THE PHONETICS OF THE QUR'ĀNIC PHARYNGEALISED SOUNDS

ACOUSTIC AND ARTICULATORY STUDIES

BY

SAEED SAAD SAEED ALSURF

SUBMITTED TO THE REQUIREMENT OF

THE DEGREE OF DOCTOR OF PHILOSOPHY IN LINGUISTICS

DEPARTMENT OF LINGUISTICS

MACQUARIE UNIVERSITY

SYDNEY, AUSTRALIA

2012

ABSTRACT

Many of the phonetic aspects of Qur'ān (the Holy book of Muslims) are yet to be investigated experimentally. This dissertation aims to investigate the acoustic and the articulatory parameters of the Qur'ānic pharyngealised consonant and vowel sounds. The articulatory units of the Qur'ānic pharyngealised syllable require grounded experimental investigation to accurately identify their nature.

This thesis consists of seven chapters. Chapter One provides a broad account of the aim of the study as well as of the Qur'ān as the source book. It also discusses the language and orality (primarily oral nature) of the Qur'ān. The chapter introduces Tajwīd as the representational and traditional phonetic system for the recitation of the Qur'ān. Tajwīd (which means improving the recitation of the Qur'ān) has not been adequately or completely presented in any Western language. There have been a number of experimental endeavours examining particular aspects of Tajwīd. This study fills a gap by examining the pharyngealised sounds of Tajwīd.

Chapter Two discusses the phonetic contributions of classical Arab and Muslim investigators especially in the domains of Tajwīd and Qur'ānic sounds. It also outlines the important contributions of classical Arabic linguists such as Al-Khalīl, Sibawayh, and Ibn Jinni in the study of Arabic and Qur'ānic sounds. Both classical and contemporary contributions to Tajwīd are of special interest to the current research as they are the base of all subsequent research and experimental studies in the Qur'ānic sounds. This chapter also discusses the phonetic characteristics of the Arabic pharyngealised and uvularized sounds.

Chapter Three explores Qur'ānic pharyngealisation; known as *Tafxīm,* with a particular emphasis on the seven Qur'nic pharyngealised consonant and vowel sounds, and discusses the most appropriate name for the Qur'ānic *Tafxīm* feature. The chapter focuses on the classification of the Qur'ānic pharyngealised sounds as well as their articulatory parameters and their degrees of pharyngealisation. The description of the Qur'ānic pharyngealised sounds is incomplete without a physiological account for each sound. This chapter discusses and describes the pharynx, the tongue, and the lips, as they are the most important articulators of the Qur'ānic pharyngealised sounds.

Chapter Four reports on an acoustic analysis of the Qur’ānic pharyngealised sounds. In order to examine the phonetic parameters of these Qur’ānic sounds, three groups of male reciters were employed for the purpose of recitation. These three groups encompass all levels of Qur’ānic recitation in Islamic world today. Acoustic analysis of the sounds of the reciters in these groups showed clear acoustic differences between the pharyngealised sounds recited by each group, and by contrasting the acoustic results of the super-standard recitations with those of professional and non-professional reciters provided a characterisation of the acoustics of the super-standard recitation of the Qur’ānic pharyngealised sounds. Qur’ānic pharyngealised sounds are also compared with the Arabic pharyngealised sounds. The findings of this experiment are crucially important for those who want to perfect their recitation of the Qur’ānic pharyngealised sounds as well for those who want to assess, classify, or improve Qur’ānic recitation.

Chapter Five outlines the procedure and results of an articulatory experiment. This chapter examines the articulatory features of the Qur’ānic pharyngealised consonants and vowels. A videofluorographic experiment was undertaken to examine the Qur’ānic pharyngealised sounds in motion. A series of X-ray frames of every sound in examined this study show the sequence of articulation from the release of the consonant to the start of the stable target of the following Qur’ānic pharyngealised vowel. The Qur’ānic samples accompanying this videofluorographic experiment were extracted and acoustically analysed to compare the articulatory configurations of the sounds with their acoustic correlates.

Chapter six discusses the findings of the acoustic and the articulatory experiments of this research. It also focuses on the relation between the findings of each experiment and how to relate them to each other. This chapter commences with a discussion of the nature of the Qur’ānic pharyngealised vowel sound and is then followed by a discussion of the various experimental results. It will also discuss the nature of the Qur’ānic vowel as well as the main acoustic and articulatory features that characterise the Qur’ānic pharyngealisation such as vowel duration and the distance between F3-F2. The idea of the auditory integration of the spectral peaks especially F1-F2 and F3-F4 will be examined for a better understanding on how the human brain deals with these Qur’ānic pharyngealised vowel sounds.

Chapter seven concludes and summarises this research with an overview of the main points and results of the experiments of this research in the light of the studies mentioned in literature review (Chapter Two). This chapter also recommends some further studies that need to be undertaken on the Qur’ānic pharyngealised sounds.

ACKNOWLEDGEMENTS

This thesis would not have been possible without the help and guidance of Allah the Creator and the Lord who bestowed me with His bounty to carry out this research. I thank Allah Who helped me complete this project and I thank Him for the countless favours he has endowed me with in every aspect of my life.

My deepest thanks go to those who helped me in every stage of this thesis. They were numerous around me so I apologise if any of them are not singled out here. I ask Allah to reward them immensely for what they have done for me.

I would like to express my deepest thanks and gratitude to my supervisor Dr. Robert Mannell for his relentless pursuit of helping and teaching me. He was cheerful, peaceful, and encouraging through all the ups and downs of this research. It is really difficult to convey my excellent gratitude and appreciation for this man who helped and taught me for several years. Robert, you were a good role model of a respectable person, and I thank you for everything.

Words cannot convey my sincere thanks to Dr. Abdullah Ali Abu-Eshi, who set my foot on this path twenty years ago. He was an instructor, an inspirer, and a perfect example of the good Muslim. Dr. Abdullah, your efforts and little notes and nods have borne fruit and your “green box” is now maturely grown! It is an honour for me that you taught me.

I thank King Khalid University in Saudi Arabia for the generous scholarship they granted me and for the support and courage they offered me through my study. I also would like to thank my friends and study partners Dr. Merzin Alshahrani and Majid Alqahtani, who witnessed the good and the tough days of this project. Thank you, Merzin and Majid, for your discussions, patience, and endless support.

My deep thanks also go to Dr. Verna Rieschild and Robyn Guilmette of Macquarie University, whose support and help are unforgettable. I also would like to express my appreciation to all those who participated in my study and helped me collect my data. I thank the staff of the Department of Linguistics at Macquarie University for all the help and support they offered me as well as all my colleagues there.

It is almost impossible that I could show my gratitude and thanks to my family overseas. The blessings of their prayers and supplications for me were a great force of encouragement and support to accomplish this project. There is no way for me to pay back the debt of my mother, whose love, care, and prayers have been around me all my life. I ask Allah to reward you with Paradise, Mum. I am more indebted to you than to anyone else and more than I can ever record here.

Finally, all of the words of thanks and appreciation fall short to express my feeling towards the partner of my journey, my wife, Huda, for her constant support, and her endless love, care, and understanding. Thank you Huda for the long times you spent waiting for me to return from university. Words cannot express my thanks to you, especially for the eight years you spent with me in Australia away from your family. Thank you for helping and supporting me to be what I am now. You spread beautiful flowers and roses in my thorny way of life.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Phonetic and Transliteration Symbols

Arabic Classical Consonant and Vowels				
No	IPA	Arabic Letters	Approximate in English	Comments and symbols used in the text
1.	ʔ	ء	oh	Used as (’) in Arabic transliteration in text
2.	b	ب	ball	b
3.	t	ت	tall	t
4.	θ	ث	think	θ
5.	dʒ	ج	journal	dʒ
6.	ħ	ح	no equivalent	ħ
7.	χ	خ	no equivalent	kh and sometimes written as x
8.	d	د	door	d
9.	ð	ذ	this	ð
10.	r	ر	room	r
11.	z	ز	zebra	z
12.	s	س	soon	s
13.	ʃ	ش	she	ʃ
14.	sˤ (ṣ)	ص	singe	capital S is used in the text for this Arabic sound to distinguish it from the Qur’āic one
15.	dˤ (ḍ)	ض	no equivalent	capital D is used in the text for this Arabic sound to distinguish it from the Qur’āic one
16.	tˤ (ṭ)	ط	no equivalent	capital T is used in the text for this Arabic sound to distinguish it from the Qur’āic one
17.	ðˤ (ð̣)	ظ	thus	ð̣
18.	ʕ	ع	no equivalent	a
19.	ʁ	غ	no equivalent	ʁ
20.	f	ف	feel	f
21.	q	ق	no equivalent	q
22.	k	ك	keen	k
23.	l	ل	learn	Arabic uses the dark ɫ as well as the light l
24.	m	م	moon	m
25.	n	ن	noon	n
26.	h	ه	home	h
27.	w	و	we	w
28.	j	ي	you	j
29.	u:	ُ	oo	u: Dammah is represented by /u:/
30.	æ a ɑ:	َ ا آ	sat cut father	a ā a: Fatħah is represented by /a/
31.	i:	ِ	feel	Ī Kasrah is represented by /i/

Qur'ānic Pharyngealised consonants and vowels Symbols

No	Qur'ānic Letter	IPA	Comments and symbols used in the text
1.	خ	χ	χˁ
2.	ص	sˁ (ṣ)	sˁ
3.	ض	dˁ (ḍ)	dˁ
4.	غ	ʁ	ʁˁ
5.	ط	ṭ	tˁ
6.	ق	q	qˁ
7.	ظ	ðˁ (ð̣)	ðˁ
8.	ُ	u:	u:
9.	َ ا آ	æ a ɑ:	a ā a:
10.	ِ	i:	i:

Remarks on the Transliteration System

1. Arabic pays attention to the segment length of the sounds. Therefore vowels that are longer than the normal IPA vowels are marked. For instance /ā/ vowel in some examples of this research is longer in duration than the /a/ vowel.
2. The phonetic symbols used in the current research were taken from the IPA chart (2009).
3. Where the Arabic word ends with a /h/ sound like Surah (chapter in Qur'ān), the final /h/ sound is kept the same in the transcription of the word.
4. In order to differentiate between the Arabic pharyngealised coronal sounds and the Qur'ānic pharyngealised coronal sounds the former are written in capital letters /D, S, T, ð̣/ in transliteration and phonetic description.
5. IPA (2009) charts uses the voiceless velar fricative sound /x/ to describe Arabic خ sound. It was found in the current research that the Qur'ānic uvularised خ sound is the voiceless uvularised fricative /χˁ/ sound.
6. In the following pairs of symbols, above, ðˁ (ð̣), sˁ (ṣ), dˁ (ḍ), tˁ (ṭ), the left symbol uses the correct IPA diacritic for pharyngealisation and the right symbol (in brackets with a sub-script dot) represents a commonly used non-IPA alternative

1. .List of Abbreviations

Abbreviation	Meaning
QPS	Qur'ānic Pharyngealised Sounds
QPV	Qur'ānic Pharyngealised Vowels

VFG	Videofluorography
Ms	Milliseconds
Secs	Seconds
SSR	Super-standard Reciters
PR	Professional Reciters
NPR	Non-professional reciters
F	Formant

Statement of Candidate

I certify that the work in this thesis entitled “The Phonetics of the Qur’ānic Pharyngealised Sounds” has not been previously submitted for a degree nor has it been as a part of requirements for a degree to any other university or institution other than Macquarie University.

I also certify that this thesis is an original piece of research which has been written by me. Any help and assistance that I have received in my research work and in the preparation of this thesis itself has been appropriately acknowledged.

In addition, I certify that all information sources and literature used are indicated in this thesis.

The research presented in this thesis was approved by Macquarie University Ethics review Committee, reference number: HE03MAY2008-D05770

Name: SAEED ALSURF

Signature: 

Date 10 / 4 / 2012

CHAPTER ONE

1. Introduction

This chapter discusses the main issues of this research including the objectives of this work and the source book of the speech samples used in this study. It also outlines the reason behind choosing the Qur'ān (the Holy book of Muslims) as well as the oral nature of the Qur'ān and the unique nature of Qur'ānic language. Tajwīd, the traditional science of the Qur'ānic sounds, is also discussed in this chapter. Tajwīd, the unique system of Qur'ānic recitation, is discussed from both paradigmatic and syntagmatic perspectives in the first two chapters. The first two chapters present both classical views of Tajwīd as well as contemporary Western contributions to Tajwīd. This chapter also presents an overview of this dissertation.

1.2. Aims

Much of the available phonetic and phonological investigation of Arabic sounds does not include the sounds of the Qur'ān.[1] The aim of this research is to investigate the pharyngealised sounds of the Qur'ān. The Qur'ānic pharyngealised syllables include both a consonant sound and a vowel sound. The phonetic parameters of the Qur'ānic pharyngealised sounds (QPS henceforth) are investigated with a special focus on the Qur'ānic pharyngealised vowel.

Another aim of this study is to examine the role of the classical Muslim phonetician in constructing the science of the phonetics of the Qur'ānic sounds, called Tajwīd. Tajwīd is so important that no Muslim could recite the Qur'ān correctly without the application of the rules of Tajwīd. Therefore, the contribution of those early scholars of Arabic and Tajwīd is of enormous importance to this research.

A third very important aim of this study is to reveal the differences between three groups of Qur'ānic reciters who will be employed in this study to examine the factors that distinguish the three groups of reciters. These groups of reciters will be referred to as the superstandard reciters, the professional reciters, and the non-professional reciters.

There have been numerous, often inadequate, accounts of Tajwīd features in general and of the QPS in particular, which have provoked this researcher to attempt to investigate the exact phonetic identity of the QPS. There are many articulatory and descriptive inadequacies in the

[1] The Qur'ān is the Holy book of Muslims.

available literature on Arabic emphatics and the QPS. The successful use of instrumental measurements is one of the best criteria for making sound judgements about the nature of Arabic and Qur'ānic sounds.

Accordingly, the current research consists of an acoustic study of a range of reciters that is supported by a preliminary articulatory study of a single reciter. The articulatory part of this study uses videofluorographic (VFG henceforth) X-rays to examine the configuration of the relevant articulators during articulation. These VFG images show the manner and place of articulation as well as the constriction that accompanies the production of the QPS.

It is hoped that this study will contribute to a better understanding of how Qur'ānic sounds, especially the QPS, are articulated.

1.3. Qur'ān, the Source Book

1.3.1. Why the Qur'ān

Last century witnessed a renaissance in scholarly interest in the effects of the Qur'ān on the spiritual and the cultural life of the Islamic community. This study of the QPS is motivated by the great importance of the Qur'ān in the life of more than one billion Muslims around the world.

The reader may ask why Muslims put such emphasis on the importance of the Qur'ān in their lives. To answer this question, one should understand how Muslims regard the Qur'ān. Muslims believe that the Qur'ān is their greatest divine scripture. They believe that it was revealed from God, "Allah" in Arabic, to the Prophet Mohammad "May the Peace and Blessings of Allah be upon him" (PBUH henceforth[2]) via Gabriel, the trustworthy angel.

Starting in 610 AD, the Qur'ānic revelation to Mohammad (PBUH) lasted for twenty three years. The Qur'ān was progressively revealed according to the needs of Muslims in the early era of Islam. Muslims at the time of the prophet Mohammad (PBUH) had a new portion of the Qur'ān revealed via the prophet whenever something significant happened among them. Muslims believe that whatever word is said by the prophet Mohammad (PBUH) in the Qur'ān is a revelation of the actual words of Allah. Nevertheless, Muslims believe that even the daily conversation and the normal speech of the prophet Mohammad (PBUH) is also an inspiration

[2] Muslims are required to use this phrase whenever referring to the prophet (PBUH), so this abbreviation will occur throughout the thesis.

and a revelation from Allah. Allah says in the Qur'ān (53:1), "By the Star when it goes down (or vanishes), your companion has neither gone astray nor has erred. Nor does he not speak of his own desire; it is only a revelation revealed" (trans. HK 1997:717)[3].

At the very end of the life of the prophet (PBUH), Allah revealed a verse in the Qur'ān stating that the religion of Islam was then complete and Allah wanted the nation of the prophet to be Muslims. Allah says in the Qur'ān (5:3), "This day, I have perfected your religion for you, completed My Favour upon you, and have chosen for you Islâm as your religion." (trans. HK 1997:142)

Throughout their history, and in their different times and places, Muslims have received the Qur'ān with total belief in its divinity. If a Muslim does not accept the Qur'ān as a divine book revealed from Allah to Mohammad, then his acceptance of Islam is at risk. More importantly, Muslims believe that the Qur'ān contains everything that they could ask about in their life. Allah says in the Qur'ān (16:89), "And We have sent down to thee the Book explaining all things, a Guide, a Mercy, and Glad Tidings to Muslims." (trans. HK 1997:360)

Muslims consider the Qur'ān a dynamic and interactive scripture that keeps them involved and connected with Allah at all times. This kind of interactive relation is spoken of by Graham (1987:87) who states, "In Islam it is in the concrete text, the very words of the Qur'ān, that Muslims most directly experience God. Scripture for Muslims is itself the divine presence as well as the mediator of divine will and divine grace. In Qur'ān God speaks with his own voice, not through inspired human writers."

In Islam, reading the Qur'ān, listening to it, or even looking at its calligraphy is considered an act of worship to Allah. Therefore Muslims are encouraged and ordered, on several occasions in the Qur'ān, to recite the Qur'ān. Allah says in the Qur'ān (73:4), , "And recite the Qur'ān in slow measured rhythmic tones." (trans. HK 1997:793)

In Islam it is also obligatory for every Muslim to pray five times a day. Hence, Muslims male or female, must memorise some parts of the Qur'ān for their prayers because they are expected to recite the Qur'ān by heart during prayer.

Muslims believe that the Qur'ān should be recited individually in a condition of a spiritual and physical purity. When reciting the Qur'ān Muslims should chant it slowly, thinking about

[3] Henceforth, whenever quotations from the Qur'ān are made in English, they will be from the translation of Khan and Al-Helali (1997), and this translation citation will be indicated by, for example, "trans. KH 1997:717" with the last number being the page number in that translation.

every verse they read. The art of reciting the Qur'ān is not meant to entertain the reciters or the listeners with its musicality.

In fact, the concept of musicality cannot be properly applied to Qur'ānic recitation, at least from a divine point of view, as the Qur'ān is believed to be the actual words of Allah and is meant to make people remember and fear Allah. There are many verses in the Qur'ān that need to be read in serious and sad tones (such as the verses that contain severe penalties for wrong-doers). A reciter of the Qur'ān must not forget that the purpose of the recitation is much more than enjoying the musicality of the recitation or of entertaining listeners. The classical Arabic concept of *Yataghanna*[4], "chant Qur'ān with rhythm", in classical Arabic treatises is totally different from the modern concept of instrumental music.

A Muslim should recite the Qur'ān seeking the great reward for the recitation from Allah as an act of worship. Al Tirmithi (1931:5/2910), quoting Abdullah Ibn Mas'ōd, the prophet's companion, reports the prophet Mohammad (PBUH) as saying "He who reads one letter of the Qur'ān is endowed one virtue for the alphabet and one virtue is (written down as) equal to ten deeds of virtue." One may ponder about the rewards and virtues of reading the whole Qur'ān, knowing that a single page of the Qur'ān could contain more than five hundred alphabetic characters and the Qur'ān is more than six hundred pages.

However, the Qur'ān cannot be perfectly read without Tajwīd. Tajwīd (the knowledge and the application of the rules of reciting the Qur'ān) was initiated by the prophet Mohammad (PBUH) at the time of the revelation of the Qur'ān. He used to read the Qur'ān in front of his companions, who thus received it directly from his mouth and imitated his Tajwīd and recitation. Abdullah Ibn Mas'ōd, one of the prophet's companions, was a great impressionistic phonetician. He used to look carefully and meticulously at the mouth of the prophet when he recited. He says "I swear by Allah, I have taken (by heart) more than seventy *Surahs* (chapters) from the mouth of the prophet (PBUH)". Consequently, this great ability of Abdullah Ibn Mas'ōd, as an impressionistic phonetician, was confirmed by the prophet (PBUH). Abdulah Ibn Abi Shaibah (1994:183) narrates, "the prophet of Allah (PBUH) said (whoever is pleased to read Qur'ān as fresh as it was revealed, he has to read it according to the reading of Abdullah Ibn Mas'ōd)".

The prophet (PBUH) used to recite the Qur'ān in a very serious, enchanted and melodious manner, but not similar to singing, making pauses between verses and giving every word its full

[4] For a glossary of the related Tajwīd terms, see the appendixes.

degree of pronunciation and Tajwīd. Muslims believe that it is crucially important for them to deal with the Qur'ān with total respect as a sacred book because it is the actual words of Allah. Therefore, for Muslims, the Qur'ān is the linguistic miracle of the prophet (PBUH) and is the most eloquent Arabic book.

The Qur'ān is the unifying book for Muslims around the world, who must read the Qur'ān with the same rules of Tajwīd regardless of their own language or background. Motivated by the issues covered in the discussion thus far, this researcher has chosen the topic, the sounds, and the source of this research to be from the Qur'ān.

1.3.2 The Qur'ānic Language

For most Muslims, there is no doubt that the Qur'ān represents the most authentic standard form of Arabic. This is because of its divine nature, eloquence, elegance, and peerless and unprecedented structure. Al-Hashmi (2004:4) states "The highest register of Classical Arabic is the language of the Holy Qur'ān." Arabic existed at the time of the Qur'ānic revelation and it was already well developed then. However, it was only after the coming of Islam that Arabic reached its current status, with the foundation and the reinforcement of the language of the Qur'ān. Kadi and Mir (2001, pp.213-216) maintain that "it was only after the emergence of Islam, with its founding scripture in Arabic, that the language reached its utmost capacity of expression and the literature its highest point of complexity and sophistication. Indeed, it probably is no exaggeration to say that the Qur'ān was one of the most conspicuous forces in the making of classical and post-classical Arabic literature."

Nevertheless, the Qur'ān can be easily understood by most present-day Arabs. When it was first revealed to the people of Arabia, Muslims received it as a linguistic miracle. Arabs and linguists at the time of the Qur'ānic revelation tried very hard to invent something that resembled the Qur'ān but were defeated by its eloquence. The Qur'ān was the miracle that Mohammad (PBUH) was given to prove the truthfulness and the authenticity of his prophet hood. Gulen (1995) states, "The text of the Qur'ān is entirely reliable. It has been as it is, unaltered, unedited, not tampered with in any way, since the time of its revelation". There have been some presumptions (Abbott 1939) that there were no Qur'ānic manuscripts in the first century of Islam. This claim would lead to the idea that Qur'ān was compiled and written after the first century of Islam. This assumption is historically inaccurate as first: Qur'ān initially was revealed to be memorised and to be understood and not to be written on paper. The companions of the prophet Mohammad (PBUH) used to immediately memorise every verse that was revealed to the prophet. After the first twenty years after the death of the prophet Mohammad, Uthman the third Caliph of Muslims feared the loss of the Qur'ān especially considering that many of the new Muslims were originally not Arabs so he ordered to writing down of the Qur'ān as a book. Second, there are many copies of Qur'ān that were written in the first century which were all very similar in every aspect of the Qur'ān. The studies of Dutton (2001, 2004) has shown that the copies of Qur'ān written at the end of the first Islamic century were remarkably similar to the first copy of the Qur'ān at the time of Utman the third Islamic Caliph. What might have mislead Abbott (1939) and many others is the later appearance of the dots above and under the Qur'ānic letters to differentiate them as well as the coloured dots around the Qur'ānic vowels to distinguish them, which were not in the first copies of Qur'ān. The reason for this is that the first copy of Qur'ān was written in Quraishi dialect so the people of Quriash (the Arabic tribe of the Prophet Muhammad) were able to read their dialect. When copies of Qur'ān were sent to the people of the Islamic states, especially new Muslims, they did not recognize the way those copies were written. Thus, the Arabic letters were dotted and the vowels were distinguished in colors. The original Qur'ān with all of its linguistic content was not altered or tampered with in any way.

In the Qur'ān (17:88) Allah says, "Say: Verily, though mankind and the jinn should assemble to produce the like of this Qur'ān, they could not produce the like thereof though they were helpers one of another." (trans. HK 1997: 381)

1.3.3. The Orality of the Qur'ān

The concept of the orality of the Qur'ān has been a topic of discussion for many Muslims and non-Muslims. Many people cannot understand the exact nature of the orality of the Qur'ān, and why the Qur'ān should be first regarded as an oral scripture then as a written text. Orality is an ambiguous term. Graham (1987:7) states, "orality itself is a loaded or at least ambiguous term, and when it is treated as a functional dimension of a written text, it can be especially problematic." To disambiguate the orality of the Qur'ān, first, those who are interested in the Qur'ān should understand that the Qur'ān is different from any other scripture in the sense of its divinity and authenticity. Any other approach (especially for Muslims) to Qur'ānic studies may not be as fruitful without belief in its authenticity. Second, more scholarly work is needed to inform people (especially non-Muslims) about the exact nature of the orality of the Qur'ān. Graham (*ibid*.) maintains that "the immense importance of the oral aspects of the scriptural piety and practice to an adequate understanding of scripture is belied by the relative paucity of the scholarly work devoted to them." The orality of the Quran as well as its classical and social meaning are discussed here.

Historically, it was clear from the beginning of the message of Islam that the Qur'ān was passed down to Muslims not only to be written in a book and kept on the shelf but to be read and memorised. At the time of the revelation of the Qur'ān the process of writing existed but was very limited. Arabs at the time of its revelation used to listen, memorise, and recite more than read. The revelation of the Qur'ān was a great challenge to them.

The Qur'ān was revealed to Muslims as the great book of instruction in their lives. Therefore, writing that divine book without memorising it, understanding it, and abiding by its rules is meaningless. Graham and Kermani (2007:115) explain, "The Qur'ān has always been primarily recited, oral scripture and secondarily inscribed, written scripture and thus its spiritual and aesthetic reception as the most beautiful of all text has been linked with its orality."

The nature of the orality of the Qur'ān helped the first Muslims to memorise it so that it could be with them in their hearts wherever they went. The Qur'ān was full of verses that encouraged Muslims to contemplate, read, and memorise it. Words like "recite", "read", and "listen" are mentioned frequently throughout the Qur'ān. Allah says in the Qur'ān (73:4) what could be translated as "And recite the Qur'ān in a slow, rhythmic, and pleasant style."

And Allah says also in the Qur'ān (17:106), "And a Qur'ān that We have divided, so you (Mohammad) may recite it to mankind (slowly) at intervals, and We have revealed it by (successive) revelation." (trans. HK 1997:384) More interestingly, the prophet (PBUH) urged Muslims to read the Qur'ān and feel the pleasure of chanting the Qur'ān. He (PBUH) said "Beautify the Qur'ān with your voices." It could be understood that the prophet wanted to emphasise the importance of its orality.

More importantly, it could also be said that Muslims should not pay so much attention to beautification of the calligraphy of the Qur'ān that they would forget about the beauty of its orality. El-Ashiry (1996:20) emphasises, "In Islam, the focus of the holy book as an oral text has predominated over its functions as a written or printed one."

Further evidence of the orality of the Qur'ān comes from its very name. In Arabic the word Qur'ān comes from the Arabic root of "qara", meaning to recite or read. It was named Qur'ān because it was intended to be recited and read. Allah says in the Qur'ān (75:18), "And when we have recited it to you (O Mohammad through Jibrīl (Gabriel)), then follow its (the Qur'ān) recital." (trans. HK 1997:801) El-Ashiry (1996:61) also points out that "the very name of the scripture al-Qur'ān points clearly to its nature as spoken word. Al-Qur'ān in Arabic means 'the reciting' or 'recitation'."

In the context of the orality of the Qur'ān, Nelson (1980:21) also states: "Further evidence given to the orality of the revelation lies in the name itself. Although the revelation is referred to with a number of terms (al-Kitāb, al-Furgān, and al-Tanzīl for example), the one most widely-used and most revealing of this nature is al-Qur'ān".

There are three main significant concepts of the Qur'ān. Firstly, it was originally meant to be heard and recited, so the means of its revelation and transmission to people was oral. Secondly, Qur'ān is in Allah's words, therefore it must be carefully preserved and accurately transferred. Thirdly, due to its divine inimitability, reciters and listeners should deal with it sacredly. Nelson (1980:23) maintains, "The written text does not exist to preserve against change; it is taken for granted that other oral tradition does that. Nor is the written text the ultimate referent to the oral. Oral tradition has served as the final arbitrator of the written tradition; only those fragments written down in the presence of the prophet (PBUH) were accepted as material for written text, and any differences in the fragments were settled by oral tradition".

Obviously, from the beginning, Mohammad (PBUH) spread Islam and the Qur'ān by sending callers of Allah with the reciters of the Qur'ān to teach people the divine words of Allah. Moreover, later, when the Qur'ān was written down and compiled in a book, Othman, the third successor of the prophet (PBUH), sent a copy of the Qur'ān, or *al-Kitab,* and a reciter of it as a teacher, to every region of the Islamic states. The importance of the recited text does not negate the importance of the written *Mushaf*[5] but this reminds us that the oral text is the primary form of the Qur'ān and the written text is there to preserve the recited text and support it.

Allah has given the Qur'ān several names, all of which refer to the same referent. *Al-Furqān, al-Tanzi:l, al-Kitāb, al-Thikr,* and *al-Shifa'* are examples of the many names mentioned for the Qur'ān. Millions of Muslims around the world believe that the Qur'ān is the absolute and

[5]*Mushaf* means the actual book of the Qur'ān that people read.

the actual words of Allah and that any addition or subtraction of even one letter to or from it invalidates its holiness. Graham (1987:83) explains the true meaning of this term when he states, “ The Qur’ānic use of *Kitab* reflects the obvious association of this term with not only the most common meaning of the root *K-T-B* ‘to write’ but also the related meaning, ‘to decree’, ‘to prescribe’, ‘to make’ something incumbent (as in God’s actions with respect to His creation).”

The oral aspect of the Qur’ān plays a crucial role in the life of Muslims as they recite it in their prayers and gatherings. This is a belief and reality for Muslims. Graham (1987:79) expresses this belief clearly when he says, “In Muslims’ piety, however, the written word of its scripture has always been secondary to a strong tradition of oral transmission and aural presence of scripture that far surpasses that of Judaic or Christian usage.” This emphasis on the orality of the Qur’ān paves the way for regulation of the sounds of the Qur’ān in a phonetic system called Tajwīd.

In the form of its text, the Qur’ān is divided into thirty *Juz’* (chapters). The word *Juz’* means “part” in Arabic. In the Qur’ān it means a separate chapter that includes two *Hizbain*, “parts”. Every *Hizb* includes four quarters. This division and subdivision was ordered by Mohammad (PBUH) and is agreed upon by Muslims. At the time of the revelation of the Qur’ān, the prophet (PBUH) used to tell his companions that Allah revealed to him that this chapter should be placed in a specific position and that each verse should be placed in a particular place until the Qur’ān was completely arranged. Nelson (1980:20) explains, “The order of the parts given to Mohammad (PBUH) reflects the circumstances of his dealing with the Arabs as he was called to warn them against disbelief, encourage the believers, and legislate for the new community”. The Qur’ān in total contains one hundred and fourteen *Suwar* (a plural form of *Surah* which means a segment of the Qur’ān). Each *Surah* varies in length. The longest consists of two hundred and eighty six verses and the shortest is three verses. There are seven long *Suwar* of the Qur’ān, namely *Albaqarah, Al-Imran, Alnisā’, Almai’dah, Alan’am, Ala’raf’ Alanfal,* and *Altawbah.* These seven *Suwar* alone constitute one third of the whole Qur’ān.

Various punctuation marks are used in the Qur’ān. These punctuation marks are used to illustrate the laws of Tajwīd. There are also fourteen positions shown in the Qur’ān that include *Sajdah,* which means to prostrate for Allah as in the Qur’ān (25:60). These punctuation marks are placed above the words or on the side margin of the page.

There are also many punctuation marks that tell readers where they can stop recitation and where they cannot, in order to recite a verse of a complete meaning, as in the Qur'ān (6:36). There are also some other places in some verses of the Qur'ān where it is preferable not to pause your recitation before the proper stop, as the meaning will not be complete when pausing inappropriately, as in the Qur'ān (10:107). These punctuation marks simplify the recitation process as they are easily noted and understood by reciters.

1.3.4. The Content of the Qur'ān

As a religious book, the Qur'ān, like other divine books, is full of laws and legislation that regulate the life of Muslims. Therefore the teachings and the content of the Qur'ān are clearly stated in many parts of the Qur'ān.

The teachings and the content of the Qur'ān can be divided into two main eras, the *Makkan*[6] and the *Madinian* eras. The *Makkan* era was before the prophet Mohammad's (PBUH) immigration to the city of *almadinah*. The *Madinian* era is whatever part of the Qur'ān descended to the prophet in the *Madinah*.

The *Makkan* and the *Madinian* revelations of the Qur'ān display certain characteristics. The *Makkan* revelation is generally characterised by a tense manner of speech and by direct strong words, because most of the addressees at that time were arrogant people and wrongdoers. The *Madinian* style is lenient, simple, and direct to the heart, because the addressees have already embraced Islam and have become good believers by the time of the revelation. In the *Makkan* style, most of the verses are short and strong because its people are still stubborn and have closed minds. On the other hand, the *Madinan* verses are longer and full of long explanation of the laws of Islam, as its people are by now Muslims. The *Makkan* verses also concentrate on great issues of Islam because they had not been permanently resolved, such as monotheism and worshiping Allah alone, while the *Madinan* verses concentrate on classification of the acts of worship as well as the ethics of relationships and fine dealing with each other. The *Madinian* Qur'ān is overwhelmingly full of principles of how Muslims can live in harmony and peacefully with humankind and the universe.

[6] A list of the relevant Tajwīd terminology is included in the appendices.

The Qur'ān mentions issues of the relations of human beings, such as the rights of individuals with respect to each other, as well as the concepts of wealth and poverty, the family, crime and punishment, and the concept of money and wealth and how to use them. The rights of women are strongly advocated in the Qur'ān. There is a whole chapter in the Qur'ān called *Al-Nisa'* "Women", in which Allah mentions every right for women and strongly confirms their dignified status. The notions of blasphemy, hypocrisy, as well as the characteristics of the good believers are elaborately discussed in the Qur'ān.

1.4. Phonetic Representations of the Qur'ān

The Qur'ān, as a self-declarative book, drew the attention of Arabs very early to its phonetic representations of Arabic sounds. Historically, Arabs regarded themselves the masters of Arabic eloquence; therefore they did not expect the Qur'ān to deliver any new linguistic dimension. Although the Qur'ān was revealed in classical standard Arabic, its phonetic and phonological representation constituted a challenge to Arabs. This is mainly because although the language of the Qur'ān was their language, there were many linguistic items that they did not understand. An example of this is in the Qur'ān (19:1) where Allah starts with the Arabic sounds, *Kāf Hā Yā* ʕeīn *sˤād*[7]. Most Arabs of the time did not understand what was meant by them. Also some words in the Qur'ān were difficult for the early Arabs to understand, such as *Abbā* (80:31), ʔ*lkhunnas* (81:15) and ʔ*lsˤamad* (112:2). The Qur'ān uses the same characters and sounds as the classical Arabic language but with different levels of eloquence and clarity. Indeed, this fact is stated in the Qur'ān (26:192-195). "And truly, this (the Qur'ân) is a revelation from the Lord of the ʔā*lāmīn* (mankind, jinns and all that exists), which the trustworthy *Rûh* [Jibrael (Gabriel)] has brought down. Upon your heart (O Mohammad PBUH) that you may be (one) of the warners, in the plain Arabic language." (trans. HK 1997:501) This, as well as many other unique linguistic features, makes many Muslims, especially Arabs, believe that the Qur'ān is a linguistic miracle.

One may ponder what kind of tradition of pronunciation Qur'ān uses for recitation. One may question whether this tradition has been studied and classified. In fact, the answer is yes. Scholars of Islam have made many efforts to adjust and regulate the tradition of reciting Qur'ān under a branch of Qur'ānic science called Tajwīd.

Due to their lack of knowledge of Tajwīd, some of the later non-professional reciters of the Qur'ān make mistakes pronouncing some sounds of the Qur'ān. A clear example of this is when they pronounce the Qur'ānic sound /dˤ/. For Arabs, this sound is the most difficult one in the inventory. It is rarely found in any other human language. For that reason the Arabic language has been called the language of the /dˤ/. The sound can be correctly produced only when the left and right edges of the tongue glide and touch the tips of the top premolars and the molars. The

[7] Arabic language makes a phonological difference in the segment length of the vowels; therefore /ā/ vowel sound is longer in duration of the vowel compared to /a/ vowel.

further the tongue is extended to the right and left molars the more correct is the pronunciation. Some early Arabs used to stretch the tongue to one side only, either right or left. Some other Arabic tribes used to stretch the tongue to both sides, which is a more reliable and correct way of pronouncing this sound. Unfortunately it is difficult nowadays to find someone who can pronounce the Arabic sound /dˤ/ by extending the lateral edges of the tongue bilaterally. Most Qur'ānic reciters, even some of the professionals selected for the recitation of this research, did not pronounce this sound in its correct place. Any deviation from the correct pronunciation shifts the sound immediately to an unrelated non-Arabic sound, such as the pharyngealised form of the Arabic /d/ sound, which is found nowadays in some dialects of Arabic.

The sound ض/dˤ/[8], and many other sounds of the Qur'ān, are difficult to pronounce correctly without studying the science of Tajwīd. It should also be mentioned that it is difficult to acquire Tajwīd without sitting in front of a professional teacher, studying and practising the sounds of Tajwīd by copying his mouth when pronouncing the Qur'ānic sounds. Thus the importance of Tajwīd cannot be underestimated or overlooked by reciters of the Qur'ān.

1.5. Tajwīd (The Phonetics of the Qur'ān)

Many Muslims consider that the Qur'ān, as a divine book, must have unique qualifying characteristics. This nature of divinity should cover all aspects of the Qur'ān. Among the unique Qur'ānic aspects is its phonetic system. Although the Qur'ān was revealed in Arabic, one can feel that its language, its style, its content, and its phonetic representation differ in some ways from standard Arabic. The language of the Qur'ān is more eloquent, formal and consistent. It is becoming increasingly difficult to ignore the important role of *Tajwīd* in the life of Muslims and in relation to perfect understanding of the Qur'ān. Al-Hashmi (2004:11) points out, "Tajwīd only pertains to the language of the Holy Qur'ān as its prime goal is to prevent the reciters of the Holy Book from making mistakes when reciting; in other words, to maintain the sacredness of the Holy Book."

It has been argued by al-Rajhi (1969:96-201) that many Arabic words show that Tajwīd existed in the dialects of the Arabs even before the Qur'ān. Al-Rajhi (1969:96-201) mentions

[8] Qur'ānic pharyngealised sounds are written in this thesis with the IPA pharyngealisation symbol /ˤ/.

many Arabic words that were in the dialects of Arabian tribes before Islam.That kind of Tajwīd, or phonetic system, is not important to the present research, as the core of this research (the emphatic uvularised and pharyngealised sounds of the Qur'ān) lies in the Qur'ānic Tajwīd.

The Qur'ānic Tajwīd is in general the art of reciting the Qur'ān. Etymologically, the word Tajwīd comes from the Arabic root "*jawwada*" (to make something better). Tajwīd is the Qur'ānic phonetic representation of rules that govern the oral recitation of the Qur'ān. The definition of Tajwīd in Arabic goes beyond the rules of recitation. It means the ability to deal with every sound in a given Qur'ānic word as a separate and independent entity, as well as dealing with every part of the mouth as a different manufacturer of a separate and independent sound.

Muslims believe that the knowledge of Tajwīd is a prerequisite of reciting Qur'ān. Nelson (1980:36) states, "Tajwīd is believed to be the codification of the sound of the revelation as it was revealed to the prophet Mohammad and as he subsequently rehearsed it with the angel Gabriel. Thus the sound itself has a divine source and significance, and, according to Muslim tradition, is significant to the meaning."

The Qur'ān is the core of Tajwīd and the text that inspires it. It is common knowledge for Muslims that Tajwīd exists only for recitation of the Qur'ān. It is not used in any other form of Arabic speech. Since it is the codification and the regulation of the Qur'ān, Tajwīd cannot be acquired without verbal examples recited by an instructor in front of the learner. Thus to a great extent, learning Tajwīd is an imitative process. Students imitate their teacher by looking at his mouth when he pronounces the word and they pronounce it after him. Nelson (1980:37) writes, "The science of Tajwīd, itself, is transmitted orally; the student imitates the sound produced by his teacher. This process if not restricted to Tajwīd as it was also found in the learning the Cardinal Vowels of Daniel Jones. The many texts, which set out the rules of Tajwīd, are considered supplementary to the oral transmission. Since many of the rules for pronunciation of the phonemes are uniquely applied to the Qur'ān, and not heard in the literary language, or in the colloquial dialect, standard verbal descriptions of some of these sounds are incomprehensible without oral example." The production of *Qalqalah*, "an echoing sound at the end of the some

Qur'ānic sounds", for instance, as well as so many aspects of Tajwīd, cannot be properly acquired without a teacher who listens to and corrects the learner.

The consonant sounds of Tajwīd are classified into three natural sound classes, the sonorants, the obstruents and the gutturals. The sonorant sounds of Tajwīd are the same as the Standard Arabic ones, such as the م /m/, ل /l/, and ر /r/ sounds. The Qur'ānic obstruent sounds that are of importance to this study are /sˤ/, /ðˤ/, /ʁˤ/, /χˤ/, /tˤ/, /qˤ/, and /dˤ/ sounds.. Other obstruents have been ommitted as they do not not cause immediately following /a:/ vowels to become Qur'ānic Pharyngealised Vowels (QPS) and it is the QPS volwes that are the main focus of this study. Arabic gutturals have been thoroughly investigated by Zawaydeh (1999), Watson (2002), and Bin-Muqbil (2006), and have been subjected to analysis by recently developed phonetic and acoustic instruments. Al-Hashmi (2004:47) explains, "A guttural class in the language of the Holy Qur'ān includes six sounds which can be broken down into the two pharyngeals /ħ/ and /ʕ/, laryngeals /h/ and /ʔ/ and uvular /χ/ and /ʁ/."

Among the Qur'ānic vowel sounds, three main basic vowels control all the other subsidiary vowels. In Tajwīd they are called "the diacritics of the Qur'ān". Gairdner's (1925) vowel chart includes the main vowels of Arabic, which are /a/, /i/, and /u/. Mitchell (1993:138) summarised the Arabic vowels. "The vowel system of Classical Arabic/Modern Standard Arabic is a simple one of three vowel units or phonemes – open, close front, close back – with a superposed short/long distinction applicable to all three."

Tajwīd has nine vowels that are developed from the above three main vowels. These nine vowels include all vowels used in the classical Arabic inventory, as shown in Figure 1.1.

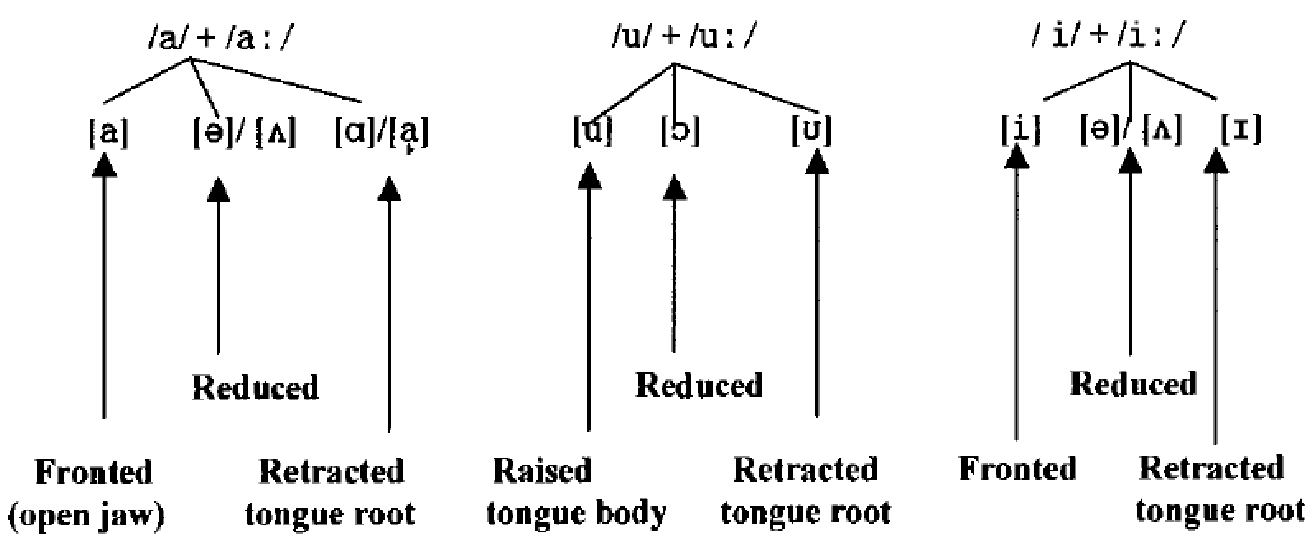

Figure 1.1.The nine Arabic allophones of the three main Arabic vowel phonemes and their place of articulation, from Al-Hashmi (2004:29).

Diphthongisation of vowels also occurs in Tajwīd, where more than one sound is combined to produce another sound. Of the nine allophones in figure 1.1, this research focuses on the Qur'ānic /a:/, /i:/, and /u:/ vowels, which are essential in the production of the syllables commencing with the Qur'ānic pharyngealised and uvularised emphatics /sˤ/, /ðˤ/, /ʁˤ/, /χˤ/, /tˤ/, /q/ˤ, and /dˤ/ sounds. These sounds are the core of this research and they are investigated further throughout this thesis. Al-Hashmi (2004:31) states, "Another observed change in vowels' quality is the diphthongization where a single vowel becomes two vowels. Specifically, following pharyngeal or uvular (guttural) consonants, vowels tend to change their quality between raising and falling."

Qur'ānic vowels are all governed by *Madd*, which is lengthening of the vowel, or by *Qasr*, which is the shortening of the vowel. The segment length in the Qur'ānic vowel is so important in defining the right amount *Madd* or *Qasr*.

1.6. Tajwīd in Western Scholarship

The last century witnessed the contribution of some Western scholars in the domain of Arabic phonetics. Only a few of these works pertain to the phonetics of the Qur'ānic "Tajwīd". Al-Hashmi (2004:13) states, "It is striking that little has been written about the recitation of the Holy Qur'ān by modern linguists." Western scholars have tended to overlook the significance of the Qur'ān and the importance of Tajwīd as a complete and codified system of Qur'ānic recitation.

This is mainly because most Westerners focus only on the form and the content of the Qur'ān and almost never go beyond its meanings and exegeses. Yet the study of any language is not confined to its form or content only. There are aesthetic aspects of many languages that are hidden in between the form and the content. A clear example of this is the phonetic system of the Qur'ānic Tajwīd, which has been overlooked by most Western scholars.

The importance of Tajwīd comes from the fact that this traditional system of Qur’ānic sounds has a much to contribute to the study of the Arabic phonetics and phonology. Tajwīd is full of insights into important features that can contribute greatly to Arabic phonology and which might be considered for incorporation into a theoretical and phonological framework.

Western studies of the Qur’ān in general and Tajwīd in particular have rarely as yet been able to supportively direct their research into the sounds of the Qur’ān in a modern scientific and experimental way. They have dealt with Qur’ān and its related sciences as a part of the history of Muslims, not as a living and developing science that is progressively rejuvenated by further research. Ayoub (1993) came to the conclusion that “until recently, the Qur’ân has been treated in the curricula of Western universities and colleges as a historical and literary document. Little attention was paid to the Qur’ān as a sacred scripture and the vital role it continues to play in the spiritual, social and cultural lives of millions of men and women around the world.”

This neglect applies not only to the text of the Qur’ān itself; many Western scholars also overlook the iconic role of scholars of the Qur’ān in the formation of Arabic and Islamic culture. McIntyre (1991:13) states: “Qur’ānic scholars, influential in their own cultures (but generally overlooked in statistics on literacy published by such august bodies as UNESCO!), are the bearers of a rich cultural heritage, and are comparable to professors of the classics in European universities and schools, not only in their knowledge and social status, but also in their function of providing a ready source of potential lexical innovations.” It is common knowledge that the contribution of a scholar cannot be fully understood or even criticised without investigating the scholar’s thoughts and the background of this scholarship.

During the last century, many Muslims regarded the science of Tajwīd as a purely religious matter because of its relation with the sacred book of Muslims. Most Arabs who were in contact with Westerners over the last two centuries were not interested in issues related to the Tajwīd. Therefore, the nineteenth and the twentieth centuries witnessed few contributions from Arabs or Muslims in presenting Tajwīd to Western readers. It is indeed astonishing that Westerners and orientalists preceded Muslims in writing about Tajwīd in Western languages. In 1925 Gairdner describes Tajwīd, stating, “Orthoepy or the correct recitation of the Qur’ān was the sole object of phonetics with the Arabs.” Unfortunately, most of the Western contributions in the domain of

Tajwīd consisted only of a description of the sounds, with no explanation of their nature, their phonetic properties or even their exact place and manner of articulation.

Stimulated by her interest in ethnomusicology, Nelson in 1977 journeyed to Egypt to determine what gave Egyptian reciters such great systematicity and regularity in reciting the Qur'ān. She contributed much by introducing Tajwīd as an art to the Western world. Her main interest, however, was not Tajwīd in itself but rather the musicality of the Qur'ānic recitation. Westerners still lack a comprehensive work that introduces Tajwīd as an authentic contribution to the field of Qur'ānic recitation. The responsibility lies first on Arabic phoneticians and secondly on Western Orientalists to make Tajwīd an accessible branch of knowledge for researchers.

Many fascinating phonetic and phonological processes await research and investigation in Tajwīd. It is amazing that a contemporary Arabic phonetician, such as Semaan (1968:35-67), attributes Tajwīd to the Arabic language. He does not mention that Tajwīd is ultimately the tradition of reciting the Qur'ān. Semaan defines Tajwīd as "the cantillation of the scripture." Some other scholars have studied the Qur'ānic recitations of their informants without mentioning Tajwīd as the science responsible for those rules. If we refer to the sounds of the Qur'ān without relating them to Tajwīd then we may be only describing the sounds without any real application to the actual Qur'ānic patterns of recitation . Utimately, Qur'ān is Arabic and the words and the sounds it uses are basically those of Arabic. For the sake of indicating its independence and divinity, those words and sounds when recited in Qur'ān, must be recited according to the rules of Tajwīd, which governs Qur'ānic recitations. Muslims can easily identify whether any passage is from Qur'ān or not when recited. This research records some passages from Qur'ān recited once and also read normally once by the same speaker. This is hypothesised to show that Qur'ānic recitation is significantly different in its phonetic system from that of normal Arabic. As stated earlier, the Qur'ān has its own inimitable language, which is different from Arabic.

Contemporary scriptures have no exact counterpart to the concept of Tajwīd. For this reason, in many Western studies (al-Faruqi 1987, Mcauliffe 2003; Graham and Kermani 2007) Tajwīd is confused with cantillation or chanting. These two terms cannot be applied to Tajwīd as the latter has its individual identity and cannot be applied to the cantillation of the scripture of the Jews or to the Bible.

Cantillation and chanting are usually performed with music and melodies. The Qur'ān, on the other hand, is well removed from music and its application. The *Shorter Oxford Dictionary* defines cantillation as to "recite with musical tone. Hence, cantillation (means) musical recitation." The *Macquarie International English Dictionary* also defines cantillation as "To chant or intone something especially passages of the Hebrew Scripture." Similarly, *Collins English Dictionary* attributes cantillation to chanting Hebrew Scriptures. The nature of Tajwīd is totally different from cantillation. Tajwīd is not merely a style of chanting but rather a system of Qur'ānic codification and an independent science. Though using the term cantillation, Graham and Kermani (2006:118) highlight the Qur'ānic nature when they state that "among Muslims, Qur'ān 'cantillation' has its own forms that set it forever apart from all other recitation and all musical forms." Tajwīd pays much attention to the place and the manner of articulation of the Qur'ānic sounds whereas musical cantillation is mostly concerned with melody.

1.7. Principles of Tajwīd

Tajwīd as a science deals with fundamental issues such as *Makhārij al-Hūrūf* (points of articulation) and *Sifāt al-Hūrūf* (manners of articulation). Tajwīd also studies the *Ahkām* (laws) of the quiescent *Mi:m* and *Nu:n* as well as the sounds of al-Tajwīd.

Places of articulation for Tajwīd are classified according to the position of the sound production inside the mouth. These places extend from the larynx to the lips. Scholars of Tajwīd have paid extraordinary attention to the place of articulation of every Qur'ānic sound. The twenty-eight phonemes of Arabic have been assigned their correct places in the mouth by the science of Tajwīd.

In the domain of *Sifāt al-Hūrūf* (manners of articulation), scholars of Tajwīd have contributed much in ascribing to every sound its exact phonetic properties and parameters. Though the exact nature and functions of the vocal cords were not very clear to the classical Arabic scholars of TajwīdTajwīd, they introduced phonetic properties of the Qur'ānic sounds such as *Mahmūs* 'breathed', *Majhūr* 'unbreathed', *Mufakham* 'pharyngealised', *Mustafil* 'depharyngealised', *Iħtikaki* 'fricative, and *Infijari* 'stop sound'. A glossary of the relevant Tajwīd and other Arabic technical terms is included in the appendixes.

In relation to the laws of the recitation, scholars of Tajwīd have defined four main phonological laws that govern the quiescent /n/ in Qur'ānic recitation. They are (1) *Iðhār*, which means the appearance of the sound where there is no assimilation. An example of this is وانحر /wanħər/ which is also read [wanħər]. (2) *Ikhfāʔ*, which means the hiding of a sound. An example of this is ولئن قلت /walaʔin qulta/ which is read in Qur'ān as [walaʔiŋqulta]. (3) *Iqlāb* which is transforming the sound /n/ into /m/. An example of this is من بعد /min baʕdu/ which is read in Qur'ān as [mimbaʕdu]. (4) *Idghām*, which is the coalescence or assimilation. An example of this feature is the Arabic word من ربهم /min rabbihim/ which read in Qur'ān as [mir rabihim]. These four laws govern the sound that comes after the quiescent /n/ in Tajwīd.

Tajwīd has many characteristic features. Among them are the Qur'ānic consonantal segments, the sonorants and the obstruents. Each of these has many subclasses according to their category of natural classes. The features of manners and place also play a very important role in the learning of Tajwīd.

Pharyngealisation and the production of the Qur'ānic emphatics and uvular sounds are highly important in Tajwīd to secure the correct recitation of these sounds in the Qur'ān. This phonological phenomenon (pharyngealisation) is a universal one and not specific to certain languages.

Classical Arabic scholars have contributed enormously to the development of the science of Tajwīd throughout the last ten centuries. Their work and achievements, especially concerning the phonetics and the sounds of the Qur'ān, are discussed in detail in the next chapter.

1.8. An Overview of the Dissertation

This dissertation consists of six chapters. Chapter one is an introduction to the concept of Qur'ānic recitation, content, orality, and the phonetic system of the Qur'ān, called Tajwīd. This chapter also invokes classical and current works that have discussed Tajwīd as a phonetic system of Qur'ānic recitation. The main principles of Tajwīd are also highlighted, in a comparative way that shows the compatibilities between the classical views of Tajwīd and the contemporary scientific method of presenting its features.

Chapter two shifts towards the classical contribution of Arabs in the field of Arabic phonetics in general and the Qur'ānic sounds in particular. It is difficult to discuss Tajwīd without the including the classical contribution of the first Arabs who devoted most of their lives to the study of the sounds of their language.

Chapter Three discusses the concept of the Qur'ānic pharyngealised sounds in greater detail. Many issues are particular to Qur'ānic pharyngealisation, such as the five levels of pharyngealisation as well as the degrees of constriction of these sounds. The other Qur'ānic sounds that are less frequently pharyngealised are also discussed in this chapter. The Qur'ānic pharyngealised vowel /a:/ has a great role to play in the Qur'ānic pharyngealised sounds, especially when it follows a Qur'ānic pharyngealised consonant. This role is highlighted in this chapter. The other Qur'ānic vowels /i:/ and /u:/ are also examined in this research for the purpose of comparing them with the Qur'ānic pharyngealised vowel /a:/. In order to understand the nature of the Qur'ānic pharyngealised vowel and consonant sounds, their physiological configurations are studied and highlighted.

Chapter Four deals with the acoustic analysis of the sounds of this research . It outlines the methodology and the results of the acoustic analysis of the Qur'ānic pharyngeal sounds (QPSs). In order to understand the phonetic identity of the Qur'ānic pharyngealised vowels, it is necessary to demonstrate a clear relationship between the articulatory configuration of the studied sound and its acoustic correlates. It is well known that there is a strong correlation between the different spectral cues of a given sound and the articulatory configuration of that sound.

Chapter Five deals with a pilot artculatory experiment using videofluorography. This experiment will investigate the Qur'ānic pharyngealised sounds through an articulatory and an acoustic analysis. The articulatory experiment in this chapter will make use of a videofluorographic experiment to trace the different places of articulation of the Qur'ānic pharyngealised sounds including the primary and secondary articulations.

Chapter six is the discussion of the findings of the acoustic analysis and the articulatory experiment. It discusses the nature of the Qur'ānic pharyngealised vowel sound and it then discusses the various experimental results. It also discusses the nature of the Qur'ānic vowel as well as the main acoustic and articulatory features that characterise the Qur'ānic pharyngealisation such as vowel duration and the distance between F3-F2. The idea of the auditory integration of the spectral peaks especially F1-F2 and F3-F4 will be discussed for a better understanding on how the human brain deals with these Qur'ānic pharyngealised vowel sounds.

Chapter seven deals with the conclusion of the research and the further research of the issues that has not been covered in this research.

CHAPTER 2

Literature Review

2. Introduction

Scholarly study of the Arabic language has a long history. Early scholars of Arabic were motivated by both their love of their language as well as by its status as the language of their holy book, the Qur'ān. This chapter discusses the major contributions of some of the most prominent classical Arabic scholars. The chapter details both classical and contemporary contributions of scholars of Tajwīd. Previous studies of Arabic pharyngealised sounds, as well asstudies of Arabic emphaticness, uvularisation, and pharyngealisation,will also be reviewed.

2.1. Classical Arab and Muslim Contributions to Phonetics

2.1.1. Al-Khalīl Ibn Ahmad

Arabic sounds were described and investigated many centuries ago. The first documented description of Arabic sounds comes from the eighth century AD. The Arabic text of al-Khalīl Ibn Ahmad al-Farahīdi (who lived between 718 and 791 AD) was an unprecedented contribution to Arabic phonetics and linguistics. The approach and methodology in his dictionary *Kitāb 'al- Ayn* /ʕeīn/ were new in almost every respect.

Al-Khalīl was the first Arabic scholar to develop a connection between Arabic phonology, morphology, and syntax. Ryding (1988) states that he "was the most original and influential early scholar of Arabic morphology, syntax, and lexicography. He is most famous for having discovered and classified the quantitative meters of Arabic poetry, but he also compiled the first dictionary of Arabic, with an introduction in which he laid the foundation of the standard theory of Arabic morphology based on discontinuous roots."

The study of Arabic sounds owes a great deal to the contribution of Al-Khalīl. He logically reordered the old hierarchy of Arabic sounds according to their correct places of articulation. This development was unique because it depended on knowledge of the sounds and their properties. Al-Khalīl divided *Kitāb 'al- Ayn* /ʕeīn/ into two parts. The first part was an introduction to the text, outlining its original linguistic and statistical procedures. The second part concerned the sounds that should, or should not, be used in Arabic. An examination of the book reveals the author's enormous phonetic knowledge.

In introducing the sounds in *Kitāb 'al- Ayn* /ʕeīn/, al-Khalīl did not start with the normal order of the Arabic alphabet. Innovatively, he chose to systematically examine the sounds produced in order of their place of articulation, starting from the back of the vocal tract and proceeding to the front. He observed that the most backed or retracted consonantal sounds were the Arabic laryngeal sounds ء/ʔ/, and ه /h/.

He did not start with the Arabic *hamzah* /ʔ/ or the *alif* /æ/ because he considered them to be variable phonetically in different Arabic words. As for the sound *Haaʔ* /h/, he claimed that because it was a weak unvoiced sound he did not like to start his dictionary with it. He found that the Arabic sound *Ayn* /ʕeīn/ was next, from the back of the vocal tract, after the laryngeal sounds ء/ʔ/, أ/ æ/, and ه /h/. Sara (2009:2) found that al-Khalil described *Ayn* /ʕeīn/ as the innermost letter [Harf] and started with it.

He decided that the Arabic sound *Ayn* /ʕeīn/ was clearer and stronger than the other backed consonants. Hence, he started his book with it and named it *Kitab al Ayn* /ʕeīn/

There were no phonetic instruments to test the sounds at the time of al-Khalīl but he was innovative in his method of testing and selecting the sounds with which to start his phonetic dictionary. His phonetic method was to observe himself during the production of the Arabic sounds.

Al-Khalīl divided the Arabic sounds into ten types and allocated a separate name for each category, such as the لهوية *Lahawiyah* (uvulars), theنطعية *Nat'iyah* (alveo-palatals), and the شفوية *Sahfawiyah* (labio-dentals).

The contribution of al-Khalīl to the study of the Arabic sound system is not limited to the phonetic categorisation of the sounds. He also, in certain parts of the *Kitab al-' Ayn* /ʕeīn/, outlines general phonological rules that are applied to the sounds of the Arabic language. For instance al-Khalīl (HD) states that if you find any Arabic word of four or five letters that does not contain any of الذلق*al-Thalaq* (alveolars) sounds /l/, /r/, and /n/ or the *Sahfawiyah* (labials and labio-dentals) /f/, /b/, and /m/ then the word is extraneous.[9]

In the domain of the physiological anatomy of the human speech organs al-Khalīl was innovative in his description and explanation of the contributions of the various articulators to the production of human sounds. What makes his description particularly noteworthy is that he depended only on observation of his own patterns of speech production. He divided the process of sound production into three main stages: the lungs, the oropharynx, and the mouth. Al-Khalīl was the first Arabic phonetician to maintain that sound production starts at the lungs with the air pushed out; then at the throat, which is closed, restricted or open; then at the mouth to form the final shape of the sound.

Due to his limited knowledge of the anatomy of the throat, al-Khalīl did not elaborate in detail on the production of pharyngeal or pharyngealised sounds. He also did not explain how the vocal folds vibrate and articulate to produce voiced and unvoiced sounds. But when one considers his lack of equipment during the eighth century one realises that he was a genius in observing and categorising these sounds.

The arrangement and description of the sounds in his book reveals al-Khalīl's sensitive and systematic phonetic insight and his patience in the detailed process of observation and of making conclusions based on those observations. Modern studies in Arabic phonetics have not deviated greatly from what al- Khalīl discovered in his time. It should be clear that al-Khalīl was not merely a linguist but also an outstanding scholar who was talented in the description of most dimensions of the Arabic language. Shahid (1998:ix) points out, "Al-Khalīl's versatility and the diversity of his achievements have often been commented upon, but he remains basically a philologist and what is striking about his achievement in this area is the comprehensiveness; witness his contribution to phonology, grammar and lexicography."

The great linguistic and phonetic contributions of al-Khalīl were not limited to his time or contemporaries. He laid the foundations for a school of thought that benefited linguists coming after him. Among those who followed in the footsteps of al-Khalīl was his intelligent student Sibawayh, who was originally Persian but nevertheless was a scholar of Arabic.

[9] Meaning that word is not originally an Arabic one and might have come from another language.

2.1.2. Sibawayh

It is notable that classical Arabs were aware of the sounds, words, and expressions of their language. This is clear from the enormous literature that recorded their speech, prose, and poetry since the time of al-*Mu'allāqāt*[10]. The great manuscript of Sibawayh *al-kitab* is a clear example of this.

Sibawayh (who lived between 760 and 796 AD) was a pioneering Arabic grammarian who devoted his life to Arabic and to the production of his masterpiece, الكتاب *al-Kitāb*. In the domain of phonetic studies Sibawayh was heavily influenced by al-Khalīl's school of thought. The descriptions of the organs of speech are the same for both the scholars, as are the descriptions of the manner of articulation of the sounds. The places of articulation are also similar in the treatises of both scholars. There were, however, some differences between them. Sibawayh did not start his dictionary with the sound *Ayn* /ʕeīn/ as did al-Khalīl, but rather he started with *al-Hamzah,* the "glottal stop" sound. Sibawayh developed an alternative point of view concerning the sound of *Hamzah.* He allocated a whole chapter to discussion of this Arabic sound. He argued that although this sound is clear and essential in Arabic, it tends to be a soft (lenis) sound. Watson and Dickens (1994) maintain, "Sibawayh observes that this consonant has a strong propensity to lenition, and suggests that this is because the glottal stop requires relatively greater effort to produce."

Careful study of the two books and the biographies of al-Khalīl and Sibawayh reveals that though they evolved from the same school of thought, they are divergent in their grouping of Arabic consonants. Their different methods of observation as well as the lack of connection between them led to their different opinions in determiningArabic phonetic rules.

The main phonetic contribution of Sibawayh in his treatise *al-Kitab* was his concern for the phonetic categorisation and characteristics of the Qur'ānic and Arabic sounds. His classification of sounds into *Majhūr* (unbreathed) and *Mahmūs* (breathed) and the way each sound is produced make his contribution innovative.

[10] These were great poems that poets used to compose and hang on the wall of al-Ka'bah, the black sacred stone in Makkah, for one year for discussion and criticism.

For Qur'ānic sounds Sibawayh preferred to cite examples firstly from the Qur'ān when possible, and secondly from Arabic. He described the ideal pronunciation of the Qur'ānic verses. From time to time he explained the rationale behind the Qur'ānic choice of some meanings and utterances. Card (1983:10) states that "Sibawayh describes the pronunciation preferred for formal speech and reading from the Qur'ān."

Al-Nassir (1993) produced a comprehensive work on the biography and the contributions of Sibawayh as a phonologist. He presents a critical analysis of Sibawayh's arrangement of sounds and their production. He also discusses Sibawayh's theory of inappropriate Arabic sound formation phonetically and phonologically. Al-Nassir then discusses the Sibawayh's contribution to phonological terminology such as *Idghām, Ixfā' ItTbāq* and *Ist'lā'*. He also discusses the notion of Arabic pharyngealised sounds, which are the core of this study.

It can be said that the book of al-Nassir has many inadequacies, especially in the transcription of the sounds and the exact description of the Arabic *Itbāq* sounds. Watson and Dickens (1994) gave a detailed criticism of some parts of al-Nassir's book, presenting some suggestions to correct mistakes in his analysis. It should be noted that criticising a work of Sibawayh or even dealing with it as a normal reference is difficult to a certain extent. Though no human work is above criticism, Sibawayh's work, as an iconic scholar, is hard to be easily investigated or criticised. Although there are some shortcomings in the work of al-Nassir, his writing is still influential as little analysis or the criticism of the works of Sibawayh has been done subsequently.

It is very important to stress that Sibawayh was the first, in Arabic classical treatises, to notice that *Majhūr (unbreathed)* sounds are produced from the lungs, the throat and the mouth, while *Mahmūs (breathed)* sounds are produced only in the mouth. He means that in producing the *Majhūr* the additional contribution of the vocal folds is the vocal cord vibration.

Sibawayh utilized his knowledge of Arabic and the Arabic knowledge of his contemporaries to give the various phonetic processes certain Arabic names. People have, since then, taken them for granted. Watson and Dickins (1993) cite many Arabic phonetic terms that were invented by Sibawayh, such as *Mahmūs (breathed)* vs. *Majhūr (unbreathed)* and *Mutbaq* (semi-closed) vs. *Munfatiħ* (open).

In the third chapter of *al-Kitab*, we find a thorough explanation of the Tajwīd phonological processes such as *idgham* (fusion),*ibdāl* (replacement) and *ikhfā'* (concealment). Though his treatise was not designed to be a phonetic book about Tajwīd, Sibawayh almost laid the foundations for the Qur'ānic phonetic system. It is impressive that such a great phonetic contribution depended only on personal observation. The contributions of al-Khalīl and Sibawayh helped to lay the foundation for a new generation of scholars of Arabic linguistics. Those scholars such as al-Jaħidh were multidimensional in their linguistic enquiry.

2.1.3. Al-JāħiD

Amr Ibn Baħr al-JaħiD (who lived between 781 and 868 AD) was among the first classical Arabs to examine Arabic linguistics in general and Arabic phonetics in particular. When he started his study of Arabic, he was able to build upon the prior study of some of the early scholars such as al-Khalīl, Sibawayh, Ibn al-Siraj, and Ibn Duraid. He built his knowledge upon what he found from those scholars but added a new phonetic dimension relating to the disorders of the Arabic speech.

In his book *al-Bayan wa al-Tabi:n* al-JaħiD paid special attention to the treatment of speech disorders. He focused on the sounds that are affected by the symptoms of aphasia. He described the norms of the Arabic sounds then he introduced the aspects of dysarthric[11] pronunciation. He elaborated particularly on dysarthria, which is responsible for poor articulation of speech sounds. He also suggested treatments and bio-training for aphasic people. Al-JaħiD further elaborated on the dysarthric problems of subsystems of Arabic articulation such as phonation, assimilation and jaw movements.

Al-JaħiD also focused on aphasia from a social perspective. He studied the aspects of aphasia in three social groups, the eloquent, lay people, and non-Arabic-speakers. Moreover, he defined the differences and the boundaries among Arabic dialects of his time. He was among the first to study second language learners' creation of varieties of Arabic sounds, which were gradual, and often imperfect, modifications of the norms of the first language speakers. It should be noted that in the work of al-JaħiD his phonetic interest was not only in the Arabic phonemes and their phonology but also in problems of the production of these phonemes. It is evident that

[11] A nervous system disorder affecting the pharynx, tongue, and lips that impedes proper pronunciation

at the time of al-JaħiD, Arabic phonetic studies began to be more focused and specialised. This normal process of the advancement of knowledge opened the doors of linguistic investigations for Ibn Jinni, who was more focused in his investigation of the Arabic sounds.

2.1.4. Ibn Jinni

Abu al-fatħUthman Ibn Jinni (who lived between 933 and 1001 AD) discovered early in his life his interest in the study of the phonetics of the language. Ramadan (2007:3) states that "Ibn Jinni has been somewhat ignored by modern researchers … as his contributions and efforts have not been highlighted. In fact, he has not got the attention he deserves as one of the most original scholars in this field."

Though Ibn Jinni's phonetic descriptions were based on Sibawayh's classifications, he wanted to investigate the Arabic phonemes more accurately than in previous studies, focusing on their place of articulation and the physiology of the speech organs.

Ibn Jinni defined language as "sounds with which every people express their needs". This definition focuses on the distinctive orality of language, and on the function of language as a means of exchanging thoughts and expressions. More interestingly, Ibn Jinni's definition points out the linguistic differences between different human societies.

He was the first Arabic phonetician who linked human sounds with the actions and the sounds of nature. Ibn Jinni's onomatopoeic theory was new and no one (to the knowledge of this researcher) had introduced it previously, especially in the study of Arabic language. Al-Masri (2008) explains that Ibn Jinni established the theory of Arabic onomatopoeia when he classified it into four main ranks. The first rank is phonetic onomatopoeia, the naming of things after their sounds. The second rank is the similarity between the construction of the utterance and the semantic connotation of the named object. The third rank is functional onomatopoeia, denoting the similarity between the function of an object and its physical characteristic. The fourth rank is the onomatopoeia of sequential structure, that adds the same intonation or stress to more than one consecutive word.

It can be said that Ibn Jinni was the first to consider the sounds of the language as an independent science with its own rules in Arabic. This notion of the sound as a science was asserted in the Ibn Jinni's masterpiece, سرصناعةالاعراب "*Sirr Sinā'at al-Iʕrāb*". Until then, Arabs had not known a book confined to the study of sounds.

Among his many contributions, in this book Ibn Jinni gathered the scattered knowledge of Arabic sounds introduced before him by classical Arabic scholars to firmly establish what he called the science of the sounds. He meticulously described the mouth as the organ responsible for speech. Then he classified the sounds of Arabic by their manner and places of articulation. He then proceeded to the anatomical description of Arabic sounds. He examined the natural duration for every Arabic sound, and he categorised them into different groups based on their duration. Ibn Jinni elaborated on each sound and its phonological properties when it is combined with another sound, as well as the changes that occur when two sounds are adjacent. He stated clearly in this book that he was not interested in the phonology of Arabic at that stage. Ibn Jinni wrote another book, الخصائص "al-Khasā'is" in which he introduced the phonological properties of Arabic in an unprecedented way.

Ibn Jinni was aware of the articulatory processes of speech sound production. He emphasised in many places of his book سرصناعةالاعراب "*Sirr Sina'at al-Iʕrāb*", that sound production is not limited to lip rounding or to putting the tongue in the right place inside the mouth; sound production is also controlled by the two vocal folds, the tongue, and the articulation points of the tongue with the palate.

Ibn Jinni was the first to compare the mouth with the flute. He suggested that the sound comes out of the flute in a smooth unobstructed flow. When the artist puts his fingers on the holes of the flute and plays with it we hear different sounds. We hear a different sound for every hole. He suggests that it is the same in the vocal tract. Thus when the sound is produced from the lungs and is impeded by the tongue in each place of articulation in the mouth we hear a different sound. In fact, this comparison was almost echoed by Western scholars eight centuries after Ibn Jinni. Modern scholars of phonetics, such as Fant (1960) and Steven and House (1961) compared the vocal tract when pronouncing a uvular /k/ sound to a tube that is closed at the velum but open at the glottis for a voiceless stop.

Unlike contemporary scholars of phonetics, Ibn Jinni did not describe the speech production process but he described in detail the organs of speech production, such as the lungs, the throat, the tongue, and the mouth.

It should again be noted that the great contribution of Ibn Jinni to Arabic phonetics and phonology depended only on his introspective personal observation. Recent research into Arabic sounds have corrected some of the misunderstandings of the classical Arabic phoneticians. Ibn Jinni, for instance, stated that the place of production of the Arabic /q/ sound is at the tip of the uvula, and he placed it between the sounds /ʁ/ and/x/ sounds. This actually is not consistent with what we know today. The Classical Arabic /q/ sound is produced at the tip of the uvula and behind the sound /x/. Ibn Jinni also thought that the sounds /s/, /z/, and the /S/ are produced when the tip of the tongue articulates against the roots of the upper teeth, which is not what we know today about these sounds. These sounds are normally produced from a place behind the upper teeth, particularly in the alveolar area. As stated above, these misunderstandings as to the identity of these sounds in Ibn Jinni's work should not, however, lead us to underestimate his contribution to the field of Arabic phonetics, especially when we know that he relied only upon his personal observation. Ibn Jinni's life and contribution has been the subject of some recent studies examining his contribution to the field from a different perspective. Bakalla (1982) investigated most of Ibn Jinni's phonetic contribution in his book *Ibn Jinni: an early Arab Muslim phonetician. An interpretive study of his life and contributions to linguistics.* The book focuses not only on Ibn Jinni's contribution to phonetics but also on his contribution to phonology, morphology, and syntax.

Ramadan (2007), in his study *Ibn Jinni's role and contribution to Arabic semantics,* studied the semantic contribution of Ibn Jinni in the Arabic language. Ramadan (2007:2) states that "Ibn Jinni used a unique method when dealing with problems of sounds produced by an Arabic word and the meaning transmitted when that word was produced orally."

In the history of classical Arabic phoneticians, Ibn Jinni has been thought of as a key factor in the development of this science as early as the eleventh century. However, although the contributions of Ibn Jinni, as well as those of many other Arab phoneticians, were unprecedented, they have somehow been overlooked in modern studies. It was not only particular scholars who were overlooked but also particular branches of knowledge. An example of this are the sciences of the Qur'ān, especially the phonetic system of the Qur'ānic "Tajwīd". Unlike Arabic sounds (as spoken in daily life), which have been heavily studied and investigated, the sounds of the Qur'ān have not received until now the warranted experimental study and investigation. On this point Newman and Verhoeven (2002:78) write, “the phonological and phonemic variants (of the Qur’ān) have on the whole received far less attention.” Books of Ibn Jinni such as الخصائص “*al-Khāsa’is*” (the Characteristics) and سرصناعةالاعراب “*Sirr Sina’at al-Iʕrab*” and others are full of Arabic linguistic and phonetic hypotheses, which await modern scholarly experimental investigation.

2.1.5. Ibn Sina

Successful classification of the articulation of a sound cannot be obtained without knowledge of the physiology of that sound. The great Arabic physician Ibn Sina[12] (who lived between 980 and 1037 AD) was also interested in sound production. He was interested generally in medicine, but his observations regarding the articulation of Arabic sounds were considerable. His book on Arabic sounds, *al-Risalah,* presented a detailed description of the airstream of the lungs, the mouth and the tongue. He nominated two major phonetic processes as responsible for the production of Arabic sounds: *Qarʕ* (which means to knock two things together) and *Qalʕ* (which means to extract something from another thing). Ibn Sina's contribution to Arabic linguistics was not as great as that of al-Khalil, Sibawayh, and Ibn Jinni due to his particular focus on medicine.

Most of the work that came after these medieval contributions added little to Arabic phonetics. It is only very recently that experimental studies in Arabic phonetics have examined and verified many medieval theoretical assumptions. Some recent researchers have tried to bridge the gap between medieval and recent studies. Most such studies are reproductions of the medieval Islamic studies in phonetic and phonology. Among them is the study of Khalīl Semaan (1968) who translated the points of articulation of the speech sounds in *Ibn Sina's al-Risala.* Semaan cites Hitti (1937: 3) who wrote that "of all lands comparable to Arabia in size and all the people approaching the Arabs in historical interest and importance, no country and no nationality has received so little study in modern times as has Arabia and Arabs."

Semaan (1968) explains the Arabic system of vowel sounds from *al-Risalah* of Ibn Sina and then provides a summary of the six chapters of *al-Risalah.* A great deal of the translated book is devoted to the life of Ibn Sina as well as to the place and manner of production of the Arabic sounds. Though minor in its content and contribution to the field, Semaan's book has paved the way for many researchers during the last forty years to look for such contributions in Arabic medieval studies and instrumentally examine and reproduce them.

It is noticeable that until 1970, most of the classical and contemporary studies of Arabic sounds were descriptive and articulatory. That year saw the true beginning of the instrumental acoustic investigation of Arabic sounds. Sulaiman al-Ani (1970) conducted a pioneering acoustic

[12] Known as Avicenna in Western scholarship

and descriptive study of Arabic sounds. He also employed X-rays to reveal the exact places of articulation of Arabic sounds, which was at that time an innovative experiment. Most recent and current research in the acoustics of Arabic sounds is still dependent on this study. There were some minor attempts before al-Ani to investigate some rural dialects of Arabic but they were not significant enough to be considered a new beginning for the study of the acoustics of Arabic sounds. Newman and Verhoeven (2002:77) claim that "the first acoustic study of Arabic vowels, which was also the first and hitherto only full-blown phonetic study of Arabic sounds, was that by S. al-Ani (1970)".

In his investigation of the Arabic vowels, Al-Ani presents them in isolation of the adjacent consonant sounds. He outlines the three main long vowel phonemes of Arabic, /i/, /u/, and /a/, as well as their allophones. The difficulty of controlling the production of different allophones of the Arabic vowels in non-connected speech is enormous.

2.2. Qurʾānic Science and Tajwīd

The term "Qur'ānic sciences" in Arabic is an inclusive term that encapsulates every branch of knowledge that has a connection with the Qur'ān. Every field of the scholarly study of the Qur'ān, such as Qur'ānic exegesis, Qirā'āt (ways of Qur'ānic recitation), Islamic jurisprudence, Tajwīd (the phonetic tradition of reciting Qur'ān) are aspects of the Qur'ānic sciences. Qur'ānic sciences began at the beginning of the tenth century when Muhammad Ibn al-Marzubān wrote his book الحاوي في علوم القران al-Hawi fi Ulūm al-Qur'ān (912) (the Compiler of the Qur'ānic Sciences). It should be understood that al-Marzuban did not invent this branch of knowledge; rather he collected what had been written before in the different areas of Qur'ānic sciences. This era of Qur'ānic sciences also witnessed a revolution in every kind of Qur'ānic research. Tajwīd as a phonetic system of the Qur'ānic recitation was one of them.

2.2.1. Classical Contribution of Tajwīd

As mentioned in the first chapter, Tajwīd is the codification system of the phonetics of the recitation of the Qur'ān. The true beginning of Tajwīd was with the revelation of the first verse revealed to the prophet Muhammad (PBUH). It was not known in Arabia before the Qur'ānic revelation and nothing was similar to it. The reciters at the time of the Qur'ānic revelation learned the Qur'ān and Tajwīd simultaneously. There was no other way to recite the Qur'ān except with Tajwīd.

Tajwīd, the core of this study, is a science deeply rooted in the Qur'ān and in the Arabic language. Its appearance as a separate science was delayed because people practised Tajwīd intuitively. The first emergence of an independent book on Tajwīd was during the tenth century, more than three hundred years after the revelation of the Qur'ān. There were some minor attempts before that, such as the last chapter of al- *Ayn's* /ʕeīn/ book of al-Khalīl, which was devoted to the Qur'ānic *Idghām* "assimilation". Tajwīd is mainly connected to two sciences, Arabic language and Qur'ānic sciences. This is because its segments and items are from the Arabic language and its application is in the Qur'ān. Though there is some similarity between Tajwīd and the *Qirā'āt* (ways of reciting Qur'ān), because both are focused on the Qur'ān, it should be noted that Tajwīd is concerned with matters of pronunciation, place and manner of articulation, and the nature of the Qur'ānic sounds, while Qirā'āt is concerned with the differences among Qur'ānic words whether they are in single or plural forms or they are addressing the first or the second addressee. An example of this is where Tajwīd stipulates that the /l/ sound must be pharyngealised whenever it occurs in the word Allah /ʔllˤāh/. Thus Tajwīd is interested in the manners and the places of articulation of the Qur'ānic sounds. Qirā'āt, on the other hand, examines the different forms of the words and the connotations of these differences. For instance, in Qur'ān (1:3) al-Kisā'i and Asim (two scholars of Qirā'āt) read the word *Māliki as* /māliki/ which means "*the owner"* and the rest of the scholars of Qirā'āt read it as /məliki/ which means the king. Both words mean the same in that context.

One of the first known books about Tajwīd was التنبيه علي اللحن الخفي واللحن الجلي (warning about the hidden and apparent errors during recitation) by Abu al-Alhasan al-Sa'eedi (who died in 1068 AD). Another book that appeared in that era was الرعاية لتجويد القراءة وتحقيق لفظ التلاوة (taking care of Qur'ānic Tajwīd and its pronunciation) by Makki al-Qaisi (who died in 1045 AD). Some other books were mentioned in the classical Arabic manuscripts of Tajwīd. Some of them have been lost, others have survived and have been republished in the present day.

Ibn Aljazari (died at 1425 AD) wrote a long poem called طيبة النشر في القراءات العشر (the magnificent poem in the ten ways of reciting Qur'ān) in which he described the laws of Tajwīd and how to recite Qur'ān in a perfect way. He attributed the correct way of reciting Qur'ān and taking care of the manners and places of articulation to exercising the recitation and the long-term exposure to Tajwīd. He believes that the long exposure to the laws of Tajwīd is like practising exercises for the mouth. Hence, the best reciters are those who have the longest exercise and exposure to Tajwīd rules.

It should be clearly understood that there is a major difference between the laws of Tajwīd and research into them. For Muslims, Tajwīd on one hand is a sacred system of Qur'ānic recitation. It requires the same degree of respect and has the same degree of sacredness as the Qur'ān. On the other hand, research into the laws of Tajwīd may be a place of agreement or disagreement among scholars according to their understanding of these laws.

2.2.2. Contemporary Phonetic Representation of Tajwīd

This section examines the contributions of contemporary scholars and phoneticians in presenting Tajwīd in the English language as a complete and codified phonetic system of the Qur'ān. There are two kinds of contemporary phonetic research into Tajwīd. First, there are contemporary works on Tajwīd in Arabic. This era has seen the publication of many books and manuals on Tajwīd research. There are also many ways of presenting Tajwīd in these manuals. Al-Hamad (2006) states: "I have counted more than thirty resources in Tajwīd for contemporary scholars." The main characteristics of these publications were their brevity and focus. More recently, some contemporary publications in Arabic have been considerably longer. Some of these books and manuals reach hundreds of pages, due to the tracking and investigation of Tajwīd issues and to the use of graphs, practical examples and practical exercises. However, the dominant feature of such publications is the quoting of words from old books, mostly verbatim. Al-Hamad (2006) indicates that most of these Arabic publications in Tajwīd revolve around the places of articulation of the Qur'ānic sounds, the characteristics of these sounds, the structure of development and the phonology of these sounds, and finally, the how to exercise the tongue to produce these sounds efficiently.

The second kind of contemporary studies of Tajwīd are specific studies in English, and other languages, that present aspects of it articulatorily, acoustically, or even auditorily.

At a quick glance the whole idea of studying or presenting Tajwīd might seem naive to some people, as it is going to be no more than a work of translation. The reality is that presenting

Qur'ānic Tajwīd in any different linguistic system is very hard work. This is mainly because there are no counterparts for some of the sounds, actions, and terminologies of Tajwīd in other phonetic systems, as Tajwīd is Qur'ān-bound. Such terms are derived from the Qur'ān or specifically from Arabic for the Qur'ān. An example is الإشمام "*al-Ishmām*" which means to observe the trace of the /u/ sound on the mouth without hearing it clearly in pronunciation. Another example is الروم "*al-Raom*" which means to mostly mitigate the effect of the sounds /a/, /i/, and /u/ on the adjacent sound.

It should be remembered that at the beginning of Tajwīd there were no phonetic instruments that could help or assist in determining the exact nature of the sounds. Hence, most of the ancient works on Tajwīd were descriptive and depended mostly on personal observation. There were noexperimental studies that could present the exact shapes and figures of the sounds of Tajwīd to build upon.

These rules, among many other rules of Tajwīd, are not found in any other system; that is what makes the presentation of Tajwīd in any other language a difficult yet not impossible contribution to phonetics. Added to the aforementioned points is the fact that scholars of Tajwīd insist that Tajwīd cannot be perfectly acquired without a professional teacher and a mouth-copying process by the learner[13].This is somewhat clear from contemporary Western studies of Tajwīd, where the writers have possessed knowledge of Tajwīd, such as Abu Bakr (1974), Nelson (1980), El-Ashiry (1996), Graham (1987) and al-Hashmi (2004). These works are reviewed in detail in this chapter.

Studies of Tajwīd so far suffer from the lack of systematic phonetic instrumental and acoustic investigations. Most of the available literature on Tajwīd is a description of the articulatory characteristics of the sounds of the Qur'ān. This research does not underestimate the importance of this step in research into Tajwīd. Nevertheless, it should be noted that Arabic literature is enriched with many scriptures and manuals of Tajwīd that go back to the eighth century. Scholars such as Gairdner (1925) translated some of them into English. The available literature in Tajwīd also lacks (except for the work of al-Hashmi, 2004, which is discussed later) an empirical base that instrumentally and acoustically investigates the individual sounds of

[13]The same reliance on copying from an instructor can be found in other vowel systems like the Cardinal Vowel system of Daniel Jones.

Tajwīd. There has not been (to the knowledge of this researcher) a comprehensive acoustic study of any of the Qur'ānic sounds in English language. This observation inspired the researcher to investigate the pharyngealised and uvularised emphatic sounds of the Qur'ān, articulatorily and acoustically.

In the domain of the principles of Tajwīd, Abu Bakr (1974) presented his study of the rules of Tajwīd in a descriptive way. Though he carried out some experimental investigations, they were limited and insufficient to systematically describe a traditional phonetic system such as Tajwīd. His pioneering presentation of that study in English is a credit to Abu-Bakr, yet the limitations of his informants and data might disappoint many of today's researchers into Tajwīd. El-Ashiry (1996:19) maintains that "in his [Abu-Bakr] study only three utterances are measured and the material is based upon the pre-recorded data of one professional reciter and in just one style of recitation."

The next research presented into Tajwīd is that of Christina Nelson (1982) which she published later on as book in 1985. Coming to the research into Tajwīd from an ethnomusical background, Nelson embarked on a journey to Egypt to investigate the phenomena of the Qur'ānic recitation. She lived with the actual reciters and their audience and experienced the registers of the Egyptian Qur'ānic recitation. Throughout her work, she demonstrates that Qur'ānic recitation is a combination of a sacred text, human behaviour, and organised sounds. She wanted to be a part of the total cultural system of the recitation, attending the recitation sessions, mixing with the audience and wearing the Islamic scarf. More interestingly, she applied an interdisciplinary method that enabled her to listen to the reciters, watch the audience reaction, and measure the parameters of recitation with its musicality.

Although Nelson came from a different culture and background, she mostly presented Tajwīd in an adequate and accurate way. Her chapter on Tajwīd is informative and inspiring. It is so because Tajwīd was tackled differently by a non-Arab researcher who came from a different background. She explained that the mistranslation and the misunderstanding of the identity of the science of Tajwīd led to what she calls "the inaccessibility of Tajwīd" (p. 39). Nelson also wondered (p. 39) how phoneticians could ignore the great role of Tajwīd in shaping the whole picture of the Qur'ān when they describe its sounds. She stated, "One can only describe the sound not account for it, if one ignores the role of Tajwīd."

In light of the discussion by Nelson (1980), about Qur'ān in Egypt, it is true that the Egyptian way of recitation which she experienced is not the only kind and register of recitation for all Muslims, and therefore it cannot and should not be generalised to apply to more than one and a half billion Muslims. However, Nelson (1980) sampled the Egyptian recitation at a certain point in time, and the judgement she made about Qur'ānic recitation is good for that period, and for the kinds of reciters that she investigated.

Muslims believe that the tradition of the prophet Muhammad (PBUH) in relation to the Qur'ān and recitations must be meticulously followed. Hence, it should be stressed that the way the prophet Muhammad (PBUH) used to recite Qur'ān was not in a musical or melodious way. Allah says in the Qur'ān {ورتلالقرأنترتيلا} "and recite the Qur'ān (aloud) in a slow, (pleasant tone and) style."

Among the contemporary works of note about Tajwīd is the contribution of Graham (1987 and 2006). In his discussion of the oral aspects of the written word of the scriptures, he tackles Tajwīd from a different angle, explaining the rationale behind Tajwīd as a science. In his comparison and contrast between the contemporary divine scriptures, Graham emphasises the fact that for Muslims it is necessary to maintain a purely Arabic recitation of the Qur'ān. He stresses that it is difficult to overemphasise the importance of the scriptures in all religion. Graham also tackles the different authentic kinds of *Qirā'āh* (the seven modes of reciting Qur'ān) and the differences between them. He also elaborates on the art of Tajwīd and the fact that recitation is "inextricable" from Tajwīd. Moreover, he describes the different styles of recitation (*Mujawwad, Murattal*) and what is the best place and time for each style. Graham also emphasises the role of the "recitative sciences in the Muslim society", in which he mentions the *Sālāh* "Muslim's prayer" as the most important act of worship in which the Qur'ān must be recited. He ends his chapters on Tajwīd with a description of the permeation of the recitation in the Muslim's education, communal life, and in family and personal life.

Another work that investigates the recitation of Egyptian reciters is that of Mohammad el-Ashiry (1996). The main themes of Tajwīd that he investigates are the register of the Qur'ānic voice and the prolongation of the Qur'ānic sounds. In Chapter Three of his book el-Ashiry focuses on Tajwīd as the phonetic system of his source text, the Qur'ān. His Chapter Four is sociophonetic in approach, where he concentrates on the style of recitation in contemporary Egypt. He introduces the two Qur'ānic styles مجود *Mujawwad* andمرتل*Murattal*.

The main goals of el-Ashiry's study are the descriptions of the register and of the prolongation of the Qur'ānic sounds. To explore these features he tested them acoustically. His study involves what he describes as an "unfortunately limited" (p. 411) set of seven informants, four of whom were nonprofessional reciters and three of whom were professional reciters. The data that el-Ashiry collected from his informants and his acoustic quantitative investigation reveal that his non-professional informants used the low and medium registers. In contrast, his professional informants used all of the low, medium, and high registers. He also shows the differences between the Qur'ānic recitations and Western singing in terms of the frequency ranges of voice registers.

El-Ashiry concludes by advocating that investigation of Qur'ānic recitation and especially the *Mujawwad* style should be controlled technically and physiologically. By "technically" he means in terms of Tajwīd and the laws of recitation. By "physiologically" he means in terms of the training of the breath. The research of al-Ashiry is unique in exploring the dimensions of the register and the prolongation of the Qur'ānic vowels. His study would be more informative if it included an acoustic analysis of the vowel duration of the Qur'ānic vowel sounds of his groups of reciters.

Another kind of contemporary Tajwīd investigation in English is feature-specific studies, which concentrate on one feature of Tajwīd. The research of Shadiya al-Hashmi (2004) is a clear example of this. She has undertaken research on the phonology of the nasal /n/ in the language of the Qur'ān. Unlike previous Qur'ānic scholars, al-Hashmi starts her investigation sociolinguistically by associating the language of the Qur'ān with the geographical distribution of the ancient Arabian tribes that existed at the time of the Qur'ānic revelation.

She then links a particular aspect of Tajwīd (nasalization) with the different Arabic dialects before Islam. She believes that it is difficult and rare to find any aspect of Tajwīd in the different Arabic dialects nowadays. As al-Hashmi was mainly concerned with the patterns of nasal /n/ in the language of the Holy Qur'ān she examined the four patterns of *'idghām, 'ikhfā', 'iqlāb* and *idhār'* as the most effective phonological processes in nasalization.

As a theoretical framework for her research, al-Hashmi adopts the optimality theory of grammar, especially in the three levels of grammar, generator, and lexicon. She (2004:19) states that "Optimality Theory plays a very important role in analysing the data of the Language of the Holy Qur'ān especially assuming output-output mapping rather than input-output mapping. This is related to one leading principle of OT labelled as richness of the base." Though simple and short, the masters thesis of al-Hashmi is a milestone in the way of investigating individual aspects of the Qur'ānic sounds. Careful study of the phonetic system of the Qur'ān reveals the huge number of phonetic aspects that have not been experimentally examined.

Only a few instrumental studies have examined specific phonetic features of the Qur'ān in a way that can be built upon. Among them is the study of Yeou (2003), who investigates the Qur'ānic *madd*"lengthening the Qur'ānic vowel" in a contrastive study between six reciters from Egypt and from Saudi Arabia. He found that "the Egyptians are consistent with the timing of the extensions realizing the required 4 and 6-beat distinctions, while the Saudis extend the duration of lengthening beyond the required 4 and 6 counts. The Egyptians constantly produce flat pitch contours, whereas the Saudis have much variation in pitch movements." Yeou relates these differences to the improvisation of long melodies by Saudi reciters which exceed the regulated length of *Madd*.

One of the recent analyses of the Qur'ānic vowels is that of Iqbal et al. (2008). They provide an analysis of cues that can identify Arabic vowels. They also develop a new algorithm using the formant frequencies of Arabic vowels. The focus of their study is the three basic Qur'ānic cardinal sounds /a/, /e/, /u/. They state, "The vowel identification system developed here has shown up to 90% average accuracy on continuous speech files comprising around 1000 vowels." This study suffers some inadequacies, especially in the chosen Qur'ānic examples. Examples such as "*zabar* /a/, *zair* /e/ and *pesh* /u/" are not words used in the Qur'ān.

To carry out intensive experimental phonetic and phonological analysis of all aspects of Tajwīd will take a very long time. Research into the Qur'ānic phonetic system must be performed item by item. It will take the work of numerous people, working independently and collaboratively, to fully present the Qur'ānic phonetic system to the world. That is why the current research is limited to examination of the pharyngealised and uvularised emphatics of the Qur'ān, or more accurately the effect of these sounds on the following vowel.

2.3. Arabic Pharyngealised Sounds

2.3.1. Arabic Emphatics and Uvularised Sounds

Languages share many phonetic and phonological properties. Some languages have developed their own additional phonetic features that distinguish them from other languages. The last three decades have witnessed a revolution in the field of linguistic research. Research in phonetics and phonology is conducted all around the world in many languages. The Arabic language, which is spoken in more than twenty-five countries, has many dialects and is the language of millions of people around the world.

The sounds of this language have been described, studied, and analysed, particularly in Arabic. Like any other language, Arabic has its own set of sounds that are peculiar and specific to Arabic. Arabic pharyngealised emphatics and uvulars are clear examples of this individuality.

Arabic emphatic sounds /S/ ص ,/D/ض, /ð̣/ظ , /T/ط, and /q/ق and Arabic uvulars/χ/خ, /ʁ/غ have been the subject of many classical and contemporary studies. Classical Arabic articulatory treatises such as *al-Kitāb* of Sibawayh, *al- Ayn* /ʕeīn/ of al-Khalīl, and *Sirr Sinā'āt al-I'rāb* of Ibn Jinni have explained some of the phonetic properties of these sounds. Recent and contemporary scholars (Gairdener 1925, Lehn 1963, al-Ani 1970, Ghazeli 1977, Card 1983, Zawaydeh 1999, Shahin 1997, and bin Mugbil 2006) have examined the acoustics and the articulation of Arabic emphatics and uvulars. These sounds are the focus of this current research, as the emphatics and the uvulars of the Qur'ān are originally Arabic ones. The current research also examines the pharyngealisation of the Qur'ānic/a:/, /i:/, and /u:/ vowel sounds in various contexts and as realised by different reciters.

As previously mentioned, this chapter examines contemporary works that have contributed in the investigation of the identity of the pharyngealised emphatic and uvular sounds of Arabic. These works vary in the methods of examination of these sounds. They range from the descriptive, to the articulatory, to the acoustic studies. Recent articulatory studies in Arabic emphatics and uvulars start with Marcais (1948), as mentioned in Card (1983), who did palatograms and cinefluorographic films. Ali and Daniloff (1970a, 1970b) researched the Arabic sounds cinefluorographiclly. Ghazeli (1977) contributed significantly to knowledge of the accurate positioning of the tongue, the pharynx, and the larynx during the production of the Arabic pharyngeals.

One of the first cited acoustic studies to test Arabic sounds was that of Sulaiman al-Ani (1970). He presented a general acoustic description of Arabic sounds. He also presented a physiological analysis of the places of articulation of every Arabic sound. It is rare to find a contemporary study that does not refer to the study of al-Ani as a leading study in its field.

Emphatic sounds appear in many languages. They are, however, more apparent in Arabic. Elizabeth Card (1983) presents an informative work on the field of the Arabic emphatics entitled *A Phonetic and Phonological Study of the Arabic Emphatics*. Since Arabic emphatics are a central component of this study, Card's work is examined in detail here.

In her introduction, Card points out that emphatics are common sounds in Arabic and they occur as a secondary articulation of some other sounds. Some recent Western studies (Lehn 1963) misunderstand Arabic emphatics as allophones of non-emphatic sounds or simply a property of the syllable as a whole and not of the consonant. The reality is that /s/ is not an allophone of the sound /S/, nor is /t/ an allophone of the sound /T/. The Arabic emphatic sounds are different phonemes and are totally different from their non-emphatic sounds in many ways. Some contemporary Arabic dialects use these two classes of sounds interchangeably and yet speakers still understand the meanings of the words. This might be applicable in dialects where people develop their languages differently and use them accordingly but not in Standard Arabic or the Qur'ānic language. The substitution of the sound /S/ by the sound /s/ in the word صيف /Seif/ "summer" changes the whole meaning into سيف /seif/ "sword". It is essential to explain that emphatics require another articulation which produces another sound for a different meaning in Arabic.

In her chapter about the articulation of emphatics, Card (1983) starts with a description of the medieval Arabic contribution to the study of emphasis from classical scholars such as Sibawayh, Ibn Ya'ish, and Ibn Sina. However, she does not mention al-Khalīl as the father of the Arabic grammarians and the teacher of Sibawayh. It was mentioned earlier in this chapter that al-Khalīl was the first Arabic scholar to develop a connection between Arabic phonology, morphology, and syntax.

Card then discusses the different names that have been given to the Arabic feature "emphaticness". She discusses the choice of Jakobson (1957) in calling emphatics "*Mufaxxama*" sounds. She argues that this name should be used exclusively for the pharyngealised sounds in particular, not for the normal Arabic emphatics. In fact, Card was not the first to maintain this; Vollers (1893, cited in Card 1983:8) and Lehn (1963) expressed the opinion that *Mufaxxama* sounds are not the only Arabic emphatics. They also include Arabic uvularised sounds.

In her discussion of the modern contribution to the Arabic emphatics, Card presents the works of Ghazeli (1977), Ali and Daniloff (1972) as the main contributions of the era. They studied Iraqi and Tunisian dialects of Arabic. Their experiments showed that the "pharyngeal constriction that signals emphasis is largely due to a rearward movement of the tongue dorsum root" Card (1983:14).

In her study of the Arabic emphatics, Card (1983) investigated them acoustically and phonologically. Acoustically, she tested 82 Arabic words, putting them in a frame sentence, which contained no emphatic sound at all. Her informants were four Palestinians. Two-thirds of her words were minimal pairs and the other third were nonsense words. She used a wide band spectrogram to measure the lowest three formants.

Card found that the first and the third formants of her informants did not vary in most of the tokens. Thus, she (p. 49) "used the second formant to measure the effect of emphasis in various environments". She (as well as al-Ani 1970 and Obrecht 1968) found that the main acoustic cue of emphasis is the lowered second formant. Card (1983:49) stated that "the emphatic non-emphatic contrast is especially noticeable in the low and the back values."

In her discussion of the spread and the directionality of the Arabic emphatics, Card points out that Ghazeli (1977) found that right-left spread is stronger than left-right spread for Tunisian speakers. She presents the example of the emphatic word "Sooda" which means "baking" and the non-emphatic "sooda" which means "black". She maintains (p. 49) that "in the emphatic words, the second formant of each segment is considerably lower than the second formant in its non-emphatic counterpart. Emphatic features do not spread only in one direction but effectively exert their influence in either direction." In her findings, Card here contradicts the findings of Ali and Daniloff (1972b) who claimed that emphasis could not extend all over the word "except in nonsense words". Card mentions that the Iraqi words examined in the study of Ali and Daniloff are of the syllables CVC, CVCC, and CVCVCVC, where the vowel sound could be a long or a short one like the /ə/ sound. In this context, Card presents Arabic words that are all emphatic such as (باص "bus", ضرب "beating"). She maintains that the emphaticness here is extended to the whole word, saying (p. 62) that "there is no reason to support that such a word would not be entirely emphatic." Card (1983) believes in the spread of the emphasis throughout the whole word and she considers this spread in the emphatic word to be a word-bound one. The examples that Card (1983) presents for word-bound syllables are single syllable words, which could instead be evidence for syllable-bound coarticulation.

Card (1983) presents an acoustic strategy to distinguish primary emphasis from secondary emphasis. She found (p. 107) that the Arabic sound /T/ has a second formant which ranges between 1350 Hz and 1400 Hz. Thus if the acoustic value of the second formant in a given /T/ sound is greater than this then the emphasis here is a secondary one. Likewise, if the value of the second formant is less than 1400 Hz it means that the emphasis in this word is primary.

Card presents a clear discussion of the differences between pharyngeals, pharyngealisation, emphatic, and uvular sounds of Arabic. Phonologically, Card points out that any phonological analysis of the Arabic emphatic sounds must take into consideration where the sound comes from. She stresses the importance of meticulous articulatory and acoustic analysis of the emphatic sound to produce its valid phonological description. She found that the feature of primary emphaticness could be best described as [+F2 drop]. She (1983:153) states that "this feature [+F2 drop] which has the articulatory counterpart 'upper pharyngeal constriction' models the behaviour of emphasis more accurately than any feature previously proposed."

Card also stresses the importance of the degree of the spread as well as the direction of the emphasis for a given Arabic emphatic sound.

It is noticeable how much the work of Card (1983) depends on an articulatory analysis of the Arabic emphatic sounds to complete the clear picture she draws of the identity of the Arabic emphatic sounds. What is really missing in her work is an articulatory account of Palestinian Arabic. The articulatory part of Palestinian Arabic is presented in the study of Kimary Shahin (2002).

Spurred by her interest in exploring the phonological processes of two unrelated languages, Shahin[14] (2002) chose the Palestinian Arabic and the Salish Sta'at'imcets languages (spoken in the north-west of America and the south-west of Canada) to investigate and compare. The phonological process she studied was what she called "postvelar harmony". She found that postvelar harmony includes pharyngealisation and the uvularisation. Pharyngealisation in her study is the outcome of the articulation of gutturals and emphatic sounds, whereas uvularisation is the outcome of the articulation of the emphatic sounds alone. Shahin intended to provide a formal theoretical model of these phonological processes from the perspective of Optimality Theory. She found that the responsible feature for postvelar harmony is the [RTR] (retracted tongue root). Although she tried to focus on the similarities between these two languages and wanted to standardise a unified phonological feature for both of them, she was not successful. She admitted (p. 49) that phonetically, some of the properties of these languages are "cognitive" and cannot be theoretically stipulated. Hence, it was not possible to find a unified phonological feature for both of Shahin's languages.

To obtain a better grasp of the sounds of the two languages, Shahin reviewed previous articulatory studies, adding to them the outcomes of her acoustic analyses in the domain of postvelar articulation. In her pursuit to provide additional support for her phonological analysis she presented the result of her acoustic analysis. In some other cases, she went further to present a perceptual analysis. Kochetov (2003) observes that "Shahin's 'Postvelar Harmony' is a solid work, impressive both in its breadth and in its attention to detail. It is one of only a very few recent published dissertations on theoretical phonology based on the author's original field work data."

Notable about Shahin's study is her ability to compare two unrelated languages (Semitic and Salish) and come up with such interesting similarities and generalities. It is also clear from her highly professional and theoretical phonological analysis that many phonological terms need to be better explained for the outsider reader of her study, such as "harmony" and "phonological visibility". The same project was tackled, in a much simpler but still professional manner, by Bushra Zawaydeh (1999).

[14] Shahin submitted her work as a PhD thesis, which she defended at University of British Colombia in 1997. She subsequently published her work in a book in 2002.

Zawaydeh's (1999) study is significantly informative. It is one of the great contributions to the field of study of the acoustics of Arabic guttural sounds. It is also considered very relevant to this present research, as the Qur'ānic pharyngeals are originally Arabic sounds and some of them are gutturals. Zawaydeh's study investigates two major themes. The first is Arabic uvulars, emphatics, and pharyngeals, pondering the question that if they have different articulations then why are they all considered to be one natural class? The second issue is the investigation of the uvularisation spread of the sounds /T/, /D/, /S/ and / ð̣/.

It can be clearly seen that recent research in the domain of the phonetics of Arabic sounds was able to instrumentally verify or refute, in an authentic way, previously held beliefs about these sounds. The research of Shahin (2002) forms an interesting line of research with that of Zawaydeh (1999) that helps to verify or refute alleged notions about Arabic and Salish sounds. Zawaydeh tries to show the real identity of the emphatic and pharyngealised sounds. She also groups and classifies these sounds into a natural phonological class.The experimental method she applies (related to the field of otolaryngology) is of great value in identifying the exact nature of the sounds. Her study included all the gutturals: uvulars, pharyngeals and laryngeals.

Zawaydeh (1999) showed that the Salish language resembles Arabic in terms of the gutturals, in that both have a "cooccurrences restriction" in the root. Another similarity she found between these two languages is that their guttural nature causes lowering of the adjacent vowel sound.

Her comparative study is reinforced by the findings of Kimary Shahin (2002), who related the gutturals of the Palestinian Arabic and St'at'imcets Salish. Kimary found that both languages share two similar types of phonological processes, namely pharyngealisation and uvularisation. Kimary describes them using the term "Post velar Harmony". Zawaydeh and Shahin investigated the same languages but with two different dialects, and their results consequently reinforce each other.

It is important to note that the phonetic and phonological parameters are not the same for all cues of the gutturals. Zawaydeh (1999:85) found that constriction as the main function taking place in the guttural does not occur for all the guttural sounds, but the Arabic /ʔ/ sound has a constriction which might not be a supralaryngeal one. Constriction occurs for pharyngeal, laryngeal, uvularised, and emphatic sounds. The constriction itself is made to different degrees, as mentioned by Shahin (2002:30). Thus, discussion of the constriction is vital in this study and is further developed in Chapter Three.

Zawaydeh's endoscopic experiment is informative. She presents a clear description of the behaviour of the epiglottis and the arytenoids, which control the vocal folds.

In her articulatory discussion of the identity of the Arabic /x/ sound, Zawaydeh discontinues discussion of that sound because, as she claims, the exact point of articulation of /x/ sound is not clear. Others (Delattre 1971, Ghazeli 1977, Bin Muqbil 2006) have intensively investigated the /x/ sound articulatorily and acoustically.[15] The sound /x/ is not found alone in Arabic, unlike in German, Hebrew, and Pashtu (the second language spoken in Afghanistan). Zawaydeh's endoscopic articulatory experiment and the acoustic analysis she conducted do not help in explaining the exact phonetic parameter of the sound /x/. She states in her footnote (p. 91), "the sound/x/ has been dropped from this study since it was not clear whether it was articulated as a uvular or a velar." In fact, Arabic literature has exhaustively explained the articulation of every Arabic sound including /x/. The Arabic medieval contribution is full of manuscripts and books dealing with such a sound articulatorily. The sound /x/ has also been recently investigated by Card (1983), and many others, who clearly state the velar identity of the sound. Acoustically, al-Khairy (2005) discusses the sound /x/ as one of the Arabic fricatives and presents its phonetic properties.

It is clear from the study of Zawaydeh (1999) that there is a connection between the pharyngealised sounds in Arabic and the rise in F1and F2. Moreover, she found (p. 96) that when the first sound is a guttural consonant (pharyngeal, uvularised, emphatic, or even laryngeal) then F1 for an immediately following low vowel will be higher than F1 in segments starting with a non-guttural sound. This actually gives priority to the high F1 in pharyngealised sounds.

The study of Zawadeh (1999) is a considerable milestone in research into the acoustics of the Arabic gutturals, yet it suffers some limitations. The limited number of the informants in the endoscopic study (only one person) may affect generalisation of her findings. This limitation is clear because the current researcher had to undertake serious risks of X-ray exposure during his

[15] Further investigation of this sound appears later in this chapter.

experiments. In all Arabic acoustic studies there seems to be a problem of classifying some Arabic sounds into one formal natural class. To resolve this problem Zawaydeh (1999) suggests a combination of articulatory and acoustic experimentation to determine the exact natural class of Arabic sounds. She recommends (p. 102) that “those phonologists should consider auditory features more seriously. A natural class could be grouped not just articulatorily but also acoustically.”

Watson’s book (2002) about the phonetics and phonology of the Arabic language is significantly informative. Indeed, Zawaydeh (2003) wrote that “interestingly, prior to the publication of this book there had been no book-length study of Arabic phonology and morphology”. Watson devotes her study to two Arabic dialects, San’ani Arabic, which is at present spoken in Yemen, and Cairene Arabic, which is at present spoken in Egypt. The ten chapters of Watson’s book detail the phonology, morphology, syntax, and semantics of Arabic. Watson developed sound inventories of both the Arabic dialects under investigation. The San’ani dialect, as shown by Watson, has all the classical Arabic places of articulation. Watson found some similarities between the two dialects, such as substitution of the Arabic emphatic /D/ sound with the non-emphatic /d/. The voiced post-alveolar affricate sound /dʒ/ is also replaced by a velar /ɡ/ in both dialects.

The title of Watson’s book, *The Phonology and Morphology of Arabic*, suggests to the reader that the book (if it is not going to discuss classical Arabic or modern Standard Arabic) is going to cover varieties of Arabic dialects from different Arabic states. However, it discusses only two Arabic dialects, San’ani and Cairene Arabic. Despite the fact that it is almost impossible for one book to discuss the enormous variety of Arabic dialects, the title should reveal its limitations. McCarthy (2004) also questions the title of this book and its applicability to cover Arabic language systems, saying that “despite its title, though, it does not achieve the coverage or authoritative status of some of the other books in the series ‘The Phonology of The World’s Languages’. Indeed, perhaps no work short of an encyclopaedia could achieve this when it comes to the large and varied linguistic entity called Arabic.”

In particular, Watson’s (2002) discussion of the San’ani dialect is significant and detailed. Her residence in San’a for a while enabled her to collect many accurate examples of the San’ani dialect. McCarthy (2004) maintains that “the greatest value of *The Phonology and Morphology* *of Arabic* lies in its careful documentation of the little-studied San'ani dialects." The discussion of the Cairene dialect is not as detailed and informative as that relating to San'ani. As Egypt has the largest population of Arabs in one state its dialects constitute a fruitful topic for researchers. Many Western scholars have focused on various aspects of the Egyptian and in particular Cairene dialects. McCarthy (2004) adds that "Cairene syllable structure and stress have received a great deal of attention previously (e.g. Broselow 1976, 1979, Hayes 1995, Kenstowicz 1980, McCarthy 1979, Selkirk 1981), so it is difficult to find much new to say."

Regarding the articulation of the Arabic emphatic sounds, Watson (2002:42) states that they are "produced with primary [coronal] accompanied by pharyngeal constriction." This articulation process, as shown, includes two articulations, a primary and a secondary one. There is almost no dispute around the coronal primary articulation of the Arabic emphatics. The secondary articulation of the Arabic emphatic is, however a locus of dispute. The work of Ghazeli (1977) shows that the secondary articulation in the Arabic emphatic is not pharyngealised but rather uvularised. Zawaydeh also (1999) ascertains that the secondary articulation of Arabic emphatics is a uvularised one. She (2003:280-283) states, "I disagree with this 'pharyngealised' description of the articulation of the emphatics." Her reason for this disagreement is that "these doubly articulated sounds thus have a primary coronal articulation and a secondary uvular articulation." A more detailed discussion of this feature of the articulation of Arabic emphatics appears later in this chapter.

In the dialects Watson (2002) studied, she found that the emphasis spread is effectively enhanced by Arabic coronals, especially when they are pharyngealised more than the Arabic pharyngeals. Watson also found that the greatest emphasis spread is more heavily affected by the pharyngealised coronals than when it is triggered by pharyngeals. This is in harmony with the general understanding of the [TRT] and the lowering of F2 and the raising of F1.

Watson (2002) believes that the spread of emphasis in Arabic words is optional, especially when the emphatic sound is adjacent to a short vowel. Zawaydeh (2003) refutes this claim, distinguishing between the "lowering near gutturals" and the emphasis spread. Zawaydeh's (2003:282) reason for this refutation is that "guttural-induced lowering causes F1 rising, while emphasis spread causes F2 lowering and F1 rising." In the case of such a conflict, acoustic data should reinforce or refute the articulatory data. The role of the acoustic analysis here is invaluable; it might resolve the conflict over emphasis spread from a different phonological angle. An example of this is the study of al-Khairy (2005).

Acoustic and articulatory studies of the Arabic and Qur'ānic pharyngealised emphatic and uvulars has shown that [+friction] plays an important role in the primary articulation of the Arabic sounds /ð/,/S/, /x/, and /ʁ/. These sounds are fundamental in this research. Mohammad al-Khairy (2005) conducted a comprehensive acoustic investigation of the exact place of articulation of these sounds. He (2005: xii) explains that "the acoustic characteristics of fricatives were investigated with the aim of finding invariant cues that classify fricatives into their place of articulation." Currently, acoustic studies of frication, and speech signals of the fricatives, are sometimes confusing. In order to come up with a meaningful acoustic analysis of the Arabic fricative sounds, al-Khairy (2005) conducted amplitude measurement, a spectral measurement, a temporal measurement, and an analysis for the F2 at the transition of the adjacent vowel to the fricative sound. All the measurements in his study show consistency with the previous studies. The spectral measurements play a very important role in determining the exact place of fricative articulation. However, Bin Muqbil (2006) found that his investigation of spectral measurements did not reveal any reliable differences between the spectral shapes of Arabic emphatics and non-emphatics.

In the domain of the F2 in transition and in "locus equation", al-Khairy (2005: 118) reported that his data were consistent with relevant previous studies such as Obrecht (1968), and Al-Ani (1970). The F2 of the pharyngealised fricative showed lowering and a similarity with the F2 after any other pharyngealised sound. Pharyngealised F2 lowering has also been confirmed by Shahin (1997), Zawaydeh (1999) and Watson (2002).

Al-Khairy also hypothesises that the similar grouping of the Arabic fricatives and Arabic pharyngeals suggests a similar articulation for both of them. In this way, he (2005:119) reinforces the suggestion of McCarthy (1994) and Zawaydeh (1999) "to name co-articulated emphatics in Arabic as 'uvularised' rather than 'pharyngealised'". Disagreement about naming of the feature accompanying the pharyngealisation or uvularisation of the sounds continues for two reasons. The first relates to the different acoustic and articulatory methods of testing these sounds. The second relates to the variety of Arabic dialects and their degrees of variation/deviation from Standard Arabic. This conflict does not change anything in the progress of the research into these sounds, as every group of researchers must rely on their experiments. As researchers build upon experiments the of others, it is hoped that Arabic sounds in general and the pharyngealised emphatics and uvulars in particular will be better investigated and explained.

Musaed Bin-Muqbil (2006) has gone further in the research into the phonetic and phonological aspects of the Arabic emphatics and gutturals. He was encouraged by many “inadequacies” in the analysis of many aspects of the emphatics and gutturals. He (2006:2) states that the main goal of his study “is to highlight the inadequacies of the existing formal proposals for representing Arabic emphatics and gutturals and to propose alternative representations that overcome those weaknesses.”

Bin-Muqbil (2006) focuses on showing the exact identity of the Arabic gutturals and the differences among their subsets, the emphatics, the uvulars, and the pharyngeal sounds. He also focuses on the differences between these groups of gutturals and more deeply on the differences between the primary and the secondary articulation of every kind of Arabic guttural.

To either prove or refute the available hypothesis concerning the Arabic gutturals, Bin-Muqbil preferred to reanalyse these sounds acoustically. Bin-Muqbil’s dissertation (2006:8) “is built on the belief that the acoustic attributes of speech sounds are a reflection of their articulatory qualities.”

The first experiment he conducted was twofold. First he compared the spectral qualities of the guttural consonants. He found that the spectral qualities of Arabic emphatic and non-emphatic sounds are not the same. He found that the formant values of the emphatics are significantly different from those non emphatics in Arabic. Secondly, he tested, through the power spectra of the Arabic pharyngeals, whether these continuants are fricatives or approximants. Bin-Muqbil found that they are approximants, not fricatives. Al-Khairy (2005:3) found that Arabic emphatic fricatives are /x/, /S/,/ ð/, and / ʁ/.

The findings in these experiments led Bin Muqbil to his second experiment. In the second experiment, he (2006: 145) investigates what he calls “the anticipatory and carryover effects of MSA emphatics, non-emphatics, and gutturals on adjacent vowels.” His main target was to identify the main effects of vowel and consonant coarticulations and to compare and contrast them. He found a great difference between emphatics and non-emphatics in the VC/CV coarticulations. The main difference between emphatics and non-emphatics is that emphatics lower the formants of the adjacent vowels in the transition process. Non-emphatics do not have the same effect. He also found that uvulars lower the formants of the adjacent vowel and have the same effects as the emphatics. Though there are some differences in the size and stability of these sounds, Bin Muqbil (2006: 204) found that both pharyngeals and uvulars are a result of retraction of the tongue dorsum.

To develop a better grasp of consonant-vowel coarticulation, Bin Muqbil carried out a third experiment to reveal vowel-vowel coarticulation. This experiment presents a clearer picture of the differences between the anticipatory, the coarticulatory and the carryover articulation of the Arabic emphatics and non-emphatics. Bin Muqbil stated two hypotheses prior to the commencement of this experiment. The first is that Arabic emphatics would behave differently in accepting vowel-to-vowel coarticulation. He explains (2006:206) this vowel-to-vowel experiment saying that "it shows that Arabic non-emphatic coronals, pharyngeals, laryngeals, and the velar [k] allow significant amount of anticipatory and carryover vowel-to-vowel coarticulatory effects."

Bin Muqbil also found that Arabic emphatics show relatively strong resistance to vowel-to-vowel coarticulation. He concluded that though Arabic uvulars and emphatics share the same kind of tongue dorsum restriction, his experiment showed that the muscles responsible for the constriction of the emphatics (styloglossus and hyoglossus) are not used identically in the constriction of the uvulars. Arabic uvulars use the hyoglossus muscles in general and conditionally use the styloglossus muscles. Bin Muqbil found that the involvement of the styloglossus in the production of the uvulars and vowel-to-vowel articulation is conditioned by the degree of constriction of the uvularised sound. Another difference between the articulation and the constriction of the Arabic emphatics and uvulars is the place of articulation. Bin Muqbil (2006:231) emphasises: "It should be kept in mind that all uvulars involve active participation by the soft palate that is absent in emphatics."

The three experiments and the phonological representation in the work of Bin Muqbil qualify his work as refuting what he calls "inadequacies" in the domain of Arabic emphatics. He presents a well-crafted work that is based mainly on the results of acoustic studies of Arabic emphatics. It can be said that theworks of Watson (2002), al-Khairy (2005), and Bin Muqbil (2006) have contributed much in clarifying the exact nature of Arabic emphatics, pharyngealised, and uvular sounds. It is difficult also to deny the amount of dispute around the naming and the identities of these sounds. These sounds need more investigation as they are essential in Arabic and in some other languages.

2.3.2. Arabic Emphaticness, Uvularisation, and Pharyngealisation

Recent studies focusing on the issues of emphaticness, uvularisation, and the pharyngealisation of Arabic sounds have shown interesting variation in their models, methodologies, experiments, and results. The current research does not address these parameters, as they are not at its core; rather it aims to shed light on some issues related to the naming of these features, the relation between their articulatory and acoustic studies, as well as the identity of the Arabic velarised sounds.

Arabic emphasis is widely referred to as a secondary articulation process. Traditionally, it is considered as an inherent process of the Arabic coronal obstruents. This emphasis sometimes influences the preceding or the following syllables of the word. There are many studies of dialectal Arabic that investigate the direction, spread, and intensity of Arabic emphaticness. Arabic emphaticness has been described frequently but many of the studies are inadequate in one or more ways. This inadequacy can best be overcome by a combination of descriptive, articulatory, acoustic and phonological analysis. Examples of such studies are those of Card (1983), McCarthy (1994), and Bin Muqbil (2006). The main reason behind the success of these analyses of Arabic emphaticness is the combination of acoustic and articulatory measurements, a combination that produces a better understanding of Arabic emphaticness.

Studies such as those of Hughes and Halle (1956) and Evers at al. (1998) showed that the form, power, and amplitude of the spectra of the sounds are controlled and presented by the constriction of the vocal tract involved in their production. Hence the intensity, the degree of constriction, and the place of constriction of an emphatic sound determine its exact acoustical cues. In other words, orosensory involvement in the production of a sound affects its acoustic results.

Bin Muqbil (2006) examined the canonical spectra quality (patterns and characteristics of the spectrogram) of the modern Standard Arabic emphatic sounds. His analysis showed that Arabic continuant emphatics and non-emphatics are slightly distinguished from each other. The stop emphatics and non-emphatics, however, are remarkably distinguishable from each other.

In fact, this kind of acoustic investigation, built upon a sound articulatory method, is the approach desperately needed for study of Arabic sounds in general and emphatics in particular. It has also to be known that it is not always accurate to infer articulatory features from acoustic features. Stevens (2000) believes that different articulatory configurations can have very similar outputs. Descriptions by Arabic, English, French, and German scholars of Arabic emphaticness which lack these conditions have produced much inadequate output. Some of these outputs are built upon personal beliefs that need to be experimentally verified. Newman and Verhoeven (2002:77) quote the American researcher G. Oscar Russell who wrote, “phoneticians are thinking in terms of acoustic fact, and using physiological fantasy to express the idea.” They continue, “and Arabic ‘sounds’ is by no means an exception.” Debate concerning the identity of Arabic emphaticness is endless between acoustical and articulatory studies. Only acoustical studies that are built upon sound articulatory parameters are qualified to present a better analysis of Arabic emphaticness.

Acoustically, Arabic emphaticness should be generally marked with the lowering of F2 and the raising of F1. Recent studies (Shahin 1977, Zawaydeh 1999, Watson 2002, and Bin Muqbil 2006) have all come to the conclusion that the key factor in distinguishing the formants of the Arabic emphasis is the high F1 and the low F2. Moreover Watson (2002:270) argues that the lowering of F2 is “more significant than F1 rising in the identification of emphasis.” Nevertheless, this might not be the only significant indicator of Arabic emphaticness. Enlargement of the vocal tract when articulating Arabic emphatic coronals as well as enlargement of the emphatic secondary articulation (dorsals and gutturals) contribute to a general enlargement in the whole oral cavity. Watson (2002: 270) explains that “enlargement of the tract at the pharynx may be enhanced by enlargement of the tract at the lips through lip protrusion or rounding.” This enlargement is not restricted to Arabic emphaticness, as Arabic uvularised and pharyngealised sounds share the same feature of enlargement.

Arabic uvularised sounds are among the most controversial in the Arabic inventory. Their place of articulation, their coarticulation, their grouping with other emphatics, and dialectal variations have helped develop disagreements about uvularisation identity and articulation.

Arabic uvulars and uvularisation have been issues of conflict in phonetic scholarship during the last three decades. There is no dispute about the identity of the uvularised sounds, as they are legitimate Arabic sounds. The conflict concerning phonetic representation centres around their place of articulation, which leads to different terminology.

One way of resolving this ambiguity is by relying on the classical Arabic articulation of these sounds. The first of these sounds in the mouth progressing back from the lips is the /q/ sound. Classically, description of this sound was by personal observation. Bin Muqbil (2006:40) states that Sibawayh described the place of articulation of the /q/ as "at the portion of the tongue furthest back and the part of the palate just above it." Because he was well established in his knowledge and he utilised a lot of the linguistic knowledge of his ancestors, Ibn Jinni was more accurate in his personal phonological observation of the Arabic sounds, describing the Arabic /q/ as a guttural voiced sound . Ibn Jinni determined that the /q/ place of articulation should be accurately put between the two Arabic sound /x/ and /ʁ/ which makes it a voiced sound. On the contrary, some recent studies (Zawaydeh 1999, Watson 2002, and others) show that the /q/ sound is a voiceless uvular stop (plosive) sound, particularly the classical /q/ sound. The movement of the tongue during the production of the Arabic /q/ is unique. X-rays presented in Delattre's (1971) study show the systemic articulation of the Arabic uvular sounds /q/, /χ/, and /ʁ/. Delattre explains that the articulation of these uvular sounds starts primarily when the tongue retracts horizontally backward and secondarily moves up to form a constriction against the upper part of the pharynx. The difference between /q/ and the other two sounds is that in the former the tongue goes up toward the pharynx until it makes full closure.

Different contemporary Arabic dialects vary in their pronunciation of /q/ sound. Watson (2002:17) mentions that although the original form of /q/ is maintained in parts of Syria and some parts of North Africa, it has changed in some other dialects. It has developed into a voiceless velar stop in some Palestinian dialects and into a glottal stop in some Mediterranean and Egyptian dialects. Fischerand and Jastrow (1980:52, cited by Watson 2002) believe that uvular fricatives are generally maintained but for some dialects they are phonetically and phonologically better described as velar or post-velars.

The other two uvular sounds, /χ/ and /ʁ/, are more closely related to each other as they are both continuants. Classical scholars of Arabic sounds, like Sibawayh and Ibn Jinni, have described these sounds as مستعليه*Must'liyah* sounds, "that are produced with a raised tongue." The difference between the articulation of these two sounds is firstly that the /χ/ sound is articulated like the sound /q/ but as a continuant and not with the full closure that occurs with the /q/. The X-rays of Delattre (1971) show that in the case of the /ʁ/ sound the tongue is pulled up towards the uvula and the uvula is curved down to articulate against the raised back of the tongue. Another difference between the two sounds is that the /ʁ/ sound is articulated with less constriction than the /χ/ sound. It should be clear now that the production of the Arabic continuant uvulars is different from that of the Arabic closed uvulars. Al-Khairy (2005:6) reports that Shadle (1990) found that "spectrums of sounds generated by a wall source, like voiced and voiceless velar fricatives, /χ/, /ʁ/, are characterized by a flat broad peak with less amplitude than sounds of obstacle sources."

Acoustically, the study of al-Ani (1970) found that the sound /ʁ/ looked like vowels with a light noise which represents the fricative part of the sound. Al-Ani also found that the effect of neighbouring vowels on the Arabic continuant uvulars /χ/ and /ʁ/ is strong. Bin Muqbil (2006:43) presents a range of formant values of the Arabic continuant uvulars from different studies which measured the effect of the neighbouring /i/, /a/ and /u/. He reports that al-Ani (1970) explained that "the lower limit of the spectral energy depends on the vowel context: around 1500Hz, 1000Hz, and 800Hz next to /i/, /a/, and /u/ respectively." Al-Ani (1970) emphasised the importance of the formant transition to distinguish the Arabic continuant uvulars /χ/ and /ʁ/. Later, Jongman (1989) found that in a large range of different languages, formant transition is not crucially important in identifying the fricative sounds. Formant transition is more important in the analysis of uvularisation, which necessitates coarticulation of the uvular sound and the adjacent vowel sound. The same importance is given to pharyngealisation as well.

Arabic pharyngealised sounds are simply those which have a primary and a secondary articulation. These two stages of pronunciation are coarticulated in one unified pattern of sound pronunciation. Arabic has two pharyngeal sounds that have a primary articulation only, /ʕ/ and

/ħ/. Qur'ānic Pharyngealisation is the addition of the /a:/, /i:/, or /u:/ vowel sound which is articulated following one of the Arabic emphatic sounds /T/, /D/, /S/, / ð̣/or the Arabic uvulars /X/, /q/, and /ʁ/. This feature is clear and distinguishable in Arabic. In Arabic, pharyngealised and non-pharyngealised consonants are distinct from each other. Most of the studies that present Arabic pharyngealisation give the example of the تين*teen* 'fig' andطين *teen* 'mud'. They may sound the same to an English speaker but they are very different in Arabic. They are different in meaning, typology, and lexicography. These differences refute the hypothesis that emphatic and non-emphatic sounds are allophones. Non-native speakers of English can also feel the difference between these two sets of Arabic sounds. An experiment by Zaba (2007) on the perception of Arabic pharyngealised sounds by English native speakers revealed that those speakers were aware of Arabic pharyngealisation. They were able to demonstrate a significant amount of discrimination between Arabic pharyngealised and non-pharyngealised sounds.

2.4. Experimental Studies in Arabic Pharyngealisation

Articulatory phonetic studies of Arabic were carried out as early as the eighth century by Arabic scholars such as Sibawayh and Ibn Jinni. In their descriptions of the manners and places of articulation, these scholars depended largely on their observations of their own speech.

Recent technologies have permitted greater accuracy and precision in the classification and the description of the Arabic sounds. In articulatory studies, endoscopies (fibreoptics and stroboscopy), video scanning and imaging including X-rays, ultrasound, xeroradiography, videofluorography and many other experimental techniques have all contributed enormously to revealing the exact phonetic nature of Arabic sounds.

Though introduced more than 100 years ago, X-rays are still effective and are considered to be one of the most important techniques in somehow revealing the nature and of some the organs responsible for human speech. But in X-rays teeth usually hide the front part of the mouth which sometimes makes it difficult to figure out what happens in the front mouth during articulation.

The past three decades witnessed many experimental studies in Arabic pharyngealised sounds. Probably the first linguist to use X-rays in examining the articulations of Arabic and

Somali sounds was Panconcelli-Calzia (1920 and 1921, cited by Jakobson, 1957). Panconcelli-Calzia's X-rays were the first to reveal the projection of the tongue root towards the back wall of the pharynx, producing a constriction and a reduction in the size of the pharynx.

The pioneering work of Fant (1960) examined the production of vowels and consonants in Russian by using X-rays, articulatory and acoustic modelling, and analog speech synthesis that was based on the results of the X-ray study. This is one of the most influential early studies of the relationship between speech production and acoustics.

Delattre (1965) compared the phonetic features of four European languages (English, French, German, and Spanish). His study consisted of three main aspects, acoustic analysis, acoustic synthesis, and an articulatory study through X-ray motion pictures to investigate the vowels and the consonants of the languages studied. Although, due to the limitations of sophisticated equipment in his time, the book contained no actual X-ray frames of his informants, his schematic illustrations were very effective in capturing and comparing his sounds.

The X-rays of Arabic sounds presented in the study of Delattre (1971),as mentioned in Chapter Two, showed the systematic articulation of the Arabic uvular sounds /q/, /χ/, and /ʁ/. The X-rays of his Arabic Lebanese informant showed that the articulation of these uvular sounds starts primarily when the tongue retracts horizontally backward and secondarily moves up to form a constriction against the upper part of the pharynx. The difference between /q/ and the other two sounds is that in the former the back of the tongue goes up toward the pharynx until it forms a full closure. Through his X-rays Delattre was able to present a sound demonstration of what occurs in the pharynx during the articulation of the Arabic uvular sounds.

Ali and Daniloff (1972a, 1972b) presented a different view of Arabic uvulars in their cinefluorographic experiments of Iraqi Arabic. They were interested in what they referred to as the R-L and L-R spread of uvularisation. Their general findings were not free of contradictions. Their convention of the L-R spread of uvularisation to whole words in Iraqi Arabic was contradicted by the pattern in words such as "Qalb" (heart) where the spread of the pharyngealised /q/ sound stops at the beginning of the /l/ sound. Ghazeli (1977:147) presented a more convincing solution for the Iraqi words that deviated from the general findings of Ali and

Daniloff, such as “Qalb”. Ghazeli (1977:147) stated, “This uvular consonant, due to its posterior articulation, results in backing adjacent low vowels. In many languages, uvulars induce a lowering and/or a backing effect on adjacent vowels. The presence of a [q] in a language that has pharyngealized consonants does not entail that it should comply to the overall behaviour of these consonants.”

The experimental study of Ghazeli (1977) is a milestone in the experimental investigation of Arabic back coarticulated sounds. He conducted a cinefluorographic film experiment examining twelve adults to determine the articulatory correlates of the Arabic guttural consonants. He was interested in the shape and the movement of the tongue, the pharyngeal width, the soft palate movement, and the lip rounding.

Ghazeli analysed his film by hand using “a frame counter and a single frame advancement mechanism” (p. 28). He was looking for the midpoint of the sound to be captured. His film was focused on lips, jaws, mandible, and the pharyngeal area.

His discussion of the Arabic pharyngealised sounds did not include the Arabic /D/ sound. This was probably because of confounding and substituting the /D/ sound with the /ð̣/ sound in the Tunisian dialect that he studied. He presented a detailed discussion of the available names of the Arabic pharyngealisation feature, preferring to name the relevant sounds coronal pharyngealised consonants and uvular consonants.

Ghazeli’s experiments showed that there are a number of Arabic sounds that are articulated in the oropharynx area. These sounds are Arabic uvulars, pharyngeals, and pharyngealised consonants. He also pointed out that there are different degrees of constriction for every Arabic sound depending on the nature of the sound and its place of articulation. Moreover, he studied the effect of the Arabic pharyngealised sounds on the adjacent vowel. He found that this effect is different according to the adjacent sound and the degree of constriction of the Arabic pharyngealised consonant. In his examination of the spread of the Arabic pharyngealised sounds Ghazeli found (p. 175) that “Arabic pharyngealised coronals exhibit an L-R and R-L backing coarticulation that can generally extend over the entire word.”

The coarticulation and spread of the Arabic pharyngealised sounds are somewhat difficult to characterise precisely, especially when we have primary and secondary places of articulation and their influence on different vowels. One of the possible ways to overcome this difficulty is by applying more than one experimental technique to determine the nature of the pharyngealised sound and its exact place and degree of constriction. Widad Laradi (1983), in her investigation of Libyan pharyngealisation, applied several experimental techniques simultaneously to reveal the exact nature of her sounds. She was able through fibreoptic endoscopy, X-rays, xeroradiography, videofluorography, spectrography, palatography, and labiography to account for the precise nature, place and degree of constriction of Libyan Arabic pharyngealised sounds.

Laradi’s study focused on the articulatory features of the pharyngeal, uvular and pharyngealised consonants of Libyan Arabic and the extent to which they are related to or different from each other. She also traced the movement of the epiglottis from its rest position to the highest position that it can reach against the root of the tongue during the articulation of the /i:/, /a:/, and /u:/ vowel sounds. She found (p. 290) that “the root of the tongue is in contact with the epiglottis only at the top edge, though in the endoscopic films, the tip of the epiglottis is usually a little distance away from the root of the tongue.”

Laradi (1983) also found that no significant correlation between the tongue root retraction and the forward movement of the back wall of the pharynx. She attributed previous findings of the shape and measurements of other authors to the vertical measurements of the pharyngeal area which were ineffective in determining whether it was the back wall or the side wall of the pharynx that moved forward or backward and was responsible for the pharyngeal constriction. Laradi (1983:303) concluded her discussion of the movement of the back wall of the pharynx saying, “One can only conclude that constrictions of the pharynx are mainly achieved by the by the projection backwards and in certain cases upwards of the tongue.”

The distinction between phonemic pharyngealisation (as in the Arabic and Qur’ānic emphatic sounds) and the allophonic pharyngealisation (which is represented in the effect of the non pharyngealised phoneme in the environment of a Qur’ānic emphatic sound) should be clear. In her discussion of the exact phonetic properties of the pharyngealised sounds, Laradi (1983) critiqued the results of the contemporary analyses prior to her work, and found that these studies suggested that “all the consonants can be phonemically pharyngealised and non-pharyngealised with the vowels being retracted in the environment of the pharyngealised consonants.” She rejected this concept of Arabic pharyngealisation, simply because it increased the number of Arabic pharyngealised consonants. She expressed her agreement with Ghazeli (1977), who claimed (p. 133) that some alleged pharyngealised sounds were "pseudo-pharyngealised consonants". Gazeli and Laradi's main argument here is that we cannot consider any consonant as pharyngealised simply because it is followed by the /a:/ sound. Consequently, Laradi (1983:234) believed that Arabic pharyngealised sounds generally "exhibit certain characteristics which are more or less attested by phoneticians and linguists."

The study of Bukshaisha (1985) shows some important points in the relation between the Arabic vowels and the emphatics. In her investigation of the Qatari Arabic, Bukshaisha examined the effect of the Arabic vowel sounds on the adjacent plain /t/ and emphatic /tˤ/. She found that the onset of the Arabic vowels /i, i:, e:. a, a:, u, u:, o:/ is lower when adjacent to non-emphatic consonant than when they become adjacent to an emphatic consonant. She found also that the F2 onset difference of /t/, /T/ when adjacent to /i:/ is 1.15 KHz, while it is only 0.2 KHz when they are adjacent to Arabic /a:/ vowel sound. That means F2 is slightly lowered with /a:/ (0.2 KHz) while it is significantly lowered with /i:/ (1.15 KHz).

The data collected by Bukshaisha from Qatari Arabic supports the idea that lowering F2 is significant to the acoustic cues of Arabic emphasis. She also found that /i:/ vowel has the strongest effect on emphatics among the eight vowels she studied. This judgment is not properly justified as there are some studies (Al-Ani (1970) and El-Dalee (1984) who concluded that Arabic /a:/ vowel sound has a greater frequency than /i:/ vowel sound. This actually goes in line with the classical classification of the scholars of Tajwīd who ranked the Arabic and Qur'ānic /a:/ sound to have the strongest Tafxīm among all the other Arabic and Qur'ānic sounds.[16] Ordering vowels according to their strength of frequency may look attempting to some phoneticians but one should not forget that every studied language or dialect has its own unique phonetic and phonological system.

Review of the aforementioned experimental studies of the Arabic pharyngealised sounds shows that the main significant finding is the projection of the tongue towards the back wall of the pharynx. It is clear that the constriction of the tongue root is a key issue in the study of these sounds. The spread of the effect of Arabic pharyngealisation (L-R, R-L) provides a significant

[16] Chapter three discusses these classical classifications for the degrees of Qur'ānic pharyngealisation.

indication of the intensity of the pharyngealisation and its effect on the adjacent sounds. It is also clear that the focus of the aforementioned studies was on Arabic dialects, and thus some Arabic and Qur'ānic pharyngealised sounds such as /$d^{ʕ}$/, /$\chi^{ʕ}$/ were not discussed as they are not obvious in those dialects. Discussing the classical Arabic /D/ sound, Ghazeli (1977:6) stated, "This sound, to my knowledge, no longer exists as described by the Arab grammarians."

Every one of the aforementioned experimental studies has its weak and strong points. However, this researcher agrees with the view of Ghazeli (1977:3) that "the contributions of these studies to Arabic phonetics and phonology are so valuable that it seems rather churlish to criticize them." Though they have an important role in phonetic research, normal X-rays and still images cannot reveal the dynamic nature of the articulated sounds. Endoscopic experiments are useful in the way they reveal the exact nature of a given articulation but they provide only a single perspective. If they are optimised for revealing the vertical configuration of an organ, they cannot reveal the precise horizontal dimensions. Xeroradiography is useful for revealing the borders of the investigated organ as the X-ray is printed out on normal paper. Though the result is a clear X-ray, it is not a dynamic X-ray that can reveal the different places of articulation when they are simultaneously coarticulated. Normal X-rays in phonetic experimental studies have the drawback of unavoidable apparent displacements of the investigated articulators. If the X-ray room is not equipped with a stationary headrest then differences in head positions from one frame to another may lead to a misunderstanding of the real positions of the articulators. These misunderstandings were described by Perkell (1969:8) as "slight shifts in the positions of the structure, … slight movement of the vertebra relative to one another, and … a lack of consistency in the X-ray beam and the resulting image."

Acoustic spectrography is also useful in displaying the spectrum of a sound, from which articulatory gestures can be inferred. The current experimental study is based upon the idea that the acoustic correlates of a sound should replicate its articulatory properties. Bin Muqbil (2006:8) states, "It has been shown in various seminal works that the different configurations assumed by the vocal tract correspond to systematic acoustic output." Accordingly, the experimental study of this research intertwines the results of articulatory findings with the acoustic correlates of the same sounds. This approach strengthens the reliability of the results of these experiments and reinforces our understanding of the phonetic properties of the QPSs.

Many experimental techniques have been developed to test specific aspects of speech production, including palatography and labiography. A review of experimental studies shows that each technique has its merits and limitations. There is no specific experimental methodology that can be used alone to reveal a complete account the exact nature of a given sound. A better solution is to examine a speech sound from multiple perspectives to obtain a more complete and accurate result. An example of this is the combination of an acoustic and an articulatory experiment in the investigation of a given sound.

All the aforementioned articulatory studies are related to dialectal Arabic; none of them discussed Standard Arabic or any of the Qur'ānic sounds which are the focus of the current research. The researcher is not aware of any experimental phonetic investigation of any of the Qur'ānic pharyngealised sounds.

CHAPTER THREE

The Qurʾānic Pharyngealised Sounds

3.1. Introduction

Classical Arabic, prior to the revelation of the Qur'ān, was one of the many languages of the Arabian Peninsula, including languages such as those of Ghasasinah[17] and Manathirah[18] in the northern parts. With the advent of Islam, Arabic was chosen to be the language of the Qur'ān. This selection of the Arabic language made it, for Muslims, the sacred basis of Qur'ānic language; eternal, fixed, and unchangeable. Wild (2006:50) observes that "the Qur'ān was for Arab grammarians, lexicographers, and scholars of rhetoric the paradigmatic example of Arabic; its form and content were considered 'inimitable'". He continues, "Islamic dogma saw in the Qur'ān divine speech."

Muslims believe that Arabic is not only a language for everyday use but also a means of religious connection with Allah. For Muslims, reciting the Qur'ān, prayers, supplications, and mentioning Allah must be all performed in Arabic. Thus the importance of Qur'ānic language in the life of Muslims exceeds the boundaries of a normal Arabic language. Wild (2006:50) states that "Qur'ānic Arabic was held to surpass not only all other utterings in Arabic but all that could be expressed in all other human languages." Indeed, this explains the great respect accorded to Classical Arabic and its sounds as the language of the Qur'ān.

The language of the Qur'ān has been described in different terms by many contemporary Western accounts. These terms vary according to the perception and the understanding of the researcher as to its identity. This language has been called "Arabic high style" by Ferguson (1959) and "pure speech" by Belkaid (1984). " *Fusħā al-Turāth*" (Classical eloquent speech) was the term proposed for the Qur'ānic language by al-Badawai (1973). To someone who knows the Qur'ān very well these names do not sound appealing. The simple descriptor used by Newman and Verhoeven (2002), 'the language of the Qur'ān', aligns most closely with this Muslim perspective.

---

[17] An ancient kingdom which was under the protection of the Eastern Roman Empire.
[18] An ancient kingdom which was under the protection of the Persian Empire.

Among the many phonetic aspects of the Qur'ānic language we find that some are Qur'ān-bound. These aspects derive essentially from the Arabic language but they are used in the Qur'ānic context in a different way. These phonetic aspects in the Qur'ān were formalised by Tajwīd, as mentioned in the first two chapters. As this research focuses on Qur'ānic pharyngealisation, this chapter examines the nature of Qur'ānic pharyngealisation as well as that of classical Arabic. This chapter also discusses the various names given to the feature of Qur'ānic pharyngealisation and the appropriateness of calling this phenomenon pharyngealisation. The degrees of Qur'ānic pharyngealisation, as well as its governing conditions, are examined. A complete picture of Qur'ānic pharyngealisation cannot be presented without a physiological analysis of the sounds, so this chapter examines the articulation of each of the seven sounds studied.

3.1.1. The Qur'ān and Pharyngealisation

The term "pharyngealised" incorporates two meanings" the place of articulation, which is the pharynx, and the suffix "-ised", which describes the secondary articulation of the pharyngealised sound. In fact, it has been suggested by some linguists that the relationship between pharyngeal and pharyngealised sounds should be "intimate". In Arabic, however, which is the most closely studied language to contain both groups of sounds, "they interact only sporadically" (Hoberman:1985). This characteristic actually differentiates Arabic pharyngeals from Arabic pharyngealised sounds. The difference is clearly stated by Card (1983:16): "Pharyngealised consonants have a secondary articulation in the pharynx: the primary articulation, or region of greatest constriction, occurs elsewhere in the vocal tract. For pharyngeal consonants, on the other hand, maximal constriction is in the pharynx." The difference should now be clear, that for Arabic pharyngeals, the primary articulation is in the pharynx, whereas for Arabic or Qur'ānic pharyngealised sounds (QPSs) the primary articulation is elsewhere. Arabic and QPSs are traditionally referred to as emphatic sounds (Embarki et al. 2007).

The sounds under examination in this research are best classified as displaying secondary articulation. The main articulation of a sound, the articulation with the greatest degree of constriction, is referred to as its "primary articulation". Elgendy (2001:6) expresses this articulation in terms of minor and major, when he writes, "The articulation is a secondary when a major constriction is combined with another minor constriction." Therefore, this research deals with the QPSs and Qur'ānic pharyngealisation from the perspective of the basic unit of the articulatory planning. This means the application of the concept of the syllable as a basic unit of articulatory planning.

The pharyngealisation feature is dynamically and strongly connected with Arabic and the Qur'ān. Amongst the Semitic languages, Classical Arabic is the major language to have developed many kinds of pharyngealisation (McCarthy 1994). Zemanek (1996:17) concludes that "Arabic is then probably the originator and without any doubts the propagator of pharyngealisation." More importantly, Hoberman (1985) asserts that pharyngeals and pharyngealisation are looked upon as closely related to Arabic, which is the best known language that incorporates them.

Phonologically, the term pharyngealisation derives from the word "pharynx". As is clear from its name, pharyngealisation is a twofold word. It indicates a secondary place of articulation in the pharynx and also suggests that the pharyngeal articulation has a lesser degree of stricture (different manner of articulation) compared with the primary articulation of the sound. Moreover, the name suggests the occurrence of simultaneous articulation in more than one place in the mouth. A pharyngealised consonant sound has a primary articulation with a greater degree of stricture (e.g. stop or fricative stricture) at one place in the mouth and a secondary pharyngeal articulation with a lesser degree of stricture (e.g. approximant stricture) at another place in the mouth. A pharyngealised vowel sound has an articulation that has been pulled back into the pharynx as a consequence of coarticulation with an adjacent pharyngeal or pharyngealised consonant sound.

Many researchers (such as Lehn 1963, al-Ani 1970, Ghazeli 1977, Card 1983, Watson 2002, Bin Muqbil 2006) have stressed that pharyngealisation in Arabic is a combination of the primary and the secondary articulation of Arabic sounds. These Qur'ānic consonant sounds are articulated with different degrees of constriction in the pharynx (the degree of constriction is considered in the fourth chapter). Thus, to understand Qur'ānic pharyngealisation, one should deal with it from the perspective of the basic unit of the articulatory planning. In other words, QPSs are usually composed of two sounds (especially the sounds under examination in this research), a consonant and a vowel sound. Hence, Qur'ānic pharyngealisation is represented in the coarticulation of the pharyngealised sounds. This coarticulation means the impact of the primary Qur'ānic sound /tˤ/, /dˤ/, / Sˤ/,/ðˤ/,/χˤ/, /qˤ/, and /ʁˤ/ on the secondary sound which is one of the Qur’ānic vowel sounds /a:/, /i:/, and /u:/. The result of the coarticulation of these two sounds in the Qur’ān is called QPSs.

3.1.2. Arabic Classical Pharyngealisation “Tafxīm”

Classical treatises of Arabic (books by al-Khalil, Ibn Jinni, Ibn Sina, scholars of Tajwīd and many others) have addressed pharyngealisation as تفخيم*Tafkhīm* “thickening”. Most of the classical treatises of Tajwīd define Qur’ānic pharyngealisation as a state of thickening that covers the sounds at the time of pronouncing them, causing the mouth to be full of the echo of the sound. The pharyngealised sounds of the Qur’ān are not different from those of Arabic. Classical scholars of Arabic and the Qur’ān have combined them in three words, naming them ق ظ ض غ ط خ ص. These sounds are /tˤ/, /dˤ/, / sˤ/,/ðˤ/,/χˤ/, /qˤ/, and /ʁˤ/. Classical scholars of the Qur’ān and Arabic have classified and described every Arabic sound in great detail. Classical scholars of Tajwīd have also invented their own terms to describe the phonological properties and processes of Tajwīd. Some of these terms were discussed in the Chapter Two.

Historically, different names have been applied, especially to the pharyngealised sounds of the Qur’ān. They are إطباق *ITbāq*, “when the tongue is almost close to the palate”, and إستعلاء *Ist’la*, “when the tongue come up to the palate but does not close it”. If the sound is not مطبق from *ITbāq* then it is منفتح*Munfatiħ* “open”, and if the sound is not *Musta’li* from *Ist’la’* then it is منخفض *MunkhafiD* “lowered”. Card (1983:7) adds *Tafxīm* to the *Ist’ālā’* and the *ITbāq*. In fact, the Qur’ānic phonetic feature that can accommodate all of the Qur’ānic sounds under investigation in this study is the classical feature of *Must’liyah.* In the words of Habis (1998:77), “the consonants specified for the feature [Musta’li] (or [Musta’liyah]), “elevated/raised”, are 7: the four coronals /ṭ, ḍ, ṣ, ð̣/ and the three gutturals /q, χ, ʁ/. They share this feature because their production requires the raising of the tongue back towards the palate which is a secondary articulation with the coronals (to distinguish them from /t d ð s/).” Classical differences in describing the features of Arabic and Qur'ānic pharyngealisation are less significant and controversial than the contemporary differences and discrepancies in naming them.

3.2. Inadequate Representations of QPSs

3.2.1. Naming Discrepancies

The Qur'ānic sounds examined in this study have been named differently in various studies. These names include some that are remote from, and some that are very close to, the real nature of these sounds. Terms such as thickened, dark, emphatics, heavy sounds have been proposed by general phonetic studies. Other names such as velarised, uvularised, and pharyngealised sounds have also been proposed in specialised studies. Until the discussion is settled, the present study prefers to name this feature pharyngealisation and these Qur'ānic sounds as pharyngealised sounds.

One of the first names that appears in a Western account is *Tafxīm.* Card (1983:8) mentions that Lehn (1963:29) was among the first to describe it as *Tafxīm.* She also mentions that Voller (1893) rejected the translation of *Tafxīm* as "emphatic sounds", as it is an inaccurate description of the process involved in Arabic pharyngealisation. In his description of the Arabic pharyngealised sounds, Jakobson (1957) named them "Mufaxxamah" sounds. His study is interesting because of the scholarly treatment of the Arabic phonology and the prolonged survey of phonological studies, from 1914 to 1968. Jakobson was able to determine the exact nature of the Mufaxxamah sounds through X-rays more than sixty years ago. He wrote (1957: 303-310), "The X-ray reveals the projection of the root of the tongue towards the back wall of the pharynx and the resulting reduction of the pharyngeal aperture." Jakobson wanted to use a term that most closely described the pharyngealisation feature in Arabic. He was aware of the connotations of the different terms for pharyngealisation, but in an attempt to be most accurate he relied upon the Arabic word *Mufaxxama*, meaning "thickened or heavy sounds". It is clear that *Mufaxxama* was meant to be an eye-catching name and that pharyngealisation is the real name of the feature that Jakobson was describing. Indeed, in his article (1957) he frequently used the term "pharyngealisation". The use of this term in an English context gives the reader the sense that the writer is fully aware of the connotations and the parameters of this phonological feature. The term "Qur'ānic emphatics" encapsulates the two terms of the *tafxim* and pharyngealisation. The term *tafxim* is best thought of as an auditorily or acoustically-motivated term, and the term pharyngealisation is best to describe the articulatory configuration of the sounds. *Tafxim* describes the classical point of view of these Arabic and Qur'ānic sounds and at the same time the term "Arabic emphatics" has been heavily used to mean the Arabic sounds but not the Qur'ānic ones. Thus, for the purpose of distinction, this research uses the term Qur'ānic pharyngealisation to encapsulate the pharyngealised emphatics and uvulars of the Qur'ān.

The term *Tafxīm* was proposed by al-Ani and el-Dalee (1984). They discussed the feature of *Tafxīm* which they later called "retraction". They also investigated the adjacent vowels that help in forming the retraction. They confirmed that "the vowel which shows the feature of retraction most significantly is /ɑ:/." Discussion of the effects of the pharyngealisation on the vowels appears later in this chapter.

Arabic pharyngealised sounds have been called "velarised" sounds in many studies (Obrecht 1968, Catford 1977).

Watson and Dickens (1993:130) had a different view of this feature. They made a connection between *ITbāq*, pharyngealisation, and velarisation. They mentioned that al-Khalil's *Ibaq* is different from Sibawayh's *ITbāq*. Watson and Dickens depended on what Ibn Munthōr, in his famous book *Lisan al-Arab,* mentioned in regard to the production of the sound *mīm*. Ibn Munthōr stated that al-Khalil thought that the sound mīm is *muTbaq*. Al-Khalil meant that the lips are closed when the sound is produced. He did not mean that the sound *mīm* is one of the *ITbāq* sounds. For a native speaker of Arabic, the *MuTbaq* mīm means that the lips are completely closed when the sound is produced. Watson and Dickens (1993:130) stated, "for Sibawayh's teacher, Farhīdī (al-Khalil), *mutbaq* is used to describe the lip closure in *mīm*, and thus had a different sense of Sibawayh's *mutbaq*." In fact the word *muTbaq* is the name of a process that can be used to describe action in the Arabic language, as it means a closed thing. Al-Khalīl used the word to show that the lips are closed when producing the *mīm* sound. To clarify this dispute, one can say that *ITbāq* is a general word in Arabic that can be used for many features. In this case it was used by al-Khalil to describe the *ITbāq* of the sound *mīm*, which is the closed lips when the sound is pronounced. The *ITbāq* of Sibawayh is when the roof of the mouth is almost closed by the tongue whenever the Arabic pharyngealised sounds are produced. Al-Khalil himself did not indicate anything that violates the *ITbāq* of the pharyngealised sounds. Sibawayh did not invent the name, as it occurred before him in the writing of al-Khalil. More importantly many Arabic sources indicate that Sibawayh followed the steps of al-Khalil in the classification of the Arabic sounds, including *ITbāq*. Watson and Dickens (1993:130) confirm that "in modern linguistics, *ITbāq* denotes pharyngealisation or velarisation." When considering these two features meticulously, we find each means something different. These differences are in the place and the manner of the articulation of these sounds.

ITbāq, in Arabic is when the sound is produced with the tongue raised up to the palate. Norlin (1987) argues against the idea of calling the pharyngealised sounds velarised. According to his findings, the acoustic features of velarised sounds differ significantly from those of emphatic sounds (Arabic pharyngealised sounds). His rejection of describing Arabic pharyngealised sounds as velarised is based on his acoustic analysis. He (1987:75) describes velarisation as a "raised tongue dorsum towards the velar region." In fact, the difference between velarisation and pharyngealisation is not easily clarified in a sentence or a paragraph. Many scholars of phonetics and phonology have indirectly expressed the vague nature of this class of Arabic sounds. Laver (1994:326-327) is correct when he states that "pharyngealization, where the root of the tongue is drawn back towards the back wall of the pharynx (or alternatively where the constrictor muscles of the pharynx reduce its diameter), gives a very similar auditory effect as a secondary articulation to that of velarization." This suggests that the similarity in the retracted tongue root as well as the work of the constrictor muscles has led to the differences in naming these Arabic and Qur'ānic sounds.

Pharyngealisation in modern linguistics is related to *ITbāq*, as the former necessitates a primary and a secondary articulation. The primary sound may be a coronal and the secondary articulation may be in the pharynx. This relationship between *ITbāq* and pharyngealisation is expressed by Yeou (2001), who emphasises that "pharyngealized consonants were traditionally defined as 'emphatic' by linguists and were previously categorized as '*muTbaqah*' by ancient Arab grammarians."

The phonetic chart of the IPA treats the Arabic /x/ sound as a voiceless velar fricative. When describing the normal Arabic sound /x/ this research concurs with researchers such as Newman (2002), Al-Khairi (2005), and Bin Muqbil (2006), who believe that the classical Arabic /x/ sound is a voiceless uvular fricative. The Qur'ānic pharyngealised /$\chi^{ʕ}$/ sound on the other hand is a voiceless uvular fricative one. It becomes uvular when it is flowed by /a:/ or /u:/ vowel sounds. If it is followed by /i/ sound in Qur'ān then it becomes a voicless velar fricative one as in خيانة[19] / χˤiyānah/.

During the primary articulation of the sounds of *ITbāq* a semi-closure should occur at the roof of the mouth and the palate, in *ITbāq*, whereas in modern velarisation there is not complete closure at the palate. It is the tongue dorsum which articulates (either with an approximant stricture as in /X/ or /ʁ/ or with full occlusion as in /q/) against the velum to produce velarised sounds, as explained by Watson (2002), and Bin Muqbil (2006). If the classical *ITbāq* means the position of the tongue when it goes up and forms a semi-closure with the palate when producing one of the four Arabic coronal sounds /T/, /D/,/S/and , /ð/, then it has nothing to do with the velarised sounds which primarily take place in the velar area. Those who have used "velarisation" to mean Arabic coronal and uvular sounds have generalised the feature of velarisation to mistakenly encapsulate more than one place of articulation. More importantly, they have generalised their findings from the study of an Arabic dialect to mean the Arabic sound in general.

This feature (Arabic pharyngealisation) should not be called velarisation, as velarisation in Arabic is a carryover of the velar gesture into the following vowel (i.e. velarization of the following vowel). Some early Western studies describe pharyngealisation as velarisation, though Habis (1998:124) states that "the assumption that emphasis is velarization is conventional". He ponders what we should call the Arabic uvulars. He writes, "treating emphasis as velarisation has the drawback of eliminating the uvulars from the class of emphatics since the tongue back raising is primary for their production."

Some acoustic and articulatory experiments (al-Ani 1970, Ghazeli 1977, Card 1983, and Watson 1999) confirm that what happens in the production of the pharyngealised sounds is not an articulation between the dorsum of the tongue and the velum but rather a constriction in the upper pharynx. Hence they believe that these Arabic sounds are pharyngealised.

The debate around the identity of these sounds is not over, as some researchers (McCarthy 1994, Shahin 1997, Zawaydeh 1999) have proposed 'uvularised' as the secondary feature of the Arabic pharyngealised sounds. They find that during the production of these sounds, the constriction takes place in the uppermost part of the oropharynx. The upper part of the oropharynx is very close to the uvula and the uvula also forms the front wall of the nasopharynx.

[19] Qur'ān (8:58)

Constriction in this region is perhaps more appropriately referred to as a uvular place of articulation rather than pharyngeal. Thus, these sounds are uvulars with a following uvularised vowel sound rather than pharyngealised. Watson (2002:269) justifies this analysis, for those who adopted it, saying that it is “due to upper pharyngeal constriction found in the uvular fricatives.” Some other experimental studies, however, such as that of Yeou (2001), confirm that the place of the constriction of the Arabic pharyngealised sounds is in the middle of the pharynx.

These two phonological terms (pharyngealisation and uvularisation) are difficult to distinguish from each other, for three main reasons. Firstly, the definition of both phonological terms needs more investigation. For instance, when speaking about uvularisation, Zawaydeh (1997) argues that “a secondary articulation is defined as the retraction of the back of the tongue accompanying primary articulation at another point in the vocal tract.” Clearly, this definition is applicable to the Arabic pharyngealised sounds too. This definition does not show a clear difference between the features of pharyngealisation and uvularisation. If there is any difference between these two patterns of Arabic sounds then it should be revealed through further analysis

Secondly, the distinctive feature that is behind both of the terms is also confusing. The feature Retracted Tongue Root [RTR] is the same for both pharyngealised and the uvularised sounds. For instance, Zawaydeh (1997) states that “since the retraction of the tongue root is one of the basic components for the articulation of uvularised and uvular segments, the feature [RTR], was found to be appropriate.” On the other hand, recent studies (Watson 2002, Bin Muqbil 2006) have described the [RTR] feature as accompanying the Arabic pharyngealised and emphatic[20] sounds. The use and application of this feature to more than one natural class of sounds (pharyngealisation, velarisation, and uvularisation) has led to this confusion.

Thirdly, acoustically, these phonological processes (pharyngealisation, velarisation, and uvularisation) share the same properties of raising of the F1 and the lowering of the F2. The X-rays of Delattre (1971) Ghazeli (1977) and the acoustic study of al-Ani (1970) show similar images and acoustic effects of these phonological processes.

Watson (2002) presents a better explanation. She thinks that in the case of the uvularised sounds the tongue dorsum is stretched and retracted towards the uvula, whereas in the case of pharyngealised sounds the root is retracted towards the upper pharynx, to narrow it.

[20] Bin Muqbil (2006:64) confirms this. “Note that the SPE model assumes emphatics are truly pharyngealised since their tongue body specification is identical to those of pharyngeal sounds.”

The articulatory experiments of Ghazeli (1977) and Laufer and Baer (1988) showed that Arabic pharyngealised sounds are pharyngealised more than velarised. Laufer and Baer (1988) used the term "emphaticness" to mean pharyngealisation. They concluded that their "study rules out the theory that emphaticness is realized as velarisation … they are realized as pharyngealised, having a secondary articulation in the lower part of the pharynx."

Lehn (1963) listed many different terms, such as "strongly articulated, pharyngealised, heavy, retracted, velarized and uvularized", for these Arabic sounds. The reason behind these discrepancies and the inadequacies in naming this phonological feature is the lack of a correct concordance between the findings of acoustic, articulatory, and auditory analyses of the sounds. Some studies (Shahin 1997, Zawaydeh 1997) have relied primarily upon acoustic analysis in describing the sounds as uvularised. Acoustically this choice is misleading, as both pharyngealised and uvularised sounds show a high F1 and a lower F2. Bin Muqbil (2006:204), in his discussion of the difference between these two phonological processes, points out that "generally, uvulars show similar effects on adjacent vowels as do emphatics (pharyngealised)." He also discusses at length the possibility of velarisation, uvularisation, and pharyngealisation. Interestingly, his acoustic analysis findings for the Arabic pharyngealised sounds show some differences between the spectral cues for uvularisation and pharyngealisation.

Although acoustic correlates may be sufficiently accurate for some researchers, they cannot be trusted to reveal the exact articulatory identity of a given sound. Many studies (Stevens 1960, Bulmstein and Stevens 1979, Evers at al. 1998, Yeou 2001, Bin Muqbil 2006) have confirmed the importance of a strong association between the acoustic correlates and the articulatory analysis. Researchers who choose "uvularisation" as the name for the Arabic pharyngealised sounds base their decisions on studies of the acoustic correlates only. Zawaydeh (1997) maintains that "this feature 'uvularisation' has been chosen because it follows the findings of the literature on the acoustics of uvularized segments."

Bin Muqbil (2006) indicates that these inadequacies in addressing the nature of Arabic pharyngealised sounds are the result of the various acoustic analyses which have not been correlated well with articulatory findings. Furthermore, he (2006:80) states that "the location and degree of the articulatory constriction for a certain sound determines its acoustic output." Yeou (2001), however, asserts that "any comprehensive description of consonants should include data on acoustic, articulatory, aerodynamic and perceptual parameters."

3.2.2. Applicability of Pharyngealisation

The current research assumes a pharyngealised identity for the /tˤ/, /dˤ/, /sˤ/, /ðˤ/ sounds as well as a uvular identity for the /χˤ/, /qˤ/, and /ʁˤ/ Arabic sounds which are followed in the Qur'ān by uvularised vowel sounds. This section discusses whether the term "pharyngealisation" is applicable to all those sounds. Careful reading of the available classical and contemporary literature on Classical Arabic sounds suggests that there is no underlying conflict as to the identity of the pharyngealised sounds in the classical treatises.

Because of the underlying consistency in these classical studies, they should ideally be the basis, or starting point, for modern studies and investigations. We find that studies which deviate from the more common descriptions of these sounds do not start from a consideration of the Arabic classical description of these sounds. The descriptions of Zawahdeh (1999), McCarthy (1994), and Davis (1995) of the Arabic pharyngealised sounds are at odds with both the classical articulatory and the modern experimental investigation of these sounds. The inspiring discussion of Bin Muqbil (2006:75) should be taken into consideration. He writes, "Zawaydeh subscribes to the idea that emphatics are uvularized which, as noted earlier, is articulatorily problematic. Additionally, the role of the tongue dorsum in her representation of uvulars is quite vague. It is implicated twice: as implementer of the [dorsal] feature and as implementer of the [Retracted Tongue Back] feature. To complicate things further, the two implementations are nested under two different vocal tract nodes."

It is clear that later phoneticians (e.g., Zawaydeh 1999, Shahin 2002) have adopted the notion of the uvularisation of the Arabic pharyngealised sounds with no strong experimental evidence. Careful examination of studies which claim uvularisation of the Arabic pharyngealised sounds reveals some weaknesses. The whole study of Lehn (1963) is a phonological one, lacking any experimental evidence that can support his invention, "uvularisation". Habis (1998:126) finds the description of the uvularisation by McCarthy and Lehn to be "ill-defined", "not quite clear" and "a bit confusing". McCarthy (1994) also claims that the Arabic coronal should be called uvularised but this has not been supported by empirical physiological experiments.

The discussion of Hassan and Esling (2007) around the identity of Arabic pharyngealisation is significant. They do not deny that Arabic pharyngealisation has been described as velarisation and uvularisation, but more importantly they write: "The acoustic and laryngoscopic evidence indicates that the prevailing nature of emphatics in Iraqi Arabic is pharyngealization." Moreover, when they discuss the studies that adopt the term uvularisation for Arabic pharyngealisation, they say "although the data suggest pharyngealization, they do not exclude uvularization." They mean that even if the tongue dorsum is slightly moved back towards the posterior pharyngeal wall then this feature should not be called uvularised but rather pharyngealised.

The term "uvularization" itself is somehow misleading. It has not been reported in any language other than Arabic. Furthermore, the IPA has no specific phonetic sign for it. The discussion of Bin Muqbil (2006:202-203) deserves to be highlighted. He posits some assumptions around the identity of uvularisation. He says that if it is believed that uvularisation is a secondary articulation then it must include a sound that is a copy of the /χ/, or /ʁ/ sounds, as its name suggests. In this case, Arabic pharyngealised coronals such as the Qur'ānic /tˤ/, /dˤ/, /sˤ/, /ðˤ/ cannot be included under uvularisation. More importantly, if uvularisation has something to do with the Arabic velar sound /x/ or the uvular sound /q/, then physiologically there is a difference between them and the Arabic emphatic (pharyngealised sounds), as Arabic emphatics involve the contraction of both the styloglossus and the hyoglossus muscles whereas uvulars involve only contraction of the styloglossus muscles, as shown by Bin Muqbil (2006).

A second possibility outlined by Bin Muqbil (2006:202-203) is that uvularisation is a process of secondary articulation and the tongue is retracted and raised toward the uvular place. Bin Muqbil (2006:202-203) states that "either way, uvularization is a superset of velarization since primarily uvular sounds are considered complex pharyngeal-velar sounds. Uvularization, then, is expected to display the same acoustic effects as velarization, which is exactly what Catford (1977) states." In this case, velarisation and uvularisation are connected in the way in which they are primarily and secondarily articulated. Velarisation cannot stand alone for Arabic pharyngealised sounds as their identity is different. Furthermore, uvularisation also cannot stand alone for Arabic and Qur'ānic pharyngealisation, as the most prominent Arabic vowel that is affected by pharyngealisation, the /a:/ sound, is pharyngeal. Bin Muqbil (2006:203) states, "it is counterintuitive to expect two relatively rare types of secondary articulations, velarization and pharyngealization, to coexist as a double secondary articulation in the same sound."

Recent studies (Keating 1988, Zawaydeh 1997, Watson 1999, al-Khairy 2005) show that the choice of the descriptors "uvularised" or "pharyngealised" depends largely on the dialects studied as well as on the preference of the researchers themselves.

The term "pharyngealisation" to describe the Arabic /T/, /D/, /S/, /ð/ sounds as well as the uvularised /x/, /q/, and /ʁ/ sounds has been adopted in many studies (e.g. Steven 1998, Watson 2002, Bin Muqbil 2006, Hasan and Esling 2007 and many others). Bin Muqbil (2006:2) confirms that "the most prominent proposal is that these sounds are pharyngealized. This is basically a place of articulation term that reflects the fact that the pharynx is generally narrowed during the articulation of these sounds." The question that has to be asked here is whether the sounds under investigation in this study are divided into two groups or not. First, there are the Qur'ānic coronal sounds (/tˤ/,/dˤ/,/sˤ/,and /ðˤ/). In these sounds the tongue articulates the coronal primary place of articulation and simultaneously, the second articulation takes place when the root of the tongue retracts backward. In the Qur'ān, these sounds are followed by the Qur'ānic pharyngealised vowel sound /a:/.

The second group are the Qur'ānic uvular sounds, which are primarily articulated in the uvular area. They are also followed by the Qur'ānic pharyngealised vowel sound /a:/. Now, how can we unify these two groups under one feature? The answer is that although these two groups have different primary articulations (coronal and uvular), both are followed by the same Qur'ānic pharyngealised vowel sound /a:/. More importantly, in classical studies, the Qur'ānic coronal sounds were classified as *MuTbaq* "semi-closed" sounds and the uvular sounds were not. However, these two groups were both classified as *Must'li* sounds, which means that during the articulation of these Qur'ānic sounds, the tongue is elevated or raised. Every basic unit of articulatory planning of any one of these sounds (the primary articulation, the secondary articulation, and the added pharyngeal vowel sound /a:/) is represented by the phonetic feature called "Qur'ānic pharyngealisation".

Laradi (1983:1) expresses her desire to call both of these sounds (the consonant and the following vowel) pharyngealised. She explains, "the term pharyngealisation is used here in its broadest sense to cover those consonants that are articulated by a constriction or otherwise in the pharynx from soft palate to larynx irrespective of other factors, as in the case of the pharyngealised consonants which involves a primary articulation of tip or blade of tongue and a secondary articulation of tongue roots besides factors of lip rounding or protrusion that undoubtedly have acoustic consequences." Hence her research supports this unifying idea of calling all the sounds under investigation in this research the QPSs. It must be stated here that due to the different experimental methodologies and the different dialects of Arabic (which contain these sounds), the discussion of the identity of these sounds and the discussion around a phonological feature that unify all of these sounds, seem endless.

3.2.3. Qur'ānic Pharyngealisation and the Current Phonological Theory

The classification of the QPS coronals and uvulars needs to be aligned with current phonological theory. These sounds would be more unified phonologically if they can be bound under one class or distinctive feature. When discussing these Arabic emphatic sounds, Obrecht (1968:41) states "If these sound are to be considered as members of the same class, then they must possess at least one common feature, or combination of features". One would expect to find some overriding similarity which crosses all the phonetic classes in which they are customarily said to occur." That is true for the QPS. It was mentioned earlier (in chapter two) that the classical scholars of Tajwīd have classified Qur'ānic pharyngealised and guttural sounds as Musta'li and QPS in particular as *MuTbaq*. What is significant to the current research are the classical phonological features outlined by the scholars of Tajwīd, who stress that the QPS (coronals and uvulars) are all Musta'li and the coronals are only MuTbaq. What is needed is an alignment of the Tajwīd category of Musta'li with a current phonological class or feature.

The last 40 years have witnessed several initiatives that aimed to stipulate a unified feature description for the Arabic emphatic sounds. Jakobson (1962) proposed the feature of [+flat] which indicates that there is a reduction in one of the formants (F2) for this group of sounds. This is somewhat applicable to the acoustics of the QPS. But Jakobson extended this feature articulatorily to more than pharyngealisation, to labialisation. The phonological feature "labialisation" is not applicable to the description of the QPS. This is not mean that lip protrusion does not occur, but that Qur'anic lip protrusion needs to be distinguished from the more familiar feature related to lip rounding. The intended role of Qur'anic lip protrusion is to reinforce the perception of pharyngealisation. It appears that Jakobson was economical in his features when corresponding the Arabic emphatics with the labialisation of the Uzbek and Pantu languages. Therefore this feature [+flat] of Jakobson is not adequate to encapsulate QPS.

General SPE[21] articulatory features such as [+low+back] were also proposed for Arabic emphatics but these features also have some inconsistencies with the current articulatory configuration of the Arabic pharyngeals and QPS. Though QPS all share the feature of [+back], it was stated in the second chapter that the coronal QPS are Musta'lia which means they are produced with the back of the tongue high. Thus this SPE feature is not applicable to these QPS. Similarly Stewart's (1967) feature of [+RTR] (retrected tongue root) also excludes the Musta'lia sounds. Therefore this features is also not applicable to encaptulate the QPS under one unifying feature.

Different studies proposed different features to suit the investigated languages. The feature of [+CP] (constricted pharynx) was also proposed by Broselow (1976) to mean the constriction of the pharynx. This is again only a partial description of the production of the QPS. The constriction of the pharynx is assisted and reinforced by the retraction of the root of the tongue in order to make a successful production of the QPS.

The proposal of Parkhurst (1990) [+PH] (pharyngealised) gives a more appropriate consideration of the featural characteristics of the QPS. Habis (1998:182) states "Parkhurst (1990) argues that it is more appropriate than [+CP] because the pharynx itself does not constrict but it is actually the tongue which moves backward in the pharyngeal area and causes the constriction.

It appears that the debate around a precise feature for a given sound can be endless as everyone tackles the feature from a different phonological prospective. Habis (1998:186) concludes his discussion about the Arabic emphatic sounds stating " The modern feature analysis of emphatic consonants, from Jakobson [+flat] (1962) to the geometrical representations as proposed by McCarthy (1994), is still subject to considerable disagreement." The phonological identity of the sounds of this research is difficult to exactly determined when we remember that some of the Arabic and Qur'ānic pharyngealised sounds are yet to be accurately investigated. The current research is mainly interested in determining the acoustic and the articulatory configuration of the QPS rather than naming a phonological feature for these sounds. Therefore this research will refer to the feature for QPS as [Qur'ānic pharyngealised sounds].

[21] SPE is the Sound Pattern of English. It is the work of Chomsky and Halle in 1968 in phonology. It is usually referred to as ESP.

The acoustics of the QPSs are not expected to be completely different from their Arabic counterparts. Arabic emphatic studies have heavily investigated the role of F1, F2, and F3 to determine the nature of the Arabic emphatic sounds.This research is going to explore and investigate the role of the first four formants in the production of the QPS. The height of F1 is associated with the lowering of the tongue and the lowering of F2 is associated with the retracted tongue (e.g. Ladefoged, 1972) . Ibn Muqbil (2006:36) states “The articulatory effect of nieghbouring vowels or emphasis spread (ES) is a well known acoustic attribute of the sound. The most reported effects are a lowered F2 and a raised F1.” What happens in the acoustics of the QPS and the Arabic emphatics is that F1 and F2 come close to each other as if they were one formant. Habis (1998:147) states “Emphatic sounds are charactrised by narrower distance between F1 and F2 than in their non-emphatic cognates (El-Halees 1985). Both formants move towards each other to produce a more compact spectrum than in plain context. (Ghazeli 1977 and Obrecht 1968). ” The study of Ghazeli (1977) also showed that the drop in F2 extends throughout all the /a/ sound whilst it does not for the /i/ sound.

Several acoustic studies found that F2 is a clear cue in determining the spectral shape of the Arabic emphatics. Obrect (1968) found that F2 is powerful in the perception of emphasis irrespective to the phonetic class examined. The acoustics cue F3 showed less importance in the acoustic analysis of the Arabic emphatics. El-Dalee (1984) showed that F3 in particular is a less powerful formant for the determination of emphasis and that it is a “non-significant correlate.” Ibn Muqbil (2006:37) states “ F3 in vowels does not seem to reflect any coarticulation influence by adjacent emphatics. Giannini &Pettorino (1982) found no change in F3 locus next to the emphatics while El-Dalee (1984) reports that the change in F3 were inconsistent.”

Most relevant previous studies have examined F1, F2 and F3. In the present study, F4 was added to the formants examined because casual visual examination of the spectrograms of SSR participants, at a very early stage in this study, indicated a potentially interesting pattern for F3 and F4 that suggested that these two formants, at least for SSR reciters. F3 and F4 were very close together in Qur’ānic pharyngeal vowels and that this appeared to cause these two formants to reinforce each other and to make them more intense.

3.3. Classification of Qurʾānic Pharyngealised Sounds

3.3.1. Degrees of QPS

Classically, descriptions of the pharyngealised and non-pharyngealised Qur'ānic sounds were strongly concomitant with إستعلاء*Isti'la'* "lifting the tongue up" and استفال *Istifāl* "putting the tongue down" at the time of producing the sound. In Tajwīd, all the QPSs are characterised by إستعلاء*Isti'lā'.* The Arabic classical counterpart of *Ist'la'* is *Istifāl,* which is represented through the rest of the Classical Arabic sounds.

Classical scholars of Tajwīd have classified the QPS into degrees of pharyngealisation. Some Qur'ānic sounds must always be pharyngealised. Some others should be pharyngealised in certain positions and depharyngealised in some other phonological environments. This section examines the degrees of pharyngealisation of the Qur'ānic sounds as agreed upon by classical scholars of Tajwīd. Recent studies of the degree of Arabic pharyngealisation are also discussed. More importantly, this section sheds light on the Qur'ānic sounds that should be pharyngealised or depharyngealised[22].

Degrees of pharyngealisation have been classified by both classical scholars (al-Khāqāni; d.937, al-Qairāwāni; d.1046) as well as by many contemporary scholars of Tajwīd in Arabic (Habis 1998; al-Hamad 2003; al-Showaihi 2003). Habis (1998:119) states "TajwīdTajwīd scholars adopt the notion of *marātib al-tafkhīm* 'degrees of emphasis', meaning that certain vowels exhibit more emphasis than others." According to classical and contemporary studies of Tajwīd, there are five degrees of Qur'ānic pharyngealisation:

1. The strongest degree of Qur'ānic pharyngealisation occurs when any of the QPS (/tˤ/, /dˤ/,/sˤ/,/ðˤ/,/χˤ/, /qˤ/, and /ʁˤ/) is followed by /a:/ as in الصائمين[23] /ʔsˤā:ʔimīn/, ق[24] /Qā:f/, and الطامة[25] /ʔtˤā:məh/. This degree of Qur'ānic pharyngealisation shows clearly the articulation of the QPSs which are followed by the QPV /a:/. The coronal sounds (/tˤ/, /dˤ/,/sˤ/,/ðˤ/ and the uvular sounds /χˤ/, /qˤ/, and /ʁˤ/) are fully pronounced followed by the articulation of the Qur'ānic pharyngeal sound /a:/. The QPS /a:/ that follows Qur'ānic pharyngeal sounds must have full lengthening of the vowel /a:/ which amounts to three seconds. This kind of pharyngealisation necessitates lip protrusion to

[22] Depharyngealisation is the term used by Heath (2002) to describe sounds which are not pharyngealised.
[23] Qur'ān (33:35)
[24] Qur'ān (38:1)
[25] Qur'ān (79:34)

strengthen the perceived pronunciation of pharyngealisation. The result then is the strongest degree of Qur'ānic pharyngealisation.

2. The second strongest degree of Qur'ānic pharyngealisation occurs when any of the QPS (/tˤ/, /dˤ/, /sˤ/, /ðˤ/,/χˤ/, /qˤ/, and /ʁˤ/) is followed by the Arabic vowel sound /a/, as in ضرب[26] /dˤarabā/ ,طبع[27] /tˤabaʕā/, and قمر[28] /qamar/. The degree of pharyngealisation here is controlled by the following vowel sound. The QPS here does not require lip protrusion.
3. The third strongest degree of Qur'ānic pharyngealisation occurs when any of the QPS (/tˤ/, /dˤ/, /sˤ/, /ðˤ/,/χˤ/, /qˤ/, and /ʁˤ/) is followed by the Arabic vowel sound /u/. The /u/ sound colours the QPS in a way that minimises its perceived degree of pharyngealisation, as in فضرب[29] /fadˤuriba/, and فقطع[30] /faqˤuTiʕa/.
4. The fourth strongest degree of Qur'ānic pharyngealisation occurs when the QPS is ساكن*Sakin* ("unvowelled") as in واقصد[31] /wəqˤsˤid/, and واضرب[32] /wadˤrib/. In this case there is no lip protrusion during articulation. The mass of the tongue is raised towards the palate to complete the articulation of the Qur'ānic /dˤ/ sound while the tongue root is slightly retracted towards the pharynx, creating the right degree of pharyngealisation.
5. The least strong degree of Qur'ānic pharyngealisation occurs when the QPS is followed immediately by the /i/ sound as inخيانة[33] /xˤiyānah/, andالقيامة[34] /ʔlqˤiyāmah/. In this degree of Qur'ānic pharyngealisation it is difficult for the non-professional reciter to notice any sign of pharyngealisation, yet all of the QPS (/tˤ/, /dˤ/,/sˤ/,/ðˤ/,/χˤ/, /qˤ/, and /ʁˤ/) must be given the right degree of pharyngealisation which is governed by the diacritic or the vowel before or after it.

It has been mentioned earlier that all these QPSs must always be pharyngealised according to their different degrees of pharyngealisation. Depharyngealisation of any of these sounds is inappropriate in Qur'ānic recitation. Each of these sounds has its own identity that affects and

[26] Qur'ān (16:112)
[27] Qur'ān (9:93)
[28] Qur'ān (54:1)
[29] Qur'ān (57:13)
[30] Qur'ān (6:45)
[31] Qur'ān (31:19)
[32] Qur'ān (18:32)
[33] Qur'ān (8:58)
[34] Qur'ān (75:6)

governs its phonological environment. The strongest sound in its resonance parameters and degree of pharyngealisation is the sound /tˤ/, followed by /dˤ/, then/sˤ/ followed by /ðˤ/, then /qˤ/ followed by /ʁˤ/, then /xˤ/. These sounds do not have one unified degree in their pharyngealisation. Articulatorily, they can be divided into two main groups, emphatics and uvulars. The Qur'ānic emphatics مطبقه "closed" sounds /tˤ,dˤ,sˤ, ðˤ/ are stronger than the Qur'ānic uvulars / qˤ ,ʁˤand χˤ/.

Ghazeli (1977) compared the degrees of constriction of Arabic pharyngeals, uvulars, and pharyngealised sounds. He states (p. 174) that "a number of consonants in Arabic are articulated in the back of the vocal tract. All of these consonants do in fact exhibit varying degrees of tongue retractions and pharyngeal constriction." This difference is actually governed by the nature of the sound. Ghazeli continues, "the articulatory manoeuvres for achieving these pharyngeal constrictions varied according to whether these consonants were uvulars, pharyngeals, or pharyngealised coronals."

Acoustically, it has been found (Bin Muqbil 2006) that the degree of the tongue retraction (pharyngealisation) varies when Arabic emphatics and uvulars are articulated. More importantly, the stability of the Arabic (Qur'ānic) uvular sounds next to the vowel sound is less rigid than that of the Arabic emphatics. This has been found by Bin Muqbil (2006:204) who confirms that "while dorsal retraction in emphatics is highly stable regardless of the adjacent vowel, it is more adaptable to the vowel environment in uvulars. This indicates that the articulatory implementation of dorsal retraction in emphatics and uvulars might be different."

3.3.2. Conditioned QPS

The Qur'ānic conditioned pharyngealised sounds are those sounds which are sometimes pharyngealised and at other times are depharyngealised. Besides the above mentioned seven Qur'ānic sounds, which must be pharyngealised at all times, three other sounds in Qur'ānic recitation are pharyngealised or depharyngealised in certain conditions. These are the Qur'ānic /r/, /l/, and /a:/ sounds.

3.3.2.1. Pharyngealisation of the Qurʼānic sound /r/

The Qur'ānic sound /r/ differs from the normally doubled Arabic /r/ sound and from all of the other forms of /r/ sounds elsewhere. The /r/ sound in the Qur'ān is characterized by التكرير*Takreer* "repetition". The kind of repetition when /r/ is pronounced should be slight and should not be noticed by listeners. It is a kind of micro-repetition that doubles the sound and clearly produces it in a controlled manner.

The Qur'ānic /r/ sound should be maintained as a pharyngealised sound except when it is affected by the adjacent sounds or diacritics. This sound can be affected by its own حركة "diacritic" or by the sounds before it or after it. Unlike Arabic consonants, Arabic vowels are not represented in the orthography by separate full graphemes but by diacritics. A diacritic in Arabic is a special symbol above or under the Arabic consonant to show the short vowel before or after it. Habis (1998:39) explains, "the basic three diacritics used to represent short vowels are *al-fatħah* (َ◌) for /a/, *al-Dammah* (ُ◌) for/u/ and *al-kasrah* (ِ◌) for /i/. Long vowels are represented by letters like consonants".

The Qur'ānic /r/ sound has two allophones (pharyngealised and depharyngealised) and should be pharyngealised in the following cases at all times:

1. When the diacritic of /r/ is dammah (رُ) (when the /r/ is followed by the /u/ sound) as inرزقنا[35] /ruziqna/ and عرباً [36] /ʕuruban/, then the /r/ should be pharyngealised at all times.
2. When the diacritic of the /r/ is fatħah (رَ_) (when the /r/ is followed immediately by the /a/ sound) as in الرحمن[37] /ʔrraħmān/ and اترابا[38] /ʔtrāba/, the /r/ must be pharyngealised at all times.

3. When the Qur'ānic /r/ sound is ساكن "unvowelled" and preceded by the dammah (ُ◌) sound as in القرأن[39]/ʔəlqur'æn/ and يكفر[40]/yəkfur/ or preceded by the /i/ sound as in فرقة[41] /firqah/ and مرصادا[42] /mirsˤa:dā/, the /r/ sound should be pharyngealised at all times. It is very important to note that in the Qur'ān, the true meaning of the application of Tajwīd is to give each sound its

[35] Qur'ān (2:25)
[36] Qur'ān (56:37)
[37] Qur'ān (2:163)
[38] Qur'ān (56:37)
[39] Qur'ān (2:185)
[40] Qur'ān (2:99)
[41] Qur'ān (9:122)
[42] Qur'ān (87:12)

full right of the due pronunciation. This means that there is no right or left spread of pharyngealisation in the Qur'ān as the Qur'ānic pharyngealised syllable is strictly controlled with the exception of the word *Allah* in the Qur'ān and its deriviatives. *Alif Altafxīm* here in the word of *Allah,* is consistent with an intrinsically pharyngealised/uvularised vowel which can be thought of as a variant of QPVS /a:/. Untrained reciters of the Qur'ān may find it difficult to resist the effect of the adjacent QPS on the neighbouring sound. This aspect of Tajwīd needs further investigation in the future.

4. When the reciter stops recitation on a /r/ sound which is ساكن "unvowelled" (not followed immediately by a vowel) and the /r/ sound is preceded by Dammah (ُ) or fatħah (َ_) as in سرُر[43] /surur/ and القمر[44]/ʔəlqæmər/, full pharyngealisation is required for the /r/.

There are certain instances in which the Qur'ānic sound /r/ should be depharyngealised. It should be depharyngealised in the following instances:

1. When its حركة "diacritic" is الكسر al-kasrah (ـِ) (the /r/ is followed immediately by the /i/ sound) as in رجال[45] /ridʒāl/ and الطارق[46] /ʔTa:riq/. The position of the /r/ sound in the word here, whether initial, medial or final, makes no difference.
2. When the Qur'ānic /r/ sound comes in Qur'ān in a word of *Imalah* .*Imalah* which means "The act of bending the sound of the *fatħa* in the direction of the *kasra*, and more often, the *alif* in the direction of the /ei/. This is the pure form of the declension." (Fareed 2001) In the recitation mode of (Asim via ħafs) that this research follow, *Imalah* occurs once in the Qur'ān in the word مجراها[47] /madʒreıhā/. The /ei/ sound that comes after the /r/ sound was originally /a/ sound. Due to the application of *Imalah* the /a/ sound becomes /ei/ sound and the preceding /r/ sound should be depharyngealised
3. When the /r/ is a medial unvowelled sound and is preceded by the /i/ sound and followed by استفال "depharyngealised sound" as in شرذمة[48] /ʃirðimah/, and فرعون[49]firʕɔʊn/. In these examples the /r/ sound should always be depharyngealised.

[43] Qur'ān (73:44)
[44] Qur'ān (6:77)
[45] Qur'ān (7:46)
[46] Qur'ān (86:1)
[47] Qur'ān (11:41)
[48] Qur'ān (62:45)

[49] Qur'ān (2:49)

3.3.2.2 Pharyngealisation of the Qur'ānic sound /lˤ/

The ninth sound of QPSs is the /l/ sound. The two Qur'ānic sounds /l/ and /lˤ/ should be dealt with as two separate phonemes. Substitution of the sound /lˤ/ in the name of Allah /ʔlˤa:h/ to /ʔllah/ changes the meaning from the name of Allah to an "inattentive" person. This great difference between Arabic pharyngealised and non-pharyngealised /l/ was clear to Ferguson (1956), who emphasised the difference between /l/ and /lˤ/ in Arabic, saying that they should not be dealt with as allophones of one sound. Ferguson (1956) looked at the Arabic dark /ɫ/ as an independent sound and not as an allophone of the Arabic /l/ sound. He thinks that the light and dark /l/ in Arabic should not be used as allophones of the same sound as long as the existence of the this sound (whether in the classical Arabic name of *Allah* or in some colloquial words) is unpredictable and cannot be attributed to context, then this sound should be regarded as a separate phoneme. What is missing in the treatment of Ferguson here is that this sound is sometimes predictable in Arabic, but not in the same sense as an allophone conditioned by its surrounding phonetic context. There is a rule in Qur'ānic recitation for using this sound. This sound should be pharyngealised (pronounced like the English dark /l/) in the word الله "Allah", as a special case, wherever it occurs in the Qur'ān. The Qur'ānic sound /lˤ/ is pharyngealised for the name of Allah only, except when it is preceded by the Arabic diacritic *Kasrah* (/i/ vowel sound) as inلله Lillahi (for Allah). Here, the /l/ sound is depharyngealised even when it occurs in the name of Allah, because it is preceded by *Kasrah* (/i/) sound. The Qur'ānic /l/ is depharyngealised in all other contexts.

Thus this sound /l/ should be depharyngealised in all cases (except for the name of Allah, as in الله /ʔlˤah/ اللهم /ʔlˤahɒma/ andمن الله/minʔlˤahi/) when it is preceded by /a/ or /u/ vowel sounds. When the Qur'ānic /l/ sound is preceded by *Kasrah* it is depharyngealised in the word Allah and in all other contexts.

3.3.2.3. Pharyngealisation of the Qur'ānic Vowel sound /a:/[50]

All vowel sounds are affected by Qur'ānic pharyngealisation. Classical scholars of Tajwīd have emphasised the great effect of the sounds on their adjacent vowels. Classical scholars, in their descriptions of the Qur'ānic vowels, paid meticulous attention to detail. After identifying the

[50] The precise phonetic quality of this vowel sound is found in between the IPA back open rounded vowel sound /ɒ/ and the back mid open rounded vowel /ɔ/. This research chooses to name it /a:/ vowel.

Qur'ānic vowels they legislated a name and the duration or lengthening of that vowel. That is why nowadays we can specify any long vowel in the Qur'ān by its name and its length.

Recent phonetic studies of vowel-consonant coarticulation recognise that neighbouring vowels and consonants affect each other immensely. Habis (1998:164) states, "there is a general agreement among phoneticians that all the vowels fall under the coarticulatory effects of neighbouring emphatics and that the effects vary from one vowel to another. It is also generally assumed that the effect is clearer on /a(:)/ than on other vowels." Ali and Daniloff (1974) examined the effect of vowel sounds on emphatics. After separating the vowel sounds from the emphatic consonants, they asked their informants to identify the words based only on listening to the vowel sounds. The majority of their informants were able to identify these words immediately even without the consonants. The informants could match the vowels with the emphatic consonants. This indicates that those vowels were under the coarticulatory effect of these emphatic sounds. Habis (1998:163) notes, "yet it is quite possible that the non low vowel (e.g. /i(:)/) exhibits a smaller amount of emphasis if compared to /a(:)/, for example." The importance of correctly coarticulating the Qur'ānic pharyngealised consonant with the Qur'ānic vowel /a:/ is obvious in terms of the perception of that QPS. The combination of the QPS and the QVS is perceived as one syllable. Mannell (2008) remarks that "there is a very large, and growing, body of research that suggests that the syllable is the most basic unit of articulatory planning in the brain. Gestures interact with each other to a greater extent within syllable boundaries than they do across syllable boundaries." The concept of *basic unit of articulatory planning* is significant in dealing with the QPSs, and the interaction between QPSs and QPVs is an example of complex articulatory planning within a single syllable.

The Qur'ānic vowel sound /a:/ takes its strength as a pharyngealised sound from the preceding sound. Whenever /a:/ is preceded by a pharyngealised consonantal sound, it becomes pharyngealised. This sound cannot be described as pharyngealised or depharyngealised as it does not have this feature in itself; rather it reflects the effects of the preceding sound. The /a:/ sound is regarded as perfectly pharyngealised when it follows any of the seven Qur'ānic sounds that are always pharyngealised. It is perceptually obvious that /a:/ is the most salient vowel sound to study because pharyngealisation is easily perceived in this context. This importance was particularly noticeable to Card (1983:26), who considered that the Qur'ānic low vowel is changed from front /æ/ to the back /a:/ because of the influence of pharyngealisation.

Although other Qur'ānic vowels, such as /i/ and /u/, also follow Qur'ānic pharyngealised consonants, the choice of the /a:/ sound in this research is mainly because of the greater clarity of positioning and movement of the tongue and the effects during the acoustic and articulatory experiments of this research. Ouni and Ouni (2007:4) found that "the context of the vowel /a:/ helped in identifying pharyngeal and pharyngealised phonemes because the tongue is partially visible." They identified this vowel as a low back cardinal 5 vowel.

This Qur'ānic vowel is phonetically an open back rounded vowel. Rounding is not a phonemically distinctive feature of the QPS but the effect of lip protrusion during recitation makes this vowel share some phonetic characteristics of rounded vowels. The phonetic IPA symbol of the back open rounded vowel is /ɒ/. This research does not use this symbol as it does not fully represent the Qur'ānic vowel, which has a length of 2, 4 or 6 seconds depending on its context and which has lip protrusion. Hence, this research prefers to use /a:/ symbol to represent the Qur'ānic pharyngealised open back rounded vowel.

A very important question arises in relation to the effect of the Qur'ānic vowel sound /a:/. What creates the constriction in the QPS? Is it the consonant or the vowel sound? In fact, both the consonant and the vowel have their own constriction. The application of the concept of the syllable as the basic unit of articulatory planning is applied to the analysis of the videofluorographic articulatory experiment in this research, which in turn should shed light on the sequence of articulatory gestures in the QPS. Laradi (1983:319) confirms that "this phenomenon (Arabic pharyngealisation) is not attributable to either the consonant or the vowel, but to both, and any attempt to separate the two is more or less impossible. One can only treat the pharyngealized sounds in terms of syllable CV or VC." The importance of dealing with the QPSs as syllables should be explicit in our understanding of phonetic structures. Mannell (2008) states that "coarticulation tends to be stronger within syllables rather than across syllable boundaries. This greater coarticulation within syllables is evidence for the cognitive existence of the syllable as a fundamental unit of articulatory organization." Thus the QPSs are sounds that coarticulate with the adjacent consonants. Visual examination of spectrograms shows that there are clear transitions from the preceding consonant into a short initial part of the vowel or from a short final part of the vowel into the following consonant. So the beginning and end parts of the /a:/ sound are clearly coarticulated with any of the seven QPS. Additionally, for the more expert reciters, the initial transition is quickly followed by very stable vowel targets that are very similar from one consonant context to another. For less expert reciters (e.g. NPR reciters), more of the vowel appears to be much more affected by the consonant context. This effect needs to be examined in more detail in future research.

3.4. Physiology of Qur'ānic Pharyngealisation

As mentioned earlier, Qur'ānic sounds are not different from Classical Arabic sounds. The sounds of Tajwīd are Arabic; but the traditional rules for Tajwīd during Qur'ānic recitation are different from those of Arabic. Tajwīd closely prescribes the manners and the places of articulation used in Qur'ānic recitation in ways that significantly contrast with the speech patterns used in everyday Arabic speech. The phonetic and phonological features added by Tajwīd to the Qur'ān make Qur'ānic sounds distinctive in their construction. The seven QPSs under investigation in this research, /tˤ/, /dˤ/, /sˤ/, /ðˤ/,/χˤ/, /qˤ/, and /ʁˤ/, all consist of a single primary articulation and are followed by the Qur'ānic pharyngealised vowel sound /a:/. This kind of Qur'ānic coarticulation with the long Arabic vowel /a:/ produces a unique sound that is found only in Qur'ānic recitation and is called Qur'ānic pharyngealisation. It has also been mentioned in this chapter that the Qur'ānic long /a:/ sound is not regarded by many scholars as a separate pharyngealised sound that follows the preceding sound. Habis (1998:121) states that "they [scholars] do not specify vowels for either emphasis or plainness, on the assumption that vowels acquire either feature from the preceding consonant."

This section examines the anatomy and physiology of these seven pharyngealised Qur'ānic sounds. This section depends largely on the works of other scholars who have described the organs responsible for producing the pharyngealised sounds. It begins by giving the classical and the contemporary articulatory definition of every sound and then describes the physiological and anatomical properties of each sound. The study of these sounds shows that their secondary articulation is no less important than the primary articulation and may even be more important. It is noticeable that what distinguish these Qur'ānic sounds from other sounds is their pharyngealised nature as well as the articulatory pattern of the organs of speech involved in their production. The production of the consonants and vowels in these pharyngealised syllables is only achieved by the correct constriction by one or more of the speech organs. Stevens (2000) explains, "the production of a consonant is usually achieved by forming a narrow constriction in the oral portion of the vocal tract. This constriction is made with one of three different articulators: the lips, the tongue blade, or the tongue body. The narrowing can result in complete closure of the airway or just a partial closure." Hence it is necessary to examine the physiology of the pharynx, the tongue, and the mouth as the places where the primary and the secondary articulations and pharyngealisation occur.

3.4.1. The Pharynx

The pharynx is an area in the human throat that links the nasal cavity, the oral cavity, and the laryngeal cavity. It is used as a passage for food to the stomach and air to and from the respiratory system. It has the shape of a cone. The pharynx is encased in two layers of muscle, referred to as the inner and the outer layers. Physiologically, the human pharynx consists of three parts.

- The nasopharynx is located behind the nasal cavity. It functions with the respiratory system more than the digestive system. Zawaydeh (1999:19) explains, “The nasopharynx is the only part of the pharynx which is open permanently. During deglutition, this part of the pharynx may be shut off from the rest of the pharynx by the uvula and the soft palate.”
- The oropharynx is the part behind the oral cavity starting from the end of the soft palate and ending at the edge of the hyoid bone (Kaplan 1960:201).
- The laryngopharynx is the lower part of the pharynx extending from the end of the oropharynx to the oesophagus. It is bounded by the epiglottis at the top and by the oesophagus at the bottom (Seikel et al. 1997:302).

The outer muscles are responsible for reducing the diameter of the pharyngeal space. These muscles as shown in Seikel et al. (1997:346) are:

- The superior pharyngeal constrictor, whose upper end fibres are attached to the sphenoid bone and the lower end is attached to the mandible. The superior constrictor muscles are mostly found at the sides and in the posterior wall of the nasopharynx as well as in parts of the posterior side of the oropharynx. Its functions require several points of attachment. Seikel et al. (1997:328) state that contraction of this muscle pulls the walls of the pharyngeal forward, constricting its diameter. This function is fundamental during swallowing and producing pharyngeal and pharyngealised sounds. It is observed that the superior constrictor is an important oropharyngeal muscles in the production of the QPSs.

Obtaining empirical confirmation of the functions of these muscles in speech would be extremely difficult as currently there are no techniques available that allow close monitoring of muscle activity in this part of the oral cavity during speech. What is shown in Figure 3.1. of Seikel et al. (1997) are the pharyngeal constrictor muscles which may have a role in pharyngeal constriction during the production of pharyngeal and pharyngealised speech sounds.

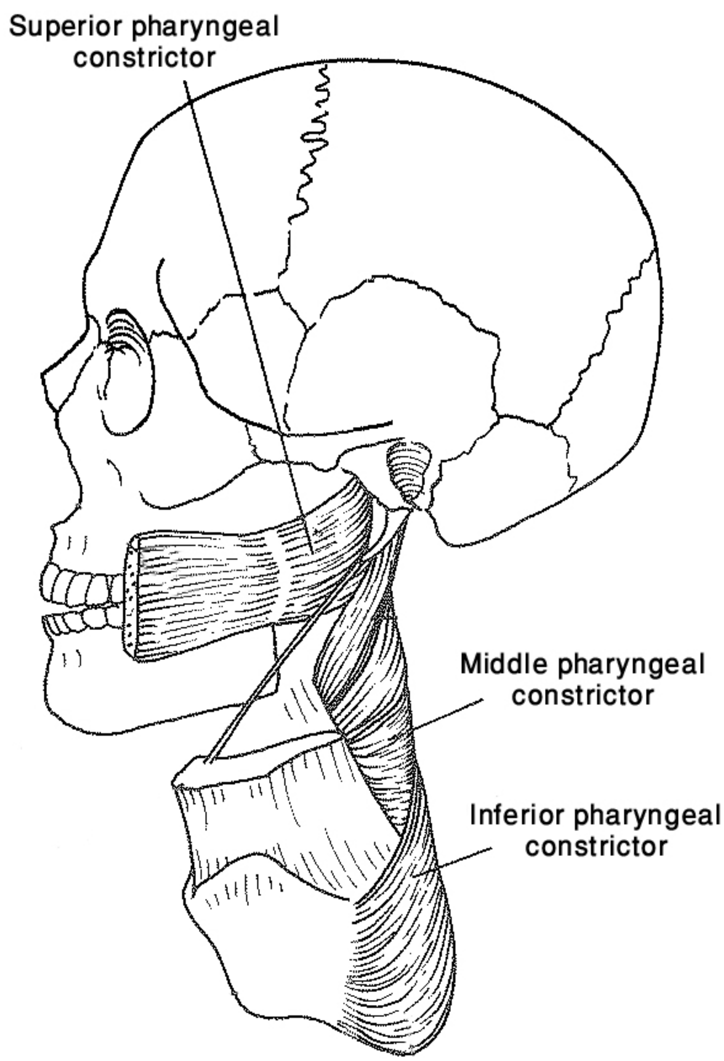

Figure 3.1. Schematic illustration of the pharyngeal constrictors' configurations that are essential in producing Qur'ānic pharyngealisation. (This schematic is amended and highlighted from Seikel et al. (1997).

- The middle pharyngeal constrictor, which is located below the stylopharyngeus muscle. It also constricts and narrows the diameter of the pharynx. Seikel et al. (1997:328) explain: "The middle constrictor courses up and back, inserting into the median pharyngeal raphe." This constrictor couples with the superior constrictor in the production of the QPS /a:/.
- The inferior pharyngeal constrictor, which underlies the mucous membrane at the back of the pharynx. It is also called the cricopharyngeal muscle as it arises from the sides of the cricoid cartilage. It can be said that this muscle is the main structural element of the back wall of the pharynx. Constriction of this muscle is used to narrow the diameter of the lower pharynx.

The inner fibres of the pharyngeal muscles may work to reinforce the outer muscles to give more precise constriction when it is needed. The following description and illustration of the inner muscles is taken from Seikel et al. (1997:318). The inner muscles responsible for the production of the QPSs as shown in Figure 3.2.are:

- The styloglossus muscle, which is the internal muscle that originates at the temporal bone. At its lower end it divides into two portions, interweaving with the longitudinal muscles of the tongue and the hyoglossus muscles. Seikel et al. (1997:318) observe that the "contraction of the paired styloglossi will draw the tongue back and up." Obviously, this is what occurs during the production of the QPS.
- The hyoglossus muscle, which generates from the lateral body of the hyoid bone, is also fundamental in the production of the QPS. The hyoglossus muscle pulls the lateral sides of the tongue backward and up, producing the required degree of pharyngealisation.
- The stylopharyngeus muscle, which is generated from the styloid process of the temporal bone. This muscle "appears on the lateral wall of the pharynx as a flattened cylinder." (Kaplan 1960:205). It goes deeply between the superior and the middle constrictors. The main function of this muscle is to elevate and open the pharynx (Seikel et al. 1997:318).
- The palatoglossus muscle, known classically as the depressor of the soft palate. Kaplan (1960) and Seikel et al. (1997) confirm that this muscle elevates the posterior section of the tongue, narrows the pharyngeal cavity, and lowers the soft palate. This process is exactly what is needed in the production of the Qur'ānic uvularised sounds /χˤ/, /qˤ/, and /ʁˤ/.

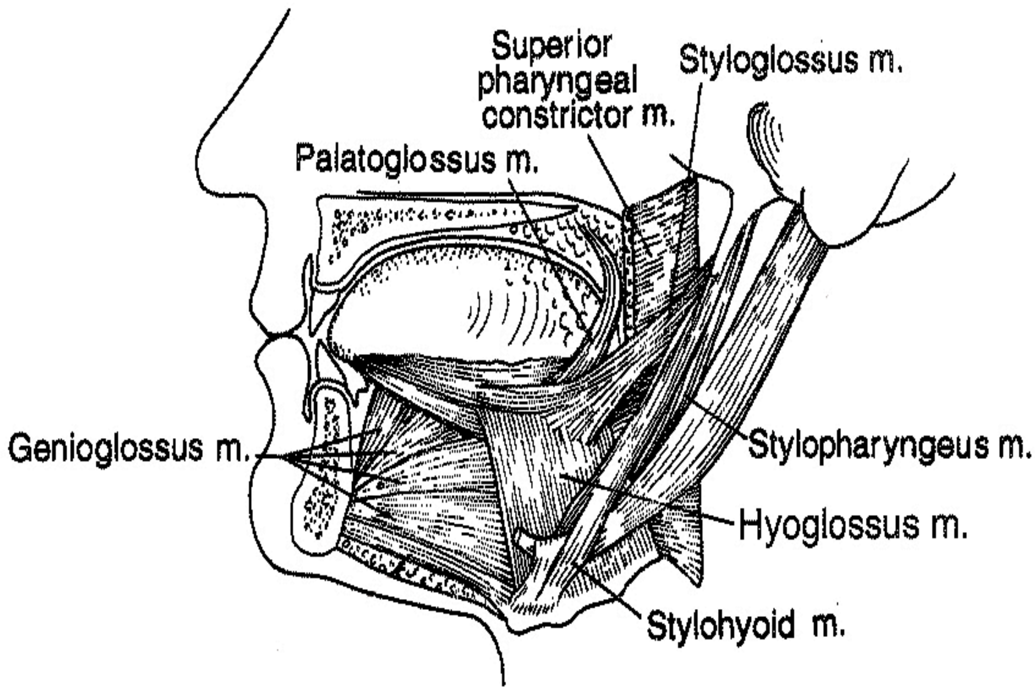

Figure 3.2. Schematic illustration of the extrinsic muscles of the tongue as well as some pharyngeal muscles. The pharyngeal muscles in this diagram are the Superior Pharyngeal Constrictor and the Stylopharyngeus. The Superior Pharyngeal Constrictor is involved in the constriction of the pharynx and may be involved in the production of pharyngeal and pharyngealised speech sounds. Constriction of the stylopharyngeus muscle is usually described as contributing to greater stiffness of the pharynx back wall. This schematic is from Seikel et al. (1997).

3.4.2. The Tongue

During the articulation of the QPSs, the tongue is one of the most important active articulators. Physiologically, the human tongue is a massive collection of tissues and muscles that occupy most of the cavity of the mouth. Hardcastle (1976:90) states that "the tongue is shaped a little like an inverted shoemaker's iron with the inferior part attached to the hyoid bone. The substance of the muscles is mainly muscle with a mucous membrane covering (called epithelium), a lamina propria of connective tissues, glands and lymph nodules." The tongue has three main areas for the functions of speech and for moving food in the mouth. These areas are the tip of the tongue which is followed by the blade of the tongue and the body of the tongue which Seikel et al. (1997:312) call "the oral or the palatine surface". Hardcastle (1976:91) also describes the tongue as being mainly divided into an oral part and a pharyngeal part. Then there is the third part of the tongue, which lies at the pharyngeal surface of the tongue, which Hardcastle (1976:91) calls "the dorsum or the upper surface of the tongue." It can be said that the tongue dorsum includes both the palatine and the pharyngeal surface of the tongue.

It is important for this study to show which part of the human tongue articulates the Qur'ānic pharyngealisation. The Qur'ānic /tˤ/, /dˤ/, /sˤ/, and /ðˤ/ sounds have the primary articulation in the front or the oral part of the tongue. Hardcastle (1976:92) cites Pike (1943:120) when he describes this front area of the tongue as having "convenient arbitrary points of reference", by which he means "the tip or apex, the blade, and the middle" of the tongue. Ladefoged (1971:37) is not happy with these divisions of the tongue, believing that there are no such discrete sections and no strong evidence of them. He does, however, prefer to retain the "apicality" (p. 38) articulatory division of the tongue.

The Qur'ānic uvularised sounds, /χˤ/, /qˤ/, and /ʁˤ/, are articulated in the uvular area at the back of the palatine/oral surface of the tongue when the body of the tongue goes upward to articulate against the soft palate and the uvula in total occlusion, as in the Qur'ānic sound /qˤ/, or in a constriction, as in the Qur'ānic uvularised sounds /χˤ/, and /ʁˤ/.

The tongue includes the muscles that move the tongue forward, backward, and to the lateral sides. These moving muscles constitute the fundamental structure of the tongue. Physiologists divide them into two parts: the extrinsic muscles and the intrinsic muscles. Hardcastle (1976:92) says: "The extrinsic muscles have their attachment outside the tongue on the hyoid bone, the mandible, and styloid process of the skull, and are capable of altering both the form of the organ and its position in the mouth." He continues, "the intrinsic muscles on the other hand, are located entirely within the tongue and so are capable, for the most part, of altering the configuration of the tongue only." During the production of the QPS, they help in directing the tongue to the correct position in the mouth. The intrinsic muscles of the tongue provide a fine control of the shape of the tongue when producing a given sound. These muscles as shown in Seikel et al (1997:314) are:

- The superior longitudinal muscle of tongue, which is located along the length of the tongue. It is located in the upper layer of the tongue and moves and controls the upper part of the tongue forward and backward. If one lateral side of these muscles contracts without the other then only one side of the tongue will be elevated. This muscle is very important in shaping the exact pronunciation of the QPS /tˤ/, /dˤ/, /sˤ/, and /ðˤ/ sounds, especially in their primary articulation. Hardcastle (1976:93) states: "The longtitudinalis superior is the most superficial muscle of the tongue, lying directly beneath the lamina propria of the dorsum and extending from the root of the tongue to the lip." He also states that the main function of this muscle is to shorten the tongue when contracted or make it wider. It is capable of moving extremely quickly. In terms of working together with other muscles, Hardcastle (1976:93) says that"the longtitudinalis superior acts in conjunction with the other intrinsic and extrinsic muscles in altering the shape of the tongue for certain articulations."
- The inferior longitudinal muscle of the tongue, which occupies the lower parts of the tongue. Hardcastle (1976:95) defines it as "a paired narrow muscle oval in transverse

cross-section extending longitudinally throughout the length of the tongue in a lateral ventral part.” It shortens the tongue intrinsically. This muscle pulls the tip of the tongue down. Hardcastle (1976:95) further states, “the general function of this muscle is probably to pull down and retract the tip. In doing this, it can act in synergism with the anterior fibres of the genioglossus and hyoglossus with the hyoid fixed by the infrahyoid muscles. This activity is important for the release of stop consonants articulated in the anterior part of the mouth such as [t].” The Qur’ānic coronal sounds /tˤ/, /dˤ/, /sˤ/, and /ðˤ/ need this muscle in their primary articulation.

- The transverse muscles of the tongue constitute a great part of the bulk of the tongue. The physiology of these muscles shows that they are composed of horizontal layers of fibres that go laterally towards the edges of the tongue. They are responsible for controlling the lateral sides of the tongue. These muscles effectively pull up the edges of the tongue towards the midline. Hardcastle (1976:96) states that “upon contraction, the transverses fibres, particularly the more superficial fibres, draw the edges of the tongue upwards, and by compressing the width of the tongue, may help to elongate it longitudinally.” These muscles clearly function during the pronunciation of the QPS /sˤ/, and /ðˤ/ as the tongue should be grooved in its front part when articulating the Qur’ānic fricatives /sˤ/, and /ðˤ/. Hardcastle (1976:96) continues, “together with the posterior part of the genioglossus, it [transversus muscle] may help to push forward the tongue for frontal articulation such as the alveolar stops and fricatives, when proceeded, for instance, by a low back vowel.”
- The vertical muscles of the tongue, which are responsible for flattening the tongue. These muscles take the lateral edges of the tongue to the edges of the lateral molar teeth. They are important for pronunciation of the QPS /tˤ/ and /dˤ/ sounds, which need the tongue to be flattened to the lateral edges of the molar teeth. When these muscles intervene and interact with the tongue’s extrinsic muscle, the styloglossus, they elevate the bulk of the tongue upward and flatten it to maintain the optimal configuration of the Qur’ānic alveolar stops /tˤ/ and /dˤ/.

The Qur’ānic pharyngeal vowel sound /a:/ that is attached to the QPSs is produced when the hyoglossus muscles interact and intervene with the styloglossus muscles. In this configuration, the tongue will be flattened and pulled back to produce this pharyngeal low back vowel and give it a convex shape. This convex configuration is clear in the images from the VFG experiment in this research. Hardcastle (1976:100) maintains that “it [hyoglossus] may also work in conjunction with the styloglossus in positioning the tongue body for the production of back vowels.” The “horizontal backward movement” (Hardcastle 1976:103) of the tongue, which is very important to this study, occurs when the styloglossus muscles intervene and collaborate with the middle pharyngeal constrictor. This kind of backward movement is responsible for the production of the low back unrounded vowel /ɒ/ which is dealt with as /a:/ in this research.

In summary, Hardcastle (1976:100) mentions seven important articulatory parameters that characterise the configuration of the human tongue during speech. They are:

1. Horizontal forwards-backwards movement of the tongue body.
2. Vertical upwards-downwards movement of the tongue body.
3. Horizontal upwards-downwards movement of the tip blade.
4. Vertical upwards-downwards movement of the tip blade.
5. Transverse cross-sectional configuration of the tongue body: convex-concave, in relation to the palate.
6. Transverse cross-sectional configuration extending throughout the whole length of the tongue, particularly the tip and blade – degree of the central grooving.
7. Surface plan of the tongue dorsum – spread, tapered.

This summary is based on several speech physiology references (Kaplan 1960, Hardcastle 1976, Laver 1980, Seikel et al. 1997) all of which agree on the muscles, locations, and constrictions that are responsible for pharyngealisation.

3.4.3 The Lips

In the production of the QPS, the muscles of the lips help effect the shape of the sound. The risorius and the zyogmatic (major and minor) muscles mentioned in Kaplan (1960), and Seikel et al. (1997) play a very important role in controlling the lateral sides of the lips. When contracted, these muscles can help to widen the opening of the lips to change vowel quality. Lip protrusion plays an important role in providing more perceived pharyngealisation to the QPS. The muscles of the lips (the orbicularis oris superioris and inferioris) protrude during the pronunciation of the /a:/ vowel sound to strengthen the perception of pharyngealisation in Tajwīd. Lip protrusion or rounding has been shown to help produce the right degree of perceived emphasis or pharyngealisation. El-Halees (1985) and Lehn (1963) consider that Arabic emphasis (pharyngealisation) is associated with a noticeable degree of lip protrusion. In QPS the degree of lip protrusion varies according to the different sounds. Habis (1998:138) points out that "impressionistically, the lips are spread for /tˤ/ and /dˤ/ and closed rounded for /ð/" This was also observed by Jakobson (1957), who confirmed that there is "a tendency ... to emit pharyngealised phonemes with lip protrusion and slight rounding". Watson (1999) goes further in declaring that "it is known that pharyngealized consonants are often articulated with a degree of lip protrusion." Hence, the lips with all their muscles are crucially important in adding the perception of an enhanced degree of pharyngealisation as required by the conventions of Tajwīd. This final role of the lip protrusion in accurately shaping the QPS is best described by Watson (2002:270), who states that the constriction of the pharynx during the production of the Arabic pharyngealised sounds can be supported and enhanced by the enlargement of the lips through protrusion.

Lip protrusion plays an important role in the perception of a person listening to the QPS. This impressionistic role is clear in an experiment by Ouni and Ouni (2007) who investigated lip-reading recognition of Arabic sounds. They found that lip protrusion plays an important role in the informant's recognition of the pharyngealised phonemes. They (2007:4) also found that "the difference in the degree of the mouth opening between /ɑ/ and /æ/ helps to guide perceivers to distinguish between pharyngealised sounds and their non-pharyngealised equivalents and between pharyngeals and their closest non-pharyngeal phonemes, from an articulatory point of view."

This section has investigated the physiology of the pharynx, the lips, and the tongue as well as the canonical role played by the muscles responsible for the pronunciation of the QPS. The phonetic and phonological properties of these QPSs are now discussed further. Classical and modern phonetic views of the manner and place of articulation of these sounds are investigated.

3.5. Articulatory configuration of QPSs

3.5.1. Qurʾānic Pharyngealised ص /Sˤ/ Sound

This Qur'ānic sound was classically characterised by scholars of Tajwīd as *Mahm*ūs "breathed", *MuTbaq* "semi-closed", *Mufaxxam* "pharyngealised", *Safīri* "fricative" and *Asali* "produced from the tip of the tongue". This sound is totally different from the other Arabic /s/ sound as in the word /seil/ This phonemic contrast can be clearly seen in the minimal pair صيف /Seif/ "summer" and سيف /seif/ "sword" . They are not two allophones of the same sound in Arabic, as the /s/ corresponds to the twelveth Arabic letter while /S/ corresponds to the fourteenth letter in the Arabic consonant inventory. The abovementioned characteristics of the /S/ sound are the same in the classical, the Qur'ānic /sˁ/, and the modern Arabic languages. Zemanek (1996:12) describes the characteristics of this sound when he writes that "in Arabic, from the first attestations by the Arabic grammarians (Sibawaih, ˇHalīl – cf. Roman 1977, etc.) this sibilant is put among the emphatic sounds, i.e. pharyngealized (the so-called *mu˙tbaqa*) series. It is one of the phonemes that appear as pharyngealized in all the Arabic dialects in the role of 'emphatisant'." Arguably, this might be true in most Arabic dialects. In the Qur'ān, this is certainly true as the /sˁ/ sound occurs only as pharyngealised, with different degrees of pharyngealisation depending on its adjacent sounds.

The Qur'ānic /sˁ/ sound is alveolar in its primary articulation. Some modern dialects of Arabic, as well as some other Semitic languages (Ethiopian and Hebrew), produce the sound in an affricated way which makes it difficult to pharyngealise (Zemanek 2006). Classical treatises of Arabic (Sibawayh, al-Khalil, and Ibn Jinni) have all confirmed the alveolar ridge as the primary place of articulation of the Qur'ānic /sˁ/ sound. The recent study of Laufer (2009) on the Arabic and Hebrew pharyngeals and pharyngealisation confirms this.

The primary articulation of this sound is in the dental-alveolar area, where the tip of the tongue articulates against the dental-alveolar area with fricative stricture. The secondary articulation takes place in the pharynx, where the root of the tongue is pulled backward to facilitate the simultaneous articulation of this sound.

The acoustic correlates of the QPSs are very important for demonstrating their true articulatory properties. If there are some disputes around the articulation of these sounds, it is not the case with their acoustic correlates. Contemporary researchers, such as al-Ani (1970) and Ghazeli (1977), have presented their findings on the acoustic correlates of Arabic emphatic and uvular sounds. Habis (1998:144) compares the findings of both acoustic studies, showing that the similarities attest that there is no noticeable difference between the acoustic correlates of both studies.

3.5.2 Qur'ānic Pharyngealised /dˤ/ض Sound

This Qur'ānic sound is one of the most difficult sounds of Arabic. The correct pronunciation of the classical Arabic Arabic /dˤ/ sound is a somewhat hard for the non-Arabic speakers . All the Arab scholars have repeated the statement made by Sibawaih that this is the most difficult sound in Arabic to be pronounced." Hence, some Arabs sometimes call their language the language of /dˤ/ sound. Historically, scholars of Tajwīd have described this sound as *Rakhw* "continuant", *MuTbaq* "semi-closed", *Mufaxxam*[51]"pharyngealised", *Majhūr* "unbreathed", *MuSmat* "essential and pronounced in a heavy way", and *Musta'li* "produced with the back of the tongue raised". This sound has its own unique articulatory configuration that resembles none of the other Qur'ānic or Arabic sounds.

Contemporary articulatory studies (Cohen 1970:161, Card 1983:11) have stressed the pattern of lateral contact of the classical Arabic and Qur'ānic /dˤ/ sound. To produce this sound perfectly is very difficult for many Arabs and non Arabs, for two main reasons. First, perfect pronunciation of this Qur'ānic sound can be obtained by stretching the lateral sides of the tongue to the edges of the molars and raising the back of the tongue to produce the right *ITbāq* and Isti'lā', which are essential for producing the right amount of pharyngealisation. The sides as well as the front part of the tongue are not completely closed while articulating the sound, in contrast to articulating the Arabic /D/ sound. There is an audible amount of friction that produces some air which passes out during articulation of the sound. Perfect production of this sound does not depend on the articulation of one side of the tongue or even both sides with the molars, but depends on pressing all sides and the front of the tongue on the front teeth and the molars. There is a difference in the distribution of pressure among the lateral and the front edges of the tongue. Perfect pronunciation of the Qur'ānic /dˤ/ sound occurs when greater pressure is put on the lateral edges of the tongue and the molars. If more pressure is put on the front teeth and the tip of the tongue, the resulting sound will be a pharyngealised /d/ sound, which is not found in the Qur'ānic sounds.

---

[51] Writing Mufaxxam with double xx for the Arabic /x/ or kh sound appeared in many recent studies. We use the same transliteration here for simplicity.

Second, this Qur'ānic sound is the only sound that has the *IstiTālah,* which means extending out the tongue backward and forward simultaneously. That means the tongue root should be retracted for the sound to be pharyngealised and at the same time the blade and the tip of the tongue must stretch out to reach the front teeth. The Qur'ānic /dˤ/ sound then is produced. Physiologically, the superior longitudinal muscles retract the tongue tip backward and forward to the teeth and simultaneously the vertical muscles of the tongue flatten and stretch out the tongue muscles laterally to reach the molars.

In fact, very few native speakers of Arabic can stretch both sides of the tongue to both edges of the molars as it is difficult and requires a pause while producing the sound. Absence of Classical Arabic use in many contemporary Arabic dialects accounts for this difficulty. The sound is a part of standard Classical Arabic, which is rarely used today. It is difficult for many Arabic native speakers to produce the classical Arabic /dˤ/ sound nowadays because few people seem to be able to learn how to produce it when they are adults. Consequently this sound in Arabic is one of the most historically changed sounds, having been substituted by other sounds. Dialectally, /dˤ/ sound has been changed in modern Arabic dialects into emphatic /d/ or /z/ (Card 1983:11).

In Qur'ānic recitation, the nearest sound to the Qur'ānic /dˤ/ sound is the Qur'ānic /ðˤ/ sound. Hence, most of the recruited professional and non-professional reciters analysed in this study substituted the Qur'ānic /dˤ/ sound with the Qur'ānic /ðˤ/ sound, though they are not allophones and the substitution entirely changes the meaning. An example of this is in the Qur'ān (75:22), where the word ناضرة /nādˤirah/ means "resplendent faces" whereas ناظرة /nāðˤirah/ means "looking". The Qur'ānic /dˤ/ sound is dental while the Qur'ānic /ðˤ/ sound is interdental. This change in articulation also changes the degree of pharyngealisation. Though the sounds /dˤ/ and /ðˤ/ may look identical to the non-Arabic speaker, they behave differently with two different places of articulations.

A critical question is whether there is anyone who still can produce the exact form of the classical or the Qur'ānic /dˤ/ sound. The answer is yes. Many professional and super-standard reciters around the Islamic world still maintain the correct pronunciation of the Arabic /dˤ/ sound. Reciters of the Qur'ān must make sure that they are pronouncing the right sound in the right place.

3.5.3 Qur'ānic Pharyngealised /tˤ/ Sound

This Qur’ānic sound is the strongest in terms of pharyngealisation. It has been classically described as *Majhūr* “unbreathed and loud”, *Shadeed* “strong”, *MuSmat* “essential and pronounced in a heavy way”, *Musta’li* “produced with the back of the tongue raised”, *MuTbaq* “semi-closed”, and *Mufaxxam* “pharyngealised”. Unlike many contemporary studies, most of the classical treatises of Tajwīd have described this sound as *Majhūr* “unbreathed and loud”. Recent investigation of the Arabic and Qur’ānic /tˤ/ sound found that the sound in the Qur’ān and in Arabic is a voiceless one. In fact, this issue is subject to continuing debate between scholars of Tajwīd and other researchers of Arabic sounds. It appears that there is a possibility that the scholars of Tajwīd erred when they described the /tˤ/ sound as voiced, especially without phonetic instruments to investigate the sound except observation. Another possibility is that the /tˤ/ sound was voiced when they first described it and changed into a voiceless sound at a later date. A third possibility is that the Arabic classical description was for an allophone of the /T/ sound which no longer exists. It is possible to conclude that the description by the classical scholars of Tajwīd of the /tˤ/ sound as *Majhūr* “unbreathed and loud” is correct. However, the contemporary Arabic /T/ sound has not retained its characteristics and has been changed into a voiceless one (Al-Hamad 2003:212). This understanding of the classical and the contemporary identity of the Arabic /T/ was examined by Cantineau (1960:21-22), who believed that the three Arabic sounds /d/, /t/, and /T/ exist in the form of a triangular pattern which are related to each other in their place of articulation and which also were changed by later different dialects of Arabic. This means that classically these sounds were not used interchangeably, as they are nowadays in some Arabic dialects. He also believed that Arabic /T/ was originally voiced then changed in some Arabic dialects into a voiceless sound.

Accurate description and analysis of the Qur’ānic sounds needs two pillars to stand on. First, it needs accurate acoustic and experimental analysis of the place and the manner of articulation of those sounds, and second, it needs the authentic classical descriptions of them, as many Arabic sounds have been subject to many dialectal changes. This is exactly the methodology of this research in explaining the identity of the QPSs.

3.5.4 Qur’ānic Pharyngealised ظ /ðˤ/Sound

This Qur'ānic sound is subject to much misunderstanding, as many Arabic speakers confuse it with the Arabic /dˤ/ sound. The Qur'ānic /ðˤ/ sound has been classically characterised as *Majhūr* "unbreathed and loud" ,*Raxw* "continuant", *MuTbaq* "semi-closed", *Mufaxxam* "pharyngealised", *MuSmat* "essential and pronounced in a heavy way", and *Musta'li* "produced with the back of the tongue raised". In fact, it resembles the Qur'ānic sound /dˤ/, but with a difference between them. The difference lies in the place of articulation. Qur'ānic /dˤ/ sound is an alveolar voiced stop sound while the Qur'ānic /ðˤ/ sound is an interdental voiced fricative sound.

Contemporary researchers (Alkhairy 2005:42, Bin Muqbil 2006:31) have stressed that this sound is a fricative interdental voiced sound. This Arabic sound has been modified into /z/ or /dˤ/ sounds. This modification is not accepted in Qur'ānic recitation as it leads to a change in meaning, as explained in the description of the Qur'ānic sound /dˤ/.

3.5.5 Qur'ānic Pharyngealised **غ** */ʁˤ/ Sound*

This Arabic sound has been classified classically as *Majhūr* "unbreathed and loud", *Raxw* "continuant", *Mufaxxam* "pharyngealised", *Munfatiħ* "produced with the mouth and the tongue open", and *Musta'li* "produced with the back of the tongue raised". In Tajwīd, this voice is not *MuSmat* as it is not pronounced in a heavy way like the Qur'ānic /tˤ/ and /dˤ/ sounds. In fact there is little debate in classical treatises around the identity of this sound, as most such treatises did not pay much attention to exactly which part of the throat produces the Qur'ānic /ʁˤ/ sound.

Recent phonetic studies have shown that this sound is a fricative, voiced and uvular. There is some dialectal variation in producing this sound in most Arabic states (Watson 2002:17). The exact nature of this sound has been a question of debate for many phoneticians. The question is: are the Qur'ānic sounds /ʁˤ/, /χˤ/, and /qˤ/ pharyngeals or uvulars? In fact, many contemporary researchers (Zawaydeh 1999, Shahin 2002) have rejected the traditional assumption that these sounds are pharyngeals. Habis (1998:57) maintains that "the traditional claim that /χ and /ʁ/ are pharyngeal is confusing because their primary articulation involves the back of the tongue and the uvula, as stated, for example, by Ladefoged (1982)." The description becomes more difficult in the case of the Qur'ānic pharyngealised /ʁˤ/, /χˤ/, and /qˤ/ sounds, as the first and the second articulations are very close to each other. The primary articulation of the Qur'ānic pharyngealised /ʁˤ/ sound is where the uvula articulates against the back of the tongue. The secondary articulation is where the adjacent vowel sound /a:/ is pronounced from the pharyngeal area. What has misled many people when discussing the identity of this sound is the fact that the primary and secondary articulations are simultaneously articulated in very near areas. Also often forgotten is the fact that that the fundamental unit of articulatory planning is the syllable, and not the phoneme. So even when the uvular part of the syllable's articulation dominates the gesture, the following part of the gesture is already planned and may already be subtly being prepared for.

3.5.6. Qur' ānic Pharyngealised خ */χˤ/Sound*

Classically, Arabic scholars of Tajwīd have impressionistically described the Arabic /χˤ/ خ sound as *Mahm*ūs "breathed", *Raxw* "continuant", *Munfatiħ* "produced with the mouth and the tongue open", *Musta'li* "produced with the back of the tongue raised", and *MuSmat* "essential and pronounced in a heavy way".

Current articulatory studies (Ghazli 1977, Bin Muqbil 2006, to name a few) have indicated that the Arabic /xˤ/ خ sound is a fricative voiceless uvular sound. The Qur'ānic pharyngealised /χˤ/ خ sound is different from the classical and from the dialectal Arabic in that the Qur'ānic /χˤ/ خ sound is followed by the Qur'ānic pharyngealised vowel /a:/ sound which forms part of the syllable's articulatory plan in Tajwīd. Consequently, some Arabic speakers find some difficulty in pronouncing the correct form of this Qur'ānic sound.

3.5.7 Qur' ānic Pharyngealised /qˤ/ Sound

This QPS has been described in the classical literature by scholars of Tajwīd as *Majhūr* "unbreathed and loud", *Musta'li* "produced with the back of the tongue raised", *Shadīd* "strong", *Munfatiħ* "produced with the mouth and the tongue open" and *MuSmat* "essential and pronounced in a heavy way". The classical description of the /q/ sound as voiced has raised many questions among contemporary scholars of Arabic sounds. Most of the contemporary scholars of Tajwīd and Classical Arabic believe that /q/ is a voiceless sound. Sibawayh and Ibn Jinn classified this sound as *Majhūr* (unbreathed). The question is whether the contemporary Qur'ānic /qˤ/ still sounds the same as the ancient one. The answer is definitely yes, as this sound has been authentically reported by thousands of contemporary reciters who are licensed with *Ijāzah*[52] through a chain of reciters to the prophet (PBUH). If the sound is still pronounced in the

[52] Ijazah is a certificate used primarily by Muslims to indicate that one has been authorised by a higher authority to transmit a certain subject or text of Islamic knowledge. This usually implies that the student has learned this

same way as at the time of revelation then how can ancient scholars of Arabic and Tajwīd make it voiced? Al-Hamad (2003:212) discusses in great detail the problem of classifying the Qur'ānic /qˁ/ sound, including information which the current research does not need (because it is not concerned with the historical and the dialectal changes of this sound). He admits, however, that the contemporary Qur'ānic /qˁ/ sound is still the same as the classical one, and as the contemporary scholars of Arabic and Tajwīd say it is voiceless we have no choice except to believe that Sibawayh and the classical scholars were mistaken in their classification. Al-Hamad continues that this theory cannot be confirmed; all that we can say is that our methods of investigation of the properties of this sound cannot determine why it was classically described as voiced. If we accept that *Majhūr* means "unbreathed" and that this means that airflow is not from the lungs but is produced above the lungs and that *Mahmūs* means that airflow is from the lungs (but not voiced) then we can say that Sibawayh and Ibn Jinn were correct. It is therefore not necessary to assume that the choice is between voiced airflow and unvoiced airflow but that the choice is between air from the lungs and air from above the lungs.

The pharyngealisation of Arabic and the Qur'ānic sounds in general is still an unclear process and many contemporary phoneticians do not know exactly how it occurs. The only way to understand Qur'ānic pharyngealisation perfectly is to consider its multiple basic units of articulatory planning. In other words, it is necessary to understand the primary and secondary articulations of the Qur'ānic consonant sounds. Another question concerns the articulation of the Qur'ānic pharyngeal vowel sound that is attached to the consonant. More importantly, one should understand the coarticulatory effect of the consonant sound on the following vowel sound. This difficulty in understanding Arabic and Qur'ānic pharyngealisation is expressed by Habis (1998:124), who declares that "modern phoneticians in spite of the availability of the advanced tools for the study of speech production, are still uncertain about the questions of how the vocal organs operate together to produce emphatics."

The pharyngealisation of the Arabic and the Qur'ānic /qˁ/ sound has also posed questions for some contemporary phoneticians. Laufer and Baer (1988) ponder how the Arabic uvularised sound /q/ sound can have a primary and a secondary articulation at the same time and the same place. In fact, what occurs during the production of the Qur'ānic pharyngealised /qˁ/ sound is

knowledge through face-to-face interactions "at the feet" of the teacher. (Wikipedia http://en.wikipedia.org/wiki/Ijazah) what Ladefoged (1993:271) calls “anticipatory coarticulation”. The tongue during the production of this Qur’ānic sound goes back and the root of the tongue goes up to make the needed occlusion and the upper pharynx is constricted too.

What makes this Qur’ānic sound difficult to describe and analyse is the fact that it is simultaneously uvular and pharyngealised. The relationship between the Qur’ānic /qˤ/ sound and other QPSs is only in the adjacent pharyngealised vowel /a:/ attached to it, which represents the secondary articulation of Qur’ānic /qˤ/ sound. Ghazeli (1977:147) explains, “in fact, [q] has very little in common with pharyngealized consonants. It is uvular, while [t], [s] and [ð] are dental-alveolar and interdental with a secondary tongue retraction.”

In the case of the Qur’ānic /qˤ/ sound, impressionistically one can find that the “anticipatory work” takes the tongue root, which is the secondary articulation of the Qur’ānic /qˤ/ sound, to its position before the production of the primary articulation, which is the tongue dorsum. Thus, the tongue root is retracted first, and then the tongue dorsum is drawn up to close with the uvula.

CHAPTER FOUR

Acoustics Of The Qur'ānic Pharyngealised Vowel Sounds

4.1. Introduction

This chapter outlines the methodology and the results of the acoustic analysis of the Qur'ānic pharyngeal sounds (QPSs). In order to understand the phonetic identity of the Qur'ānic pharyngealised vowels, it is necessary to demonstrate a clear relationship between the articulatory configuration of the studied sound and its acoustic correlates. It is well known that there is a strong correlation between the different spectral cues of a given sound and the articulatory configuration of that sound (Fant, 1970, Stevens, 1998, Ibn Muqbil 2006). "The sound produced by the vocal tract can be described in terms of a number of parameters such as relative frequencies of formants, descriptors of the waveform of glottal excitation, amplitude and spectrum of turbulence noise, fundamental frequency changes, etc. These parameters change as the positions and states of the various articulators are manipulated." (Stevens, 1997, pp 462-463). They then point out, based on the work of Stevens (1989), that changes in acoustic values that occur with changes in articulation do not occur smoothly and that some ranges of acoustic parameters show stable smooth relationships with "acoustic parameters" (e.g. formant values) and that some changes in articulation result in abrupt acoustic changes. Stevens (1989) refers to this type of pattern, regions of stability separated by regions of sudden acoustic change, as "quantal".

Perturbation theory (Mratati, Carre and Guerin, 1988) examines the relationship ("sensitivity functions") between small changes ("perturbations") in cross sectional area of one region of the vocal tract (e.g. one of the tubes in a four tube model of the vocal tract) and the effect of this change on formant frequency and bandwidth. This theory is based on an 8 region (tube) model of the vocal tract. These regions, from figure 19 of Mratati et al. (1988, p276) are:-

1. Between the lips and teeth
2. Between the front of the tongue (below the alveolar ridge) and the teeth
3. Between the alveolar ridge and the back of the hard palate
4. Between the back of the hard palate and the top of the uvula
5. From the top of the uvula to the bottom of the C3 vertebra
6. From the bottom of the C3 vertebra to the top of the C5 vertebra

7. From the top of the C5 vertebra to the top of the laryngopharynx
8. The laryngopharynx

Given that one of the major articulatory parameters being examined in this thesis is tongue body constriction in the area of the oropharynx, especially in the region adjacent to the C2 vertebra (see chapter 5), then region 5 (from the above list) is a region of particular interest in this current study. It is of interest that this region captures the primary places of constriction for both uvular and pharyngeal consonants and the place of secondary articulation of pharyngealised consonants. These consonant articulations will also affect the articulation of the following vowel and in TajwīdTajwīd reciters are trained to produce a characteristic pharyngealisation for certain vowels, especially /a:/, in certain consonant contexts.

A decrease in cross-sectional area at the lips (the open end of the tube for a vowel) causes a decrease in the frequency of all formants whilst a decrease in cross-sectional area near the glottis (the closed end of the tube for a voiced sound[53]) causes an increase in the frequency of all formants (Stevens, 1998, pp 150-151). Constrictions in the middle of the vocal tract in a vowel can be dealt with in a multiple tube model (e.g. a 3 or 4 tube model)[54]. A constriction at such a location would be at an open end of one of the tubes[55]. Constrictions at an open end of a tube cause a decrease in formant frequencies so it can be hypothesized that a pharyngeal constriction might reduce the frequency of one or more formants. Constrictions in the lower pharynx, and especially the laryngopharynx which is near a closed end (at the glottis) would be expected to increase formant frequencies. Lip protrusion increases the length of the vocal tract and this would be expected to decrease the frequency of some formants. A tradeoff between these effects might see a reduction of some formants and an increase in other formants.

The main goal of this chapter is not only to show the acoustic correlates of the Qur'ānic pharyngealised sounds (QPSs), but also to determine the differences between the three groups of reciters. Additionally, a long term aim of this research (of which the research in this thesis is the

[53] The open area at the vocal folds during the open phase of a glottal cycle is very small compared to the width of the vocal tract tube and the opening at the mouth and so it can be ignored mathematically. That is, the vocal tract at the glottis, during voicing, can be treated as closed.
[54] Note that Stevens (1998) was referring to a 3 formant model (F1-F3), so F4 is excluded, but a similar pattern might also occur for F4.
[55] In a vowel only the tube closest to the glottis is considered to be closed at one end, the glottis, and open at the other end. All other tubes are open at both ends in a vowel.

first stage) is to characterize the best way of producing Qur'ānic pharyngealisation. The acoustics of the three different levels of skill in recitation, under investigation in this study, is expected to reveal acoustic differences among the three groups of reciters as well as to characterize the articulations of the superstandard reciters who are internationally regarded as the best exemplars of the golden standard for reciting the QPSs. It is not the main goal of this empirical investigation to compare the different styles of recitation but rather to make objective judgments about the correct oral configurations of the QPSs which will lead to a greater understanding of the relationship between the production and perception of the sounds under investigation. To this end, this chapter will examine whether these three groups of reciters can be objectively separated on the basis of the acoustics of their productions of QPSs. It is hypothesized that there are characteristic patterns of formant values that represent the continuum of good through to poor QPS articulations and specifically that this will be characterized by smaller values of F4-F3, and a pattern of larger F3-F2, as well as greater vowel prolongation *(Madd)* for the gold standard reciters compared to the non-professional reciters and that the pattern for the professional reciters will be intermediate between these two groups. Chapter 5 will examine the relationship between the acoustic and x-ray derived physiological measurements from a single reciter pilot study. That reciter, the author, is a member of the professional reciter ("PR") group. The goals of the x-ray analysis will be to supplement the present acoustic study and to generate some hypotheses on the relationship between articulation and acoustics in Qur'ānic pharyngealisation of vowels that can be examined in more detail in future research.

It is hypothesized that an acoustic comparison of the reciter groups will provide information about the differences between more and less professional Qur'ānic recitations. It also is hypothesized that a greater distance between F2 and F3 will be a distinguishing mark for the SSRs as well as for the PRs when compared to the NPRs. This hypothesis has arisen from initial observations of the recorded recitations of the SSR reciters from which it became clear that there were distinctive patterns of F3-F2 and F4-F3. Vowel duration in Qur'ānic recitation plays an important role in perfecting the recitation. Therefore it is also hypothesized that members of the more professional groups of reciters will have longer Qur'ānic pharyngealised vowel duration than is the case for less professional reciters.

4.2. Methods

4.2.1. Subjects

Three groups of male reciters participated in this acoustic investigation. They were selected to cover the range of different reciters of Qur'ān in the Islamic world. These groups were the super standard reciters (SS), the professional reciters (PR), and the non-professional reciters (NP). They are all native speakers of Arabic and can read Qur'ān.

4.2.1.1. Superstandard Reciters

The superstandard reciters group (SSR henceforth) consists of three reciters recognized by Muslims in most of the Islamic world as the preeminent practitioners of Tajwīd. The reason behind selecting these individuals for this study is that they have spent most of their life studying and teaching Qur'ān and Tajwīd. Their main concern during their life was to read Qur'ān identically to the way that the prophet Muhammad (PBUH) used to read it. They also participated significantly in the development and the constitution of the modern principles of Tajwīd through books and journal articles. Two of the SSRs (SS1 and SS2) were also selected in the study of Yeou (2003) for the purpose of investigating the lengthening of the Qur'ānic vowel sounds. SSRs are religious, pious, and truly committed to Qur'ān. Hence, their recitation is considered by many Muslims as the closest recitation to the original revealed one. For this reason, synopses of their biographies will be mentioned here. Those reciters are:

1. *Shaikh*[56]*Ali bin Abdulrahman Alhuthaifi*: was born 1946 in Saudi Arabia. He finished his early Islamic studies in Saudi and then travelled to Egypt where he acquired the degrees of Master and Doctorate in Qur'ānic recitations. When he returned to Saudi Arabia he was appointed as a lecturer in Islamic university in Madinah. He was also appointed to supervise the committee for revising and publishing Qur'ān in Madinah Saudi Arabia. Because of his qualifications and achievements, the King Fahad Complex for Printing the Qur'ān in Saudi Arabia has chosen Shaikh al-Huthaifi as the best reciter to, officially, record his Qur'ānic recitation on cassettes for the purpose of teaching and distribution. Shaikh al-Huthafi is a well-known reciter in the Islamic world, widely recognised for his

[56] In Arabic, 'Shaikh' means someone who is an Islamic scholar and who is knowledgeable in Qur'ān and in the traditions of the prophet Mohammad (PBUH).

beautiful voice when reciting Qur’ān. He also is well known for his great concern for the correct places and the manners of articulation when reciting Qur’ān. He also mastered the seven ways of reciting Qur’ān. He has been teaching Tajwīd and Qur’ānic recitation in the Islamic university of Madinah and in the Grand mosque of Madinah for more than thirty years. He is enabled to give *Ijazah*[57] in Qur’ānic recitations for his students.

2. *Shaikh Mahmōd Khalīl al-Ħusari* was born in 1917 in Egypt. He memorized Qur’ān when he was eight years old. In 1928 he started to recite Qur’ān on different occasions and in 1944 he was officially appointed as a reciter in the Cairo Broadcast Station. In 1963 he was appointed as a president of the committee for correcting and revising the published versions of the Qur’ān. Many Muslims around the world were taught by the recitations of *al-Ħusari* who has a very clear voice and an unprecedented mastery of the places and manners of articulation of Tajwīd.
3. *Shaikh Abdullah Ali Basfar* was born in 1961 in Saudi Arabia. He finished his Bachelor, Master, and Doctorate in Islamic studies in Saudi Arabia. In 1987 he acquired the *Ijazah* in teaching Qur’ān and since then he passes it on to his students. Currently he is the president of the International Organization of Memorizing Qur’ān. He has recorded the whole Qur’ān four times on cassettes.

Superstandard reciters will be called S01, S02, and S03, henceforth. It is important to mention that S01 and S02 were also selected by some other studies (Yeou 2003) for the purpose of finding the best reciters of Qur’ān.

4.2.1.2. Professional Reciters

The professional reciters (PR) are the second category of informants in this study. There are eleven professional reciters in this study. They are all from Saudi Arabia. All of them have finished their tertiary level of education. They are between twenty five and forty eight years old. They will be called PR01 to PR11 henceforth. All of the professional reciters are professionally trained in the phonetic system of the Qur’ān, and all lead the prayers at mosques. They have, at certain times in their life, taught Qur’ān and Tajwīd. Although they are professional in Qur’ānic

[57] Ijazah is a certificate used primarily by Muslims to indicate that one has been authorized by a higher authority to transmit a certain subject or text of Islamic knowledge. This usually implies that the student has learned this knowledge through face-to-face interactions "at the feet" of the teacher. (Wikipedia http://en.wikipedia.org/wiki/Ijazah)

recitation, they are not as perfect as the superstandard reciters. That is mainly because Qur'ānic recitations and Tajwīd is not the only concern in their life as they also have their normal life. Their exposure to Qur'ān and Tajwīd early in life enabled them to be professionals not only in Qur'ānic recitation but also in Tajwīd. PR03 (who is the author of this research) has also participated in the Videofluorographic experiment of this research in chapter five.

4.2.1.3. Non-professional Reciters

This group of non-professional reciters (NP) consists of twelve informants. They are all from Saudi Arabia (where the recording of this experimental study took place). Their age is between twenty five and thirty five. Though participants of this group know how to read Qur'ān, they are not considered to be good reciters of Qur'ān. Some of them have early exposure with the principles of Tajwīd yet they are not concerned with it and thus they do not read Qur'ān according to it. They are as a group less religious than the first two groups. Some of them know how to chant Qur'ān but without the application of the principles of Tajwīd. They will be called N01 to N12 henceforth.

4.2.2. Speech Materials.

The Qur'ānic speech tokens for this study are taken from certain verses from Qur'ān. The normal Arabic speech tokens are taken from a list of normal Arabic words and phrases. The linguistic context adjacent to the consonants and the vowels in this study were controlled. The same Qur'ānic and normal Arabic words were chosen in the same context. Each participant recited the Qur'ānic verses plus the additional non-Qur'ānic Arabic words and phrases. The Arabic text of these passages is in appendix I. These recordings were made in a quiet room in a mosque. The acoustics of this room was improved by hanging extra curtains and other sound absorbing materials around the room. The recordings were edited so that the syllables used in this study were available as a separate sound file for each Qur'ānic syllable and each normal non-Qur'ānic syllable. These sounds are all available in the "acoustic_analysis_sound_files" folder of the CD-ROM that is distributed with this thesis. The Qur'ānic verses were selected so that they represented appropriate patterns of Qur'ānic pharyngealisation. Long vowels were selected rather than short vowels. These vowels were selected in pharyngealised and non-pharyngealised contexts. The author has not been able to contact any of the SSR to collect the Arabic data from them as one of them has passed away and the other two were unreachable at the time of the data collection. Collecting Arabic data from the SSR would have enabled this research to better separate the effect of different recitation styles among the three groups of reciters.

In addition to the Qur'ānic Arabic verses, all PR and NP reciters were recorded speaking a short sample of normal Arabic speech and from these samples a number of syllables were extracted.

The Qur'ānic and normal Arabic syllables used in this research are shown in table 4.1.

Qur'ānic /a:/	Qur'ānic /i:/	Qur'ānic /u:/	Arabic /a:/
χˤa:			Kha
sˤa:			Sad
dˤa:	dˤi:	dˤu:	Dha
ʁˤa:	ʁˤi:	ʁˤu:	Gha
tˤa:	tˤi:	tˤu:	Ta
qˤa:	qˤi:	qˤu:	Qaf
ðˤa:			Tha

Table 4.1 The syllables utilized in this study. In this table the pharyngealisation diacritic is used, for the Qur'ānic tokens, to emphasize this study's hypothesis that the vowels in these syllables are pharyngealised. The Arabic /a:/ syllables are written in an orthographic format, here and elsewhere in the thesis, to distinguish them from the equivalent Qur'ānic /a:/ syllable.

Several things need to be mentioned about this table. Firstly, the Qur'ānic syllables, according to TajwīdTajwīd principles, are wholly pharyngealised and that means that the vowels are pharyngealised. None of these consonants have a pharyngeal primary place of articulation in normal Arabic. Four of these consonants are pharyngealised in normal Arabic (sˤ, dˤ, tˤ, and ðˤ) and so pharyngealisation of the following vowels might be expected in normal Arabic. Three of these consonants, the uvular consonants χ, ʁ and q are not pharyngealised in normal Arabic (they have a primary uvular constriction). In Qur'ānic recitation, according to TajwīdTajwīd and to the hypothesis of this study, the following vowels are, in all these cases, pharyngealised. For the other syllables the consonants are pharyngealised in both Qur’ānic recitation and normal Arabic. The reason for the different coding of the Qur’ānic and normal Arabic syllables is to emphasize the distinction between the production of the Qur’ānic and Arabic syllables. A second point to note, from table 4.1, is that only a subset of Qur’ānic /u:/ and Qur’ānic /i:/ syllables have been used. These syllables have a lesser degrees of pharyngealisation required by TajwīdTajwīd, compared to syllables containing /a:/ and are a secondary focus in this study.

4.2.3 Subjects and Speech Materials

Data for all subjects was used for the examination of the Qur’ānic syllables containing the /a:/ vowel. Data from only a subset of subjects was used for the other two Qur’ānic vowel contexts and for the /a:/ vowels in normal Arabic. This occurred because normal Arabic and /i:/ and /u:/ data was not collected in an earlier set of recording sessions and some reciters were no longer available. Further, normal Arabic recordings are not available for the SS group. Table 4.2 shows which tokens were recorded and analysed for each participant.

Group	Num	Q /a:/	Q /u:/	Q /i:/	A /a:/
SS	3	1-3	1-3	1-3	none
PR	11	1-11	6-11	6-11	6-11
NP	12	1-12	7-12	7-12	7-12

Table 4.2 There were 3 Super Standard (SS) reciters, 11 Professional Reciters and 12 Non-Professional Reciters (NP). The three SS reciters produced all Qur’ānic tokens (all three vowels) but no normal Arabic tokens. All 11 Professional Reciters (PR) produced all Qur’ānic /a:/ tokens but only PR reciters 6-11 produced all of the Qur’ānic /u:/ and /i:/ tokens and the normal Arabic tokens. All 12 Non-Professional Reciters (NP) produced all Qur’ānic /a:/ tokens but only PR reciters 7-12 produced all of the Qur’ānic /u:/ and /i:/ tokens and the normal Arabic tokens.

4.2.4 Acoustic Analyses

For every recorded token the following acoustic parameters were measured using the software MU-spectra (developed by Robert Mannell, Macquarie University). Formant measurements were made by observing both spectrogram and LPC/FFT analyses of each token. For every vowel, F1, F2, F3 and F4 were measured and these measurements were taken from the vowel target at approximately the mid-point of each vowel. From these measurements, the derived formant difference measurements, F3-F2 and F4-F3 were also calculated. Only for the Qur'ānic /a:/ vowel was the duration of the vowel measured. The details for all of these measurements, for each reciter and vowel, can be seen in appendix 2 at the end of this thesis. PDF copies of all SPSS sessions can be found on the CD-ROM accompanying this thesis.

The possibility of normalising the vowel data was considered for this analysis. This procedure minimises the effects of vocal tract differences between subjects. Larger vocal tracts have, on average, smaller vowel formant values and smaller vocal tracts show the opposite pattern. This methodology is very commonly carried out when comparing data between adults and children and between adult males and adult females. As this study's participants were all male the advantages of normalisation would be minimal, so normalisation was not carried out for this study.

4.2.5 Statistical Analyses: Univariate ANOVA

4.2.5.1 /a:/ F1 Qur'ānic

A Univariate ANOVA was carried out on Qur'ānic /a:/ F1 for factors Group (reciter group) and Sound (consonantal context). A significant effect was found for Group (F 17.855 sig 0.000). No significant effect was found for Sound. A post hoc Tukey HSD showed a significant difference for Groups SS vs NP (Sig. 0.000) and PR vs NP (Sig. 0.000), but not for SS and PR.

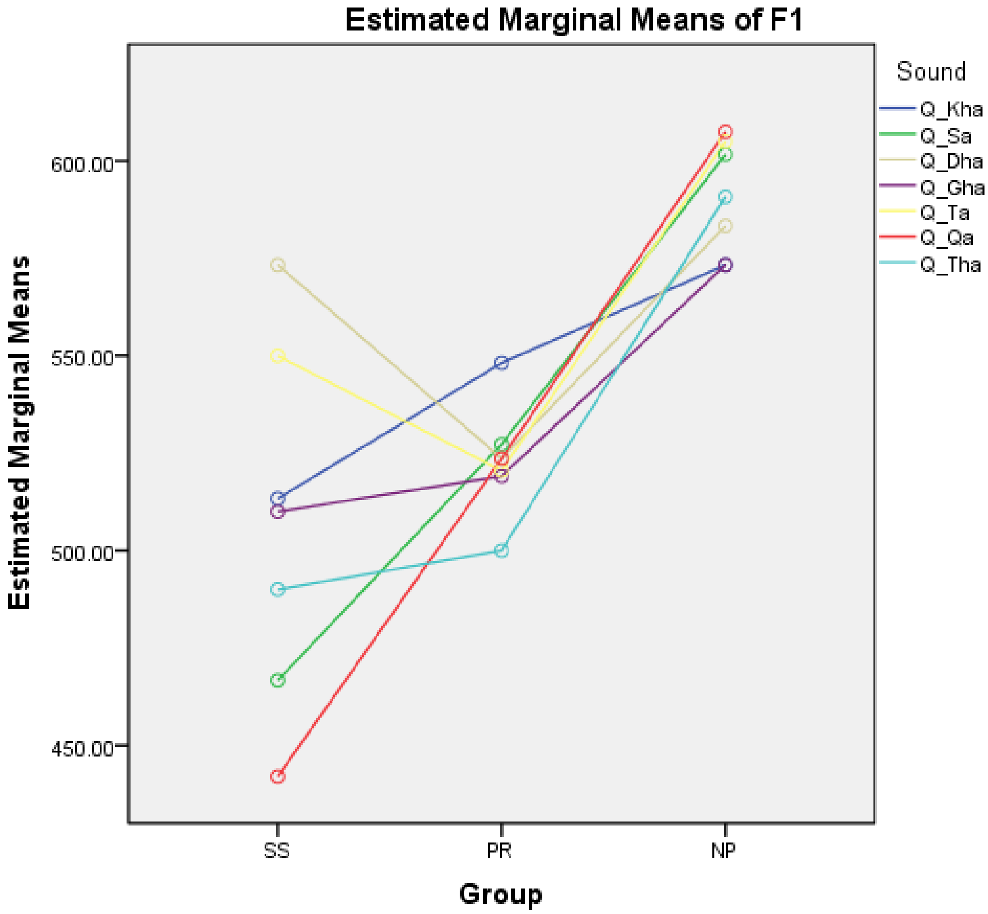

Figure 4.1 Reciter group by F1 formant frequencies, with the separate lines representing the different Qur'ānic syllables.

4.2.5.2 /a:/ F1 Arabic

A Univariate ANOVA was carried out on normal Arabic /a:/ F1 for factors Group (reciter group) and Sound (consonantal context). No significant effects were found for Group and Sound.

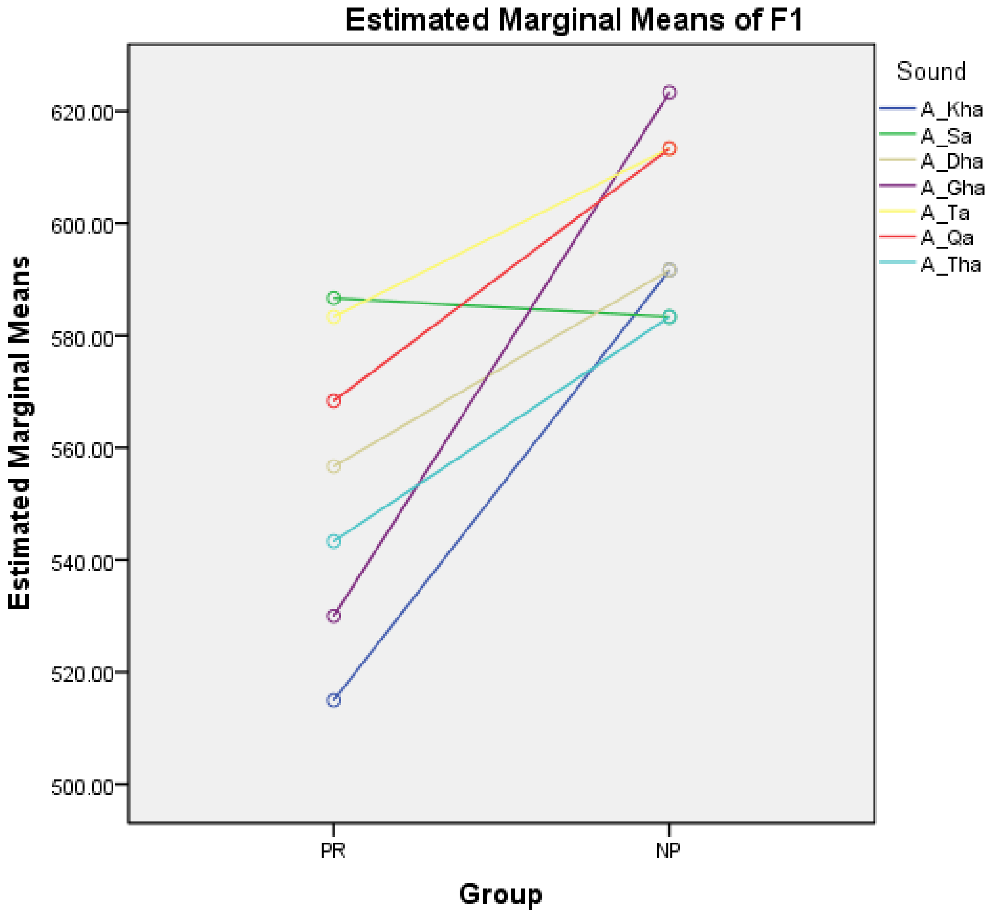

Figure 4.2 Reciter group by F1 formant frequencies, with the separate lines representing the different normal Arabic syllables.

4.2.5.3 /a:/ F2 Qur'ānic

A Univariate ANOVA was carried out on Qur'ānic /a:/ F2 for factors Group (reciter group) and Sound (consonantal context). A significant effect was found for Group (F 6.311 sig 0.002). No significant effect was found for Sound. A post hoc Tukey HSD showed a significant difference for Groups SS vs NP (Sig. 0.005) and PR vs NP (Sig. 0.038), but not for SS and PR.

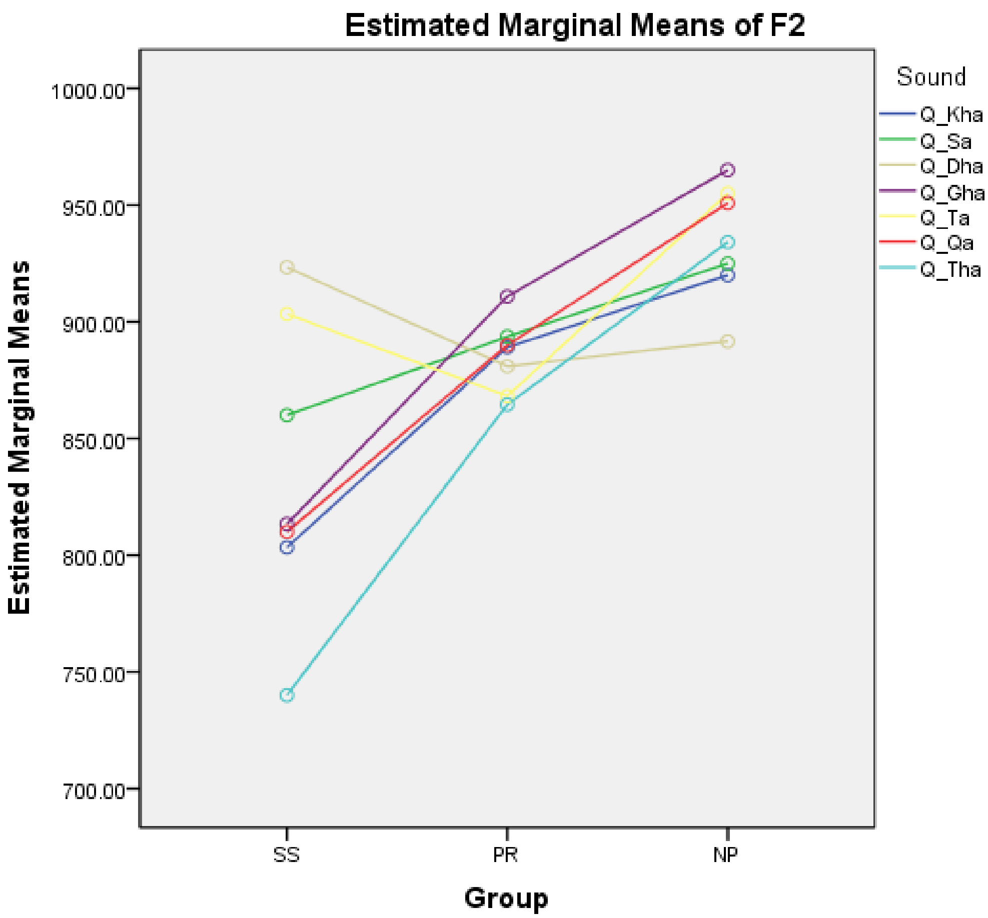

Figure 4.3 Reciter group by F2 formant frequencies, with the separate lines representing the different Qur'ānic syllables.

4.2.5.4 /a:/ F2 Arabic

A Univariate ANOVA was carried out on normal Arabic /a:/ F2 for factors Group (reciter group) and Sound (consonantal context). A significant effect was found for Group (F 7.300 sig 0.009) and a significant effect was also found for Sound (F 2.353 sig 0.040). A post hoc Tukey HSD showed a single significant difference for sounds A_Gha (Arabic Gha) and A_Ta (Arabic Ta), sig = 0.047.

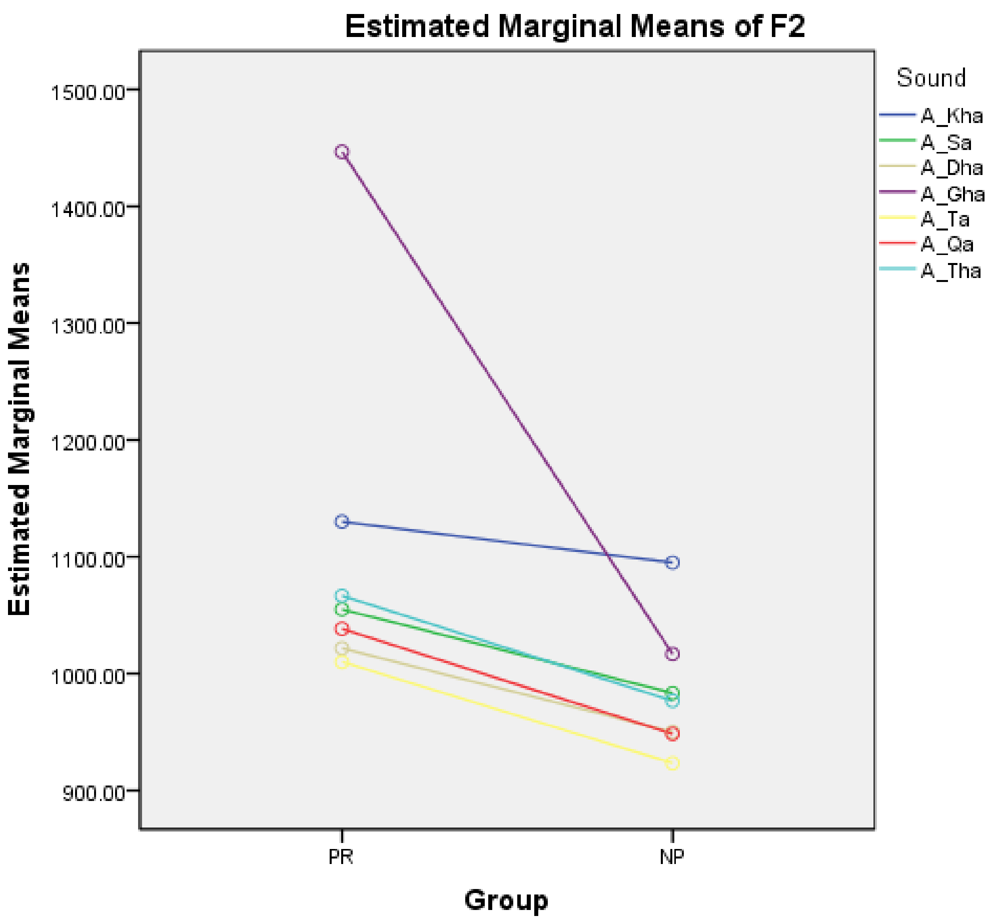

Figure 4.4 Reciter group by F2 formant frequencies, with the separate lines representing the different normal Arabic syllables.

4.2.5.5 /a:/ F3 Qur'ānic

A Univariate ANOVA was carried out on Qur'ānic /a:/ F3 for factors Group (reciter group) and Sound (consonantal context). A significant effect was found for Group (F 24.186 sig 0.000) but no significant effect was found for Sound. A Post Hoc Tukey HSD showed significant differences for SS and PR (sig 0.000) and SS and NP (sig 0.000) but no significant difference for PR and NP.

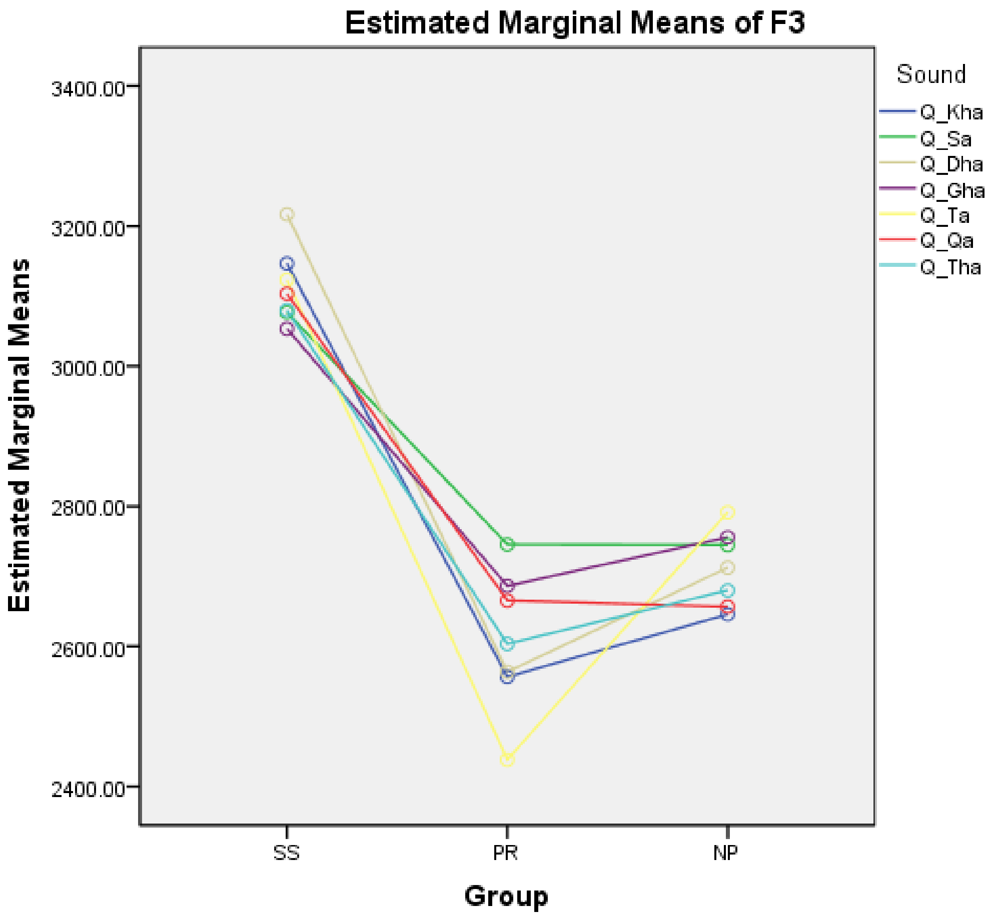

Figure 4.5 Reciter group by F3 formant frequencies, with the separate lines representing the different Qur'ānic syllables.

4.2.5.6 /a:/ F3 Arabic

A Univariate ANOVA was carried out on normal Arabic /a:/ F3 for factors Group (reciter group) and Sound (consonantal context). No significant effect was found for Group or Sound.

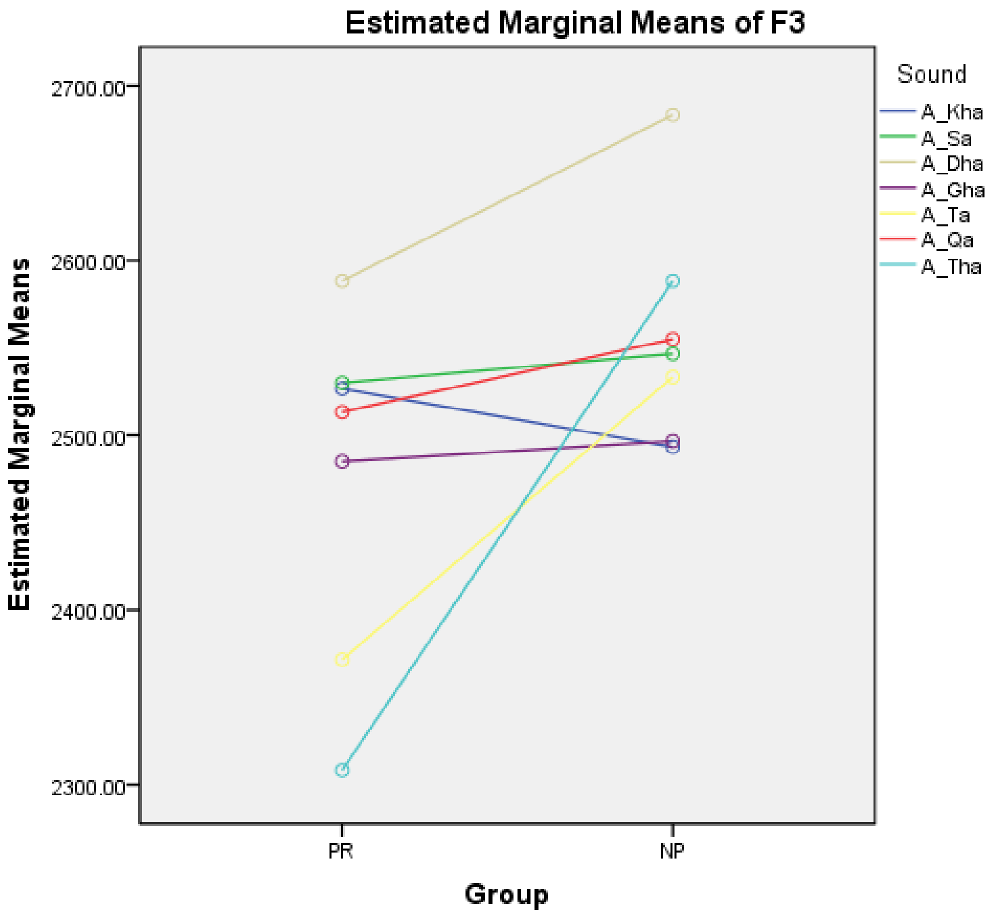

Figure 4.6 Reciter group by F3 formant frequencies, with the separate lines representing the different normal Arabic syllables.

4.2.5.7 /a:/ F4 Qur'ānic

A Univariate ANOVA was carried out on Qur'ānic /a:/ F4 for factors Group (reciter group) and Sound (consonantal context). A significant effect was found for Group (F 6.761, Sig 0.002). No significant effect was found for sound. A Post Hoc Tukey HSD found a significant effect for PR and NP (sig 0.001) and no significant effect for the other two pairs.

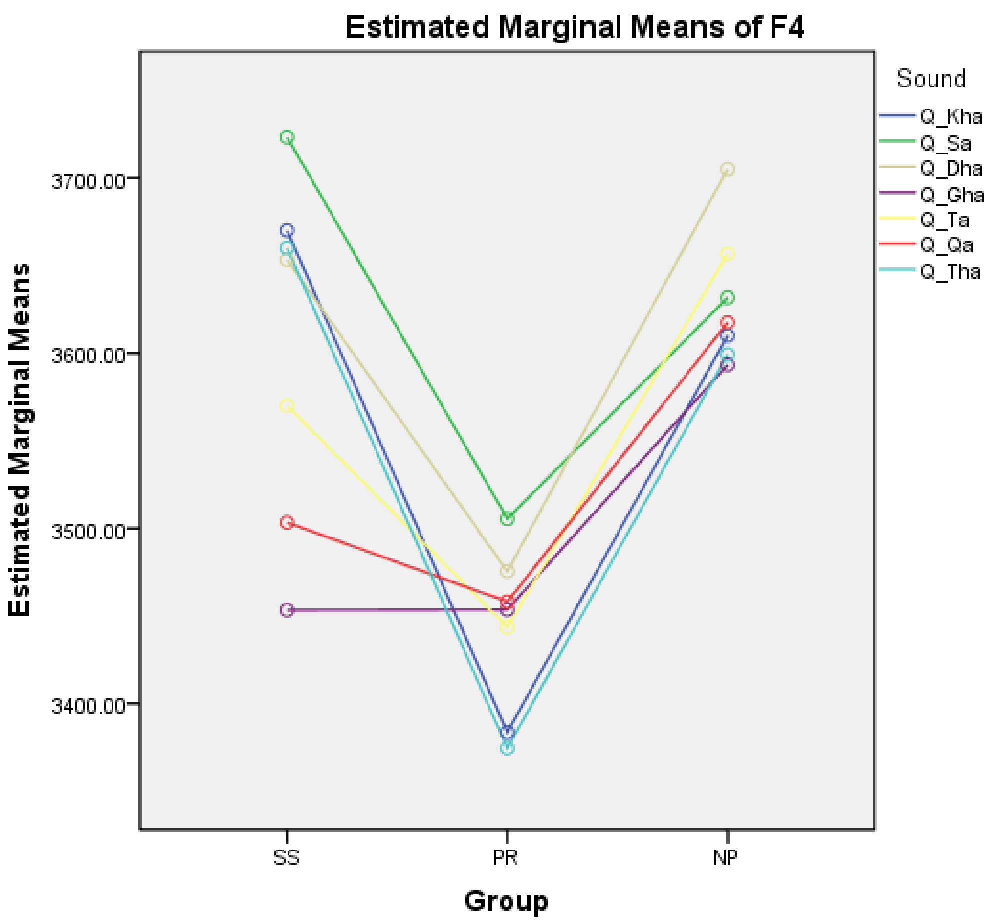

Figure 4.7 Reciter group by F4 formant frequencies, with the separate lines representing the different Qur'ānic syllables.

4.2.5.8 /a:/ F4 Arabic

A Univariate ANOVA was carried out on normal Arabic /a:/ F3 for factors Group (reciter group) and Sound (consonantal context). No significant effect was found for Group or Sound.

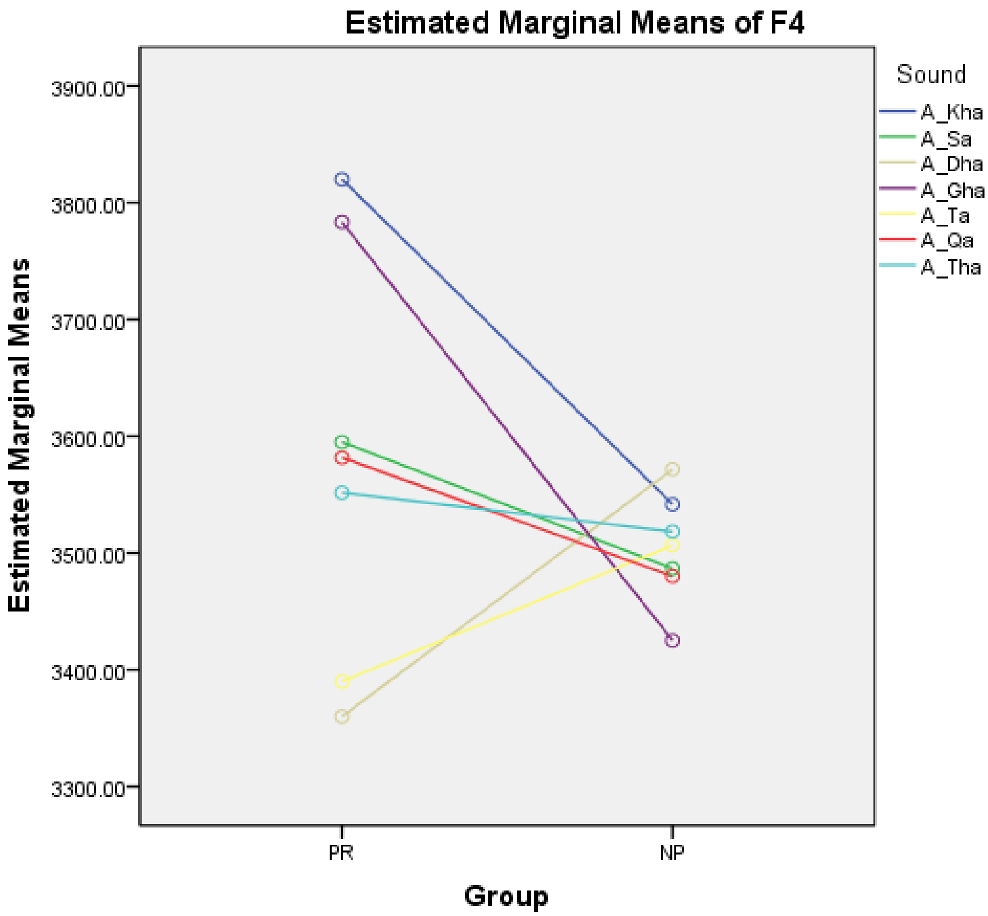

Figure 4.8 Reciter group by F4 formant frequencies, with the separate lines representing the different normal Arabic syllables.

4.2.5.9 /a:/ F3-F2 Qur'ānic

A Univariate ANOVA was carried out on Qur'ānic /a:/ F3-F2 for factors Group (reciter group) and Sound (consonantal context). A significant effect was found for Group (F 25.461 Sig 0.000). No significant effect was found for sound. A Post Hoc Tukey HSD found a significant effect for SS and PR (sig 0.000) and for SS and NP (sig 0.000), but not for PR and NP.

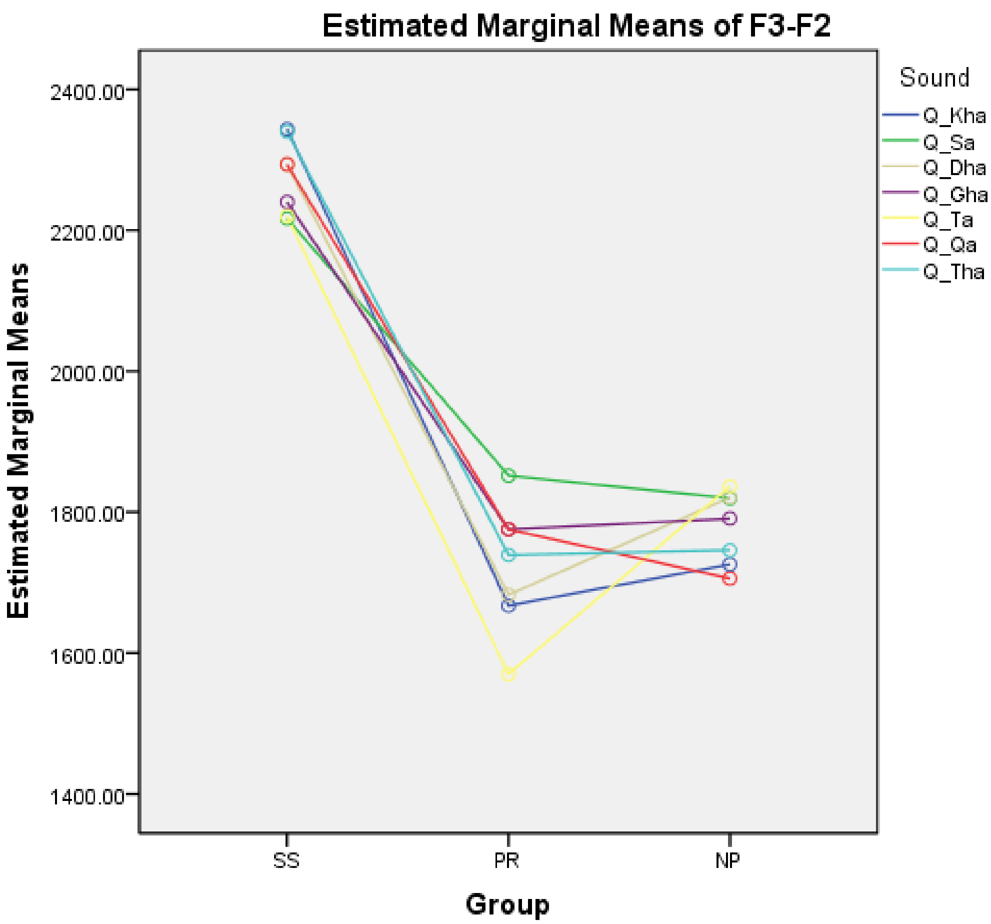

Figure 4.9 Reciter group by F3-F2 formant frequencies differences, with the separate lines representing the different Qur'ānic syllables.

4.2.5.10 /a:/ F3-F2 Arabic

A Univariate ANOVA was carried out on normal Arabic /a:/ F3-F2 for factors Group (reciter group) and Sound (consonantal context). A significant effect was found for Group (F 10.044 Sig 0.002). No significant effect was found for sound.

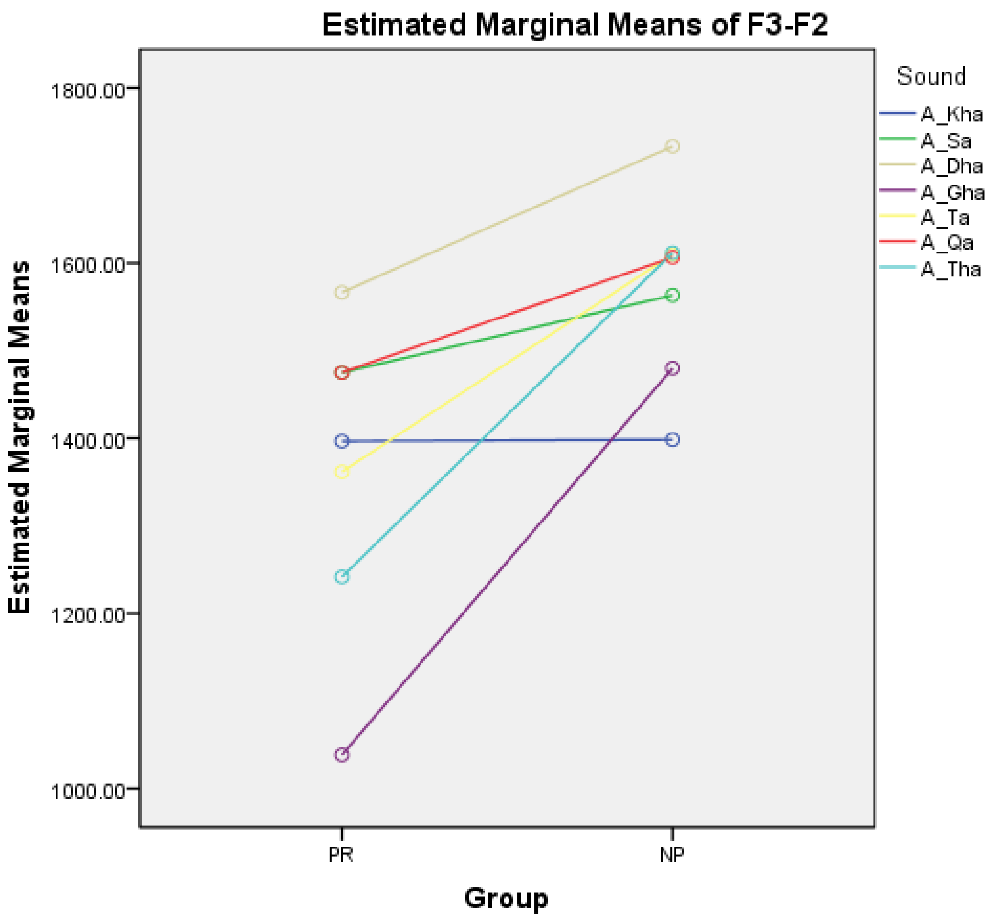

Figure 4.10 Reciter group by F3-F2 formant frequencies differences, with the separate lines representing the different normal Arabic syllables.

4.2.5.11 /a:/ F4-F3 Qur'ānic

A Univariate ANOVA was carried out on Qur'ānic /a:/ F4-F3 for factors Group (reciter group) and Sound (consonantal context). A significant effect was found for Group (F 15.086 Sig 0.000). No significant effect was found for sound. A Post Hoc Tukey HSD found a significant effect for SS and PR (sig 0.000) and for SS and NP (sig 0.000), but not for PR and NP.

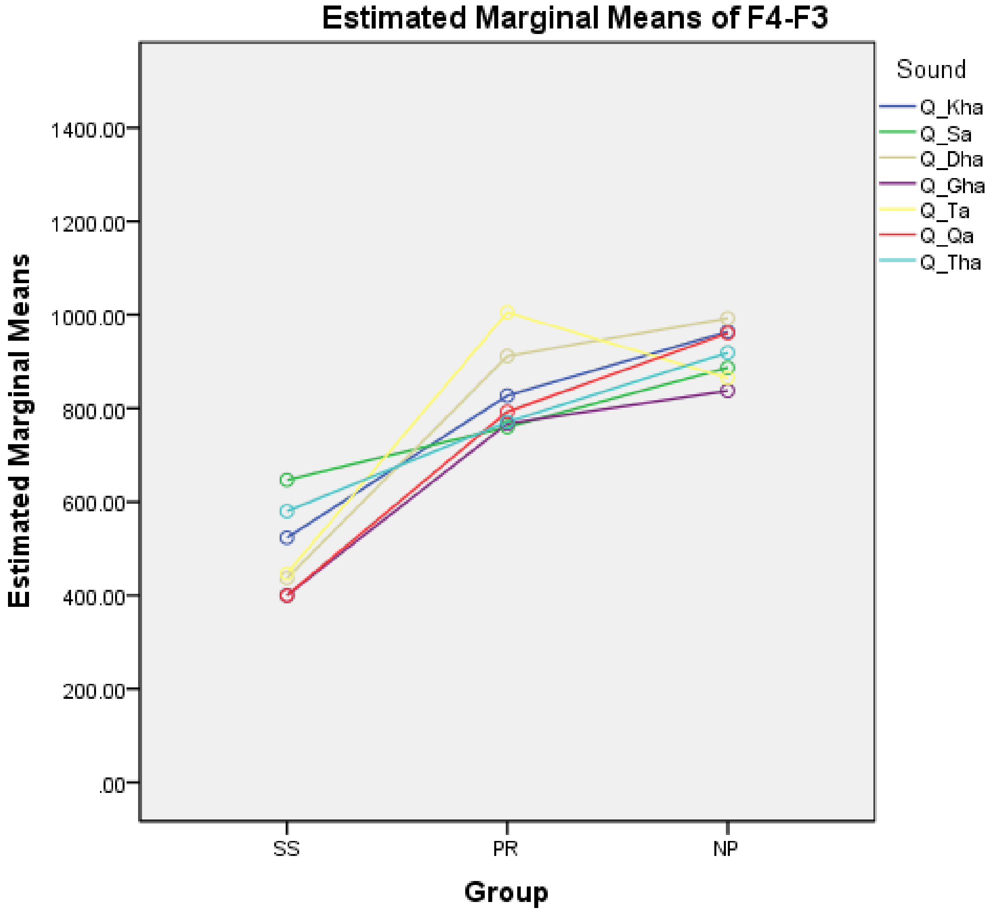

Figure 4.11 Reciter group by F4-F3 formant frequencies differences, with the separate lines representing the different Qur'ānic syllables.

4.2.5.12 /a:/ F4-F3 Arabic

A Univariate ANOVA was carried out on normal Arabic /a:/ F4-F3 for factors Group (reciter group) and Sound (consonantal context). A significant effect was found for Group (F 8.176 Sig 0.006). No significant effect was found for sound. A Post Hoc Tukey HSD found a significant effect for A_Kha and A_Dha (sig 0.029).

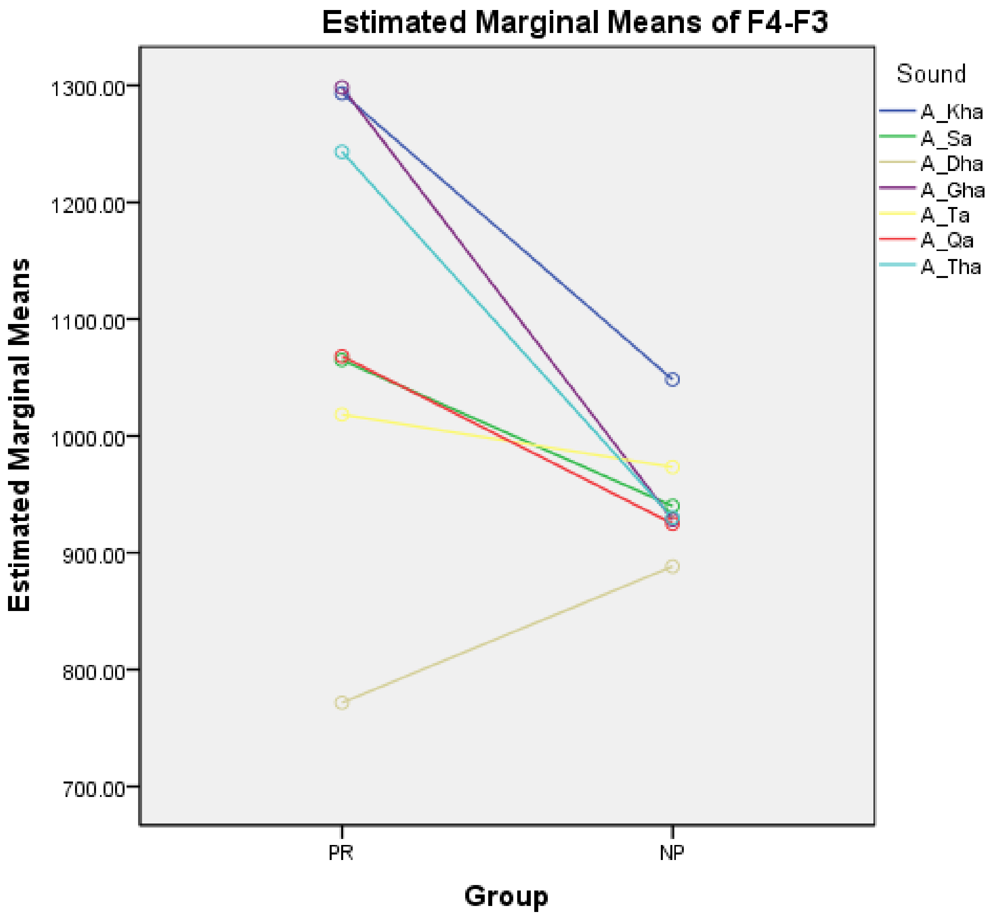

Figure 4.12 Reciter group by F4-F3 formant frequencies differences, with the separate lines representing the different normal Arabic syllables.

4.2.5.13 /a:/ VDur Qur'ānic

A Univariate ANOVA was carried out on Qur'ānic /a:/ VDur (vowel duration) for factors Group (reciter group) and Sound (consonantal context). Significant effects were found for Group (F 118.875 sig 0.000) and for Sound (F=5.022 sig 0.000). A Post Hoc Tukey HSD showed significant effects for all combinations of Group (SS vs PR sig=0.000, SS vs NP sig = 0.000, and PR vs NP sig = 0.000). A post hoc Tukey HSD showed significant differences for Q_Kha vs Q_Dha (sig = 0.000) and Q_Kha vs Q_Ta (sig = 0.013).

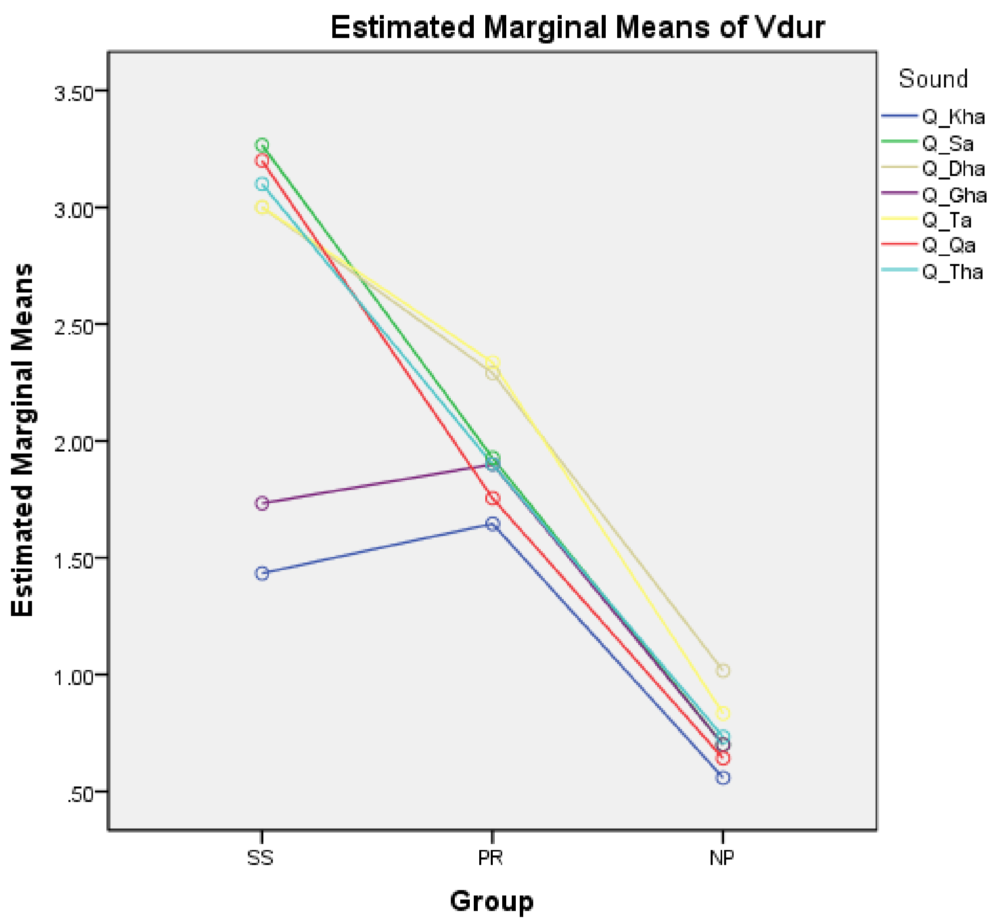

Figure 4.13 Reciter group by VDur (vowel duration), with the separate lines representing the different normal Arabic syllables.

4.2.5.14 /u:/ F1 Qur'ānic

A Univariate ANOVA was carried out on Qur'ānic /u:/ F1 for factors Group (reciter group) and Sound (consonantal context). A significant effect was found for Sound (F=4.794, sig=0.005). No significant effect was found for group. A post hoc Tukey HSD showed significant differences for Q_Dhu and Q_Ghu (sig=0.01), Q_Dhu and Q_Qu (sig=0.016) and Q_Dhu and Q_Tu (sig=0.004).

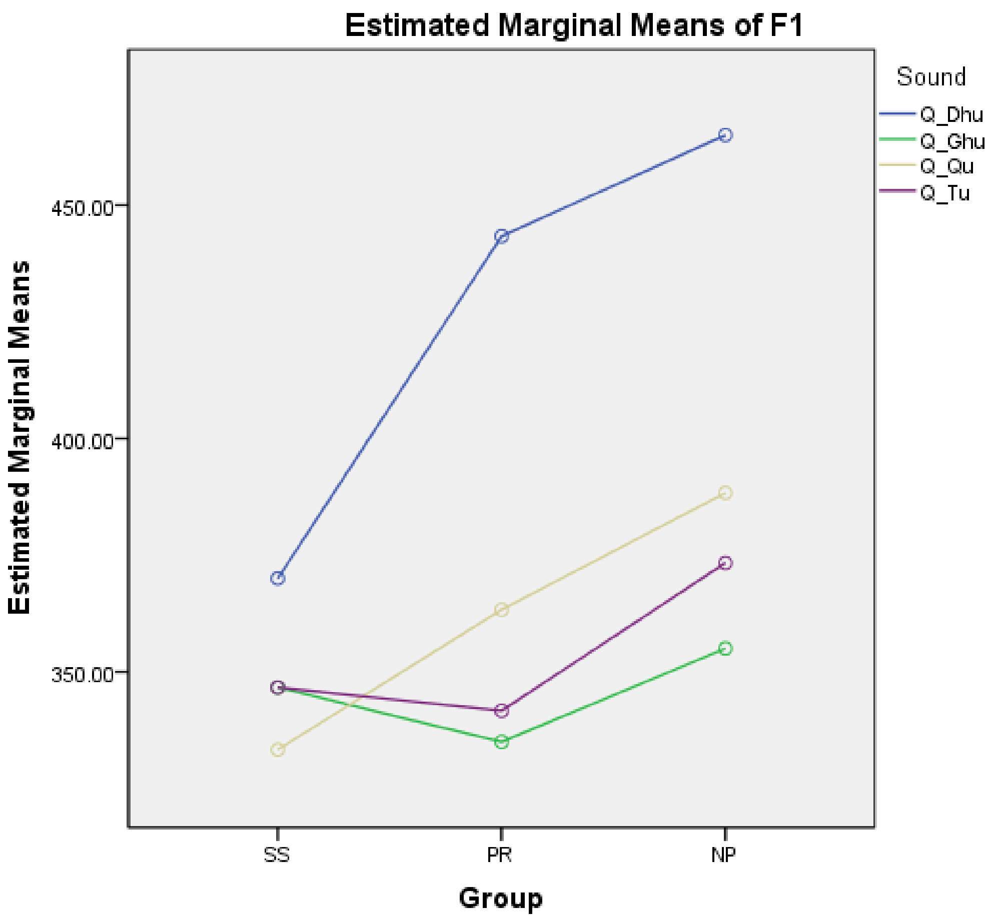

Figure 4.14 Reciter group by F1 formant frequencies, with the separate lines representing the different Qur'ānic syllables.

4.2.5.15 /u:/ F2 Qur'ānic

A Univariate ANOVA was carried out on Qur'ānic /u:/ F2 for factors Group (reciter group) and Sound (consonantal context). No significant effects were found for Group or Sound.

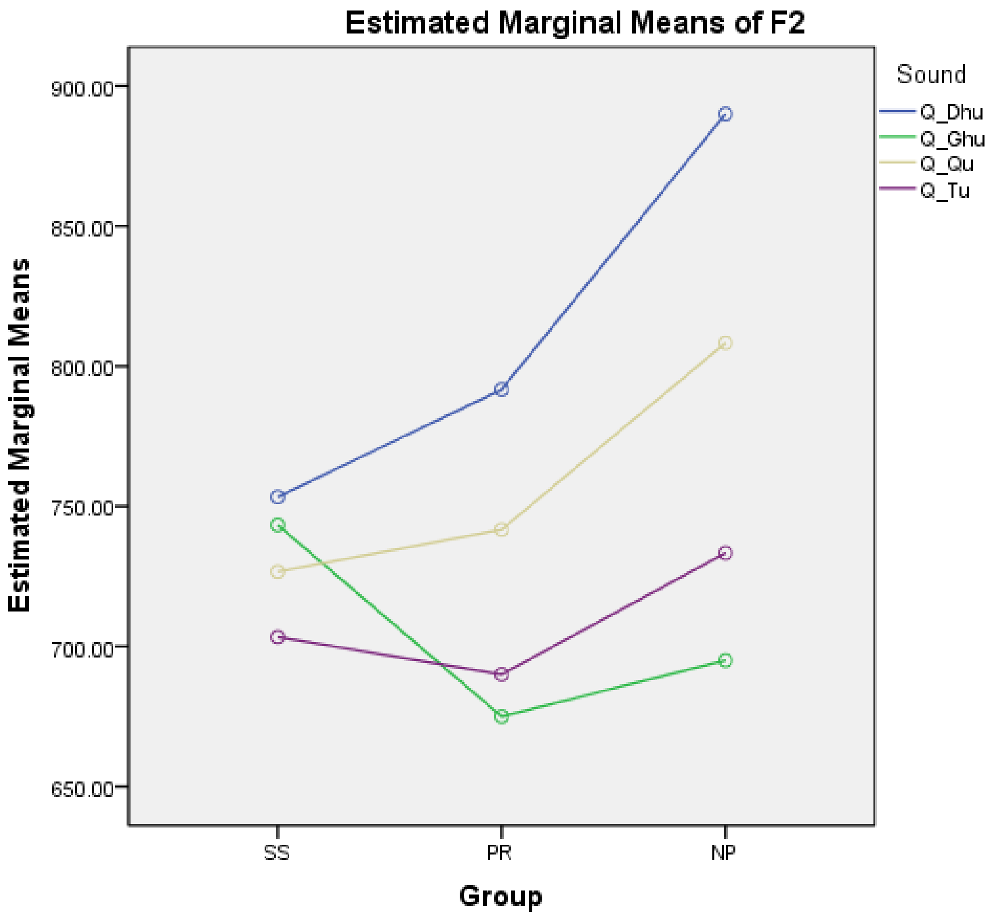

Figure 4.15 Reciter group by F2 formant frequencies, with the separate lines representing the different Qur'ānic syllables.

4.2.5.16 /u:/ F3 Qur’ānic

A Univariate ANOVA was carried out on Qur’ānic /u:/ F3 for factors Group (reciter group) and Sound (consonantal context). No significant effects were found for Group or Sound.

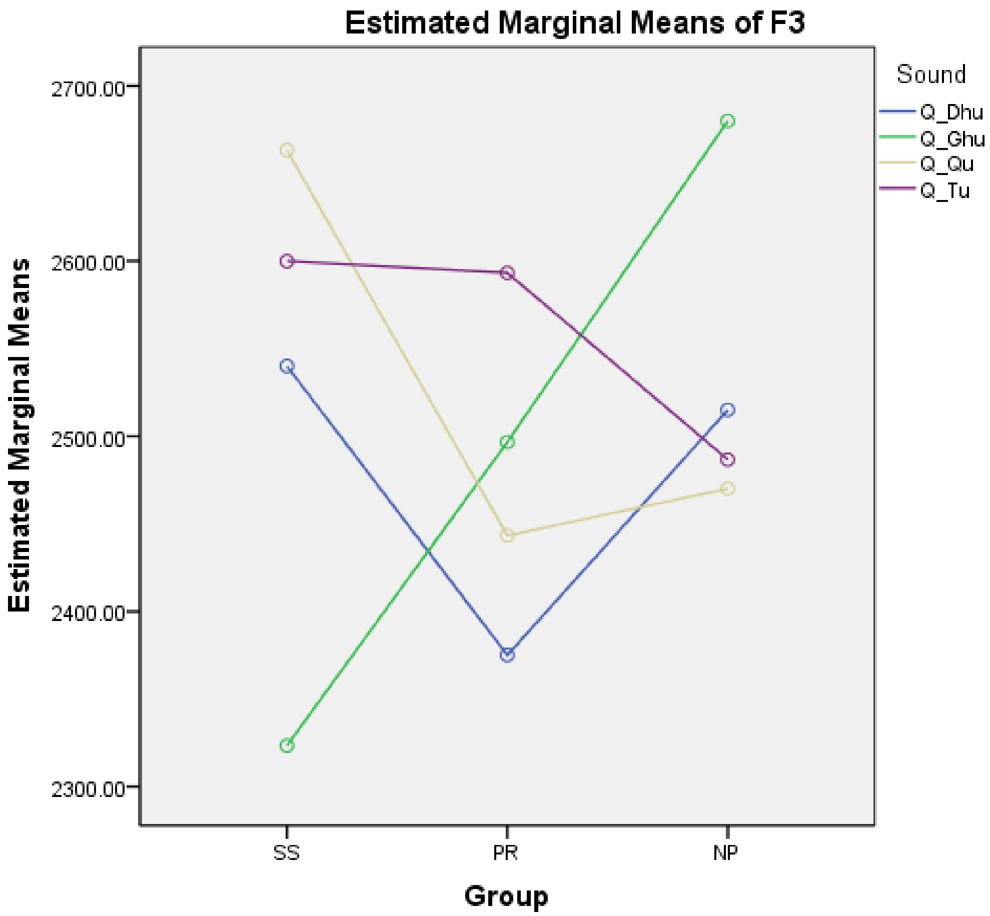

Figure 4.16 Reciter group by F3 formant frequencies, with the separate lines representing the different Qur’ānic syllables.

4.2.5.17 /u:/ F4 Qur'ānic

A Univariate ANOVA was carried out on Qur'ānic /u:/ F4 for factors Group (reciter group) and Sound (consonantal context). No significant effects were found for Group or Sound.

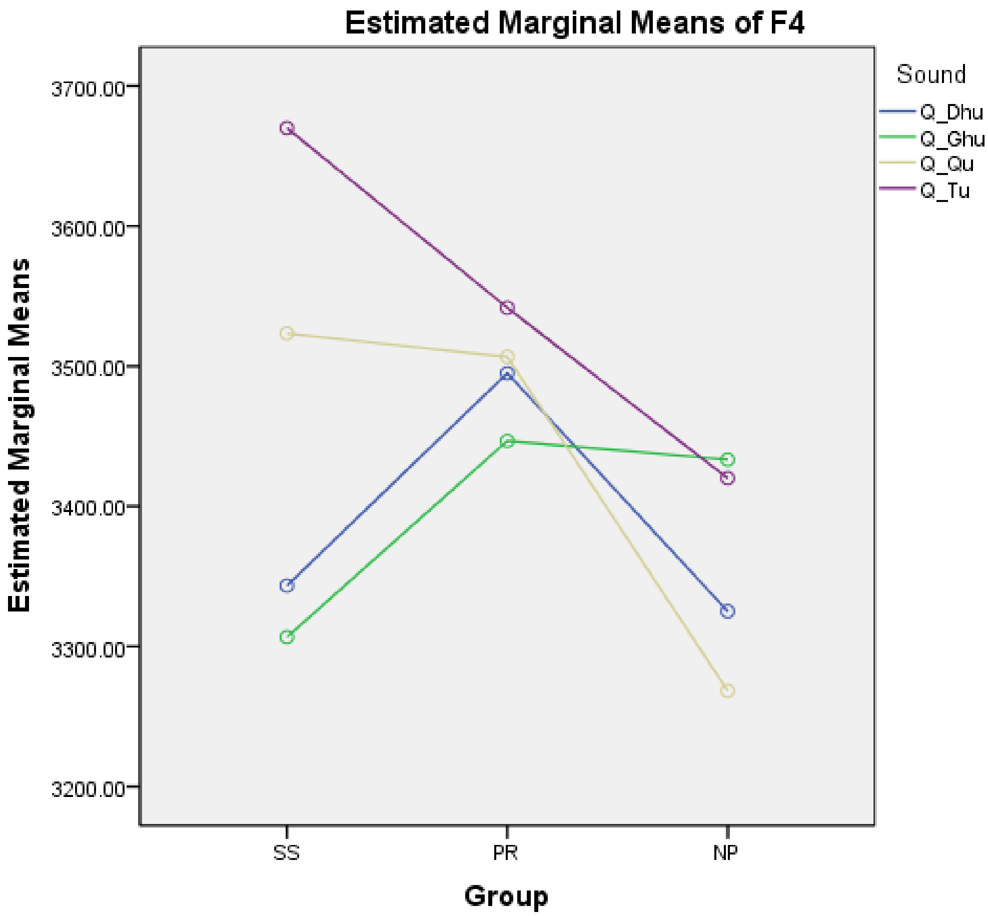

Figure 4.17 Reciter group by F4 formant frequencies, with the separate lines representing the different Qur'ānic syllables.

4.2.5.18 /u:/ F3-F2 Qur’ānic

A Univariate ANOVA was carried out on Qur’ānic /u:/ F3-F2 for factors Group (reciter group) and Sound (consonantal context). No significant effects were found for Group or Sound.

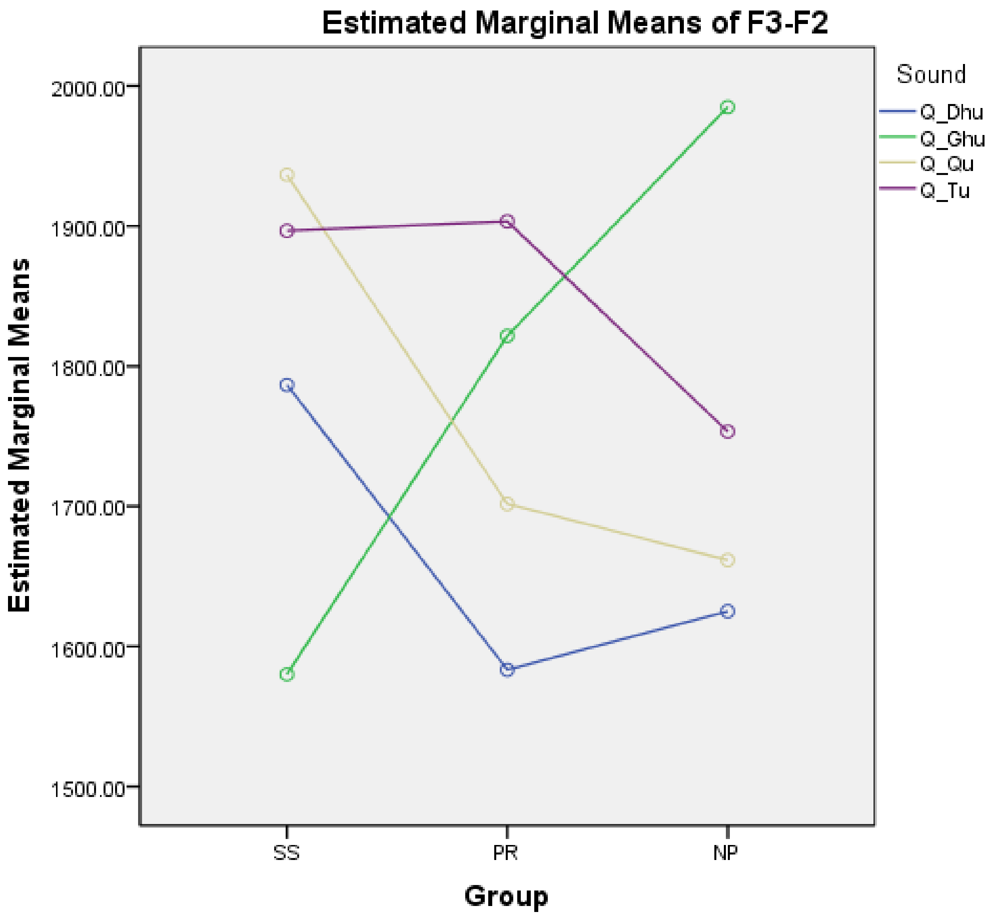

Figure 4.18 Reciter group by F3-F2 formant frequency differences, with the separate lines representing the different Qur’ānic syllables.

4.2.5.19 /u:/ F4-F3 Qur'ānic

A Univariate ANOVA was carried out on Qur'ānic /u:/ F4-F3 for factors Group (reciter group) and Sound (consonantal context). No significant effects were found for Group or Sound.

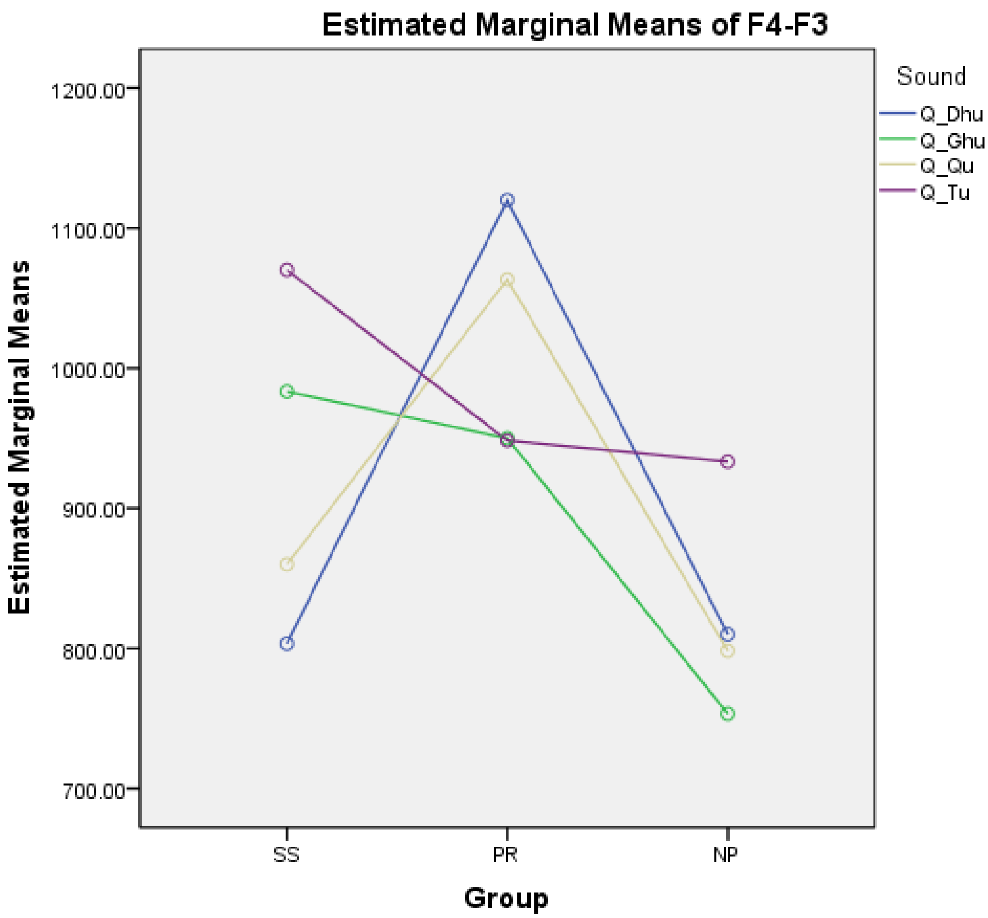

Figure 4.19 Reciter group by F4-F3 formant frequency differences, with the separate lines representing the different Qur'ānic syllables.

4.2.5.20 /i:/ F1 Qur'ānic

A Univariate ANOVA was carried out on Qur'ānic /i:/ F1 for factors Group (reciter group) and Sound (consonantal context). No significant effects were found for Group or Sound.

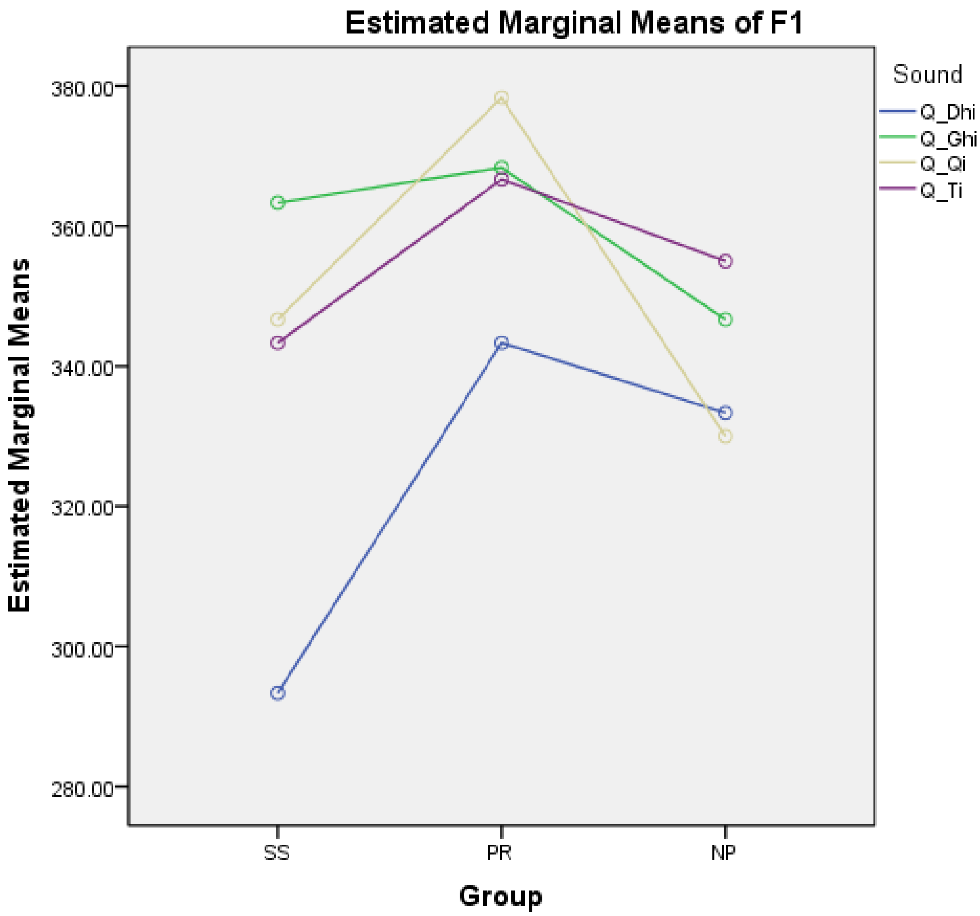

Figure 4.20 Reciter group by F1 formant frequencies, with the separate lines representing the different Qur'ānic syllables.

4.2.5.21 /i:/ F2 Qur'ānic

A Univariate ANOVA was carried out on Qur'ānic /i:/ F2 for factors Group (reciter group) and Sound (consonantal context). There was no significant effect for Sound. A significant effect was found for Group (F=17.028, sig=0.000). A post hoc Tukey HSD showed significant differences for Groups SS and NP (sig=0.000), and PR and NP (sig=0.00).

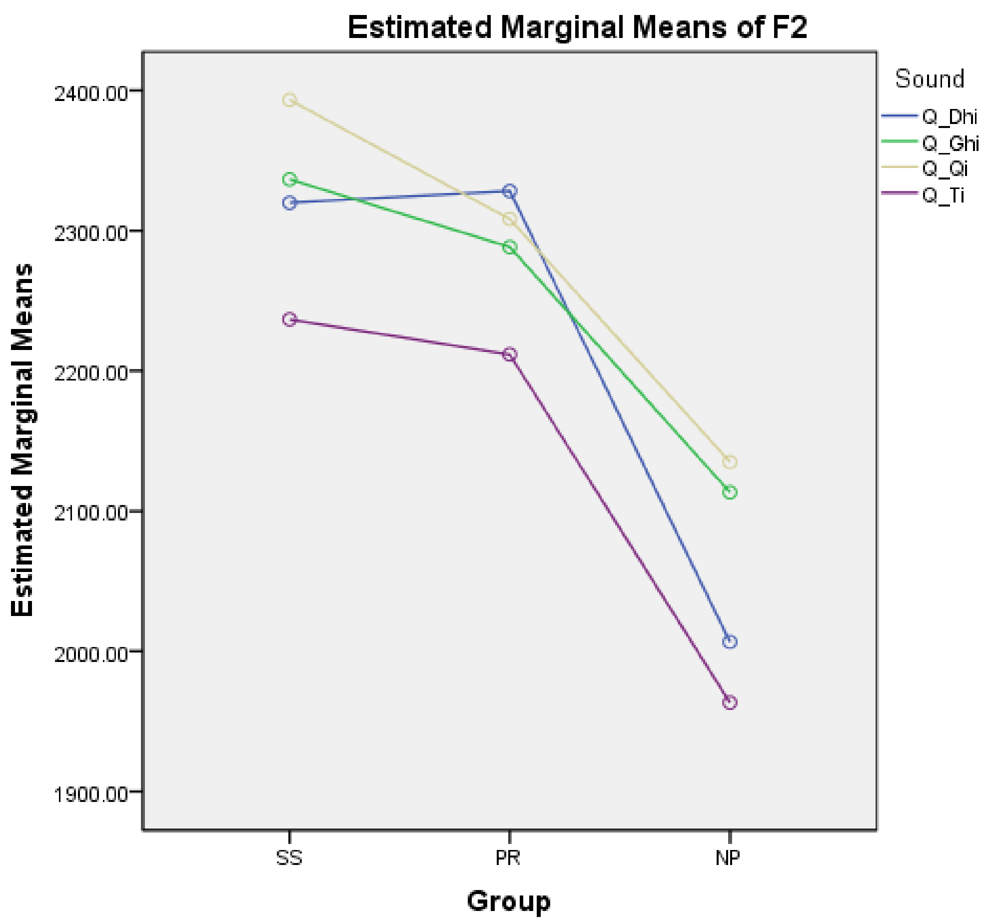

Figure 4.21 Reciter group by F2 formant frequencies, with the separate lines representing the different Qur'ānic syllables.

4.2.5.22 /i:/ F3 Qur'ānic

A Univariate ANOVA was carried out on Qur'ānic /i:/ F3 for factors Group (reciter group) and Sound (consonantal context). There was no significant effect for Sound. A significant effect was found for Group (F=9.029, sig=0.000). A post hoc Tukey HSD showed significant differences for Groups PR and NP (sig=0.000).

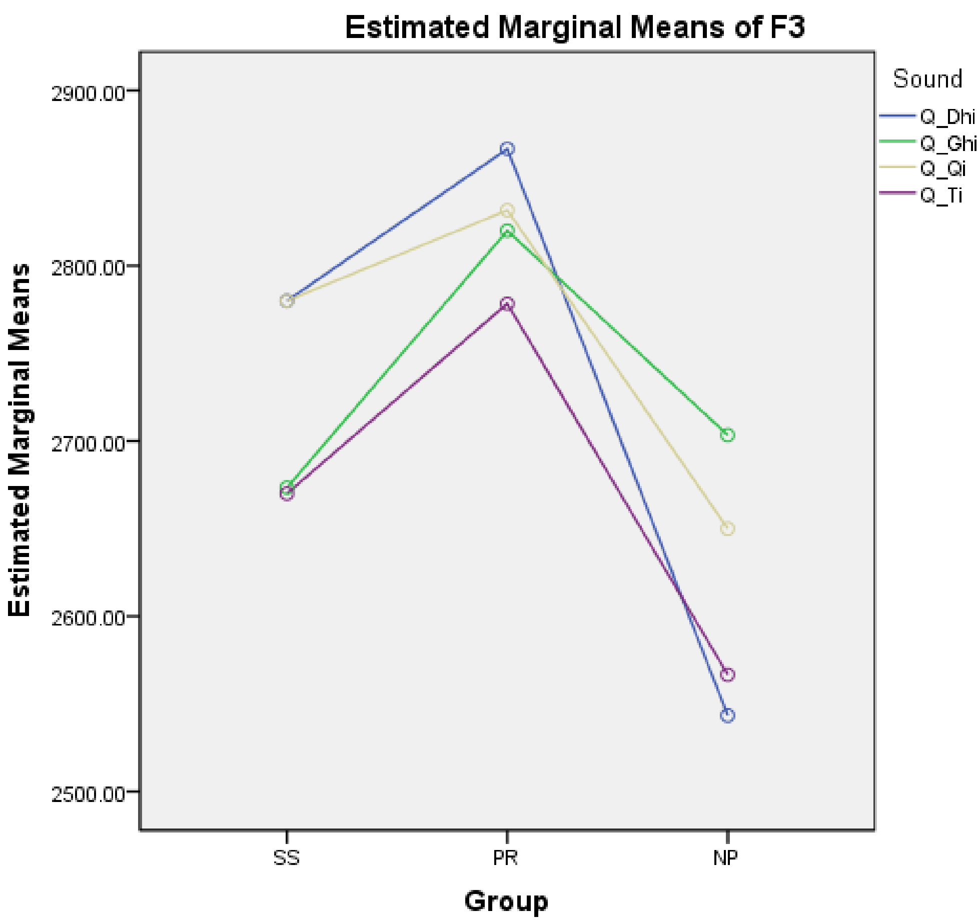

Figure 4.22 Reciter group by F3 formant frequencies, with the separate lines representing the different Qur'ānic syllables.

4.2.5.23 /i:/ F4 Qur'ānic

A Univariate ANOVA was carried out on Qur'ānic /i:/ F4 for factors Group (reciter group) and Sound (consonantal context). There was no significant effect for Sound. A significant effect was found for Group (F=24.862, sig=0.000). A post hoc Tukey HSD showed significant differences for Groups SS and NP (sig=0.000) and Goups PR and NP (sig=0.000).

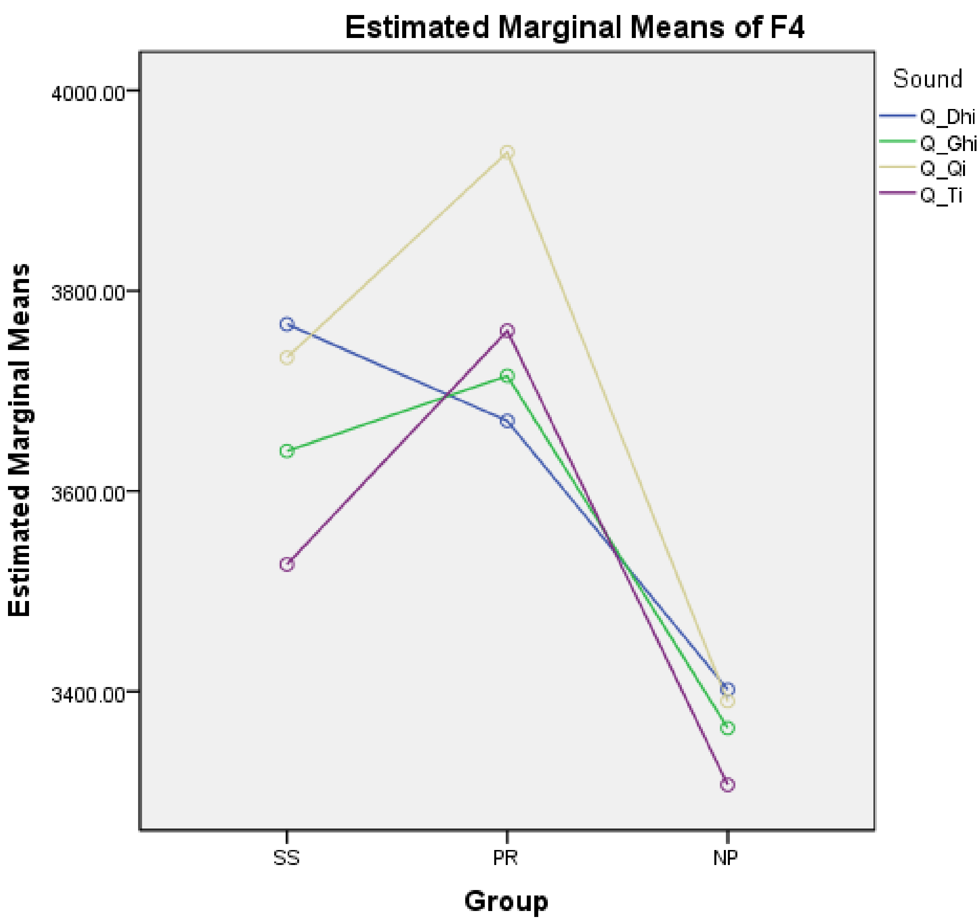

Figure 4.23 Reciter group by F4 formant frequencies, with the separate lines representing the different Qur'ānic syllables.

4.2.5.24 /i:/ F3-F2 Qur'ānic

A Univariate ANOVA was carried out on Qur'ānic /i:/ F3-F2 for factors Group (reciter group) and Sound (consonantal context). There was no significant effect for Sound. A significant effect was found for Group (F=5.874, sig=0.005). A post hoc Tukey HSD showed a significant difference for Groups SS and NP (sig=0.005).

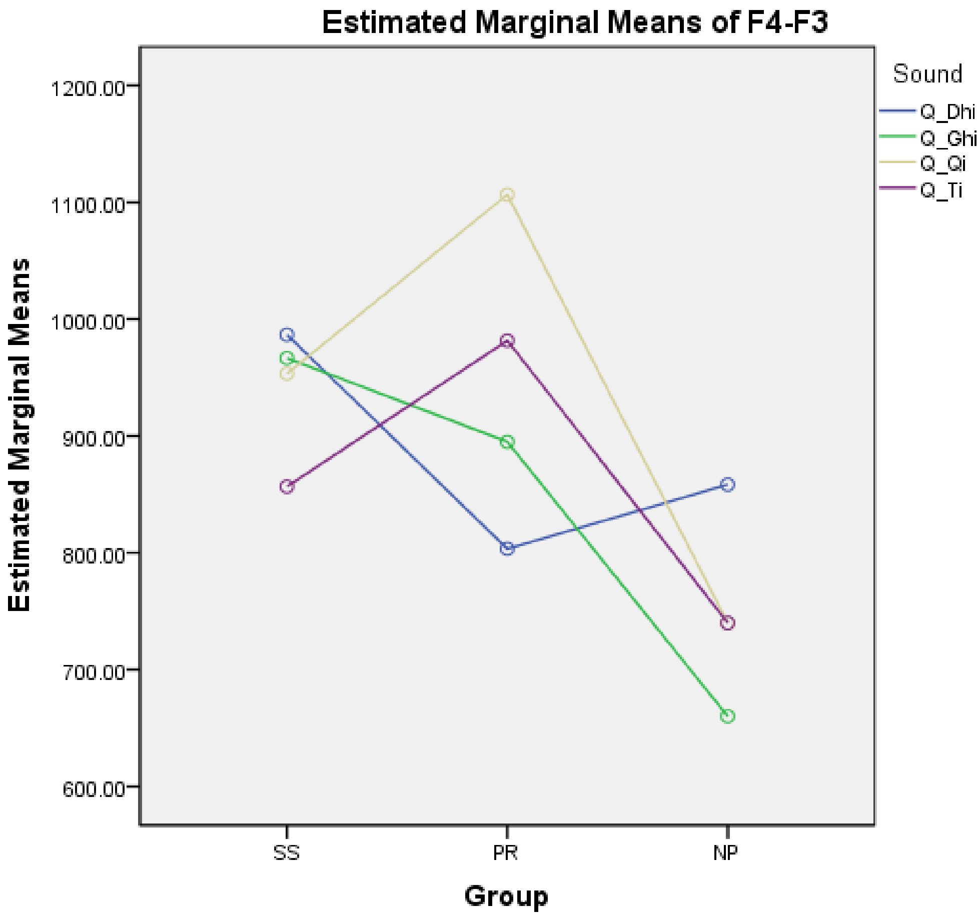

Figure 4.24 Reciter group by F4-F3 formant frequencies, with the separate lines representing the different Qur'ānic syllables.

4.2.5.25 /i:/ F4-F3 Qur'ānic

A Univariate ANOVA was carried out on Qur'ānic /i:/ F4-F3 for factors Group (reciter group) and Sound (consonantal context). There was no significant effect for Sound. A significant effect was found for Group (F=5.216, sig=0.009). A post hoc Tukey HSD showed a significant difference for Groups PR and NP (sig=0.012).

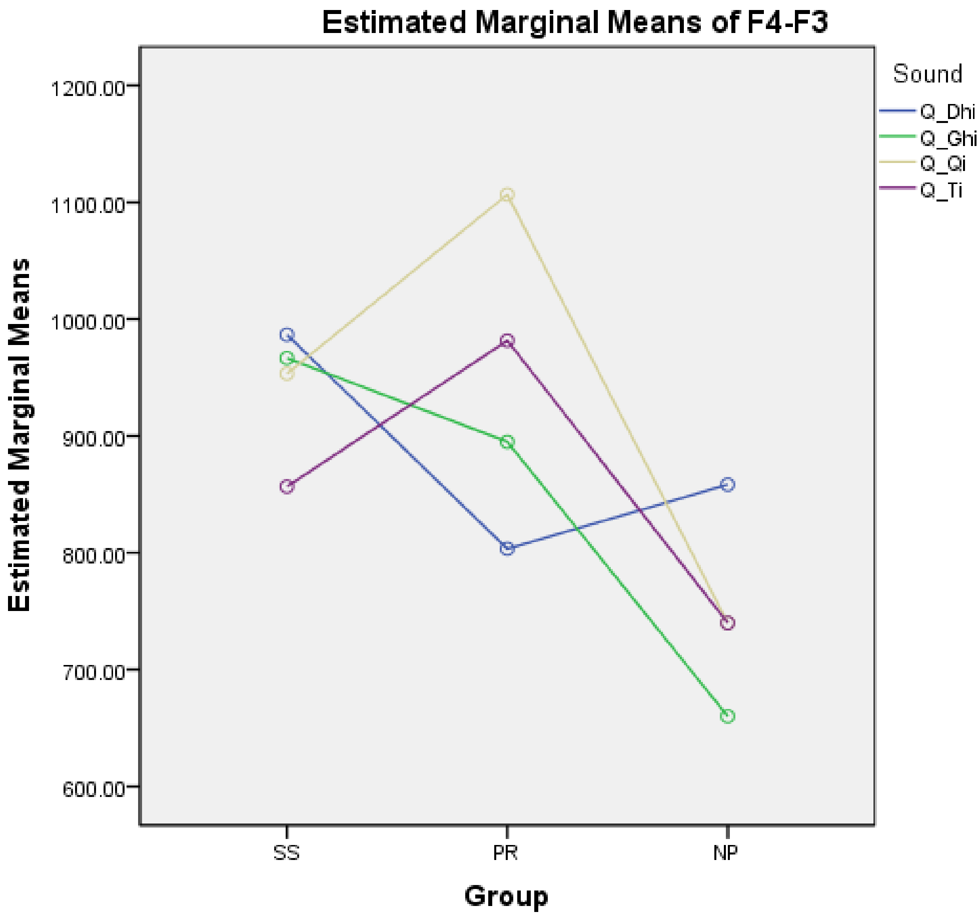

Figure 4.25 Reciter group by F4-F3 formant frequencies, with the separate lines representing the different Qur'ānic syllables.

4.2.6 Data Pooled for Sound

In the previous section the statistical analysis examined the data from the perspective of both Group (reciter group) and Sound (preceding consonantal context of each analyzed vowel). In these analyses almost all acoustic parameters showed no significant effect for Sound. The exceptions were Qur'ānic /u:/ F1, Qur'ānic /a:/ VDur, Arabic /a:/ F2 and Arabic /a:/ F4-F3. In each of these cases the significant differences were either for a single pair of consonantal contexts, or they were for a single sound with several other sounds. In this section these context differences are ignored and the data is presented as individual reciter means across all consonant contexts. This has been done for two reasons:-

1. It allows the presentation of easy to read summary data that covers the most important independent variable (Group) and all of the acoustic dependent variables
2. It presents data that may be used in statistical analysis of contrasts that don't require examination of Sound but that examine the acoustic independent variables against the dependent variable Group and an additional independent variable (e.g. Qur'ānic vs. normal Arabic)

4.2.6.1 Summary Reciter Means

The following tables are individual subject (reciter) means for each acoustic measurement taken across all consonantal contexts. In each case R means reciter number. The row "mean" is the grand mean across all reciters.

R	**F1**	**F2**	**F3**	**F4**	**F3-F2**	**F4-F3**	**Vdur**
1	384	759	3020	3407	2261	387	3.0
2	567	880	3064	3396	2184	331	2.7
3	569	870	3259	4011	2389	753	2.3
mean	506	836	3114	3605	2278	490	2.68
stdv	106	67	127	352	103	229	0.37
num	3	3	3	3	3	3	3

Table 4.3 Qur'ānic /a:/ Superstandard Reciters (SS)

R	**F1**	**F2**	**F3**	**F4**	**F3-F2**	**F4-F3**	**Vdur**
1	607	987	2621	3167	1634	546	1.80
2	456	719	2821	3130	2103	309	2.04
3	489	746	2679	3070	1933	391	2.96
4	478	943	2574	3736	1631	1161	2.06
5	551	837	2654	3391	1817	737	1.16
6	584	894	2509	3901	1614	1393	1.66
7	551	844	2654	3503	1810	849	2.97
8	536	996	2947	3741	1951	794	1.71
9	400	970	2917	3809	1947	891	1.84
10	553	839	2096	3127	1257	1031	1.21
11	550	964	2220	3287	1256	1067	2.21
mean	523	885	2608	3442	1723	834	1.97
stdv	61	96	263	310	278	329	0.59
num	11	11	11	11	11	11	11

Table 4.4 Qur'ānic /a:/ Professional Reciters (PR)

R	F1	F2	F3	F4	F3-F2	F4-F3	Vdur
1	559	816	3024	3816	2209	791	0.93
2	540	864	2430	3357	1566	927	1.26
3	544	817	2790	3876	1973	1086	1.61
4	624	929	2725	3571	1797	846	0.87
5	620	1070	2750	3520	1680	770	0.60
6	573	1069	2956	4033	1887	1077	0.40
7	670	1009	2734	3630	1726	896	0.27
8	601	947	2647	3666	1700	1019	0.41
9	529	864	2661	3487	1797	826	0.69
10	634	1017	2571	3391	1554	820	0.94
11	599	951	2614	3624	1663	1010	0.43
12	596	861	2646	3594	1784	949	0.47
mean	591	935	2712	3630	1778	918	0.74
stdv	43	92	161	197	182	111	0.40
num	12	12	12	12	12	12	12

Table 4.5 Qur'ānic /a:/ Non-professional Reciters (NP)

R	F1	F2	F3	F4	F3-F2	F4-F3
1	305	2163	2638	3803	475	1165
2	295	2223	2513	3493	290	980
3	410	2580	3028	3705	448	678
mean	337	2322	2726	3667	404	941
stdv	64	226	269	159	100	246
num	3	3	3	3	3	3

Table 4.6 Qur'ānic /i:/ Superstandard Reciters (SS)

R	**F1**	**F2**	**F3**	**F4**	**F3-F2**	**F4-F3**
6	305	2248	2888	3685	640	798
7	340	2385	2815	3913	430	1098
8	460	2415	2808	3638	393	830
9	358	2178	2793	3748	615	955
10	328	2318	2908	4008	590	1100
11	395	2163	2735	3635	573	900
mean	364	2284	2824	3771	540	947
stdv	56	106	64	155	103	130
num	6	6	6	6	6	6

Table 4.7 Qur'ānic /i:/ Professional Reciters (PR)

R	**F1**	**F2**	**F3**	**F4**	**F3-F2**	**F4-F3**
7	330	2113	2698	3383	585	685
8	335	1918	2573	3550	655	978
9	305	2083	2490	3450	408	960
10	370	2018	2653	3348	635	695
11	365	2203	2683	3240	480	558
12	343	1995	2600	3223	605	623
mean	341	2055	2616	3365	561	750
stdv	24	100	78	125	97	177
num	6	6	6	6	6	6

Table 4.8 Qur'ānic /i:/ Non-professional Reciters (NP)

R	F1	F2	F3	F4	F3-F2	F4-F3
1	318	668	2575	3660	1908	1085
2	288	663	2718	3435	2055	718
3	443	865	2303	3288	1438	985
mean	349	732	2532	3461	1800	929
stdv	82	115	211	188	322	190
num	3	3	3	3	3	3

Table 4.9 Qur'ānic /u:/ Superstandard Reciters (SS)

R	F1	F2	F3	F4	F3-F2	F4-F3
6	403	720	2483	3335	1763	853
7	375	670	2705	3530	2035	825
8	408	895	2405	3530	1510	1125
9	320	603	2695	3530	2093	835
10	358	750	2305	3530	1555	1225
11	363	710	2270	3530	1560	1260
mean	371	725	2477	3498	1753	1020
stdv	32	98	188	80	257	205
num	6	6	6	6	6	6

Table 4.10 Qur'ānic /u:/ Professional Reciters (PR)

R	F1	F2	F3	F4	F3-F2	F4-F3
7	400	805	2770	3628	1965	858
8	385	783	2530	3575	1748	1045
9	383	765	2395	3285	1630	890
10	430	773	2438	2950	1665	513
11	358	713	2490	3228	1778	738
12	418	853	2605	3505	1753	900
mean	395	782	2538	3362	1756	824
stdv	26	46	135	257	117	181
num	6	6	6	6	6	6

Table 4.11 Qur'ānic /u:/ Nonprofessional Reciters (NP)

R	F1	F2	F3	F4	F3-F2	F4-F3
6	576	1204	2701	3534	1497	833
7	543	924	2400	3497	1476	1097
8	544	1166	2377	3449	1211	1071
9	467	1143	2824	3800	1681	976
10	609	1129	2231	3823	1103	1591
11	590	1093	2314	3396	1221	1081

mean	555	1110	2475	3583	1365	1108
stdv	50	98	234	183	220	257
num	6	6	6	6	6	6

Table 4.12 Normal Arabic /a:/ Professional Reciters (PR)

R	**F1**	**F2**	**F3**	**F4**	**F3-F2**	**F4-F3**
7	611	1089	2561	3410	1473	849
8	627	1110	2673	3659	1563	986
9	589	881	2507	3480	1626	973
10	627	1087	2521	3427	1434	906
11	546	774	2284	3284	1510	1000
12	600	967	2793	3766	1826	973
mean	600	985	2557	3504	1572	948
stdv	31	136	172	177	141	58
num	6	6	6	6	6	6

Table 4.13 Normal Arabic /a:/ Nonprofessional Reciters (NP)

4.2.7 Comparison of Qur'ānic /a:/ and normal Arabic /a:/ for the Professional and Nonprofessional Reciters.

This section looks at whether there are any significant acoustic differences between Qur'ānic /a:/ and normal Arabic /a:/. The Professional Reciters and the Nonprofessional Reciters are each examined separately. The data being compared are summarised in tables 4.4, 4.5, 4.12 and 4.13 above.

T-tests were carried out on the following pairs of data sets consisting of the formant data for vowel /a:/:-

1. PR Qur'ānic /a:/ vs. PR Arabic /a:/
2. NP Qur'ānic /a:/ vs. NP Arabic /a:/
3. PR Qur'ānic /a:/ vs. NP Qur'ānic /a:/
4. PR Arabic /a:/ vs. NP Arabic /a:/

The following acoustic parameters were tested:- F1, F2, F3, F4, F3-2, F4-F3.

A PDF version of the SPSS session (Compare_Q_and_A_aa_vowel_02.pdf) can be found on the CD-ROM in folder \acoustic_analysis_SPSS\Q_vs_A_aa.

In the following analysis an alpha level of 0.05 has been used. Only significant differences are reported in full below. In all cases statistical results assume equal variances (Levene's test for equality of variances showed no significant differences in variance for any pairs of acoustic parameters shown to be statistically different).

4.2.7.1 Professional Reciters: Qur'ānic vs Arabic /a:/

There was a significant difference for F2 (t=-4.563, sig = 0.000).

- Qur'ānic F2 (PR) mean = 885 Hz (sd = 96.2)
- Arabic F2 (PR) mean = 1110 Hz (sd = 98.3)

That is, for Professional Reciters, Qur'ānic F2 is significantly lower than Arabic F2. F2 is an acoustic correlate of vowel fronting and a lower value indicates greater tongue backing. This suggests that Professional reciters have a more retracted tongue body. This might relate to greater pharyngealisation for the Qur'ānic vowel compared to the normal Arabic vowel.

There was also a significant difference for F3-F2 (t=2.715, sig=0.016).

- Qur'ānic F3-F2 (PR) mean = 1723 Hz (sd = 278)
- Arabic F3-F2 (PR) mean = 1365 Hz (sd = 220)

That is, for Professional Reciters, Qur'ānic F3-F2 is significantly higher than Arabic F3-F2. This value is partly a result of the F3 values above, but the difference between the F3-F2 values was greater and so F3 must also have contributed to this result, even though it is not significantly different for these two varieties of this vowel.

There were no significant differences for the other acoustic parameters.

4.2.7.2 Non-Professional Reciters: Qur'ānic vs Arabic /a:/

There was a significant difference for F3-F2 (t= 2.421, sig = 0.028)

- Qur'ānic F3-F2 (NP) mean = 1778 Hz (sd = 182)
- Arabic F3-F2 (NP) mean = 1572 Hz (sd = 142)

That is, for Non-Professional Reciters, Qur'ānic F3-F2 is significantly higher that Arabic F3-F2. Whilst the differences between Qur'ānic F2 and Arabic F2 and between Qur'ānic F3 and Arabic F3 are not significant they both contribute to the F3-F2 values. A close examination shows only a 50 Hz difference between the means for Qur'ānic F2 (935 Hz) and Arabic F2 (985 Hz) whilst there is a 155 Hz difference between the means of Qur'ānic F3 (2712 Hz) and Arabic F3 (2557 Hz).

There were no significant differences for other acoustic parameters.

4.2.7.3. Qur'ānic /a:/: Professional vs. Non-Professional Reciters

There was s significant difference for F1 (t=-3.103, sig = 0.005)

- Professional F1 (Qur'ānic) mean = 523 Hz (sd = 60.8)
- Non-Professional F1 (Qur'ānic) mean = 591 Hz (sd = 42.9)

That is, Professional reciters have a significantly lower F1 than Non-Professional reciters.

F1 is related to tongue height and higher values of F1 correlate with lower tongue position. These results suggest that Professional reciters have a higher tongue position, than Non-Professional reciters, during the production of pharyngealised Qur'ānic /a:/ vowels.

4.2.7.4. Normal Arabic /a:/: Professional vs. Non-Professional Reciters

There were no significant differences between Professional reciters and Non-Professional reciters, on any of the measured acoustic parameters, when producing /a:/ in normal Arabic. These results suggest that in normal Arabic there is no acoustic distinction between Professional and Non-Professional reciters.

4.2.7.5 Summary of Acoustic Results

Professional Reciters make a significant distinction between Qur'ānic and normal Arabic for both F2 and F3-F2. Non-Professional Reciters only make a significant distinction between Qur'ānic and normal Arabic /a:/ for F3-F2 (but not for F2) during the production of pharyngealised /a:/ vowels. This suggests that Professional Reciters have a stronger pattern of acoustic difference between Qur'ānic and Arabic pharyngealised /a:/ than the Non-Professional Reciters. It is interesting how some of the NPRs have a lower F2 than the PRs while lowering F2 in QPVs is hypothesised to indicate a greater degree of phayrngealisation. It needs to be remembered that F2 also correlates with tongue fronting and so this pattern for NPRs might simply indicate a more backed /a:/ vowel. However, it is also true that highly backed vowels may result in greater degrees of pharyngealisation.

Professional Reciters have a significantly lower F1 than Non-Professional Reciters during the production of Qur'ānic pharyngealised /a:/ vowels. This suggests that Professional Reciters have a higher tongue position for Qur'ānic pharyngealised vowels than Non-Professional reciters. On the other hand, there is a lack of a difference between these two groups for the same sound in normal Arabic.

4.2.8 Statistical Analyses: Discriminant Analysis

4.2.8.1 Discriminant Analysis: /a:/ vowel with all parameters

This section examines a discriminant analysis for the Qur'ānic /a:/ with all acoustic parameters included. In the coding of the statistics the /a:/ vowel is coded as "V1". In this analysis we examine the effect of including F1, F2, F3, F4, F3-F2, F4-F3 and VDur (vowel duration) in the discriminant analysis. The goal of this discriminant analysis is to group reciters into three groups. An ideal discriminant analysis would separate the tokens into the three separate reciter groups based. By including all parameters we can see which parameters are included and which are excluded. It is hypothesized that there will be a reduction of the following parameters, F2, F3, F4, F3-F2, and F4-F3 because two of these parameters are derived from three other parameters.

The results of this procedure resulted in parameters F3-F2 and F4-F3 being removed from the discriminate analysis by SPSS. This has occurred because they are each derived from two of the other parameters (they are redundant). This means that the discriminant analysis is based on F1, F2, F3, F4, and VDur. For full details, please refer to the folder \01-appendices\cdrom_appendix on the CD-ROM included with this thesis.

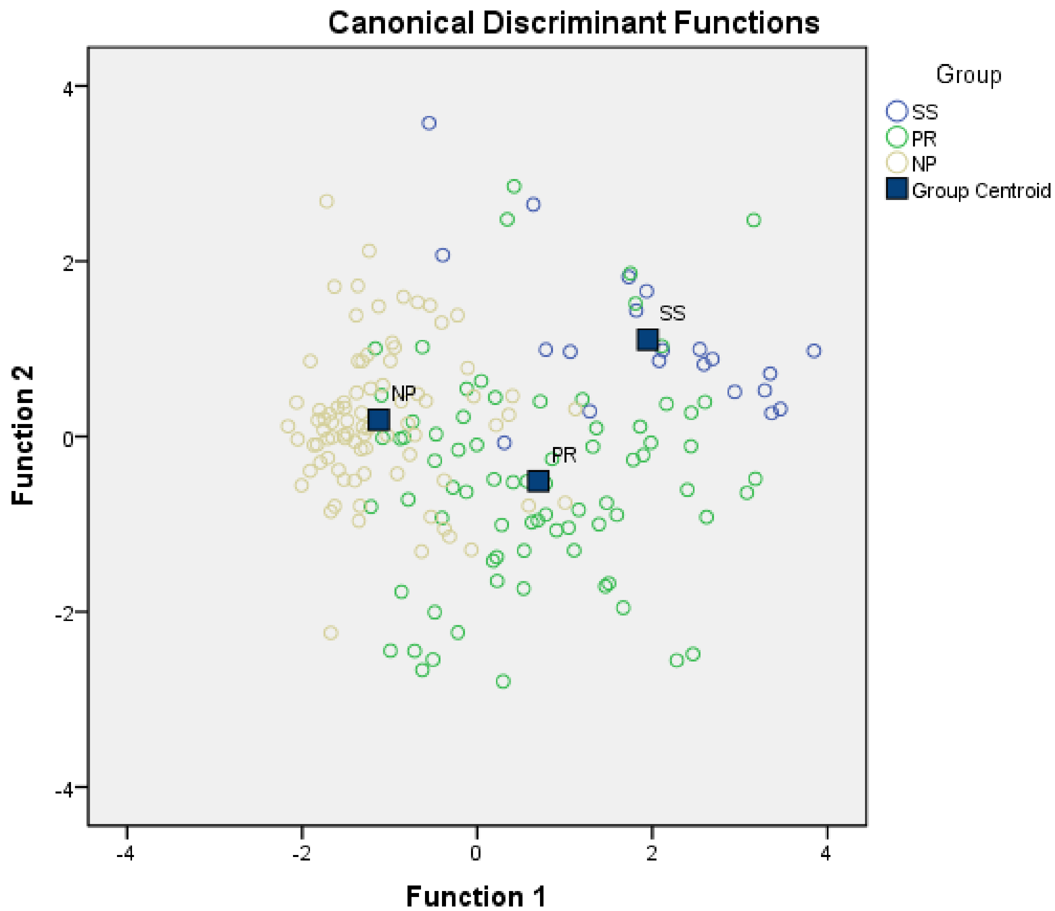

Figure 4.26 This discriminant analysis plot for /a:/ is based on the following submitted parameters:- F1, F2, F3, F4, F3-F2, F4-F3, VDur. SPSS excluded F3-F2 and F4-F3 because they are redundant and because the other combination of parameters best predicted the membership of individual vowels in the correct group.

It can be seen that there is good separation of the three groups although there is a bit of overlap. The most spread out group is the Professional Reciter (PR) group. This probably happens because different PR reciters have different levels of skill and training. Some PR reciters are more like the SS group and some are more like the NP group. There is no overlap between the NP and the SS group.

4.2.8.2 Discriminant Analysis: /a:/ vowel with some parameters removed

In this section we look at the result of presenting to the SPSS Discriminant Analysis software only the following parameters:- F1, F3-F2, F4-F3 and VDur. The idea here is to force SPSS to use the F3-F2 and F4-F3 values instead of F1, F2 F3, F4 and VDur. (Wilks' Lambda sig 0.000)

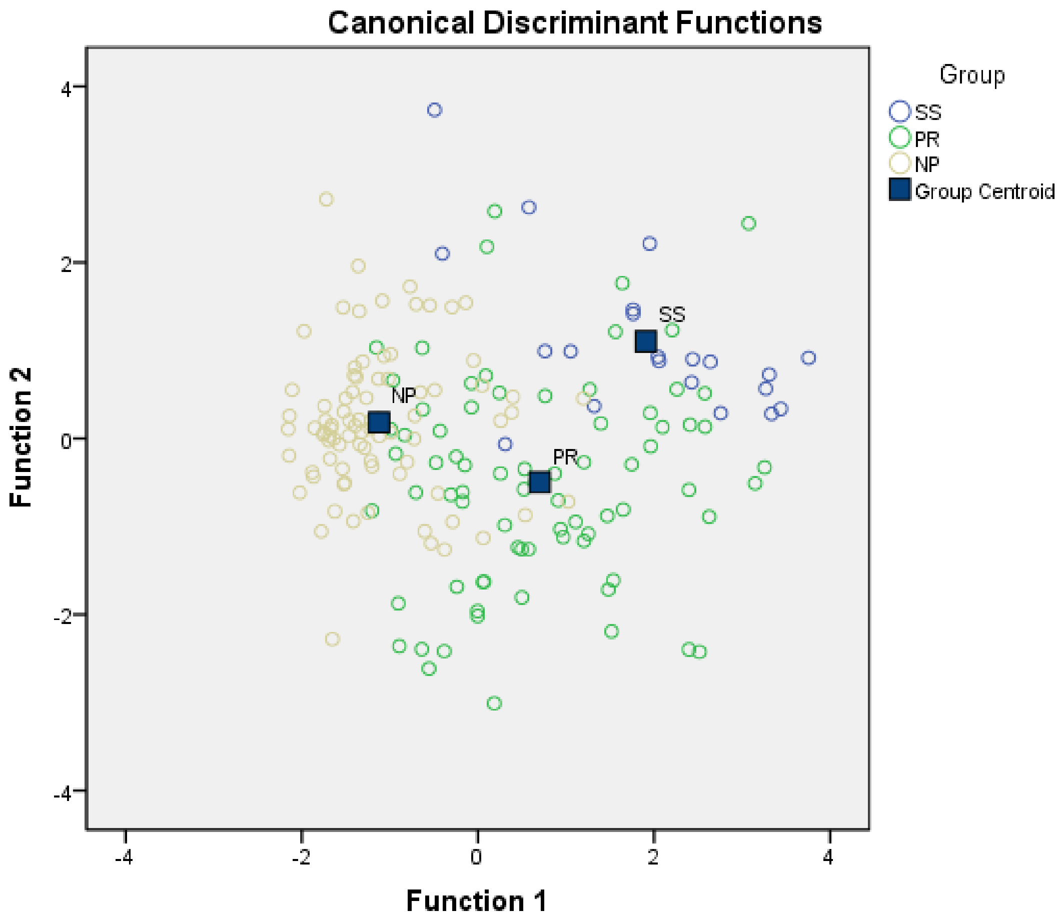

Figure 4.27 This discriminant analysis plot for /a:/ was based on the following submitted parameters:- F1, F3-F2, F4-F3, VDur. All of these remaining parameters are used by SPSS in classifying this data. The result is very similar to the result shown in figure 4.26, but with some slight movement of data points.

4.2.8.3 Discriminant Analysis: /a:/ vowel with VDur removed

In this section we look at whether the formant values alone can separate the three reciter groups. This is important as it can show whether formant values on their own can separate the three groups. In this case the discriminant analysis was carried out with only the F1, F2, F3 and F4 parameters.

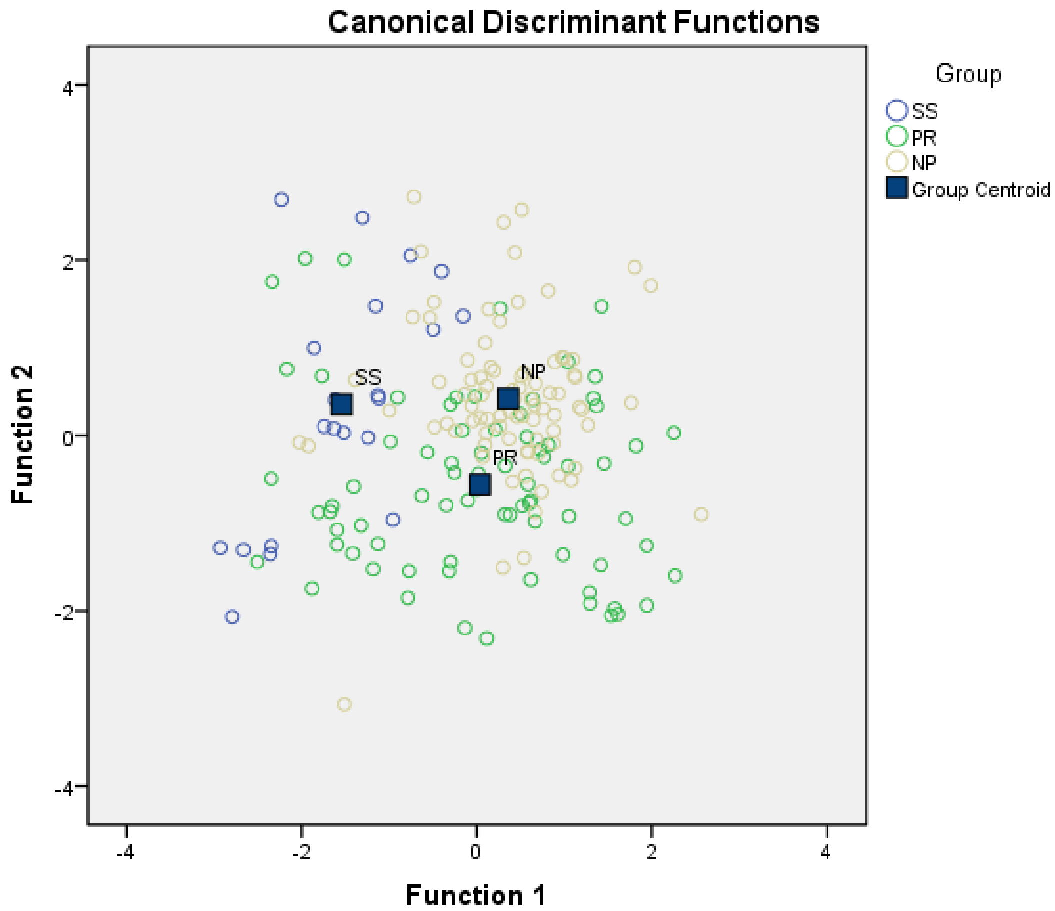

Figure 4.28 This discriminant analysis plot for /a:/ was based on the following submitted parameters:- F1, F2, F3, and F4 (VDur is not included).

Removing VDur still allows some significant separation of the three reciters groups (Wilks' Lambda, sig 0.000), but the group central points are closer together than before and there is more overlap. NP and SS also now overlap a bit whereas they did not when VDur was included. This also allows us to see that a large part of the distinction between the Professional Reciters (PR) and the Non-Professional Reciters (NP) is due to the PR group's control of vowel duration in Qur'ānic recitation.

4.2.8.4 Discriminant Analysis: /i:/ vowel with all parameters

In this section we examine discriminate analysis of Reciter Group for /i:/.

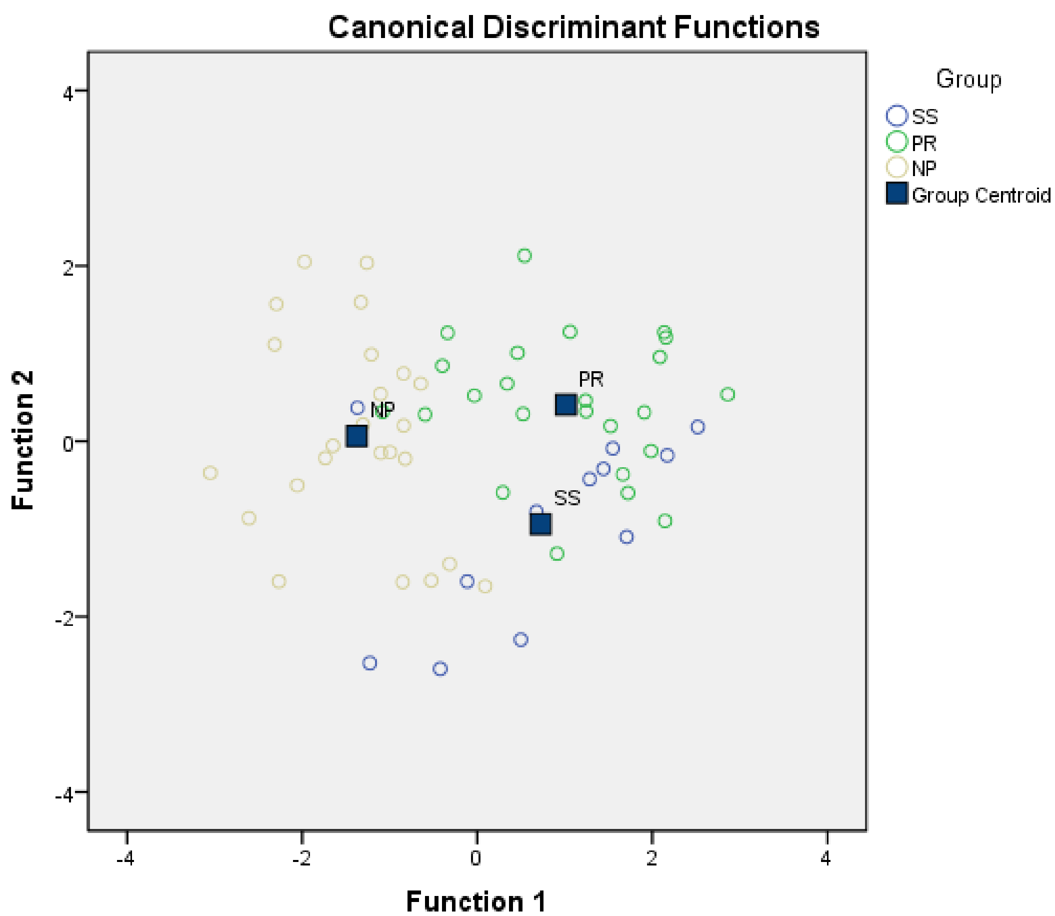

Figure 4.29 This discriminant analysis plot for /i:/ was based on the following submitted parameters:- F1, F2, F3, F4.

Duration was not measured for this vowel, but duration in /i:/ is not considered by TajwīdTajwīd to be as important as it is for /a:/. As was the case with /a:/ the F4-F3 and F3-F2 variables were discarded by the SPSS Discriminate Analysis program as they are redundant (already covered by F2, F3 and F4). These parameters produce a reasonable discrimination of the three reciter groups, but there are some interesting details. For example, there is a single SS data point very close to the NP mean. A Wilks Lambda test (sig 0.000) indicates that the derived functions significantly separate the three groups.

4.2.8.5 Discriminant Analysis: /u:/ vowel with all parameters

In this section we examine discriminate analysis of Reciter Group for /u:/.

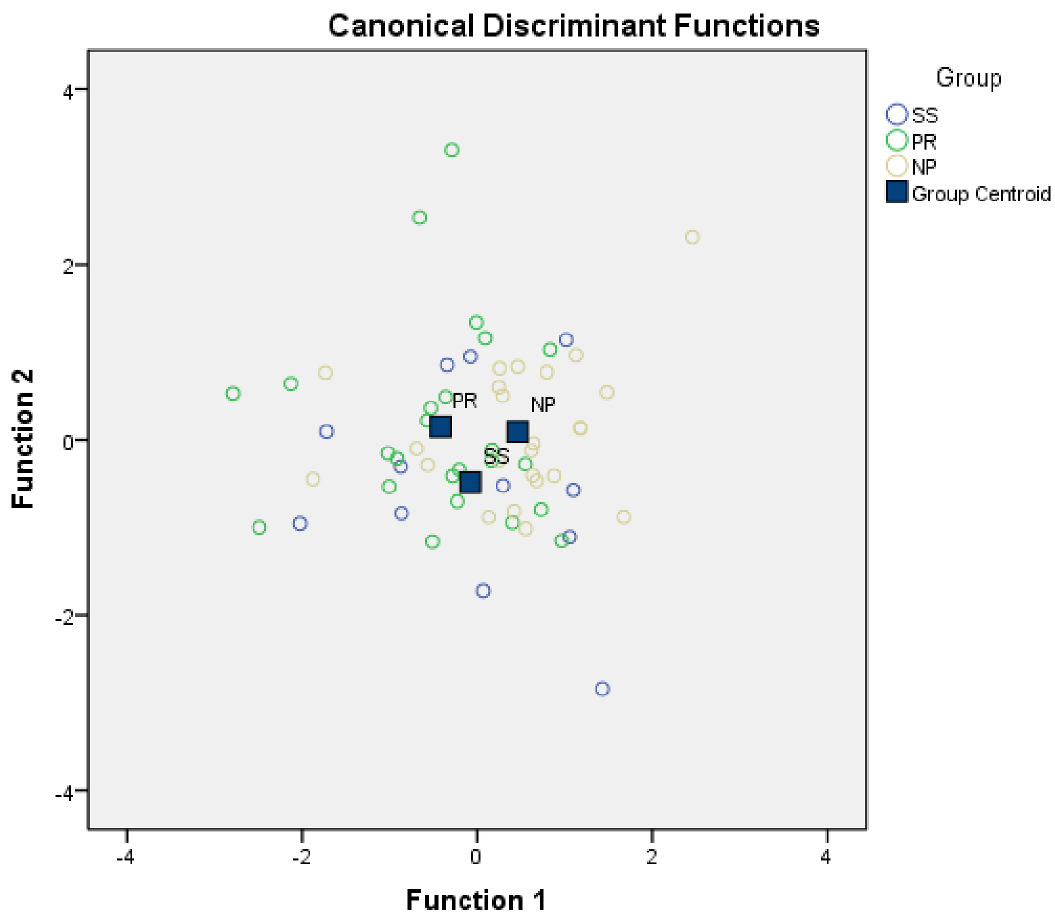

Figure 4.30 This discriminant analysis plot for /u:/ was based on the following submitted parameters:- F1, F2, F3, F4.

Both Wilks' Lambda (0.807, sig 0.156) and Chi-square (11.888, sig 0.156) tests indicate that this discriminant function does not significantly discriminate the three reciter groups.

4.3 Summary of Results

4.3.1 Qur’ānic /a:/

4.3.1.1 Group Effects

1. F1 increases significantly from SS to PR to NP.
2. F2 increases significantly from SS to PR to NP.
3. F3 increases significantly from PR and NP to SS
4. F4 increases significantly from NP to PR
5. F3-F2 increases significantly from PR and NP to SS
6. F4-F3 increases significantly from SS to PR and NP
7. VDur increases significantly from NP to PR to SS

4.3.1.2 Initial Consonant Effect

No significant effects

4.3.2 Arabic /a:/

4.3.2.1 Group Effects

1. F1 no significant effect
2. F2 increases significantly from NP to PR.
3. F3 no significant effect
4. F4 no significant effect
5. F3-F2 increases significantly from PR to NP
6. F4-F3 increases significantly from NP to PR

4.3.2.2 Initial Consonant Effects

No significant effects for Acoustic Measurements and Discriminant Analysis

4.3.3 Qur’ānic /u:/

1. F1 significant effects for three pairs of sounds (dˤu: vs ʁˤu:, tˤu: and qˤu:)
2. No other significant effects for group and sound

4.3.3 Qur'ānic /i:/

1. No significant effects for initial consonant sound.
2. No significant effects for group, except …
   - F2 SS and PR > NP
   - F3-F2 SS > NP
   - F4-F3 PR > NP

4.3.4 Arabic versus Qur'ānic /a:/ and Professional versus Non-Professional Reciters

In section 4.2.7 pairs of data sets were compared. These results showed:-

1. A strong pattern of distinction, for Professional reciters, between Qur'ānic and Arabic pharyngealised /a:/ for F2 (higher value for normal Arabic) and F3-F2 (greater for Qur'ānic Arabic)
2. A weaker pattern of distinction, for Non-Professional reciters, between Qur'ānic and Arabic pharyngealised /a:/ for F3-F2 (higher value for Qur'ānic Arabic) but not for F2.
3. Significant difference, for Qur'ānic /a:/ F1, between Professional reciters (higher) and Non-Professional reciters (lower).
4. No differences, for any acoustic parameters, between professional and non-professional reciters, for normal Arabic /a:/

These results suggest that these Professional reciters and Non-Professional reciters do not differ, for the /a:/ vowel, when speaking normal Arabic, but for Qur'ānic /a:/ there are distinctions between these two groups. These distinctions include lower F1 for Professional reciters when producing Qur'ānic /a:/ and stronger patterns of differences between Arabic and Qur'ānic /a:/ for professional reciters, compared to Non-Professional Reciters.

4.3.5 Relationship Between Acoustic Analyses and Discriminant Analyses

Qur'ānic /u:/ has, with the exception of three pairs of sounds, no acoustic parameters that vary significantly. It is not surprising that discriminant analysis was unable to discriminate the three reciter groups, especially because there are no parameters relating to group that are significantly different for this vowel.

In the case of Qur'ānic /a:/ and Qur'ānic /i:/ there are number of significant group effects seen in the acoustic study. Without these significant group effects it seems extremely unlikely that a successful discriminate analysis could occur.

Some significant group effects occur for Arabic /a:/. As this is normal Arabic and not Qur'ānic recitation it may be possible that these group effects do not pattern in a way that might result in a successful discriminate analysis of reciter groups.

4.4 Conclusion

This chapter has examined pre-defined reciter groups, Super Standard (SS), Professional (PR) and Non-Professional (NP) to determine what are the acoustic correlates of their Qur'ānic recitation and how these recitations vary from normal spoken Arabic. It has also examined the extent to which discriminate analysis can separate reciters into the three reciter groups and which acoustic parameters make that separation possible. It has also been possible to show that the distance between F3-F2 in the Qur'ānic /a:/ vowel sound effectively distinguishes the groups of reciters. The vowel duration also showed a significant effect in in discriminating among the groups in the recitation of the Qur'ānic /a:/. It has been found that it is possible, with the current data, to separate the three reciter groups using discriminate analysis with a reasonably high success rate, but that this only works for certain vowel contexts. The Qur'ānic pharyngealised /a:/ vowel tokens and the Qur'ānic pharyngealised /i:/ vowel tokens have both been separated into separate reciter groups with a good degree of accuracy. On the other hand, the Qur'ānic pharyngealised /u:/ vowel acoustic parameters have not proven able to reliably separate tokens into reciter groups.

What this chapter has not addressed is the extent to which the observed acoustic features (i.e. formants, etc.) are related to specific articulatory patterns and in particular, the extent to which some of these acoustic patterns (e.g. F3-F2) are related to pharyngeal constriction. Chapter 5 will report on a single speaker pilot x-ray study that attempts to relate acoustic patterns to articulatory patterns, in the hope that it can generate hypotheses that can be tested in future research.

CHAPTER FIVE

Articulatory Videofluorography – A Pilot Study

5.1. Introduction

Articulatory phonetic studies of Arabic were carried out as early as the eighth century by Arabic scholars such as Sibawayh and Ibn Jinni. These scholars depended largely, in their descriptions of the manners and places of articulation, on their observations of their own speech.

Recent technologies have permitted greater accuracy and precision in the classification and the description of the Arabic sounds. In Articulatory studies, endoscopies (fiberoptics and stroboscopy), video scanning and imaging including X-rays, Ultrasound, Xeroradiography, Videoflurography and many other experimental techniques have all greatly contributed to our knowledge of Arabic phonetics.

Though introduced more than 100 years ago, X-rays are an still effective tool and are still considered to be one of the most important techniques in examining human speech physiology.

5.2. Experimental Studies of Arabic Pharyngealisation

Arabic pharyngealised sounds have been examined by many experimental studies in the past three decades. Probably, the first linguist who used X-rays for examining the articulation of Arabic and Somali sounds was Panconcelli-Calzia (1920 and 1921, cited by Jacobson, 1957). Panconcelli-Calzia's X-rays were the first to demonstrate a backward movement of the tongue body towards the back wall of the pharynx producing a constriction and a reduction in the size of the pharynx.

The pioneering work of Fant (1960) examined the production of vowels and consonants in Russian by using x-rays, articulatory and acoustic modelling and analog speech synthesis that was based on the results of the x-ray study. This is one of the most influential early studies of the relationship between speech production and acoustics.

Delattre (1965) compared the phonetic features of four European languages (English, French, German, and Spanish). His study consisted of three main aspects, acoustic analysis, acoustic synthesis, and an articulatory study using X-ray motion pictures to investigate the vowels and the consonants of the languages studied. Though his book contained no actual X-ray frames, due to publishing limitations, his schematic illustrations were very effective in capturing and comparing his sounds.

The X-rays of Arabic sounds presented in the study of Delattre (1971), as mentioned earlier in chapter two, showed the systematic articulation of the Arabic uvular sounds /q/, /χ/, and /ʁ/. His X-rays of his Arabic Lebanese informant showed that the articulation of these uvular sounds starts primarily when the tongue retracts horizontally backward and secondarily moves up to make the constriction against the upper part of the pharynx. The difference between /q/ and the other two sounds is that the former goes up toward the pharynx until it reaches a full closure. Delattre was able through his X-rays to present a sound demonstration of what happens in the pharynx during the articulation of the Arabic uvular sounds.

Ali and Daniloff (1972a, 1972b) presented a different view of Arabic uvulars in their cinofluorographic experiments of Iraqi Arabic. They were interested in what they referred to as the R-L and L-R spread of uvularization. Their general findings were not free from contradictions. Their model of L-R spread of uvularization to whole words in Iraqi Arabic was contradicted by the pattern in words such as “Qalb” (heart) where the spread of “uvularization” stops at the beginning of /l/ sound. Ghazeli (1977:147) presents a more convincing solution for the Iraqi words that deviated from the general findings of Ali and Daniloff, such as “Qalb” (heart). Ghazeli (1977:147) states “This uvular consonant, due to its posterior articulation, results in backing adjacent low vowels. In many languages, uvulars induce a lowering and/or a backing effect on adjacent vowels. The presence of a [q] in a language that has pharyngealized consonants does not entail that it should comply to the overall behaviour of these consonants.”

The experimental study of Ghazeli (1977) is a milestone in the experimental investigation of Arabic back coarticulated sounds. He employed a cinoflurographic film experiment examining twelve adults to determine the articulatory correlates of the Arabic guttural consonants. He was interested in the shape and the movement of the tongue, the pharyngeal width, the soft palate movement, and the lip rounding.

He analysed his film by hand using “a frame counter and a single frame advancement mechanism.” (p.28). He was looking for the midpoint of the sound to be captured. His film was focused on lips, jaws, mandible, and the pharyngeal area.

His discussion of the Arabic pharyngealised sounds did not include the Arabic /dˤ/ sound. This was probably because of the mixing and substituting the /dˤ/ sound with the /ðˤ/ sound in the Tunisian dialect that he studied. He presented a detailed discussion of the available names of the Arabic pharyngealisation feature and his preference for naming them coronal pharyngealised consonants and uvular consonants.

His experiments showed that there are a number of Arabic sounds that are articulated in the oropharynx area. These sounds are Arabic uvulars, pharyngeals, and pharyngealised consonants. Ghazeli also pointed out that there are different degrees of constriction for every Arabic sound depending on the nature of the sound and its place of articulation. He also studied the effect of the Arabic pharyngealised sounds on the adjacent vowel. He found that this effect is different according to the adjacent sound and the degree of constriction of the Arabic pharyngealised consonant. In his examination of the spread of the Arabic pharyngealised sounds Ghazeli found (p.175) that “Arabic pharyngealised coronals exhibit an L-R and R-L backing coarticulation that can generally extend over the entire word.”

The coarticulation and spread of the Arabic pharyngealised sounds are somewhat difficult to characterize precisely especially when we have primary and secondary places of articulation and their influence on different vowels.

One of the possible ways to overcome this difficulty is by applying more than one experimental technique to determine the nature of the pharyngealised sound and its exact place and degree of constriction. WidadLaradi (1983) in her investigation of Libyan pharyngealisation applied several kinds of experimental techniques simultaneously to determine the exact nature of her sounds. She was able through her fibreoptic endoscopy, x-rays, xeroradiography, videopfluorography, spectrography, palatography, and labiography to account for the precise nature, place and degree of constriction of Arabic Libyan pharyngealised sounds.

Laradi's study focuses on the articulatory features of pharyngeal, uvular and the pharyngealised consonants of Libyan Arabic and the extent to which they are related to or different from e ach other. She also traced the movement of the epiglottis from its rest position to the highest position against the root of tongue that it can reach during the articulation of the /i:/, /a:/, and /u:/ vowel sounds. She found (p290) that “The root of the tongue is in contact with the epiglottis only at the top edge, though in the endoscopic films, the tip of the epiglottis is usually a little distance away from the root of the tongue.”

Laradi (1983) also found that there was no significant correlation between the tongue root retraction and the forward movement of the back wall of the pharynx. She attributes previous findings of the shape and measurements of other authors to the vertical measurements of the pharyngeal area which were unable to show whether it is the back wall or the side wall of the pharynx that is moving forward or backward and responsible for the pharyngeal constriction. Laradi (1983:303) concludes her discussion on the movement of the back wall of tongue saying “One can only conclude that constrictions of the pharynx are mainly achieved by the by the projection back-wards and in certain cases upwards of the tongue.”

In her discussion of the exact phonetic properties of the pharyngealised sounds, Laradi (1983) interprets the results of the contemporary treatments prior to her work, and says that these studies suggested that “all the consonants can be phonemically pharyngealised and non-pharyngealised with the vowels being retracted in the environment of the pharyngealized consonants.” She rejects this idea about Arabic pharyngealisation simply because it increases the number of Arabic pharyngealised consonants. She expresses her agreement with Ghazeli (1977) when he mentioned (p.133) that some alleged pharyngealised sounds are “pseudo-pharyngealised consonants”. Gazeli and Laradi’s main argument here is that we cannot consider any consonant as pharyngealised simply because it is followed by an /a:/ sound. Consequently, Laradi (1983:234) believes that Arabic pharyngealised sounds, generally, “exhibit certain characteristics which are more or less attested by phoneticians and linguists.”

The review of the aforementioned experimental studies shows that the main significant finding of experimental investigations of the Arabic pharyngealised sounds is the projection of the tongue towards the back wall of the pharynx. It is clear that the constriction of the back of the tongue is a key issue in the study of these sounds. The spread of the effect of Arabic pharyngealisation (L-R, R-L) forms a significant indication of the intensity of the pharyngealisation and its effect on the adjacent sounds. It is also clear that the focus of the aforementioned studies was on the Arabic dialects. This is why some Arabic and Qur'ānic pharyngealised sounds such as (/dˤ/, / χˤ/) were not discussed as they are not obvious in those dialects. When he discussed the classical Arabic / dˤ/ sound, Ghazeli (1977:6) stated "This sound, to my knowledge, no longer exist as described by the Arab grammarians." /tˤ/, /dˤ/, / Sˤ/,/ðˤ/,/χˤ/, /qˤ/, and /ʁˤ/

Every one of the aforementioned experimental studies has its own weak and strong points. However, this researcher agrees with the views of Ghazeli(1977:3) that "the contribution of these studies to Arabic phonetics and phonology are so valuable that it seems rather churlish to criticize them." Though they have an important role in phonetic research, normal x-rays and still images cannot reveal the dynamic nature of the articulated sounds. Endoscopic experiments are very useful in the way they reveal the exact nature of a given articulation but they only provide a single perspective. If they are optimised for revealing the vertical configuration of an organ, they are unable to reveal the precise horizontal dimensions. Xeroradiographies were useful for revealing the borders of the investigated organ as the x-ray was printed out on normal paper. Though the result is a clear x-ray, it is not a dynamic x-ray that can reveal the different places of articulation when they are simultaneously coarticulated. Normal x-rays in phonetic experimental studies have their own risks for unavoidable apparent displacements of the investigated articulators. If the x-ray room is not equipped with a stationary headrest then the differences in the head positions from one frame to another may lead to a misunderstanding of the real positions of the articulators. These misunderstandings are described by Perkell (1969:8) as "…slight shifts in the positions of the structure, to slight movement of the vertebra relative to one another, and to a lack of consistency in the X-ray beam and the resulting image."

Acoustic spectrography is also useful in displaying the spectrum of a sound, from which articulatory gestures can be implied. However, acoustic analysis cannot stand alone to precisely indicate the articulatory properties of a given sound. The current experimental study is based upon the idea that the acoustic correlates of a sound should correlate with its articulatory properties. There is a major debate around this point but as IbnMuqbil (2006:8) puts it "It has been shown in various seminal works that the different configurations assumed by the vocal tract correspond to systematic acoustic output."

Accordingly, this preliminary single speaker experimental study intends to relate the results of the articulatory findings with the acoustic correlates of the same sounds in order to provide hypotheses for a possible future multi speaker study.

There are many experimental techniques that have been developed to test specific aspects of speech production, such as palatography, and labiography. A review of the available experimental studies shows that they each have their own merits and limitations. There is no specific experimental methodology that can stand alone to reveal a complete account the exact nature of a given sound. A better solution is to examine a speech sound from multiple perspectives in order to obtain a more complete and accurate result. An example of this is the combination of an acoustic and an articulatory experiment in the investigation of a given sound.

All of the aforementioned articulatory studies are related to dialectal Arabic and none of them discussed Standard Arabic or any of the Qur'ānic sounds that this current research is interested in. The researcher is not aware of any phonetic experimental investigation that has investigated any of the Qur'ānic pharyngealised sounds.

This research intends to investigate the Qur'ānic pharyngealised sounds through an articulatory and an acoustic analysis. The articulatory experiment in this chapter will make use of a videofluorographic experiment to trace the different places of articulation of the Qur'ānic pharyngealised sounds including the primary and secondary articulations.

5.3 Single Speaker X-ray Analysis of Pharyngeal Constriction During Pharyngealised Qur'ānic Vowels

This x-ray study is based on data collected from a single subject (the author). For this reason it cannot be considered to be an exhaustive study of the relationship between articulatory patterns and acoustic measurements for pharyngealised vowels. The acoustic data collected at the same time as the x-ray images is not intended to stand alone and the reader should refer to chapter 4 for the main acoustic study. What is examined here is the relationship between the main measured physiological parameter, pharyngeal constriction in the vicinity of the C2 vertebra, and the acoustic (formant) data collected simultaneously with the x-ray data.

5.3.1 Methodology

5.3.1.1 Production of X-Ray Video, X-Ray Still Images, and X-Ray Audio

A single adult male professional reciter (the author) read from a script whilst being x-rayed in a hospital radiology department. Barium meal was applied to the tongue and the lips in order to ensure the best possible visibility of the tongue and lips. The x-ray sequence was videoed using a VHS video camera at a frame rate of 30 frames per second (available digital x-ray video technology only has a maximum frame rate of about 2 frames per second). It proved impossible to transfer the video directly to digital format, frame by frame, because of compatibility issues between the produced video cassette and various video players available outside the hospital. Therefore the movie was transferred by the less desirable method of projecting onto a wall and the projected image recorded into a digital format. This resulted in images that were not of perfect quality, but were nevertheless of sufficient quality for the analysis described here. Simultaneous to the video recording, was a digital recording of the speech produced. At the beginning and end of the recording the reciter produced three alveolar clicks that were both audible and visible and were used in the synchronisation of the video and audio. The video and audio tracks were carefully synchronised using Sony Vegas Pro 9 video editing software. Once the audio was synchronised with the video, so that the beginning and end of the audio exactly matched the beginning and end of the video, a separate copy of the aligned audio track (without leading or trailing tape) was also produced for the purposes of spectral analysis. Also, using the Sony Vegas Pro 9 software, numerous still images were extracted from the video and the processing of those still images is outlined below.

A copy of both the full video as well as the time synchronised, but separate, audio track are supplied on CD-ROM with all official copies of this thesis.

5.3.1.2 An Explanation of Certain Visual Features in the X-Ray Video Images

In figure 5.1 we can see that the two rows of teeth (A and B) furthest from the x-ray machine are lower down on the image than the two rows of teeth (C and D) closest to the x-ray machine. This occurred because the x-ray machine was aligned a bit lower than the mouth, and angled upward a bit, so that the more distant teeth appeared below the level of the closer teeth from the perspective of the x-ray machine. That is, we can see the more distant teeth apparently below the closer teeth for both the upper and lower teeth.

The reason why A and D are darker than B and C is that the x-rays that pass through A and D also pass through B and C so more x-rays are absorbed and the image is darker, whilst the x-rays passing through the tips of the C teeth and through the tips of the B teeth only pass through that one row of teeth.

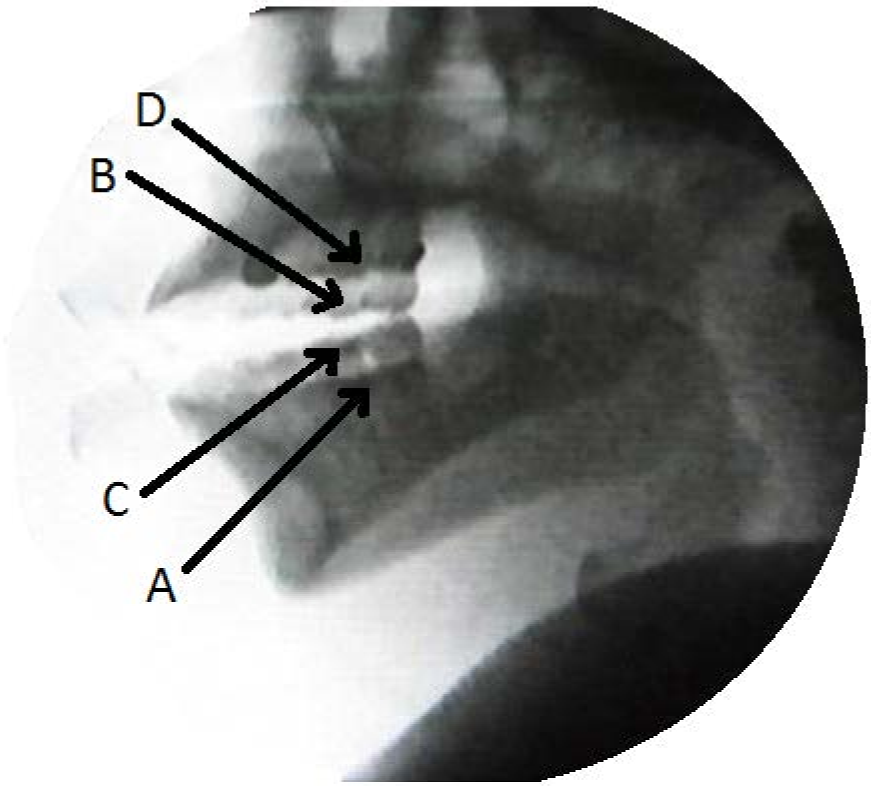

Figure 5.1 A and B indicate the two rows teeth on the right side of the face which is the side of the head furthest from the x-ray machine. C and D indicate the two rows of teeth on the left side of the face which is the side of the head closest to the x-ray machine.

This alignment of the x-ray camera might have a slight effect on the visual measurement of constrictions above the top surface of the tongue but should have no effect on the visual measurement of pharyngeal constrictions.

5.3.1.3 Procedure for Converting Distances on Printed X-Ray Images to Real World Distances

Figure 5.2 shows the reference point on the x-rays that can be used for converting distances on the x-ray to distances in the speaker's mouth. The front to back length of the left lower teeth, ignoring the curve of the teeth, was measured directly for this speaker and was found to be 51 mm. The still x-ray images selected for the following analysis were each printed out, to the same scale, and the front to back distance of the of the left lower teeth was measured from these images. This distance (call it "X") was consistent across all of these images. In order to convert a measurement of a physiological distance (call it "Y") a measurement was made in mm from each of these images and was converted to a real world measurement using the formula:- D = Y * 51/X (where "*" means times)

Figure 5.2 The Lines superimposed on this image indicate the full length, in a straight line from front to back, of all the teeth in the left side lower jaw (ignoring the curve of the teeth).

5.3.1.4 Various Reference Points on the X-Rays

In order to capture the outline of the lips barium meal was applied, but in spite of this it has not been possible in all cases to determine the position of the lips, and in a small number of cases only one lip has been identified. The position in the pharynx where the “P” symbol appears is also the location of where the measurements of pharyngeal constriction have been made in this study.

In a number of cases in the following analysis it is not always obvious from a printed image exactly where the back wall of the pharynx is, but this is clearer in the x-ray movie and so the still pictures together with the movie were used in deciding the exact location of the back wall of the pharynx.

In Figure 5.3, graphical outlines have been added to the images to clarify the position of various physiological features and codes have been added to indicate the lips (“L”), the top surface of the tongue body (“TB”), the velum (“V”), the bulge of the epiglottis (“E”) , the pharynx (“P”) and the second cervical (C2) vertebra (“2”).

The C2 vertebra is a major reference point for locating the predicted point of maximal oropharynx constriction.

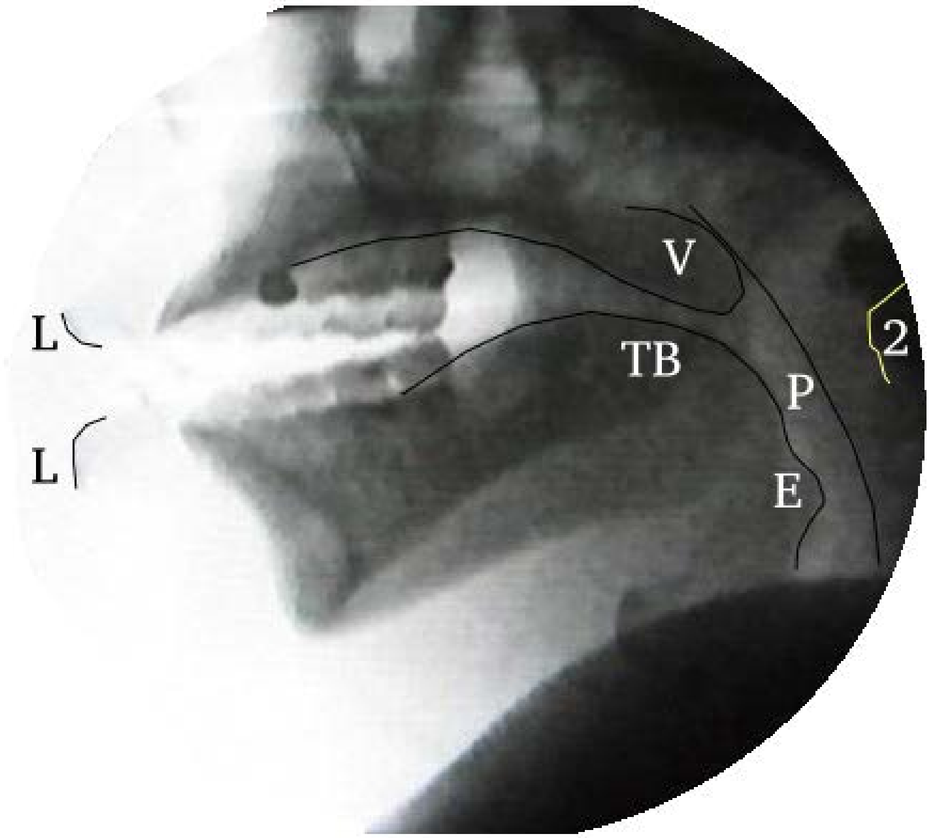

Figure 5.3 The lines superimposed on this image have been added by hand and show the outline of the lips ("L"), the top surface of the tongue body ("TB"), the velum ("V"), the bulge of the epiglottis ("E") , the pharynx ("P") and the second cervical (C2) vertebra ("2").

5.3.1.5 Acoustic Analysis

An acoustic analysis was carried out, using the software package MU-spectra (R. Mannell, Macquarie University). Formants F1, F2, F3, F4 and formant differences F3-F2 and F4-F3 were carried out.

5.3.1.6 Visual Analysis

A visual analysis was carried out of the x-ray movie sequences and a description of each syllable is provided below.

5.3.2 Results

5.3.2.1. Description of X-ray Articulatory Patterns

The following articulatory descriptions have been produced by close observation of the articulator movements in the x-ray movie of the Qur'ānic pharyngealised sounds.

1. **qˤa:** Velar/uvular closure occurs during consonant. Tongue drops vertically to create an opening between the tongue and velum/uvula. Pharynx has slightly more constriction during consonant and transition but constriction reduces a little (becomes more open) about 20% into the vowel. Velum stays closed for whole syllable.
2. **sˤa:** Tongue tip fricative stricture occurs during consonant. Tongue body doesn't drop during transition as there is no velar/uvular closure during the consonant. Tongue body has a pharyngeal constriction (approximant stricture). Velar/uvular tongue constriction is greater than the pharyngeal constriction during the syllable. Constriction reduces (opens) a little about 20% into the vowel. Velum stays closed for syllable.
3. **χˤa:** Velar/uvular closure during consonant. Fricative stricture must be present as a fricative is produced, but the opening is not evident in the x-ray and may be a hidden medial groove. The pharynx is a bit more constricted during the consonant but becomes slightly more open during the consonant vowel transition.
4. **ðˤa:** Tongue tip fricative stricture occurs during this interdental consonant. Uvular approximant stricture also occurs during consonant. Pharyngeal constriction is consistent throughout consonant and vowel.
5. **dˤa:** Very similar pattern toðˤa:but not interdental.Difference between consonant apical alveolar stop stricture of dˤa: and consonant apical dental fricative stricture of ðˤa: is not visible in the x-rays.
6. **tˤa:** A very similar visual pattern to dˤa:
7. **ʁˤa:** The initial fricative stricture spreads across almost the whole soft palate to the bottom of the uvula. The fricative stricture is not visible on the x-ray so the pattern resembles stop stricture. The uvula is closed throughout. During the transition to the vowel the body of the tongue rolls down so that the stricture becomes a uvular and then

the back of the oral cavity opens. By this point the vowel pharyngeal stricture is achieved and is maintained steadily through the vowel.

8. **ʁˤi:** The initial part of this syllable is similar to 7 above. Before the release of the consonant the tongue is retracted and the back of the tongue creates a pharyngeal constriction. As the consonant is released the tongue body moves forward and up to create the front vowel gesture and at the same time the forward movement of the tongue body greatly increases the distance between the back of the tongue and the back of the pharynx. Velum is closed throughout.
9. **tˤi:** During the /t/ occlusion the tongue tip can be seen in contact with the alveolar ridge. At the same time there appears to be contact (stop or fricative constriction) between the back of the tongue and the bottom of the uvula. At that point there is a typical pharyngeal constriction adjacent to the C2 vertebra. The tongue body then moves forward and up to the /i:/ vowel target. Velum is closed throughout.
10. **qˤi:** The consonant consists of contact between the body of the tongue and most of the soft palate including the tip of the uvula. There is a typical pharyngeal constriction adjacent to the C2 vertebra. The tongue body then moves forward to the /i:/ vowel target. Velum is closed throughout.
11. **dˤi:** This commences with alveolar tongue contact and a simultaneous tongue body constriction adjacent to the C2. The tongue then moves forward to the /i:/ vowel target. Velum is closed throughout.
12. **qˤu:** During the consonant the tongue body is in contact with most of soft palate and uvula. There is also pharyngeal constriction. Tongue moves slightly forward and down to produce u:. Velum is closed throughout.
13. **sˤu:** During sˤthere is an alveolar fricative tongue gesture simultaneous with a uvular approximant constriction and a pharyngeal constriction. For the vowel the tongue body raises and moves forward to the soft-hard palate boundary to produce the high back vowel gesture. Velum closed throughout except for transition into following /m/
14. **ðˤu:** Interdental primary stricture occurs plus uvular secondary stricture and pharyngeal constriction with closed velum. Dental tongue tip gesture is very fast and brief. Velum opens for following /n/.

15. **dˤu:** Primary alveolar stop stricture with secondary approximant stricture occurs for most of soft palate and all of the velum and uvula. Tongue body drops slightly to produce u: vowel. Velum closed throughout.
16. **tˤu:** Alveolar stop stricture occurs plus retracted tongue body with the tongue body closest to the closed uvula. There is also some pharyngeal constriction. This is followed by vowel stricture along the length of the soft palate and uvula (still closed).
17. **ðˤu:** Dental fricative stricture is not obvious. Tongue body is raised to produce approximant stricture along the whole length of the soft palate including the uvula.
18. **xˤu:** Mostly approximant stricture occurs along the soft palate with fricative stricture near the front of the soft palate. Velum is closed.
19. **qˤā** Stop stricture for whole soft palate including uvula. Vowel with approximant stricture for most of soft palate including all of the uvula. Pharyngeal constriction for vowel.
20. **sˤā** Simultaneous primary alveolar fricative stricture and secondary uvular approximant stricture, with some pharyngeal constriction. Increased pharyngeal stricture during vowel plus continuing consistent degree of uvular constriction.
21. **xˤā** Visible fricative stricture between tongue body and soft palate, especially the soft palate. Tongue a bit lower for vowel and increased pharyngeal stricture (compared with preceding consonant).
22. **dˤā** Secondary uvular approximant stricture accompanying primary dental constriction. Pharyngeal constriction increases relative to preceding consonant.
23. **tˤā** Strong secondary uvular approximant constriction accompanying primary alveolar stop constriction. Uvular and pharyngeal constrictions during vowel.
24. **ðˤā** Consonant has primary dental fricative constriction and a secondary uvular approximate constriction. Vowel maintains uvular constriction but has increased pharyngeal constriction (relative to the consonant).
25. **ʁˤā** Has tight uvular constriction which presumably is of fricative stricture. The fricative stricture isn't visible but the audible voiced fricative indicates that the stricture is fricative. During the vowel the uvular constriction is visible and there is pharyngeal constriction.

In this table, and elsewhere, a: represents the long Qur'ānic pharyngealised (QPS) vowel and ā represents the long non-Qur'ānic (non-QPS) vowel following pharyngealised consonants.

5.3.2.2. Acoustic Data and Pharyngeal Constriction

Full details of the analysis of the x-ray data, including all relevant still images, and associated acoustic data, can be found in appendix 3. Table 5.1 summarises the acoustic and physiological data taken from the x-ray video.

Image	**Syllable**	**Position**	**F1**	**F2**	**F3**	**F4**	**F3-F2**	**F4-F3**	**PhCons**
1	/qˤaː/	9.967s	570	950	2740	3220	1790	480	12.4
2	/sˤaː/	14.667	560	950	2730	3110	1780	380	10.8
3	/xˤaː/	20.167 s	560	880	2750	3100	1870	350	10.8
4	/ðˤaː/	25.933s	560	910	2860	3210	1950	350	9.3
5	/dˤaː/	33.267s	560	730	2780	3200	2050	420	4.5
6	/tˤaː/	42.333s	650	730	2720	3200	1990	480	7.7
7	/ʁˤaː/	47.767s	560	750	2710	3150	1960	440	9.3
8	/ʁiː/	56.600s	210	2600	3000	3710	400	710	29.4
9	/tˤiː/	61.000s	260	2420	3120	4600	700	1480	34.8
10	/qˤiː/	65.467s	220	2460	3120	4600	660	1480	32.5
11	/dˤiː/	70.667s	210	2460	3120	4200	660	1080	30.1
12	/qˤuː/	75.467s	310	590	2830	3250	2240	420	16.2
13	/sˤuː/	82.767s	260	650	3060	4030	2410	970	17.0
14	/ðˤuː/	85.533s	300	700	2080	2960	1380	880	15.5
15	/dˤuː/	90.600s	450	680	2510	2950	1830	440	10.8
16	/tˤuː/	93.467s	350	600	2710	3380	2110	670	14.7

17	/ðˤuː/	99.433s	280	460	2480	3440	2020	960	18.5
18	/xˤuː/	103.100s	330	590	2730	3800	2140	1070	18.5
19	/qˤā/	111.233s	640	900	2480	3310	1580	830	7.0
20	/sˤā/	111.800s	630	950	2630	3220	1680	590	7.7
21	/xˤā/	118.133s	600	830	2570	3160	1740	590	9.3
22	/dˤā/	119.067s	560	750	2640	3170	1890	530	8.5
23	/tˤā/	121.533s	570	820	2690	3630	1870	940	7.0
24	/ðˤā/	123.667s	550	780	2670	3820	1890	1150	7.7
25	/ʁˤā/	126.533s	600	960	2630	3160	1670	530	10.8
14B	/lā/	88.267s	300	630	2400	3220	1770	820	20.1
17A	/li/	97.600s	380	2350	2700	3280	350	580	31.7
13A	/muː/	83.533s	300	620	2240	2910	1620	670	19.3
14A	/nuː/	87.000s	300	630	2430	3240	1800	810	24.7

Table 5.1 Images 1 to 25 have provided data for pharyngealised vowels. The bottom 4 rows (with numbers ending in A or B) are taken from non-pharyngealised vowels interspersed amongst the other tokens. “Position” is the location in seconds, in the video, of each of the analysed vowel tokens. Formant values (F1, F2, F3, F4), formant differences (F3-F2 and F4-F3) and the size of the pharyngeal constriction in millimetres (PhCons) are in the other columns.

5.3.2.3 Comparison of Unpharyngealised and Pharyngealised Vowels

The last four rows in table 5.1 are unpharyngealised versions of the three vowel qualities [i], [a] and [u]. This very small selection of vowels, from a single reciter, is not sufficient to make any definite conclusions, but the following observations can be made very tentatively.

1. The /u:/ vowels in unpharyngealised syllables /muː/ and /nuː/ have pharyngeal constrictions respectively of 19.3 and 24.7 mm. All of the pharyngeal constrictions for the /u:/ vowel in syllables commencing with a pharyngealised consonant are more constricted at the pharynx (10.8 to 18.5mm), than for the two /u:/ vowels in non-pharyngeal contexts (19.3 and 24.7).
2. The pharyngeal constriction for /lā/ is 20.1 mm. The pharyngealised syllables with the vowel /a:/ have pharyngeal constrictions ranging from 4.5 to 12.4 mm and the pharyngealised syllables with the vowel /ā/ have pharyngeal constrictions ranging from 7.0 to 10.8 mm. That is, the pharyngeal constriction is greater (smaller distance) for both categories of [a] vowel than is the case for the single unpharyngealised example of /lā/.
3. The single Unpharyngealised example of an [i] vowel in /li/ has a pharyngeal constriction of 31.7 mm while the [i] vowels in the context of a pharyngealised consonants have pharyngeal constrictions of 29.4 to 34.8. In other words, the /i/ vowel in unpharyngealised context has a similar pharyngeal constriction to the /i:/ vowels in pharyngealised contexts.

These very tentative results suggest that, for the present data, /u:/, /a:/ and /ā/ vowels, but not /i:/ vowels, are pharyngealised when preceded, in the same syllable, by a pharyngealised consonant. A larger number of preceding unpharyngealised consonants needs to be examined to reinforce these tentative results, but this creates the problem of requiring a longer, and less safe, period of x-ray video data acquisition.

Vowels in the context of the plain cognates are not addressed in this study as this research focusses upon the Qur'ānic pharyngealised vowels and consonants. It is, however, acknowledged that the analysis of the acoustics of these vowels in the contexts of the plain cognates of the pharyngealised consonants can provide additional tokens against which the QPRs can be contrasted. Such analysis was not carried out in the study as this would have greatly increased to scope of the research and the time required to complete the research. Many Arabic studies have concentrated on the the other Arabic sounds in general, but there is no inclusive study that studied the seven Qur'ānic pharyngealised sound /tˤ/, /dˤ/, / Sˤ/,/ðˤ/,/χˤ/, /qˤ/, and /ʁˤ/. Whilst many studies of Arabic pharyngealisation studied the Arabic system of pharyngealisation in general, this study focuses on the traditional phonetic system of Qur'ān.

5.3.2.4 Correlations between Pharyngeal Constriction and Formant Data

Here we examine the correlation between Pharyngeal Constriction (PhCons) and selected formant data for the three groups of syllables containing the vowels /a:/, /ā/ and /u:/. Syllables containing the vowel /i:/ are excluded because (a) there are only 4 instances of this vowel (the other vowels have 7 distinct instances each) and (b) pharyngeal constriction is not contrasted in pharyngealised versus non-pharyngealised contexts.

Pearson Correlations were carried out for Pharyngeal Constriction (PhCons) against each of F1, F2, F3, F4, F3-F2 and F4-F3, for each of the vowels /a:/, /ā/ and /u:/. Data was pooled for consonant context as visual examination of the xrays showed no variation in constriction based on consonant context and also the main acoustic study showed no effect for consonant context. There were only three significant correlations. They were:-

1. /a:/ PhCons vs. F2 Pearson Correlation = +0.804, Sig. (2 tailed) = .029, N = 7
2. /a:/ PhCons vs. F3-F2 Pearson Correlation = -0.902, Sig. (2 tailed) = .005, N = 7
3. /u:/ PhCons vs. F1 Pearson Correlation = -0.841, Sig. (2 tailed) = .018, N = 7

Correlations 1 and 2 are related as an increase in F2 results in a decrease in F3-F2. So, as the pharyngeal constriction becomes smaller (more constricted), then F2 becomes lower (and F3 a little bit higher) and so F3-F2 becomes greater.

Correlation 3, for the vowel /u:/, suggests that as F1 decreases (higher vowel tongue position) pharyngeal constriction increases (more constricted). In other words, as /u:/ becomes less like /a:/ by becoming higher in the mouth (lower F1 correlates with higher vowel tongue position) it becomes more pharyngealised. Perhaps lower /u:/ vowels are too much like /a:/ and so lower /u:/ vowels are distinguished from /a:/ by having less pharyngeal constriction.

5.4 Conclusions of the X-ray Study

These results relate specifically to the vocal behaviour of this reciter and it is not possible to say with certainty that these results generalise across reciters. However, this reciter is fairly typical acoustically of professional reciters and the process of reciter training would be likely to reduce interpersonal variation amongst professional reciters.

For this reciter:-

1. There is no significant and consistent tighter pharyngeal constriction for /i:/ in the context of a pharyngealised consonant.
2. Increased F3-F2 is the most reliable acoustic predictor of tighter pharyngeal constriction for the vowel /a:/.

Decreased F1 (higher vowel) correlates with tighter pharyngeal constriction for the /u:/ vowel. This suggests that tighter pharyngeal constriction for /u:/ might be related to vowel height with higher /u:/ vowels (in the context of a pharyngealised consonant) having tighter pharyngeal constriction. As mentioned in section 5.2, Laradi (1983:303) noted that “constrictions of the pharynx are mainly achieved by the projection back-wards and in certain cases upwards of the tongue”. Projection upwards of the tongue is correlated with lower F1, and this is what is observed for /u:/ in this experiment.

5.5 Relating the X-ray Data to Chapter 4 Acoustic Data

Chapter 4 examined the relationship between various acoustic measures (F1, F2, F3, F4, F3-F2, F4-F3, VDur) and two additional dimensions, (a) Qur'ānic vs normal Arabic and (b) Reciter Group (Super Standard SS, Professional PR, and Non-Professional NP). The Qur'ānic /Arabic dimension was only examined for the vowel /a:/ whilst the Reciter Group dimension was examined for all three vowels, but only for Qur'ānic tokens.

The x-ray study has the advantage of having explicit measurements of actual pharyngeal constriction dimensions and these can be related to the acoustic data taken at the same points in time to each of the x-ray images. The x-ray study has the disadvantage of only having a single subject from only one reciter group (the Professional, "PR", group). More x-ray data needs to be collected from more participants covering more than just the PR group. The x-ray study examines vowels in both pharyngeal and non-pharyngeal contexts.

The acoustic study also has the advantage of covering all three monophthong vowel qualities of Arabic (/i:/ /a:/ and /u:/, but ignoring the short versions of these vowels). There is, however, no explicit measure of pharyngeal constriction in the acoustic study. In the next section we will examine a strategy for determining likely (implicit) degrees of constriction in the acoustic data.

5.5.1 Implicit Degrees of Pharyngeal Constriction in the Acoustic Study

It has been argued in a number of places in this thesis that one of the goals of TajwīdTajwīd training is to produce a certain consistent degree of pharyngealisation for each of the three long monophthong vowels /i:/ /a:/ and /u:/ in the context of certain preceding consonants. Further, the goal is to maintain the pharyngealisation across the whole length of the vowel, rather than to have pharyngealisation decrease gradually or rapidly across the following vowel as might be expected in normal Arabic.

A closer analysis of the acoustic data (all participants) and videophluroscopic data (one participant) indicates that reciters very quickly moved from a brief initial transitional phase to a very acoustically stable period and in one subject the x-ray data also had a brief transition followed quickly by a stable period of articulation. In both cases, these patterns are hypothesised to be related to pharyngealisation in each pharyngealised vowel. This pattern of Qur'ānic pharyngealisation is best achieved by the SSRs and then by the PRs and finally by the NPRs.

This indicates that the better trained a reciter is in TajwīdTajwīd the more likely that reciter is to achieve and maintain pharyngealisation across the length of the syllable. This aspect of the data has not been reported in detail in this thesis, but will be reported on in more detail in the future.

The following three hypotheses are based on these assumptions.

1. Degree of pharyngealisation will decrease (constriction will become more open) from Superstandard (SS) to Professional (PR) to Non-professional (NP) reciters. So, for example, PR reciters will produce more pharyngealised vowels (greater degree of pharyngeal constriction) than NP reciters, for the relevant consonant contexts. This would predict a greater degree of constriction for PR vs NP reciters.

2. The distinction, in hypothesis 1, between PR and NP reciters would only occur in Qur'ānic contexts and not in normal Arabic contexts.

3. The degree of pharyngealisation in the middle of a vowel in a pharyngealised or uvular context will be greater for Qur'ānic vowels than for normal Arabic tokens. This is because (a) pharyngealisation is more transitional in normal Arabic and tends to decrease further away from the preceding consonant, and (b) a goal of TajwīdTajwīd is to produce clearer, stronger and sustained pharyngealisation during the vowel.

The ideal way of testing these hypotheses would be to repeat the x-ray study outlined in this chapter on a number of PR and NP reciters across both Qur'ānic and normal Arabic contexts.

5.5.2 Restating the Acoustic Study in Chapter 4 in Terms of Degrees of Pharyngeal Constriction

Section 4.2.7 (summarised in 4.3.4) examined Professional (PR) reciters and Non-professional (NP) reciters producing pharyngealised /a:/ vowels in both Qur'ānic and normal Arabic contexts.

5.5.2.1 Professional Reciters: Qur'ānic and Arabic /a:/

For professional reciters there was a strong pattern of distinction between pharyngealised Qur'ānic /a:/ and normal Arabic pharyngealised /ā/.

1. F2 was lower for Qur'ānic Arabic, compared to normal Arabic. Based on hypothesis 3, above, this can be restated as F2 is lower for a greater degree of pharyngeal constriction (ie. narrower constriction for Qur'ānic Arabic). In 5.3.2.4 the first correlation listed was for the vowel /a:/ and was a positive correlation between PhCons and F2. In that study smaller values of PhCons represent greater (narrower) constriction. That is, in the x-ray study narrower constriction resulted in lower F2. The acoustic study and the x-ray study have matching results for F2 /a:/.
2. F3-F2 was higher for Qur'ānic Arabic, compared to normal Arabic. Based on hypothesis 3, above, this can be restated as F3-F2 was higher for a greater degree of (narrower) constriction. In 5.3.2.4 the second correlation was a negative correlation between PhCons and F3-F2. As above, smaller values of PhCons represent greater (narrower) constriction. That is, in the x-ray study narrower constriction resulted in higher F3-F2. The acoustic study and the x-ray study have matching results for F3-F2 /a:/.

5.5.2.2 Non-Professional Reciters: Qur'ānic and Arabic /a:/

For non-professional reciters the distinction between Qur'ānic and Arabic /a:/ is assumed to be smaller than is the case for professional reciters. This is mainly realised in the acoustic study (4.3.3, point 2) as no significant difference for F2 but a significant difference for F2-F1. This is mainly because the high F2 in normal Arabic pharyngealisation is a normal process that Arabic speakers can make without specific training. But the large F2-F1 difference in Qur'ānic pharyngealisation, is strongly related to the level of training in Tajwīd. The comments for 5.5.2.1, point 2, above also apply for this result.

5.5.2.3 Qur'ānic /a:/ F1: Professional and Non-professional Reciters

There is no exactly matching correlation in section 5.3.2.4. The closest correlation is the third correlation in 5.3.2.4 between PhCons and /u:/ F1. This is a negative correlation between PhCons and F1. As above, smaller values of PhCons represent greater degree of (narrower) constriction. That is, in the x-ray study narrower constriction resulted in higher F1. In the acoustic study (4.3.4, point 3) there was a higher F1 for professional reciters, compared to non-professional reciters. Since professional reciters are assumed to have greater (narrower) degree of constriction compared to non-professional reciters, this means that narrower constriction correlates positively with lower F1. If the difference in vowel (/a:/ vs /u:/) is ignored the x-ray and acoustic studies match for F1. It is, however, not clear whether the difference between /a:/ and /u:/ can be ignored.

5.5.3 Conclusion: X-ray and Acoustic Data

Hypothesis 3 in section 5.5.1 is supported by these results. That is, the implicit degree of pharyngeal constriction represented by Qur'ānic /a:/ vowels is greater than the degree of pharyngeal constriction represented by normal Arabic /a:/ vowels.

Hypothesis 1 in section 5.5.1 is only indirectly supported by these results. That is the results in 5.5.2.1 for professional reciters showed significant differences for both F2 and F3-F2 whilst the results for non-professional reciters only showed significant differences for F3-F2 but not for F2. This suggests a weaker pattern of pharyngealisation for non-professional reciters compared to professional reciters.

Hypothesis 2 was not tested in this part of the study as all of the analysed data was Qur'ānic.

The usefulness of the idea of implicit constriction represented by categories Qur'ānic vs normal Arabic and by categories Professional vs Non-professional is supported by this study, but this investigation needs to be expanded by including more participants and better control of the variables.

CHAPTER SIX

General Discussion.

In the acoustic analysis, a number of formant-based measurements were found to differ significantly across reciter groups but not across consonantal context. There were also significant differences for vowel duration. Most significant differences for duration were between reciter groups, although there was also an effect of consonant context for vowel duration for the SSR group.

This section commences with a discussion of the nature of the Qur'ānic pharyngealised vowel sound and is then followed by a discussion of the various experimental results. It will also discuss the nature of the Qur'ānic vowel as well as the main acoustic and articulatory features that characterise the Qur'ānic pharyngealisation such as vowel duration and the distance between F3-F2. The idea of the auditory integration of the spectral peaks especially F1-F2 and F3-F4 will be examined for a better understanding on how the human brain deals with these Qur'ānic pharyngealised vowel sounds.

6.1 The /a:/ Vowel

6.1.1. The Nature of the Qur'ānic Pharyngealised /a:/ Vowel Sound

In normal Arabic a vowel has a pharyngealised allophone in the context of a preceding pharyngeal or pharyngealised consonant and an unpharyngealised allophone in other contexts. The vowel in a normal Arabic syllable does not have pharyngealisation as one of its phonemic characteristics or as an essential characteristic of its linguistic identity. So the pharyngealisation that occurs in the vowel in normal speech is allophonic and is completely a consequence of coarticulation. Tajwīd has formalised the requirement of pharyngealisation for the Qur'ānic vowels in these contexts. The Qur'ānic pharyngealised syllable is composed of one consonant sound (e.g. a phonemically pharyngeal or pharyngealised sound) and a following vowel sound that also must have a heavier and consistent kind of pharyngealisation. This is a very special vowel quality of the Qur'ānic pharyngealised /a:/ sound. It is not just a spread of secondary articulation from the preceding consonant. This is an intrinsic quality to the vowel itself.

What happens during the production of the Qur’ānic vowel sound can be called "a meta-linguistic feature" of the vowel sound. It is not an allophone of the normal /a/ sound conditioned by the normal process of coarticulation. It is produced by all of the reciters of this research, whether they are SSR or NPR or PRs. Muslims understand that this feature belongs to a specific Qur’ānic genre and it is an essential religious characteristic of these syllables as defined by Tajwīd.

The nature of this Qur’ānic feature is different from any other sociolinguistic feature that distinguishes people’s speech from each other. It is more than a sociolinguistic feature in that a sociolinguistic feature occurs as a consequence of following behavioural patterns that are part of belonging to a specific culture. This Qur’ānic feature “*Tafxīm*” is a formalised requirement of Qur’ānic recitation. It does not belong to a particular people or culture, as the Qur’ān should be recited in the same way among all Islamic cultures and nations regardless of their backgrounds and languages.

If this feature is omitted from a Qur’ānic recitation then the outcome would be perceived as inadequate pharyngealisation of the Qur’ānic syllable. The possession of normal Arabic patterns of pharyngealisation in normal Arabic speech is not a prerequisite for the understanding and use of this feature. This feature is an additional requirement of Tajwīd. Thus if a vowel requires this Tajwīd feature during recitation, then it is a feature that must be there in order to maintain a good level of Qur’ānic pharyngealisation. Qur’ānic pharyngealisation is not a characteristic of the Arabic phoneme but rather it is a characteristic of the phoneme in the context of the Qur’ānic pharyngealisation only. This kind of sound is produced in that context correctly only according to the rule of Tajwīd. This meta-linguistic feature is called in Arabic *tafxīm*. If a speaker of normal Arabic applied this feature in any of his vowels in normal speech he would be regarded as a strange speaker. This is mainly because he is applying what is recognised as a Tajwīd feature (that is, especially for the Qur’ān) in normal speech. Yet, it is also not completely true to say that Qur’ānic coarticulation is totally different from that of the nomal Arabic

One may speculate wither Qur’anic coarticulation is different from that of Arabic or the same as Arabic coarticulation. Coarticulation is a normal process that occurs in all languages, without which, articulation would be impossible. In synthetic speech where poor coarticulation sometimes occurs, it becomes difficult to understand what is articulated. Qur'ānic coarticulation is different. In Qur'ānic "coarticulation" the second segment, which is the vowel, is articulated with a meta-linguistic feature, which is the Qur'ānic Tafxīm. Not only this, but during the normal transitional phase at the very start of the vowel we can see a coarticulation between the consonant and the vowel that is then quickly modified into a pattern consistent with Tajwīd. An examination of both the acoustic and x-ray data suggests that this feature is not part of the process of coarticulation but it appears to be composed shortly after the transition. There is a transition from a normal consonant articulation to normal pharyngealisation of the vowel, to a heavier pharyngealised articulation. It is clear from spectrograms of these sequences that the more professional the reciters are the more quickly they make this transition between the consonant and the vowel. In the x-ray study it is clear (from the full video sequences, available in the included media) that this PR reciter adjusts the vowel's pharyngeal constriction very quickly after the transition from the preceding consonant. It is a feature of the SSRs that they articulate the pharyngealised consonant, then they have a brief transitional sequence between the consonant and the vowel, and then they very quickly produce a heavier kind of Qur'ānic pharyngealisation in the following vowel in the Qur'ānic pharyngealised syllable. However, because this study only examines the mid-vowel point and the Qur'ānic sound /a:/ is originally the Arabic sound /a/ and differences between reciters are a matter of degree rather than kind, it would be desirable to examine in a follow up study what happens at the begininng and end of each vowel. Informal examination of this data suggests that the preceding consonant influences a brief following transition period that then quickly changes to the expected Qur'ānic pharyngealised vowel. It is hypothesised that (a) more proficient reciters will establish the Qur'ānic pharyngealised more quickly than less proficient reciters. Also, SSR and PR reciters tend to have longer Qur'ānic pharyngealised vowels than NPR reciters.

It was also found that there is a strong relationship between the spectral shape of the Qur'ānic sounds and their oral configurarion in the Videofluorographic experiment. It was stated in the second chapter that there should be a relation between the two outputs ; the acoustic and the articulatory configuration. This was shown in the study of Bin Muqbil (2006:8) who states, "It has been shown in various seminal works that the different configurations assumed by the vocal tract correspond to systematic acoustic output."

There is a direct relationship between the configuration of the vocal tract and the acoustics of the sound produced. These relationships between speech acoustics and speech production are well established (for example see, Stevens and House (1955), or Stevens (1998)). There is always a strong relation between the acoustic and the oral configuration of a sound and this is also true for the Qur'ānic vowel sound /a:/. Though this research has no articulatory data for the SSR reciters to support any specific claim about a special articulatory when analysing the SSR recitation, it has been found (at least from the pilot study of one of the PR) that there is a correspondence beween the acoustics and the oral configurarion as in figure 6.1, 6.2, and 6.3.

This research has found a strong relationship between the spectral cues for Qur'ānic pharyngealisation, especially the distance between F2 and F3 and the degree of constriction of the same sound. Images 6.1., 6.2., and 6.3. for the Qur'ānic syllable /dˤaː/ in the Qur'ānic token /dˤaːli:n/ show the greatest constriction of all of the sounds of this research. The main acoustic defining feature here for this Qur'ānic sound is the distance between F2 and F3. This image shows also the greatest value (F3-F2 =2050 kHz). This correlation between the point of greatest constriction and the F3-F2 value means that the more constricted the Qur'ānic pharyngealised vowel sound is, the more F3 is distant from F2.

Sound	Position	F1	F2	F3	F4	F3-F2	F4-F3
/dˤaː/	33.267s	560	730	2780	3200	2050	420

Figure 6.1. (frame 00:33;08 = 33.267s) /dˤaː/ 4.5 mm (7.0)

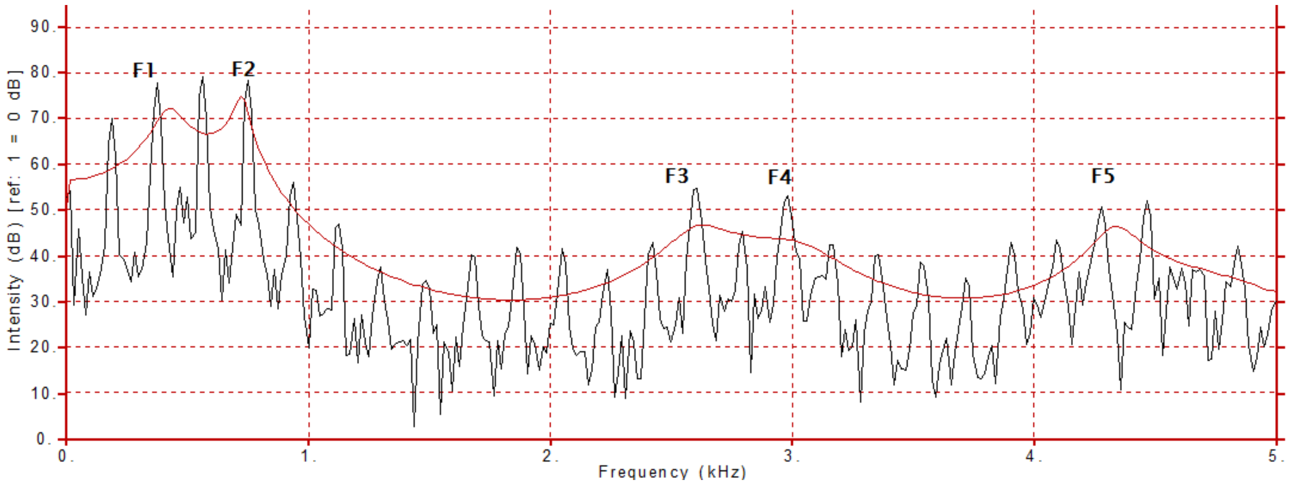

Figure 6.2. FFT/LPC spectrum for Qur’ānic /dˤa:/ (for the x-ray reciter)

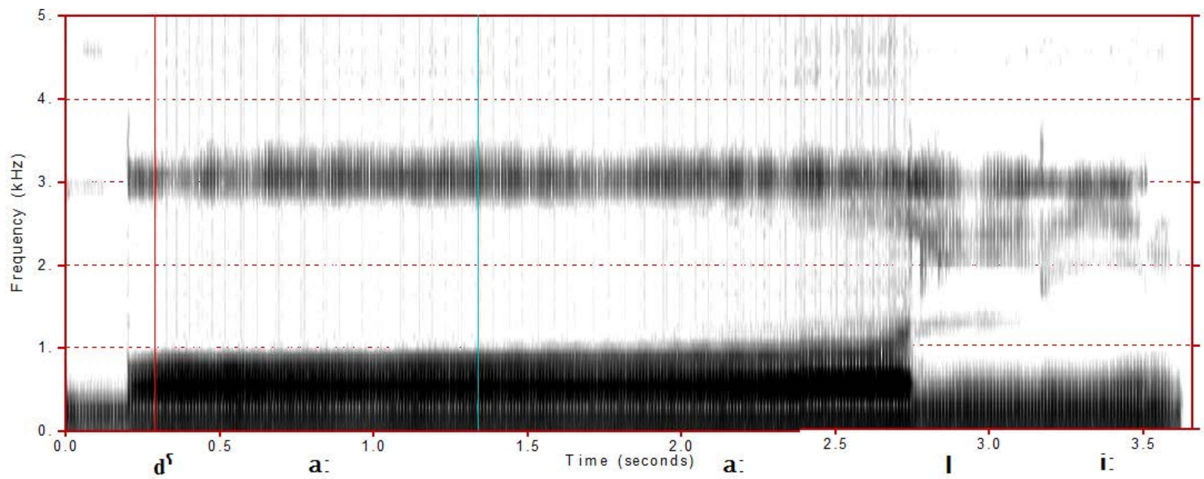

Figure 6.3. A spectrogram for the Qur’ānic token /dˤa:li:n/.

6.1.2. Effect of Preceding Consonant on Vowel Formants

Some previous studies of Arabic pharyngealisation have found some effect of pharyngealised consonants on the adjacent vowels. Bin Muqbil (2006:189) found that it is possible to identify emphatic and non-emphatic sounds according to their effect on the adjacent vowel. He states, “The results of the present experiment show that the coarticulatory acoustic affects of MSA (Modern Standard Arabic) emphatics on neighbouring vowels distinguish these sounds very reliably from their non-emphatic counterparts. The main coarticulatory correlates of emphasis is a sizeable drop in F2 transition in adjacent vowel". Ladefoged and Madison (1996) also found significant effects of the consonants on the adjacent vowels in the languages they studied.

For the Qur'ānic pharyngealised sounds, there was no effect of the pharyngealised consonants on the sustained targets of the adjacent vowels. In no case was any formant data found to vary significantly as a consequence of preceding consonants. Though this study has focused on the center of each vowel to calculate for the stability of the QPSs, this study also looked at the onset and the offset of the vowels (see Figure 6.4) to assess whether the degree of vowel pharyngealisation is related to spread of the degree of pharyngealisation of the preceeding consonant. Figure 6.4. is typical for the QPSs across all preceding consonant contexts that are followed by QPSs in that after a brief initial transitional period the formant patterns stabilised to a common formant pattern for all QPS contexts and the formant pattern was then held constant until the near the end of the vowel. What this shows is that there is no spread of the pharyngealisation in QPSs. The results alsostrongly suggest that the different reciters, regardless of their reciter group, were all very consistent with respect to their own production of the target vowel. In other words, whereas individual reciters had their own individual production patterns for the pharyngealised /a:/ vowel, they were each internally consistent across consonant contexts to their chosen articulatory pattern for this vowel. This lack of vowel formant variation with preceding consonant, measured at the temporal centre of the vowel, suggests that after an inevitable coarticulatory effect of the preceding consonant at vowel onset, all reciters moved to their own consistent vowel articulation. The consistency of the quality of this vowel across various preceding consonantal contexts (the contexts examined in this study) is a requirement of Tajwīd, and reciters of all groups appeared to be aware of this need for consistency even though the groups varied significantly in their choices of vowel quality.

In Tajwīd, every consonant and vowel is highly controlled. In other words there is no right or left spread for pharyngealisation unless the following vowel is eligible to receive pharyngealisation as discussed in the third chapter (3.3.1.) of this research. Should the following sound be one of the sounds that do not receive Qur'ānic pharyngealisation, then Qur'ānic pharyngealisation will stop immediately before that sound or after it. Image 6.4. for the Qur'ānic word /ʔlbiʁˤa:ʔi/ (Qur'ān 24:33) recited by SS1, shows that the Qur'ānic pharyngealised syllable /ʁˤa:/ is preceded by a non pharyngealised syllable /bi/ and followed also by the non pharyngealised /i/ sound. Neither the preceding nor the following sound was affected by the Qur'ānic pharyngealised syllable /ʁˁa:/. Many examples in the data showed that the pharyngealisation here and elsewhere in Qur'ān is not hindered by the following /ʔ/ sound or any other sound. This is a defining characteristic of the Qur'ānic recitation. It is also, as stated earlier, the long process of Tajwīd training and exercising of the articulators, which results in this pattern of production. Unlike most of the studied Arabic dialects, in Qur'ān there is no uncontrolled right or left spread of pharyngealisation. This aspect of the spread of Qur'ānic pharyngealisation needs to be examined in more detail in future research.

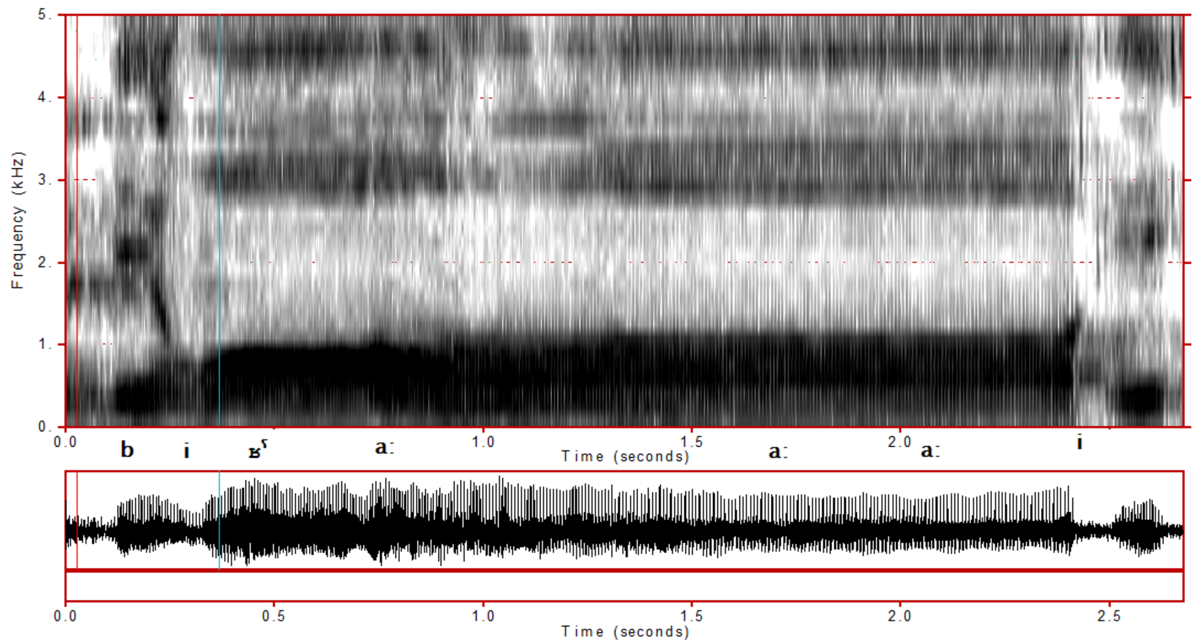

Figure 6.4. Qur'ānic token /ʔlbiʁˁa:ʔi/ for SS1.

6.1.3. Vowel Duration

Duration data varied significantly between reciter groups, with progressively shorter vowel length as we progress from the SSR group to the PR group to the NPR group. The SSRs held each vowel for about three seconds for all consonantal contexts except for two, following Gh /ʁ/ غ and Kh /χ/ خ. The holding of the following pharyngealised /a:/ vowel for about 3 seconds, and the exception of the vowel in those two prevocalic consonantal contexts (which should be half as long), are both requirements of Tajwīd. Only the SSRs made this distinction between the vowel lengths and only the SSRs (with the mean of 2.68 sec. and standard deviation of 1.03) had the correct vowel duration for all the pharyngealised vowels. Vowels recited by the PRs were about half the duration (about 1.5 seconds) of those recited by the SSRs. Additionally, the PRs made no consistent distinction between the durations of the pharyngealised vowels, so the two vowels that were (and should be) shorter for the SSRs were similar in length to the vowels in the other contexts for the PRs. Vowels recited by the NPRs were even shorter than for the PRs.

TajwīdTajwīd asserts the importance of *Madd* and *Qasr* (vowel duration) in the process of Qur'ānic recitation. The allocation of duration in TajwīdTajwīd is strictly controlled by the recited syllable. Without the right duration (*Madd* and *Qasr)*, Qur'ānic vowels do not have the correct form during recitation. The knowledge of the vowel duration and the right application of *Madd* and *Qasr* is a great indication of the professionalism in Qur'ānic recitation. The study of Yeou (2003) of the lengthening of the Qur'ānic sounds which was applied to six reciters (two of them are the SS1 and SS2 of this research) showed that the correct application of *Madd* and *Qasr* for for the Qur'ānic vowel sounds means a better understanding of the TajwīdTajwīd and henceforth more professional reciters.

The data analysis of this research showed that greater vowel duration is connected with the more professional reciters and groups. It is found that Qur'ānic vowel duration is one of the best classifying factors among groups and reciters. Significant effects were found for Group (F 118.875 sig 0.000) and for Sound (F=5.022 sig 0.000). A Post Hoc Tukey HSD showed significant effects for all combinations of Group (SS vs PR sig=0.000, SS vs NP sig = 0.000, and PR vs NP sig = 0.000). Figures 4.3, 4.4, 4.5 show that SSR were the best performing group (relative to the requirements of TajwīdTajwīd) for vowel duration followed by PRs then NPRs. SS1 produced the vowel duration closest to 3 seconds for the Qur'ānic vowel sound. This result is consistent with the presumed classification of the groups at the start of the study; SSR will be better than PRs who will be better than NPRs. Further research in future is needed for the Qur'ānic vowel duration in other contexts with other Qur'nic consonants.

6.1.4. Vowel Formants and Reciter Group

None of the formant values or derived formant differences, measured at the vowel medial position, varied significantly with the preceding consonant, but there were numerous formant measurements that varied significantly with reciter group. In the following sections the results for the relationship between formant measurements, and their variation with reciter group are discussed and, where possible, articulatory explanations for these differences are examined. The acoustic analysis showed that the Qur'ānic vowel sound /a:/ is unique and it resembles no other sound. It was stated in the second chapter that the traditional sound system of the Qur'ān is unique. When comparing the Qur'ānic /a:/ with the normal Arabic sound /a:/, the formant values of the former were significantly different from those of the Arabic sound /a:/. The statistical analysis of F1, F2, F3, F4, for the Qur'ānic showed significant effect (sig 0.000) for the sounds and the groups of the reciters. This means that all of the reciter groups with their different levels of performance are aware of the characteristics of the Qur'ānic /a:/ sound. Even the group with performance least consistent with TajwīdTajwīd, NP, were able to demonstrate a reasonable recitation that distinguished the Qur'ānic /a:/ sound from the normal Arabic /a:/ sound. This very particular identity of this Qur'ānic vowel sound was called earlier "the meta linguistic feature of the Qur'ānic vowel sound /a:/".

It was hypothesised that the SSR would show more pharyngealisation and more consistency. It was found that the degree of pharyngealisation decreases among the groups from SS to PR to NP. In other words constriction will become more open from Superstandard (SS) to Professional (PR) to Non-professional (NP) reciters. So, for example, PR reciters will produce more pharyngealised vowels (greater degree of pharyngeal constriction) than NP reciters, for the relevant consonant contexts. This would predict a greater degree of constriction for PR vs NP reciters.

The normal Arabic sounds of this research are consistent with the studied Arabic sound in the recent acoustic studies of Arabic sounds. It was found that F2 lowering is the main effective formant pattern that correlates with the pharyngealisation. F2 for Arabic /a:/ showed a significant effect for group (F 7.300 Sig. 0.009). There was also a significant effect for preceding consonant sound (F2.353 Sig. 0.047). This is consistent with the recent research (e.g. Obrecht 1968, Al-Ani 1970, Ghazeli 1977, El-Dalee 1984). Even though this study is not focussed on examining the role of F2 lowering in Arabic pharyngealisation, this feature is clear in the acoustic analysis of the normal Arabic sound /a:/ in this research.

The Videofluorographic experiment in chapter five showed that the greatest pharyngeal constriction was for the Qur'ānic vowel sound /a:/ then /u:/ followed by /i:/ vowel sounds. It was also found that the normal Arabic sounds showed less constriction in general when compared with the Qur'ānic sounds. The effect of the preceding consonant in both Qur'ānic and Arabic context was very clear especially when it is pharyngealised. In the Qur'ānic context we found that the constriction ranges from 4.5mm to 12.4mm for the Qur'ānic pharyngealised consonant syllable. The same constriction in the normal Arabic context was from 7mm to 10.8mm. The last three rows in Table 5.1 show the clear effect of the pharyngealised consonant on the following vowel. In these four syllables we found that the constriction ranges from 19.3mm to 31.7mm.

6.1.5 Qur'ānic and Arabic F3-F2.

The acoustic and the statistical analysis showed that the most consistent feature that distinguishes Qur'ānic pharyngealised vowel sounds from normal Arabic /a:/ sound is F3-F2. Though it is a pilot study, the articulatory experiment showed that smaller values of PhCons represent greater (narrower) pharyngeal constriction near the C2 vertebra. That is, in the x-ray study narrower constriction resulted in higher F3-F2. The acoustic study and the x-ray study have matching results for F3-F2 /a:/. It is the defining acoustic feature of the Qur'ānic pharyngealised vowel /a:/. The author is not aware of any study that used F3-F2 to measure the degree of constriction especially in the study of the Qur'ānic sounds. Our data showed significant effect of (sig. 0.000) among groups and reciters. A major hypothesis of this research is that the more distant F3 is from F2:-

1. the more professional the reciter is,
2. the more constricted the sound is.
3. the more pharyngealised the Qur'ānic vowel is.

Our data showed that F3-F2 showed the clearest distinction between the groups and the reciters. A significant effect was found for Group (F 25.461 Sig 0.000). No significant effect was found for sound. A Post Hoc Tukey HSD found a significant effect for SS and PR (sig 0.000) and for SS and NP (sig 0.000), but not for PR and NP. This means that the SSR are doing something that is not being done by the rest of the groups. It is the high degree of constriction that lowers F2 and raises F3 (nearer to F4). What is achieved by the SSR is a consequence of their long exposure to Tajwīd. Their training has enabled them to achieve this high degree of constriction. This is consistent with what Ibn Aljazari (died 1425 AD) stated (see chapter 2 of this thesis). He believed that the long exposure to Tajwīd rules and the long term of exercising the rules of Tajwīd is the reason for the best recitation. That great distance between F3 and F2 is not attained for the other two groups as it was for the SSR. This explains their superiority in Qur'ānic recitation. Another factor could be linked to oral configuration. Though they are apparently physically average people they might have pharyngeal anatomical characteristics that suit them for the production of excellent pharyngealisation, or, perhaps more likely, they may have been able through their long exposure to Tajwīd to develop a very fine control of pharyngeal constriction. It is a pity that none of the SSR can be available for a videofluorography study of these sounds so we can know exactly what happens in their oral configuration during the production of this Qur'ānic pharyngealised vowel sound. It should be stated clearly here (as concluded from the acoustic and the articulatory experiment of this research) that increased F3-F2 is the most reliable acoustic predictor of tighter pharyngeal constriction for the vowel /a:/.

The statistical analysis showed that the SSR group showed less variance as a group and therefore they are more consistent than the other groups. The fact that they came from three different places of the Islamic world and they speak three different Arabic dialects (Southern Saudi, Hijazi Saud, and Egyptian Arabic dialects) did not contribute to variation between them. The reason is that they are all super professional in the traditional system of reciting Qur'ān. It has been stated earlier that the better trained a reciter is in TajwīdTajwīd the more likely that reciter is to achieve and maintain pharyngealisation across the length of the syllable. This also supports the idea that Tajwīd as a system of reciting Qur'ān is a way to unify its reciters.

6.1.6. Comparison of Formants F1 to F4 (Hertz and Auditory Scales)

Figure 5.20 graphically compares the mean productions of the Tajwīd pharyngealised /a:/ vowels. It should be noted that smaller differences of F2 and F1 are perceptually more salient than is the case for the higher formants as we have a much finer degree of auditory discrimination at lower frequencies than at higher frequencies (for differences in Hertz). Moore (2003, pp18-19) discusses the ERB (Equivalent Rectangular Bandwidth) model of auditory bandwidth (Moore and Glasberg, 1986). A basic assumption is that acoustic features that are 1 or fewer auditory filter bandwidths (e.g. ERBs) apart are not resolved auditorily (i.e. not heard as two features but as a single broader feature). If the two features (such as formants) have a significant bandwidth then they need to be more than one ERB apart in order to be resolved as separate features.

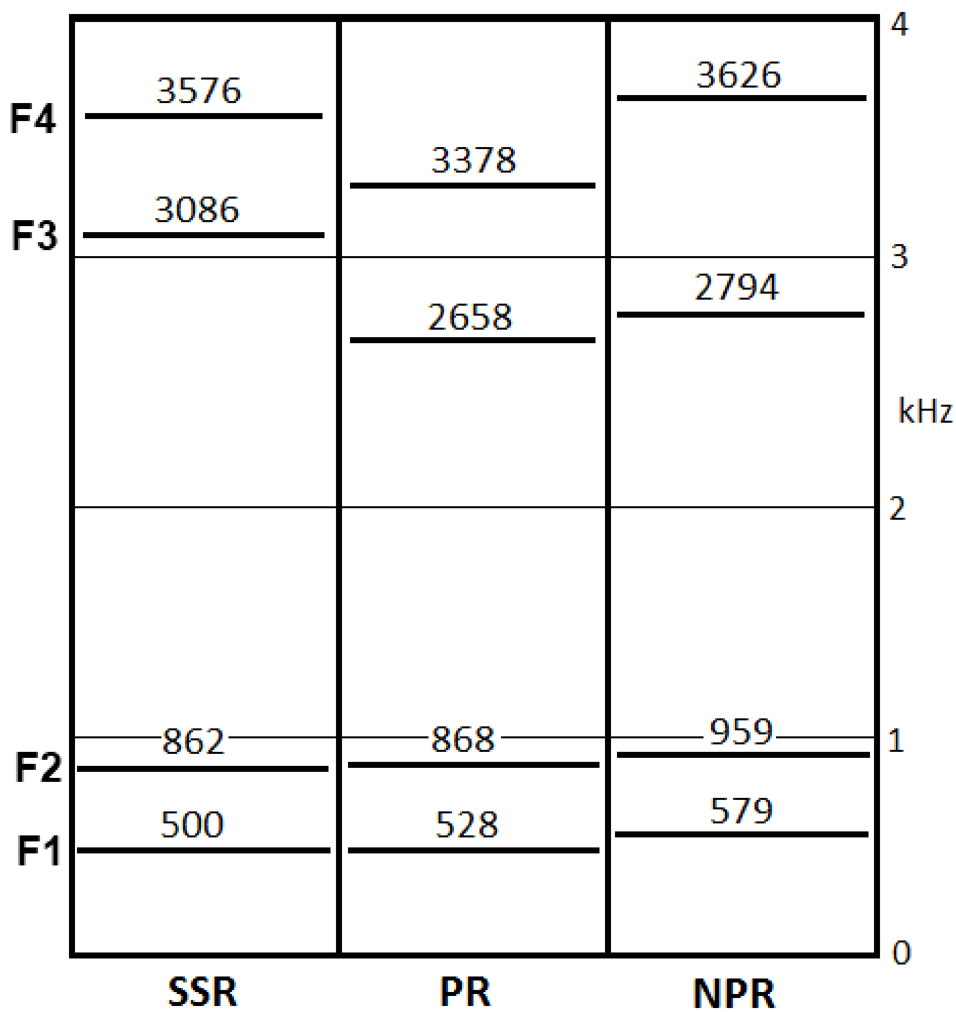

Figure 6.5. Comparison of mean F1, F2, F3 and F4 values for reciter groups SSR (SS), PR and NPR (NP). Frequency is shown on the right in kHz. Thin horizontal lines indicate the 1000 Hz grid lines and thicker horizontal lines indicate formant means.

Figure 6.5 uses a non-auditory Hertz frequency scale. It is not easily possible to determine from a Hertz scaled display whether pairs of formants are likely to be auditorily resolved or not. In order to examine the relative pattern of formants in a form that would be closer to what the brain receives, the formant values were rescaled from Hertz to an auditory frequency scale, known as the ERB-rate scale, or "equivalent rectangular bandwidth" based scale (Moore and Glasberg, 1986).

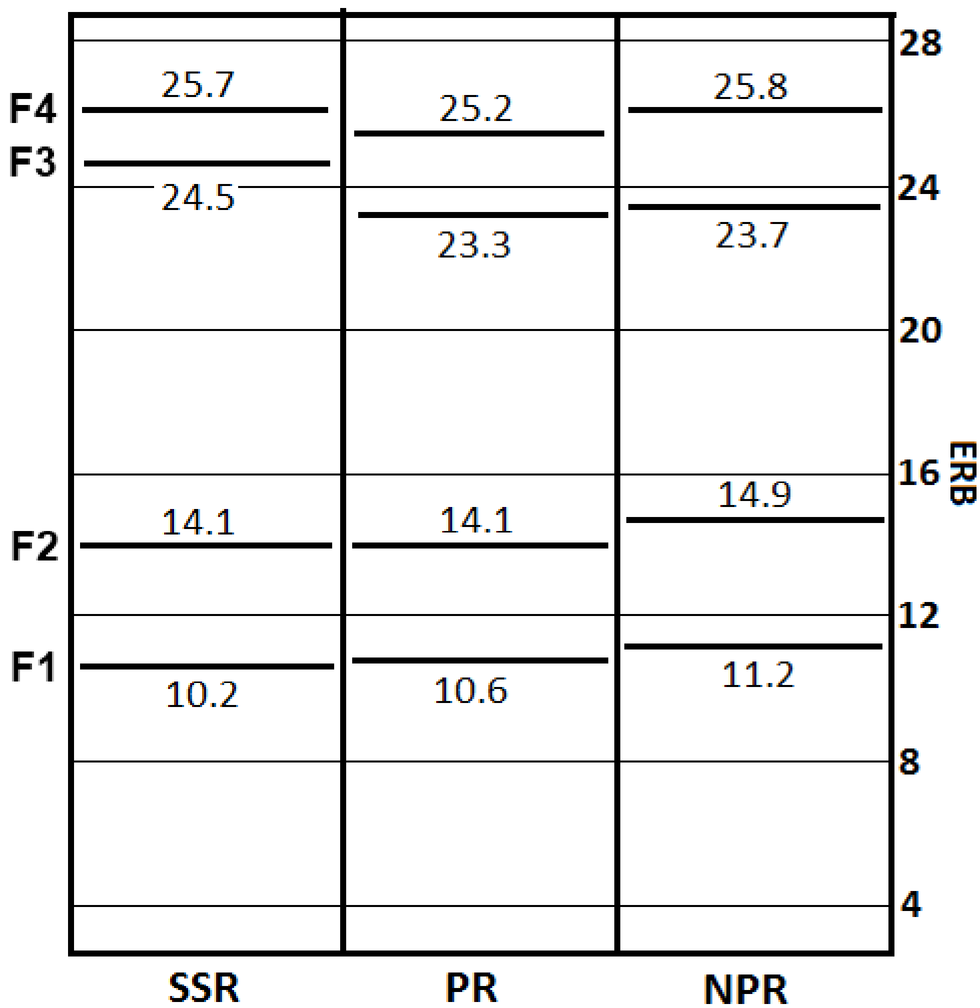

Figure 6.6. Comparison of mean F1, F2, F3 and F4 values for reciter groups SSR (SS), PR and NPR (NP). Frequency is shown on the right and is in the auditory ERB-rate scale. Thin horizontal lines indicate the 2 ERB grid lines and thicker horizontal lines indicate formant means.

It is evident from Figure 6.6, when compared to Figure 6.5. that the separation between F1 and F2 is more perceivable, compared to the difference between F3 and F4, than seems to be the case when looking at the Hertz scaled figure. This is important because F1 and F2 carry a larger proportion of the information used for identifying vowels than do the other formants. In order to correctly perceive vowel height (from F1) and vowel fronting (from F2) it is essential that we are able to clearly separate them perceptually.

The only pair of formants that approach a separation of about 1 ERB is F3 and F4 for the Superstandard Reciters (difference of 1.2 ERB). As these two formants must have a non-zero bandwidth it is extremely likely that these two formants would be perceived as a single peak. It is not clear whether the PR and NP reciters' F4-F3 values would be perceived as a single peak and this would need to be determined in a future psychoacoustic study or by a full modelling of the effects of auditory filter characteristics on each actual spectrograph or FFT.

The following psychoacoustic studies are some ideas that are under consideration for the future:-

1. Are different F4-F3 values resolved by the auditory system or are they together heard as a single peak? Contrast synthetic peak pairs with broad single peaks covering the same frequency range.
2. When two peaks are close together, do they reinforce each other and are therefore louder than peaks further apart. If we hear a difference, is it only because of differences in loudness?

6.1.7 Perturbation Theory and Tube Models of Pharyngealisation

As outlined in section 4.1, the Perturbation theory of Mratati et al. (1988) is an extension of earlier tube based models of vocal track physiology and acoustics (e.g. Fant 1970). Their perturbation theory requires that the vocal tract be divided into 8 tubes in order to model three formants (F1, F2 and F3) (ibid. p261), so that for vowels 7 of the tubes are open at both ends and only tube 8 (the laryngopharynx) is closed at one end (at the glottis). If we are only interested in

F1 and F2 then it is possible to use a much simpler model based on four tubes. In their three formant model the most relevant region for the present study is region 5 (from the bottom of top of the uvula to the bottom of the C3 vertebra). The present study utilises four formants (F1, F2, F3 and F4) and four formants require the vocal tract to be divided into 14 tubes with, for vowels, 13 tubes open at both ends and one tube closed at one end, near the glottis.This 14 tube model requires a complex mathematical model to study the relationship between articulation and formant frequencies, and this is beyond the scope of this study. The idea of a perturbation is where one of the tubes is, for example, reduced in size (more constricted). If the constriction is near the closed end of a tube, all resonances decrease. For a vowel this is only at the glottis as the lips and all other parts of the oral tract are open for a vowel. If the decrease in cross sectional area is elsewhere in the vocal tract during the production of a vowel (i.e. near the open end of one of the tubes) then all resonances increase. If we examine the x-ray in image14B (appendix 3) we can see that the main constriction for this unpharyngealised /lā/ is below the soft palate and ending adjacent to the tip of the uvula. The pharynx is quite open for this unpharyngealised vowel sound. If we compare this with image07 /ʁˤaː/ we can again see a fairly tight constriction below the soft palate and particularly adjacent to the uvula but we can also see the strong constriction in the pharynx adjacent to the C2 vertebra. Since this pharyngeal constriction is an additional constriction near the boundary between the tube adjacent to the uvula and to the upper pharyngeal tube (i.e. the new constriction is near the opening between these two tubes) this should, according to perturbation theory, result in an increase in all resonances, This might account for the increase in F3 with pharyngealisation, and the resulting increase in F3-F2, especially for the SS productions of this vowel. Increases to F1 and F2 caused by this perturbation can be counteracted by adjustments to tongue fronting and height so it is possible with considerable practice, to learn an articulatory pattern that increases F3 without increasing F1 or F2.

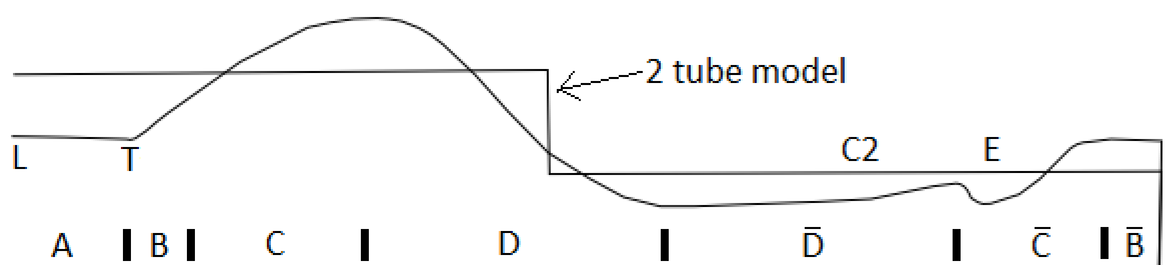

Figure 6.7. The x-ray image in Figure 6.1 has been adjusted so that the continuously changing curve (starting near the letters “L” and “T”) represents changes in vocal tract opening from the lips “L” at the left of the diagram, to the right end of the diagram (a short distance above the larynx). “L” means “lips’, “T” is the front teeth, “C2” is adjacent to the C2 vertebra, “E” is the epiglotis. The letters at the bottom of the diagram represent the boundaries of 7 of the 8 tubes in a 3 formant, 8 tube Perturbation Theory model (the laryngolarynx tube to the far right is missing – not available in the x-ray). Superimposed over this curve is a very simple two tube model of the same vowel (made up of straigth lines).

In order to use this model it is necessary to understand how tube constrictions affect formant values. Also it is necessary to understand the effect of lip protrusion.

There are two main effects of lip protrusion. Firstly, lip protrusion increases the length of the vocal tract as a whole and in particular increases the left tube of the two tube model. In this diagram the right hand tube is shorter than the left hand tube (remember that part of the right tube isn’t visible). This makes the shorter left tube of this two tube model a bit longer (reducung the resonances of this tube). This should reduce F2, and we see this in the acoustic data for the PR reciters. But this is not so obvious for the SSR and NPR reciters, possibly because the NPR reciters don’t protrude the lips, and because the SSR reciters do something else to prevent F2 from reducing.

Next we need to look at nodes and antinodes in the resonance patterns of these complex tubes (see figure 6.8). At open ends of tubes, and at open ends of each of the sub-tubes in a more complex model (e.g. a 2 tube model), the main resonances have antinodes (points of maximum air particle movement). During voicing the vocal folds are much more closed than open and are treated as closed. Tubes or sub-tubes that have a closed end and the main resonances have nodes (points of minimum particle movement) at such points. These two facts are true reganrdless of the number of tubes in our model of a vowel. See figure 6.8.

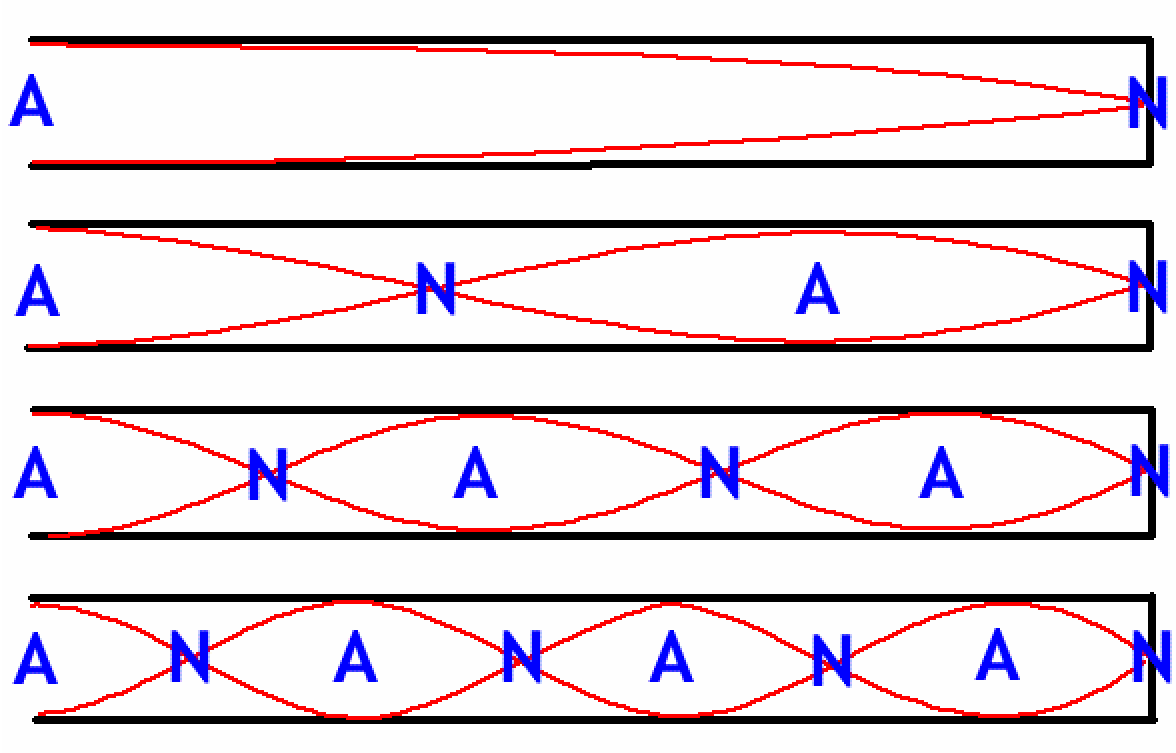

Figure 6.8 “In this diagram we can see antinodes “A” (points of greatest air partical movement/vibration) and nodes “N” (points of least air partical vibration). If this was a vowel the the top tube illustrates F1, the next F2, then F3 and F4. In the real world they are all happening in the same tube at the same time but this diagram makes each of them easier to see by separating them.” (Mannell, 2013)

Chiba and Kajiyama (1958) (also described in Johnson, 2003) showed that if a constriction occurs at an antinode of a resonant wave, the resonant frequency decreases, whilst if a constriction occurs at an node of a resonant frequency the resonant frequency increases. In voiced sounds there is always a node at the glottis, but if there is a constriction in the laryngolarynx (right next to the larynx) this should have the effect of reducing all resonant frequencies for vowels.

Hypotheses that need to be further tested are:-

1. NPR reciters don’t protrude their lips and don’t constrict their laryngopharynx
2. PR reciters protrude their lips but don’t constrict their laryngopharynx
3. SSR reciters both protrude their lips and constrict their laryngopharynx

4. Lip protrusion lowers F2, F3 and F4 for both SSR and PR reciters (but not NPR reciters, who most likely don't protrude their lips (this needs testing).
5. Laryngopharynx constriction raises F3 and F4 for SSR reciters cancelling out the effect of lip protrusion for these formants
6. The low F3 and F4 values for PR reciters are not cancelled out by laryngopharynx constriction.

6.2 /u:/ and /i:/ Vowels

6.2.1 Qur'ānic /u:/ Vowel

There were no significant effects for group or sound. There were, however, a small number of effects for F1 across three pairs of sounds (all pairs included dˤu:). Discriminant analysis failed to make any separation between the reciter groups. There was a reduced number of subjects for this vowel, compared to /a:/ so perhaps weak trends might become clearer with an extended study with additional subjects. It would also be useful to include contrasting Qur'ānic and normal Arabic tokens as part of such an additional further study.

6.2.2 Qur'ānic /i:/ Vowel

Discriminate analysis, based only on formant data resulted in a good separation of the three reciter groups for the /i:/ vowel. Duration data was not collected as duration is not a strong TajwīdTajwīd feature for this vowel. There were no effects for preceding consonant, so the quality of this vowel, after an initial transition, is consistent across contexts, similarly to the /a:/, suggesting an intention on the part of all reciters to produce a consistent TajwīdTajwīd quality for this vowel. There are significant differences between groups for vowel F2 (SS > NP and PR > NP), F3-F2 (SS > NP) and F4-F3 (PR > NP). If we assume that SS reciters have a greater degree of pharyngeal constriction than PR, who in turn have a greater degree of pharyngeal constriction than NP then we can hypothesise that greater F2, greater F3-F2 and greater F4-F3 may indicate greater /i:/ vowel pharyngealisation. In order to confirm this it will be necessary to extend this study so that more reciters are tested, and to also include a normal Arabic as well as a Qur'ānic recitations. It will also be useful to extend the x-ray analysis to include some NP reciters and more PR reciters (it is not possible to do this for the SS reciters). It should, however, be remembered that the x-ray study on one of the PR reciters showed no significant relationship between any acoustic cue and x-ray based physiological measures of vowel constriction.

6.3. Conclusion

This chapter discussed the results of the acoustic analysis of the Qur'ānic pharyngealised vowel sounds as well as the pilot articulatory experiment of this research. The acoustic correlates of the sounds of the three groups selected for this research showed clear differences between them, allowing clearer classification among these groups. One of the main aims of this study was the acoustic characterisation of the best way of reciting Qur'ānic pharyngealised vowel sounds. To achieve this it was necessary to make the reasonable assumption that the SSRs produced Qur'ānic pharyngealised vowel sounds that are more consistent with Tajwīd than those the PRs and NPRs. It was also assumed that the NPRs produced Qur'ānic pharyngealised vowel sounds that were least consistent with Tajwīd. The acoustic characteristics that most clearly separated SSR productions of Qur'ānic pharyngealised vowel sounds from those of the PRs and NPRs are therefore assumed to be the acoustic correlates of those aspects of recitation that distinguish these preeminent reciters from the other reciters.

SSRs and PRs had quite similar F1 and F2 values, which were significantly different from those of the NPR group. In other words, the PRs produced similar degrees of vowel backing and vowel height to the SSRs but the NPRs varied significantly from that pattern.

Separating the SSR productions most clearly from those of the other two groups were the very consistent vowel durations of the SSR group and the significantly greater F3-F2, and significantly smaller F4-F3 value, of the SSR group compared to the other two groups of reciters.

The comparison of the Qur'ānic pharyngealised vowel sound with the normal Arabic pharyngealised sounds showed that Qur'ānic vowels, especially the /a:/ sound, are more pharyngealised (greater degree of constriction). That showed a different identity of the Qur'ānic sounds, compared to normal Arabic /a:/. The Qur'ānic /u:/ sound and /i:/ sounds were also compared with the Qur'ānic /a:/ sound. Significant acoustic effects were found for vowel /i:/ when comparing tokens that could be assumed to have predictable degrees of pharyngealisation and similar acoustic features (e.g. F3-F2) found to be significant for /a:/ were also found to be significant for /i:/ Additionally it was possible, using discriminant analysis, to separate the three groups of reciters based on the acoustic characteristics of these two pharyngealised vowels. Nevertheless, both the acoustic and x-ray data suggested that pharyngealised /a:/ appeared to be more constricted and more consistent among reciter groups than was the case for /i:/. The acoustic analysis of /u:/ failed to find any significant evidence of greater pharyngealisation for different reciter groups or for different contexts and discriminant analysis based on acoustic data for /u:/ failed to separate the three reciter groups.

The pilot articulatory investigation showed that there is a correlation between the degree of constriction and the distance between F2 and F3 in the Qur'ānic vowel sound /a:/. It has also showed that the Qur'ānic pharyngealised syllable is more controlled than the Arabic pharyngealised syllable. Qur'ānic syllable is not affected by the preceding or the following sound. Thus there is no right or left spread of pharyngealisation in the Qur'ānic pharyngealised syllable.

Finally, it appears that the PRs, but not the NPRs, produced the Qur'ānic pharyngealised vowel sounds with a similar tongue position to that of the SSRs. The PRs and NPRs were less consistent in their control of vowel duration than the SSRs. There was also some other aspect of the QPV articulation of the SSR group, possibly related to lower pharynx constriction, that resulted in a characteristic pattern of F3 and F4 that was not shared by the PR and NPR groups.

CHAPTER SEVEN

Conclusion and Further Research

This research is generally motivated by the examination of the Qur'ānic traditional sound system TajwīdTajwīd. The contributions of the early Arabic and Muslim scholars to the study of the Qur'ānic sounds are significant to this research. The lives and contributions of those early scholars were examined for the purpose of better understanding the sounds to be examined in this research. The importance of studying such classical Arabic sounds (as the Qur'ānic sounds that are the focus of this research) can only be fully understood in the context of their religious status among those who recite them. For this reason, the primarily oral nature of the Qur'ān was outlined, to emphasise the importance for Muslims of correct oral recitation of the Qur'ān. The Qur'ān must be recited according to the principles of Tajwīd. The form and content of the Qur'ān were discussed in detail so that the reader might understand the commitment of its reciters to the rules of Tajwīd and the unique identity of Tajwīd as the authoritative phonetic representation of the Qur'ānic sounds. The fact that more than 1.5 billion Muslims around the world today are required to recite Qur'ān according to the correct rules of Tajwīd makes clear the importance of the study of Tajwīd for every Muslim.

The confusing and often contradictory nature of previous studies of the identity of the Arabic pharyngealised sounds and the often inadequate representations of the Arabic classical sounds also motivated this researcher to investigate the contradictions and the discrepancies in naming these Arabic sounds. The results of the acoustic study and of the articulatory study are believed to support the view that the studied Qur'ānic sounds should be referred to as pharyngealised (rather than velarised or uvularised) sounds.

This research is hoped to be a step toward the formal representation of the Qur'ānic sounds. This research aims to further enhance the understanding of this traditional sound system of Qur'ān. This research also aims at finding evidence for grouping the Qur'ānic sounds examined in this research under one phonological feature or in a single natural class which is the Qur'ānic pharyngealised sounds.

In order to achieve these goals, this research has undertaken two main experiments; an acoustic and an articulatory one. The findings of these two experiments were related to each other according to models and theories of the relationship between acoustics and articulatory physiology, such as the acoustic theory of speech production, including tube models of speech production acoustics (e.g. Fant, 1970) and including the Perturbation theory of Mratati et al. (1988). The acoustic experiment of this research examined the Qur'ānic pharyngealised syllable (the Qur'ānic consonant followed by the pharyngealised vowel). The major focus was on the Qur'ānic pharyngealised vowel sounds.

The Qur'ānic pharyngealised syllable has not (to the knowledge of this researcher) been the sole subject of any modern instrumental research. Therefore it was necessary to explain the classical Qur'ānic concept of *Tafxīm* as well as the way it relates to pharyngealisation. The five degrees of pharyngealisation, as well as the related degrees of constriction were also described, along with the reason for choosing the first degree of Qur'ānic pharyngealisation for this research. The other Qur'ānic sounds that are less frequently pharyngealised were also described. The Qur'ānic pharyngealised vowel /a:/ is particularly important, as this vowel, according to the rules of Tajwīd, takes the greatest degree of pharyngealisation when it follows the Qur'ānic pharyngealised consonants, and it is the most perceptually salient of the pharyngealised sounds during the recitation of the Qur'ān. In order to understand the nature of the QPSs, the acoustic and physiological attributes of this most pharyngealised Qur'ānic sound were examined.

In the acoustic experiment, three groups of the reciters were recruited for the purpose of analysing and comparing their recitation of the Qur'ānic pharyngeaslied syllable. The comparison of the groups showed that the presupposed idea that the super-standard reciters will be the best group is a true hypothesis. The professional reciters came in the middle between the other two groups. The non-professional reciters came in the third place.

This research also compared two other Qur'ānic pharyngealised vowel sounds which are the /i:/ and /u:/. The acoustic analysis of /i:/ showed significant contrasts between pharyngealised and unpharyngealised versions of this vowel and discriminant analysis separated the three reciter groups. These patterns appeared to be weaker than for /i:/ than for /a:/, but this requires further analysis (more subjects and more contrasts need to be tested). There was no acoustic evidence for significant pharyngealisation of the /u:/ vowel in the tested contexts and discriminant analysis failed to separate the reciter groups based on the acoustic data for this vowel. This data clearly suggests a much weaker or even absent pharyngealisation for the /u:/ vowel compared to the /a:/ and /i:/ vowels.

Another comparative analysis was made between the normal Arabic pharyngealised /a:/ sounds and the Qur'ānic pharyngealised /a:/ sounds. They were significantly different from each other. Arabic sounds showed no acoustic differences from other current studies of the Arabic guttural and pharyngealised sounds. High F3 and low F2 were the main acoustic characteristics of the Arabic pharyngealised /a:/ sounds.

This study examined the production of the pharyngealised /a:/ vowel in the context of seven preceding Qur'ānic consonants /sˤ/, /ðˤ/, /ʁˤ/, /χˤ/, /tˤ/, /q/ˤ, and /dˤ/ sounds and also examined the transitions from consonant release to pharyngealised vowel target using a videoflurographic X-ray for these consonant vowel sequences. The X-ray experiment demonstrated that there is internal similarity between the coronal sounds /sˤ/, /ðˤ/, /tˤ/, and /dˤ/ as well as internal similarity between the Qur'ānic uvular sounds /ʁˤ/,/qˤ/ and /xˤ/, particularly with respect to their transition patterns into the following vowel and their effect upon the articulation of the following pharyngealised vowel. The acoustic correlates of the Qur'ānic pharyngealised vowel after these sounds also showed similarity in their F1, F2 ,F3, and F4 values. The coronal sounds evidenced a lower tongue, especially during the transitional articulation to the vowel sound /a:/, and the uvular sounds evidenced a higher tongue position due to the nature and the place of their articulation. These findings support the classical categories of the early scholars of Tajwīd of *ITbāq* (when the tongue forms a semi-closure with the palate) and *Ist'la'* (elevation of the tongue). The X-ray experiment images showed that the degree of constriction is governed by the degree to which the sound is lowered and retracted. This experiment also found that the Qur'ānic vowel sound after these Qur'ānic pharyngealised consonants is unique to Qur'ānic Tajwīd and resembles no other sounds in Arabic. It is different from the Arabic vowel sound /a/. This feature is a meta-inguistic feature of the vowel sound that is specific to Tajwīd. It is not an allophone of the normal /a:/ sound conditioned by the normal process of coarticulation. It was recited by all the reciters of this research regardless of their different levels of expertise in Tajwīd. It was also found as a result of this articulatory experiment that vowel duration plays an important role in perfecting Qur'ānic pharyngealisation, as a certain amount of time is required to move beyond the normal coarticulatory interaction between the preceding consonant and the following vowel before the correct degree and position of Qur'ānic pharyngealisation is achieved. More importantly, the consistency of the quality of this vowel following the various preceding consonantal contexts (the contexts examined in this study) is a requirement of Tajwīd, and reciters of all groups appeared to be aware of this need for consistency even though the groups varied significantly in their choices of vowel quality. What should be highlighted here, as found by this X-ray experiment, is the oropharyngeal identity of the Qur'ānic pharyngealised sound, which means that the maximum constriction of these pharyngealised /a:/ sounds occurs in the upper pharynx adjacent to the second cervical vertebra.

The acoustic analysis in Chapter Four determined the acoustic correlates of the Qur'ānic pharyngealised /a:/ sound and showed the differences between the three groups of reciters of this research. This analysis also showed that there are characteristic patterns of formant values that represent the continuum of good through to poor QPS articulations, demonstrating specifically that this is characterised by smaller values of F3-F2 (and a dependant pattern of smaller F4-F3) as well as greater vowel prolongation (*Madd*) for the gold standard reciters compared to the non-professional reciters, and that the pattern for the professional reciters is intermediate between these two groups. The super-standard reciters were assumed to be unique in their recitation due to their enormous amount of Tajwīd training and their full dedication to their Holy book, the Qur'ān, and were treated as the gold standard reciters against which the other reciters were compared. Differences between the SSRs and the other reciters were always assumed to be an indication of the lesser ability of these other reciters to accurately recite the Qur'ān. This was justified by the preeminent international status of the SSRs as reciters of the Qur'ān. None of the members of the other two groups showed the same ability as the SSRs to recite the Qur'ān and produce Qur'ānic pharyngealisation. It should also be noted that the SSRs lived in different cities of the Islamic world and might never have met each other, yet their recitation was almost identical. This is mainly because Tajwīd is the universally applied phonetic system of the Qur'ān and the SSRs are widely recognised as the most expert in the application of Tajwīd.

The F1 and F2 measurements of pharyngealised vowels showed higher (lower F1) and more retracted (lower F2) tongue position for the SSRs and PRs compared to the NPRs. The SSRs had a higher F3 than the other two groups of reciters, and the distance between their F3 and F4 (F4-F3) was much less than for the other two groups of reciters. It is hypothesised that the absence of F3 and F4 lowering for these reciters is due to an additional articulatory gesture that possibly involves the lower larynx and which brings F3 and F4 closer together and also counteracts the F3 and F4 lowering effect of simultaneous lip rounding. With respect to F4-F3, the PRs and NPRs were closer to each other than to the SSRs. The Qur'ānic pharyngealised vowel sound /a:/ was measured medially in all the recitations of the participants, and while there were differences between individuals and groups of reciters, each reciter showed a great deal of consistency between his different articulations of this vowel. The feature that can explain these self-consistent vowel productions for each of the reciters is Qur'ānic pharyngealisation, which is a meta-linguistic feature of the vowel sound. This feature is mastered perfectly only by those who have studied or were trained to recite the Qur'ān with Tajwīd. Having the least exposure to Tajwīd training affected the recitations of the NPRs. Most of them had some idea of the need for a consistent vowel production and some sort of implicit (unconscious) awareness of the need to be consistent regardless of the preceding pharyngealised or uvular consonant.

Importantly enough, this research found that the main acoustic features that distinguished the Qur'ānic vowel sounds are the vowel duration and the distance between F2 and F3. Vowel duration is unique for Qur'ānic sounds. The Qur'ānic vowel sound /a:/ takes the longest Qur'ānic vowel duration which six beats or three seconds. Other Qur'ānic sounds and normal Arabic pharygealised sounds did not show any *Madd* (vowel prolongation). The vowel duration depended largely on the proficiency of the group in Qur'ānic recitation. It was found that the super-standard reciters were the best in obtaining the right Qur'ānic vowel duration, then the professional reciters and then the non-professional reciters.

The other important acoustic feature that has to be emphasised in this research is the distance between F2 and F3. The super-standard reciters showed the greatest distance between the F2 and F3 followed by professional reciters and then the non-professional reciters. No other Qur'ānic or Arabic vowel sound showed the same distance between F2 and F3. This distance again was related to the proficiency of the group.

The acoustic-articulatory relation of the Qur'ānic pharyngealised vowel sounds showed that the more distant F2 from F3 the more articulatorily the tongue root is retracted to the back and the more constriction the sound exhibits. Though the X-ray experiment is only a pilot study and used only one subject, it was significantly useful in helping to understand the nature of the vowel pharyngealisation and its relationship with the preceding consonants. The acoustic analysis of this research yielded more important results as it produced the acoustic correlates of the reciters, comparing a number of reciters from different reciter groups.

The studies of the Qur'ānic pharyngealised vowel sounds still require further research. Further acoustic and physiological research into the other Qur'ānic pharyngealised sounds such as the /r/ and the /l/ sounds. A more condensed and focused physiological analysis with more participants is needed. It is a pity that there is no way for the super-standard reciters to participate in the X-ray experiment or at least evaluate the recitations of the groups. Further articulatory research into the Qur'ānic pharyngealised vowel sounds using ultrasound or MRI of additional subjects will contribute to providing a clearer picture of these sounds.

The final goal of this research was to contribute to the understanding of Qur'ān and to introduce Tajwīd and QPSs to those who know little or nothing about these sounds. This research may have made a small contribution to the larger picture of Qur'ānic sounds but still an important and essential one. The researcher hopes that this research will benefit himself firstly and benefit anyone who is interested in the Qur'ān and its sounds.

REFERENCES

HD : Historical Document (The date is unspecified)

Abu al-Alhasan, A. (HD). *Al-Tanbeeh Ala Al-Lahn Al-Khafi wa Al-Lahn Al-Jali (warning about the hidden and apparent errors during recitation).*

Abu-Bakr, Y. E.-K. (1974). *The text of the Qur'ān With Reference to the Phonetic Aspects of TajwīdTajwīd.* Unpublished thesis, University of Manchester, Manchester.

Al-Faruqi, L. (1978). Accentuation in Qur'ānic Chant: A Study in Musical Tawāzun. *Yearbook of the International Folk Music Council, 10,* 53-68.

Al-Faruqi, L. (1987). The Cantillation of the Qur'ān. *Asian Music, 19*(1).

Al-Ani, S. (1970). *Arabic Phonology*. Mouton: The Hague.

Al-Ani, S., & EI-Dalee, M. (1984). Tafkhim (Emphasis) in Arabic: the Acoustic and Psychological Parameters. *Proceedings of the Tenth International Congress ofPhonetic Sciences*, 385-389.

Al-Badawi, A, S. (1973). *Mustwayat al-`Arabiyya al-mu`asira fi Misr, (Levels of contemporary Arabic in Egypt)*. Cairo: Dar al-Ma'arif.

Al-Hamad, G., G. (2003). *Al-Dirasat al-Sawtiyah ind Ulama' al-Tajweed*. Amman: Dar Amman Linashr Wa-Tawzeea'.

Al-Hamad, G., G. (2006,). Ilm Al-Tajweed Bain Al-Qadeem Wal-Hadeeth. Retrieved 01/07, 2009, from http://www.tafsir.net/tafsir/index.php?a=interviews&action=read&id=4#_ftn65

Al-hashmi, S. A. (2004). *The Phonology of nasal n in the Language of the Holy Qur'ān.* University of Victoria.

Ali, L., & Daniloff, R. (1972a). A Cinefluorographic-phonological Investigationof Emphatic Sound Assimilation in Arabic. *Seventh International Congress of Phonetic Science*, 638-648.

Ali, L., & Daniloff, R. (1972b). A Contrastive Cinefluorographic Investigation of the Articulationof Emphatic-nonemphatic Cognate Consonants. *Studia Linguistica, 2*(26), 81-105.

Al-Jahidh, A. (HD). *Al-Bayan Wa Al-Tabyeen*

Al-khairy, M., Ali. (2005). *Acoustic Characteristics of Arabic Fricatives*University Of Florida, Florida.

Al-Khalil, A. (HD). *Kitdb Al-'Ayn (The Book of [the Sound of] 'Ayn*.

Al-Khaqani, M. (Reproduced by Ghanim al-Hamad 1980). *AL-Qaseedah al-Khaqaniyah*. Baghdad: Publication of the facuty of Shari'ah University of Baghdad.

Al-Masri, A. (2008). Alsawtiyat Ind Ibn Jinni Fi Dhaw' Aldirasat Allughawaiyah Alarabiyah. Retrieved 25/5, 2009, from http://www.voiceofarabic.net/index.php?option=com_content&view=article&id=71:158&catid=7:2008-06-07-09-32-46&Itemid=15

Al-Nassir, A. A. (1993). *Sibawayh The Phonologist : A Critical Study of The Phonetic and Phonological Theories of Sibawayh as Presented in His Treaties al-Kitab* London , New York: Kegan Paul International.

Al-Qairawani, M. (Reproduced by Ahmad Farhat1973). *Al-Ria'yah Litajweed al-Qira'ah Wa Tahqiq Lafth al-tilawah*. Demascus: Dar al-Ma'arif.

Al-Rajhi, A. (1969). *AI-Lahajat AI-Arabiyyah fi I-Qira'at AIQur'āniyyah*. Cairo: Dar AI-Ma'arif.

Al-Showaihi, K. (2003). Mukhtasar Kitab al-Tibyan Fi Tajweed al-Qur'ān Available from http://quran.maktoob.com/vb/quran6946/#closeMe

Al-Tamimi F., A. F., Tarawnah R. (2009). A Videofluoroscopic Study of the Emphatic Consonants in Jordanian Arabic. *Folia Phoniatrica et Logopaedica*, (61), 247-253

Al-Tirmithi, M. I. I. (1931). *Sahih Altirmithi*. Cairo: Al-Maṭbaʻah al-Miṣrīyah bi-al-Azhar.

AlWohaibi, S. (1982). *Qur'ānic Variants*. University of Cornell, Cornell.

Anis, I. (1961). *Al-Aswat al-Lughawiyyah*. Cairo: Dar al-Nahdhah al-Arabiyyah.

Arberry, A. J. (1955). *The Koran interpreted*. London, New York,: Allen & Unwin; Macmillan.

Ashby, M., & Maidment, J. A. (2005). *Introducing phonetic science*. Cambridge, U.K. ; New York: Cambridge University Press.

Ayoub, M. (1993). The Qur'ān Recited. *Middle East Studies Association Bulletin* Retrieved 10/2/, 2009

Bakalla, M. H. (1982). *Ibn Jinni: an early Arab Muslim Phonetician*. London/Taipei: European Language Productions Ltd.

Belkaid, Y. (1984). Les voyelles de l'arabe littéraire moderne. Analyse spectrographique. *Travaux de l'Institut de Phonétique de Strasbourg, 16*, 217-240.

Bin-Muqbil, M. (2006). *Phonetic And Phonological AspectsOf Arabic Emphatics And Gutturals.* University Of Wisconsin-Madison.

Broselow, E. (1976). *The Phonology of Egyptian Arabic.* University of Massachusetts, Amherst.

Broselow, E. (1979). Cairene Arabic Syllable Structure. *Linguistic Analysis, 5*, 345-382.

Bukshaisha, F. (1985). An Experimental Study of Some Aspects of Qatari Arabic. Unpublished Ph.D dissertation. The University of Edinburgh.

Bussmann, H., Trauth, G., Kazzazi, K., & Bussmann, H. (1996). *Routledge dictionary of language and linguistics*. London ; New York: Routledge.

Cantineau, J. (1960). Cours de phonetique arab. *Centre of Social and Ecnomic Research and Studies*.

Card, E. (1983). *A Phonetic and Phonological Study of Arabic Emphasis.* Unpublished PhD, Cornell university.

Catford, J. (1977). *Fundamental Problems in Phonetics*. Bloomington: Indiana University Press.

Chiba, T.& Kajiyama, M. (1958) *The vowel: Its nature and structure*, Phonetic Society of Japan

Cohen, D. (Ed.). (1970). *Les Deux Parlers Arabes de Tunis*. Mouton: The Hague.

Crystal, D. (1980). *A first dictionary of linguistics and phonetics*. [London]: Andre Deutsch.

Crystal, D. (1985). *A dictionary of linguistics and phonetics* ([2nd ed.). Oxford ; New York, N.Y.: B. Blackwell in association with A. Deutsch.

Crystal, D. (1991). *A dictionary of linguistics and phonetics* (3rd ed.). Oxford, UK ; Cambridge, Mass., USA: B. Blackwell.

Crystal, D. (1992). *An encyclopedic dictionary of language and languages*. Oxford, UK ; Cambridge, Mass., USA: Blackwell.

Crystal, D. (1997). *A dictionary of linguistics and phonetics* (4th ed.). Oxford, UK ; Cambridge, Mass., USA: Blackwell.

Davis, S. (1995). Emphasis spread in Arabic and Grounded Phonology. *LinguisticInquiry, 26*, 465-498.

Delattre, P. (1965). *Comparing the Phonetic Features of English French German and Spanish*. London: Geogge G. Harrap & company Ltd.

Delattre, P. (1971). Pharyngeal features in the consonants of Arabic, German, Spanish, French, and American English. *Phonetica, 23*, 129-155.

El-Ashiry, M. R. (1996). *Some Phonetic Aspects of Qur'ānic Recitation.* University of London, London.

Elgendy, A. (2001). *Aspects of Pharyngea Coarticulation*. Amsterdam: ACLC.

El-Halees, Y. (1985). The Role of F1 in the Place of Articulation Distinction in Arabic. *Journal of Phonetics, 13*, 287-289.

Elobied, A., & Maaly, I. (1997). Towards A Parametric Presentation of Arabic Speech Signals. *Sudan Engineering Society Journal, 43*(43).

Embarki, M., Yeou, M., Guilleminot, C., & Magtari, A. A. (2007). An Acoustic Study of Corrolation in Modern Arabic and Dialectal Arabic:Pharyngealised vs Non-Pharyngealised Articulation. *ICPHS, XVI*.

Esling, J. H., Clayards J.A.W., Edmondson, J.A., Qiu F-Y., & Harris, J.G. . (1998). *Quantification of pharyngeal articulations using aryepiglottic angle measurements from laryngoscopic images.* Paper presented at the Proceedings of the 5th International Conference on Spoken Language Processing, Sydney: Australian Speech Science and Technology Association.

Evers, V., Reetz, H., & Lahiri, A. (1998). Crosslinguistic acoustic categorization of sibilants independent of phonological status. *Journal of Phonetics, 26*, 345-370.

Fant, G. (1960). Acoustic Theory of Speech Production The Hague: Mouton & Co.

Fant, G., 1979, "Acoustic Theory of Speech Production: With Calculations based on X-ray Studies of Russian Articulations", Mouton, The Hague

Fareed, M. (2008). The Deflection (al-Imala) the Opening (al-Fath) and that which is in between. . Retrieved 8/1, 2012, from http://www.muneerfareed.com/storage/al-itqan-fi-ulum-al-quran/imala.pdf

Ferguson, C. (1956). The Emphatic l in The Arabic Language. *Language, 32*, 446.

Ferguson, C. (1959). Diglossia'. *Word, 15*, 325-340.

Fischer, W., & Jastrow, O. (Eds.). (1980). *Handbuch der Arabischen Dialekte*. (Wiesbaden: Harrassowitz).

Gairdner, W. H. T. (1925). *Phonetics of arabic: A Phonetic Inquiry and PracticalManualfor the Pronunciation of Classical Arabic and one Colloquial (Egyptian)*: Oxford University Press.

Ghazeli, S. (1977). *Back Consonants and Backing Coarticlationin Arabic.* University of Texas, Austin.

Gibb, H. A. R., & (1980). *Islam : a historical survey* (2nd ed.). London: Oxford University Press.

Graham, W., Kermani, N. (Ed.). (2007). *Recitation and Aesthetic Reception*. Cambridge: Cambridge University Press.

Graham, W. A. (1987). *Beyond the Written Word, Oral Aspects of Scripture in the History of Religion*. Cambridge: Cambridge University Press.

Gulen, M. F. (1993). *Questions This Age Puts to Islam*. London: Truestar.

Habis, A. A. (1998). *Emphatic Assimilation In Classical and Modern Standard Arabic.* University of Edinburgh, Edinburgh.

Hardcastle, W. J. (1979). *Physiology of speech production. An introduction forspeech scientists*. London: Academic Press.

Hassan, Z., & Esling, H. (2007). *Laryngoscopic (Articulatory) And Acousticevidence Of A Prevailing Emphatic Feature Over The Word In Arabic.* Paper presented at the 16th International Congress of Phonetic Sciences, Saarbruken.

Hayes, B. (1995). *Metrical Stress Theory: Principles and case studies*. Chicago: The University of Chicago Press.

Heath, J. (2002). *Jewish and Muslim Dialects of Moroccan Arabic*. London: Curzon.

Hitti, P. K. (1937). History of the Arabs. London.

Hoberman, R. (1985). The Phonology of Pharyngeals and Pharyngealization in Pre-Modern Aramaic *Journal of the American oriental Society, 105*(2), 221-231.

Hughes, G., & Halle, M. (1956). Spectral properties of fricative consonants. *Journal of the Acoustical Society of America, 28,* 303-310.

Ibn Al-Jazari (HD) *Al-Nashr Fi Al-Qirā'āt al-Ashr* (the magnificent poem in the ten ways of reciting Qur'ān).

Ibn Al-Marzubam, M. (HD). *Al-Hawi Fi Ulum Al-Qur'ān (The Container of the Qur'ānic Sciences).*

Ibn Jinni, A. (HD). *Al-Khasa'is (the Characteristics).*

Ibn Jinni, A. (HD). *Sirr Sina'at Al-'Irab (The Secret of the Making of Syntax).*

Ibn Sina. (HD). *Al-Risalah (the Letter).*

Ibn-Mujahid, A. B. A. (1980). *Kitab al-Sab'ah Fi alQira'at.*Unpublished manuscript, Caire.

Iqbal, H., Awais, M., Masud, S., & Shamail, S. (Eds.). (2008). *On Vowel Segmentation and Identification Using Formant Transition in Continuous Recitation of Quranic Arabic*. Wroclaw: Springer.

Irving, T. B. (1985). *The Qur'ān : the first American version*. Brattleboro, Vt.: Amana Books.

Jacobson, R. (1962). Mufaxxama: The Emphatic Phonemes In Arabic. *In Pulgram E., editor Studies Presented To Joshua Whatmough On His Sixtieth Birthday,The Hogua: Moton* 105-115.

Johnson, K. (2003). *Acoustic and Auditory Phonetics*, 3rd Edn., Wiley-Blackwell

Jongman, A. (1989). Duration of fricative noise required for identification of English fricatives. *Acoust Soc Am, 85*, 1718-1725.

Kadi, W. M., T. (2001). Literature and the Qur'ān, *Encyclopaedia of the Qur'ān* (Vol. 3, pp. 213-216). Leiden, The Netherlands ; Boston, Mass.: Brill.

Kahn, M. (1975). Arabic phonetics: The Evidence of Cutural Determinants of Phonetic Sex Typing. *Phonetica, 31*, 38-50.

Kaplan, H. (1960). *Anatomy and Physiology of Speech*: McGraw-Hill book company, inc.

Keating, P. (Ed.). (1988). *The Phonology-phonetics Interface* (Vol. I). Cambridge: Cambridge University Press.

Kenstowicz, M. (1980). Notes on Cairene Arabic Syncope. *Studies in Linguistic Sciences, 10*, 39-54.

Kent, R., & Read, C. (2002). *Acoustic analysis of speech*. Albany, NY: Singular.

Khan, M. M. A., & Al-Helali, M. T.-U.-D. (1997). *Interpretation of the Meanings of The Noble Qur'ān in the English Language: A summarized Version of Al-Tabari, Al-Qurtubi and Ibn Kathir with Comments From Sahih Al-Bukhari: Summarized in One Volume*. Riyadh: Dar-us-Salam.

Kochetov, A. (2003). Review of Postvelar Harmony. *linguistlist* Retrieved 9/6, 2009

Kreidler, C. W. (Ed.). (2001). *Phonology: Critical Concepts in Linguistics* (Vol. 1). London: Routledge.

Ladefoged, P. (1962). *Elements of Acoustic Phonetics*. Chicago: University of Chicago Press.

Ladefoged, P. (1971). *Preliminaries to linguistic phonetics*. Chicago: University of Chicago Press.

Ladefoged, P. (1982). *A Course in Phonetics*. Orlando: Harcourt Brace Publishers.

Ladefoged, P. (1993). *A course in phonetics* (3rd ed.). Fort Worth, Tex. ; Sydney: Harcourt Brace Jovanovich.

Laradi, W. (1983). *Pharyngealization in Libyan (Tripoli) Arabic: An Instrumental Study*. University of Edinburgh.

Laufer, A. (2009, 6/10/2009). Pharyngeal Articulation in Hebrew. Retrieved 6/10, 2009, from http://www.ncl.ac.uk/linguistics/assets/documents/AsherLaufer.pdf

Laufer, A., & Baer, T. (1988). The Emphatic and Pharyngeal Sounds in Hebrew and in Arabic. *Language and Speech*, *31*(2).

Laver, J. (1980). *The Phonetic Description of Voice Quality*: Cambridge University Press.

Laver, J. (1994). *Principles of Phonetics*. Cambridge: Cambridge University Press.

Lehn, W. (1963). emphasis in Cairo Arabic. *Language, 39*, 29-39.

Ma'bad, M. (1989). *Al-Mulakhkhas Al-Mufid Fi Ilm Al-TajwīdTajwīd (A useful summary in the Discipline of TajwīdTajwīd).* Al-Madinah: Maktabat Taybah.

Makki, a.-Q. (HD). *Al-Riayah Litajweed Al-Qur'ān Wa Tahqeeq Lafth Al-Tilawah (taking care of Qur'ānic Tajwīd and its pronunciation)*.

Mannell, R. (2008). Coarticulation and Assimilation. *Phonetics and Phonology* Retrieved January 2012, from http://clas.mq.edu.au/phonetics/phonetics/coarticulation/index.html

Mannell, R. (2013) "Standing Waves and Resonance", Retrieved January 2013, from http://clas.mq.edu.au/speech/acoustics/frequency/resonance.html

Margais, P. (1984). L'articulation de l'emphase dans un parler arabe meghrebin. Annales de l'Institut d'Etudes Orientales. *Alger,, 7*, 5-28.

McAuliffe, J. D. (2003). The Persistent Power of the Qur'ān. *Proceedings of the American Philosophical Society 174*(4), 339-346.

McAuliffe, J. D. (2006). *The Cambridge companion to the Qur'ān*. Cambridge, UK ; New York: Cambridge University Press.

McCarthy, J. (1979). On Stress and Syllabification. *Linguistic Inquiry, 10*(443-66).

McCarthy, J. (Ed.). (1994). *The phonetics and phonology of Semitic pharyngeals*. Cambridge: Cambridge University Press.

McCarthy, J. (2004). Review of the Phonology and Morphology of Arabic Book. By Janet C. E. Watson. *Language, 80*(4).

McIntyre, J. A. (1991). Lexical Innovation In Hausa. *Standarization of National Languages*, 13. Retrieved from http://unesdoc.unesco.org/images/0009/000906/090676E.pdf

Mir, W. K. M. Literature and The Qur'ān, *Encyclopedia of the Qur'ān* (Vol. 3, pp. 213-216).

Mitchell, T. (1993). *Pronouncing Arabic* (Vol. 2vols): Oxford University Press.

Mrayati, M., Carre, R., and Guerin, B., 1988, "Distinctive regions and modes: A new theory of speech production", Speech Communication, 7, 257-286

Moore, B.C. (2003). *An Introduction To The Sychology Of Hearing.* Elsevier Academic Press. London

Muhammad, A. M. (912). *Al-Hawi Fi Ulum Al-Qur'ān*.Unpublished manuscript.

Nelson, K. (1980). *The Art of Reciting the Qur'ān.* University of California, Berkeley.

Nelson, K. (1982). Reciter and Listener: Some Factors Shaping the Mujawwad Style of Qur'ānic Reciting. *Ethnomusicology, 26*(1), 41-47.

Nelson, K. (1985). *The art of reciting the Qur'ān* (1st ed.). Austin: University of Texas Press.

Newman, D., & Verheeven, J. (2002). Frequency analysis of Arabic vowels in connected speech. *Antwerp papers in liguistics, 100*, 77-86.

Newman, D., & Verhoeven, J. (2002). Frequency Analysis of Arabic Vowels in Connected Speech. *Antwerp Papers in Linguistics 100*, 77-86.

Norlin, K. (1987). A phonetic study of emphasis and vowels in Egyptian Arabic. *Lund University, the Department of Linguistics Working Papers, 30*.

Obrecht, D. H. (1968). *Effects of the second formant on the perception velarization consonants in Arabic* Mouton: The Huge.

Ouni, S., & Ouni, K. (2007). Arabic Pharyngeals in Visual Speach. *AVSP 2007*, 25.

Panconcelli-Calzia, G. (1920). Experimental- Phonetic Untersuchungen. *ZES, ll*.

Parkhurst, Stephen. (1990). *Pharyngealization in Arabic*. M.A. dissertation, The University of Texsas at Arlington.

Perkell, S. J. (1969). Physiology of speech production. *Research monograph, 53*.

Pike, K. (1943). *Phonetics, a Critical Analysis of Phonetic Theory and a Technique for the Practical Description of Sounds*: University of Michigan Press.

Ramadan, M. M. (2007). *Ibn Jinni's Role and Contributions to Arabic Semantics.* Universiti Sains Malyasia.

Roman, A. (1977). Les zones d'articulation d'aprés Al-Chalîl. *Arabica*, *24*, 139-144.

Ryding, K. C. (Ed.). (1998). *Early Medieval Arabic: Studies on Al-Khalil Ibn Ahmad* Washington D.C.: Georgetown University Press.

Sara, S. (2004). Al-Khalil ibn Ahmad Al-Farahidi: The sound system of Arabic *Arabic Linguistic Tradition, 7*, 1-15.

Seikel, J., King, D., & Drumright, D. (1997). *Anatomy and Physiology for speech, Language, and Hearing*. London: Singular Publishing group.

Selkirk, E. (Ed.). (1981). *Epenthesis and degenerate syllables in Cairene Arabic*. Cambridge MIT Department of Linguistics and Philosophy.

Semaan, K. (1963). *Arabic Phonetics* Lahore: Sh. Muhammad Ashraf.

Semaan, K. (1968). *Linguistics in the Middle Ages: phonetic studies in early Islam*. Leiden.

Shadle, C. H. (1990). Articulatory-acoustic relationships in fricative consonants. *Speech Production and speech modelling*, 187-209.

Shahid, I. (Ed.). (1998). *Foreward*. Washington DC: Georgetown University Press.

Shahin, K. (1997). *Postvelar harmony.* John Benjamins Publishing Company Amsterdam.

Shahin, K. (2002). *Postvelar Harmony*. Amsterdam: Jhon Benjmins.

Shalabi, A.F. (1960). *Rasm al-Mushaf wa al-Ihtijaj bihi fi al-Qira'at*. Cairo: Maktabat Nahdhad Misr.

Sibwayah. (HD). *Al-Kitib (The Book).*

Steven, K., & House, A. (1961). An Acoustical Theory of Vowel production and some of its Implications *Journal of Speech and Hearing Research, 4*, 303-320.

Stevens, K.N., 1989, "On the quantal nature of speech", Journal of Phonetics, 17, 3-46

Stevens, K.N., 1998, "Acoustic Phonetics", The MIT Press, Cambridge Massachusetts, USA

Stevens, K. N. (1997). "Articulatory-acoustic-auditory relationships". In W. J. Hardcastle and J. Laver, Eds., *Handbook of Phonetic Sciences*, Cambridge, MA: Blackwell, pp. 462-506.

Stevens, K. (1998). Acoustic invariance in speech production evidencefrom measurements of the spectral characteristics of stop consonants *Journal of the Acoustic Society of America, 66*, 1001-1017.

Stevens, K. (2000). *Acoustic Phonetics (Current Studies in Linguistics)* (Vol. New Ed edition): The MIT Press.

Strevens, P. (1960). Spectra of fricative noise in human speech. *Language and Speech, 3*, 32-49.

Tzortzis, H. A. The inimitable Qur'ān. Retrieved 28 of January, 2009, from www.theinimitablequran.com

Vollers, K. (1893). The System of Arabic Sounds as Based Upon Sibaweih and Ibn Ya'ish. *Transactions of the ninth International Congress of orientalists, II*, 130-154.

Watson, J. (1999). The directionality of Emphasis Spread in Arabic. *Linguistic Inquiry, 30*, 289-300.

Watson, J., & Dickens, J. (1994). Sibawayh the Phonologist: A Critical Study of the Phonetic and Phonological Theory of Sibawayh as Presented in His Treatise al-Kitab by A.A. al-Nassir. *British Journal of Middle Eastern Studies, 21*(1), 135-136.

Watson, J. C. E. (2002). *The phonology and morphology of Arabic*. Oxford: Oxford University Press.

Wild, S. (2006). Arabic Language. In O. Leaman (Ed.), *The Qur'ān : An Encyclopedia*: Routledge.

Yeou, M. (2001). Pharyngealization in Arabic:Modelling, acoustic analysis, airflow and perception *Revue de La Faculté des Lettres El Jadida, 6*, 51-70.

Zaba, A. (2007). Native english speakers and Arabic pharyngealization contrasts. *The Acoustical Society of America.*(Proceedings of the Conference of the Acoustical Society of America).

Zavadovsky, N. (1981). *Mavritanskiy dialekt arabskogo yazyka (xassaniya)*. Moskva.

Zawaydeh, B. (1997). *Endoscopic and acoustic evidence for the guttural natural class.* Paper presented at the Third Mid-Continental Workshop on Phonology, Bloomington.

Zawaydeh, B. (1999). *The Phonetics and Phonology Of Gutturals In Arabic.* Unpublished PhD, Indiana University, Indiana.

Zawaydeh, B. (2003). Review of The Phonology and Morphology of Arabic of Janet Watson *Phonology*, *20*(2), 280-283.

Zemanek, P. (1996). *The Origins of Pharyngealisation in Semitics*. Parha: enigma corporation, Ltd.

APPENDIX 1

A Glossary of the Related Tajwīd Terms

NO	Tajwīd Term	Meaning
1.	Tafkhīm	Thickness that enters to the sound to make it back and pharyngealised. Written sometimes in text as Mufaxxamah sound
2.	Makkan	The portions of Qur’ān that were revealed to the prophet in Makkah
3.	Madinian	The portions of Qur’ān that were revealed to the prophet in Madinah
4.	Makharij al-ħuruf	Places of articulation of the sounds
5.	Sifat al ħuruf -	Manners of articulations of the sounds
6.	Mujawwad	Reciting Qur’ān with the application of the laws of Tajwīd
7.	Murattal	The relaxed, quite, and slow recitation of the Qur’ān
8.	Madd	Vowel prolongation
9.	Qasr	Vowel shortening
10.	Yataghannā	Enchanting and making melodies with rhythm during recitation
11.	Iđ̣hār	The manifestation of the sound which prevents assimilation
12.	Ikhfā’	Covering and concealing the sound
13.	Iqlāb	The transformation of the /n/ sound into /m/ sound
14.	Idhgām	Assimilation to the following sound
15.	Lahawiyyah	Arabic uvular /q/ and /k/ sounds
16.	NaT’iyyah	Arabic alveolar-palatal sounds /d/,/t/, and /T/
17.	Shafawiyyah	Arabic labio-dental sounds /b/, f/, /m/, and /w/
18.	Qalqalah	Pronouncing sounds with echoing, agitated, and strong tone
19.	Safi:ri or Asali	Whistling fricative Arabic sounds /s/, /z/, and /z/
20.	Takri:r	Repetition of the Arabic /r/ sound
21.	IstiTālah	Stretching the tongue when pronouncing Arabic sound /ḍ/
22.	Ist’lā’	Elevating and raising the back of the tongue towards the palate
23.	Istifāl	Lowering the tongue when producing the sound
24.	ITbāq	Almost closing the alveolar ridge by both sides of the tongue. The adjective is MuTbaq sound
25.	Infitāħ	The opposite of ITbāq
26.	Mahmūs	Arabic whispered or breathed sounds
27.	Majhūr	Arabic loud or unbreathed sounds
28.	Shadi:d	Arabic strong sound
29.	Rakhw	Arabic loose or soft sounds
30.	Thalqiyah	Arabic peripheral sounds produced by tip of tongue or by outer part of lips such as /l/, /n/, /r/, /f/, /b/, and /m/.
31.	MuSmat	Arabic solid sounds produced with heavier articulation. All Arabic sounds except Thalaqiyah sounds
32.	Infijari	Arabic plosive sounds /d/,/q/,/T/,/b/,/k/,/D/

33.	Iħtikaki	Arabic fricative sound
34.	Ibdāl	The substitution of the sound by another sound
35.	Imālah	bending the sound of the Arabic *fatħa* in the direction of the *kasra*, and more often, the *alif* in the direction of the /ei/

APPENDIX 2

ARABIC RECORDED SAMPLES

من فضلك اقرأ الايات التالية بصوت معتدل غير مرتفع ولا منخفض مع مراعاة احكام التجويد

قال تعالى

ق والقران المجيد
ص والقران ذي الذكر
ان الله لا يهدي كيد الخائنين
الظانين بالله ظن السَوء
غير المغضوب عليهم ولا الضالين
فاذا جاءت الطامة
ومامن غائبة في السموات والارض

++

وغِيض الماء ،،، جنة من نخيل وعنب
نعم المولي ونعم النصير ،،،،،،، واطيعو الله ورسوله
وقيله يا رب ان هؤلاء ،،،،،، وهو العلي العظيم
تلك اذا قسمة ضيزى

++

قولوا امنا بالله

وان تصوموا خير لكم

وتظنون بالله الظنونا
والضحى

والطور

افحكم الجاهلية يبغون

والراسخون في العلم

+++

اقراء النص العربي التالي
حرفي القاف والصاد من احرف التفخيم في اللغة العربية

ذكر الله في القران ان الخائنين والضالين ليسوا من اهل الجنة يوم الطامة وكذلك الظانين بالله ظن السوء فما من غائبة في ذلك اليوم الا وهي عند الله تعالى

PHONETIC DESCRIPTION OF THE ARABIC SAMPLES

(1) Qur'ānic Pharyngealised sounds

qˁa:f

sˁa:d

ʔl **χˁa:**'ini:n

ʔ**ðˁa:**ni:nā billāh

wālālə**dˁa:**li:n

fa'iðādʒā'a**titˁa:**mmah

wamā min **ʁˁa:**'ibah

(2) The /i:/ sound after these seven Qur'ānic pharyngealised sounds:

wā**ʁi:**dˁa ʔlmā

waʔ**tˁi:**'o ʔɫɫhā wārāsu:ləh

wa**qˁi:**lihi jārʌb

qismatun **dˁi:**zā

(3) The /u:/ sound after the seven Qur'ānic pharyngealised sounds:

qˁu:l ʔāmanā

wāʔntā**s^ʕu:**mu: (this example is in the Xray but it is not used in the analysis)

wātā**ðˤu**nu:na billāh (this example is in the Xray but it is not used in the analysis)

wa**dˤu**ħā

wa**tˤu:**r

ʔfaħukmaldʒāhilijati jab**ʁˤu:**n

warrasi χˤ**u:**na fil ilm (this example is in the Xray but it is not used in the analysis)

(4) The normal Arabic pharyngealised sounds

ħarfe: ʔl**qˤā**f wa**Sˤā**d min aħruf ʔtafxi:m filluʁāti ʔlʕārābjjā ðakarā ʔꞁꞁāhu filqur'āni ʔnna ʔl**xˤā**'ini:nā wa**Dˤā**lli:nā le:su min ʔhlidʒannati yaʊma ʔ**Tˤā**mma wakaðālikā ʔ**thˤā**ni:na billāhi θʌn ʔsaʊ' fāmā min **ʁˤā**'ibatin fi ðālika ʔljaʊmi illā wahijā inda ʔꞁꞁāhi taʕālaā

APPENDIX 3

Acoustic Data

On the following pages are the acoustic measurements that form the major part of this study.

Formant measurements

F1, F2, F3 and F4 have been measured for each analysed token. Derived from these measurements are the formant difference values F3-F2 and F4-F3. All of these measurements have been made near the centre of each measured vowel, but with some slight variation in the actual location in order to find the clearest spectral image from which to take the measurement and to avoid taking measurements at points of F0 change.

Duration measurements

Vowel duration "VDur" measurements have also been made, but only for Qur'ānic /a:/ vowels.

Vowels measured

The vowels /i:/, /u:/ and /a:/ were measured in various pharyngeal contexts during Qur'ānic recitation. During normal Arabic speech only /a:/ was measured.

Consonant Contexts

(a) Qur'ānic Recitiation

The three vowels occur in the following contexts:-

1. χˤa: sˤa: dˤa: ʁˤa: tˤa: qˤa: ðˤa:
2. dˤi: ʁˤi: tˤi: qˤi:
3. dˤu: ʁˤu: tˤu: qˤu:

(b) Normal Arabic

Normal, non-Qur'ānic , Arabic is represented by the following contexts:-

- χˤa: sˤa:d dˤa: ʁˤa: tˤa: qˤa:f ðˤa:

However, to distinguish them visually from the equivalent Qur'ānic contexts they are written as follows (in the same order):-

- Kha Sad Dha Gha Ta Qaf Tha

Reciter Groups (all males)

1. SS – Super Standard Reciters (world renowned reciters)
2. PR – Professional Reciters (teachers of TajwīdTajwīd - Qur'ānic recitation)
3. NP – Non-professional Reciters (all other reciters)

All reciters chosen for this study are adult male speakers of Arabic.

Key to Abbreviations in the Tables

Group: SS – Superstandard, PR – Professionals, NP – Non-professionals

G: 1 = SS, 2 = PR, 3 = NP

R: Reciter (Reciter number 1, 2, 3, 4 …)

Sound: Transcription of the sound

S: Numerical code for each sound:-

χˤa:	1
sˤa:	2
dˤa:	3
ʁˤa:	4
tˤa:	5
qˤa:	6
ðˤa:	7
Kha	8
Sad	9
Dha	10
Gha	11
Ta	12
Qaf	13
Tha	14
dˤi:	15
ʁˤi:	16
qˤi:	17
tˤi:	18
dˤu:	19
ʁˤu:	20
qˤu:	21
tˤu:	22

1. Qur'ānic Pharyngealised /a:/ vowels. Super Standard Reciters

Group	G	R	Sound	S	F1	F2	F3	F4	F3-F2	F4-F3	Vdur
SS	1	1	χˤa:	1	460	840	2760	3360	1920	600	1.5
			sˤa:	2	330	720	3160	3480	2440	320	3.4
			dˤa:	3	550	890	3120	3340	2230	220	4.0
			ʁˤa:	4	310	680	2960	3210	2280	250	1.9
			tˤa:	5	350	740	3020	3470	2280	450	3.5
			qˤa:	6	360	720	3070	3340	2350	270	3.4
			ðˤa:	7	330	720	3050	3650	2330	600	3.6
SS	1	2	χˤa:	1	520	850	3030	3350	2180	320	1.8
			sˤa:	2	520	1000	3040	3440	2040	400	3.3
			dˤa:	3	570	1000	3070	3400	2070	330	3.1
			ʁˤa:	4	560	860	3000	3410	2140	410	2.1
			tˤa:	5	720	970	3060	3360	2090	300	2.8
			qˤa:	6	516	900	3120	3370	2220	250	3.0
			ðˤa:	7	560	580	3130	3440	2550	310	2.7
SS	1	3	χˤa:	1	560	720	3650	4300	2930	650	1.0
			sˤa:	2	550	860	3030	4250	2170	1220	3.1
			dˤa:	3	600	880	3460	4220	2580	760	1.9
			ʁˤa:	4	660	900	3200	3740	2300	540	1.2
			tˤa:	5	580	1000	3290	3880	2290	590	2.7
			qˤa:	6	450	810	3120	3800	2310	680	3.2
			ðˤa:	7	580	920	3060	3890	2140	830	3.0

2. Qur’ānic Pharyngealised /i:/ vowels. Super Standard Reciters

Group	G	R	Sound	S	F1	F2	F3	F4	F3-F2	F4-F3
SS	1	1	dˤi:	15	250	320	2150	2650	1830	500
			ʁˤi:	16	250	320	2130	2600	1810	470
			qˤi:	17	220	270	2330	2420	2060	90
			tˤi:	18	290	350	2150	2750	1800	600
SS	1	2	dˤi:	15	250	320	2270	2420	1950	150
			ʁˤi:	16	260	320	2230	2400	1910	170
			qˤi:	17	250	320	2280	2480	1960	200
			tˤi:	18	250	300	1980	2420	1680	440
SS	1	3	dˤi:	15	330	410	2700	3300	2290	600
			ʁˤi:	16	320	470	2730	3220	2260	490
			qˤi:	17	320	420	2500	2620	2080	120
			tˤi:	18	350	420	2500	2780	2080	280

3. Qur'ānic Pharyngealised /u:/ vowels. Super Standard Reciters

Group	G	R	Sound	S	F1	F2	F3	F4	F3-F2	F4-F3
SS	1	1	dˤu:	19	340	750	2790	3370	2040	580
			ʁˤu:	20	300	550	2530	3680	1980	1150
			qˤu:	21	340	700	2670	3790	1970	1120
			tˤu:	22	290	670	2310	3800	1640	1490
SS	1	2	dˤu:	19	300	650	2500	3560	1850	1060
			ʁˤu:	20	310	880	2570	3300	1690	730
			qˤu:	21	240	550	2930	3500	2380	570
			tˤu:	22	300	570	2870	3380	2300	510
SS	1	3	dˤu:	19	470	860	2330	3100	1470	770
			ʁˤu:	20	430	800	1870	2940	1070	1070
			qˤu:	21	420	930	2390	3280	1460	890
			tˤu:	22	450	870	2620	3830	1750	1210

4. Qur'ānic Pharyngealised /a:/ vowels. Professional Reciters

Group	G	R	Sound	S	F1	F2	F3	F4	F3-F2	F4-F3	Vdur
PR	2	1	χˤa:	1	560	960	2600	3180	1640	580	1.8
			sˤa:	2	640	880	2750	3130	1870	380	2.0
			dˤa:	3	650	1170	2550	3530	1380	980	2.4
			ʁˤa:	4	560	1130	2560	3160	1430	600	1.8
			tˤa:	5	660	980	2520	3000	1540	480	2.0
			qˤa:	6	640	890	2750	3070	1860	320	1.6
			ðˤa:	7	540	900	2620	3100	1720	480	1.0
PR	2	2	χˤa:	1	470	780	2880	3130	2100	250	1.1
			sˤa:	2	470	740	2870	3160	2130	290	2.1
			dˤa:	3	470	670	3040	3120	2370	80	2.7
			ʁˤa:	4	430	730	2800	3200	2070	400	1.1
			tˤa:	5	440	720	2490	3020	1770	530	1.9
			qˤa:	6	460	690	2870	3130	2180	260	2.8
			ðˤa:	7	450	700	2800	3150	2100	350	2.6
PR	2	3	χˤa:	1	500	800	2460	3000	1660	540	2.4
			sˤa:	2	480	740	2660	3000	1920	340	3.6
			dˤa:	3	450	740	2640	3030	1900	390	3.5
			ʁˤa:	4	540	830	2760	3350	1930	590	2.4
			tˤa:	5	470	670	2720	3110	2050	390	3.1
			qˤa:	6	520	690	2790	3000	2100	210	3.1
			ðˤa:	7	460	750	2720	3000	1970	280	2.6
PR	2	4	χˤa:	1	600	990	2540	3850	1550	1310	1.5
			sˤa:	2	330	970	2460	3820	1490	1360	2.5
			dˤa:	3	530	900	2710	3150	1810	440	2.6
			ʁˤa:	4	520	1060	2790	4080	1730	1290	2.1
			tˤa:	5	516	960	2600	3970	1640	1370	1.5
			qˤa:	6	420	880	2390	3190	1510	800	2.4
			ðˤa:	7	430	840	2530	4090	1690	1560	1.8
PR	2	5	χˤa:	1	560	880	2970	3480	2090	510	0.9
			sˤa:	2	530	850	2700	3430	1850	730	1.1
			dˤa:	3	520	830	2570	3310	1740	740	1.6
			ʁˤa:	4	530	850	2670	3380	1820	710	0.8
			tˤa:	5	550	790	2520	3430	1730	910	1.9

			qˤa:	6	590	790	2720	3500	1930	780	0.8
			ðˤa:	7	580	870	2430	3210	1560	780	1.0
PR	2	6	χˤa:	1	600	930	2320	3460	1390	1140	2.1
			sˤa:	2	570	840	2630	3810	1790	1180	0.9
			dˤa:	3	580	820	2690	4530	1870	1840	1.4
			ʁˤa:	4	600	850	2520	3950	1670	1430	2.4
			tˤa:	5	560	880	2260	4120	1380	1860	3.0
			qˤa:	6	600	900	2930	4090	2030	1160	0.8
			ðˤa:	7	580	1040	2210	3350	1170	1140	1.0
PR	2	7	χˤa:	1	530	820	2350	3320	1530	970	2.4
			sˤa:	2	550	840	3520	4110	2680	590	3.6
			dˤa:	3	560	860	2480	3560	1620	1080	2.8
			ʁˤa:	4	560	890	2600	3260	1710	660	3.2
			tˤa:	5	590	910	2500	3410	1590	910	3.5
			qˤa:	6	510	830	2450	3420	1620	970	2.3
			ðˤa:	7	560	760	2680	3440	1920	760	3.0
PR	2	8	χˤa:	1	500	800	2900	3560	2100	660	1.4
			sˤa:	2	650	1080	2680	3690	1600	1010	1.0
			dˤa:	3	570	1060	2750	3570	1690	820	1.4
			ʁˤa:	4	520	890	3340	3580	2450	240	2.4
			tˤa:	5	470	1070	2080	3620	1010	1540	1.8
			qˤa:	6	520	1030	3560	4480	2530	920	1.5
			ðˤa:	7	520	1040	3320	3690	2280	370	2.4
PR	2	9	χˤa:	1	530	930	2700	3610	1770	910	1.3
			sˤa:	2	520	1000	3650	4110	2650	460	1.4
			dˤa:	3	370	990	2680	3860	1690	1180	1.7
			ʁˤa:	4	310	890	3150	3690	2260	540	2.8
			tˤa:	5	380	1030	2780	3680	1750	900	2.2
			qˤa:	6	390	1100	2510	3960	1410	1450	1.5
			ðˤa:	7	300	850	2950	3750	2100	800	2.0
PR	2	10	χˤa:	1	580	750	2000	2900	1250	900	1.4
			sˤa:	2	540	920	1990	2990	1070	1000	1.1
			dˤa:	3	550	770	1990	3370	1220	1380	1.7
			ʁˤa:	4	570	950	2440	3150	1490	710	0.6
			tˤa:	5	570	720	2320	3470	1600	1150	1.5

			qˤa:	6	540	900	1970	2930	1070	960	0.9
			ðˤa:	7	520	860	1960	3080	1100	1120	1.3

PR	2	11	χˤa:	1	600	1140	2400	3730	1260	1330	1.8
			sˤa:	2	520	970	2290	3310	1320	1020	1.9
			dˤa:	3	510	880	2100	3200	1220	1100	3.4
			ʁˤa:	4	570	950	1920	3190	970	1270	1.3
			tˤa:	5	520	820	2030	3050	1210	1020	3.3
			qˤa:	6	570	1090	2380	3270	1290	890	1.6
			ðˤa:	7	560	900	2420	3260	1520	840	2.2

5. Qur’ānic Pharyngealised /i:/ vowels. Professional Reciters

Group	G	R	Sound	S	F1	F2	F3	F4	F3-F2	F4-F3
PR	2	6	dˤi:	15	310	2210	2800	3660	590	860
			ʁˤi:	16	370	2180	2800	3700	620	900
			qˤi:	17	320	2250	2970	3350	720	380
			tˤi:	18	520	2190	2800	3550	610	750
PR	2	7	dˤi:	15	320	2400	3020	3780	620	760
			ʁˤi:	16	350	2310	3350	3930	1040	580
			qˤi:	17	330	2380	3080	4100	700	1020
			tˤi:	18	300	2370	2940	3960	570	1020
PR	2	8	dˤi:	15	430	2660	3570	4300	910	730
			ʁˤi:	16	480	940	2600	3800	1660	1200
			qˤi:	17	430	1010	2730	3610	1720	880
			tˤi:	18	450	930	2710	3790	1780	1080
PR	2	9	dˤi:	15	260	2300	2950	3820	650	870
			ʁˤi:	16	300	2230	2940	4100	710	1160
			qˤi:	17	300	2300	3000	4150	700	1150
			tˤi:	18	220	2130	2830	3160	700	330
PR	2	10	dˤi:	15	310	640	2470	3960	1830	1490
			ʁˤi:	16	330	890	2700	4130	1810	1430
			qˤi:	17	300	730	2390	3960	1660	1570
			tˤi:	18	320	590	2390	3930	1800	1540
PR	2	11	dˤi:	15	340	2120	2840	3560	720	720
			ʁˤi:	16	390	1810	2390	3540	580	1150
			qˤi:	17	410	2290	2780	4140	490	1360
			tˤi:	18	390	1640	2580	3420	940	840

6. Qur'ānic Pharyngealised /u:/ vowels. Professional Reciters

Group	G	R	Sound	S	F1	F2	F3	F4	F3-F2	F4-F3
PR	2	6	dˤu:	19	560	890	2100	3320	1210	1220
			ʁˤu:	20	310	650	2150	3030	1500	880
			qˤu:	21	430	750	2780	3390	2030	610
			tˤu:	22	310	590	2900	3600	2310	700
PR	2	7	dˤu:	19	470	720	2490	3530	1770	1040
			ʁˤu:	20	350	610	2750	3530	2140	780
			qˤu:	21	350	730	2540	3530	1810	990
			tˤu:	22	330	620	3040	3530	2420	490
PR	2	8	dˤu:	19	420	1000	2280	3530	1280	1250
			ʁˤu:	20	430	1000	2400	3530	1400	1130
			qˤu:	21	390	800	2580	3530	1780	950
			tˤu:	22	390	780	2360	3530	1580	1170
PR	2	9	dˤu:	19	400	640	2840	3530	2200	690
			ʁˤu:	20	300	630	3150	3530	2520	380
			qˤu:	21	250	570	2030	3530	1460	1500
			tˤu:	22	330	570	2760	3530	2190	770
PR	2	10	dˤu:	19	350	650	2050	3530	1400	1480
			ʁˤu:	20	320	630	2500	3530	1870	1030
			qˤu:	21	410	880	2430	3530	1550	1100
			tˤu:	22	350	840	2240	3530	1400	1290
PR	2	11	dˤu:	19	460	850	2490	3530	1640	1040
			ʁˤu:	20	300	530	2030	3530	1500	1500
			qˤu:	21	350	720	2300	3530	1580	1230
			tˤu:	22	340	740	2260	3530	1520	1270

7. Normal Arabic Pharyngealised /u:/ vowels. Professional Reciters

Group	G	R	Sound	S	F1	F2	F3	F4	F3-F2	F4-F3
PR	2	6	dˤu:	19	560	890	2100	3320	1210	1220
			ʁˤu:	20	310	650	2150	3030	1500	880
			qˤu:	21	430	750	2780	3390	2030	610
			tˤu:	22	310	590	2900	3600	2310	700
PR	2	7	dˤu:	19	470	720	2490	3530	1770	1040
			ʁˤu:	20	350	610	2750	3530	2140	780
			qˤu:	21	350	730	2540	3530	1810	990
			tˤu:	22	330	620	3040	3530	2420	490
PR	2	8	dˤu:	19	420	1000	2280	3530	1280	1250
			ʁˤu:	20	430	1000	2400	3530	1400	1130
			qˤu:	21	390	800	2580	3530	1780	950
			tˤu:	22	390	780	2360	3530	1580	1170
PR	2	9	dˤu:	19	400	640	2840	3530	2200	690
			ʁˤu:	20	300	630	3150	3530	2520	380
			qˤu:	21	250	570	2030	3530	1460	1500
			tˤu:	22	330	570	2760	3530	2190	770
PR	2	10	dˤu:	19	350	650	2050	3530	1400	1480
			ʁˤu:	20	320	630	2500	3530	1870	1030
			qˤu:	21	410	880	2430	3530	1550	1100
			tˤu:	22	350	840	2240	3530	1400	1290
PR	2	11	dˤu:	19	460	850	2490	3530	1640	1040
			ʁˤu:	20	300	530	2030	3530	1500	1500
			qˤu:	21	350	720	2300	3530	1580	1230
			tˤu:	22	340	740	2260	3530	1520	1270

8. Qur'ānic Pharyngealised /a:/ vowels. Non-Professional Reciters

Group	G	R	Sound	S	F1	F2	F3	F4	F3-F2	F4-F3	Vdur
NP	3	1	χˤa:	1	420	660	3090	3770	2430	680	1.0
			sˤa:	2	600	850	3040	3800	2190	760	0.7
			dˤa:	3	420	680	3130	3770	2450	640	1.1
			ʁˤa:	4	610	910	3090	3860	2180	770	1.0
			tˤa:	5	570	880	2810	3880	1930	1070	1.1
			qˤa:	6	690	920	2950	3890	2030	940	0.7
			ðˤa:	7	600	810	3060	3740	2250	680	0.9
NP	3	2	χˤa:	1	460	800	2350	3520	1550	1170	1.1
			sˤa:	2	550	1020	2490	3450	1470	960	1.1
			dˤa:	3	620	930	2470	3180	1540	710	2.3
			ʁˤa:	4	580	770	2420	3150	1650	730	0.6
			tˤa:	5	560	860	2360	3190	1500	830	1.3
			qˤa:	6	580	920	2540	3430	1620	890	0.9
			ðˤa:	7	430	750	2380	3580	1630	1200	1.5
NP	3	3	χˤa:	1	550	800	2770	3870	1970	1100	1.2
			sˤa:	2	540	790	2810	3970	2020	1160	1.6
			dˤa:	3	530	780	2810	3880	2030	1070	2.4
			ʁˤa:	4	550	830	2700	3680	1870	980	1.0
			tˤa:	5	530	850	2800	3850	1950	1050	1.8
			qˤa:	6	590	840	2880	4060	2040	1180	1.6
			ðˤa:	7	520	830	2760	3820	1930	1060	1.7
NP	3	4	χˤa:	1	530	720	2580	3530	1860	950	0.6
			sˤa:	2	620	890	2476	3590	1586	1114	0.8
			dˤa:	3	600	910	2820	3560	1910	740	1.8
			ʁˤa:	4	690	1120	2920	3650	1800	730	0.6
			tˤa:	5	660	1040	2960	3690	1920	730	0.8
			qˤa:	6	640	940	2560	3490	1620	930	0.7
			ðˤa:	7	630	880	2760	3490	1880	730	0.8
NP	3	5	χˤa:	1	560	1160	2930	3840	1770	910	0.7
			sˤa:	2	690	1050	3230	3640	2180	410	0.5
			dˤa:	3	590	1020	2030	3540	1010	1510	0.6
			ʁˤa:	4	600	1190	3030	3530	1840	500	0.5
			tˤa:	5	570	930	2970	3320	2040	350	0.6
			qˤa:	6	700	1120	2400	3310	1280	910	0.7

			ðˤa:	7	630	1020	2660	3460	1640	800	0.6

NP	3	6	χˤa:	1	590	1190	2740	3460	1550	720	0.4
			sˤa:	2	520	790	2810	3650	2020	840	0.6
			dˤa:	3	600	1140	2990	4420	1850	1430	0.2
			ʁˤa:	4	660	1280	3260	4480	1980	1220	0.3
			tˤa:	5	630	1080	3200	4490	2120	1290	0.6
			qˤa:	6	490	800	2690	3900	1890	1210	0.5
			ðˤa:	7	520	1200	3000	3830	1800	830	0.2

NP	3	7	χˤa:	1	670	1100	2620	3500	1520	880	0.1
			sˤa:	2	690	1040	2640	3420	1600	780	0.3
			dˤa:	3	670	900	3330	4050	2430	720	0.3
			ʁˤa:	4	560	810	2720	3430	1910	710	0.4
			tˤa:	5	750	1120	2680	3830	1560	1150	0.3
			qˤa:	6	590	1040	2600	3500	1560	900	0.2
			ðˤa:	7	760	1050	2550	3680	1500	1130	0.3

NP	3	8	χˤa:	1	600	1000	2490	3670	1490	1180	0.2
			sˤa:	2	590	950	2910	3750	1960	840	0.5
			dˤa:	3	570	910	2540	3700	1630	1160	0.5
			ʁˤa:	4	600	920	2680	3580	1760	900	0.5
			tˤa:	5	600	940	2630	3610	1690	980	0.4
			qˤa:	6	640	960	2660	3680	1700	1020	0.4
			ðˤa:	7	610	950	2620	3670	1670	1050	0.4

NP	3	9	χˤa:	1	600	850	2550	3490	1700	940	0.3
			sˤa:	2	560	900	2690	3540	1790	850	0.6
			dˤa:	3	580	890	2650	3490	1760	840	0.8
			ʁˤa:	4	250	830	2630	3460	1800	830	0.8
			tˤa:	5	560	860	3100	3450	2240	350	0.9
			qˤa:	6	590	860	2650	3480	1790	830	0.7
			ðˤa:	7	560	860	2360	3500	1500	1140	0.7

NP	3	10	χˤa:	1	690	1000	2590	3430	1590	840	0.4
			sˤa:	2	680	1010	2630	3480	1620	850	0.7
			dˤa:	3	640	1010	2600	3660	1590	1060	1.1
			ʁˤa:	4	600	1000	2500	3160	1500	660	1.9
			tˤa:	5	600	1030	2570	3320	1540	750	1.2
			qˤa:	6	600	1100	2460	3390	1360	930	0.3
			ðˤa:	7	630	970	2650	3300	1680	650	1.0

NP	3	11	χˤa:	1	620	960	2500	3600	1540	1100	0.3
			sˤa:	2	560	950	2540	3700	1590	1160	0.5
			dˤa:	3	590	900	2620	3560	1720	940	0.5
			ʁˤa:	4	620	960	2670	3620	1710	950	0.4
			tˤa:	5	600	940	2560	3610	1620	1050	0.4
			qˤa:	6	600	950	2740	3780	1790	1040	0.5
			ðˤa:	7	600	1000	2670	3500	1670	830	0.4

NP	3	12	χˤa:	1	590	800	2540	3640	1740	1100	0.4
			sˤa:	2	620	860	2670	3590	1810	920	0.5
			dˤa:	3	590	630	2560	3650	1930	1090	0.6
			ʁˤa:	4	560	960	2450	3520	1490	1070	0.4
			tˤa:	5	630	930	2860	3640	1930	780	0.6
			qˤa:	6	580	960	2750	3500	1790	750	0.5
			ðˤa:	7	600	890	2690	3620	1800	930	0.3

9. Qur'ānic Pharyngealised /i:/ vowels. Non-Professional Reciters

Group	G	R	Sound	S	F1	F2	F3	F4	F3-F2	F4-F3
NP	3	7	dˤi:	15	310	2390	2880	3500	490	620
			ʁˤi:	16	300	2390	2760	3520	370	760
			qˤi:	17	270	550	2500	3500	1950	1000
			tˤi:	18	480	1150	2400	3060	1250	660
NP	3	8	dˤi:	15	300	1940	2860	3570	920	710
			ʁˤi:	16	400	1550	2560	3400	1010	840
			qˤi:	17	350	1950	2520	3530	570	1010
			tˤi:	18	330	1850	2630	3620	780	990
NP	3	9	dˤi:	15	300	2120	3100	3840	980	740
			ʁˤi:	16	320	2250	3110	3630	860	520
			qˤi:	17	310	2150	2590	3600	440	1010
			tˤi:	18	300	1870	2600	3330	730	730
NP	3	10	dˤi:	15	320	2000	2550	3330	550	780
			ʁˤi:	16	430	2000	2620	3330	620	710
			qˤi:	17	350	1940	2400	3200	460	800
			tˤi:	18	350	1890	2670	3370	780	700
NP	3	11	dˤi:	15	340	2230	3080	3420	850	340
			ʁˤi:	16	430	2560	3330	3640	770	310
			qˤi:	17	440	2050	2790	3490	740	700
			tˤi:	18	340	2000	2820	3260	820	440
NP	3	12	dˤi:	15	350	1830	2660	3460	830	800
			ʁˤi:	16	350	2270	2830	3500	560	670
			qˤi:	17	350	2350	3440	4170	1090	730
			tˤi:	18	350	1910	3000	4030	1090	1030

10. Qur’ānic Pharyngealised /u:/ vowels. Non-Professional Reciters

Group	G	R	Sound	S	F1	F2	F3	F4	F3-F2	F4-F3
NP	3	7	dˤu:	19	520	1030	2560	3560	1530	1000
			ʁˤu:	20	350	710	3300	4280	2590	980
			qˤu:	21	390	820	2570	3330	1750	760
			tˤu:	22	340	660	2650	3340	1990	690
NP	3	8	dˤu:	19	470	920	2600	3700	1680	1100
			ʁˤu:	20	260	500	2750	3860	2250	1110
			qˤu:	21	380	880	2420	3410	1540	990
			tˤu:	22	430	830	2350	3330	1520	980
NP	3	9	dˤu:	19	410	890	2400	3370	1510	970
			ʁˤu:	20	380	750	2380	3110	1630	730
			qˤu:	21	420	810	2400	3330	1590	930
			tˤu:	22	320	610	2400	3330	1790	930
NP	3	10	dˤu:	19	570	970	2430	2880	1460	450
			ʁˤu:	20	410	740	2460	2880	1720	420
			qˤu:	21	410	730	2370	3000	1640	630
			tˤu:	22	330	650	2490	3040	1840	550
NP	3	11	dˤu:	19	410	730	2450	3180	1720	730
			ʁˤu:	20	300	610	2540	3110	1930	570
			qˤu:	21	340	750	2530	3430	1780	900
			tˤu:	22	380	760	2440	3190	1680	750
NP	3	12	dˤu:	19	410	800	2650	3260	1850	610
			ʁˤu:	20	430	860	2650	3360	1790	710
			qˤu:	21	390	860	2530	3110	1670	580
			tˤu:	22	440	890	2590	4290	1700	1700

11. Normal Arabic Pharyngealised /a:/ vowels. Non-Professional Reciters

Group	G	R	Sound	S	F1	F2	F3	F4	F3-F2	F4-F3
NP	3	7	Kha	8	500	1250	2690	3430	1440	740
			Sad	9	600	1080	2540	3560	1460	1020
			Dha	10	620	1010	2600	3400	1590	800
			Gha	11	640	1170	2480	3140	1310	660
			Ta	12	720	1000	2500	3500	1500	1000
			Qaf	13	700	1080	2480	3360	1400	880
			Tha	14	500	1030	2640	3480	1610	840
NP	3	8	Kha	8	600	1100	2500	3780	1400	1280
			Sad	9	600	1080	2600	3660	1520	1060
			Dha	10	600	1130	3000	3800	1870	800
			Gha	11	630	1230	2650	3600	1420	950
			Ta	12	600	1000	2600	3560	1600	960
			Qaf	13	670	1000	2630	3740	1630	1110
			Tha	14	690	1230	2730	3470	1500	740
NP	3	9	Kha	8	600	1030	2380	3610	1350	1230
			Sad	9	600	920	2600	3320	1680	720
			Dha	10	560	820	2600	3470	1780	870
			Gha	11	600	860	2290	3500	1430	1210
			Ta	12	580	860	2870	3520	2010	650
			Qaf	13	600	840	2480	3580	1640	1100
			Tha	14	580	840	2330	3360	1490	1030
NP	3	10	Kha	8	670	1450	2510	3500	1060	990
			Sad	9	610	1050	2480	3410	1430	930
			Dha	10	660	970	2500	3570	1530	1070
			Gha	11	690	1140	2430	3250	1290	820
			Ta	12	600	930	2670	3470	1740	800
			Qaf	13	640	1000	2460	3180	1460	720
			Tha	14	520	1070	2600	3610	1530	1010
NP	3	11	Kha	8	550	780	2160	3370	1380	1210
			Sad	9	560	770	2150	3170	1380	1020
			Dha	10	520	840	2500	3350	1660	850
			Gha	11	550	750	2490	3310	1740	820
			Ta	12	530	750	2030	3250	1280	1220

			Qaf	13	550	770	2280	3130	1510	850
			Tha	14	560	760	2380	3410	1620	1030
NP	3	12	Kha	8	630	960	2720	3560	1760	840
			Sad	9	530	1000	2910	3800	1910	890
			Dha	10	590	930	2900	3840	1970	940
			Gha	11	630	950	2640	3750	1690	1110
			Ta	12	650	1000	2530	3740	1530	1210
			Qaf	13	520	1000	3000	3890	2000	890
			Tha	14	650	930	2850	3780	1920	930

APPENDIX 4

Details for the Statistical Analyses

F3 – F2

F3_F2_Arabic_aa.spv Arabic /a:/ F3-F2

Significant for group p=0.002 (based only on PR vs NP) NP > PR

Significant for A_Dha vs A_Gha p=0.032 (post hoc Tukey) NP > PR

F3_F2_Qur'ānic _aa.spv Qur'ānic /a:/ F3-F2

Significant for group p=0.000 (based on SS, PR and NP)

Post Hoc Tukey

SS vs PR p=.000 SS > PR

SS vs NP p=0.000 SS > PR

PR vs NP nsd

No significant differences for any pair of sounds

F3_F2_Qur'ānic _ii.spv Qur'ānic /i:/ F3-F2

Significant for group F 1.390 p=0.005 (based on SS, PR and NP)

Post Hoc Tukey

SS vs PR p=.017

SS vs NP p=0.005

PR vs NP nsd

No significant differences for any pair of sounds

F3_F2_Qur’ānic _uu.spv **Qur’ānic /u:/ F3-F2**

Not significant for group

Post Hoc Tukey

No significant difference for any pair of reciter groups

SS vs PR nsd SS vs NP nsd PR vs NP nsd

No significant differences for any pair of sounds

F4 – F3

F4_F3_Arabic_aa.spv

PR VS NP Significant for group F 8.167 p=0.006 (based only on PR vs NP)

Significant for A_Dha vs A_Kha p=0.029 (post hoc Tukey)

F4_F3_Quranic_aa.spv

Significant for group F=15.086 p=0.000

Post Hoc Tukey

SS vs PR p=0.000

SS vs NP p=0.000

PR vs NP nsd

Not Significant for any pair of sounds

F4_F3_Quranic_ii.spv

Significant for group F=5.216 0=0.009

Post Hoc Tukey

SS vs PR nsd

SS vs NP nsd

PR vs NP p=0.012

F4_F3_Quranic_uu.spv

Univariate ANOVA nsd for group and sound

Post Hoc Tukey all contrasts nsd

VDur

Only measured for Qur'ānic   /a:/

VDur_Quranic_aa.spv

Significant for group F=118.875 sig=0.000

Significant for Sound F = 5.022 sig = 0.000

Sound – significant differences – Tukey post hoc

Q_Kha vs Q Dha p=0.004

Q_Kha vs Q_Ta p=-.013

Group – significant differences

p = 0.000 for ALL combinations of SS PR and NP

F4

F4_Quranic_aa.spv

Univariate ANOVA

Significant for group F = 6.761 p = 0.000

Not significant for sound

Tukey Post Hoc

SS vs PR nsd

SS vs NP nsd

PR vs NP $p = 0.001$ (PR < NP) - similar but not significant for PR vs SS

F4_Arabic_aa.spv

Univariate ANOVA

Not significant for group or sound

Tukey Post Hoc – not significant

**** cf. F4 Quranic, above

F4_Quranic_ii.spv

Univariate ANOVA

Not significant for sound

Significant for Group F = 24.862 p 0.000

Tukey Post Hoc All Group comparisons significant

SS vs PR nsd

SS vs NP p=0.000 SS > Np

PR vs NP 0=0.000 PR > NP

PR has highest value

F4_Quranic_uu.spv

Univariate ANOVA

Not significant for sound or group

No contrast significant for Tukey Post Hoc

F3

F3_Arabic_aa.spv

Not significant for sound or group

No contrast significant for Tukey Post Hoc

F3_Quranic_aa.spv

Significant for Group p = 0.000

Not significant for Sound

Tukey Post Hoc

SS vs PR p=0.000 SS > PR

SS vs NP p=0..000 SS > NP

PR vs NP nsd

F3_Quranic_ii.spv

Significant for Group F = 9.029 p = 0.000

Not significant for sound

Tukey Post Hoc

SS vs PR nsd

SS vs NP nsd

PR vs NP p=0.00 PR > NP

F3_Quranic_uu.spv

Not significant for group or sound

No contrast for Tukey Post Hoc

F2

F2_Arabic_aa.spv

Not significant for sound or group

No contrast significant for Tukey Post Hoc

F2_Quranic_aa.spv

Not significant for group or sound

Tukey Post Hoc

SS vs PR nsd

SS vs NP p=0.005 NP > SS

PR vs NP p=0.038 NP > PR

SS is closer to PR than to NP

F2_Quranic_ii.spv

Significant for group F = 17.028p=0.000

Not significant for sound

Tukey Post Hoc

SS vs PR nsd

SS vs NP p=0.000 SS > NP

PR vs NP p=0.00 PR > NP

F2_Quranic_uu.spv

Not significant for sound or group

No contrast significant for Tukey Post Hoc

F1

F1_Arabic_aa.spv

Not significant for sound or group

No contrast significant for Tukey Post Hoc

F1_Quranic_aa.spv

Significant for group p=0.000

Not significant for sound

Tukey Post Hoc

SS vs PR nsd

SS vs NP p = 0.000 SS < NP

PR vs NP p=0.000 PR < NP

F1_Quranic_ii.spv

Not significant for sound or group

No contrast significant for Tukey Post Hoc

F1_Quranic_uu.spv

Not significant for group

Significant for sound p=0.005

Tukey Post Hoc

Not significant for group

Significant sound contrasts:-

Dhu vs Ghu p=0.001

Dhu vs Tu p=0.004

Dhu vs Qu $p = 0.016$

all other pairs not significant.

Appendix 5

X-ray Movie Analysis Frames.

On the following pages are a set of single movie frames that have been used in the x-ray analysis in chapter 5. These frames have been selected because they are located approximately in the middle of each of the vowels being analysed.

The data is organised as follows:-

1. Image 99 (e.g. “image01”) is the image title. Numbers without a following letter (e.g. “01”) are codes for the pharyngealised vowels.
2. Image 99A (e.g. “image17A”) with a letter following the number, is an image title for non-pharyngealised vowels selected from between the pharyngealised vowels.
3. Frame number is the x-ray movie frame number. Frame numbers have the format, for example, in image16, “01:33;14” which means 1 minute (“01”), 33 seconds (“33”) and 14 frames. In this movie there are 30 frames per second. One frame is therefore 1/30 second or 0.03333 seconds. So, 93.467s is 93 seconds (or 1 minute and 33 seconds) PLUS 14 frames (14x0.03333 = 0.467s). This makes it possible to locate the frame in the x-ray movie supplied with official versions of this thesis.
4. Following the frame number is a phonemic transcription of the syllable that this x-ray image is taken from. In every case the actual image is taken from near the middle of the vowel in this syllable.
5. Following the phonemic transcription are two measurements in millimetres. The first number is the calculated actual size of the pharyngeal constriction (near the C2 vertebrae). The measurement, in brackets, is the size of this same constriction on a specific printout of each image. The procedure for converting from a distance on paper to a distance in the actual oral cavity is outlined in 5.3.1.3
6. In the table following the details mentioned above is the syllable transcription, movie frame position, and acoustic measurements (F1, F2, F3, F4, F3-F2, F4-F3) taken from this point in the x-ray sound file. As well as the sound on the supplied movie file, a sound file of this recording is also supplied starting precisely at the start of the movie and synchronised with the movie so that formant measurements can be made.
7. In each x-ray frame are supplied outlines of the tongue, hard palate, soft palate, velum, upper and back surface of the tongue and the back pharyngeal wall. If the reader wishes to confirm the accuracy of the placing of these lines it is suggested that the still image be examined and verified against the x-ray movie. These walls are often a bit clearer in the x-ray movie. Using a thick black line, the point of minimum constriction in the vicinity of the C2 vertebrae is indicated. This line is angled upwards at about 45 degrees to indicate the shortest distance across the pharynx.
8. Where visible, the lips are also outlined, but sometimes they are not visible or the visible pattern is not easily interpreted.

image01 (frame 00:09;29 = 9.967s) /qˤaː/ 12.4 mm (8.0)

Sound	Position	F1	F2	F3	F4	F3-F2	F4-F3
/qˤaː/	9.967s	570	950	2740	3220	1790	480

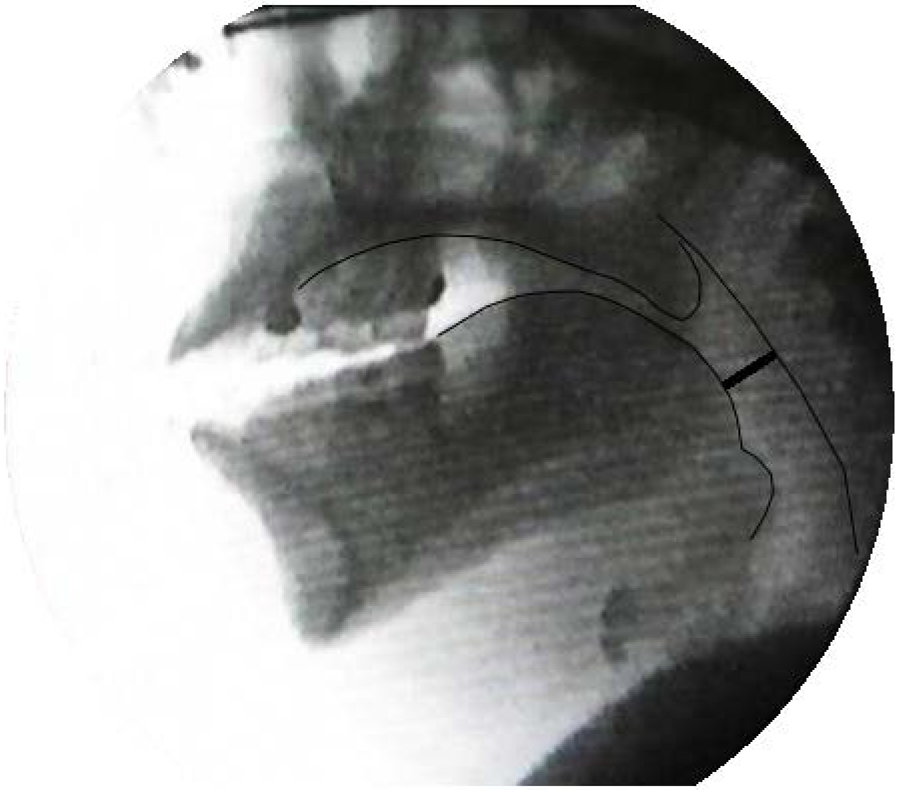

image02 (frame 00:14;20 = 14.667 s) /sˤaː/ 10.8 mm (7.0)

Sound	Position	F1	F2	F3	F4	F3-F2	F4-F3
/sˤaː/	14.667	560	950	2730	3110	1780	380

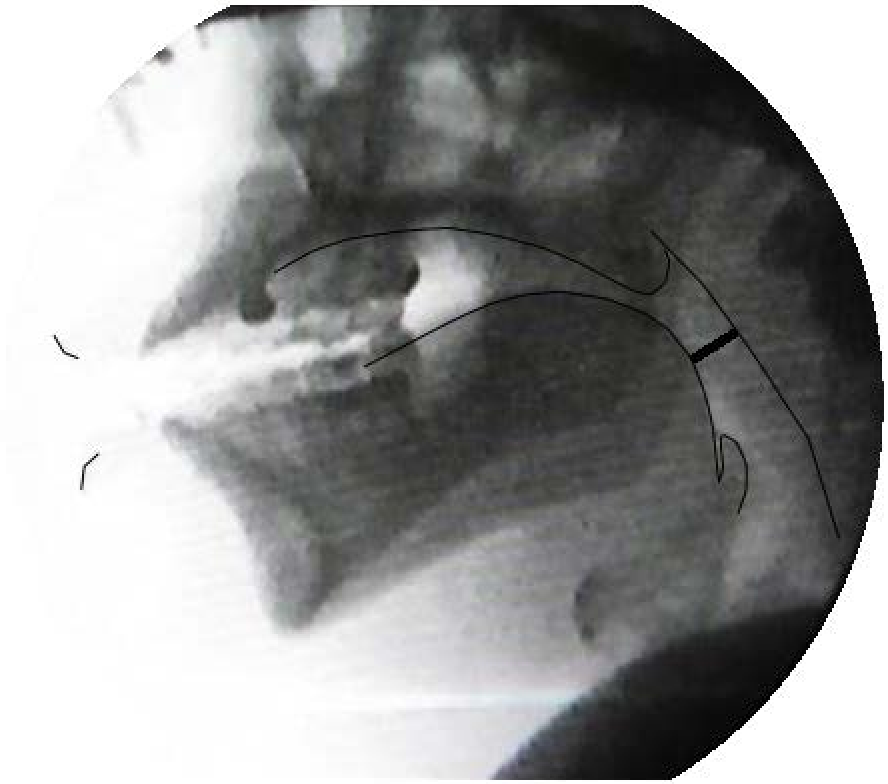

image03 (frame 00:20;05 = 20.167 s) /xˤaː/ 10.8 mm (7.0)

Sound	Position	F1	F2	F3	F4	F3-F2	F4-F3
/xˤaː/	20.167 s	560	880	2750	3100	1870	350

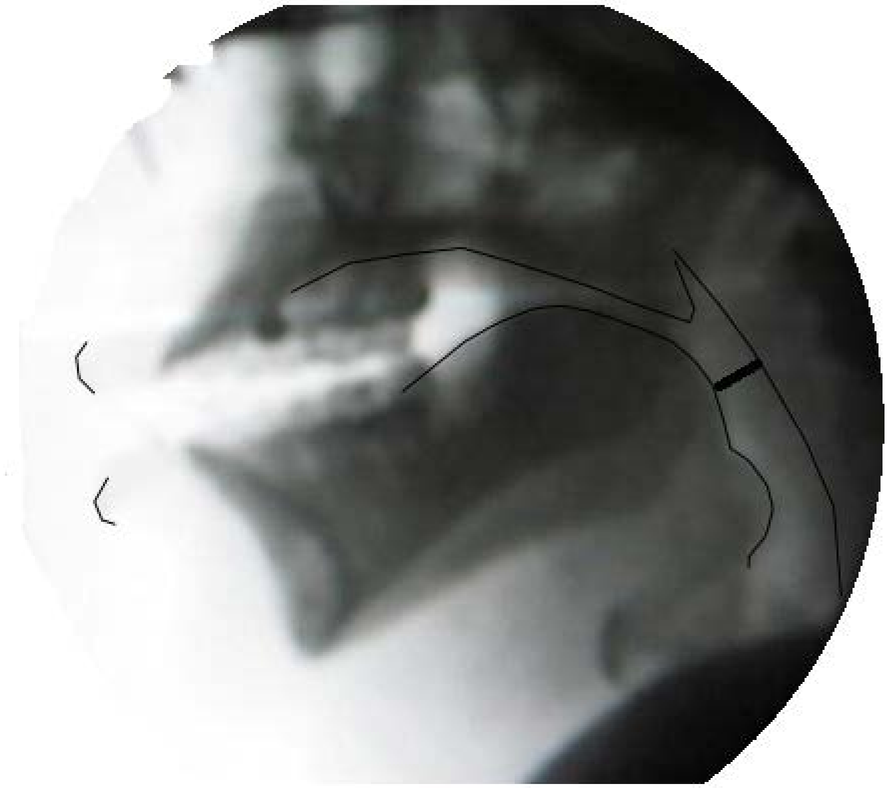

image04 (frame 00:25;28 = 25.933s) /ðˤaː/ 9.3 mm (6.0)

Sound	Position	F1	F2	F3	F4	F3-F2	F4-F3
/ðˤaː/	25.933s	560	910	2860	3210	1950	350

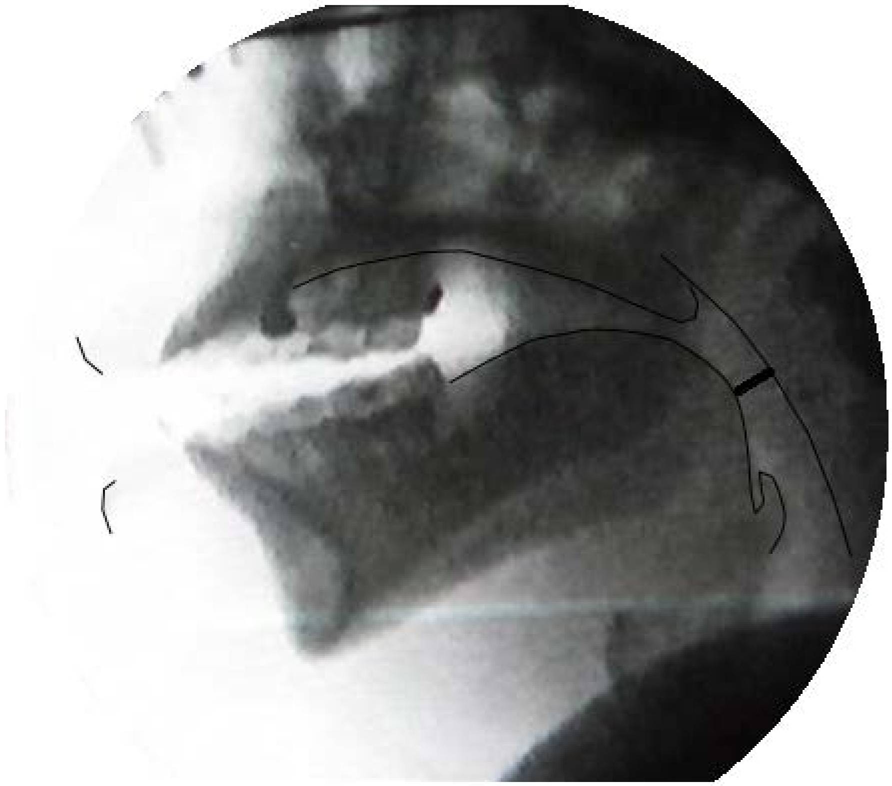

image05 (frame 00:33;08 = 33.267s) /dˤaː/ 4.5 mm (7.0)

Sound	Position	F1	F2	F3	F4	F3-F2	F4-F3
/dˤaː/	33.267s	560	730	2780	3200	2050	420

image06 (frame 00:42;10 = 42.333s) /tˁaː/ 7.7 mm (5.0)

Sound	Position	F1	F2	F3	F4	F3-F2	F4-F3
/tˁaː/	42.333s	650	730	2720	3200	1990	480

image07 (frame 00:47;23 = 47.767s) /ʁˤaː/ 9.3 mm (6.0)

Sound	Position	F1	F2	F3	F4	F3-F2	F4-F3
/ʁˤaː/	47.767s	560	750	2710	3150	1960	440

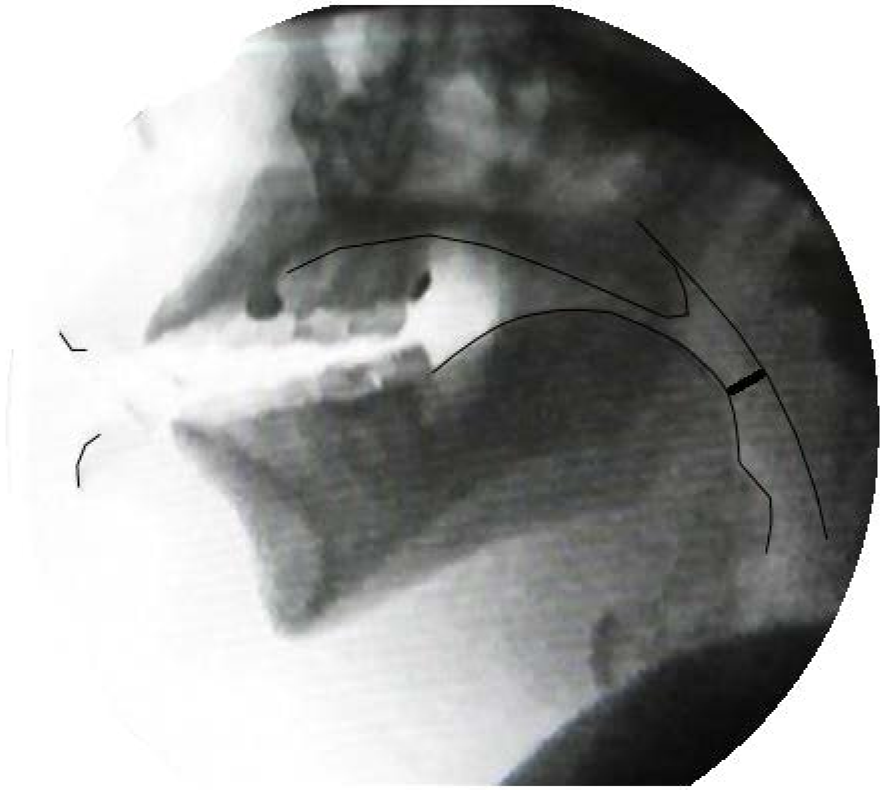

image08 (frame 00:56;18 = 56.600s) /ʁiː/ 29.4 mm (19.0)

Sound	Position	F1	F2	F3	F4	F3-F2	F4-F3
/ʁiː/	56.600s	210	2600	3000	3710	400	710

image09 (frame 01:01;00 = 61.000s) /tˤiː/ 34.8 mm (22.5)

Sound	Position	F1	F2	F3	F4	F3-F2	F4-F3
/tˤiː/	61.000s	260	2420	3120	4600	700	1480

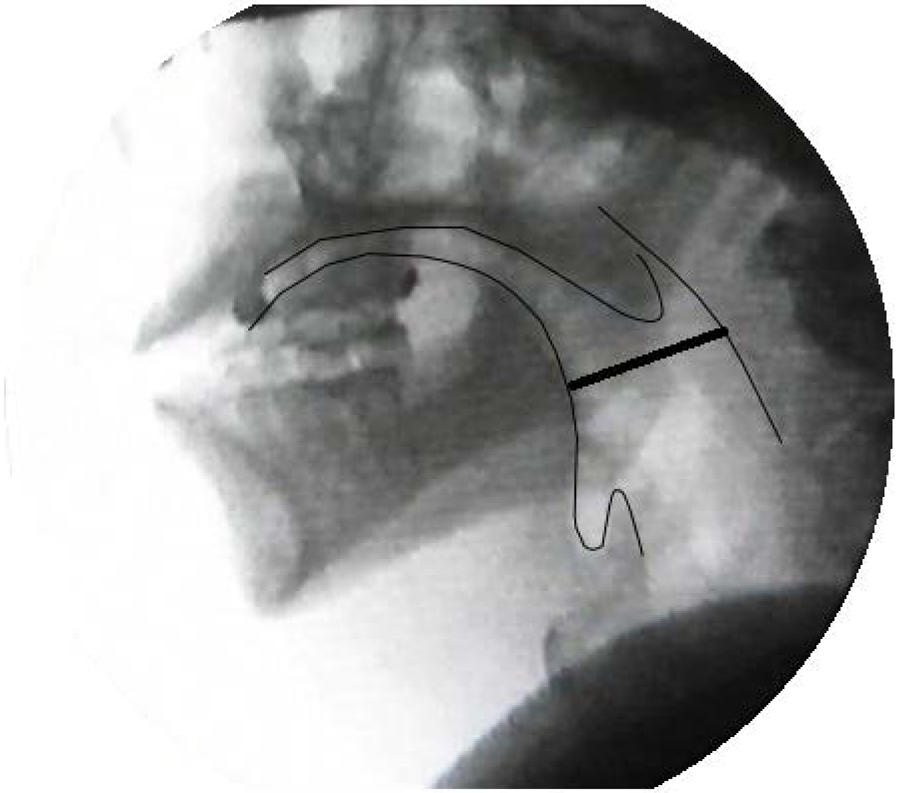

image10 (frame 01:05;14 = 65.467s) /qˤiː/ 32.5 mm (21.0)

Sound	Position	F1	F2	F3	F4	F3-F2	F4-F3
/qˤiː/	65.467s	220	2460	3120	4600	660	1480

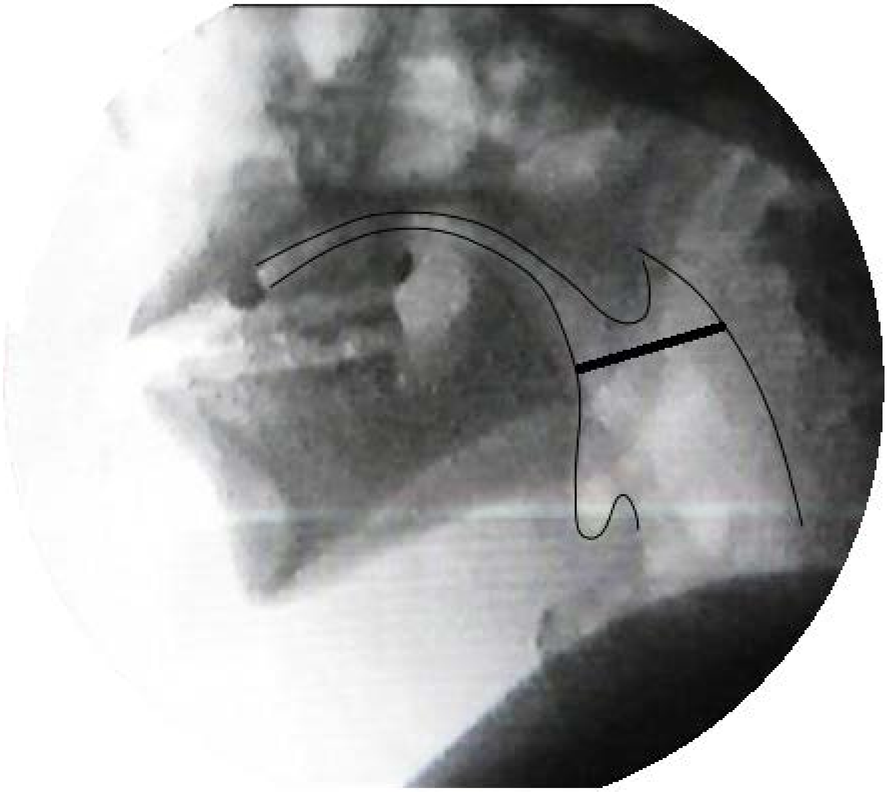

image11 (frame 01:10;20 = 70.667s) /dˤiː/ 30.1 mm (19.5)

Sound	Position	F1	F2	F3	F4	F3-F2	F4-F3
/dˤiː/	70.667s	210	2460	3120	4200	660	1080

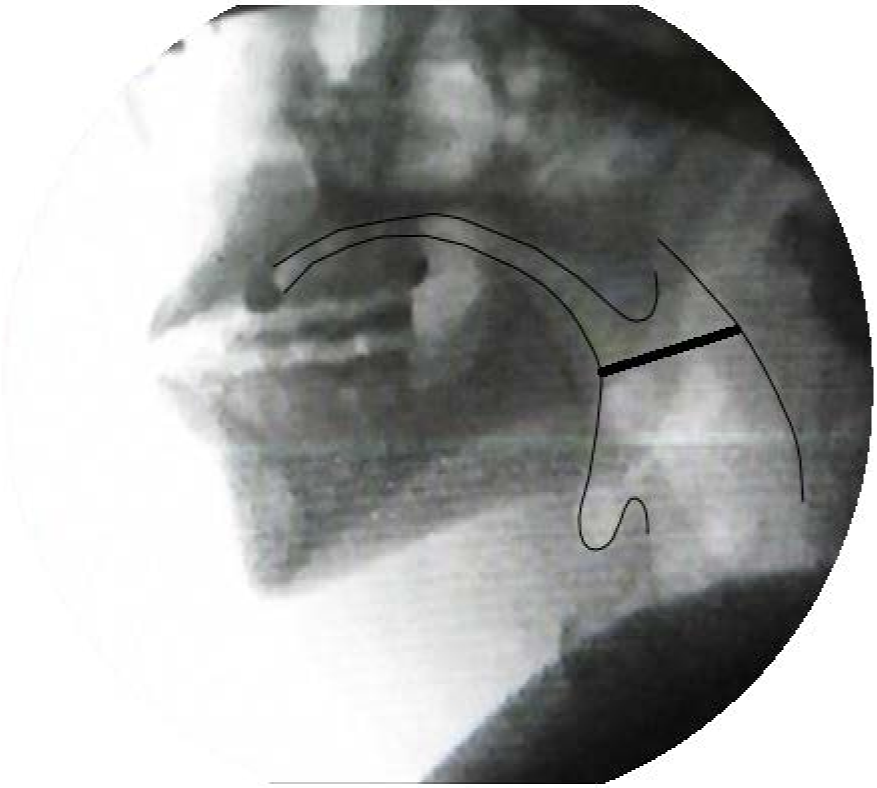

image12 (frame 01:15;14 = 75.467s) /qˤuː/ 16.2 mm (10.5)

Sound	Position	F1	F2	F3	F4	F3-F2	F4-F3
/qˤuː/	75.467s	310	590	2830	3250	2240	420

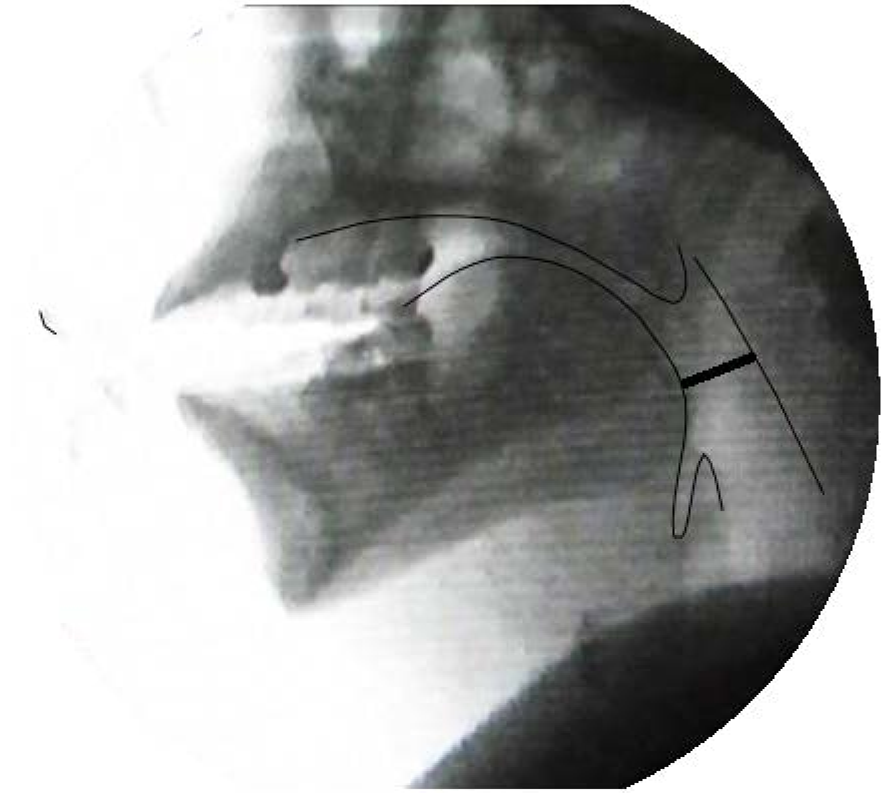

image13 (frame 01:22;23 = 82.767s) /sˤuː/ 17.0 mm (11.0)

Sound	Position	F1	F2	F3	F4	F3-F2	F4-F3
/sˤuː/	82.767s	260	650	3060	4030	2410	970

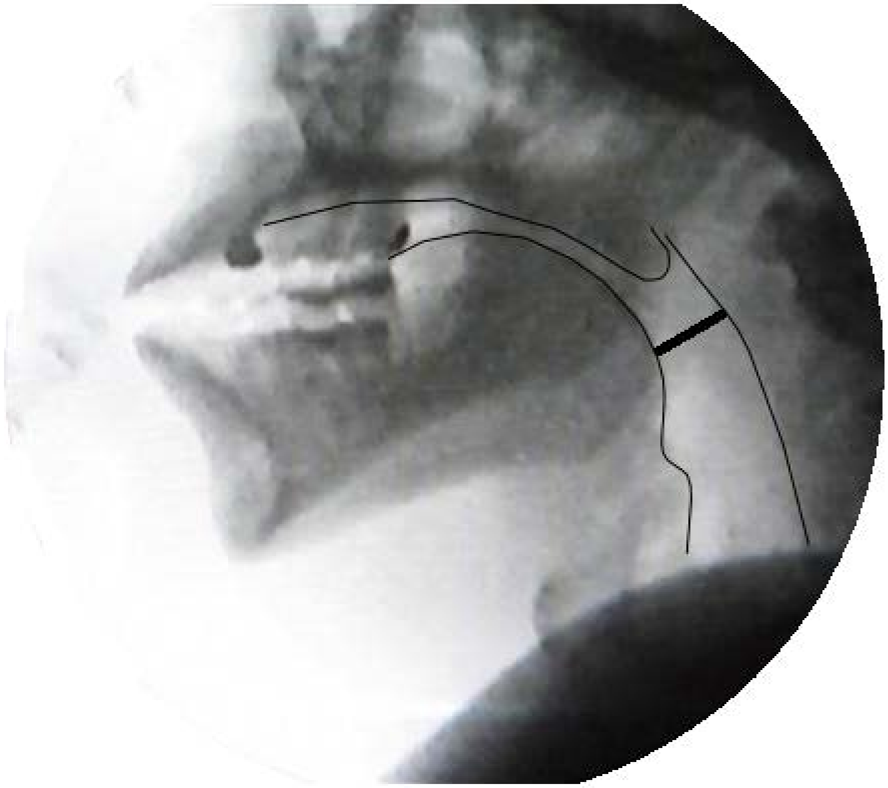

image13A (frame 01:23;16 = 83.533s) /muː/ 19.3 mm (12.5)

Sound	Position	F1	F2	F3	F4	F3-F2	F4-F3
/muː/	83.533s	300	620	2240	2910	1620	670

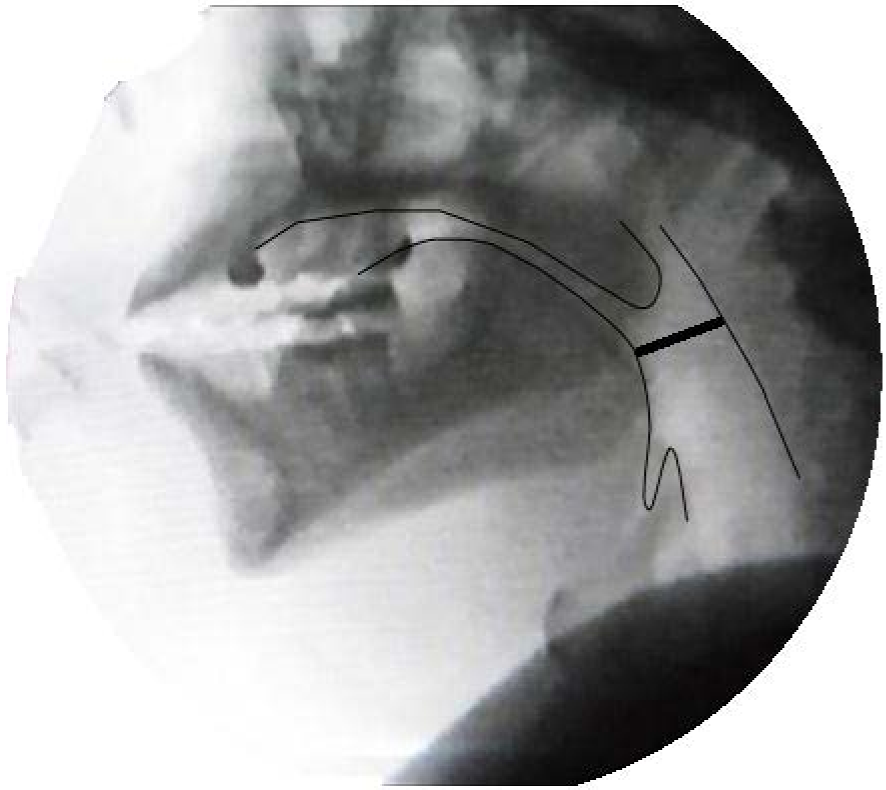

image14 (frame 01:25;16 = 85.533s) /ðˤuː/ 15.5 mm (10.0)

Sound	Position	F1	F2	F3	F4	F3-F2	F4-F3
/ðˤuː/	85.533s	300	700	2080	2960	1380	880

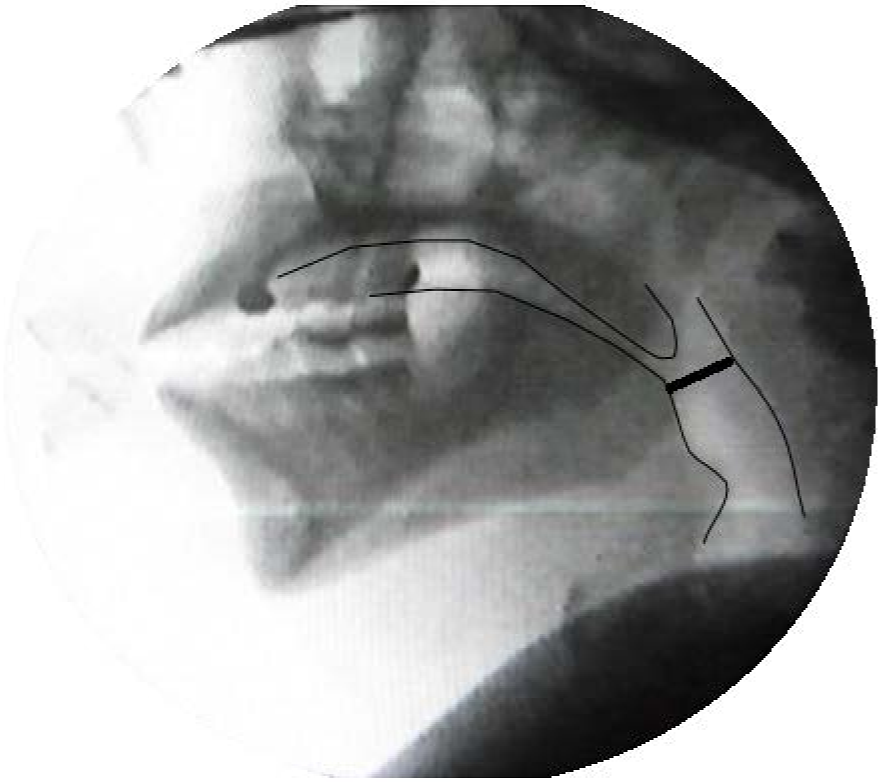

image14A (frame 01:27;00 = 87.000s) /nuː/ 24.7 mm (16.0)

Sound	Position	F1	F2	F3	F4	F3-F2	F4-F3
/nuː/	87.000s	300	630	2430	3240	1800	810

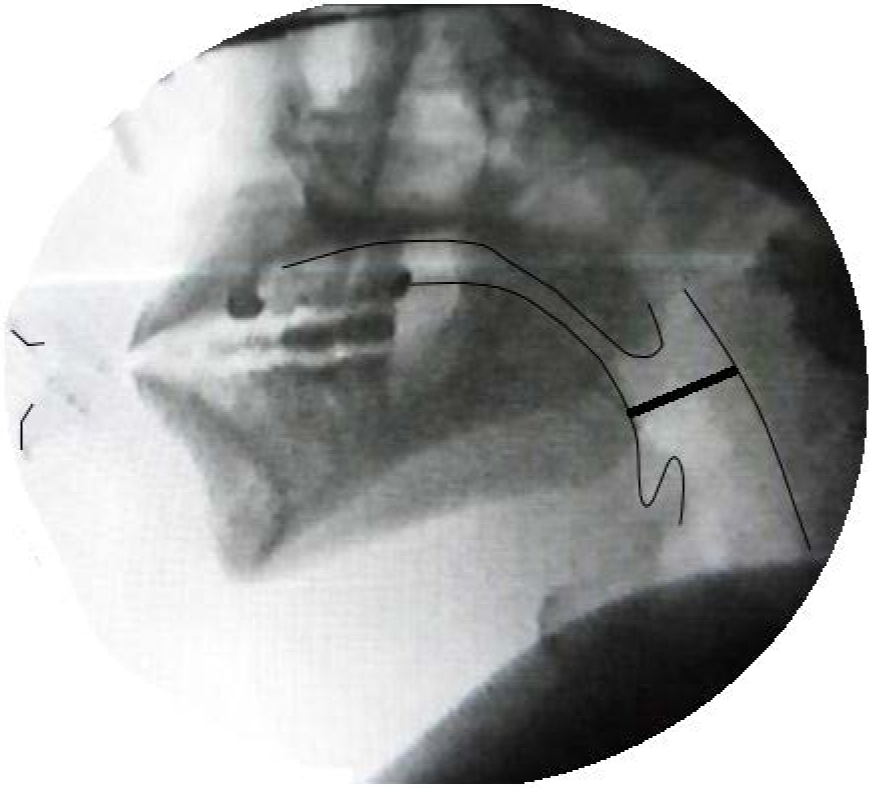

image14B (frame 01:28;08 = 88.267s) /lā/ 20.1 mm (13.0)

Sound	Position	F1	F2	F3	F4	F3-F2	F4-F3
/lā/	88.267s	300	630	2400	3220	1770	820

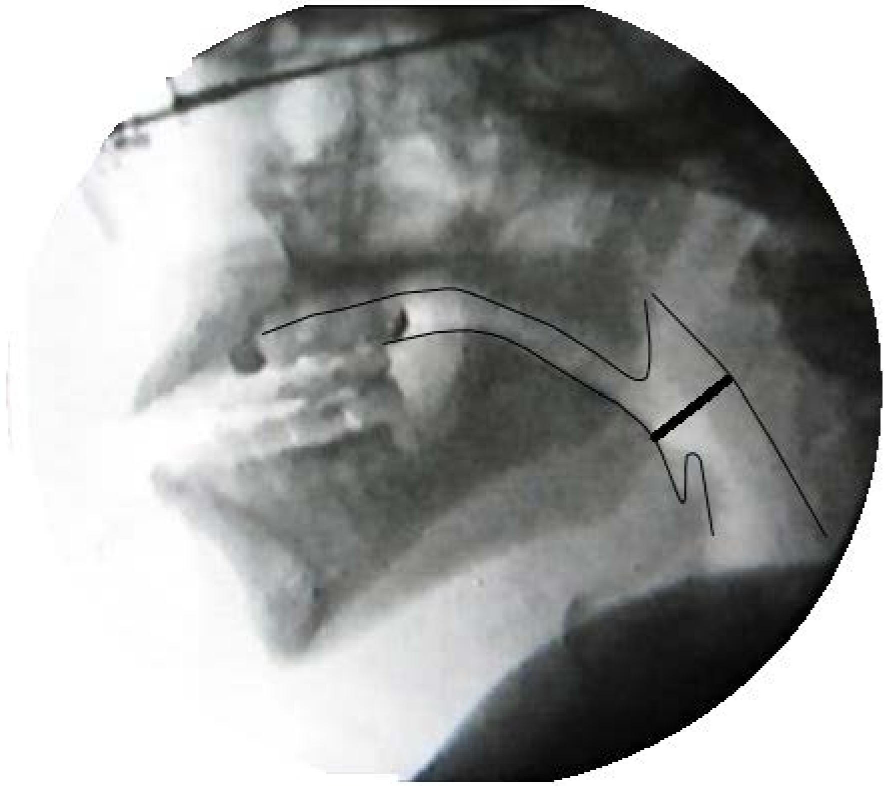

image15 (frame 01:30;18 = 90.600s) /dˤuː/ 10.8 mm (7.0)

Sound	Position	F1	F2	F3	F4	F3-F2	F4-F3
/dˤuː/	90.600s	450	680	2510	2950	1830	440

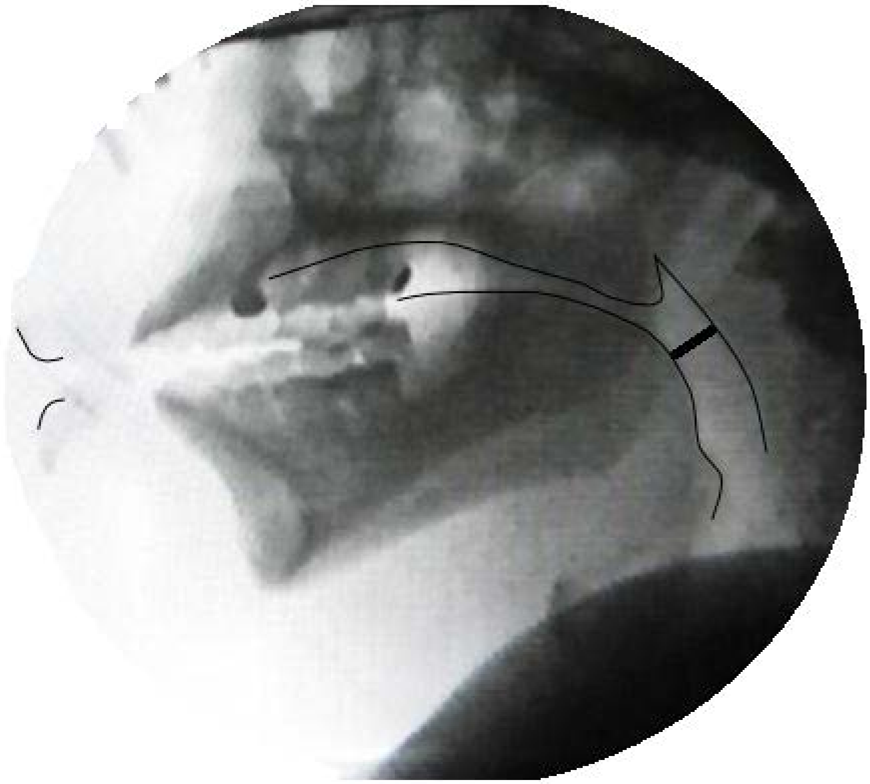

image16 (frame 01:33;14 = 93.467s) /tˤuː/ 14.7 (9.5)

Sound	Position	F1	F2	F3	F4	F3-F2	F4-F3
/tˤuː/	93.467s	350	600	2710	3380	2110	670

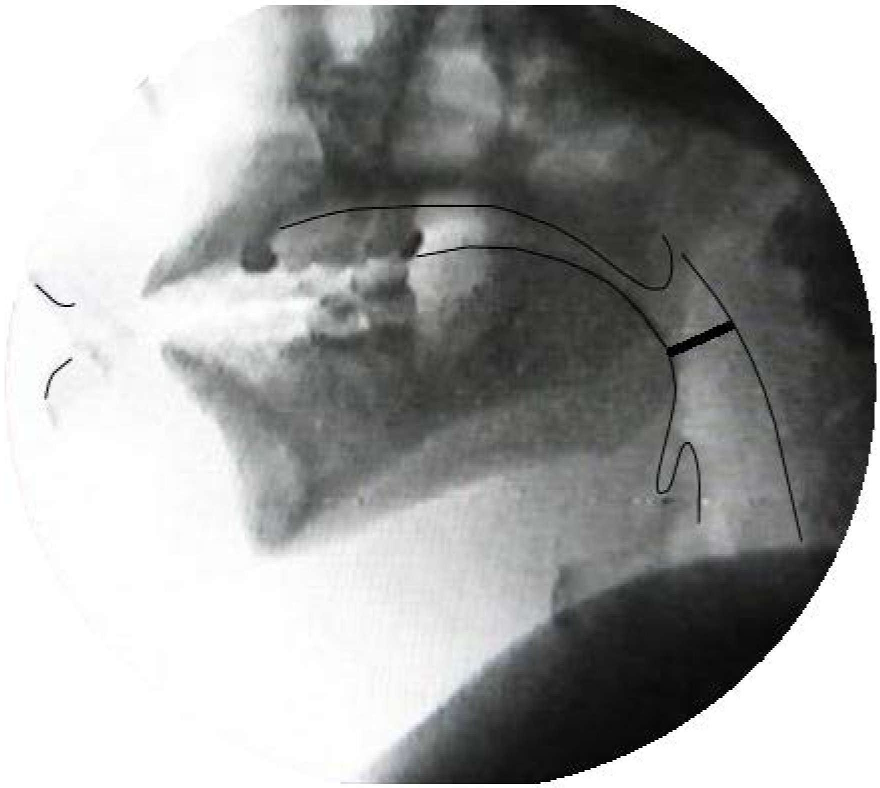

image17 (frame 01:39;13 = 99.433s) /ðˤuː/ 18.5 mm (12.0)

Sound	Position	F1	F2	F3	F4	F3-F2	F4-F3
/ðˤuː/	99.433s	280	460	2480	3440	2020	960

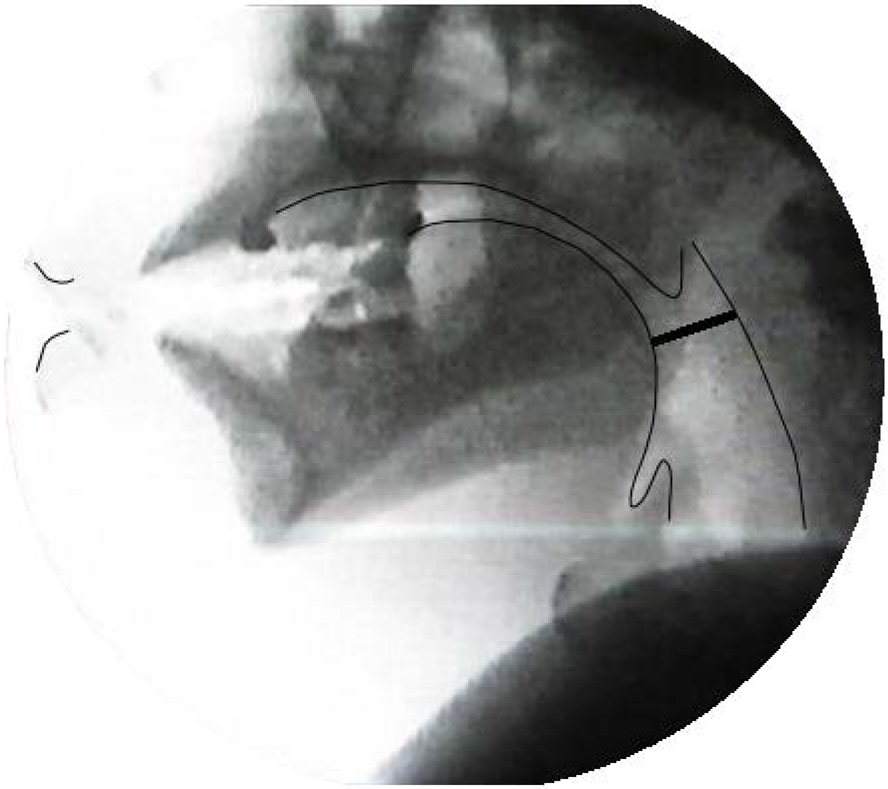

image17A (frame 01:37;18 = 97.600s) /li/ 31.7 mm (20.5)

Sound	Position	F1	F2	F3	F4	F3-F2	F4-F3
/li/	97.600s	380	2350	2700	3280	350	580

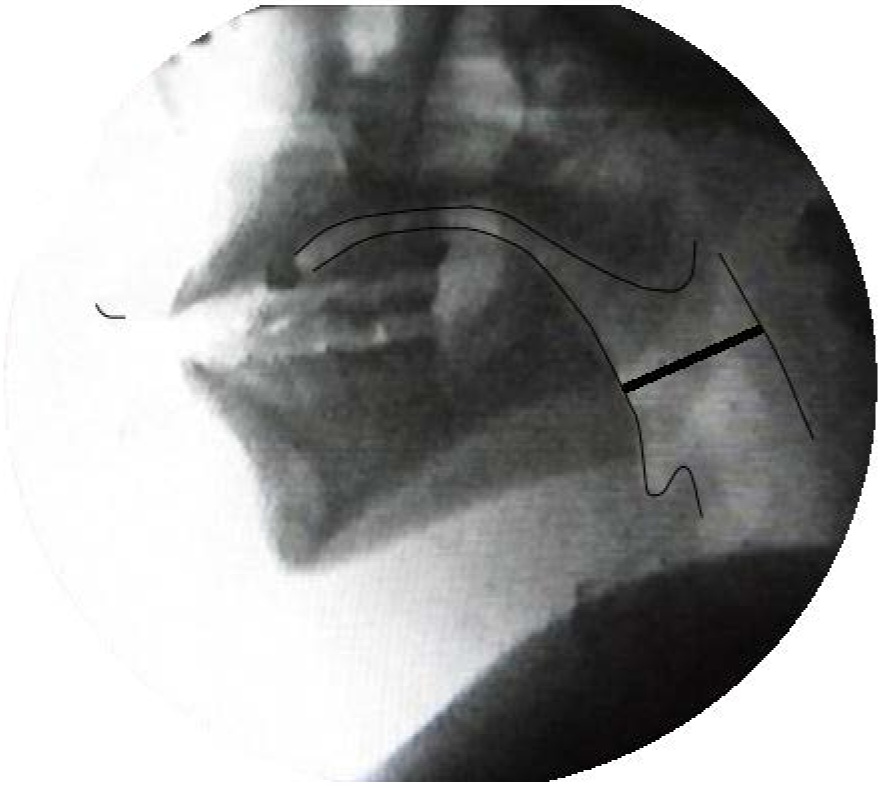

image18 (frame 01:43;03 = 103.100s) /xˤuː/ 18.5 mm (12.0)

Sound	Position	F1	F2	F3	F4	F3-F2	F4-F3
/xˤuː/	103.100s	330	590	2730	3800	2140	1070

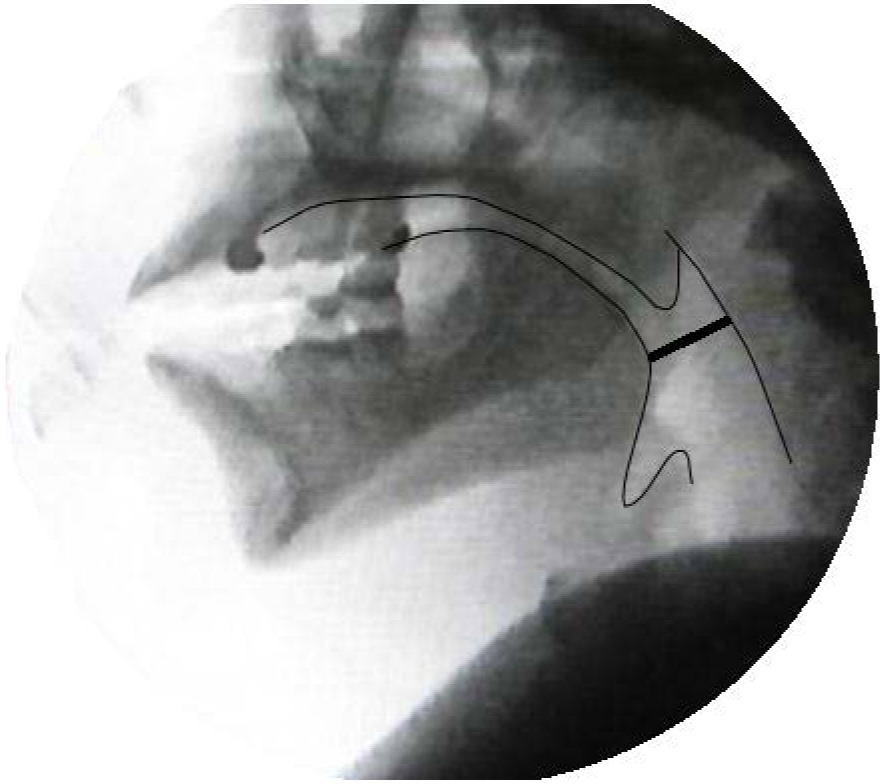

image19 (frame 01:51;07 = 111.233s) /qˤā/ 7.0 mm (4.5)

Sound	Position	F1	F2	F3	F4	F3-F2	F4-F3
/qˤā/	111.233s	640	900	2480	3310	1580	830

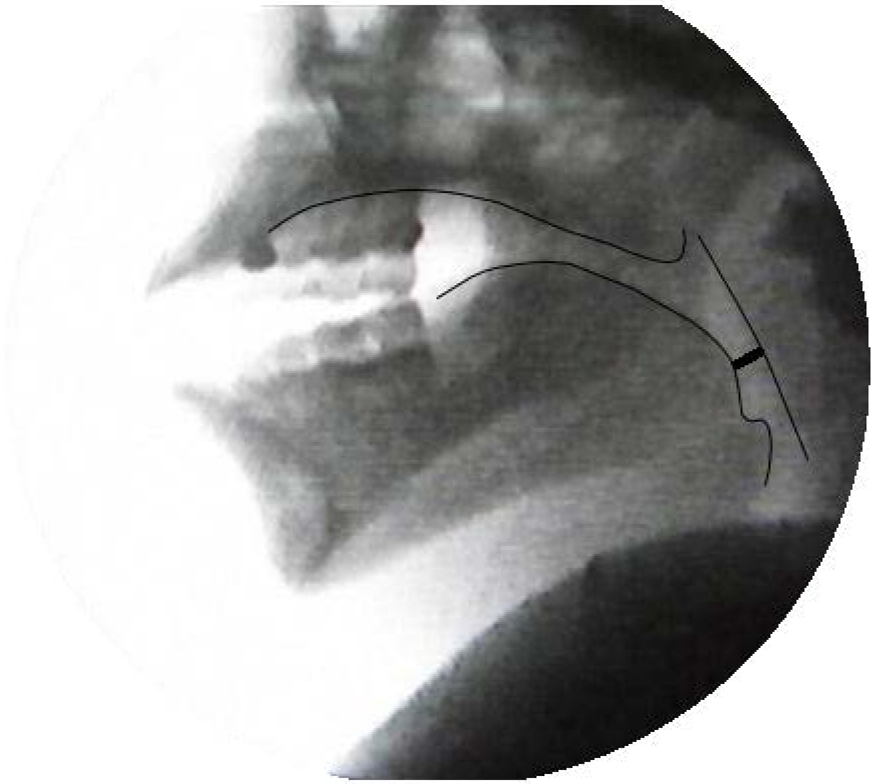

image20 (frame 01:51;24 = 111.800s) /sˤā/ 7.7 mm (5.0)

Sound	Position	F1	F2	F3	F4	F3-F2	F4-F3
/sˤā/	111.800s	630	950	2630	3220	1680	590

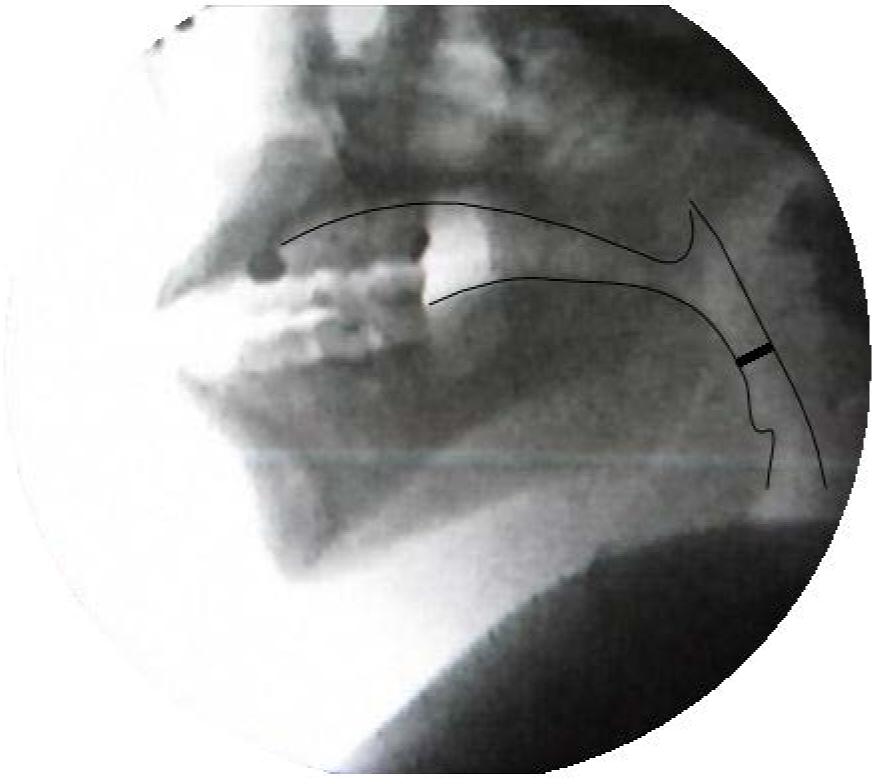

image21 (frame 01:58;04 = 118.133s) /xˤā/ 9.3 mm (6.0)

Sound	Position	F1	F2	F3	F4	F3-F2	F4-F3
/xˤā/	118.133s	600	830	2570	3160	1740	590

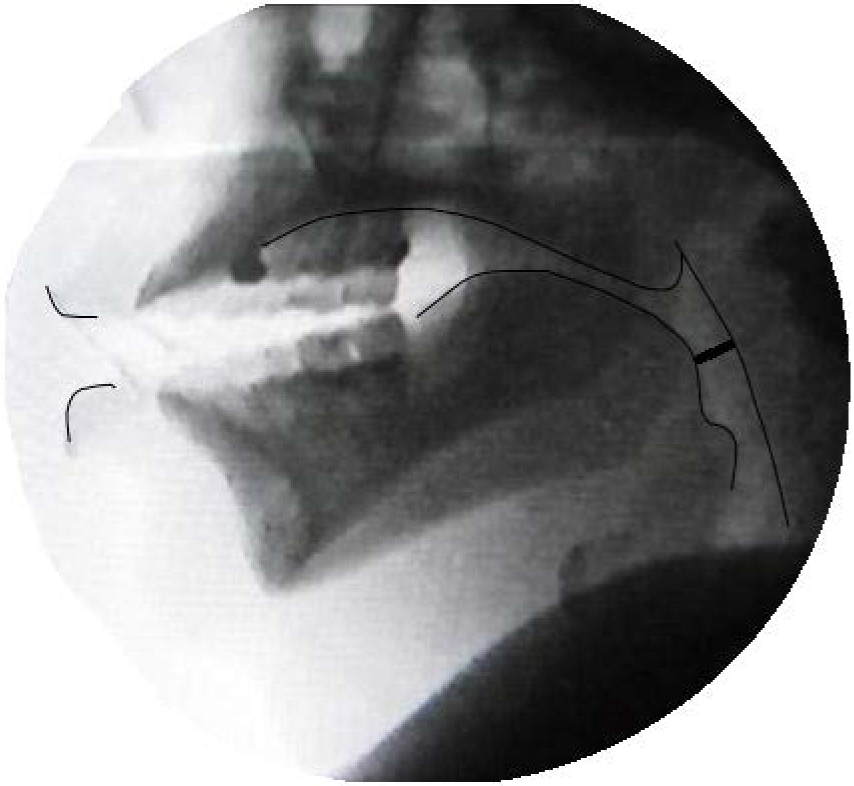

image22 (frame 01:59;02 = 119.067s) /dˤā/ 8.5 mm (5.5)

Sound	Position	F1	F2	F3	F4	F3-F2	F4-F3
/dˤā/	119.067s	560	750	2640	3170	1890	530

image23 (frame 02:01;16 = 121.533s) /tˤā/ 7.0 mm (4.5)

Sound	Position	F1	F2	F3	F4	F3-F2	F4-F3
/tˤā/	121.533s	570	820	2690	3630	1870	940

image24 (frame 02:03;20 = 123.667s) /ðˤā/ 7.7 mm (5.0)

Sound	Position	F1	F2	F3	F4	F3-F2	F4-F3
/ðˤā/	123.667s	550	780	2670	3820	1890	1150

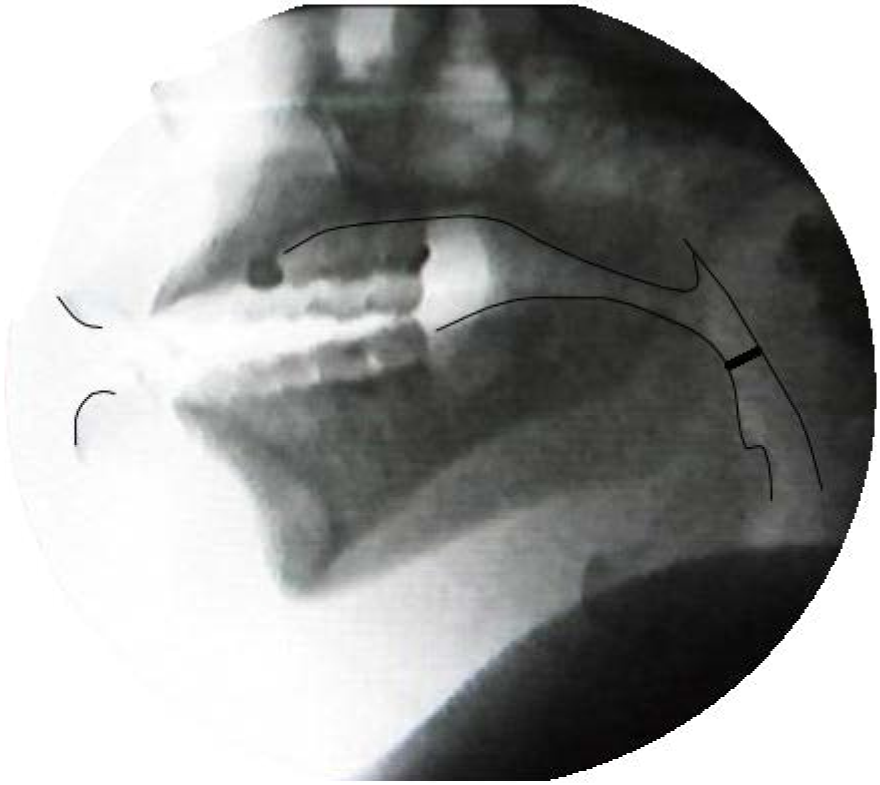

image25 (frame 02:06;16 = 126.533s) /ʁˤā/ 10.8 mm (7.0)

Sound	Position	F1	F2	F3	F4	F3-F2	F4-F3
/ʁˤā/	126.533s	600	960	2630	3160	1670	530

APPENDIX 6

A CD-ROM accompanies this thesis. It contains all of the sound samples of this research and the full movie of the videoflurographic experiment.