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Acoustic Properties of English Short Vowels as Produced by Advanced EFL University Students

A Thesis Submitted in Partial Fulfillment of the Requirements for MA Degree in Applied Linguistics

By

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Autumn, 2022

Dedication

I dedicate this dissertation to my companion of this journey, to whom has always wanted me to become a better person than him, the one I have always loved discussing life with, my reading partner, my role model, my first love. To the person whom I am proud to carry his name, whose love was always a guiding light to show me the way…. I have always dreamed of this day, to look at you, in the eye and say … we did it, baba.

to my *father*

Staff Commodore Albahlol Faraj Algezany

"Oh Allah, forgive him and have mercy on him, pardon him and grant him the highest ranks in paradise"

I also dedicate it to my lovely mother; without her love, encouragement and duaa I wouldn't have become the person I am today. My work is also dedicated to Asma, Abd-Alrahman, Alla, Rasha and little Ehab for their unconditioned love and support. I would love to thank my husband for his understanding and believing in me and my dream …. I love you all.

Acknowledgments

Praise to Allah for his mercy and blessing over my life, for the strength he gave me and belief I carried in my mind all through the journey of writing my dissertation.

First and foremost, my special thanks and gratitude to my respectful supervisor Prof.Albashir for the guidance, time and energy he devoted to have this dissertation completed. I would also like to thank him for his understanding and support through the rocky paths of this journey.

I would extend my gratitude to the professors at Tripoli University/ Faculty of Education and the Department of English students for their precious time for being a part of this work.

Finally, I would like to address special thanks to all professors at the Libyan Academy for their efforts and help.

Abstract

This study investigates the acoustic properties of British English short vowels as produced by advanced Libyan female EFL university students. It aims to compare between the quantity of British English short vowels as produced by advanced Libyan females and their equivalent native speakers. In order to answer the research questions of the study, the collected data was obtained through recording twenty native female speakers of TA from Tripoli University/ Faculty of Education using PRAAT program. An acoustic analysis of the collected measurement values was conducted to obtain systematic and objective results. The findings indicated that the production of Libyan females differed, slightly and greatly, in some of the targeted vowels and was closer to their native equivalents in others. In addition, the study presents the quality of short vowels of British English as produced by advanced Libyan females and suggests further research on aspects that need to be further investigated.

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Acronyms and Abbreviations

1. Acronyms

CA: Classical Arabic

ESL: English as a Second Language

FL: Foreign Language

GA: General American

IPA: International Phonetic Alphabet

LA: Libyan Arabic

MLA: Misrata Libyan Arabic

MSA: Modern Standard Arabic

MT: Mother Tongue

RP: Received Pronunciation

SFS: Speech Filling System

SHM: Simple Harmonic Motion

SSB: Standard Southern British

TA: Tripolitanian Arabic

TL: Target Language

TLA: Tripolitanian Libyan Arabic

VE: Voicing Effect

VOT: Voice Onset Time

2. Abbreviations

AuE: General Australian or Australian English

C: Consonant

Cps: cycles per second

CVC: Consonant Vowel Consonant

dB: Decibel

EGG: Electrograph

F0: Fundamental frequency

F1: First formant

F2: Second formant

F3: Third formant

Hz: Hertz

L1: First language

L2: Second language

Ms: Milliseconds

S: Seconds

V: Vowel

CHAPTER ONE

INTRODUCTION

1.0. Introduction

Studying phonetics and phonology is a core aspect when it comes to learning another language. Bad pronunciation may lead to judgments such as the learner is incompetent, uneducated or lacks the knowledge. Therefore, pronouncing the words properly helps the learner differentiate between similar words, avoid some spelling mistakes and being misunderstood and communicate freely with natives or other speakers of that language (Gilakjani, 2016). Unfortunately, pronunciation has always seemed to be neglected by language teachers, where more attention has been given to grammar, vocabulary and building sentences. Because of this, most of language learners find it difficult to acquire the phonology of another language and thus, hesitate to speak.

Phonetics and phonology are not less important than other parts of a language. They are significant for language learners, which will help them identify their weaknesses in pronunciation and working on improving them. As has been stated by Ladefoged and Johnson (2010):

> The representations that we write in IPA, and analyze in formal phonology, are intended to show the community's shared knowledge of how to say the words of a language … and is emergent from the aggregate behavior of the group in the sense that it captures what community members accept as correct pronunciation (p.267).

Gut (2009, p.5) has argued that "It is obvious that language teachers will not be able to support language learners adequately until they understand what exactly is entailed in the articulation and perception of speech", he also emphasized on the means of describing and evaluating the differences in pronunciation between English and the mother tongue of the learner, adding:

> For English language teachers and other professionals concerned with pronunciation … conscious knowledge of English speech sounds, of their production, properties and perception, is of course essential. They need to know which organs and mental processes are involved in speech production (p.5).

Being more precise, acoustic phonetics eases the explanation of confusing sounds for language learners when the articulatory description of sounds is not enough and as stated by Ladefoged (2003, p.104) “the best way of describing vowels [therefore] is not in terms of the articulations involved, but in terms of their acoustic properties”. Also acoustic analysis presents a better understanding of sound structure. Above all, unlike other branches of phonetics, acoustic phonetics can show the difference between males and females sound production by studying and analyzing the physical properties of each quantitatively and qualitatively.

Phonetics has been wildly covered by researchers but when it comes to acoustic phonetics the number of studies is less. This may be due to the fact that it is not well known by some researchers due to its scientific nature, which involves using computers and software to measure various sound properties. Shedding more light on the Libyan research field; the studies are even less. Most of the Libyan studies conducted in phonetics and phonology concentrated on articulation and audition but there have been no acoustic studies which deal with the physical properties of sounds in a scientific way. Also, the techniques of phonetics data collection were either questionnaires or interviews where the researcher identifies the mistakes himself/ herself bases on what he/she hears without using scientific and accurate measurements. Studies are even less when it comes to gender- specific studies, internationally and locally, most of the acoustical studies have both genders as participants without taking in consideration the difference of the articulatory system between the two genders and the possibility of affecting the results obtained. Also the data collected and analyzed in such studies is mixed without separating the results of each gender to study the similarities and differences among them which makes finding references and similar research papers and studies even harder and time consuming.

Based on this account of neglecting acoustic phonetics and the physical properties of the English sounds as produced by EFL female students in the Libyan context, This study will pioneer the acoustics of the English sounds produced by advanced Libyan female EFL students. In particular the study will concentrate on short vowels and discover how approximate their production is to that of female native speakers of English based on the acoustic properties of these vowels.

1.1. Focus and Aims of the Study

The focus of this study is on short vowels of British English, the variety taught in Libyan schools and universities. The Acoustic properties of British English short vowels produced by advanced Libyan female EFL learners has not, to the best knowledge of the researcher, been investigated yet. Hence, the study aims to analyze the results of an experiment, where British English short vowels are produced by Libyan female EFL learners, the choice of advanced students is because they are supposed to have reached a level where they can speak fluently and produce sounds accurately. The analysis will cover the measurement of the values using PRAAT, a common program for studying the acoustics of sounds, and then comparing these values with those of the British counterparts as produced by native female speakers. The properties which will be focused on are the quantity and quality of these vowels by measuring their formants and duration.

The aim behind this experiment is to figure out to what extent the acoustic properties of English short vowels as produced by native female speakers and those produced by Libyan female speakers are different or similar.

1.2. Importance of the Study

English vowels, short or long, have been discussed by linguists. There is a large number of studies that compare the vowel systems of English, British or American, with those of other languages; such as, Hunter and Yarkiner (2018), Mahmoud and Ali (2013) and Ahmed (2010). However, comparing the English vowels as produced with female native speakers with those produced by non-native female speakers still needs investigation especially in terms of acoustics.

The researcher has come across a number of studies showing how the formant frequencies of English vowels differ when produced by non-natives, and this might be due to the differences between the target language which is English and the native language of the learners. And due to the small number of studies that gender specify their study population, it is encouraging to explore the Libyan female EFL learners' production of British short vowels.

The findings of this study provide linguists and language learners with the acoustical properties of English short vowels as produced by Libyan female EFL learners, both qualitatively and quantitatively. Finally, the study will encourage other researchers to conduct more studies related to other acoustic aspects of the English sound system as produced by Libyan males, females or both, with the overall aim of improving EFL learner's pronunciation and enhancing their knowledge of the acoustic properties of the English sound system and raises their awareness of how such system works.

1.3. Research Questions

This study investigates the acoustic properties of the English short vowels as produced by advanced female EFL university students in Tripoli faculty of Education. This study aims at answering the following research questions:

1. What are the acoustic properties of English short vowels as produced by advanced female EFL university students in Tripoli faculty of Education?
2. How close these acoustic properties are to those of the short vowels produced by female native speakers of British English?

1.4. Methods

This study is mainly a quantitative one, which involves measuring the quality and the quantity of short vowels. The quality refers to the place of articulation which is affected by the shape of the vocal track during the production of these vowels and which can be specified by measuring the formants of these vowels. The study takes place in the Department of English at the Faculty of education at Tripoli University. The sample is from the last semester students which are considered to be at an advanced level. the data is collected from 20 students, all females, by recording their production of carrier sentences that each contains a target word with one of the studied short vowels. The recording procedure is done using high quality equipment to ensure good quality of the recorded voice. Analysis of the recorded material is carried out using PRAAT program, the software is commonly used among researchers and phoneticians to measure the physical properties of sounds.

To collect data, each participant reads a total number of fourteen sentences, each contains one of the targeted vowels. The studied vowels are found in a monosyllabic word each of the CVC syllable type formula, except for the schwa sound, since it cannot occur in such form.

After collecting the data, the researcher analyzes the acoustic properties of each of the targeted vowel by measuring the first and the second formant and its duration. These values then are put side by side with those obtained by another researcher for the same vowels produced by female native speakers of English. The aim is to see whether these values are similar or different and to what extent and what the implications are.

1.5. Organization of the Study

This study is organized in six chapters as follows:

Chapter one consists of an introduction to the topic, aims of the study and its importance. Research questions and methods of data collection, analysis and instrument used are also briefly covered in this section.

Chapter two presents a review of the literature related to the study, including a description of phonetics, acoustic phonetics and how sounds are formed. After that, a detailed discussion of both English and Arabic vocalic systems is given. Speakers' variability and how this affects the sound production of each individual. Finally, a number of studies, international and local, conducted in the same field are reported.

Chapter three entitled Research Methodology gives a detailed description of the population and location of the study. The instruments are discussed with detailed description of the program used to collect the data with the help of figures. Also designing the pronunciation test and the choice of carrier sentences are dealt with in this chapter.

Chapter four is devoted to data analysis and how formants and duration are measured using PRAAT. All the results of data analysis will be represented with the use of graphs and tables to make the participants' recordings visible to the reader.

Results and discussion, how data collected and analyzed are put together to answer the research questions, are discussed in the fifth chapter. A comparison of the results of the study and their native counterparts are dealt with organized sections. It also includes the conclusion of the study, recommendations and limitations and some suggestions for further research.

CHAPTER TWO

REVIEW OF LITERATURE

2.0. Introduction

In this chapter, a brief introduction of phonetics and acoustic phonetics will be given followed by a description of the sensation of sound and the properties of vowels. A description of Arabic and English vocalic systems will be given in detail. Speakers' variability in speech production is also covered before reviewing a number of previous related studies that were conducted in the field.

2.1. Phonetics

Phonetics is one of the main sub-disciplines of linguistics, which has been derived from the Greek word phone meaning sound or voice. In the late 19th century an alphabet known as the International Phonetic Alphabet (IPA) was developed using the Roman and Greek alphabet to represent the phonetic symbols (see section 2.4) that come in hand in helping EFL learners.

This branch of linguistics has been a subject of interest among lots of linguists hundreds of years ago. Unfortunately, to trace back the history of phonetics adequately and accurately has proven to be an extremely difficult task (Ashby and Przedlacka, 2014).

Phonetics is commonly defined as the study of the sounds of speech. However, this definition is very broad and can include phonology since it, like phonetics, studies speech sounds. Therefore, some researchers and phoneticians have provided more precise and inclusive definitions of phonetics to differentiate between phonetics and phonology and shed light on what concerns each branch.

Thuong (2003, p.1) defined Phonetics as "The *physical* aspects of speech sounds", and explained that phonology is "the study of the *patterns* of sounds in languages".

Brown (2014, p.3-4) stated in his book ‘Pronunciation and Phonetics’ that phonetics can be defined as "the scientific study of all aspects of the spoken form of language". The researcher finds this definition different from other definitions in the field, because as the reader breaks down the different terms making up the definition, it is noticed that Brown highlighted the fact that phonetics is a scientific study. It is objective rather than subjective, where the phoneticians are describing the sounds of languages without being biased to their own or trying to convince people how language ought to be. Therefore, phonetics is a descriptive subject and not prescriptive. Another thing is that he used the word *language* not *a language* to clarify that phonetics can describe any language, human ability to communicate, even the exotic ones spoken by a small number of people.

Another definition was given by Ogden (2009, p.1) where he defined it as "the systematic study of the sounds of speech, which is physical and directly observable". Odgen's definition gave more attention to phonetics as it is not only a study of the sounds a human can produce, but also to the fact that this study is systematic and can be physically and directly observed. This means that linguists, language teachers and learners can see how speech sounds are produced, perceived, processed and understood.

Phonetics was also described as a linguistic sub-discipline that is concerned with sounds and pronunciation and which draws heavily on other scientific disciplines such as anatomy, physiology, neurology and physics depending on its three different branches, namely articulatory phonetics, acoustic phonetics and auditory phonetics (Gut, 2009, p.6).

The four definitions gave an accurate idea about phonetics and its concerns describing it as a scientific and systematic study which shows the importance of how valid and reliable the observed data is and what it can provide for learners. Also its contribution to other sciences highlights the significance of studying speech sounds in different fields.

As mentioned previously, phonetics is one of the sub-disciplines that, along with phonology, is concerned with the production and perception of sounds. However, each one of these sciences has its own different way in describing and analyzing the speech sounds. As said earlier, phonetics has three types or branches which deal with human beings' production of the sounds found in different languages. They are:

- **Articulatory phonetics** analyses which organs and muscles are used by speakers to produce speech.
- **Acoustic phonetics** is concerned with the physical properties of speech sounds as they travel in the air between a speaker's mouth and a listener's ear.
- **Auditory phonetics** focuses on the effect those sounds have when they reach the listener's ear and brain (Gut, 2009, p.6).

The three separate branches of phonetics are related to the speaker (articulatory), the listener (auditory) and both the speaker and the listener (acoustic), and which are, in fact, complement with each other.

Since this study is concerned with acoustic phonetics a detailed description of what acoustic phonetics is about, sound sensation and properties of sound waves and vowel sounds will be discussed in the following subsections.

2.2. Acoustic Phonetics

Acoustic phonetics is one of the three branches of phonetics, which is concerned with the scientific analysis and description of speech sounds and its physical properties as explained earlier. It first started in the late 19th century with Edison's invention of the phonograph, which enabled to record voice to be processed and analyzed later. After that a series of papers by Ludimar Hermann were published in the last two decades of the 19th century and which investigated the spectral properties of vowels and consonants using the Edison phonograph, where it was the first time to present the term Formant, an acoustic feature that reflects the acoustic properties of a sound. After World War II, further developments were made and it was possible to measure vowel formants, voice quality etc.

According to Ogden (2009, p.173), acoustic phonetics is "The study of the physical properties of speech, and aims to analyze sound wave signals that occur within speech through varying frequencies, amplitudes and durations. "This definition shares one aspect of Lodge's (2009, p.13) definition that acoustic phonetics is "the study of the physical nature of sound waves", and which confirms the importance of acoustic phonetics and the assistance it offers in hand with articulatory phonetics, Lodge adds that:

> If we find it difficult to determine whether an articulation is a stop or a fricative or an approximant, then we can use acoustic clues to decide. It is not a question of one form of description of speech being better or more reliable than the other (despite the fact that one looks more 'scientific' because it is based on an understanding of acoustics), rather they can support one another and are often simply alternative ways of interpreting the facts of articulation (2009, p.184).

2.2.1. The Sensation of Sound

We are surrounded by sounds in our lives, either by moving the curtains to open a window, the TVs in our living rooms or talking to someone in the same room or on the phone; to be more precise any movement of some sort. All these movements have caused air to move. This air movement can be felt if the speaker puts his hand in front of his mouth while speaking. Here, the sensation of sound is created by a rapid movement in the air pressure which caused a variation or fluctuation in the surrounding air (or other acoustic medium) (Gut, 2009, p.138). These variations of air pressure propagate (travel) through the air (medium) to reach the listener's eardrum and cause it to move. Then, the auditory system translates these movements into neural impulses that we experience as sounds.

What is meant by an acoustic medium in the above lines is what the sound travels through. Generally, the pressure variations that are perceived as sound produced in the air medium, but it is possible for sound to travel through other media such as gas and water. When you swim under water, you are still capable of hearing others talking above water and hear the sounds of the bubbles under water. Also speaking after inhaling helium from a balloon, your voice will sound different because it travelled through helium. As Johnson (2012, p.16-18) explained in her book, "…sound properties depend to a certain extent on the acoustic medium, on how quickly pressure fluctuations travel through the medium, and how resistant the medium is to such fluctuations".

Sounds travel in the form of sound waves which enables them to travel for a long distance. It can be illustrated as if the sound source is a rock being thrown into a lake, the ripples created on the surface of the lake get bigger and travel away from the source, these ripples are the sound waves. As defined by Johnson (2012, p.18) a sound wave is a "traveling pressure fluctuation that propagates through any medium that is elastic enough to allow molecules to crowd together rand move apart." Of course, when sound waves travel through an acoustic medium, they lose energy because they move molecules. The number of molecules being moved increases as the wave spread out from the sound source, and the remaining energy decreases as the waves expand out of the source, hence, the number of molecules being moved will decrease as well.

Thanks to technology what is heard can now be observed through speech analysis software. Now we are able to examine and analyze sound waves, their types and their properties with the help of different software and spectrograms. There are two types of sound waves; periodic and aperiodic waves and both are divided into two as shown in figure (2.1).

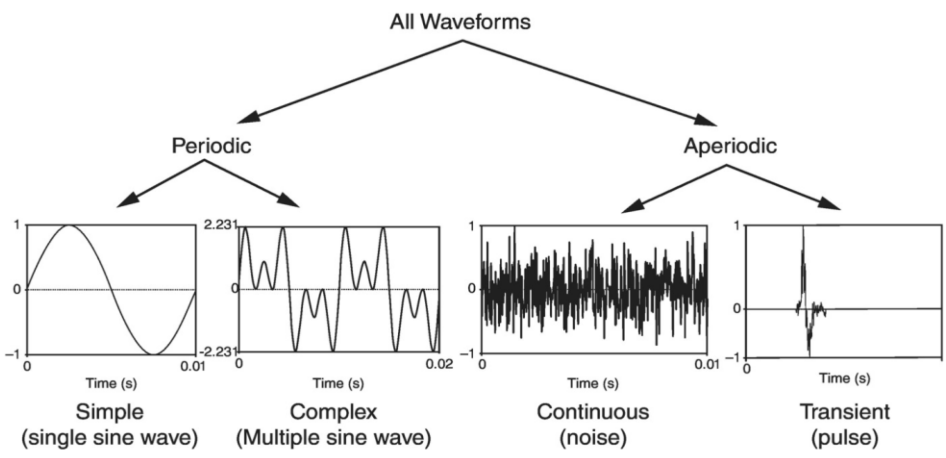

Figure (2.1) Types of wave forms (Ratree Wayland, 2018)

As explained by Johnson in her book, simple periodic waves, also known as sine waves (short for sinusoidal (Gut, 2009), are a result of simple harmonic motion (SHM) that repeats itself after a sequential amount of time, such as children's voice. On the other hand, complex periodic waves are like the simple ones but have repeating form patterns. A complex wave consists at least of two simple waves.

By contrast, aperiodic waves do not have a repeating pattern like periodic ones and they are divided into two as well, transient and continuous. A continuous wave (noise) is defined as a random pressure fluctuation that has no sharp peak; however, the amplitudes for all the components are equal. While transient waves " are various types of clanks and bursts which produce a sudden pressure fluctuation that is not sustained or repeated over time" (Johnson, 2012, p.19-27).

As linguists believe, examining and understanding the nature and different properties of those waves is crucial, and in order to obtain this, an acoustic analysis program is used to provide a visual representation of what is being uttered. Software and programs used in acoustic analysis are explained in the next chapter (see 3.3.1.1).

The first property is frequency; it refers to how many waves are made per time interval. This is usually described as how many waves are made per second, or cycles per second. The rate at which the peaks occur in terms of numbers of complete opening and closing movements (Lodge, 2009, p.187). For instance, if a hundred waves were made per second, the frequency will be a hundred cycles per second, written as 100 cps (older way of measurement). To state frequency, the unit Hertz (Hz) is used, hence; the frequency of 100 cps is 100 Hz. This shows that the speaker's vocal folds were vibrating about 100 times per second.

Another way to measure frequency is by dividing one second by the period (duration of a cycle) 1/T (T is the period in seconds). As exemplified by Johnson (2012, p.20) if a wave completed one cycle at 0.01 seconds, the equation will be 1/0.01=100, as a result this waveform has a frequency of 100 cycles per second (100 Hz). The lowest frequency is called the fundamental frequency (F0), which is perceived as pitch, and other frequencies above the fundamental frequency are called harmonics. These frequencies are in an integer multiple of the F0, meaning that if the F0 was 300 Hz the

F1 of the sine wave will be 600 Hz, and the next will be 900 Hz and so on (Gut, 2009, p.190-191).

The second property is the duration or time of an utterance which can be measured by seconds or milliseconds (ms), since the parts of an utterance (words, phoneme, syllable) are very short. Johnson (2012, p.20) talked about timing as a phase and defined it as the timing of the wave form relative to some reference point, which is shown in the horizontal axis in figure (2.2).

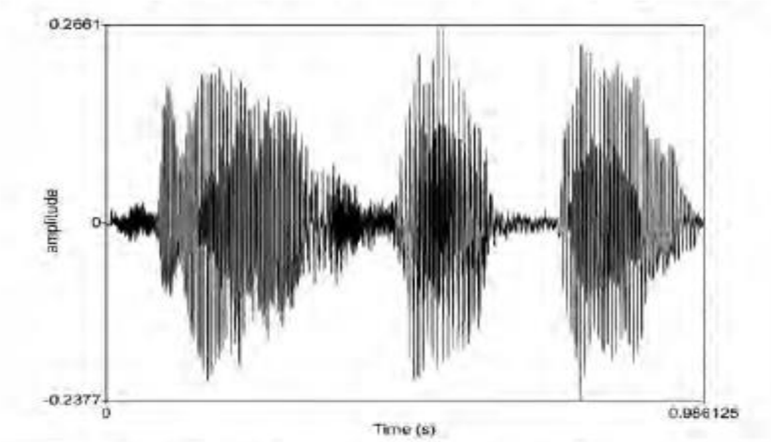

Figure (2.2) Amplitude and time (Gut, 2009, p.139)

The loudness of an utterance corresponds to the physical property intensity, which is the variation of air pressure being measured by decibel (dB). As shown above in figure (2.2), the high parts of the waveform above the zero line show high air pressure and the ones below it show low air pressure in the waveform. As explained by Gut (2009, p.140) decibel (dB) is a logarithmic scale since sound intensity is proportional to the square of the amplitude. This suggests that a slight rise in dB values leads to a much greater increase in perceived loudness and intensity. So, a 5 dB rise in amplitude occurs when one sound is considered to be twice as loud as another.

2.2.2. Acoustic Properties of English Vowels

A vowel sound is one in which the lung-air escapes freely and continually during articulation. Vowels are the most sonorous and audible speech sounds, and they usually serve as the syllable's nucleus (Huthaily, 2003, p.24).

Of course, qualities of vowels and sounds in general differ from a vowel to another and from a speaker to another, this is due to differences in their vocal folds, lower jaw movement, lips and the tongue position. Such movement in the tongue body or jaw of a vowel production might seem as slight difference, but audible enough to differentiate vowels from one another. When it comes to studying the properties and the acoustic cues of vowels, formants are the aspects to be considered. The first three formants are the most important ones to differentiate the vowels of any language. Figure (2.3) shows the frequencies of the English short vowels /ɪ/, /e/, /ɒ/, /ʊ/, /æ/, /ʌ/ and /ə/ recorded by the researcher herself using PRAAT. The dots show the formants of the vowels. The first raw is the F1, the second is F2 and so on. It is easy to measure the formants of individual vowel sounds, not as measuring them in phrases or spontaneous speech. The latter is more difficult because the linguist needs to look for a stable part, which is the mid-point of the vowel that is not affected by neighboring sounds.

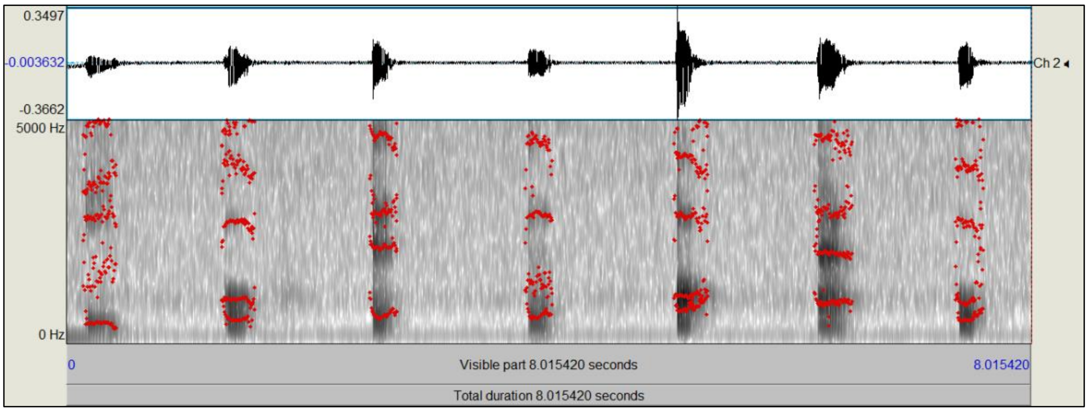

Figure (2.3) The frequencies of English short vowels

Formant values have been provided for English vowels, from different varieties, to be used as a reference for other studies. These values are average values conducted by recording a huge number of populations and getting the average of their records. However, as claimed by Gut (2009, p.154) we cannot depend on these absolute frequencies because they differ between speakers, but we can depend on the relative position of F1 and F2.

These are the IPA measurements which are approximants of the first two formants of British English short vowels. It was also possible to find the formant measurements of Libyan vowels as presented by Ahmed (2008) and the measurements of Modern Standard Arabic (MSA) in Këpuska and Alshaari study (2020) as shown in Tables (2.1), (2.2) and (2.4).

	vowel	**F1**	**F2**
British English	/ɪ/	360	2100
	/ʌ/	720	1240
	/æ/	680	1100
	/e/	570	1970
	/ʊ/	380	950
	/ɒ/	680	1100

Table (2.1) F1 and F2 formants of British English (Gut, 2009, p.153)

	vowel	**F1**	**F2**
Modern Standard Arabic	/ɪ/	440	1770
	/æ/	616	1460
	/u/	480	1170

Table (2.2) F1 and F2 formants of MSA short vowels (Alshaari and Këpuska, 2020, p.99)

It is worth mentioning that all of these average values are the result of the production of male and female participants. However, since this study is dealing with the Libyan females' acoustic properties of the British short vowels, the average values of British females is the one to be concentrated on. Both F1 and F2 values of the production of

British females was discussed by Deterding (1997) (see 2.5.1) as presented in table (2.3). These are the values to be compared with the values obtained from participants in this study.

Average F1 and F2 values of British female	vowel	F1	F2
	/ɪ/	432	2296
	/ʌ/	813	1422
	/æ/	1011	1759
	/e/	645	2287
	/ʊ/	414	1203
	/ɒ/	602	994

Table (2.3) F1 and F2 of British females (Deterding, 1997, p.52)

Formants mean values of LA short vowels	vowel	F1	F2
	/ɪ/	404	1856
	/æ/	555	1541
	/u/	443	1026

Table (2.4) F1 and F2 formants of LA short vowels (Ahmed, 2008, p.125)

The acoustic quality of a vowel is determined by its relation to its articulation. Vowel quality was defined by McCully as "where and how the vowel is produced in the oral cavity" (2009, p.108). Vowels are classified as close or open (British terminology) and high or low (American terminology). Vowels are graded depending on whether the tongue is kept close to the roof of the mouth or low in the mouth. In both terminologies, they are known as front or back depending on whether the tongue's body is pushed forward or pulled back. The shape of the lips determines whether they are rounded or spread. For instance, the short vowel /æ/ is an open front vowel.

The Fl measurement correlates with the length of the pharyngeal cavity, meaning that the lower the Fl, the longer the cavity; the higher the Fl, the shorter the cavity.F2 also corresponds to the length of the oral cavity in terms of frontness and backness of the tongue body. The lower the F2 the longer the front cavity is; the higher the F2,the shorter it is (Lodge, 2009, p.191).

Vowel duration varies significantly among English dialects and other languages, where English vowels were reported to be approximately 1.63 times longer compared to vowels of other languages. Vowel duration is affected by a number of factors, such as; the physical properties of the acoustic system limit the durational differences between vowels. High vowels, for instance, are shorter across languages than their non-high counterparts. The properties of the prosodic environment also plays a role in affecting vowel duration, unstressed syllables show less effect on vowel duration than stressed ones. Finally, voicing of vowels preceding voiced consonants are longer than their voiceless counterparts. (Tanner et.al., 2019, p.3-4).

2.3. Arabic Vocalic System

Each language has its own sound system and may share some similarities with other languages. However, carrying its own differences makes it distinct from the others. These differences may occur in vowels, consonants, clicks etc., which makes learning another language a challenging mission for FL learners.

For the reason that the focus of this study is the acoustic properties of English short vowels produced by Libyan female EFL students, a description of Arabic and English vocalic systems will be discussed. The Arabic vocalic system in 2.3 is divided into Modern Standard Arabic (MSA) and Libyan Arabic (LA) vocalic systems.

2.3.1. Modern Standard Arabic

Arabic is a Semitic language and is the first language (L1) of the Arab World. MSA is a simplified variety from the Classical Arabic (CA), the language of the Holy

Quran, which follows its grammar. The only difference between the two is that MSA has a larger number of vocabulary than the former and uses uncomplicated grammar structures (Huthaily, 2003, p.1).

Most of the studies about MSA vocalic system stated that it is uncomplicated because it consists of six pure vowels only, divided as three short vowels and three long vowels. The three letters (ا ,و , ي) represent the vowel sounds in MSA, the low central /a/, high front /i/ and high back /u/ and their long representatives /a:/, /i:/ and /u:/ as shown in figure (2.4). However, other researchers and linguists provided a wider and more detailed classification for MSA vowel system.

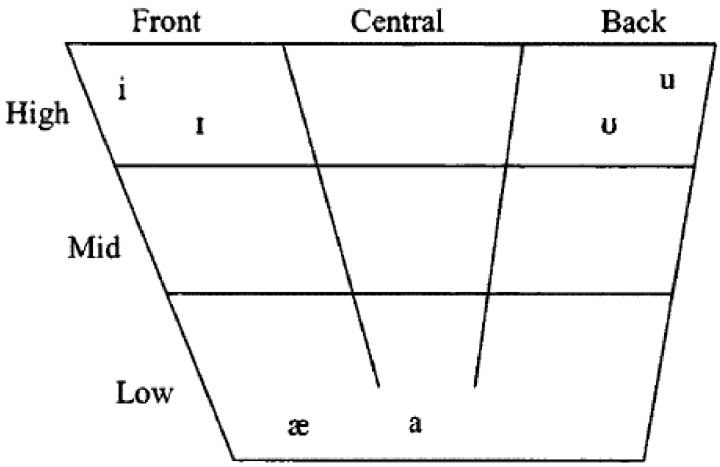

Figure (2.4) The MSA monophthongs (Huthaily, 2003, p.30)

Huthaily confirmed that MSA has six vowels, three short and three long, stating "The three long vowels /i/, /u/ and /æ/ are represented by the letters /yæʔ/, /wæw/, and ' /a.lif/ respectively. On the other hand, the three short vowels /i/, /u/, and /a/may be represented in Arabic script by diacritical marks" (2003, p.28), which will be clarified below. Also, Huthaily added that MSA has two diphthongs /ay/ and /aw/.

BaniSalameh and Abu-Melhim (2014) also agreed that MSA consisted of eight vowels, three long vowels, three short vowels and two diphthongs, and they represented them in a triangular system.

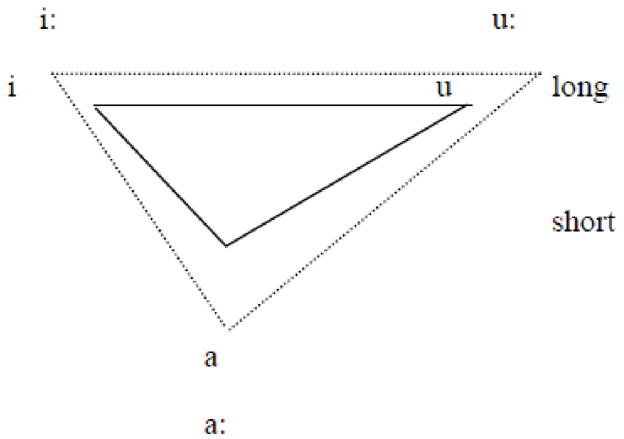

Figure (2.5) The triangular system of MSA (Abu-Melhim and BaniSalameh, 2014, p.63)

Another study conducted by Aboubaker (2008, p.7) explained that Arabic phonology contained vowels and semi-vowels represented by signs named "Harakat". Harakat are signs placed over and under consonantal letters to produce vowel sounds and these signs are important for semantics, morphology and syntax since they can change meaning and tense. Harakat are explained in table (2.5) with definitions and the sounds they represent.

Name	Sign	Explanation
Damma	◌ُ	an apostrophe-like shape written above the consonant which precedes it in pronunciation. It represents the short vowel /u/.
Fatha	◌َ	a diagonal stroke written above the consonant which precedes it in pronunciation. It represents the short vowel /a/.

Kasra	◌ِ	a diagonal stroke written below the consonant which precedes it in pronunciation. It represents the short vowel /i/.
Sukun	◌ْ	a small circle which represents the end of a closed syllable (CVC or CVVC) which in the researchers point of view represents the short vowel /ʌ/.
Shadda	◌ّ	Represents the gemination of a consonant. Where the same consonant occurs twice in a word, with no vowel between.

Table (2.5) Harakat of the Arabic language representing short vowel sounds

Aboubaker stated that Harakat are representatives of short vowel sounds and that Arabic has three letters (ا , و , ي) representing long vowel sounds, adding that "the "haraket" and the three letters of the alphabet (ا ,و , ي) are the main source for Arabic speakers to produce vowels and diphthongs" (2008, p.8).

All of the classifications and explanations given above differed in some aspects, some have emphasized "Harakat", whereas others focused more on the three letters (ا ,و , ي), but most importantly all of them have agreed that MSA has three short and three long vowels and this is what the researcher will focus on.

2.3.2. Libyan Arabic

Libyan Arabic (LA) is a variety of Arabic that is spoken by more than 6 million people in Libya. LA is divided into three main dialects, Ahmed (2008, p.3) has mentioned in his PhD dissertation that these dialects are Tripolitanian spoken in the capital city of Tripoli in the north-west, Cyrenaia spoken in Benghazi in the north-east and Fezzan spoken around the city of Sabha in the south of the country.

According to different researches conducted on the three main dialects of LA, the number of vowels differs. Some of them have counted eight vowels as Ahmed, others counted ten as Abumdas, while Griffini counted fifteen (Elramli, 2012, p.13) and Elramli who himself added the /ə/ sound that might occur in the unstressed syllables, making the number of vowels nine. In the researcher's point of view, this diversity in LA vowel number is due to the differences between the three main dialects of LA and as discussed and clarified by Elramli (2012, p.15-20) the vicinity of vowels to emphatic sounds may cause the presence of an allophone, for instance; The low central /ʌ/ was suggested by Botagga (1991) to be a vowel in the Fezzan dialect, but was identified by other researchers to be an allophone of /a/.

To be more specific and avoid the confusion between the vowels and their difference in the three dialects and the fact that the study is taking place in Tripoli. The study will be focusing on Tripolitanain Arabic (TA) vocalic system.

TA vocalic system is very similar to MSA, the two share three short vowels /i/, /u/ and /æ/ and their long counterparts /a:/, /i:/ and /u:/, adding to that TA has two additional long vowels /e:/ and /ɔ:/ (symbolized as /o:/ in Ahmed's PhD thesis, 2008, p.84) without sharing short counterparts as shown in figure (2.6) (Sheredi, 2009, p.13).

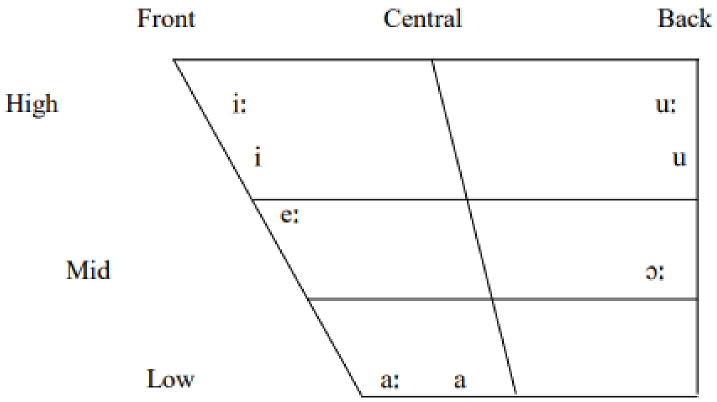

Figure (2.6) The vocalic system of Tripolitanian Arabic (Sheredi, 2009, p.13)

Sheredi clarified that the two extra long vowels are equivalents to MSA diphthongs /ay/ and /aw/ mentioned previously by Huthaily (2003, p.28-30), stating that "these /e:/ and /ɔ:/ vowels are not phonemes at all. They are the phonetic realizations of the diphthongs /ay/ and /aw/" which are also found in other Arabic dialects such as Syrian (Sheredi, 2009, p.15).

2.4. English Vocalic System

Compared to Arabic, English has a wide variation in pronunciation that differs, slightly or widely, from a region to another and from dialect to dialect. For instance; vowel reduction, vowel addition and difference in stress may occur in a certain word in a dialect but not in the other. However, regional dialects share a lot in common in their phonological systems but are not identical. Phonological analysis of English uses the most of prestigious or standard accent as a reference, such as Received Pronunciation (RP) for England, General American (GA) for the United States and General Australian or Australian English (AuE) for Australia. The term Received Pronunciation was criticized by Roach (2009) to be an old-fashioned and misleading term, explaining that if RP is the acceptable and approved accent, other accents are not acceptable, and is preferably to be named BBC pronunciation. In the researchers point of view BBC pronunciation is usually misunderstood by FL learners to refer to the accent used in the BBC channels and broadcasts. Of course other regional dialects have developed from these three standardized accents, but are only used as a limited reference or guide to EFL learners after having been familiar to the standard accents of English.

In the late 19th century the International Phonetic Alphabet (IPA) was developed in order to support language learning and provide transcription symbols for all distinctive speech sounds that occur in any language of the world. In addition, it offers transcription symbols for fine phonetic details and prosodic features called diacritics (Gut, 2009, p.53-65). Figure (2.7) shows the IPA transcription symbols of the standard vowels of all languages for language learners. Unfortunately; this chart cannot be as precise to describe the place of articulation as for consonants, and it is not an easy task to put clear boundaries for vowels.

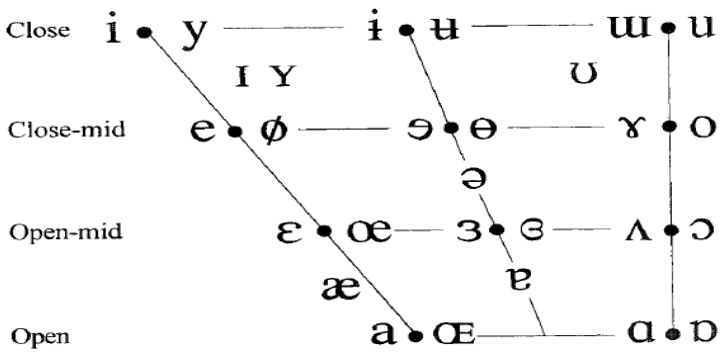

Figure (2.7) The IPA transcription symbols for the cardinal vowels (Gut, 2009, p.53-65)

The quadrilateral in (2.7) is an idealized description of the articulation of vowels (cardinal vowels) which can be used as a reference by phoneticians and phonologists to describe the vowels of a language.

RP and GA are the most familiar and mostly used varieties in dictionaries in addition to being the most widely taught varieties of English as a second or a foreign language (FL). As described in Gut's Introduction to English Phonetics and Phonology (2009, p.63-64), RP and GA shares many phonemes, but differ in some respects. RP has 23 and GA has 16 phonemic vowels divided into monophthongs or pure vowels, diphthongs and triphtongs (a set of three vowel sounds that occur in RP only).

Tables (2.6) and (2.7) show the long and short vowels of GA and RP, it is clear that the tables are very similar and contain the same long vowels with a slight difference in short vowels, but the two varieties do not use the same sounds in the same words.

	Long vowels	**Short vowels**
Received Pronunciation	/iː/	/ɪ/
	/uː/	/ʌ/
	/ɔː/	/æ/
	/ɜː/	/ə/
	/aː/	/e/
		/ʊ/
		/ɒ/

Table (2.6) Short and long vowels of RP

	Long vowels	**Short vowels**
General American	/iː/	/ɪ/
	/uː/	/ʌ/
	/ɔː/	/æ/
	/ɜː/	/ə/

	/a:/	/ɛ/
		/ʊ/

Table (2.7) Short and long vowels of GA

This study focuses on the first one to be mentioned .i.e. Received pronunciation (RP) since it is the one used in the Libyan educational institutions and curriculums.

2.5. Speakers' Variability

Speakers of any language differ considerably in their speech and language patterns, and all these differences are notable in their pitch, aspiration, enunciation, nasality and other phonetic characteristics. As discussed in this chapter and the data collection chapter, in the forthcoming pages, the sources of all these differences are the speakers' vocal tract, accent, jaw movement and many others resulting in a difference in the wave form and hence quite different utterances production. Two different speakers might produce the same sound but with different acoustic properties and the same acoustic properties for different sounds. When it comes to the differences between the sound production of both genders, we are not talking about acoustical differences (frequencies etc.) only, but also anatomy and physiology (the difference in their vocal organs). The vocal cords of males are thicker and longer than female speakers, as a result they vibrate slower compared to females. The length of the vocal tract, the distance from the vocal folds to the lips, is shorter in females which is about 14.5 cm, while the average male vocal tract is 17 to 18 cm long (Pépiot, 2012). Another thing is that female voices are more breathy than male voices, vowel formants tend to be higher when produced by females than males. In addition, the mean of the fundamental frequency (F0) is higher in females than males. In spite of all these variations listeners are able to get the linguistic meaning from a speaker's utterance almost automatically as cited in Johns Hopkins University website by

Chodroff (2017). All these differences among the two genders affect their sound production and hence the physical properties of these sounds.

2.6. Previous Studies

In the following subsections, previous studies that were conducted internationally and locally and which are related to the present study will be reviewed.

2.6.1. International Previous Studies

In this section previous studies that have been conducted in the field of acoustic phonetics will be presented. The studies took place in different countries and used different instruments to collect and analyze attained data.

Regarding studying formants and their analysis in comparison between L1 and L2 formants, a study was conducted by Hunter and Yarkiner (2018) entitled "Formant frequencies of British English vowels produced by native speakers of Cypriot Turkish (CT)" concentrating on the vowel system of Standard Southern British English (SSBE), where the measurements of F1 and F2 were compared to those of SSBE and Turkish vowels produced by L1 in previous studies. The study recorded six Cypriot participants, who were experienced as second language speakers of SSBE, four females and two males, reading a number of sentences aloud. The vowel sounds being studied were put in a /bvd/ word in a carrier phrase, for example; bed and bad, to control the phonetic environment to each vowel. While the participants were reading the phrases aloud, an audio recording and an electroglottograph (EGG) were made, the latter was used to monitor the vibration of the subject's vocal folds and facilitate pitch. To analyze the recordings the Speech Filling System (SFS) software was used to measure the formants of each vowel, which allowed to display both waveforms and spectrograms, also a playback of the recording was utilized to ease the recognition of certain words and phonemes.

As mentioned previously, the researchers measured the first two formants of the CT and compared them to the SSBE sounds. These values were presented in separate tables for males and females participants, which is rarely done in other researches. As the researchers expected, the participants produced "good" examples of SSBE vowels, taking in consideration the quality variation among the participants. However, CT speakers did a better performance with SSBE vowels that have a close equivalent in F1-F2 space in Turkish. On the other hand, they made poorer performance of vowels that had no equivalent sounds.

Another study was conducted in 2013 by Mahmoud and Ali entitled "Pronunciation problems: Acoustic analysis of the English vowels produced by Sudanese learners of English". The study focused on long and short English vowels, and the analysis covered important properties such as graphical presentations of the vowel space, classification matrix, and duration of the vowels. The data was collected from ten Sudanese students from semi-final learners by recording their production of English vowels of monosyllabic words, which were embedded in sentence carriers. The recorded data from the targeted population of the study was compared to the ones of a controlled group of ten native speakers, males and females. Unlike Hunter and Yarkiner (2018), Mahmoud and Ali used another software to analyze the data. PRAAT speech processing program was used because of the various acoustical analyses and manipulations it offers such as spectrograms, formant analysis, and duration measurements.

The first two formants and vowel duration were measured of the 11 monophthongs, the collected data was then analyzed with SPSS statistical software. The study revealed that the Sudanese speakers and their British counterparts use different distinction categories when producing English vowel sounds. In addition, Sudanese EFL learners performed lower formant value and failed to achieve correct movement when producing a vowel sound that has no equivalent in their L1, especially the duration of some vowel sounds seemed to be longer than the ones of their native counterparts. However, they faced no difficulty in pronouncing similar vowel sounds in their L1. The researchers claimed that the differences between L1 and L2 are one of the reasons behind the production problems. Also, the way English is being taught and the lack of TL/L2 phonemic knowledge are other factors resulting Sudanese learners of English to have such performance.

A similar research paper that focused on formant structure and vowel duration of English vowels was done by Paunović (2011) under the title "Sounds Serbian? Acoustic properties of Serbian EFL students' speech". In spite of that, the study did not compare the production of the participants to the natives' nor to the participants' L1 vowels; as explained by the researcher "we did not aim to make explicit comparisons of our participants' vowel qualities with these 'reference' formant values, but, rather, to observe the differences between 'neighboring' vowels in our participants' vowel space" (Paunović, 2011, p.359). It provided the formant measurement of the first two formants of the American English vowels and the ones of the five Serbian vowel sounds. The population of the study consisted of 12 students from the English Department at the faculty of Philosophy, females and males, who were all Serbian L1 speakers (level B+). Data collection was divided into three tasks. Task 1, participants were asked to read a number of individual words with the studied vowels in a stressed syllable, except for the schwa sound. Task2, reading aloud a story in order to observe how participants used phonetic cues across different speech styles and contexts. In the third task, the participants were asked to retell the story they have read in task 2 (semi-spontaneous speech), mentioning that the coarticulation effect in connected speech has been taken into consideration.

Paunović used the same instrument that has been used by Hunter and Yarkiner (2018) which is Speech Filing System (SFS). The measurements included vowel formant frequency values (F1, F2) and vowel duration. The results showed that the vowel qualities and duration of English vowels produced by the Serbian EFL learners were not appropriate in different categories, but they used duration as a phonological signal to support vowel distinctions. As suspected by other researchers, this may be due to the interference of L1. Paunović claimed that studying language interference is important, but shedding light on the students' interlanguage vowel system and the categories in it is not less important, for the reason that it helps to trace the development of the students' vowel system, and work on their weak points.

In 2020, Bello et al. conducted a study under the heading An acoustic analysis of English vowels produced by Nigerian and Malaysian ESL speakers'. 20 Nigerian and 20 Malaysian ESL speakers, all males from an intermediate level, were asked to read aloud ten sentences containing the targeted vowels within the carrier phrase "Please say… again". The recordings were recorded on a laptop using Logitech headset, later the recordings were analyzed using PRAAT and saved as a Wave file. The studied vowels were within a /hvd/ frame, as stated by the researchers "The /hvd/ context is best in measuring acoustic properties of vowels, because the environment is potentially important in reducing the effect of the preceding and the following consonants" (2020, p5-6). To have accurate results, F1 and F2 were measured twice and averaged at the vowel position.

The results showed that both Nigerian and Malaysian ESL speakers have produced some vowel sounds with sufficient phonetic distance while producing others without sufficient phonetic distance and this may be the cause of some intelligibility problems where the participants of the study may not even understand each other. The data collection and analysis is well organized and detailed in the study, in addition to the tools and calculations used to get accurate results. Also, the measurements of the first two formant frequencies and repeating it twice and the use of Euclidian distance formula to measure the distance between the adjacent sounds is not found in some other acoustic studies.

Most of the studies conducted in this field dealt with the obtained data from the population as a whole and the results were rarely presented separately for each gender as in Hunter and Yarkiner (2018). Thus, makes the journey of finding a reference to compare harder and time consuming. However, it was possible to compare the results of this study to Deterding's (1997). "The Formants of Monophthong Vowels in Standard Southern British English Pronunciation" was the title of his study. Deterding's study compared the production of the eleven English monophthongs in connected speech to his previous work in (1990) to non-connected speech forms in a /hvd/ formula, except for the /ə/ sound which was seen by Deterding as a reduction of the long monophthong /ɜ:/. The measurements were made using linear-prediction-based formant tracks overlaid on digital spectrograms. The measurements of the first three formants of males and females were measured and presented separately in separate tables for each gender for the connected speech production. After that average values were calculated and compared to the ones of non-connected speech from (1990), all was presented and compared in separate tables as well as a presentation of F1 and F2 plots was displayed. Deterding concluded that

"It was found that the male vowels were significantly less peripheral in the measurements from connected speech than in measurements from citation words", which emphasizes the difference between males' and females' production of sounds when acoustically investigated.

These were some of the studies discussing English vowels acoustical properties and measurements of vowel formants and duration. However, the number of such studies and research conducted in this field is not well covered in the Libyan region. The following lines summarize a number of acoustical studies in the Libyan field.

2.6.2. Local Previous Studies

A study was conducted by Zabiya (2017) entitled "Difficulties encountered in pronouncing English consonant clusters by EFL Libyan students of the English Department in the Faculty of Education/ Misurata". The study included the syllable structure of both English and Arabic, MSA and LA, with a comparison between both languages and a focus on investigating the phonological phonotactics in English syllable-initial and syllable-final consonant clusters by Libyan learners of English (Zabiya, 2017). To collect data, forty students of the English department had a pronunciation test. The students' sample contained 30 females and 10 males, where they were asked to read a number of words containing English syllable-initial and syllable-final consonant clusters while being recorded in a quiet room. Twelve teachers were asked to answer a questionnaire, and four of them were observed during teaching Phonetics 1, 2, 3 and 4 classes to observe their way of teaching English clusters. The collected data was analyzed with the percentage and mean procedure. The results of the students' pronunciation test showed that Libyan students faced difficulties when pronouncing English consonant clusters and inserted a vowel sound in clusters. In addition, the researcher claimed that it was an interesting phenomenon that students produced initial and final English clusters such as reduction, deletion or a substitution, which might be the effect of their mother tongue. Furthermore, teachers' questionnaire revealed that teachers face difficulties in teaching English consonant clusters, without mentioning that they lack time to check each student's performance and correct it.

Zabiya's Masters dissertation discussed an interesting topic that most of university Libyan students suffer from. The researcher tried to collect data from both teachers and students. However, data analysis was not systematic to some point, the recorded data was not used in the analysis phase and if it was, the analysis would have been done by the researcher herself.

Another master dissertation was conducted by Sheredi (2009) entitled "Assimilation Phenomena in Tripolitanian Arabic: A Non-Linear Approach". The study gave a descriptive account of phonological and morphological aspects dealing with assimilation in TA. The study provided a description of TA consonants, emphatics and vowels in addition to the syllable types with the help of three diagrams. The data was taken from everyday speech of TA, which was compared and contrasted to their counterparts in other Arabic dialects, if occurred. After that the data was analyzed using the theory of Feature Geometry which represents distinctive features as a structured hierarchy rather than a matrix or a set.

Likewise, assimilation was also discussed by Elramli (2012) for his PhD dissertation entitled "Assimilation in the phonology of a Libyan Arabic dialect: a constraint-based approach". Unlike the previous study, Elramli's focused on the variety spoken by the inhabitants of the city of Misrata, Misrata Libyan Arabic

(MLA). He discussed the sound system of MLA regarding consonants, glides, vowels, syllables and germination. The researcher depended on his own knowledge of the language since it is his mother tongue and interviewed and consulted other native speakers. Both studied and analyzed lateral /l/, nasal /n/, imperfective /t-/ and the regressive voicing assimilation of the continuant gutturals /ʕ/ and /ɣ/. In spite of the fact that the two studies considered two systems of two dialects of LA, the data analysis was not achieved using a systematic instrument to give more accurate measurements nor recording of samples production, not mentioning that Elramli depended on his own knowledge of the dialect with the help of some other speakers.

Another study was Mohamed's Master dissertation (2018) under the title "The pronunciation of American English vowels produced by Libyan speakers". The study aimed to compare the English vowels produced by Libyan speakers and American speakers to decide on whether the language interference was a dialect-specific interference or not. A description of the vowel system of both languages was discussed and data was collected using a questionnaire and an experiment of voice recordings. The researcher claimed that the main problems facing Libyan speakers in pronouncing English vowel sounds, especially diphthongs, was a result of the absence of such sounds in their mother tongue and the differences between them. This has caused the participants to substitute non-existing vowels in their L1 to the closest equivalent. Unfortunately, the data provided did not mention how the recorded data was analyzed nor the tool used to analyze it with. Also the statistical methods were not assessable which makes it unclear for the researcher to assess and examine the studied properties and the instrument used to analyze them.

An Acoustic and Articulatory Analysis of Consonant Sequences across Word Boundaries in Tripolitanian Libyan Arabic (TLA) was the PhD. of Ghummed (2015).

The study used articulatory phonology as a theoretical framework and aimed to provide a description of coronal and dorsal stop consonants and their interaction across word boundaries in TLA. The focus was on the timing and duration of these stops in the following environment: -C#C-, -C#CC-, -CC#C-, and -CC#CC- sequence (# denotes a word boundary). The population of the study consisted of ten males, who were native speakers of TLA including Ghummed himself and two of the participants were used to the EPG study. The participants were asked to read lists of two words separated by a word boundary in the carrier phrase "ma tguli:ʃ …", lists were used in both phases of data collection, EPG and acoustic data. Data was analyzed using three methods, the EPG analysis, the statistical software analysis SPSS and acoustic data analysis using PRAAT, since it provides waveforms which come in hand in measuring durations.

Elramli and Maiteq (2019) conducted a research entitled "Regressive rounding harmony in Libyan Arabic". It studied the regressive rounding harmony influenced by a suffixal back round vowel in the Libyan Arabic dialect spoken in the city of Misrata. The skeletal structure in the collected words is a /CVCVC-/ stem followed by the third person plural suffix /-u/. Since the LA dialect of Misrata was the authors' mother tongue, they used their own examples to investigate the process, and the third person plural suffix /-u/ has been added to each example to see the influence of this vocalic suffix on the vowels of the stem.

A study conducted by Ahmed (2010) entitled "English and Arabic Vowels, A comparative study of vowel quality and duration". The study aimed to investigate how Arabic and English vowels were similar and how such similarities, if there is any, affect the learning procedure of these English sounds by Arabic native speakers. The study first described the vocalic systems of both languages, followed with a comparison and contrast between both English and Arabic vowel sounds. For the population, two male participants, around the age of 11 and 12, were chosen to read eighteen words, two words for the nine vowel sounds in each language, in order to check the reliability of the formant measurements. Qualitative and quantitative i.e. formants and duration results were both presented in tables to ease the comparison procedure. Ahmed found out that the vocalic system of Arabic and English are similar in some aspects and that such similarities made Arabic native speakers try to reach the target sound even if their production was not very successful instead of replacing the similar sound with the one in their mother tongue.

As mentioned in the above lines, some of the international studies have investigated the production of British English or General American (GA) to speakers of other languages and suggested that such differences encountered were a results of the differences from the speakers' first language. Also, most of the studies were not gender specific and rarely presented the data collected and results of each gender separately. Most of the studies in the Libyan region were phonological studies. However, there is a lack of studies that were conducted in the field of phonetics. Also, very little literature is available on acoustic phonetic. The study conducted by Ahmed (2010) was the only Libyan study to investigate the differences and similarities between the vocalic systems of Arabic and English. However, it did not investigate one of the Libyan dialects, in this case TA, in comparison to English, also the participants were only two male speakers, aged around 11 and 12, who produced the studied vowels of both languages, namely Arabic and English. None of the local studies have studied the production of Libyan females of the British English short vowels. Thus, the study is motivated by this lack of current research concerning acoustic properties of British English short vowels produced by advanced Libyan females EFL university students.

CHAPTER THREE

RESEARCH METHODOLOGY

3.0. Introduction

The third chapter explains how the research questions are systematically and scientifically answered. The adopted steps in studying the research problem and the logic behind selecting them are specified and clarified. A detailed description is given of how data was firstly designed, recorded by the selected participants, and how those participants were chosen. Furthermore, a detailed explanation of the program used to analyze the data is given with the help of figures for clarity. Finally, the data analysis procedure is discussed at the end of the chapter.

3.1. Research Design

This study aims to answer two main questions concerning the acoustic properties of English short vowels produced by Advanced Libyan female EFL university students in Tripoli University/ faculty of Education and how close these studied properties are close to those produced by female British English native speakers. To answer these questions the researcher analyzes the properties of the seven studied short vowels including their quality and quantity, and compare them to the ones produced by female native speakers of British English. In order to obtain accurate, reliable and unbiased results, the quantitative method was the one to be chosen for numerous reasons.

As described by Kumar (2011, p.103) quantitative research designs are distinct, well-structured, and can be explicitly described and recognized. They have been checked for validity and reliability. In addition, quantitative approach is an approach that is used for collecting data by using questions and responses, that uses standard structures and criteria for assessment. Most importantly, data analysis is obtained through comparing or relating variables using statistical analysis. Last but not least, quantitative approach helps in construing results by comparing them to previous research or data (formant measurement of native speakers in the case of this study) (Creswell, 2012, p.13).

3.2. Participants of the Study

The targeted population of the study was Libyan Female university students at Tripoli University, Faculty of Education from the Department of English. All of the participants live in Tripoli and are native speakers of Arabic; specifically, speakers of Tripolitanian Arabic (TA). It is expected that participants' mother tongue (MT) affects their production of the studied sounds of the English language due to the differences of the linguistic characters that form each language and dialect and the impact it has on their sound formation to acquire an accurate pronunciation of the foreign or targeted language (Elwahab,2020, p.489-499).

The researcher aimed to collect data from female participants only, for the reason that the differences in the anatomy of the vocal folds of both genders affect their sound production, hence, their formant measurements (Gut, 2009, p.19-20) (see 2.5). Added to this is the difficulty of obtaining data from males due to the small number of male students in the department.

The choice of participants from the last semesters (sixth semester and above) was in order to ensure that they have had phonetics courses in their first semesters and reached the upper-intermediate or advanced level. Data was collected from 20 female participants.

3.3. Data Collection Procedure

3.3.1. Instrument

The human ear might be capable of discriminating different sounds, but it gets more challenging and confusing when it comes to vowel sounds, especially the ones that have an indistinguishable manner of articulation. It was expected that the mid central /ə/, the mid front /e/ and the high central /ɪ/ are the most difficult vowel sounds to differentiate among EFL Libyan female university students.

According to Bello et al., (2020) sounds that differ in formant frequencies from 20 Hz and below cannot be detected by the human ear, meaning that if two or three sounds had such differences, the listener will perceive them as if they belong to the same category not two distinct categories. In spite of that, adjacent vowel sounds that are above 60 Hz are expected to be less confusing for the human ear.

It was quite surprising that in numerous studies the researchers used interviews and questionnaires as a method to study and analyze phonetic data, and depended only on the human ear to determine the studied sounds or vowels, their qualities, length, addition or deletion. Such measurements have to be accurate, reliable, scientific and systematic. To obtain such results, there are several software packages used in the field of phonetics and in particular acoustic phonetics for the analysis of speech signals available free via the internet, such as Speech Filling System (SFS), WASP, WaveSurfer, Emu, PRAAT and many more.

PRAAT, has been used in more than a study such as Bello et al. (2020), Mohmoud and Ali (2013), Ahmed (2008), Ghummed (2015) and Al-Shoufi (2015) and many others. In addition, Excel was used to present vowel plots of the studied vowels. The following lines give a detailed description about the program, the features it provides including recording, saving, visual display, formant and duration measurements and analysis, etc.

PRAAT, version 6.1.08, is a program that can be downloaded from the website http://www.praat.org for free. The Dutch programmers Paul Boersma and David Weenink of the University of Amsterdam were behind this significant program, which is named after the Dutch word that means "Talk". It can be easily used by linguists, teachers and language students by following the guide book provided online.

The forthcoming subsections describe how PRAAT is used for acoustic analysis of speech. A full description of the steps followed in recording, saving, visual display, formant and duration measurements, analysis etc., of the data of this study will be explained with the use of images.

A Description of PRAAT and Excel

Two windows will be shown when clicking on PRAAT icon, an objectives window and the picture window as in Figure (3.1). Most of the work will be done using the former where different and useful options come in hand to any linguist. It should be noted that when PRAAT is first opened the objectives list will be empty and the analysis and synthesis tools in the objectives window, pointed with a red arrow on the right side, do not show until there is a saved sound record in the objects list.

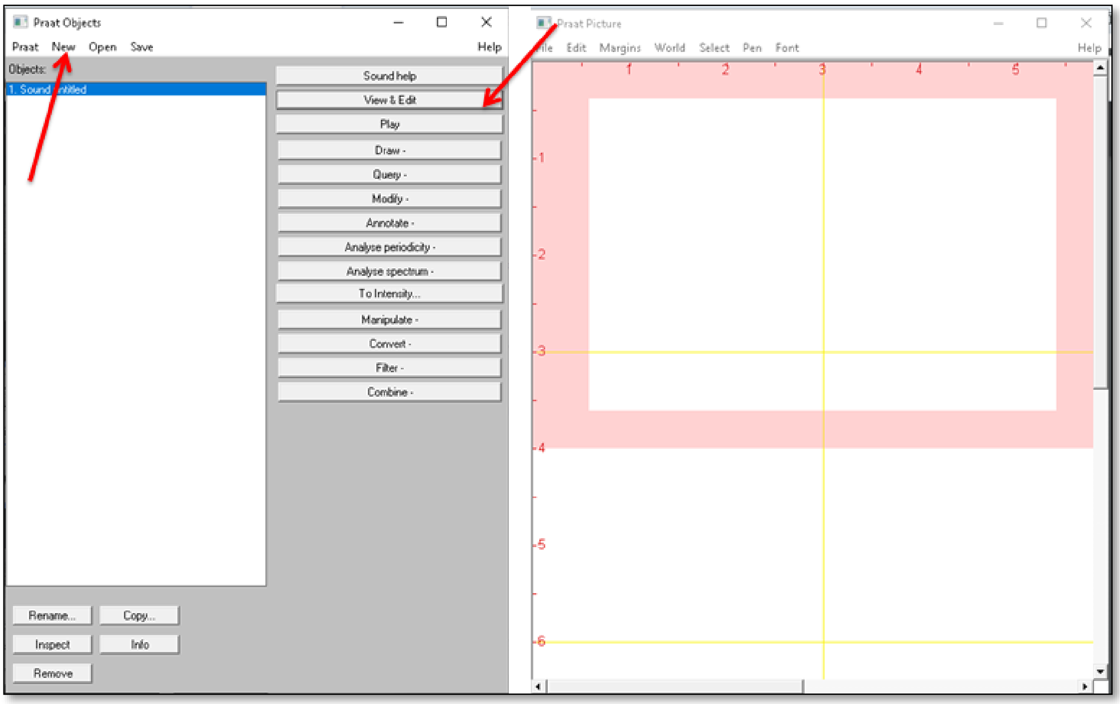

Figure (3.1) PRAAT objectives and pictures windows

To record voice on PRAAT, namely the carrier phrase "Please say … again", all needed is to click new in the main menu of the objectives window, then Record→ mono sound (the researcher used 22050 Hz as a sampling rate). After finishing click Stop → Name the sound record→ Save to list. The saved sound file will appear in the objectives list to be viewed and edited. Finally, click Save → Save as WAV file and choose the folder you desire to save your recordings at, preferably a separate file to avoid data loss. It is important that the volume bar is fluctuating while recording, otherwise it is not recording and there might be a problem with the laptop being used or the speaker's voice is not loud enough to be recorded. Another thing is clipping, which has been mentioned before in the previous chapter. If the recording is too high and went red, the recording will be clipped and shown as a clipped signal that is not analyzed.

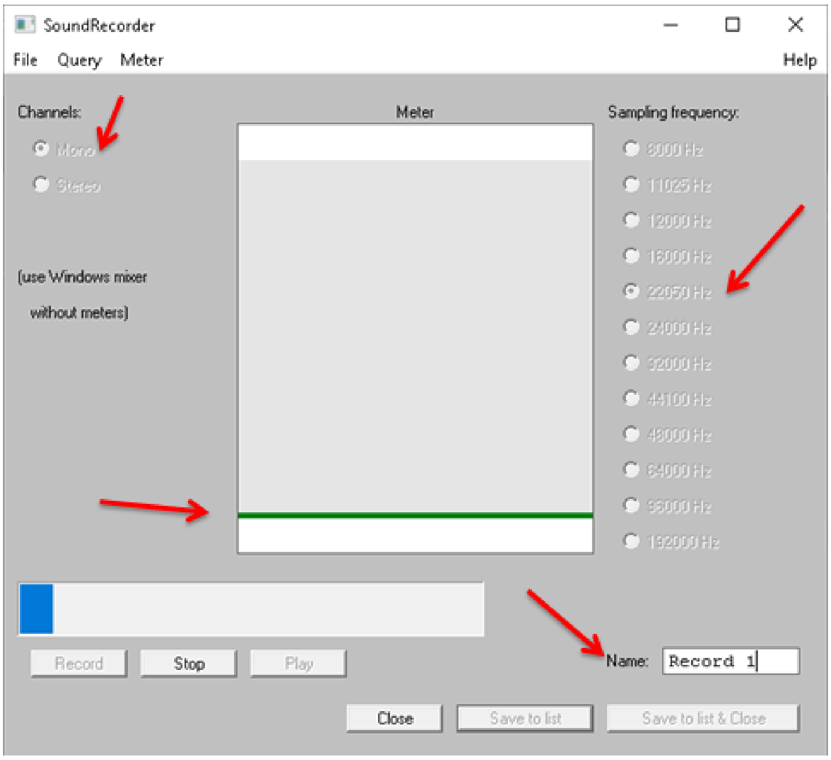

Figure (3.2) Recording sounds on PRAAT

After the required sound has been recorded and saved, now it is time to analyze it by clicking on View & Edit on the “Analysis and synthesis tools” panel. Two things are being displayed in the Edit window, as shown in figure (3.3), the waveform on the upper level and the spectrogram on the lower level. Depending on the default setting on the program the researcher is using, the visual display may show different properties, if not, click Pulses → Show pulses (blue vertical lines on the waveform), Formant →Show formants (red dots on the spectrogram), Pitch → Show pitch (blue lines on the spectrogram). Listening to a sound file can be done in the View & Edit Window, it is possible to listen to the sound file or a selected portion by clicking on one of the panels at the bottom of the display.

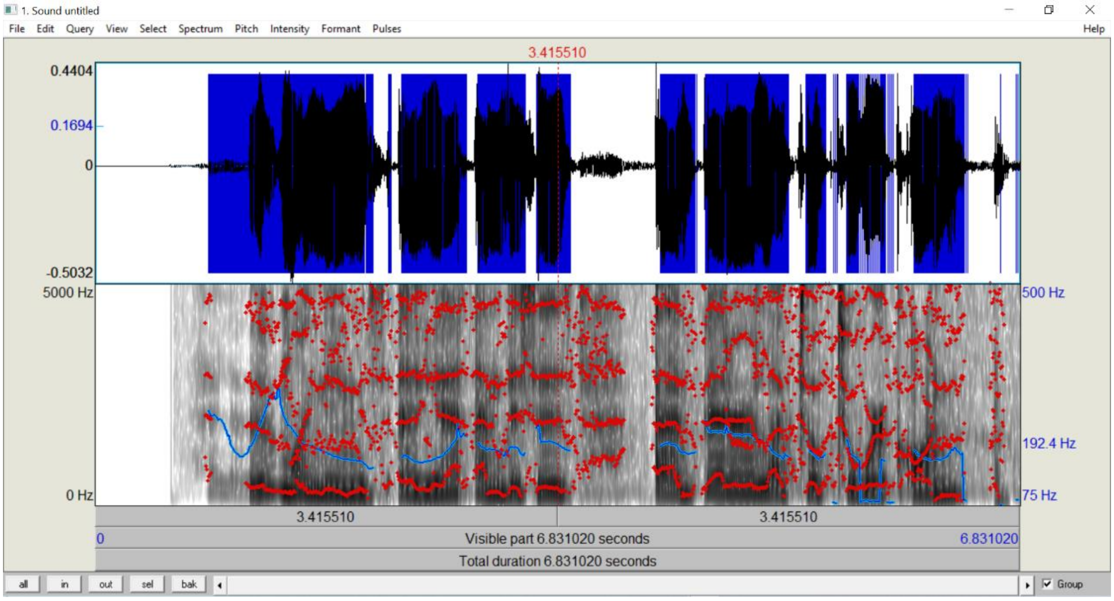

Figure (3.3) Waveform and the spectrogram

For vowel duration measurements, all needed is selecting the portion of the sound. Here the researcher or linguist needs to make sure they are measuring the vowel by listening to the sound file more than once and pay closer attention to the voice onset time (VOT) of the preceding and following sounds. To select the appropriate portion of the sound file, the cursor needs to be placed at the starting point on the waveform or spectrogram and dragging the mouse over the targeted portion. The duration of the selected portion will be shown in black at the top and bottom of the selected display, where the two red numbers on each side of the selection (on the top only) indicate the starting and ending time of the selection. As shown in figure (3.4) the duration of the selected part is 0.148 seconds, where (6.755/s) indicates the number of cycles per second. Another useful property that comes in hand for vowels analysis is Zooming, which helps in identifying formants and energy change from the preceding and following consonants to the vowel sound (Wright and Nichols, 2015). By selecting a specific portion from the sound file and clicking on Zoom from the Sel option at the bottom of the spectrogram or by clicking on View to either zoom "in" or "out" within the sound file.

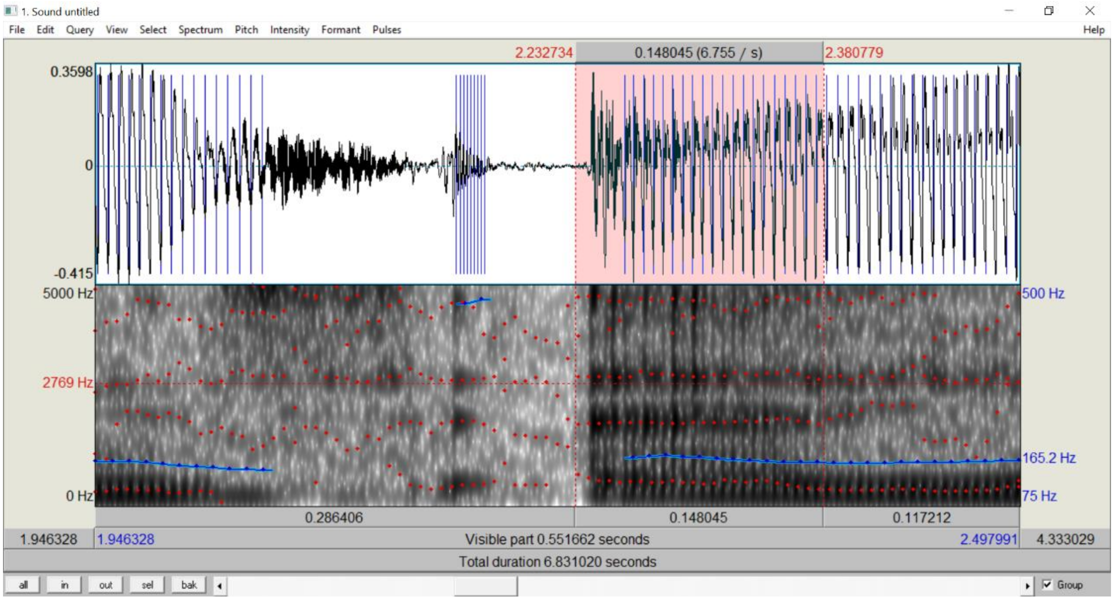

Figure (3.4) Measuring a selected sound duration

Formants are shown easily on PRAAT, as previously mentioned by clicking on Formant → Show formants. It will be shown as red dots on the spectrogram. To get the formant measurements, I can either click on F1 on the keyboard for the first formant and F2 for the second. The formant will be shown in a pop-up window with the required formant written to the nearest Hertz. It can also be done manually by clicking on a stable part (midpoint) in the F1 line and the formant will be shown in Hertz on the left of the spectrogram in red. As it is shown in figure (3.5) the pop- up window shows F1 with 379Hz (379.32 Hz) and the manual measurement differed with a slight number of 382.1 Hz (382.1 Hz).

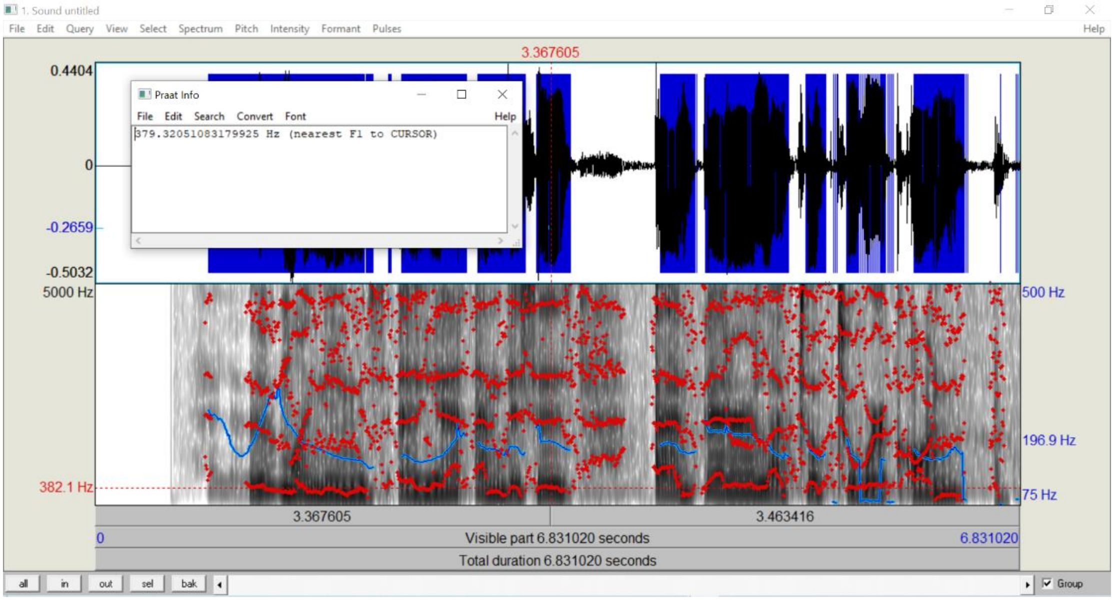

Figure (3.5) Measuring formants of a selected sound

For visual representation of F1 and F2 of vowel sounds, Excel was used to create formant plots. The process of creating those plots was not very complicated but it needed practice and attentiveness. After writing the data in an Excel sheet, choose Insert→ Charts → Scatter. At first the chart shown will be empty that you need to right click it and choose→ Select data. A window will be shown as in figure (3.6).

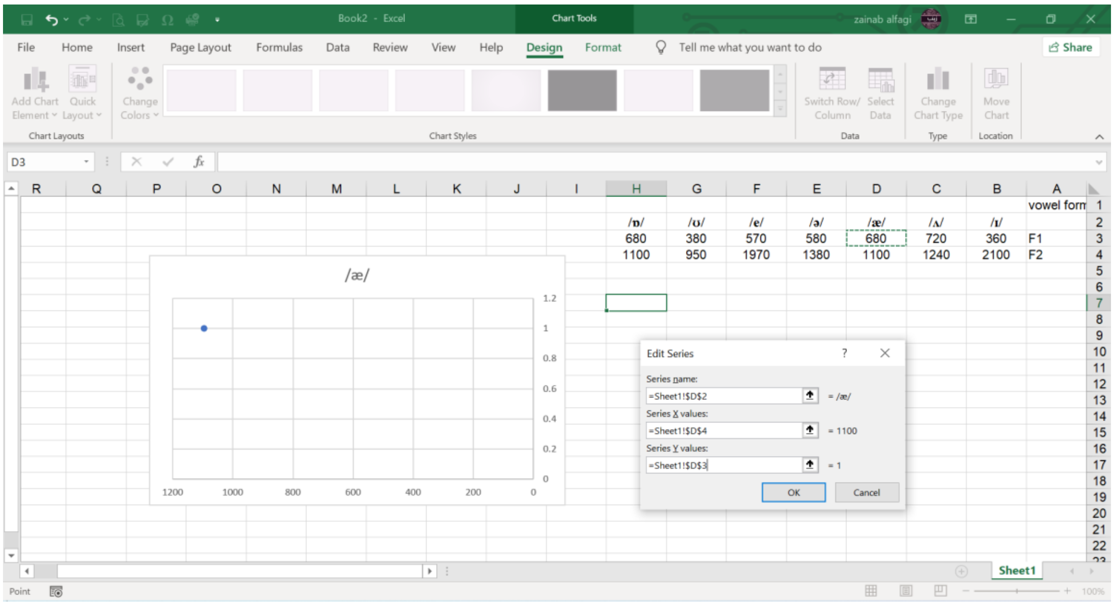

Figure (3.6) Inserting data to create a vowel plot in Excel

By clicking on Add, an Edit series, a window will pop up as shown in figure (3.7) on the left (number 1). For the Series name, choose the targeted vowel sound. Series X value, choose F2, and for Series Y value, choose F1. Then, I click Ok. As a result, the chosen vowel formants will be shown in the formant plot, as in (number 2) on the right side of figure (3.7).

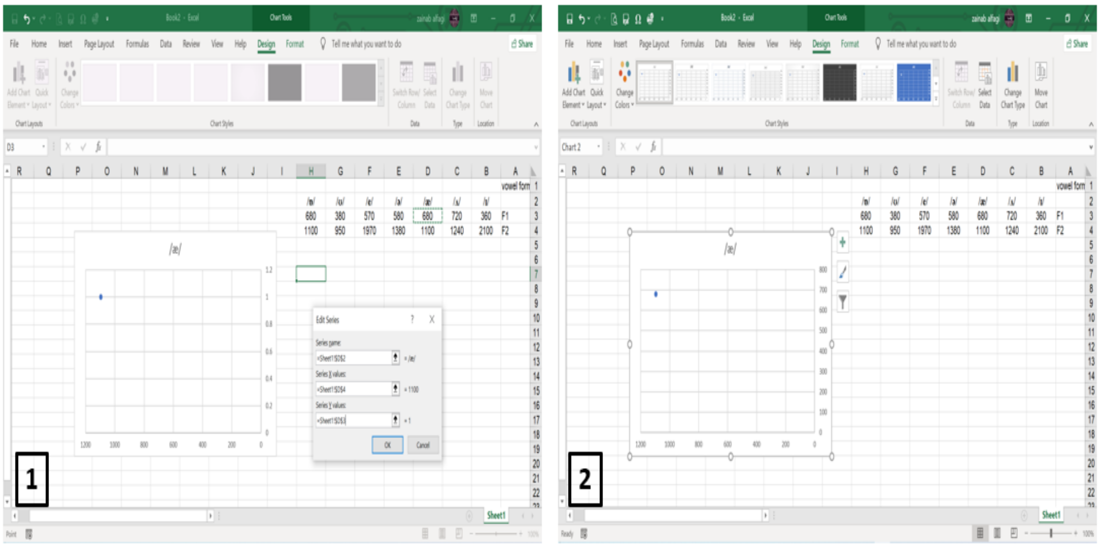

Figure (3.7) Creating a vowel plot in Excel

Finally, to reverse the formants order, right click the X value →Formant axis →Value in reversed order, as shown on the left side of figure (3.8). The rest of the studied vowels were added to the vowel plot following the same mentioned steps above. Another thing that can be changed is the minimum and maximum of formant values by right clicking Formant axis → minimum, then changing it to the wanted value. Also, the same step was followed to choose the maximum value of the vowel formant. Excel offers other layout options for the vowel plot, such as, changing the formant plot area, the color, the transparency, the gridlines and many other options.

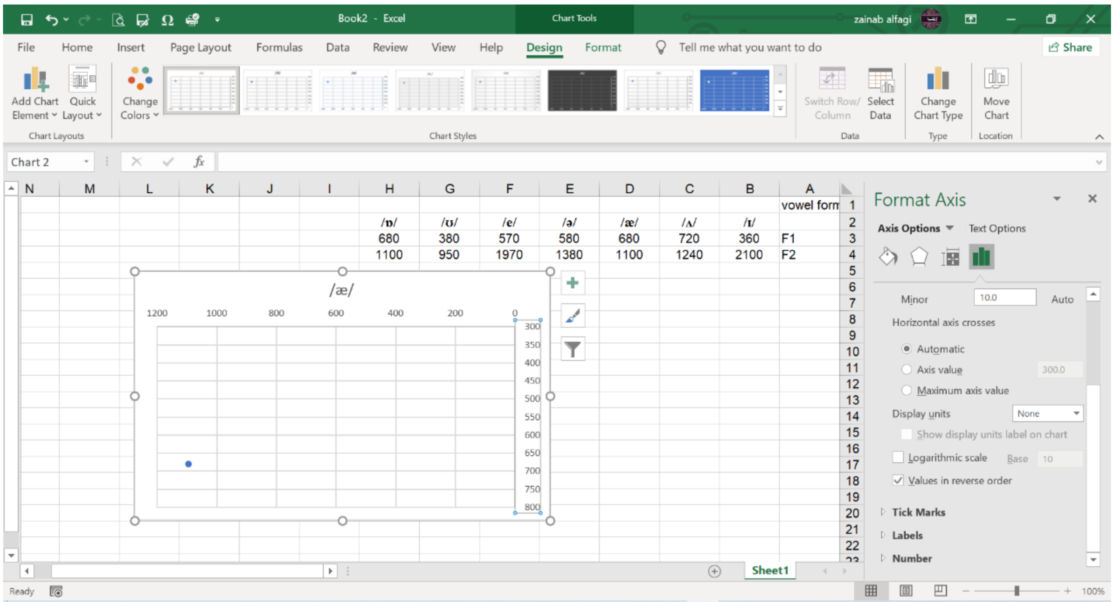

Figure (3.8) Reversing formants in a vowel plot

3.3.2. Designing the Pronunciation Test

To investigate the targeted vowels, a list of fourteen words was prepared, fourteen tokens for each participant. It was assured that the words are in the form of Consonant Vowel Consonant (CVC) as /hvd/ and /hvt/ formula. As /hvd/ context was widely used in reducing the effect of both preceding and following sounds; where the /h/ sound does not have much of an effect on the following vowel and the final /d/ helps to find out the offset of the vowel since it's a stop (Bello et al., 2020, p.5-6). On the other hand, /hvt/ was used for the reason that the researcher wants to measure the formants of English short vowels preceding voiced and voiceless sounds. Stops were the ones to be used, as they have less effect on the duration of the preceding vowels. The mean of both pair, words with voiced and voiceless sounds preceding the studied vowel, will be calculated from each of F1 and F2. As a result, the effect of voicing will be minimized.

As mentioned above, it was assured that the studied vowels are in /hvd/ and /hvt/ formula. However, finding such words in the required forms was not an easy task to accomplish, especially for the **/ə/** sound. Table (3.1) shows the selected words followed with definitions of words that might be unfamiliar to the participants.

Vowel	**/hvd/**	**/hvt/**
/ɪ/	Hid	hit
/ʌ/	Hudd	hut
/æ/	Had	hat
/ə/	Adopt	atomic
/e/	Head	het
/ʊ/	Hood	chutzpa
/ɒ/	Hod	hot

Table (3.1) The primary list of words used for data collection

Meanings:

Hudd: Brave ruler and is of English origin, which has been used primarily by parents who are considering baby names for boys.

Chutzpa: /hʊtspə/ informal; shameless audacity (origin from Yiddish).

Het: dialect, a past tense and past participle of heat (Adj. a Scot word for hot).

Hod: an open metal or plastic box fitted with a handle for carrying bricks, mortar, etc,.

Due to the fact that some words may be unusual or mysterious to the participants which might affect their pronunciation even if a transcription was provided, more research on voicing effect (VE) was done to prepare an alternative list of words. It was proven that "vowels preceding voiceless consonants are shorter than those preceding their voiced counterparts." (Tanner et al., 2019,p.1). This was the reason behind choosing the stops /t/ and /d/, as mentioned earlier, to be the sounds following the studied vowels in the form of (_vd) and (_vt), except for /**ə**/ sound in the form of (vt_ _ _ _) and (vd _ _ _) as will be explained below.

Within the carrier phrase "Please say …….. again", as used in the study of Bello et al. (2020) and Mahmoud and Ali (2013), the target vowels will be studied in a CVC word. To minimize the effects on the quality of the studied vowels, examining the studied vowel sounds within a monosyllabic word was chosen because in words consisting of more than one syllable, vowels seem to be shorter (Ahmed, 2008, p.106).

The reason behind studying the acoustic properties of the studied vowels within a carrier phrase is that the voicing effect (VE) will be smaller compared to the ones studied in isolation and in spontaneous speech, where the latter is affected by a number of factors (e.g., speed, stress, following sound, situation etc.,) (Tanner et al., 2019, p.3-4).

Vowel	/vd/	/vt/
/ɪ/	Hid	hit
/ʌ/	Bud	but
/æ/	Had	hat
/ə/	Adopt	atomic
/e/	Led	let
/ʊ/	Hood	foot
/ɒ/	Hod	hot

Table (3.2) The list of words used for data collection

The words were printed on an A4 sheet, font size 14 and in Time New Romans script. The words were organized within the carrier phrase, that each pair of voiced and voiceless sounds will not follow each other and affect the speaker's sound production. The organization was as follows:

Please say hid again. /hɪd/ Please say led again. /led/

Please say foot again. /fʊt/ Please say hat again. /hæt/

Please say adopt again. /ədɒpt/ Please say hot again. /hɒt/

Please say but again. /bʌt/ Please say hood again. /hʊd/

Please say had again. /hæd/ Please say let again. /let/

Please say atomic again. /ətɒmɪk/ Please say hit again. /hɪt/

Please say hod again. /hɒd/ Please say bud again. /bʌd/

3.3.3. Piloting the Pronunciation Test

To assure that the collected data is accurate and clear to be measured, a few sentences were recorded by the researcher using a Toshiba laptop and headphones with an attached microphone in a quiet room. Using PRAAT version 6.1.08 the sentences were recorded and saved as a WAVE file form. Unfortunately; the recordings were not audible, in spite of the fact that it was possible to display the waveform, spectrogram and formant measurement. As a result, it was necessary to use another device, an HP laptop, where the same version of the program was installed and tested to have the recordings clearly audible and ready for taking measurements.

3.3.4. Recording Procedure

After having consents from the participants, they were asked to accompany the researcher one at a time to a closed quiet room, in the English Department at Tripoli University, to minimize the noise effect and start the recording procedure. They were asked to be seated, wear the headphones and keep the microphone on the side of their mouth to obtain reliable measurements and avoid blowing noise resulted from the participants' breath or aspiration of plosives (Gut,2009, p.177-178). It was taken in consideration to sanitize the microphone and headphones after each recording session. Participants were given time to check and read the phrases before starting. They were also allowed to ask question about the phrases or the description provided. They were asked to speak in their normal speed rate while reading the phrases and pause after each one.

As mentioned above, the recordings of the fourteen carrier phrases were made using an HP laptop attached with a head-mounted close-talking micro-phone. The material was recorded using PRAAT, 22050 Hz, mono and then saved as a WAV file, using numbers to represent the participants for anonymity, in a separate folder for recordings.

It is worth mentioning that prior to the vowel measurement process, the setting of the spectrogram, formants, pitch and intensity were checked and reset. The following values were selected:

Maximum Formant (Hz)	Number of formants	Window length (s)	Dynamic range (dB)	Dot size (mm)
5500.0	5.0	0.025	30.0	1.0

Table (3.3) PRAAT settings used in data analysis

The Spectrogram, Intensity and Pitch settings were also reset to the values shown in table (4.2).

Spectrogram settings			Intensity settings		Pitch settings	
View range (Hz)	Window length (s)	Dynamic range (dB)	View range (dB)	Average method	Pitch range	Unit
0.0	0.005	50.0	40.0 – 100.0	Mean energy	70.0 – 250.0	Hertz

Table (3.4) Spectrogram, intensity and pitch settings

As a result of interruption and misreading some of the studied words, some participants needed to repeat the recording procedure from the beginning. Also, three of them were excluded because of the bad quality of the recording, clipping and the pronunciation mistakes. The recording procedure took two weeks to reach the target number and the research had to pay several visits on certain days when final semester students were available having their final exams.

3.4. Ethical Considerations

First, the researcher presented herself to the participants and gave a detailed description of the study and its aims before having the participants' confirmation. The recordings and the anonymity of the participants' identities were also confirmed, before having their acceptance, to be kept and accessed by the researcher only and be referred at by numbers. Moreover, participants were informed that they have the freedom to withdraw at any stage if they found any difficulty or discomfort in participating or being recorded.

3.5. Data Analysis Procedure

The process of studying and analyzing the collected data was conducted, following the steps explained in (3.3.1.1 description of PRAAT and Excel), as in the following steps:

For vowel properties measurements, duration and formant measurements were done. The first two formants, namely F1 and F2,were the ones taken in consideration since they are the most important acoustic cues to distinguish between vowel sounds in any language (Gut, 2009). Ladefoged (2001 cited in Ahmed, 2008, p.111) also believed that the first three formants are important to describe vowel sounds; however, studying only the first two formants is sufficient.

First of all, vowel formant measurements were conducted. The recordings were not short enough to show a spectrogram, that the researcher needed to zoom in and out on the targeted vowel to show the spectral analysis of the phrase, the word, and finally the vowel.

The measurements of each token were done manually once and using the formant track provided by the program i.e. PRAAT itself a second time. The measured values of the fourteen studied vowels were written down to calculate the average of each. Even though this step was time consuming, it was taken to ensure that the measurements are accurate and reliable. PRAAT formant measurement is not very complicated as discussed previously in this chapter (see 3.3.1.1). However, measuring formants by hand needed a number of things to be taken in consideration such as Voice Onset Time (VOT) as well as the acoustic properties of the following and preceding consonants. In addition, to get accurate results, a stable part (mid-point) was chosen that is far from the influence of neighboring sounds on the formant shape of the vowel sounds. After that, F1 measurement was taken twice by showing formants from the formant tracker in the tool bar once and manually one more time, to assure that the measurements are accurate and reliable. The researcher intended to do this step to make sure that the results are accurate even if the difference between both measurements is slight (Ahmed, 2008, p.112). After that, the mean of both measurements was taken and saved in a separate sheet for each token. The same steps were conducted to measure the F2 of the same vowel sound. The same steps were also followed to get F1 and F2 for the rest of the studied vowel sounds. It is crucial to explain that each vowel was studied in two cases, preceding voiced and voiceless sounds, meaning that the F1 and F2 of each vowel sound were measured two times. The mean of these two measurements was first calculated. After that, the mean of both means was calculated to get the F1 and F2 for each short vowel sound as produced by Libyan EFL learners. Lastly, the final measurements were compared to the ones of female native speakers of British English.

The second step was vowel duration measurement, which was less complicated than measuring formats. Using PRAAT, all was needed that the targeted vowel was zoomed in, listened to, and selected to get the duration of the vowel in seconds. The second phase was also followed as in the first one; the mean of both durations, vowel preceding voiced and vowel preceding voiceless sounds, was calculated to get the duration of the studied vowels as produced by Libyan EFL learners.

These steps were considered to study and analyze the collected data of the study. Later, the results of the twenty participants are presented separately, along with separate tables for the first two formants and duration presenting each studied vowel for each token. All of that was demonstrated with figures using Excel to present vowel plots. The process of creating detailed tables for each of the twenty participants made it easier to compare the results to their British English counterparts and therefore finding an answer to the research questions with clarity.

CHAPTER FOUR

DATA ANALYSIS

4.0. Introduction

This chapter analyses the data of the study. Formant measurements of the seven studied vowels are displayed in tables for the twenty tokens. Tables of the average vowel formant measurements for each speaker are also provided. Vowel duration is measured and examined as well. The results of each vowel duration are also put in tables to ease the comparison and discussion phase. In addition, vowel duration and formant measurements were dealt with in detail to highlight the important points considering short vowels acoustic properties.

4.1. Formant Analysis

Acoustic properties differ across consonants, voiced or voiceless, due to the diversity of their manner of articulation. The forthcoming lines explain the difference between each group of the consonant sounds preceding and following the studied vowels. All of the carrier phrases contained words ending in /t/ and /d/ following the studied vowel. However, a variety of sounds preceded the targeted vowels, namely /b/, /d/, /t/, /f/, /h/ and /l/.

To start with, plosives acoustic pattern consists of three separate events: closure, burst and aspiration, which is produced with a total obstruction of air in the vocal tract that distinguish them from other consonants as shown in figure (4.1). In the first event, the air stream is being hold or blocked, then the restrained air steam is released suddenly (Gut, 2009, p.156-158). Formant transition is shown at the last event, which was very helpful at determining the vowel sound limits.

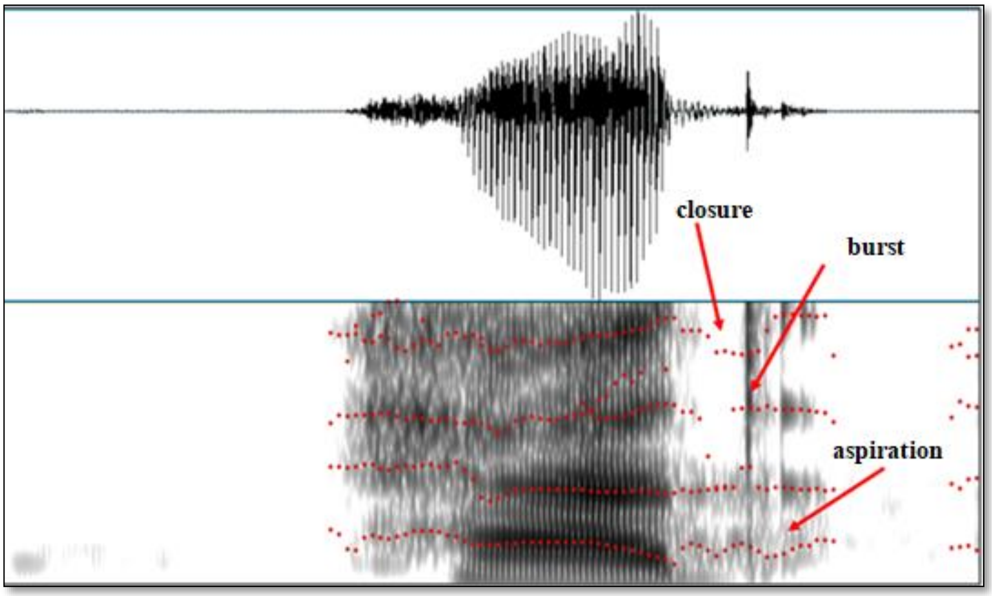

Figure (4.1) The spectrogram of the word had (/hæd/)

Regarding the voiceless labiodental fricative /f/, the friction in the sound production is similar to the burst of the voiceless plosives, which could be shown clearly in a spectrogram. However, the burst takes place with upper frequencies only. On the other hand, the voiced fricative /h/ does not show any changes in the formant transition since it does not involve any articulators while being produced. However, it was not difficult to distinguish on a spectrogram. Unlike the voiced lateral/ approximant /l/, formants are the ones that differentiate this sound from vowels, even though its formant measurements have little energy, where it has a higher F3 and a lower F1. It is worth mentioning that the /l/ sound was used twice and in both occasions in the carrier phrases, the prevocalic /l/ was a ‘clear /l/’, which has a lower F1 and F2 than the post vocalic one in British English.

Another thing that was taken in consideration was the Voice Onset Time (VOT), which was also helpful in determining the beginning of the studied vowel sounds. VOT was defined by Gut (2009, p.159) as "the period of time between the burst and the beginning of voicing". For instance, in the voiced plosives the VOT takes 20ms before and 20 ms after the vocal folds start to vibrate. Conversely, the typical VOT for voiceless plosives is between 40 and 80 ms and aspirated plosives can have a VOT up to 120 ms. This is shown clearly on a spectrogram where formants start to change at the beginning and end of each sound (Gut, 2009, p.159- 163).

Two hundred and eighty vowel tokens were studied and analyzed (i.e., twenty speakers times fourteen words). After all tokens were measured twice and the average of the two measurements was calculated, F1 and F2 values were put into tables. Table (4.1) shows the studied first two vowel formants preceding a voiced and a voiceless sound.

		hɪd	**hɪt**	**hʊd**	**fʊt**	**ədɒpt**	**ətɒmɪk**	**bʌt**	**bʌd**	**hæd**	**hæt**	**hɒd**	**hɒt**	**led**	**let**
Speaker 1	**F1**	586	527	524	571	712	733	684	703	776	750	608	643	508	579
	F2	2108	2256	1791	1486	1579	1564	1586	1630	1815	1576	1740	1818	2212	2188
Speaker 2	**F1**	607	643	624	549	705	741	692	689	872	895	675	772	597	574
	F2	1537	1996	1549	1346	1839	1883	1372	1519	1844	1875	1657	1423	1804	1975
Speaker 3	**F1**	734	688	500	522	805	673	812	691	818	898	557	773	578	657
	F2	1734	1069	1423	1293	1624	1344	1383	1471	1579	1565	1588	1306	1777	1767
Speaker 4	**F1**	607	720	643	596	669	644	926	846	910	955	726	737	555	682
	F2	2382	2309	1733	1741	2187	1958	1455	1527	2202	1966	1688	1681	2385	2288
Speaker 5	**F1**	589	584	436	531	845	789	906	815	1032	1033	550	815	572	601
	F2	2316	2385	2048	1761	1829	1726	1623	1495	1981	1946	2040	1519	2242	2096
Speaker 6	**F1**	768	726	516	525	744	820	653	662	893	1038	713	734	612	700
	F2	2153	2359	1901	1610	1913	1932	1707	1533	1841	2000	1735	1327	2457	2260

Speaker 7	**F1**	708	689	743	570	697	663	642	659	858	951	751	703	659	633
	F2	1473	2122	1116	1857	1763	1873	1216	1222	1631	1546	1185	1029	2165	2194
Speaker 8	**F1**	789	786	771	573	787	928	820	826	953	926	794	832	671	687
	F2	1609	2234	1716	1294	1942	1839	1426	1889	1864	2000	1795	1624	1878	2328
Speaker 9	**F1**	619	576	339	583	764	756	713	702	907	955	706	772	576	665
	F2	2253	2329	1224	1249	1728	1662	1282	1397	1634	1681	1188	1273	2124	2156
Speaker 10	**F1**	649	680	573	537	763	805	688	638	834	851	573	682	616	576
	F2	2177	2125	1541	1501	1928	1936	1402	1541	1857	1856	1563	1485	2116	2068
Speaker 11	**F1**	757	764	767	480	609	565	1004	1003	949	1088	886	950	729	870
	F2	1581	1849	1689	1942	2163	2426	1515	1592	1490	1680	1323	1494	2038	2074
Speaker 12	**F1**	719	777	754	535	852	859	825	706	880	777	625	816	542	592
	F2	1542	1446	1147	1765	1372	1547	1160	1269	1402	1075	1082	1120	1784	1860
Speaker 1 3	**F1**	582	439	538	519	695	819	770	667	777	827	535	552	635	630
	F2	2264	2315	1585	1343	1850	1500	1463	1433	1940	1855	1561	1637	2027	2042
Speaker 14	**F1**	579	438	526	531	704	841	771	680	801	815	536	565	625	628
	F2	2257	2301	1552	1343	1782	1540	1472	1449	1943	1865	1552	1582	2020	2055
Speaker 15	**F1**	607	711	635	593	712	651	644	873	851	897	614	799	696	719
	F2	797	1427	1341	885	1373	1529	1192	1747	1430	1457	1774	1324	2205	1939
Speaker 16	**F1**	675	678	806	708	829	814	967	941	936	971	796	906	618	728
	F2	1805	2217	1427	2579	1863	1959	1622	1604	1946	1817	1436	1363	1963	1558
Speaker 1 7	**F1**	700	738	725	656	751	807	906	783	901	877	675	740	611	687
	F2	1073	2172	1683	1577	1940	1972	1683	1665	1916	1933	1670	1738	2122	2080
Speaker 18	**F1**	682	624	797	613	621	905	830	774	1076	963	857	801	656	656
	F2	1900	2101	1154	1356	1619	1464	1208	1180	1693	1610	1220	964	1947	2094
Speaker 19	**F1**	657	658	666	614	800	764	852	814	930	923	759	740	630	695
	F2	2166	2146	1426	1360	1663	1655	1387	1434	1768	1755	1361	1388	2164	2170
Speaker 20	**F1**	567	624	486	496	815	863	712	701	877	881	517	808	639	728
	F2	2078	2021	1871	1687	1654	1256	1177	1185	1775	1690	1731	1192	1971	1756

Table (4.1) Formant measurements of all speakers

On the other hand, table (4.2) shows the average vowel sound formant values of each token. The final formant values were measured by calculating the average of the first formant of both words containing the same vowel sound. For instance, F1 values of the first speaker are 586 Hz in /hɪd/ and 527 Hz in /hɪt/. The average was calculated to have the final measurement of 556 Hz of the short vowel/ɪ/.

The formants frequencies will be plotted on a formant chart for the study population in the fifth chapter (see 5.1.1.1), which will ease the comparison procedure of the tokens to their native counterparts.

		/ɪ/	**/ʌ/**	**/æ/**	**/ə/**	**/e/**	**/ʊ/**	**/ɒ/**
Speaker 1	**F1**	556	693	763	722	543	547	625
	F2	2182	1608	1695	1571	2200	1638	1779
Speaker 2	**F1**	625	690	883	723	585	586	723
	F2	1766	1445	1859	1861	1889	1447	1540
Speaker 3	**F1**	711	751	858	739	617	511	665
	F2	1401	1426	1572	1484	1772	1358	1447
Speaker 4	**F1**	663	886	932	656	618	619	731
	F2	2345	1491	2084	2072	2336	1737	1684
Speaker 5	**F1**	586	860	1032	817	586	483	682
	F2	2350	1559	1963	1777	2169	1904	1779
Speaker 6	**F1**	747	657	965	782	656	520	723
	F2	2256	1620	1920	1922	2358	1755	1531
Speaker 7	**F1**	698	650	904	680	646	656	727
	F2	1797	1219	1588	1818	2179	1486	1107
Speaker 8	**F1**	787	823	939	857	679	672	813
	F2	1921	1657	1932	1890	2103	1505	1709

Speaker 9	**F1**	597	707	931	760	620	461	739
	F2	2291	1339	1657	1695	2140	1236	1230
Speaker 10	**F1**	664	663	842	784	596	555	627
	F2	2151	1471	1856	1932	2092	1521	1524
Speaker 11	**F1**	760	1003	1018	587	799	623	918
	F2	1715	1553	1585	2294	2056	1815	1408
Speaker 12	**F1**	748	765	828	855	567	644	720
	F2	1494	1214	1238	1459	1822	1456	1101
Speaker 13	**F1**	510	718	802	757	632	528	543
	F2	2289	1448	1897	1675	2034	1464	1599
Speaker 14	**F1**	508	725	808	772	626	528	550
	F2	2279	1460	1904	1661	2037	1447	1567
Speaker 15	**F1**	659	758	874	681	707	614	706
	F2	1112	1469	1443	1451	2072	1113	1549
Speaker 16	**F1**	676	954	953	821	673	757	851
	F2	2011	1613	1881	1911	1760	2003	1399
Speaker 17	**F1**	719	844	889	779	649	690	707
	F2	1622	1674	1924	1956	2101	1630	1704
Speaker 18	**F1**	653	802	1019	763	656	705	829
	F2	2000	1194	1651	1541	2020	1255	1092
Speaker 19	**F1**	657	833	926	782	662	640	749
	F2	2156	1410	1761	1659	2167	1393	1374
Speaker 20	**F1**	595	706	879	839	683	491	662
	F2	2049	1181	1732	1455	1863	1779	1461

Table (4.2) Average formant measurement of all speakers

In spite of the fact that a detailed discussion and comparison will be given in the next chapter, it is necessary to shed light on some points regarding the participants' initial and final measurements. Generally speaking, it is difficult to have a clear cut decision, as there are several factors affecting the sound production and, thus, measurements. Hence, as discussed in the second chapter (see 2.5) the same word might differ in production even if it was uttered by the same speaker in different situations. For example, saying the same phrase "I am here" while yelling, speaking loud, whispered, as a question etc., will have different measurements as a result of the difference in pitch, air stream, intonation etc.

Each word pair of every vowel was compared in isolation to figure out if the first or the second formant was higher, and to see if this height in formant measurement was in the case of preceding a voiced or a voiceless sound. All of the twenty participants had pronunciation differences in the formant measurement phase. It was expected that the mid-central vowel /ə/ will have the most notable variation. However, it was the mid-front vowel /e/ and low-back vowel /ɒ/that had scored the highest rate of variations. In order to present a clear and a simple analysis of the first two formants of the studied vowels, the results of each vowel will be discussed separately. A brief commentary on the formant measurements of each vowel preceding a voiced and a voiceless sound is given first, then the average measurement commentary is given in detail for each token. Finally, a discussion of the duration of each vowel sound is given, illustrated with tables.

4.1.1. Formant 1

The following subsections discuss in detail the first formant measurements of the initial measurements of the twenty tokens of the seven studied vowels, in terms of the highest and lowest scores, in addition to similarities among the measurements of some participants. This will be followed with a discussion of the average measurements of the first formant for all tokens. Finally, a brief commentary is given at the end summarizing the major points of this section.

4.1.1.1. Vowel /ɪ/

The measurements of the first formant of the high central /ɪ/ differed when preceding a voiced and a voiceless sound. The highest measurement scored was 798 Hz for the eighth speaker in the case of preceding a voiced sound, voiced plosive /d/. On the other hand, the lowest score was for token number fourteen with 438 Hz in the case of preceding the voiceless sound /t/. Among the twenty tokens only two had the measurements of 438 Hz and 439 Hz, which were the lowest among the rest of the tokens. About 55% of the tokens had their F1 measurement around six hundred Hertz and about 45% of them had their F1 measurement around seven hundred Hertz. It was noted that seven speakers, namely 4, 10, 11, 12, 15, 16 and 17, had scored a higher F1 for the studied vowel when preceding the voiceless plosive /t/.

The average measurements of each token were calculated by having the mean of both F1s preceding voiced and voiceless sounds as shown in table (4.2). Results of /ɪ/ sound varied from 508 Hz to 787Hz. Speakers 1, 5, 9, 13, 14 and 20 showed the lowest F1 measurements while the rest of the participants, namely speakers 2, 4, 7, 10, 15, 16, 18 and 19 who had higher measurements that ranged from 625 Hz up to 698 Hz in addition to speakers 3, 6, 8, 11, 12 and 17 who scored the highest F1 measurements for the high central /ɪ/ ranging from 711Hz to 787 Hz.

4.1.1.2. Vowel /ʌ/

The first formant measurements of the low central /ʌ/ differed when preceding a voiced and a voiceless sound. However, this vowel was the only central vowel that had an F1 measurement of 1004 Hz which is the highest score produced by the eleventh speaker. It is worth mentioning that speaker 11 had almost similar F1 measurements in both cases, with 1003 Hz preceding a voiced sound and 1004 Hz preceding a voiceless one. The measurements of the low central vowel varied from 638 Hz to 1004 Hz, where the former is the lowest F1 measurement recorded for vowel /ʌ/ as produced by speaker 10 when preceding a voiceless sound.

The majority of vowel /ʌ/ F1 average measurements were between 650 Hz and 765 Hz, where the former is the lowest score and the highest is 1003 Hz as produced by speaker 11. Speaker 16 was the only one who had the score of 954 Hz among the other speakers who had F1 measurements under the same variation as shown in table (4.2).

4.1.1.3. Vowel /æ/

The measurements of the vowel /æ/ varied from 750 Hz to 1088 Hz, the former was the lowest score produced by the first speaker and the latter is the highest as produced by the eleventh speaker. Unlike the previously discussed vowels, the low front /æ/ had a higher F1 when preceded a voiceless sound, where more than the half of the tokens showed higher F1, namely speakers 2, 3, 4, 6, 7, 9, 10, 11, 13, 15 and 16 as shown in table (4.1).

Similar to the other vowels, the low central /æ/ had its variations, as nine speakers had their average F1 measurements ranging from 802 Hz to 889 Hz, while seven speakers had theirs ranging from 904 Hz to 965 Hz. The lowest first formant of the average measurements was of the first speaker with 763 Hz and the highest was 1032 Hz as produced by speaker 5.

4.1.1.4. Vowel /ə/

The schwa sound was the only vowel sound to be studied in a different formula instead of CVC as the rest of the studied vowels since it does not occur in this form (see 1.4). It was in a VCVCVC formula preceding the voiceless /t/ and VCVCC preceding the voiced /d/ sound. As shown in table (4.1), /ə/ had different measurements preceding the voiced plosive /d/ and the voiceless plosive /t/. The measurements ranged from 565 Hz as the lowest score produced by speaker 11 to 928 Hz as the highest score produced by speaker 8. Even though the measurements are different in the case of preceding a voiced and a voiceless sound; however, some speakers showed huge measurement differences compared to the others, namely speakers 3, 8, 13 and 18. On the other hand, speaker 12 showed a very close F1 measurements in both cases, with 852 Hz preceding a voiced stop and 859 Hz preceding a voiceless one. Another thing is that half of the tokens had a higher F1 measurement when preceding a voiceless sound when producing the word atomic /ətɒmɪk/.

The average measurements of the mid central /ə/ varied from 587 Hz up to 857 Hz. Most of the tokens had their F1 measurements ranging from722 Hz to 784 Hz. Speakers 5, 8, 12, 16 and 20 had their measurements ranging from 817 Hz to 857 Hz where the later is the highest as produced by speaker 8. Lower measurements were produced by speakers 4, 7 and 15. However, speaker 11 was the only one who had the measurement of 578 Hz which is the lowest score for the first formant of /ə/.

4.1.1.5. Vowel /e/

The highest F1 measurement of the mid front /e/ was 870 Hz when preceding a voiceless sound as produced by speaker 11. On the other hand the lowest measurement was recorded for speaker 1 with a measurement of 508 Hz. All of the twenty tokens had different measurements of vowel /e/ F1 measurement, where almost all of the speakers had higher F1s in the case of preceding the voiceless sound

/t/. However, speaker 18 was the only one to have the exact measurement in both cases with a measurement of 656 Hz.

The vowel sound /e/ had similar average measurements range compared to the high central vowel sound/ɪ/. The lowest average measurement for the first formant was 543 Hz for the first token and the highest was 799 Hz as produced by speaker 11. It is worth mentioning that the F1 measurements of the rest of the thirteen tokens had ranged from 617 Hz up to 683 Hz.

4.1.1.6. Vowel /ʊ/

The high back /ʊ/ had the lowest F1 measurement while preceding a voiced sound with 339 Hz as produced by speaker 9, and its highest in the same case while preceding /d/ sound when produced by speaker 16, with the measurement of 806 Hz as shown in table (4.1). All of the tokens scored a higher measurement when preceding a voiced sound; only seven tokens were different from the rest, where they had higher F1 measurements when preceding a voiceless sound, namely speakers 1, 3, 5, 6, 9, 14 and 20.

The average measurements of the vowel sound /ʊ/ had more variations compared to /ɪ/ and /e/ vowel sounds. The lowest average measurement was 511 Hz for the third speaker and the highest was for speaker 17 with 757 Hz. Only two speakers had the measurements of 705 Hz and 757 Hz among the twenty tokens. The measurements of fifteen speakers varied from 511 Hz to 690 Hz and the rest, namely speaker 5, 9 and 20, had the measurements of 438Hz, 461 Hz and 491 Hz respectively.

4.1.1.7. Vowel /ɒ/

The first formant measurements of the vowel sound /ɒ/ had similar ranging rate to some of the studied vowels. The lowest F1 measurement was for speaker 20 with 517 Hz followed by close measurements in the same rate as produced by speakers 13 and 14 as shown in table (4.1). The highest score for the vowel /ɒ/ first measurement was 950 Hz for the eleventh token when preceding a voiceless sound, speaker 16 was the only speaker who had a closer F1 measurement of 906 Hz. Speakers 1, 2, 10, 12, 15 and 17 had F1 measurements ranging from 608 Hz to 682 Hz, some of which were in the case of preceding a voiced sound and others in the case of preceding a voiceless one.

The lowest score of the F1 average measurements of the vowel sound /ɒ/ was 543 Hz by speaker 13 followed with the score of 550 Hz by speaker 14. However, the highest score was of the eleventh speaker of 918 Hz. Nine of the tokens had their F1 average measurements ranging from 706 Hz to 749 Hz, where speakers 2 and 6 shared the same F1 measurement of 723 Hz.

4.1.1.8. Concluding Remarks

The measurements of the first formant of each studied vowel, initial or average, had varied among the twenty tokens. Some had higher F1s, some had lower F1s and some have had the same measurement in both cases. For instance, speaker 18 had the same F1 measurement with 656 Hz in the production of /e/ vowel sound and speaker 5 had an F1 with 1032 Hz preceding a voiced sound and 1033 Hz preceding a voiceless one when producing the low front /æ/. In addition, higher measurements were reached in the case of preceding a voiceless sound in all of the studied vowel sounds as shown in table (4.1) and as mentioned previously in section (4.2.1). It was also noticeable that speaker 11 had standing results in comparison to the other participants, where she had the highest formant measurements in the production of each of the following vowel sounds: /ə/, /æ/, /ʌ/ and /ɒ/.

4.1.2. Formant 2

The following subsections discuss in detail the second formant measurements of the initial and average measurements of all tokens. Similar to section (4.2.1) differences and similarities in F2 measurements among speakers are discussed in this section. Concluding with a brief commentary summarizing the important points of this section.

4.1.2.1. Vowel /ɪ/

The second formant of the high central /ɪ/ did not show a lot of variations among the twenty tokens, almost half of the tokens had an F2 measurement ranging from 2101 Hz to2285 Hz, which is the highest score as produced by the fifth speaker. Unlike the first group, the rest of the speakers had a measurement of the second formant ranging from 1069 Hz to1996 Hz. However, speaker fifteen was the only one that scored the lowest measurement for vowel /ɪ/ with 797 Hz while preceding a voiced plosive. It was noticed that F2 measurements varied with a slight difference when preceding a voiced and a voiceless sound. However, speakers 7, 8, 15, 16, 17 and 18 showed lower F2 measurement when preceding a voiced sound compared to their pairs, especially speaker fifteen with a difference of 630 Hz.

Regarding the average measurements of the high central /ɪ/, twelve speakers had their F2 measurements around 2000 Hz ranging from 2000 Hz up to 2291 Hz, which was the highest score produced by speaker 9. On the other hand, only eight speakers had their F2 ranging from 1112 Hz to 1921 Hz, where the former is the lowest measurement among the twenty tokens. Compared to the first formant measurements of the vowel, it is noted that F1 had more variations among the tokens.

4.1.2.2. Vowel /ʌ/

Different from the other studied vowel sounds, the low central /ʌ/ was the one that did not have second formant measurement up to two thousand hertz. The lowest F2 measurement for this vowel was for speaker 12 in the case of preceding a voiceless sound with 1160 Hz. On the other hand, the highest score was of 1889 Hz in the case of preceding a voiced sound as produced by speaker 8. Seven of the twenty tokens had higher F2 measurements when preceding the voiceless /t/, namely speakers 5, 6, 13, 14, 16, 17 and 18.

Similarly the low central /ʌ/ average measurements were not higher than 1674 Hz, whereas the lowest measurement was of speaker 20 with 1181 Hz. Speakers 2, 3, 4, 10, 13, 14, 15 and 19 had an F2 measurement ranging from 1410 Hz to 1491 Hz.

4.1.2.3. Vowel /æ/

The highest measurement of the second formant of this targeted vowel sound was of the fourth speaker with 2202 Hz, when preceding the voiced plosive /d/ whereas the lowest score was of speaker 12 with 1402 Hz in the same case of preceding a voiced sound. No doubt that measurements will vary among speakers and within a speaker. However, two speakers had the same F2 measurement of 2000 Hz when preceding a voiceless sound, namely speakers 6 and 8.Similar to the low back /ɒ/, only eight among the twenty tokens had higher F2 measurement when preceding a voiceless sound, namely speakers 2, 6, 8, 9, 10, 11, 15 and 17 as shown in table (4.1).

Average measurements of the low front /æ/ were dissimilar to the other vowel sounds. The highest measurement was of the fourth speaker with 2084 Hz, while the rest of the speakers had their measurements ranging from 1238 Hz up to 1963 Hz, where the former is the lowest score as produced by speaker 12.

4.1.2.4. Vowel /ə/

The mid central /ə/ initial F2 measurements ranged from 1344 Hz up to 2426 Hz. The former is the lowest score as produced by speaker 3 in the case of preceding a voiceless sound and the latter is the highest as produced by speaker 11 in the same case. Even though F2 measurements differed while preceding a voiced and a voiceless sound for each token, it was noted that some tokens had a slight difference in their F2 measurements in each case as with speakers 1, 6, 10 and 19 as shown in table (4.1). On the other hand, speakers 12, 11 and 15 showed the biggest differences in their F2 measurements compared to the other tokens. Nine among the twenty tokens had a higher F2 measurement when preceding a voiceless sound, namely speakers 2, 6, 10, 11, 12, 15, 16 and 17.

Regarding the average measurements of the second formant of /ə/ sound, only two speakers had the measurements of 2294 Hz for the eleventh speaker and 2072 Hz for the fourth speaker, where the latter is the highest score among all tokens. The lowest score was of speaker 15 with 1451 Hz, followed with 1455 Hz, 1459 Hz, and 1484 Hz for speakers 20, 12, and 3. The measurements of the rest of the tokens ranged from 1541 Hz up to 1956 Hz as shown in table (4.2).

4.1.2.5. Vowel /e/

The highest F2 measurement for the vowel sound /e/ was produced by the sixth speaker in the case of preceding a voiced sound with 2457 Hz whereas the lowest measurement was in the case of preceding a voiceless sound with 1756 Hz as produced by speaker 20. Speakers 1, 4, 5, 6, 7, 9, 10, 11, 13, 14, 17 and 19 showed higher F2 measurements in both cases, preceding a voiced and a voiceless sound, compared to the other speakers. As in the measurements of the other studied vowels, some tokens had a higher F2 measurement when preceding the voiceless plosive /t/, which are speakers 2, 7, 8, 9, 11, 12, 13, 14 and 18.

The average measurements as shown in table (4.2) were as follows: fifteen speakers had the measurements ranging from 2020 Hz up to 2358 Hz, where the later is the highest measurement for the mid front /e/. The measurements of the rest of the speakers ranged from 1760 Hz up to 1889 Hz. The lowest F2 measurement was of speaker 16 with 1760 Hz.

4.1.2.6. Vowel /ʊ/

Unlike the measurements of the first formant of this targeted vowel, namely /ʊ/, its second formant measurements had less variations. As can be shown in table (4.1), only one speaker had an F2 measurement of 885 Hz when preceding a voiceless sound, which is the lowest F2 score for the high back /ʊ/ as produced by speaker 15. Speakers 5 and 16 had the highest F2 scores with 2048 Hz for the former and 2579 Hz for the latter. The score of the fifth speaker was in the case of preceding a voiced sound, while the score of the sixteenth speaker was in the case of preceding a voiceless sound. The rest of the seventeen speakers had their F2 measurements ranging from 1116 Hz up to 1942 Hz.

The average measurements were slightly different, where the highest score of 2003 Hz was scored by the same speaker who had the highest score in the primary measurements, speaker 16. The rest of the tokens varied from 1113 Hz to 1904 Hz. Five tokens had close measurements to one another; however, two of them shared the same F2 measurement with 1447 Hz, namely speakers 2 and 14.

4.1.2.7. Vowel /ɒ/

The measurements of the second formant of the low back /ɒ/ were somehow similar to the measurements of the second formant of the high back /ʊ/. The lowest F2 measurement was scored by speaker 18 with 964 Hz when producing the utterance /hɒt/. However, a huge formant difference between the highest and the lowest measurements occurred, where the highest score was of the fifth speaker with 2040 Hz. The rest of the tokens had their measurements ranging from 1129 Hz to 1818 Hz. It was noted that speakers 1, 9, 11, 12, 13, 14, 17 and 19 had a higher F2 measurements when preceding a voiceless sound compared to the ones preceding a voiced sound.

Regarding the average measurements of the second formant of sound /ɒ/, the lowest measurement was for speaker 18 with 1092 Hz, followed with closer measurements for speakers 7 and 12 with 1107 Hz for the former and 1101 Hz for the latter. Speakers 2, 6, 10, 13, 14 and 15 had an F2 measurement ranging from 1524 Hz to 1599 Hz. On the other hand, speakers 1, 5, 8, and 17 scored higher F2 measurements ranging from 1704 Hz to 1779 Hz, where both speakers 1 and 5 shared the same measurement of 1779 Hz, which is the highest F2 average measurement for the sound /ɒ/.

4.1.2.8. Concluding Remarks

Variations among the second formant measurements of the studied vowels occurred in both initial and final measurements. A number of tokens had their F2 measurement higher when preceding a voiced sound, while others had theirs higher when preceding a voiceless one, and as for the first formant measurements some tokens had the same F2 measurements for the same vowel sound. Starting with the high front /ɪ/ which had some variations in a similar manner to that of the rest of the studied vowels, it was the only vowel to score a difference of 630 Hz in the production of the vowel in both tokens of preceding a voiced and a voiceless sound, namely speaker 18. As for the low back /ɒ/, a huge difference was noticed in the primary F2 measurement between the lowest and the highest score with 924 Hz difference. Both of the vowel sounds /ʊ/ and /ʌ/ did not reach the measurement of two thousand hertz as the rest of the studied vowel sounds. Three of the seven vowels had the same F2 measurement, namely /æ/, /ɒ/ and /ʊ/. The /æ/ vowel sound had the F2 measurement of 2000 Hz for both speakers 6 and 8, and the/ʊ/ vowel sound had the same final F2 measurement of 1447 Hz for speakers 2 and 14. Finally, low back /ɒ/had the final measurements of speakers 1 and 5 with 1779 Hz.

4.2. Duration Analysis

Unlike vowel formant measurements, measuring vowel duration was a harder task to be accomplished. The difficulty did not lie in the procedure of measuring the length of each vowel, as covered in (3.3.1.1) in the data collection chapter, but in the upcoming phase of analyzing and comparing the results of the study to their native counterparts.

The researcher was willing to compare the duration of English short vowels as produced by advanced Libyan female speakers to their native counterpart, even though finding a reference or absolute duration measurements was time consuming and not easily found as most of the researches do not include duration measurements. The only duration measurement of British English vowels found was done by Wells in1962, which is about 59 years old. It is possible to compare the results of this study to the ones of Wells' regardless of how this comparison will affect the validity and reliability of the result for the reason that language is changeable over time and differences among recent duration measurements must occur.

Numerous factors were considered in taking this step and it was not surprising that such obstacles faced other studies concerned with the acoustical properties of English vowels spoken by non native speakers. As explained by many writers, vowel duration was a complicated task due to the fact that delimitation of sound units in an acoustic sense necessitates dealing with utterance segmentation, which might be complicated by variability in production and aural quality perceptions of sounds. Even if it is possible, the duration rates offered may not correlate to language length assessments. Absolute duration values should not be sought while making vowel claims, because the length of such vowels varies greatly depending on context and circumstances such as what utterance, how rapidly or slowly it is uttered, and whether it is followed by a voiced or voiceless consonant as described earlier, etc. In addition to the fact that the concept of using an old reference will not be valid because the used programs and measurement tools have changed over the years. For instance, Wells used an old tool to measure the formant and duration of the British vowels and then those measurements were revised and modified to match today's measurement values.

Due to the above mentioned factors, comparing British English vowels' duration to the ones of this study will not be done. However, British English short vowel duration as produced by advanced Libyan female EFL learners will be provided in order to help further research on the topic.

All of the upcoming description of the seven short vowels' duration is based on the primary vowel duration preceding voiceless and voiced consonants, followed with a discussion of the final duration measurements of each vowel sound among the twenty tokens as shown in tables (4.3–4.10). It should be kept in mind that the vowel duration and sounds duration in general are affected by a number of factors as mentioned earlier.

As suggested by Ahmed (2008) vowel length is calculated by measuring the time between the start of energy in F1 and the offset of energy in F1 and F2, which indicate vowel boundaries. The VOT of the voiceless stop that may precede the vowel was not included in the vowel duration calculation. (Ahmed, 2008, p.113). The duration of each vowel is presented in the tables in seconds; table (4.3) presents the duration of the seven vowel sounds preceding a voiced and a voiceless sound. This will be followed with a discussion of the average duration measurements of each vowel sound separately as in (4.2.1) and (4.2.2).

	hɪd	**hɪt**	**hʊd**	**fʊt**	**ədɒpt**	**ətɒmɪk**	**bʌt**	**bʌd**	**hæd**	**hæt**	**hɒd**	**hɒt**	**led**	**let**
Speaker 1	0.065	0.049	0.063	0.052	0.058	0.064	0.095	0.067	0.010	0.088	0.073	0.065	0.086	0.085
Speaker 2	0.064	0.083	0.087	0.082	0.065	0.057	0.080	0.082	0.013	0.011	0.085	0.098	0.084	0.010
Speaker 3	0.063	0.067	0.010	0.052	0.041	0.033	0.077	0.079	0.043	0.049	0.069	0.059	0.010	0.056
Speaker 4	0.061	0.034	0.037	0.036	0.045	0.038	0.046	0.066	0.050	0.062	0.041	0.039	0.053	0.056

Speaker 5	0.069	0.075	0.053	0.067	0.051	0.042	0.078	0.090	0.076	0.073	0.050	0.064	0.093	0.093
Speaker 6	0.057	0.064	0.055	0.037	0.023	0.032	0.047	0.057	0.071	0.068	0.059	0.057	0.067	0.068
Speaker 7	0.057	0.043	0.071	0.054	0.041	0.035	0.074	0.065	0.011	0.012	0.063	0.075	0.079	0.062
Speaker 8	0.074	0.033	0.043	0.054	0.032	0.037	0.040	0.037	0.048	0.045	0.044	0.038	0.084	0.037
Speaker 9	0.044	0.047	0.054	0.030	0.041	0.033	0.066	0.047	0.074	0.059	0.055	0.034	0.053	0.035
Speaker 10	0.067	0.074	0.056	0.069	0.047	0.049	0.080	0.061	0.077	0.071	0.054	0.065	0.069	0.069
Speaker 11	0.051	0.049	0.036	0.021	0.030	0.031	0.043	0.042	0.058	0.042	0.042	0.036	0.064	0.045
Speaker 12	0.037	0.048	0.057	0.055	0.043	0.044	0.064	0.053	0.056	0.053	0.050	0.083	0.053	0.058
Speaker 13	0.060	0.024	0.052	0.040	0.036	0.044	0.038	0.048	0.063	0.071	0.056	0.039	0.055	0.050
Speaker 14	0.039	0.042	0.033	0.033	0.040	0.027	0.039	0.054	0.042	0.037	0.032	0.038	0.043	0.046
Speaker 15	0.043	0.046	0.035	0.032	0.033	0.032	0.040	0.054	0.045	0.051	0.025	0.031	0.050	0.054
Speaker 16	0.046	0.035	0.031	0.036	0.043	0.035	0.049	0.052	0.054	0.047	0.035	0.034	0.036	0.030
Speaker 17	0.021	0.054	0.049	0.042	0.047	0.033	0.043	0.053	0.068	0.060	0.037	0.036	0.058	0.055
Speaker 18	0.036	0.039	0.049	0.038	0.031	0.053	0.047	0.043	0.050	0.057	0.030	0.046	0.043	0.055
Speaker 19	0.030	0.036	0.038	0.037	0.028	0.026	0.050	0.050	0.056	0.048	0.043	0.031	0.048	0.048
Speaker 20	0.036	0.051	0.055	0.038	0.040	0.048	0.045	0.049	0.051	0.069	0.049	0.051	0.059	0.056

Table (4.3) Duration measurements of all speakers

4.2.1. Vowel /ɪ/

As shown in table (4.3), vowel duration varied from a speaker to another. Starting with the high front /ɪ/, the primary duration measurements of this vowel of speakers 1, 2, 3, 4, 5, 10 and 13 were close in the case of preceding the voiced plosive /d/. Other speakers had the same vowel duration in the same case, namely speakers 6 and 7 with 0.057s and speakers 18 and 20 with 0.036s. It is clear that the vowel length is longer when preceding a voiced sound in all tokens except for seven of them, which are 2, 5, 6, 10, 12, 17 and 20.

Regarding the average measurements of /ɪ/ sound as shown in table (4.4), the shortest duration measurement was of speaker 14 with 0.029s. Speakers 17, 18 and 19 had longer durations with a slight difference, where the first two had the same vowel duration of 0.037s, as well as speakers12 and 13 with 0.042s and speakers 7 and 11 with 0.050s long. The longest duration among the twenty tokens was of the second speaker with 0.073s.

Speaker 1	**Speaker 2**	**Speaker 3**	**Speaker 4**	**Speaker 5**
0.057	0.073	0.065	0.047	0.072
Speaker 6	**Speaker 7**	**Speaker 8**	**Speaker 9**	**Speaker 10**
0.060	0.050	0.053	0.045	0.070
Speaker 11	**Speaker 12**	**Speaker 13**	**Speaker 14**	**Speaker 15**
0.050	0.042	0.042	0.029	0.044
Speaker 16	**Speaker 17**	**Speaker 18**	**Speaker 19**	**Speaker 20**
0.040	0.037	0.037	0.033	0.043

Table (4.4) Average duration measurements of /ɪ/ sound of all speakers

4.2.2. Vowel /ʌ/

The duration of this vowel differed when preceding a voiced and a voiceless sound. The longest duration was in the case of preceding a voiceless sound with

0.095s. as produced by the first speaker and the shortest was of speaker 13 with a duration of 0.038s. Only eight speakers had a longer /ʌ/ when preceding the voiceless plosive /t/, they are, 1, 7, 8, 9, 10, 11, 12 and 18, some of which were longer in duration with only one second as can be seen clearly in table (4.3). Similar to the duration measurements of the high back /ʊ/, one speaker had the same vowel duration in both cases of preceding a voiced and a voiceless sound, which is speaker 19 with a duration of 0.050s.

Average measurements started from 0.038s up to 0.084s long, the former was the shortest duration for /ʌ/ sound as produced by speaker 8 and the latter was the longest as produced by the fifth speaker. As shown in table (4.5), speakers 1 and 2, 16 and 19, 15 and 20 had the same durations. It is noteworthy that speaker 10 had the same vowel duration for the high front /ɪ/ and the low central /ʌ/ with 0.070s for each.

Speaker 1	**Speaker 2**	**Speaker 3**	**Speaker 4**	**Speaker 5**
0.081	0.081	0.078	0.056	0.084
Speaker 6	**Speaker 7**	**Speaker 8**	**Speaker 9**	**Speaker 10**
0.052	0.069	0.038	0.056	0.070
Speaker 11	**Speaker 12**	**Speaker 13**	**Speaker 14**	**Speaker 15**
0.042	0.058	0.043	0.046	0.047
Speaker 16	**Speaker 17**	**Speaker 18**	**Speaker 19**	**Speaker 20**
0.050	0.048	0.045	0.050	0.047

Table (4.5) Average duration measurements of /ʌ/ sound of all speakers

4.2.3. Vowel /æ/

Unlike other vowel sounds, low front /æ/ shortest and longest duration was produced by the same speaker, namely speaker 1, with a remarkable difference between the two measurements. The shortest duration was 0.010s when preceding a voiced sound and the longest was 0.088s when preceding a voiceless one, as can be seen in table (4.3). Also, both of the second and the seventh speaker showed shorter vowel duration in both cases compared to the rest of the tokens. As discussed previously, a vowel sound is shorter when preceded by a voiceless sound. However, speakers 3, 4, 7, 13, 15, 18 and 20 had longer vowel sound when preceding the voiceless plosive /t/.

The longest average duration measurement was of speakers 5 and 10 with 0.074s long, and the shortest was of the seventh speaker with 0.011s long. Speaker 2 was the only speaker who had a very close duration measurement to the seventh speaker with only 0.012s long. Even though durations varied among speakers, still some had the same vowel duration. 0.050s was the vowel duration of both speakers 11 and 16. Also 0.046s was of speakers 3 and 8.

Speaker 1	**Speaker 2**	**Speaker 3**	**Speaker 4**	**Speaker 5**
0.049	0.012	0.046	0.056	0.074
Speaker 6	**Speaker 7**	**Speaker 8**	**Speaker 9**	**Speaker 10**
0.069	0.011	0.046	0.066	0.074
Speaker 11	**Speaker 12**	**Speaker 13**	**Speaker 14**	**Speaker 15**
0.050	0.054	0.067	0.039	0.048
Speaker 16	**Speaker 17**	**Speaker 18**	**Speaker 19**	**Speaker 20**
0.050	0.064	0.053	0.052	0.060

Table (4.6) Average duration measurements of /æ/ sound of all speakers

4.2.4. Vowel /ə/

Looking at table (4.3), nine of the twenty tokens had a longer /ə/ sound when preceding a voiceless sound. Speakers 11 and 12 had a longer /ə/ when preceding a voiceless sound with a difference of one second only compared to the duration of preceding a voiced sound, 0.030s and 0.031s for the eleventh speaker and 0.043s and 0.044s for the twelfth speaker. The longest duration for this studied vowel was of the second speaker with 0.065s in the case of preceding the voiced stop /d/, on the other hand, the shortest duration of this mid central vowel was of the sixth speaker with 0.023s when preceding a voiced sound. Speaker 19 showed noticeable shorter vowel duration measurements compared to the other speakers.

The average measurements started from 0.027s as produced by speaker 19 up to 0.061s as produced by both of speakers 1 and 2, the former duration measurement is the shortest and the latter is the longest for the mid central /ə/ as shown in table (4.7). Speakers 3 and 9 had the same vowel duration of 0.037s. Similarly, speakers 13 and 17 had the same vowel duration of 0.040s.

Speaker 1	**Speaker 2**	**Speaker 3**	**Speaker 4**	**Speaker 5**
0.061	0.061	0.037	0.041	0.046
Speaker 6	**Speaker 7**	**Speaker 8**	**Speaker 9**	**Speaker 10**
0.027	0.038	0.034	0.037	0.048
Speaker 11	**Speaker 12**	**Speaker 13**	**Speaker 14**	**Speaker 15**
0.030	0.043	0.040	0.033	0.032
Speaker 16	**Speaker 17**	**Speaker 18**	**Speaker 19**	**Speaker 20**
0.039	0.040	0.042	0.027	0.044

Table (4.7) Average duration measurements of /ə/ sound of all speakers

4.2.5. Vowel /e/

Vowel /e/ is the only vowel to have three speakers having the same vowel duration measurement when preceding a voiced and a voiceless sound. The fifth speaker had the same vowel duration with 0.093s, speaker 10 with 0.069s as well as speaker 19 with 0.048s long. The longest duration for this mid front vowel was of the fifth speaker mentioned earlier and the shortest was of speakers 2 and 3 with 0.010s. The former was in the case of preceding a voiceless sound while the later was in the case of preceding a voiced one.

All of these named pairs had the same vowel duration, 4 and 11 with (0.054s), 3 and 16 with (0.033s), 13 and 15 with (0.052s). The duration of 0.014s is the shortest duration for this studied vowel as produced by speaker 7, whereas the longest was produced by speaker 5 with 0.093s long as can be seen in table (4.8).

Speaker 1	**Speaker 2**	**Speaker 3**	**Speaker 4**	**Speaker 5**
0.085	0.047	0.033	0.054	0.093
Speaker 6	**Speaker 7**	**Speaker 8**	**Speaker 9**	**Speaker 10**
0.067	0.014	0.060	0.041	0.069
Speaker 11	**Speaker 12**	**Speaker 13**	**Speaker 14**	**Speaker 15**
0.054	0.055	0.052	0.044	0.052
Speaker 16	**Speaker 17**	**Speaker 18**	**Speaker 19**	**Speaker 20**
0.033	0.056	0.049	0.048	0.057

Table (4.8) Average duration measurements of /e/ sound of all speakers

4.2.6. Vowel /ʊ/

More speakers had the same vowel duration when producing the vowel sound /ʊ/, some were in the case of voiced sound and some were in the case of preceding a voiceless one, they are speakers 1 and 3, 4 and 16, 6 and 19, 7 and 8, 20 and 20, 17 and 18. All of those similar vowel durations were in the case of preceding a voiceless sound except for the last pair as shown in table (4.5). Only four speakers had a longer /ʊ/ when preceding the voiceless /t/. However, speaker 3 had a longer vowel duration with a great difference compared to the other three speakers with 0.010s preceding the voiced /d/ and 0.052s preceding the voiceless /t/. Unlike other tokens, speaker 14 had the same vowel duration with 0.033s in both cases.

Regarding the average duration measurements of this high back vowel, the longest duration was of the second speaker with 0.084s. In contrast, the shortest duration was of the eleventh speaker with 0.028s. A number of tokens had the same vowel duration, namely 14, 15 and 16 with a duration of 0.033s. Speakers 6, 13 and 20 with 0.046s as well as speakers 7 and 10 with a duration of 0.062s.

Speaker 1	**Speaker 2**	**Speaker 3**	**Speaker 4**	**Speaker 5**
0.057	0.084	0.031	0.036	0.060
Speaker 6	**Speaker 7**	**Speaker 8**	**Speaker 9**	**Speaker 10**
0.046	0.062	0.048	0.042	0.062
Speaker 11	**Speaker 12**	**Speaker 13**	**Speaker 14**	**Speaker 15**
0.028	0.056	0.046	0.033	0.033
Speaker 16	**Speaker 17**	**Speaker 18**	**Speaker 19**	**Speaker 20**
0.033	0.045	0.043	0.037	0.046

Table (4.9) Average duration measurements of /ʊ/ sound of all speakers

4.2.7. Vowel /ɒ/

The shortest duration for the low back /ɒ/ was when preceding the voiced plosive /d/ with 0.025s long as produced by speaker 15. On the other hand the longest duration was of speaker 2 with 0.098s, who showed longer durations in both cases compared to the other tokens. Unlike the high back vowel /ʊ/, none of the twenty speakers had the same vowel duration in both cases. As can be seen in table (4.5) showing the initial duration measurements, speakers 14, 16 and 17 had close durations when preceding a voiced and a voiceless plosive.

The following table shows the average duration measurements of the twenty tokens for vowel /ɒ/. As can be seen, speaker 15 was the one who produced the shortest /ɒ/ sound with 0.028s. Speakers 11, 14, 16, 17, 18 and 19 had very close durations, starting from 0.035s up to 0.039s long. On the other hand, the longest duration scored was 0.091s for the second speaker, which is very high compared to the other durations of other speakers.

Speaker 1	Speaker 2	Speaker 3	Speaker 4	Speaker 5
0.069	0.091	0.064	0.040	0.057
Speaker 6	**Speaker 7**	**Speaker 8**	**Speaker 9**	**Speaker 10**
0.058	0.069	0.041	0.044	0.059
Speaker 11	**Speaker 12**	**Speaker 13**	**Speaker 14**	**Speaker 15**
0.039	0.066	0.047	0.035	0.028
Speaker 16	**Speaker 17**	**Speaker 18**	**Speaker 19**	**Speaker 20**
0.034	0.036	0.038	0.037	0.050

Table (4.10) Average duration measurements of /ɒ/ sound of all speakers

4.2.8. Concluding Remarks

Each vowel duration varied from speaker to another and some tokens were unexpectedly much lower than those of other speakers. Starting with the open front vowel /æ/, where its duration varied from 0.011 seconds to 0.074 seconds and about two thirds of the tokens' measurements were about 0.050 seconds. It is worth mentioning that /æ/ sound scored the lowest vowel duration among the seven short vowels of 0.011 seconds, followed by the mid front /e/ with the duration of 0.014 seconds.

Both of the back vowels /ʊ/ and /ɒ/ durations started with 0.028 seconds. However, /ɒ/ scored a higher duration of 0.091 seconds than/ʊ/ with the duration of 0.084 seconds. The/ɒ/ sound duration ranged between 0.035 seconds and0.043 seconds. In a similar case, two thirds of the tokens of /ʊ/ sound ranged between 0.033 seconds and 0.045 seconds.

Scored duration measurements for both of the high central /ɪ/ and the mid central /ə/ were close. The duration measurements of the /ə/ sound varied from 0.027 seconds to 0.061 seconds and /ɪ/ duration measurements started with 0.029 seconds to 0.073 seconds. Contrastively, the low central /ʌ/ started with a higher measure compared to the last two starting with 0.042 seconds, which is higher with about 0.014 seconds, and scoring 0.084 seconds as its highest duration. The last thing to be mentioned is the vowel that scored the highest duration among all vowels, the mid front /e/. As mentioned previously, its duration started with 0.014 seconds and goes up to 0.093 seconds.

CHAPTER FIVE

DISCUSSION AND CONCLUSION

5.0. Introduction

This chapter presents the findings of the study. The research questions are answered and discussed in the light of the results obtained from the analyzed data in the previous chapter. It also presents the limitations that had been encountered during conducting the study. Also, implications of the results were discussed. Finally, some suggestions for further research are given.

5.1. Discussion

This study aimed at exploring and describing the acoustic properties of the English short vowels as produced by advanced Libyan female EFL university students in Tripoli faculty of Education. The investigated properties focused on are the quantity and quality of these vowels, (i.e., formants and duration). Another goal for this study was to explore and describe how these acoustic properties of short vowels that have been gained from Libyan female advanced students (see 3.3.4) differ from those produced by female native speakers of British English. Here is a reminder of the research questions of this study:

1. What are the acoustic properties of English short vowels as produced by advanced female EFL university students in Tripoli faculty of Education?
2. How close these acoustic properties are to those of the short vowels produced by female native speakers of British English?

To fulfill these aims and answer these research questions, a recording of fourteen carrier phrases of twenty Libyan females was conducted making the total amount of investigated words 280. The obtained results which are related to the acoustic properties of the English short vowels as produced by advanced Libyan female EFL university students in Tripoli faculty of Education, are compared to their native counterparts. The discussion will be divided into two sections, formants and duration.

5.1.1. English Short Vowels as Produced by Libyan Students

This section answers the first research question, What are the acoustic properties of English short vowels as produced by advanced female EFL university students in Tripoli faculty of Education? It discusses the quality and quantity (i.e. formants and duration) of English short vowels as produced by female Libyan students in separate subsections in order to discuss each property adequately.

5.1.1.1. Quality (Formants)

As described earlier in the second chapter (see 2.2.2), the quality of a vowel refers to the shape of the vocal tract when producing that vowel and this is related directly to the first two formants.

The first two formants average values for each speaker were calculated for the seven studied vowels (see table 4.2), the mean calculation (sum of the average values/ number of the values) is used to show how the findings of this study were obtained as shown in table (5.1) in addition to the plots of the average values for advanced Libyan female EFL learners that are shown in figure (5.1).

The following lines present and discuss the quality of the seven English short vowels as produced by advanced Libyan females. A brief discussion of the first formant measurement will be given followed with the discussion of the second formant.

	/ɪ/	/ʌ/	/æ/	/ə/	/e/	/ʊ/	/ɒ/
F1	656	774	902	758	640	591	714
F2	1959	1452	1757	1754	2058	1547	1479

Table (5.1) Formant average values of English short vowels as produced by Libyan female EFL learners

As can be seen in table (5.1), the lowest F1 measurement was of the high back /ʊ/ with 591 Hz. Vowels /e/ and /ɪ/ had close measurements for their first formant with 640 Hz for the former and 656 Hz for the latter. Both of the central vowels /ə/ and /ʌ/ and the back /ɒ/ had higher F1 measurements compared to the previous vowels. However, the highest F1 measurement of the Libyan females speakers was for the low front vowel /æ/ with 902 Hz.

Unlike the measurements of the first formants, vowels /ʌ/ and /ɒ/ scored the lowest F2 measurements with 1452 Hz for the former and 1479 Hz for the latter. The high back /ʊ/ was the only vowel to have an F2 measurement around 1547 Hz. With only three formants difference, vowels /æ/ and /ə/ had a very close F2 measurements with 1754 Hz for /ə/ sound and 1757 Hz for /æ/ sound.

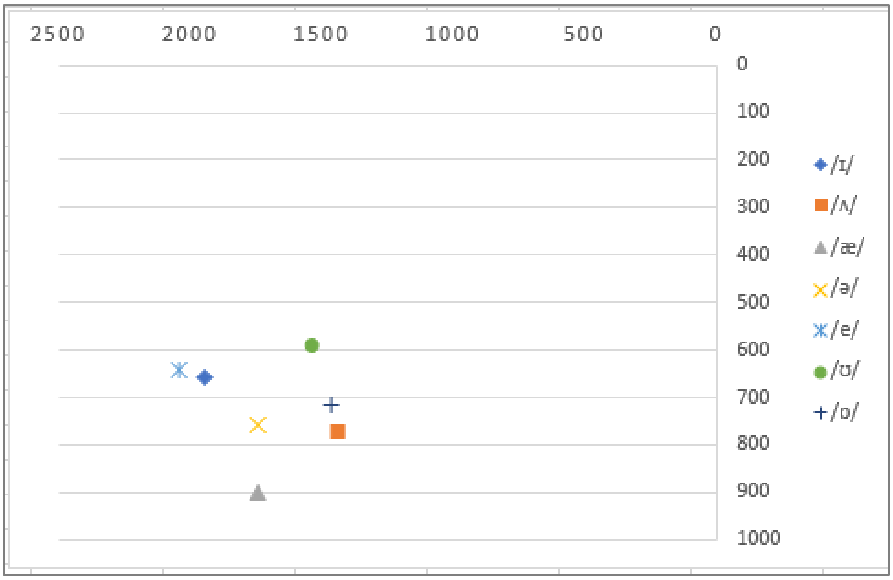

Figure (5.1) Plots of average values of English short vowels produced by advanced Libyan female EFL learners

5.1.1.2. Quantity (Duration)

Here are the mean duration of the English short vowels as produced by female Libyan speakers as presented in table (5.4) in seconds.

/ɪ/	/ʌ/	/æ/	/ə/	/e/	/ʊ/	/ɒ/
0.049	0.057	0.052	0.040	0.053	0.046	0.050

Table (5.2) The average duration of English short vowels as produced by Libyan females

It was expected that each vowel category will be in close proximity. Taking the high vowels, /ɪ/ and /ʊ/ for instance, both of which had shorter durations compared to the low vowels with a duration of 0.046 s for /ʊ/, followed with the vowel /ɪ/ with three seconds longer. This difference in the length among high and low vowels can be explained as quoted by Tanner et al (2019, p.3) that "high vowels are shorter cross linguistically than their non-high counterparts".

On the other hand, low vowels, namely /æ/, /ʌ/ and /ɒ/, were longer than the high ones as shown in table (5.4). It is fair to mention that both of the low vowels/æ/ and /ɒ/ were closer in measurements to the high front /ɪ/ compared to the low /ʌ/, which shares the same category.

The mid front /e/ had a closer duration measurement to the low front /æ/ with only one second difference. However, the mid central /ə/ seemed to be closer in duration to the one of the high vowels. Such difference, slight or major, within vowels from different categories was perfectly explained by Toivonen et al. (2015) as follows:

> If the duration of vowels depends directly on how much the jaw moves, we would expect a positive correlation within categories as well as between categories. In other words, multiple tokens of the same vowel (e.g., /I/) would be expected to display a correlation similar to the correlation between vowels; that is, a slightly lower pronunciation of a given vowel should be slightly longer (p.64).

5.1.2. English Short Vowels as Produced by Native Speakers

This section presents the acoustic properties of English short vowels as produced by female native speakers. Each will be discussed in a separate sub-section in order to pave the way to the comparison phase.

5.1.2.1. Quality (Formants)

Finding British English short vowel formant measurements was a time consuming task when it came to females only. Most of the studies who had their participants from both genders did not divide the obtained data for each gender and the results where for the entire study population. However, Deterding's Ph.D. thesis (1990) entitled "Speaker Normalization for Automatic Speech Recognition" provided the measurements of both genders in non-connected speech form i.e. as a part of a word within a carrier phrase or sentence. The results of Deterding's (1990) were compared later to his work in (1997) for connected speech for both genders (see 2.6.1).

The findings of this study will be compared to Deterding's (1990) shown in table (5.2). Later in (1997) Deterding provided both males' and females' first two formant measurements in connected speech and non-connected forms, where the latter is the one used in the comparison stage since the collected data of this study is in the same form as well. It is important to mention that Deterding did not include the schwa sound in his study as it occurs as a reduction for some vowel sounds for certain speakers as a result of their accentual difference, even though the longer form /ɜː/ was included (p.48, 1997).

	/ɪ/	/ʌ/	/æ/	/e/	/ʊ/	/ɒ/
F1	432	813	1011	645	414	602
F2	2296	1422	1759	2287	1203	994

Table (5.3) Average values of F1 and F2 in Hz of Females for citation forms (David Deterding, p.49, 1997)

5.1.2.2. Quantity (Duration)

Vowel duration varies from a speaker to another, as previously discussed and described thoroughly in the second and third chapter. At the same time it is conditioned by numerous factors related to the context in which the carrier word is a part of such as spontaneous speech, reading aloud or isolated words in a carrier phrase, as well as the circumstances when the targeted vowel was uttered as discussed in the data analysis chapter (see 4.3). Speakers variability (see 2.5) due to the differences between speakers' vocal tracts, jaw movement, aspiration, nasality and other phonetic characteristics should be considered. All these factors result in differences in enunciation and hence differences in the wave forms as well regardless of listeners perception. In addition to the difference of males and females articulatory systems that causes such difference; such as, the clarity and the production of longer utterances by females compared to males (Simpson, 2009), making such comparisons not as valid as ought to be.

All of the mentioned factors in the above lines are the reason that this section will be only stating the duration measurements of advanced Libyan female speakers.

5.1.3. English Short Vowels as Produced by Libyan Students and Native Speakers in Contrast

This section answers the second research question, how close these acoustic properties are to those of the short vowels produced by female native speakers of British English? It compares the quality (formants) of English short vowels as produced by Libyan female students to those of natives to find to which extent they are similar or different, each property will be discussed separately in order to discuss each property adequately.

5.1.3.1. Quality (Formants)

To compare the results of this study to their native counterparts the percentage difference was calculated = (difference between both F1s*100/native formant measurement) in order to figure out which vowels produced by advanced Libyan students are closer to the ones produced by native speakers. The same calculation was followed for the second formant as shown in figure (5.2). The first formant of the seven short vowels will be compared and discussed first starting from the closest one to their native equivalent, then followed with a comparison and discussion of the second formant of each.

To make the comparison step clear, the results obtained in this study compared to Deterding's are integrated in a single table as shown below in table (5.3). The first formant of the mid front /e/ is the closest to its native equivalent with only (0.77%) percentage difference, where as the first formant of vowel /e/ sound in Deterding's study is only five Hertz higher than the one of this study. The low central /ʌ/ is 39 Hz lower when produced by Libyan female EFL learners compared to the production of female native speakers.

As for the low front /æ/ the percentage difference is slightly higher than the previous vowels. The/æ/ sound of native females is higher with 109 Hz compared to the one of Libyan female speakers with (10.7%) percentage difference making the front vowel /e/ values closer to the one of natives' compared to the front /æ/.

	Deterding		This study	
	F1	F2	F1	F2
/ɪ/	432	2296	656	1959
/ʌ/	813	1422	774	1452
/æ/	1011	1759	902	1757
/e/	645	2287	640	2058
/ʊ/	414	1203	591	1547
/ɒ/	602	994	714	1479

Table (5.4) Comparison between the results of this study and Deterding's

Considering both of the high back /ʊ/ and the low back /ɒ/, the latter is closer to the ones of Deterding's average value with a percentage difference of (18.6%), as the values of average Libyan females is 112 Hz higher compared to the measurement of female native speakers. As for the vowel sound/ʊ/, it is (42.7%) higher than its native counterpart with 177 Hz.

It is surprising that the high central /ɪ/ is very high in comparison to its native equivalent with 224 Hz, which results in a percentage difference of (51.8%) as shown is figure (5.2).

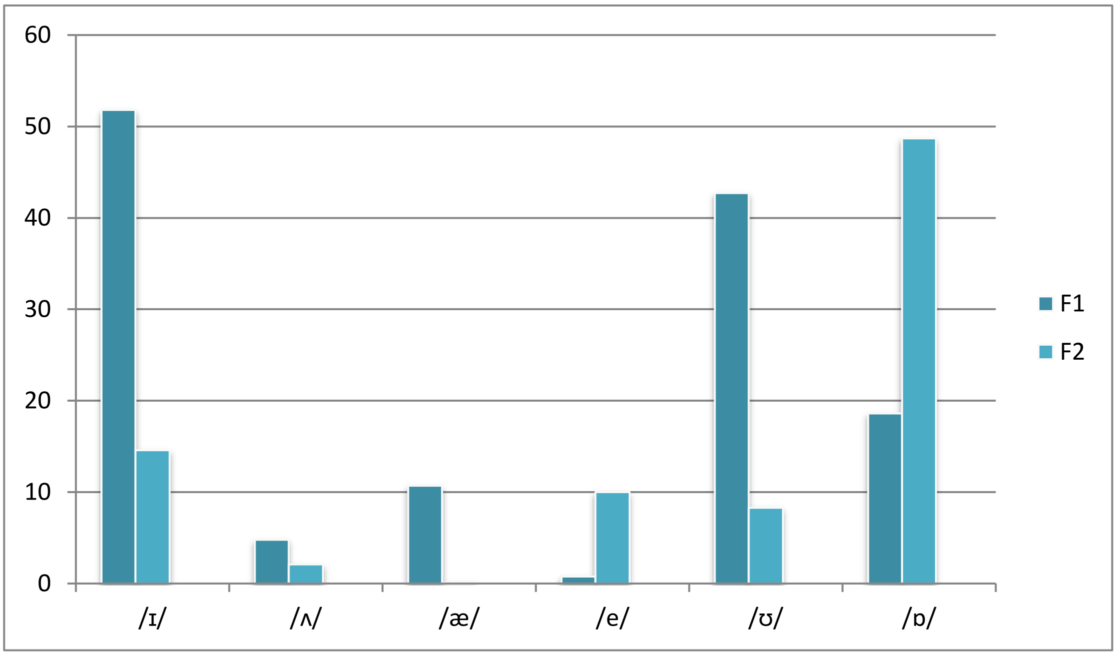

Figure (5.2) Percentage difference of short vowels produced by advanced Libyan female students and their native counterparts

However, the second formant values are lower compared to the first formant values except for both of the /e/ and /ɒ/vowel sounds, as can be seen in figure (5.2). Starting with the lowest percentage difference of (0.11%), which is barely shown on the figure, for the low front /æ/. This vowel sound is only 2 Hz lower than the one of natives when produced by Libyan females.

The vowel sound /ʌ/ comes second for the F1 values comparison as well as for the F2 with (2.1%), as the Libyan females' production of this vowel is higher with 30 Hz than the one of natives.

With the F2 average measurement of 2058 Hz, vowel /e/ is (10%) higher than the female average values of the same sound presented by Deterding (1997) as shown in table (5.3). Deterding's vowel /e/ value is 229 Hz lower than the value of this study. Followed with the high front /ɪ/, which is lower than its native counterpart with 337 Hz (14.6%).

The two back vowel sounds, namely /ʊ/ and /ɒ/, come last with a percentage difference of (22.2%) for the former and (48.7%) for the later. Table (5.3) shows how /ʊ/ sound is 344 Hz lower than Deterding's, where /ɒ/, on the other hand, is 994 Hz higher.

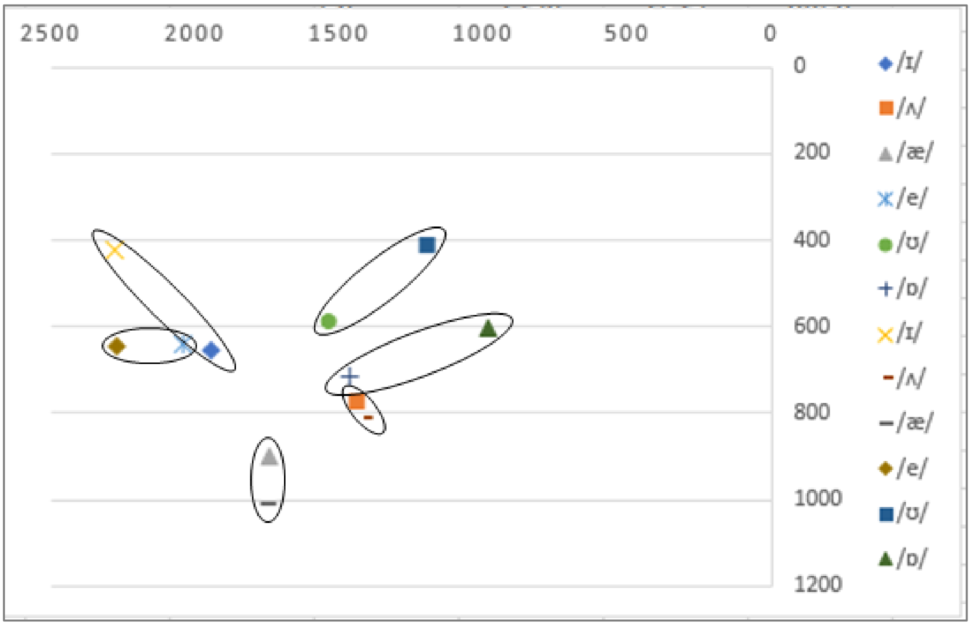

Figure (5.3) Plots of average values of this study compared to Deterding's

In a close investigation of the compared formant values and the difference percentage in (5.2) it is clear that the values of the three English vowel sounds' formants as produced by Libyan females, namely /ʌ/, /æ/ and /e/, are the closest to the production of native females. Unlike the rest of the three vowel sounds that showed higher difference percentage in the second formant, /ɪ/, /ʊ/ and /ɒ/ in the first formant values.

These similarities and differences among the values of British and Libyan females' production is a result of numerous factors and differences among speakers and the effect of the mother tongue, which can be further studied to investigate the reason behind these differences and similarities.

5.1.3.2. Quantity (Duration)

The subject of the quantity of British English short vowels as produced by native females is not covered for the researcher's best knowledge. Most of the studies found dealing with the acoustical properties of British English short vowels when produced by females concentrated on the qualitative characteristics only, leaving the quantitative characteristics unstudied for numerous reasons mentioned in (5.1.2.2) and (2.5).

Generally speaking, the environment in which the studied vowel is a part of, affects its length. For instance, if the studied vowel was in isolation or in a meaningless word, it will have different length when it is a part of a meaningful word as pronounced in a natural tempo, which will also differ from spontaneous speech. Another aspect is the effect of voicing (see 2.2.2) and how vowel sounds tend to be longer when preceding a voiced sound compared to its voiceless counterparts. Physical properties of speakers that differ from one to another, such as; vocal folds, jaw movement etc. This issue becomes more difficult and complicated when it comes to gender- specific studies, as explained by Simpson and Ericsdotter (2003) differences between males and females lies behind may reasons, such as; the clarity of females production compared to males, the difference of their articulatory systems, the use of reduction is more common among males than the other gender and may other reasons (see 5.1.2.2).

Unfortunately, finding gender-specific studies is not as common as it is thought to be. Most of the studies and research papers dealing with acoustics have both genders and the results of each gender are rarely represented separately. Thus, the results obtained in this paper will not be quantitatively compared, but provided as a reference for further research.

5.2. Implications

The study has revealed that the English short vowels have different acoustical properties when produced by Libyan females. The average values of the three English vowel sounds' formants when produced by Libyan females, namely /ʌ/, /æ/ and /e/, were the closest to their native counterparts. On the other hand, vowels /ɪ/, the back vowels /ʊ/ and /ɒ/ showed higher difference percentage rate in both the first and second formant. Such differences in the production of non natives can be a result of the speaker's variability (see 2.5) or the physiology of different speakers. However, these differences did not affect the Libyan female students' communication since their production was comprehended. Another variable is the speakers' first language, which effects their production of other languages. Non existing sounds in the learners' L1 make them either replace the sound with its closest equivalent in the L1 or mispronounce it. More research can be conducted on the effect of the LA and TA, to be more specific, on learning British English vowel sounds by Libyan female students. Regarding the duration measurements, comparison was not conducted due to the previously mentioned factors. However, the average duration of English short vowels of Libyan females is provided for further studies on the matter.

5.3. Limitations of the Study

This study aimed to investigate the production of the seven English short vowels as produced by advanced Libyan female EFL learners. However, it was limited to the study of six of them, comparing formant measurement of the mid central /ə/ to its native equivalent was not possible as it was considered as a reduction of the long vowel /ɜː/ by Deterding (1997) as discussed in section (5.2) and (2.6.1).

The second limitation was related to the participants of the study, the study participants were only females since the majority of students in the English department at Tripoli University/ Faculty of Education are females, in addition to the fact that the targeted sample was from the last semesters, advanced, which had no male students at that level.

The duration analysis and discussion was not compared to the duration of native females as was conducted in the formant analysis, for the reason that vowel duration can be affected by many factors as the linguistic context, speaking rate, pitch, jaw movement and many others (see 2.5) and (5.1.2.2).

5.4. Suggestions for Further Research

Based on the findings and discussion of the study some suggestions for further research are given.

- This study investigated the acoustic properties of English vocalic system; however, the focus was on short vowels, therefore long vowels and diphthongs produced by Libyan speakers need to be studied.
- Tripolitanain Arabic (TA) was the dialect spoken by the participants of this study, more research can be done taking in consideration the three Libyan

dialects to figure how these dialects affect the production of the English language (see 2.3.2).

- As mentioned in the third chapter (see 3.2) the participants of the study were only females, an investigation of the production of English short vowels by both genders should be conducted.
- It was found that the Formant measurements of English short vowels were different, slightly or greatly, when produced by Libyan female speakers from the native ones. This might be due to the effect of the mother tongue of the speakers, the researcher suggests more investigation of the effect of the Libyan dialect and the Libyan vocalic system on the production of English vocalic system.

5.5. Conclusion

This study is focused on the acoustic properties of English short vowels as produced by advanced Libyan female EFL university students. It compared the qualities (formants) of the studied vowels when produced by Libyan females to the ones of their native counterparts. A recording procedure was set to determine to which extent they are different or similar.

Concerning vowels' quality, the findings of the study were compared to Deterding's, except for the schwa sound (see 5.1.2.1). Then a percentage difference was calculated to conclude the following:

The production of Libyan females of the mid central /e/, the low central /ʌ/ and the low front /æ/ are the closest to the ones produced by native females. Even though the percentage differences were slight, /e/ vowel sound was the closest among the three mentioned vowel sounds.

The production of the rest of the studied vowels, namely /ɪ/, /ʊ/ and /ɒ/, resulted in a higher percentage difference. Such differences can be a result of numerous factors as individual differences, the effect of the mother tongue, jaw movement.

The quantitative characteristics of the British English short vowels as produced by Libyan females were not compared to the ones of native females, because of the lack of resources and references to be compared to. However, the researcher provided the average duration of the seven studied vowels as produced by Libyan females as a reference for further research on the matter.

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