articulate the /a:/ (179ms) and the /ʌ/ (106ms) vowels. Statistically, the difference in duration was significantly maintained, /a:/ (M = 1.7865E2, SD = 37.04, N = 17) than /ʌ/, (M = 1.0639E2, SD = 23.82), t (16) = 6.122, p = .001. The mean difference of 7.2458E1 (73ms) between the two vowels is an indication that the speakers used longer time in articulating the /a:/ vowel than the /ʌ/ vowel. The small p-value also confirmed that the speakers contrastively pronounced the two vowels in terms of duration in their free speech.

The /ɒ/~/ɔ:/ vowels

In another situation, the same two words (FAULTY/HOT) were given to the speakers during the interview engagement with the researcher for them to use the words freely in their speech to find out whether the vowels /ɔ:/ and /ɒ/ were contrastively pronounced. The results indicated that the two vowels did not last for the same period of time (see Table 10). It was recorded that the speakers spent an average duration of 208ms in producing /ɔ:/ while a mean duration of 117ms was used for the vowel /ɒ/. The statistical reported pointed at

a highly significant variation between the two vowels, /ɔ:/ (*M* = 2.0783E2, *SD* = 36.64, *N* = 18) and /ɒ/ (*M* = 1.1744E2, *SD* = 16.68), *t* (17) = 9.422, *p* = .001. The small value of the *p* is an indication that the two vowels differed in terms of duration in the free speech context. It was also observed that the difference between the two vowels was 9.0488E1 (91ms), suggesting that the /ɔ:/ vowel was longer than the vowel /ɒ/.

The /ʊ/~/u:/ vowels

In the third environment, the words HOOT and FOOT were freely pronounced by the speakers in their speech to verify the durations used in maintaining the difference between the /u:/ and /ʊ/ vowels. The results of the durational measurement used indicated that the two vowels showed some degree of variation. In maintaining the distinction, an average duration of 125ms was used for the vowel /u:/ in HOOT but 104ms was used for vowel /ʊ/ in FOOT. The difference was confirmed by the paired sample t-test report, /u:/ (*M* = 1.2656E2, *SD* = 29.21, *N* = 16) as against /ʊ/ (*M* = 1.0438E2, *SD* = 13.02), *t* (15) = 3.33., *p* = .005. Unlike the second context, the p-value (0.005) is considered less than the threshold mark (0.05), suggesting that the difference was statistically significant. This is an indication that the Ghanaian speakers maintained a significant durational difference between the /u:/~/ʊ/ vowels.

The /ə/~/e/ vowels

AGO and SET were used as the means to contrast the length of the vowels /ə/~/e/ in the third context. The data results revealed that the two vowels were differently pronounced with different durations. It can be seen that the speakers spent mean duration of 80ms in the articulation of /ə/ whereas mean

duration of 118ms was used to produce /e/ (see Table 10). The report of the paired sample t-test showed that there was a high statistical significant difference between the /ə/~/e/ vowels. It means that the /e/ (*M* = 1.1759E2, *SD* = 22.19, *N* = 17) was more than /ə/ *(M* = 82.0588, *SD* = 13.49), *t* (16) = 4.887, *p* = .001. Once the p-value is not up to the threshold mark, then it becomes obvious that the durational difference could be upheld. What this means is that the SET vowel was longer than the *A*GO vowel with the difference of 38ms.

Summary of vowel duration in the interview section

1. The length difference between the /i:/ vowel and /ɪ/ vowel was highly significant, indicating that /i:/ was longer than /ɪ/.
2. There was no significant distinction between the /ɜ:/~/e/ vowel pair. The /ɜ:/ vowel used relatively the same duration as /e/ vowel.
3. There was a highly significant length difference between the /ʌ/~/a:/ vowels, suggesting that /a:/ was longer than /ʌ/.
4. The difference between /ɒ/~/ɔ:/ vowel pair was highly significant. The /ɒ/ vowel was shorter than the /ɔ:/ vowel.
5. The length between the vowel pair /ʊ/~/u:/ was significant. The former was shorter than the latter but appeared a little close in duration.
6. The length difference between the vowel pair /ə/~/e/ was highly significant. The /e/ vowel was longer than the vowel /ə/.

Vowel length Comparison in the three contexts

The mean durations of the monophthongs produced by the speakers were compared in relation to the three different environments: citation, sentence and interview section. This comparison was intended to find out whether the

speakers used the same durations in the three contexts in pronouncing the vowels. The results are presented in Table 11 below.

	/i:/	/ɪ/	/e/	/ɜ:/	/æ/	/ʌ/	/a:/	/ɒ/	/ɔ:/	/ʊ/	/u:/	/ə/
Citation	152	115	121	202	111	109	173	122	185	122	162	91
Sentence	124	91	121	118	117	112	191	130	194	97	100	82
Interview	119	93	118	139	127	106	179	117	208	104	125	80

Table 11. The three contextual durations compared

We can infer from Table 11 that the speakers used an overall mean duration of 1554ms to produce all the vowels used for the analysis. We can read from Table 11 that the only vowels that recorded descending duration was the schwa (/ə/) and the /i:/ vowels, in the order of first context (citation), second context (sentence) and the third environment (interview section). For instance, there was a reduction from 152 > 124 > 119 in the production of the /i:/ vowel. Again, the only vowel that saw unexpected invariable increase from the first context to the third context was the /ɔ:/ vowel (185 – 194 - 208). This can be clearly seen from the bar chart (Figure 18) representing the durations used for the various vowels.

The /u:/, /ɪ/, /ɜ:/, and /ʊ/ vowels recorded a common pattern of duration decrease from the first to the second context but there was a rise in duration in the third environment. Surprisingly, the /e/ vowel maintained the same duration (121ms) in the first and second context but reduced (118ms) in the third context. In the production of the /ʌ/ vowel, the second situation recorded the highest duration (112ms) followed by the first (109ms) and lastly the third (106ms). In the case of the /a:/ vowel, the first situation, interestingly, recorded the least duration (173ms) before the third (179ms) and the second (191ms). In the case

of the /ɒ/ vowel, there was durational increase from the first situation (122ms) to the second (130ms) but the third saw the least duration (117ms).

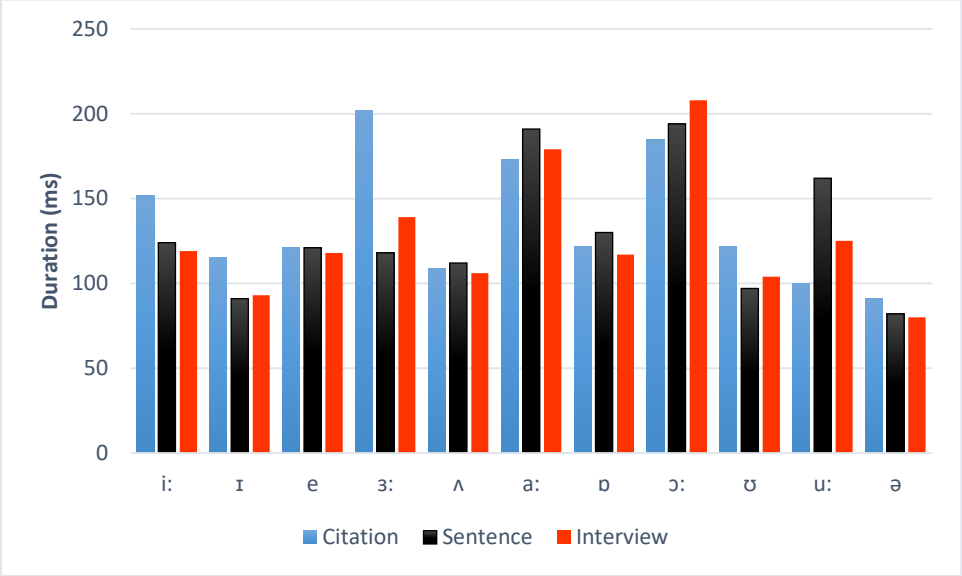

Figure 18. Bar chart comparing the mean durations used in the 3 contexts

Figure 18 shows the bar chart of three colours representing the three contextual durations of the vowels produced by the speakers. It can be seen that the blue bars represent the mean duration used in the production of the vowels in the word list form, the black bars representing the mean durations of the vowels in sentences and the red for the interview context. The height of the various bars clearly demonstrates the length of durations used by the speakers in the three different situations. We can conspicuously observe that the tallest bar in Figure 18 is the red one representing the duration used for the production of vowel /ɔː/ in the interview section, which was closely followed by the blue bar representing the production of /ɜː/ in the word list reading. The varied heights of duration are suggestive that the Ghanaian speakers who were employed as the informants of the study did not exhibit any common pattern of duration in the three different environments of the vowel identification.

Sex variation

Although this study was not primarily targeted to study sex variation in the production of English monophthongal vowels in the Ghanaian setting, the results of the data produced have shown significant sex variations in terms of formant frequencies and duration in almost all the vowels produced. This particular section pays some attention to such variations. This is also chiefly necessitated by Watt & Fabricius' (2002) claim that women speakers mostly exhibit significantly higher F1 and F2 frequency values than male speakers.

Sex formant frequencies

Table 12 displays the results of the F1 and F2 mean values (in Hz) of the monophthongal vowels produced by the male and female speakers in an attempt to explore vowel quality in the study and Figure 19 illustrates the plotting of the vowels in respect of sex. The results indicate that, generally, the females used higher formant frequencies than the males in articulating almost all the vowels. This shows that, in relation to F1 values of the vowels, the tongues of the males were raised closer to the roof of the mouth than the females. This also means that the males' vowels produced were closer to the palate than their females' vowels (see Figure 19). In terms of the F2 values produced, the females, again, showed higher values compared to the male counterparts. This suggests that the front vowels produced by the females were more fronted and looked more peripheral than the males' vowels.

	Females		Males	
	F1	**F2**	F1	F2
i:	357	2562	296	2118
ɪ	473	2390	407	2123
e	598	2062	501	1832
ɜ:	598	2089	506	1898
æ	870	1604	770	1471
ɑ:	823	1504	750	1336
ɒ	677	1123	594	1133
ɔ:	617	1059	559	1099
ʊ	547	1156	489	1198
u:	401	1226	380	1282
ʌ	834	1673	702	1478
ə	549	1848	492	1700

Table 12. Average values of males and females F1/F2 (Hz) in producing the vowels

In relation to the back vowels, the females produced vowels which appeared more back than the male speakers (see Figure 19). Interestingly, the monophthongs plots of both males and females in Figure 19 revealed that there was no discrimination between the /e/ and /ɜ:/ vowels in the words like S*E*T /set/ and TH*IR*TY /θɜ:ti/ respectively.

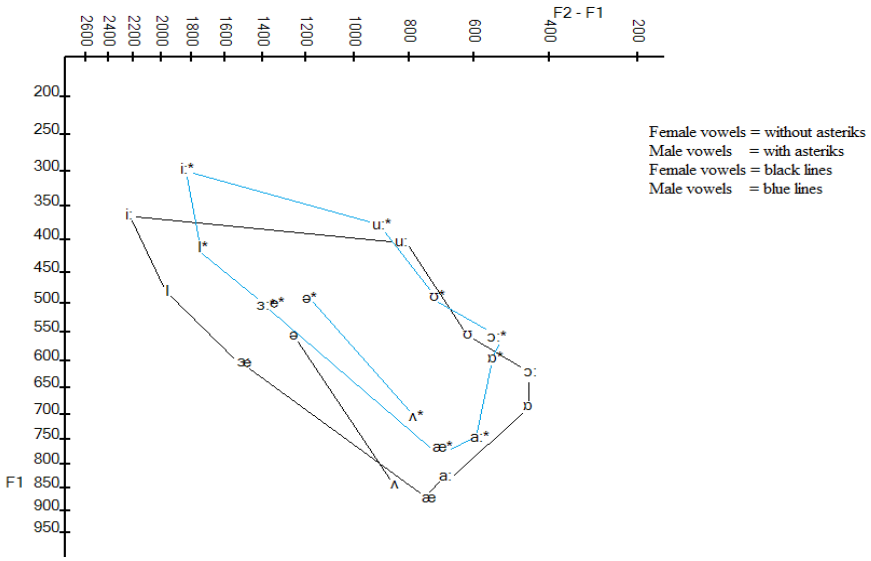

Figure 19. Sex plots of the twelve monophthongal vowels

Sex Duration

Table 13 displays the mean duration used in the production of the English twelve vowels. It can be observed from Table 13 that the females' articulation showed a higher mean duration than the males. It is clear that the longest average duration was 261ms by the females in the production of the /ɔ:/ vowel and the shortest was recorded as 99ms in producing the /ə/ vowel. On the other hand, the males used a mean duration of 240ms in articulating /i:/, which appears the highest duration than the rest of the durations for the other vowels. The closest average durations employed by both females and males were between 128ms and 120ms (difference 8ms) in producing the vowel /ɒ/ respectively. The next closest in duration by both female and male speakers were 130ms~120ms (for /ɪ/) and 99ms~89ms (for /ə/) respectively.

	/i:/ - /ɪ/		**/e/ - /ɜ:/**		**/ʌ/ - /a:/**		**/ɒ/ - /ɔ:/**		**/ʊ/ - /u:/**		**/ə/**
Females	240	130	140	236	151	197	128	261	143	183	99
Males	217	120	115	191	131	168	120	198	115	155	89

Table 13. Durations used by females and males (ms) to produce the monophthongs

Figure 20 is a bar chart displaying the durations in Table 13. The blue bars represent the average time used by the female speakers in articulating the vowels. The males' durations are represented by the red bars. From close observation, it can be seen that, generally, the longest bars are the ones representing the durations used by the females, suggesting that more duration was used in the articulation of such vowels than the males' vowels.

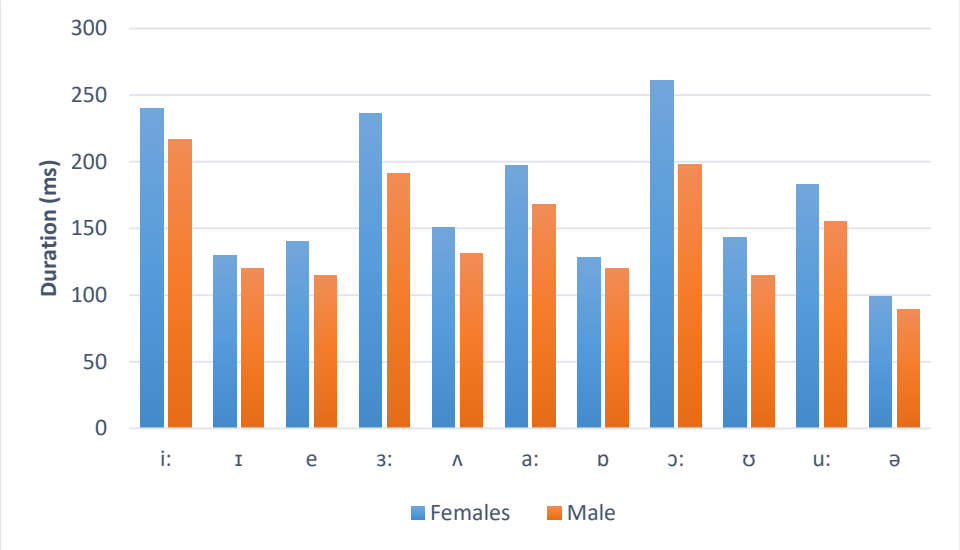

Figure 20. Bar chart for females and males' duration in producing the vowels

It is important to note that the longest blue bar is the one representing /ɔ:/ which is followed by the /i:/ bar (see Figure 20). This means that the females used more duration in producing the /ɔ:/ vowel. Interestingly, the longest red bar, unlike the female bars, is the one for /i:/ followed by the /ɔ:/ bar. This is an indication that the male speakers used the longest duration to articulate the /i:/ vowel than the rest of the vowels, which was also followed by the /ɔ:/ vowel. However, the shortest bars represent the durations used in producing the /ə/ vowel by both males and females and they are followed by the /ɪ/ bars. In general, the female production showed longer duration than that of the males for all the vowels.

Discussion

The main goal of this study was to do an acoustic investigation into the English monophthongal vowels which are articulated by Ghanaian speakers of English. Through the lenses of the Source/Filter theory, which translated into waveform and spectrogram to contain the sound spectral energies, the acoustic cues of the vowels were provided in the form of F1 and F2 for vowel qualities

and duration for vowel length. The acoustic results of the data provided by the subjects in the production of the English vowels seem to point at certain vowels which have been denied or not explored fully in GhE pronunciation studies. For the sole purpose of discussion, Figure 21 has been provided because it has almost always been the case that the results of studies on most African varieties of English have often been traditionally compared with the RP (Mutonya, 2008).

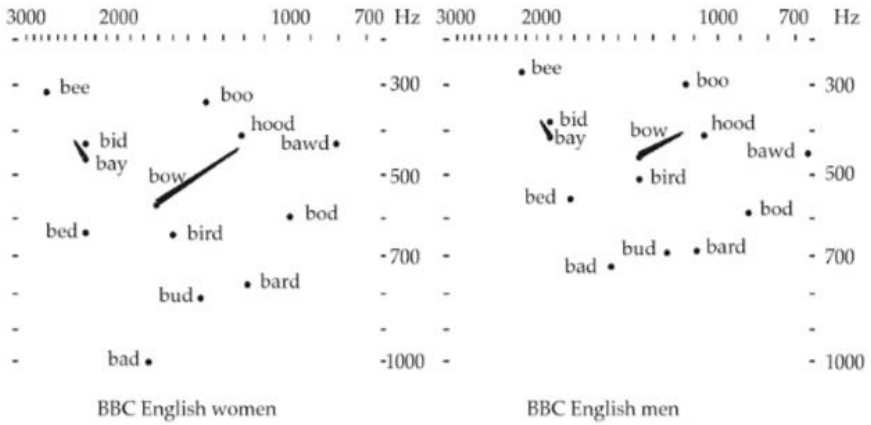

Figure 5.8 Formant charts of BBC (British) English.

Figure 21. Formant plots of BBC vowels (Ladefoged & Disner, 2012, p. 45)

A notion that is noticeably held and maintained by most researchers on GhE vowels is the merging of the /i:/~/ɪ/ vowels to /i:/, except for a few works like Adjaye (2005) and Ofori, Duah and Mintah (2014). The data in this present study have indicated that the lax vowel /ɪ/ is significantly different from the tense vowel /i:/ in all the three contexts used. The results for the two vowels are in line with the general description that the part of the tongue raised is more fronted (with higher F2) in the production of /i:/ vowel than the /ɪ/ vowel (e.g., Cruttenden, 2008; Ladefoged & Disner, 2012). At the same time, the tongue is raised higher and closer to the palate in the /i:/ vowel than the /ɪ/ vowel. In this case, the /i:/ vowel has lower F1 value than the /ɪ/ vowel. Consequently, this

current study, just like Adjaye, tends to suggest that most previous studies on the identification of the /ɪ/ vowel appear to overgeneralise the non-existence of this vowel in GhE. For instance, many scholars (see Bobda, 2000; Huber, 2008; Mutonya, 2008; Sey, 1973) have argued that the /ɪ/ vowel is absent in the spoken English of Ghanaians. However, the data produced by the Ghanaian speakers in this study have given enough evidence that Ghanaians usually realise the articulation of /ɪ/ vowel in words like *hit, bit, sit* or *fit* phonemically, which is independent of the /i:/ vowel in words like *heat, seat, beat* or *feet.* In terms of vowel space, the /i:/ vowel seemed to occupy an area which is closer to the roof of the tongue than the /ɪ/ vowel. Although the two vowels were identified as front vowels, it is also clear that the part of the tongue used in their production appeared more peripheral in vowel /i:/ than the /ɪ/ vowel in all the three contexts.

Apart from four Ghanaian speakers (10%) who pronounced HIT with the /i:/ vowel, the study revealed that 36 speakers, representing 90%, pronounced it as /ɪ/. As already pointed out in the analysis section, the same speakers realised the /ɪ/ vowel in their spontaneous speech. In relation to the use of /i:/ in place of /ɪ/, it might be probably so because it is generally perceived that the phoneme /ɪ/ is not considered as a typical feature of non-native varieties of English, unlike the Inner Circle block (Adjaye, 2005).

It is, therefore, not surprising that researchers who attempt to describe Ghanaian English pronunciations often deny the occurrence of the /ɪ/ vowel because some Ghanaians do not actually discriminate the /i:/ vowel from vowel /ɪ/ in their indigenous languages, for instance Ewe and Ga (see Adjaye, 2005). This might affect their spoken English. It was evident that five percent of the

speakers who read the words in citation form failed to pronounce the vowel /ɪ/, although words containing this sound were included. However, after thorough acoustic, and even auditory, investigation into their spontaneous speech, it was detected that there were many words in which the /ɪ/ vowel was realised by the same speakers. For example, the words *if*, *bit*, *bit*, *this* and *things* were produced with the /ɪ/ sound and not /i:/. This seems to suggest that words that are provided for informants to read are likely to provide partial or unnatural results for researchers and research work, especially in the L2 context. It therefore requires thorough investigations into non-native varieties of English in different vowel contexts because vowel realisations do not occur exactly like the native usage. The duration that was used in the articulation of the /ɪ/ vowel has also distinguished it from the vowel /i:/, with the latter being longer than the former.

This study has so far confirmed the absence of /ɜ:/ in GhE to a very large extent, which is usually argued in the literature (for example, Bobda, 2000; Mutonya, 2008; Sey, 1973). These works argue that the RP vowel /ɜ:/ is always fronted in non-native varieties like GhE. But this vowel is perceived as a central vowel produced with the tongue raised between the position of close-mid and mid (Cruttenden, 2008; Gut, 2008; Ladefoged & Disner, 2012). Cruttenden claims that it has a similar quality with the /ə/ vowel but only differentiated by length. In all the three different contextual realisations of this particular vowel, the data produced by the Ghanaian speakers did not support the existence of the /ɜ:/ vowel because it occurred within the same vowel space of the front vowel /e/. This is an indication that we can reliably confirm that the /e/ vowel is largely realised in GhE. Although there were durational differences exhibited in the first two contexts between the /e/ and /ɜ:/ vowels, the third context failed to

discriminate this vowel from the short vowel /e/. It can, therefore, be concluded that the /ɜ:/ vowel failed to be realised in this study by the speakers in quality and partly in durational too. In this regard, vowel length was not the core element in vowel discrimination by the Ghanaian speakers.

It is also generally held that Ghanaian speakers of English do not realise the /ʌ/ and /æ/ phonemes in their speech (e.g. see Bobda, 2000; Mutonya, 2008; Sey, 1973). It is therefore not surprising that these two phonemes are almost always silent in the discourse of GhE pronunciations. Surprisingly, the acoustic results in this study suggested that this central vowel /ʌ/ existed in the speech provided by the speakers in words like *cup, cut* or *duck.* This is because Cruttenden (2008) indicates that this vowel is articulated with the central part of the tongue; it is also produced just above the fully open position. In all the three contexts used in this study, the results suggested that the /ʌ/ vowel occupied the same vowel (RP vowel 10) space described by Cruttenden (2008) and Ladefoged and Disner (2012) (see Figures 8, 11 and 14), and also similar to the same RP vowel 10 in Figures 2 and 21. It was also found out that it occupied a position which was relatively above the Cardinal vowel /a/--just as described by Cruttenden. Interestingly, the /ʌ/ vowel sometimes interchanged with the vowel /a/ which appeared more central and more open in terms of vowel height than the former. It means that the vowel /æ/ which was supposed to be articulated by the Ghanaian speakers was produced as a more central phoneme in all the three contexts (see Figures 8, 11 and 14) used. Meanwhile, Cruttenden (2008) describes the /æ/ vowel as a front vowel. The results from the production of this particular vowel (/æ/) in this study can therefore be perceived as the Cardinal

vowel /a/ which is usually found in the indigenous languages of Ghana. The /a/ was found to be the most open vowel in all the three contexts.

The replacement of /æ/ by the /a/ vowel by the Ghanaian speakers in this study was possibly due to the absence of the /æ/ in most of the indigenous languages in Ghana. However, it also sounds surprising that the Akan group appears to have similar /æ/ sound in their vowel system; yet it was not realised at all in the data set. It might also be possible that the occurrence of the phoneme /æ/ in Akan language (usually before /u/ and /i/, such as ***a****buro* /æburo/ or *Kw****a****si* /kwæsi/) did not occur exactly in the same environment in the words provided for the speakers to produce. In addition, the replacement of the /æ/ vowel for /a/ is not surprising because it is a phenomenon that seems to be pervasive in most varieties of English, even the native speakers of RP are reported to do the same replacement or movement of /æ/ to /a/ in certain contexts (for instance, see Upton, 2004). It is probably possible that earlier investigations of the /a/ and /æ/ suffered proper scrutiny in situations where acoustic cues of vowel identifications were not the focus of investigation in many varieties of English.

It must also be noted that the data supported the fact that the English tense vowel /a:/ was identified as an independent phoneme from the two vowels immediately mentioned in terms of quality and quantity in words such as *calm* or *car*. It is explained that this long vowel is usually articulated between the central and back parts of the tongue often within a more open space between the tongue and the roof of the mouth (Cruttenden, 2008; Gut, 2009). It must be noted that the closeness between the /ʌ/ and /a:/ vowels in the third context was not all that different from those of RP speakers (see Figure 2 and 21), but the /ʌ/

was above /a:/ in the other two contexts. It must be noted that the tense vowel /a:/ did not occur in all the phonemic environments of words, especially in *car*. It is also not common to find Ghanaian speakers of English producing this tense vowel in its natural English context like *h**ear**t, c**ar**d, p**ar**t, f**a**ther* or *p**ar**k*.

In terms of the English /ɒ/~/ɔ:/ vowel pair, Adjaye (2005) contends that the distinction between these RP vowels does not exist in the indigenous languages of Ghanaians, who have only the /ɔ/ vowel in their indigenous vowel systems. However, in relation to the distinction between the /ɒ/ and the /ɔ:/ vowels, the data of this study supported the existence of these two vowels to some extent. The general description of the two vowels indicates that the tense vowel /ɔ:/ is articulated with the back of the tongue raised between the position of the open-mid and close-mid but the lax vowel /ɒ/ is more open in terms of the space between the tongue and the roof of the mouth (Cruttenden, 2008; Ladefoged & Disner, 2012). But in acoustics, the /ɔ:/ vowel is closer to the palate than the /ɒ/ vowel (Gut, 2009) (see Figure 21). In such instances, the F1 for /ɔ:/ is often lower than that of the /ɒ/ vowel. In terms of their F2 frequencies, the /ɔ:/ vowel has a lower value than the /ɒ/ vowel. This can be compared with the positions occupied by the two vowels in Figure 2 or 21.

In the present study, in an example like *f**au**lty*, the /ɔ:/ vowel was realised by the speakers in all the three contexts but was partially realised in the word *saw,* which was at a point replaced with the short vowel /ɒ/. Although durational variation existed between the two vowels, the most important element that distinguished them was the quality. In terms of vowel quality based on the formant frequencies, the /ɔ:/ vowel was identified as the most back vowel (with the lowest F2 values) in all the three different contexts. The realisation of

this long vowel in this study appears to contradict most studies in the literature, and even common observation, as pointed out in GhE pronunciations and other non-native Englishes around the globe (for example, see Bobda, 2000; Huber, 2008; Mutonya, 2008; Ofori, Duah & Mintah, 2014; Sey, 1973). However, it must be noted that since the long vowel /ɔ:/ could not be fully supported by the data of this study in different contexts like *saw* and *forty*, this study tends to suggest that its occurrence in GhE seems limited and that it could not be fully relied on as a common vowel. In short, its occurrence could be described as occasional. It means that most Ghanaian speakers of English might not realise the occurrence of the /ɔ:/ vowels in words such as *talk*, *sports* or *short*. It could be attributed to the fact that such long vowels do not exist in the local linguistic forms of the local speech communities in Ghana. It could also be that the difference between short and long vowels could not be transported well to non-native geographical spaces like Ghana.

Again, this study has revealed a finding about the /ʊ/ vowel which appears to partly confirm and, at the same time, to a very large extent, contradicts previous studies' claim about its existence in GhE. Many works that have described GhE pronunciations (for example, Bobda, 2000; Huber, 2008; Ofori, Duah & Mintah, 2014; Sey, 1973) have carried along the notion that the /ʊ/ vowel is not produced by Ghanaian speakers at all, although this vowel can be found in the vowel system of Akan, one of the major indigenous languages in Ghana. Contrary to what is in the literature, this study has indicated that all the speakers in all the three contexts invariably made a highly significant distinction between the articulation of /ʊ/ and /u:/ vowels in words like F*OO*T and H*OO*T respectively. However, it must be mentioned that in a word like FOOD, the /ʊ/

and /u:/ vowels were interchanged by the speakers. While 55% of the speakers used vowel /u:/ in the production of the vowel in FOOD, 45% used vowel /ʊ/ and pronounced it as /fʊd/ instead of the RP /fu:d/. In terms of vowel quality on the plane, the /u:/ vowel mostly occurred relatively closer to the palate in all the three contexts than the /ʊ/ phoneme, which is relatively similar to the positions occupied by these two vowels in Figure 21. It was also detected that the part of the tongue for the two back vowels was not static. In the first situation, the /u:/ phoneme was closer to the palate and relatively central than the /ʊ/ vowel. But the former also became more peripheral than the latter in the second context. However, the two of them, in the third context, appeared to be produced almost with the same part of the tongue. These descriptions affirm Cruttenden's (2008, p. 127) assertion that the /u:/ vowel occurs "with varying degrees of centralisation". But the most important issue is that the two vowels were clearly articulated contrastively.

It was also interesting to note that the word HOOD usually pronounced as /hʊd/ was articulated as /u:/ (/hu:d/) by all the Ghanaian speakers in this study. In the same way, Ghanaian speakers of English generally use /u:/ vowel in words such *as wood, good, book, cook, pull, full* and *bush* instead of the /ʊ/ vowel. This merging of /u:/~/ʊ/ to /u:/ has always been the phenomenon that is expressed by most researchers who are interested in studying Ghanaian English vowels and in such cases overgeneralisation exists, especially when it comes to words like *f**oo**t*, *opport**u**nity*, *caref**u**l*, *awf**u**l*, *wonderf**u**l* and *event**u**ally*. Even with impressionistic approach, it would be difficult for a researcher to convince readers that these identified words are usually articulated with the /u:/ vowel instead of the /ʊ/ vowel.

Another interesting finding about this present study is about the realisation of the schwa vowel. The data for this study partly supported the realisation of the /ə/ vowel by the Ghanaian speakers of English. Most of the speakers realised the schwa vowel as the initial vowel in *ago* and *again*, in terms of its quality (F1/F2) and length (quantity) in all the three contexts. In terms of figures to describe the quality of the schwa, Cruttenden (2008) argues that the phonetic environment causes great variation and sometimes equates it to the values of the central vowel /ɜ:/. Moreover, the schwa vowel (65%) was interchanged with vowel /e/ (35%), which is also sustained partially by some works (for example, Bobda, 2000) which arguably stress that the /ə/ vowel is generally rendered /a/ or /e/. But then, this study seems to confirm the finding revealed by Adjaye (2005) that some Ghanaian speakers use the /ə/ vowel while others prefer the /a, ɔ, ɛ/ vowels in place of the /ə/ vowels in words.

Again, the features of the schwa vowel in this study conform to Berreta's (2003) assertion that this vowel exhibits different acoustic properties of vowel reduction, i.e., the unstressed vowel is characterised by reduced acoustic energy with decreased duration. This study found out that, in words like *again* and *ago*, the vowel in the second syllable in each case carried relatively higher pitch and intensity than the first syllables in all the three contexts. It was also revealed that the schwa vowel recorded the shortest duration (length) in all the three contexts. It is, therefore, clear that the data supported the existence of the schwa vowel.

The findings about the Ghanaians' realisation of the schwa in this study appear to largely contradict many works in the literature (for example see Bobda, 2000; Huber, 2008; Lomotey, 2010; Mutonya, 2008; Ofori, Duah &

Mintah, 2014, Sey, 1973). The most important of them is Lomotey's (2010) acoustic study which was chiefly devoted to the search of the realisation of the schwa vowel in the initial, middle and final positions in GhE pronunciation. Lomotey acknowledges in her work that the schwa vowel, surprisingly, occurs as part of the vowel system of some indigenous languages in Ghana, for example, Ewe and Dagbani; yet it was not found to exist in the data provided for her work. It means that almost all the works that have described English vowels produced by Ghanaian speakers of English seem to have denied the existence of this vowel.

On the question of English vowel length discrimination in the context of Ghana, in almost all the three contexts which were used to measure vowel length, the data results indicated that there were variations between the vowel pairs. But the issue of vowel length seems not to be a major issue when discussing the variety of English used in Ghana because all the data produced by the speakers in this study largely discriminated between tense and lax vowels but did not directly support the vowel quality. For example, there was a length distinction between the /e/ and /ɜ:/ vowels but there was no contrast in terms of vowel quality. It is also possible to argue, in line with Bobda's (2000) idea that vowel length is not a phonologically marked feature of the Ghanaian indigenous languages. This also seems to confirm Skandera and Burleigh's (2005) observation that vowel contrast is not just brought about by length but what is more crucial is the quality. It must, however, be noted that the duration used in the three contexts did not show any regular pattern of time reduction from citation form to the spontaneous speech. There were instances where some vowels in spontaneous speech were longer than in the word list form. This

might be due to the fact that speakers are likely to produce words in citation slower than in continuous speech.

A general observation made in the course of the analysis was about the kind of variation that existed between males and females, in relation to the formant frequencies and length of the vowels. It was commonly observed that the females produced the monophthongs with higher formant frequencies than the males. What it means is that the vowels of the females appeared more peripheral and open from the roof of the mouth than those of the males. This corroborates general observation that women usually employ, relatively, higher F1/F2 values than male speakers (Cruttenden, 2008; Watt & Fabricius, 2002). In terms of how long the vowels lasted in their production, the females generally showed longer duration than the male speakers. However, what is important is that these differences convey the same information, and that there is no significant effect on the results (Ladefoged & Disner, 2012).

In all, it has so far been seen that almost all the vowels produced by the Ghanaian speakers for this study (as demonstrated in Figure 22) appear on the quadrilateral like the ones provided in Cruttenden (2008) and Ladefoged and Disner, 2012) on RP vowels (see Figures 2 and 21). It must also be pointed out that the English vowels /ɪ, aː, ɔː, ʊ, ʌ, ə/ which appeared absent in many studies that have described GhE, have been reported by the present study to exist, to some extent. The changes and the findings of this study might have been caused by varied factors.

Firstly, one should not lose sight of the fact that the teaching of English pronunciations seems to have improved in recent times following the training of

more experts from higher institutions to teach in the Ghanaian schools, as well as the inception of the oral English examination. This probably confirms Boadi's (1971) assertion that the English language learning recently has gained favourable conditions than before. It means that non-native speakers either consciously or unconsciously get the space to acquire some of the right sounds of the RP. This apart, it can be said that users of English in Ghana have become more conscious of the RP vowels pronunciations in recent times—possibly contributing to a paradigm shift in pronunciation. The changes can also be attributed to the fact that most Ghanaians desirably acquire higher degrees oversees nowadays, particularly in native speakers' environment to improve teaching and research in Ghana. Their speech might be influenced by the native speakers' pronunciations, although most of them still maintain their "Ghanaianness". The changes can also be seen from the perspective of current trend of modernisation in the midst of heavy inflow of trade, migration, technology, entertainment and exchange programmes. This last cause of change of pronunciation might have been predicted by Spencer (1971). To Spencer, these pressures constantly modify the sociolinguistic patterns of the users of the English language.

Chapter Summary

This section provides the summary of Chapter 4, by looking at the results derived from the acoustic analysis of the data in relation to all the three contexts employed in this study to test for vowel quality and length in GhE:

1. There was a significant F1/F2 distinction between the /i:/~/ɪ/ vowels. The /i:/ vowel looked more peripheral and closer to the palate by

carrying lower F1 and higher F2 than the /ɪ/ vowel in all the three contexts. The /i:/ vowel was significantly longer than the vowel /ɪ/.

2. There was no distinction between the central vowel /ɜ:/ and the front vowel /e/ in terms of F1/F2 in all the instances. In terms of length, the /ɜ:/ was significantly different from the /e/ in the first two contexts.
3. The F1/F2 distinguished the vowel /a/ from the vowel /a:/ in all the three contexts. Basically, the /a:/ vowel looked more back than the /a/ and /ʌ/ vowels in all the three contexts, but was second open vowel after vowel /a/. The /a:/ was longer than the /a/ and /ʌ/ in all the contexts.
4. The central vowel /ʌ/ was distinct from the vowels /a/ and /a:/ in all the three contexts. The /ʌ/ vowel generally appeared more central and slightly above the /a:/ and /a/ vowels.
5. The vowel /ɒ/ was produced differently from the vowel /ɔ:/ in all the three situations, in spite of limited realisation of the /ɔ:/. The /ɔ:/ vowel looked more peripheral with lower F1/F2 frequencies than the vowel /ɒ/ and was longer than the /ɒ/.
6. There was a significant contrast between the /ʊ/~/u:/ vowels in all the three situations. Vowel /u:/ looked closer to the palate with lower F1 than vowel /ʊ/. But there were varying degrees of back position with varying F2 frequencies for both vowels. The /ʊ/ became significantly different from the /u:/ vowel in duration only in the first context.
7. The /ə/ vowel was distinguished from the vowel /e/. It was also distinguished as the most reduced vowel in terms of decreased acoustic energy and duration used.

The results from this study have proved that the GhE vowels are likely to be more than what has been identified by Huber (2008) and Mutonya (2008) (as a five-vowel system) and similar other works. It is important to note that the results of this study have demonstrated that the three contexts which were used for studying the English monophthongs in GhE have shown almost the same vowels.

Using the acoustic approach, this study came out with eleven vowels: /i:, ɪ, e, a, a:, ɒ, ɔ:, ʊ, u: ʌ, ə/. These vowels possibly suggest that they recur in GhE. However, it is crucial to note that eight of them /i:, ɪ, e, a, ɒ, ʊ, u:, ʌ/ pervasively occurred in almost all the words used in the elicitation of the twelve English vowels. Some of such words include *heed, head, hit, hot, foot, duck, hoot* and *heat*. The other three vowels /a:, ɔ:, ə/ occurred in the data, but their occurrence ranged between 53% - 65%. It means that the three occasionally recur in GhE, and they need further study and confirmation. The words which carried such vowels in this study include *calm, saw, faulty, hat, ago, again* and *sat.* Consequently, this study proposes the vowel chart or plot (Figure 22) below based on the eleven vowels from the results of the acoustic measurements of the three different phonemic contexts provided for this study. This finding could probably serve as a model chart for considering codifying Ghanaian English pronunciations for future pedagogical purposes, in place of the RP. It would also be useful to call on works that have used auditory approach to describe the English spoken in Ghana to consider re-investigation of these vowels through acoustic means to verify their results.

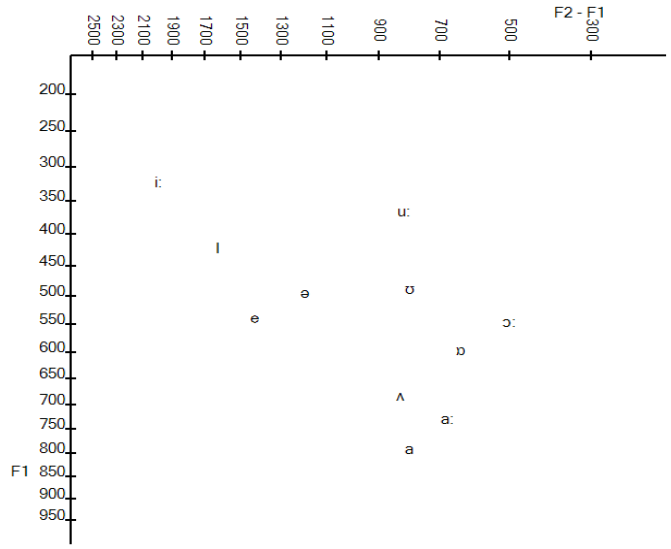

Figure 22. Proposed vowel plot of the study based on the speakers' results

CHAPTER FIVE

SUMMARY, CONCLUSION, AND RECOMMENDATIONS

Introduction

This is the final chapter of the thesis and it gives the general overview of the entire study by looking at the summary of the main findings, conclusion, recommendations and implications. The chapter specifically starts with the recap of the aims, research questions, methods, and the kind of approaches adopted in the study, which are followed by the key findings derived from the study. It then proceeds to talk about the conclusions, recommendations, implications and suggestions for further research.

Overview of the purpose, research questions and methods

The purpose of this thesis was to instrumentally investigate GhE pronunciations. Specifically, the study aimed at identifying the kind of monophthongal vowels articulated by educated Ghanaians in their spoken English in order to establish the pure vowel inventory for GhE. The study was interested in vowel quality and length by looking at vowel formant frequencies (F1/F2) and durations used by the speakers. These acoustic cues were identified through the lenses of the Source/Filter theory. This theory gives the framework within which sound spectral energies were contained to identify the quality of vowels and their respective length. The study was therefore guided by three basic research questions: (1) Which English monophthongal vowels are produced by Ghanaian speakers? (2) What are the acoustic characteristics of the English monophthongs articulated by Ghanaian speakers? (3) To what extent do GhE monophthongal vowels exhibit length contrast between vowel pairs?

In order to achieve these, the pragmatic research design was adopted to thoroughly assess the distinctiveness of the vowels produced by the Ghanaian speakers of English. The pragmatic approach constituted the mixed method approach which combined both the quantitative and qualitative approaches to the study. The quantitative method looked at the statistical aspect of the work while the qualitative approach took care of the descriptive aspect of the study and the mode of participants' selection, as well as the data collection approach.

Summary of Key Findings

This study has so far attempted to instrumentally investigate the pure vowels of GhE. The study came out with the following findings which are presented according to the research questions formulated to guide the study.

Research question one: Which English monophthongal vowels are produced by Ghanaian speakers? The purpose of this research question was to find out the kind of monophthongs articulated by Ghanaian speakers of English. Three different contexts were used (citation, sentence and interview section). The acoustic analysis gave the following results that:

1. There was a clear F1/F2 distinction between the /i:/~/ɪ/ vowels.
2. The F1/F2 did not distinguish the central vowel /ɜ:/ from the front vowel /e/, but was fronted to the /e/ vowel space in all the instances.
3. The F1/F2 distinguished the vowel /a/ from the vowel /a:/ in all the three contexts, although /a:/ was not regular in occurrence.
4. The central vowel /ʌ/ was distinct from the two vowels /a/ and /a:/ in all the three contexts.

5. The lax vowel /ɒ/ was produced distinctively from the tense vowel /ɔ:/ in all the three situations although /ɔ:/ was not regular in occurrence.
6. There was a clear discrimination between the lax vowel /ʊ/ and the tense vowel /u:/ in all the three situations.
7. The /ə/ vowel was distinguished from the other vowels like /e/ or /ɜ:/.

Research question two: What are the acoustic characteristics of the English monophthongal vowels articulated by Ghanaian speakers? The main purpose of this question was to identify basic acoustic features of the monophthongs produced by Ghanaian speakers of English. The results are summarised below:

1. The /i:/ vowel looked more peripheral and closer to the palate by carrying lower F1 and higher F2 than the /ɪ/ vowel in all the three contexts.
2. Both F1/F2 for the two vowels /e/~/ɜ/ were classified the same as front vowels because they did not show any contrast in all the three contexts.
3. Generally, the /a:/ vowel looked more back than the /a/ and /ʌ/ vowels in all the three contexts, but was basically the second open vowel after vowel /a/.
4. The /ʌ/ vowel generally appeared more central and slightly above the /a:/ and /a/ vowels.
5. The tense vowel /ɔ:/ appeared more peripheral with lower F1/F2 frequencies than the lax vowel /ɒ/.
6. The tense vowel /u:/ looked closer to the palate with lower F1 than the lax vowel /ʊ/. But there were varying degrees of back position with varying F2 frequencies for both vowels.

7. The /ə/ vowel was distinguished as a reduced vowel in terms of reduction in acoustic energy and length.

Research question three: To what extent do GhE monophthongal vowels exhibit length contrast between vowel pairs? The main focus of this question was to look at how Ghanaian speakers discriminate between English tense and lax vowels in terms of length. The following provides the summary of the acoustic data results:

1. The /i:/ vowel was significantly longer than the /ɪ/ in all respects.
2. The vowel /ɜ:/ became relatively longer in the word list form and the second context, but the third did not record any length variation.
3. The /a:/ vowel was longer than the /a/ and the /ʌ/ vowel in all situations.
4. The /ɔ:/ vowel was significantly longer than the /ɒ/ vowel in all respects.
5. The length situation between the /u:/~/ʊ/ vowels was a matter of context. The former was significantly longer than the latter in the first context, but became close in the third context. However, there was no length contrast in the second context.
6. The /ə/ vowel remained the shortest vowel in all the contexts used.

Conclusion

The main focus of this study was to acoustically investigate the pronunciation of English pure vowels in Ghana. Since many post-colonial African nations, like Ghana, have given a special place to English language as an official language (Mutonya, 2008), it is also prudent that studies are done to find out how the language is spoken in such environments. Luckily, previous studies have made some effort to describe Ghanaian English pronunciations but

seem to have concentrated on the non-existence of particular Standard English vowels mostly from the impressionistic perspective. So far, the present study has chiefly explored the data produced by the 40 Ghanaian speakers in relation to formant frequencies (F1/F2) and length in the determination to identify the quality of English vowels used in the Ghanaian setting.

The study has phonetically revealed that the eleven vowels /iː, ɪ, e, a, aː ɒ, ɔː, ʊ, uː ʌ, ə/ were articulated by the Ghanaian speakers, with eight regular (/iː, ɪ, e, a, ɒ, ʊ, uː ʌ/) vowels and three (/aː, ɔː, ə/) occasional ones. The results agree with Mutonya's (2008) assertion that tense and lax vowels exist in GhE, but contradicts many other works (see Bobda, 2000; Huber, 2008; Ofori, Duah & Mintah, 2014, Sey, 1973) on GhE. It is also crucial to accept Harrington's (2010, p. 87) view that "tense vowels generally occupy position in the F1/F2 space that are more peripheral, i.e., further away from the centre than lax vowels." It must be added that some of these vowels did not occur in certain expected phonemic contexts. The results of the present study suggest that most previous studies might have tried to overgeneralise and oversimplify such findings. The study has so far demonstrated and confirmed the notion that the actual nature of a vowel is usually embedded in its quality and not the duration distinctions (e.g., Harrington, 2010; Ladefoged and Disner, 2012; Skandera & Burleigh, 2005). This idea does not fully support the other views that follow the argument that English vowels use length dimension to differentiate themselves (for example, Klatt, 1976, Ladefoged & Maddieson, 1990; Lindau, 1975) in GhE.

It was also detected by this study that the females generally used higher formant frequencies and durations more than their male counterparts. However,

Ladefoged and Disner (2012) argue that the most crucial thing is that these differences convey the same information. Finally, this work has, therefore, demonstrated that if non-native varieties of English are studied in the same way native varieties are studied then there are likely to be gross oversimplification and overgeneralisations of outcomes. I believe that research into phonemic inventory of non-native varieties of English could be aimed at thorough exploration of what exists in such varieties. This is because words that are commonly used for the elicitation of English vowels in non-native contexts are sometimes articulated with different vowels. For example, research in native speakers English has pervasively featured words like *hood* /hʊd/ (for instance, see Hillenbrand et al., 1995; Maryam, 2015; Watson et al., 1998; Wells, 1982) but most non-native speakers, like Ghanaians, are likely to articulate the /ʊ/ vowel as /u:/, as shown in this current study. At least, the data of this study has indicated that the /ʊ/ vowel could exist in GhE but not like all the contexts of words containing /ʊ/ in native speaker's English, like *put*, *good*, *book* or *look*. By impressionistic approach, one could argue that the suffix *–ful* are commonly produced with the /ʊ/ vowel by most Ghanaian speakers of English. That is why it will be useful to look closely into the kind of English spoken by Ghanaians.

Recommendations

Based on certain observations made in the course of the analysis and the findings of this work, the study makes some significant recommendations for further study. The first of these is that further study should be conducted, paying attention to vowel duration and length in the spoken English of Ghanaians. Detailed attention to the Ghanaian vowel contrasts would be useful to talk about how the same vowel behaves in both phonetic and phonemic contexts.

The study again recommends further acoustic investigation into long vowels produced by Ghanaian speakers of English to confirm the results of this work. This should also be necessitated by the fact that some of the long vowels detected by this study were not exactly realised as they normally occur in their expected environments of typical RP vowels. In addition to this, most works, including few acoustic studies, have denied the existence of any long vowel in Ghanaian English except this particular present study and partly Adjaye (2005). It is only by further study that the present results can stand the test of proper scrutiny which would be very crucial for the codification of Ghanaian English.

It is also recommended that a further study be conducted into different realisations of the schwa vowel in Ghanaian spoken English. The current study only identified the *a* at the initial position of disyllabic words as the schwa vowel in the data produced by the Ghanaian speakers; and even its occurrence was not evenly realised or distributed in terms of vowel quality. Further study can pay attention to different positions of the schwa vowel in order to ascertain its realisation in Ghanaian English.

It will be interesting to do further study into the pronunciations of educated Ghanaian English continuum. This is to say that educated Ghanaian English has been defined by some scholars (for example Boadi, 1971; Sey, 1973) as any Ghanaian who has attained some level of elementary education up to the tertiary level. Consequently, it will therefore be interesting to study basic education English pronunciations, second cycle English pronunciations and tertiary education English pronunciations in order to compare at these levels.

Implications of the study

The findings of this study have some contributions to make to scholarship in terms of research, theory and pedagogy. In relation to research, this work contributes dialogically to the body of knowledge which contend in favour of the existence of Ghanaian English. The results of this study have indicated, of course, that Ghanaian English does show certain distinct features which are typically Ghanaian than the English produced by the native speakers. This is an indication that Ghanaians have a claim to a variety of English they speak and can talk about its resources. It is also crucial to note that this work serves as an empirical study and reference work to researchers interested in Ghanaian English studies.

In terms of its implication to theory, this study has made an attempt to put the phonological source/filter theory to test. This phonological theory served as the main lens through which the pure vowels were identified in relation to the acoustic cues and energies deposited in the vocal tracts which were captured on spectrograms and waveform. It means that the vocal tract and the resonators tend to shape and modify the airstream from the lungs in the production of speech sounds. The results of this study, compared with the vowel quadrilateral based on RP male and female speakers (taken from Cruttenden, 2008, p. 103), is an indication that the source/filter theory is a useful theory in doing acoustic phonetics. Another important theory that has been tested in this study is the Unified Classification of World Englishes model propounded by Owusu-Ansah et al, (2016). This study seems to be one of the first works to employ this new model to classify GhE in the context of Post-Colonial Speakers of English. After the publication of this thesis, readers and researchers interested in post-

colonial Englishes would find it useful to scrutinise the new model used in this study in order to make it stand the test of time and proper scrutiny.

Lastly, the findings of this study also have implication for codification of Ghanaian English and pedagogy in Ghana. The government of Ghana and the Ministry of Education might see the findings of this study very useful to make some significant reforms on the kind of English spoken in Ghana for its usage in the classroom, instead of using the RP as the norm. This is due to the fact that non-native varieties such as GhE have almost always dwelt on the RP vowels as the norm in education—education appears to be the main channel through which the majority of Ghanaians acquire the kind of English they speak in Ghana. The contributions from this study will, therefore, be relevant in a number of areas to improve academic literacy and communication in Ghana.

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APPENDICES

APPENDIX A**:** STIMULI

The stimuli used in the three contexts:

Citation

Hid	Hot	Hard
Fit	Shot	Hoot
Set	Ago	Heed
Car	Again	Heat
Cup	Hat	Hod
Duck	Sat	Salt
Sit	Thirty	Hurt
Food	Heard	Het
Foot	Firmly	Said
Seed	Hit	Calm
Had	Seat	Sword
Forty	Head	Hood
Saw	Shoe	

Sentences

1. I said you need a cup of hot tea.
2. Don’t put more salt in the food.
3. I have a set of calm colours.

4. He held the sword in his car.
5. You are not fit to sit on the seat.
6. Forty percent of the work was faulty.
7. I saw 30 ducks again.
8. The shoe was bigger than your foot.
9. Thirty years ago, I sat under this tree.
10. Our firm has shot down the proposal.
11. We need forty men who have luck.
12. I watch football all the time.
13. He firmly held her hand to hurt her.
14. The teacher heard the voice of his daughter.
15. She cut the cord at the hospital and placed her in a cot.
16. There is heat in the seed officer's room.

Interview section

The speakers were asked to use the following words freely. The words here were central to the study but other words realised in their speech were equally used for the analysis. The words were haphazardly given to the speakers to use.

Heat	Sit	Set
Seat	Hit	Head
Thirty	Ducks	Hat
Calm	Cup	Forty
Car	Sat	Saw

Faulty

Shot

Hot

Foot

Food

Hood

Again

APPENDIX B: EXTRACTED F1/F2 AND DURATIONAL VALUES

Some selected samples of the extracted values for F1 and F2 (from the word list)

heed F1	hit F1	heed F2	hit F2	hot F1	saw F1	hot F2	saw F2	foot F1	hood F1	foot F2	hood F2	calm F1	duck F1	calm F2	duck F2	head F1	thirty F1	head F2	thirty F2	ago F1	ago F2	had F1	had F2
289	457	2496	2127	629	618	1000	978	569	401	1042	1238	862	790	1528	1615	608	576	1634	2181	587	1519	864	1641
398	572	2676	2342	741	673	1331	1128	647	372	1362	1093	787	768	1465	1585	606	638	2106	2021	665	1848	853	1684
347	523	2771	2362	671	608	1078	1035	536	311	1119	1184	877	736	1376	1611	593	600	2086	2309	591	1806	875	1609
360	502	2434	2000	786	635	1144	1035	543	358	892	1579	788	669	1554	1629	590	632	2207	2049	529	1745	911	1624
267	527	2720	2280	681	553	1085	1047	565	331	1037	1177	916	676	1549	1753	456	754	2072	2039	466	1504	1005	1669
385	454	2401	2100	708	596	1014	976	495	309	1085	1256	777	632	1641	1601	522	575	1885	2053	560	1847	851	1781
388	450	2419	2292	653	603	1224	1037	550	549	1258	1353	923	676	1520	1514	539	568	2026	2556	553	1122	929	1580
286	459	2682	1912	657	584	1216	1224	580	310	1359	928	730	703	1423	1513	382	552	1874	1659	517	1290	853	1579
265	439	2522	2038	610	541	1152	1070	563	384	1025	1106	887	586	1546	1383	577	533	1782	2173	473	1806	849	1674
302	355	2500	2266	635	588	1041	1031	418	403	1386	1385	683	815	1433	1537	480	554	1928	1846	603	1448	717	1350
255	420	2301	2204	725	528	1204	700	461	426	1107	1009	719	742	1303	1539	485	492	1837	1764	663	1577	658	1340
271	445	2025	1895	585	556	1027	986	547	391	1169	1140	754	777	1371	1379	596	529	1932	1804	586	1856	743	1440
300	365	1991	2061	551	553	1106	953	414	339	1144	1363	706	768	1351	1544	499	476	1743	1777	515	1618	663	1318
273	356	2205	2093	520	548	1143	841	576	445	1654	1308	649	683	1181	1149	630	387	1944	1935	609	1516	757	1471
307	448	2408	1915	618	567	1105	1036	570	473	1332	1039	748	632	1300	1233	595	469	1907	1840	454	1782	775	1342
310	371	1932	2287	576	502	1020	967	487	404	1088	1020	669	722	1440	1526	507	504	2065	1988	614	1536	767	1401
318	440	2352	2240	555	573	1091	1227	438	302	1038	900	638	684	1406	1413	512	489	1965	1685	492	1733	670	1363
287	348	2409	2367	666	660	1125	1030	426	388	979	1601	734	745	1199	1571	507	606	1788	1852	577	1419	736	1459
370	429	2188	2173	626	568	987	840	553	306	1691	1257	745	640	1383	1559	669	498	2045	1849	509	1451	706	1261
269	356	2029	1752	700	605	1397	1032	497	317	1032	1416	673	793	1500	1544	608	563	2002	2014	462	1475	862	1348
362	465	2159	2124	637	511	1108	1148	397	335	1369	1251	901	664	1362	1421	592	555	2018	1936	456	1531	756	1424
292	386	2150	2278	523	592	1014	1044	339	339	1535	1757	608	558	1360	1634	486	446	1745	1879	596	1666	672	1432
252	485	2037	1806	519	581	1063	1231	428	494	1170	1080	654	621	1444	1458	569	537	1986	1923	557	1733	722	1538
308	413	2324	2230	546	675	1545	1089	545	305	1624	1328	729	768	1423	1463	463	449	2042	1899	569	1919	672	1447
346	406	2135	2075	501	675	1035	1376	350	275	1047	993	625	706	1398	1434	585	630	1772	2005	565	1776	881	1524
285	446	2175	2381	672	496	1188	853	574	363	1116	1486	875	602	1419	1627	592	508	1776	1753	499	1392	734	1533
302	376	2092	2266	593	622	1172	980	487	310	1319	1470	798	659	1303	1713	567	446	2028	1947			647	1352
279	428	2053	2106	630	615	1029	1150	577	267	1126	1395	644	714	1426	1368	501	418	1822	1886			779	1611
309	362	2221	2091	547	586	1329	1304	540	335	988	985	684		1529		509	441	2008	1696			709	1534
322	337	2525	2187	611	588	1108	1040	530	331	1080	1053	796		1527		544	580	1766	1708			825	1319
253	388	2305	2308	574	470	1150	1011	498		832		741		1355		444	554	1966	2147			756	1303
304	461	2049	2081	545	515	1468	1142	468		1479		736		1502		570	515	1942	1996			708	1798
278	374	1988	2106	643	531	1397	912	560		1225		634		1580		463	510	1957	1987			689	1444
259	463	2030	1987	626	493	916	971	514		936		618		1566		510	517	1993	1820			827	1669
295	433	2096	1930	583	504	1082	1070	492		1088		789		1456			586		2177			794	1348
	366		1931	553	697	1011	1142	497		1182		664		1270			560		1933			734	1462
	385		1973	604	576	1407	973	562		1499		786		1365			530		1990			738	1465
				599	453	1068	1111	553		1055		614		1128			521		2016			649	1289
				650	432	1382	897	434		850		803		1254			414		1796			763	1493
				554	498	1099	1087	440		1039		784		1182			458		1944			809	1525

Durations (ms)

heat	hit	head	set	thirty	hat	had	calm	hot	forty	foot	hoot	ago	cup
196	148	239	185	261	192	193	172	170	261	199	216	122	147
133	63	208	100	207	132	146	224	81	208	98	145	72	83
168	122	184	110	194	142	144	224	139	195	139	186	110	113
231	212	313	156	295	196	271	181	126	298	244	249	94	141
266	176	278	179	319	221	228	253	197	267	209	233	116	145
179	137	233	144	203	135	217	192	118	182	122	141	80	128
133	111	165	128	180	96	150	138	114	230	142	144	102	101
133	100	208	144	231	89	89	151	109	209	89	149	62	90
148	123	131	137	250	106	136	157	109	256	106	157	136	98
154	107	162	113	219	121	126	177	117	166	85	163	68	108
171	66	145	88	172	101	101	114	67	153	140	212	81	69
116	88	231	83	207	133	150	191	135	183	114	71	95	103
153	99	221	89	231	217	208	201	176	180	148	193	107	126
162	86	177	108	156	108	181	172	98	189	84	134	62	151
123	64	210	98	219	150	220	177	130	194	156	76	114	116
133	75	241	123	215	126	162	157	117	124	113	151	112	74
174	92	148	133	171	100	66	119	94	188	70	186	197	78
137	135	186	105	187	86	116	163	79	184	90	173	72	114
85	117	188	120	268	136	195	228	117	128	145	149	90	106
166	128	221	137	187	122	206	204	115	204	111	145	80	116
140	142	208	152	234	147	174	162	152	140	100	161	130	110
202	114	200	137	214	166	158	130	128	149	109	188	70	89
172	136	150	107	133	102	117	124	121	201	97	139	52	115
137	110	171	97	191	133	173	151	129	192	111	126	116	74
142	82	189	114	179	137	185	159	142	190	107	125	57	100
117	108	165	120	209	96	143	174	95	177	97	185	70	90
139	157	135	123	194	110	162	155	105	134	91	197	64	102
130	100	184	118	158	109	133	157	98	148	111	151	68	124
151	133	164	102	184	119	156	160	124	122	126	254	85	127
137	142	190	133	230	152	206	188	149	245	138	124	68	96
144	142	224	121	223	138	191	214	179	214	178	113	91	147
123	91	171	131	192	149	162	181	133	194	114	199	110	85
163	70	198	94	197	152	235	179	147	156	117	184	87	113
212	145	206	95	177	96	158	164	103	126	103	104	80	101
134	139	170	111	168	124	140	180	100	157	99	172	92	97
99	62	184	181	157	115	170	151	142	191	139	147	116	113
155	150	188	118	150	81	142	147	120	139	136	134	78	81
175	123	143	139	115	145	171	218	84	223	70		65	158
88	71	144	65	235	84	107	172	109	136	125		97	106
174		156	112	185	125	128	145	112	173	117			

APPENDIX C: META-DATA OF THE PARTICIPANTS

The information below contains the background of the participants in the study.

Speaker	Sex	Age	Qualification	*Years	Native language
Asante					
1	F	25	B. A	2	Twi
2	F	26	B.sc	2	Twi
3	M	35	B. ED	1	Twi
4	M	42	BA	5	Twi
5	M	46	B. ED	7	Twi
6	M	51	B. ED	6	Twi
7					
Brong Ahafo					
8	F	28	B. ED	5	Brong
9	F	29	B.sc	4	Brong
10	F	36	BED	3	Brong
11	F	26	B.sc	3	Twi
12	M	28	BA	4	Brong
13	M	30	B.sc	5	Brong
14	M	32	B. ED	4	Twi
15	M	48	B. ED	8	Twi
16	M	50	B.sc	10	Twi
17	M	28	BED	4	Fante
Central Reg.	M	30	BED	6	Fante
18	M	33	M PHIL	5	Fante
19					
20					
Eastern Reg.					
21	F	35	BED	5	Twi
22	M	33	BED	3	Twi
23	M	45	BED	7	Twi
Greater Accra	F	25	B.sc	1	Ga
24	M	41	BED	6	Ga
25	M	50	BED	8	Ga
26	M	30	BED	5	Guruni
Upper East	M	39	BA	5	Bulsa
27	M	47	BED	6	Kusaal
28	M	47	BA	3	Kassim
29					
30					
Upper West	F	25	BED	2	Dagaare
31	M	34	BA	5	Sesaale
32	M	39	BED	7	Waale
33					
Volta					
34	F	46	MED	6	Ewe
35	M	25	BA	1	Ewe
36	M	36	BED	5	Ewe
37	M	41	B.sc	5	Ewe
38	M	45	MFA	4	Ewe
39	M	29	BA	3	Sefwi
40. Western Reg.					

*Years indicates the number of years participants have been at the study site.