Voice Quality Features in the Production of Pharyngeal Consonants by Iraqi Arabic Speakers

By

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Thesis submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy,

School of Education, Communication, and Language Sciences

Newcastle University

June

2013

Declaration

I certify that all the material submitted in this work which is not my own work has been identified and that no material is included which has been submitted for any other award or qualification.

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Abstract

This study investigates nasalisation and laryngealisation in the production of pharyngeal consonants in Iraqi Arabic (IA) and as potential voice quality (VQ) settings of IA speakers in general. Pharyngeal consonants have been the subject of investigation in many studies on Arabic, primarily due to the wide range of variation in their realisation across dialects, including approximant, fricative, and stop variants. This is the first quantitative study of its kind to extend these findings to IA and to investigate whether any of the variants and/or VQ features are dialect-specific.

The study offers a detailed auditory and acoustic account of the realisations of pharyngeal consonants as produced by nine male speakers of three Iraqi dialects: Baghdad (representing Central *gelet*), Basra (representing Southern *gelet*) and Mosul (representing Northern *qeltu*) (Blanc, 1964; Ingham, 1997). Acoustic cues of nasalisation and phonation types are investigated in isolated vowels, oral, nasal, and pharyngeal environments in order to unravel the source of the nasalised and laryngealised VQ percept and to establish whether their manifestations are categorical or particular to certain contexts.

Results suggest a range of realisations for the pharyngeals that are conditioned by word position and dialect. Regardless of realisation, VQ measurements suggest that: **1-** nasalisation increases when pharyngeals are adjacent to nasals, beyond what is expected of a nasal environment; **2-** vowels neighbouring pharyngeals show more nasalisation than in oral environments; **3-** vowels in pharyngeal contexts and isolation show more laryngealisation compared with nasal and oral contexts; **4-** both nasals and pharyngeals show progressive effect of nasalisation, and pharyngeals show a progressive effect of laryngealisation; **5-** /ħ/ shows more nasalisation but less laryngealisation effect on neighbouring vowels than /ʕ/; and **6-** Baghdad speech is the most nasalised and laryngealised and Basra speech the least. These results coincide with observations on Muslim Baghdadi *gelet* having a guttural quality (Bellem, 2007). The study reveals that the overall percept of a nasalised and laryngealised VQ in IA is a local feature rather than a general vocal setting.

Dedication

I dedicate this work to my beloved Husband, Father and Mother …..

And to the *'light'* of my life, my two precious daughters ***Noor*** and ***Huda***

Acknowledgements

The completion and success of this work is the result of the efforts, encouragement and support of many people, without which this work would have not been accomplished.

My first and uttermost feelings of gratitude go to my supervisors, Dr. Ghada Khattab and Dr. Jalal Al-Tamimi, for their invaluable guidance, support and patience throughout my study. They have been the greatest of people who supported me in the hardest of times both academically and personally. No words can express how grateful I am to all their efforts and encouragement throughout this journey. Thank you and God bless you both!

My deepest gratitude goes to my little family. First to my husband, Salam, for being the greatest husband a woman would wish for. His support and selflessness had made everything possible. With his patience and kind heart, he has provided me with the best studying environment. He also went through the hardest of circumstances during my days of sickness and endured many exhausting and frightening moments. Salam, thank you! Second to my beautiful, kind and thoughtful daughter, Noor, who has been one of the best supporters and helpers throughout my study. I apologize to her for all those moments I was too busy to 'do things with her', for those precious moments I could not be with her and have for ever lost and regret. And last, but certainly not least, to little Huda who has brought laughter to our home despite all we went through to have her among us. I hope I will be able to take care of my beautiful family the way they deserve after I finish my PhD.

I would like to thank the first people who believed in me, gave me encouragement and everlasting support. I thank my dad, Prof. Dr. Abdulhussain Al-Siraih, for being an academic inspiration and a great father; I thank my mum for all her prayers, tears, fear and worry, I thank her for her endless love. I also want to apologize to them for all the worry I caused them and the long time my family and I were away from them. I am sorry you missed out on five years of Noor's life.

My gratitude extends to my sister Nawras, my brother Ali, uncle Alaa and all of my in-laws who have been constantly supportive with their prayers, best wishes and lovely chats which helped us endure our living so far away from them.

I would also like to thank my friends Aghareed Al-Ramahi, Reham Abdellatif, Rouaa Yassin Kassab, Yalda Kazemi and their families for all their kind and endless help during and following the times Huda and I were in hospital. My thanks also go to friends Dr. Haidar Ramadhan and Rand Al-Omar for their help during the data collection period by welcoming us in their home and facilitating meeting my Basra subjects in Swansea.

I would also like to thank all my Iraqi informants living in the cities of Newcastle upon Tyne and Swansea for giving up their time in volunteering to take part in the data collection, without their kind help there would not be any study.

My thanks also extend to Sarah Rylance, the HASS Senior Research Student Support Assistant, for her kind and generous professional help through the most of difficult times.

Finally, my thanks go to a special group of people whom without their dedication and passion I would not have been able to have my little girl among us. My thanks go to all staff of the Neonatal Ward at Sunderland Royal and Special Care Baby Unit at Newcastle RVI hospitals for taking care of my baby Huda, who has brought joy and happiness to our family.

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Chapter 1 Chapter 1: Introduction

1.1 Area and Topic

Iraqi Arabic (henceforth IA) is a dialect that has attracted considerable interest from researchers who have investigated many of its aspects due to the variation of its speech communities, dialectal classifications and origins under the influence of numerous factors such as language (e.g. Persian, Turkish, Kurdish, English), religion (Muslim, Christian, Jewish), and Bedouinization (Bedouin vs. sedentary), among others. In addition to the main dialect, sub-dialects spoken in different areas of Iraq have been the focus of a number of studies (Blanc, 1964; Abu-Haidar, 1988; 1991; Jastrow, 1994; Ingham, 1997). IA dialects were classified by Blanc (1964) into two main groups: *qeltu*, a group of dialects spoken by Muslims of Upper (Northern) Iraq and by Christians and Jews of the rest of the area, and *gelet*, a group of dialects spoken by Muslims of Lower Iraq and the nomads of the rest of the area. Further classifications of Lower Iraq suggest a distinction between two areas: Central and Southern (Ingham, 1997).

Most studies investigating IA and any of its dialects have concentrated on syntax, vocabulary and phonology (Van Ess, 1918; O'Leary, 1925; McCarthy and Raffouli, 1964; Blanc, 1964; Jastrow, 1994; Versteegh, 2001). Phonetic aspects have also been investigated but have mostly been researched from an impressionistic rather than an instrumental perspective (Blanc, 1964; McCarthy and Raffouli, 1964; Abu-Haidar, 1988, 1991; Ingham, 1997; Versteegh, 2001). Only a few acoustic and articulatory studies have been carried out on the IA dialect (Al-Ani, 1970; Butcher and Ahmad, 1987; Hassan et al., 2007, 2011), with the most detailed acoustic description of IA speech segments having been carried out by Al-Ani (1970), with him as the primary participant, four other speakers from Iraq and two from Jordan.

Amongst phonetic investigations of Arabic dialects, interest in pharyngeal consonants has been prominent due to their varying realisations, especially in the case of the voiced target (Ghazeli, 1977; Laradi, 1983; Butcher and Ahmad, 1987; Esling, 1999, 2005; Heselwood, 2007; Hassan et al., 2011). Most Arabic dialects have one realisation of both pharyngeals, either as fricatives (McCarthy and Raffouli, 1964; Blanc, 1964; Ghazeli, 1977; Laradi, 1983; Abu-Haidar, 1991; Holes, 2004; Alotaibi and Muhammad, 2010) or as approximants (Obrecht, 1968; Catford, 1977; Ingham, 1982; Esling, 1999; Shahin, 2002; Esling, 2005; Heselwood, 2007); with some dialects having other realisations such as a tight approximant (Heselwood, 2007) or an epiglottal stop [ʡ] (Esling, 1999; Esling, 2005; Edmondson et al, 2005; Edmondson et al, 2007). IA pharyngeals, on the other hand, have more variation and /ʕ/ has been found to be realised as a voiceless stop (Al-Ani, 1970; MacCurtain, 1981), an approximant followed by a stop at final position but a voiced fricative in other positions (Butcher and Ahmad, 1987), and as an aryepiglottic trill (Hassan et al, 2011). This variation is also thought to be dialect-specific, with the two *gelet* dialects of Lower (Central and Southern) Iraq, i.e. Baghdad and Basra, showing more stop realisations of pharyngeals than the Northern dialects, i.e. Mosul. This assumption is based upon views of some researchers like Bellem (2007: 270) who believe that the *gelet* dialects generally have more 'emphaticness' or are at least of a more 'guttural' quality due to having "a 'stronger' (creakier and more stop-like, rather than approximant-like) pharyngeal ʕ".

The investigation of aspects of Voice Quality (henceforth VQ) in the current study is triggered both by the impression of more emphaticness in some dialects of IA as well as that of nasalisation accompanying the production of pharyngeal consonants. The production of these consonants in a number of Arabic dialects, and particularly IA, has been associated with nasalisation since early studies by Rabin (1951) and Hetzron (1969), but few have tried to investigate it experimentally (e.g. Ghazeli, 1977; Laradi, 1983; Butcher and Ahmad, 1987). In these experimental investigations, Arabic pharyngeals were found to be produced with accompanying velum lowering and/or nasal airflow suggesting nasalisation. Ghazeli (1977) found a lowering of the velum but did not find any nasal airflow accompanying it; Laradi (1983) confirmed the presence of velum lowering and nasal airflow in relation to both pharyngeals, most notable in the /ħ/ environment but once again no audible nasalisation was heard; Butcher and Ahmad's (1987) investigation shows inconsistency within all speakers, with only one speaker showing nasal airflow in connection to /ħ/, suggesting speaker specific patterns. Nasalisation is a *velopharyngeal* voice quality setting, which could colour the speech of an entire speech community, have linguistic implications, or be speaker specific. The present study will investigate this setting in connection to the realisation of IA pharyngeals and explore if any particular realisations show more nasalisation.

As will be discussed in Chapter 3, VQ is "the characteristic auditory colouring of an individual speaker's voice" (Laver, 1980:1), covering the entire vocal apparatus starting from the larynx up to the lips and nostrils. What happens at the larynx, i.e. phonation, plays a major part in the colouring of that voice and therefore needs to be investigated. According to some views in the literature (Bellem, 2007), the speech of Muslim Baghdadi speakers is characterised by a guttural quality when producing pharyngeal consonants. An acoustic and auditory investigation of phonation types is therefore required to find out if those claims are true of Baghdadi speakers and if that quality is only a local or a more general quality of IA. Furthermore, some researchers believe that breathy phonation is sometimes masked as nasalisation, so what is perceived or found to be cues of nasalisation may in fact be breathiness (Chen, 2007). It is essential to rule out such claims by carrying out an acoustic and auditory investigation of phonation types alongside nasalisation cues. To the best of the present researcher's knowledge, no study has been conducted on IA, whether auditory or instrumental, to investigate velopharyngeal and phonatory settings in the speech of IA speakers.

1.2 Focus and Aims of the Study

The present study is an acoustic and auditory investigation of the pharyngeal consonants in IA in order to map out their realisations in the IA dialects under study and to explore any potential connection between the realisation of these sounds and two vocal settings: nasalisation and laryngealisation. The study is also the first attempt to investigate the phonation types produced by IA speakers in general and in connection with nasalised contexts in particular. This is accomplished in relation to the investigation of nasalisation as a feature accompanying the production of certain sounds and as a feature colouring the speech of IA speakers. The general aim is to explore the extent to which nasalised and/or laryngealised voice quality settings are a property of pharyngeal environments or whether they extend further to isolated vowels and oral contexts, suggesting general VQ features in IA.

1.3 Importance of the Study

This study brings together areas of investigation that have never been explored within a single study before. It provides a detailed account of IA, its classifications and sound inventory, with particular focus on the production of pharyngeal consonants, as produced by the speakers of three dialects each representing a dialectal group: Mosul representing Northern, Baghdad representing Central and Basra representing Southern. The study begins with an overview of the geography, history, population make-up, religion, languages and dialects of Iraq, providing more details on IA and its two main dialectal groups, *qeltu* and *gelet*, their sub-dialectal divisions into *Bedouin* vs. *sedentary*, *ḥaḍar* [ħaðˤar] vs. ‘*Arab* [ʕarab] and *xašš* [xɛʃʃ] vs. *ṭabb* [tˤʌbb], and the sound inventory of these divisions. The study highlights two of the most controversial consonants, pharyngeal consonants, as they are produced by IA speakers. Differing from speakers of other dialects, where mostly one realisation of pharyngeals (either fricatives or approximants and a few instances of stops) is associated with each dialect, IA speakers have been described as having three realisations: fricative, approximant and stop. And due to the fact that some researchers believe that speakers of the *gelet* dialectal group have more of a guttural quality (Bellem, 2007), realisations of pharyngeals will be investigated in speakers of the two *gelet* dialects, Baghdad and Basra and will be compared with those of speakers of the *qeltu* dialect, Mosul. This will be the first investigation to present a typology of realisations for the pharyngeal consonants which vary according to word position and dialect. The results are looked at in light of previous views that pharyngeal consonants are produced with accompanying creaky voice and nasalisation. This is also the first acoustic investigation of phonation types produced by speakers of the three dialects.

1.4 Research Questions

The present study is set to answer the following questions:

1- *What are the auditory and acoustic properties of pharyngeal consonants in Iraqi Arabic and are they coupled with nasalisation and laryngealisation as is suggested in the literature?*

2- *Are nasalisation and laryngealisation voice quality features of Iraqi speakers?*

3- *Does degree of nasalisation and laryngealisation vary between the three linguistic areas of Iraq, i.e. northern, central, and southern?*

1.5 Organisation of the Study

This first chapter aside, the thesis consists of 10 further chapters divided into two parts. Part one is the theoretical part and consists of four literature review chapters. Part two is the experimental part and consists of five chapters including the Methodology and four results chapters. These are then followed by the eleventh chapter, which presents a summary and discussion of results alongside conclusions and recommendations.

Chapter 2 presents a general account of Iraq's geography, population and languages. Iraqi Arabic is discussed in comparison with Standard and Classical Arabic, followed by a detailed classification of the different dialectal groups and sub-dialects. The chapter also provides an account of the phonological description of IA with particular reference to the three dialects under investigation.

Chapter 3 is an overview of voice quality, its definition, settings, types, methods of investigating VQ and the main acoustic measures used in the literature. The chapter highlights two types of cues related to two groups of settings. The first cues are supralaryngeal, or related to the vocal tract, particularly the velopharyngeal setting. The second cues are laryngeal (phonatory) and related to the action of the larynx.

Chapter 4 presents an overview of nasality and nasalisation. Acoustic features of nasal and nasalised vowels in relation to oral vowels and nasal consonants are introduced. The chapter also explores acoustic measurements that have been used in studies investigating nasalisation. Finally the chapter ends with an overview of nasal voice quality.

Chapter 5 is a detailed account of the description and classification of pharyngeal consonants as they are produced by Iraqi speakers, speakers of other languages or speakers of other Arabic dialects. A review of the relation between nasalisation and pharyngeals will also be tackled.

Chapter 6 consists of a detailed account of the methodology applied in this research. The chapter presents details of the choice of nine speakers and data; how and where the data were recorded; and the methods used to investigate nasalisation and laryngealisation.

Chapter 7 provides a description of pharyngeal consonants and their realisations. This is done by using auditory and spectrographic analysis, consisting of acoustic profiling and applying two acoustic measures: *F*1 and *F*2 frequencies in vowels neighbouring pharyngeals to show how frequencies of these formants change in comparison to when the same vowels are in isolation and oral contexts, and duration of pharyngeals as a function of their realisation. Information drawn from these two measures will be used to answer the first research question related to the acoustic properties of pharyngeal consonants in IA.

Chapter 8 covers results related to the auditory investigations of nasalisation and phonation types, their relation to the different realisations of the pharyngeals, and a comparison of nasalisation and phonation types across dialects. This is done by applying two criteria: individual contexts (with 3 broad categories for nasal, pharyngeal and oral contexts as well as show effect of type and position of pharyngeal consonant), cross-dialectal differences.

Chapter 9 covers results related to the acoustic investigation of nasalisation, its relation to the different realisations of pharyngeals, and a comparison of nasalisation across dialects. This is done by applying the same three criteria above within which results of each of the target measures (*A*1-*P*1, *A*1-*P*0, *B*1, *F*1, *F*2, *overall vowel intensity*) are presented and for each of the three vowel portions (onset, midpoint, offset).

Chapter 10 presents the results related to the acoustic investigation of phonation types. The same three criteria used above will be used to investigate each of the target measures of phonation types ($H1$-$H2$, $H1$-$A1$).

Chapter 11 consists of the summary and discussion of all the results and provides the recommendations for future research.

Chapter 2 : Iraqi Arabic

2.1 Introduction

Iraq is a country that has witnessed numerous events throughout its history influencing the number and type of population living on the land. These events have also influenced the language and dialect varieties that emerged. Similar to other varieties of Arabic and any dialect variety world-wide, Iraqi Arabic (IA) contains vocabulary and pronunciation that is unique to its speakers and that is the result of a combination of many eras of development. In order to understand the background leading to the unique aspects of IA, it is essential to provide an overview of the country's historical, geographical, and religious background which have influenced its linguistic outlay.

2.2 Geography

Iraq, a country in the Middle-East, has boundaries with 6 countries: Turkey from the north, Iran from the east, Syria and Jordan from the west, and Saudi Arabia and Kuwait from the south (figure 2.1). Two main rivers run through most of the country, the Euphrates and Tigris, the rest of which run through neighbouring countries. The country is considered as a triangle of three types of environments: mountains, desert, and a fertile river valley. The desert area is to the west of the Euphrates, the fertile valley is between the two rivers, and the mountains are in the northeast (Al-Ani and Al-Birazy, 1979; Library of Congress, 2006).

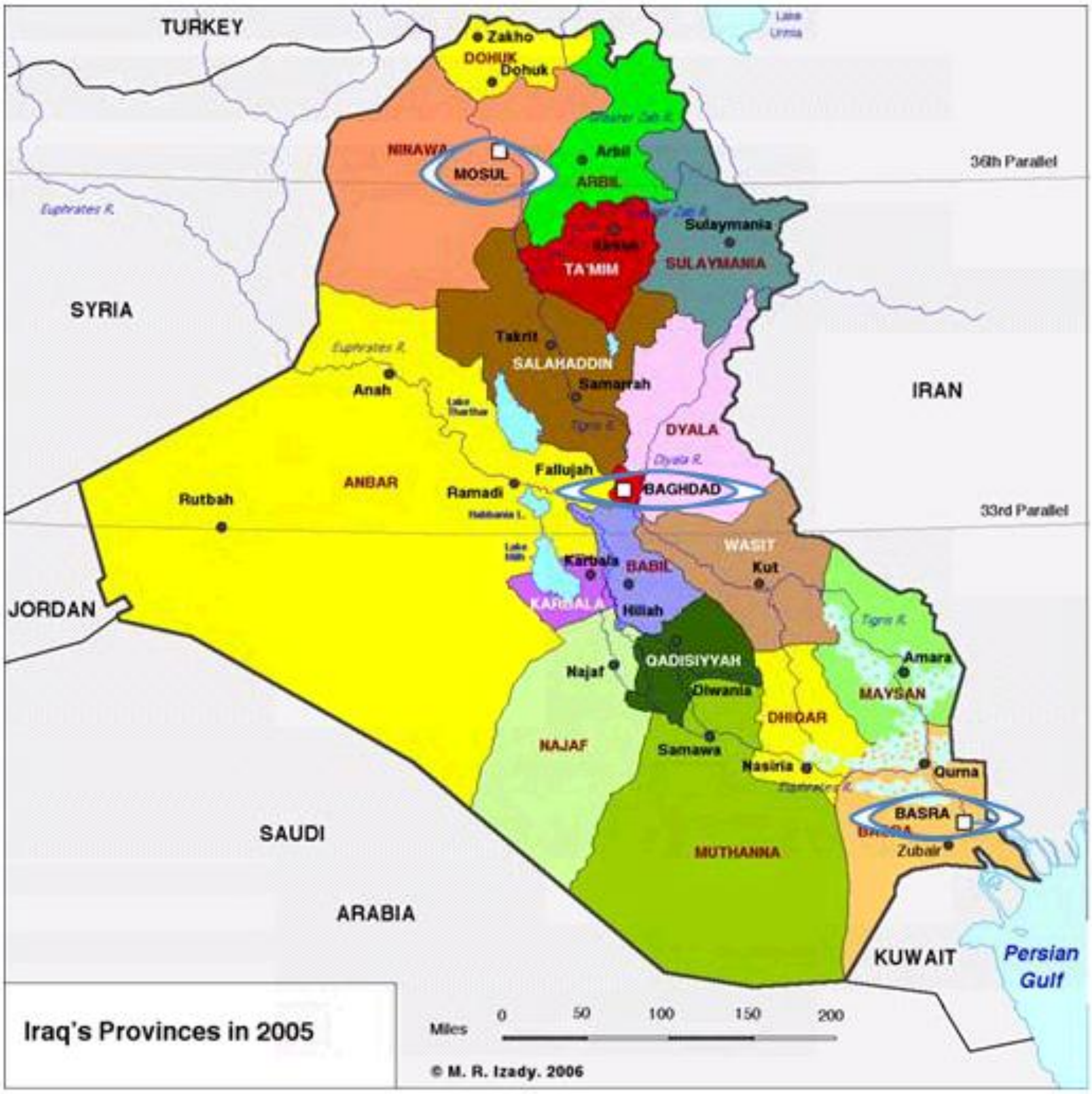

Figure 2.1: A map showing the main urban centres of Iraq with particular reference to the three cities whose dialects are under investigation in the present study: Baghdad, Basra and Mosul. [(1)]

Iraq is also referred to as Mesopotamia, which is its ancient name meaning 'the land between the rivers' (National Geographic Society, 1996; Library of Congress, 2006). Both names are interchangeably used in linguistics literature on IA (see section 2.5 for more detail). The country has always been agricultural with good soil and weather conditions, an environment that tempted people from surrounding areas to migrate to it and settle there (Al-Ani and Al-Birazy, 1979). This movement started from pre-historical ages till the 20th C, during which a struggle between nomadic and sedentary populations or Bedouins and urbanism took place. Various populations with different backgrounds have had an input into the shaping of Iraq's characteristics and society (ibid).

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(1) Map cited from: http://www.thegatewaypundit.com/2008/06/iraq-will-take-control-of-2-more-provinces-in-coming-days/

2.3 History

Iraq has witnessed a vast range of civilizations and was the target of different invasions and occupations throughout its history. This has influenced the type of population together with the languages and dialects spoken in the country. A brief history is provided below (Al-Khalaf, 1961; Al-Ani and Al-Birazy, 1979; Al-Sammak, 1985; Library of Congress, 2006; Washington Post, 2010).

By 4000 B.C., an advanced civilization existed in the area. Later, the land was the centre of such flourishing civilizations as Sumer, Akkad, Babylonia, and Assyria sometime after 2000 B.C. In 538 B.C., Mesopotamia was conquered by Cyrus the Great of Persia and later in 331 B.C. by Alexander. During 637–640 A.D., there was an Arab conquest to Iraq. Later, in 1258, the Mongols invaded the land and caused a huge destruction, especially to its written heritage. Mesopotamia was then the subject of competition between Turks and Persians during the 16th, 17th, and 18th century A.D. In the 19th century, the Ottoman Turks took control of Mesopotamia and formed the three Turkish provinces of Basra (or what is commonly known as Al-Basrah, see figure 2.1), Baghdad and Mosul (Commonly known as Al-Mosul which is part of the ancient area of Ninawa (Nineveh)). During the same period, the area was of interest to European powers such as Germany, and was later invaded by the British during World War I. Later in 1921, the country became a kingdom, which was then brought to an end in 1958 to declare the country a republic and Islam as its official religion. Following that, the country underwent many conflicts over leadership and power which led to the ruling of the Ba'ath political party that lasted from 1963 till the 2003 invasion which ended the rule of Saddam Hussein. During these years, Iraq also witnessed two wars before the final British and American invasion.

2.4 Population and Religion

Iraq consists of a diversity of origins and religions which are the result of a vast immigration process. This diversity has survived due to the geographical isolation that different communities experienced as a result of lack of development and roads to link places together. It was not until the second half of the 20th C. that the country started to develop in all aspects. However, the past isolation played a huge role in preserving the different languages, language varieties and even cultural and habitual uniqueness of each community and population (Al-Khalaf, 1961; Al-Ani and Al-Birazy, 1979; Al-Sammak, 1985; Library of Congress, 2006).

The overall population of Iraq is about 20 million, with Arabs constituting the largest community. With Islam being the official religion of the country, Muslims (mostly Arabs) constitute the majority and are divided into two sectors of Islam: Shiite (60 per cent) and Sunni (35 per cent). Other minority religious populations such as Christians (mostly in Upper Iraq and large cities of Lower Iraq) and Mandaayans (mostly in cities in the southern part of Iraq on river-banks) also live in Iraq and constitute 3 per cent of the population. Jews used to live in Iraq and had a fairly large community, but they started to leave after 1948 and those who stayed were forced to leave during Saddam Hussein's leadership (Washington Post, 2010; Encyclopaedia Britannica, 2010).

There are also other minority populations that occupy different parts of Iraq. In the mountain area called Kurdistan in the north, the majority of the population consists of Kurds who speak Kurdish but are Muslim Sunnis and Shiites. In addition, there is a community of Turkomans (Turks) who speak a dialect of Turkish and/or Arabic and who are also Muslim Sunni and Shiites. Another minority community consists of Armenian and Assyrian Christians (Nestorian Christians), who mainly live in Upper Iraq particularly in Mosul and in large cities of Central and Lower Iraq such as Baghdad, Basra and 'Amara (or what is commonly known as Al-Amara) (Washington Post, 2010; Encyclopaedia Britannica, 2010). As the present study is concerned with the Arabic spoken in Iraq, section 2.5 will deal with the dialectal differences and classifications of Arabic spoken by different populations.

2.5 Languages and Dialects of Iraq

There is a variation of languages, dialects and sub-dialects in Iraq which interrelate with each other. The present section will give an overview of how Iraqi Arabic originated and the different influences that shape the present day speech of Iraqi speakers.

2.5.1 The languages of Iraq and the origin of Iraqi Arabic

Arabic was the only official language of Iraq until the 2003 invasion when Kurdish was officially added as a second language in 2004 by the new constitution, and when Assyrian Neo-Aramaic (also known as Syriac, with Chaldan and Ashuri as its main varieties) and South Azeri (also known as Turkmen) gained official status as regional languages (Jastrow, 2005). In addition to the variety of languages spoken in Iraq, Arabic speakers are known for a local dialect variety called Iraqi, or 'Mesopotamian' Arabic (see: Van Ess, 1918; O'Leary, 1925; Blanc, 1964; Jastrow, 1994; Versteegh, 2001). Mesopotamian is one of five major Arabic dialects according to Versteegh (2001: 145); these are: dialects of the Arabian Peninsula, Mesopotamian dialects, Syro-

Lebanese dialects, Egyptian dialects, and Maghreb dialects. Each of the areas containing these dialectal groups was arabicised in two separate processes, the first resulted in innovative sedentary dialects and the second “brought into being local rural and nomadic dialects”, which in a way preserved some features of Old Arabic (ibid: 145). Mesopotamia underwent two stages of ‘arabicisation’. The first was as early as the Arab conquest around military centres founded by invaders such as Basra and Kufa where urban varieties of Arabic emerged; the second was a ‘layer’ of Bedouin dialects of tribes migrating from the peninsula (ibid: 156).

Present-day Iraqi Arabic shows cross-linguistic influence in the form of many loan-words from such languages as Persian, Turkish (due to having borders with Iran and Turkey respectively), and English (due to the British invasion during the past century, but also due to the dominant use of English in technology and the world wide web). Other dialectal influences are due to being in contact with neighbouring Arab countries such as the Gulf countries in the South and South West, i.e. Kuwait and Saudi Arabia, plus others to the West and North West, i.e. Jordan and Syria. Some of the vocabulary unique to IA speakers has been traced back to languages of ancient civilizations of Mesopotamia such as of Sumer and Akkad.

2.5.2 Classical and Modern Standard Arabic

Iraqi speakers also share two other language varieties with other Arabs and Muslims, one known as Classical Arabic and the other as Modern Standard Arabic. Although Arabic dialect varieties share many characteristics, some aspects are dialect-specific and not all dialects are mutually intelligible. However, there is an Arabic variety which could be understood by all Arabic speakers despite their local differences; this is called Modern Standard Arabic (MSA) (McCarthy and Raffouli, 1964; Blanc, 1964; Versteegh, 2001). This variety of Arabic is used in education in all the Arab countries, where most educated people (even with minimum learning) can speak and understand it but they do not usually use it in everyday speech. MSA is widely used in formal situations such as in radio and TV broadcasting, public speeches and sermons. Classical or Literary Arabic, on the other hand, is the form of the Arabic language used in literary books in the 7^{th} and 9^{th} centuries. It is based on the medieval dialects of Arab tribes, particularly those of Mecca. It is the language of the Qur’an and many of the literature of that era. Muslims of all languages learn this variety to be able to recite the Qur’an but no one speaks it.

2.5.3 Dialectal divisions in Iraq: qeltu vs. gelet

Detailed investigations of IA have led to the identification of distinctive features between regions of Iraq or communities within one region. The main distinction so far has been made on the basis of two dialectal types: *qeltu* (or *qiltu* as is referred to in some of the literature) and *gelet* (or *gilit,* also used in some of the literature). The words *qeltu* and *gelet* are derived from *qultu* meaning 'to say' in the first person singular of the present perfect tense in Standard Arabic. The word *qultu* is used as a representative of a vast number of vocabularies containing the Arabic phoneme /q/ that are realised differently among each dialectal group, with [q] and [g] as the main variants. In the case of the *qeltu*-group, speakers tend to mostly preserve the Classical Arabic[q] and only use [g] in loan-words; whereas in the case of the *gelet*-group, speakers tend to use [g] in most contexts but also preserve the [q] in many Classical Arabic origin words.

The distinction between the two dialectal groups was originally made by Blanc (1964) when he investigated the dialect of Baghdad and found that it varied across religious communities rather than regions. Blanc (ibid) found three types of communities of speakers who, although living in the same city, had dialectal differences, namely the Muslims (Sunnis and Shiites), the Christians and the Jews. The division was made on the basis of one main characteristic Blanc (ibid: 3) refers to as "the unusually profound and sharply delineated dialectal cleavage that divides these populations into three nonregional dialect groups, corresponding to the three major religious communities". He (ibid) found that the non-Muslim groups, Christians and Jews, had slight differences and shared most characteristics; thus they were deemed to belong to the same *qeltu* dialectal type; while all Muslims of Baghdad shared the same *gelet* dialectal type (see figure 2.2, p. 19).

From the speech of the few non-Baghdadi speakers he also investigated, Blanc (1964) found the same *qeltu-gelet* pattern existed in other Iraqi areas. However, the divisions beyond Baghdad included geographical as well as religious distinctions, which led Blanc (ibid: 181) to divide the whole of Iraq on the basis of the above classification into two linguistic areas corresponding roughly to the geographical areas bordered by sides of the two rivers: Upper Iraq and Lower Iraq. These two areas are also referred to as Upper Mesopotamia and Lower Mesopotamia, to cover the areas upper to the two rivers and those from Tikrīt (IPA[(2)] [tıkri:t]) to the Persian Gulf,

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[(2)] IPA transcriptions will be added following examples where Arabic references use transliterations or outdated phonetic symbols which may or may not be familiar to the reader. These will henceforth be placed between round brackets ( ).

respectively. Two main dialectal groups exist within both areas. The first group, the *qeltu*-dialects, are spoken by the non-Muslim population of Lower Iraq and the sedentary population (Muslim and non-Muslim) of Upper Iraq (mainly all people of Mosul, ʻAna ([ʕa:nɛ:]), Tikrīt and Hīt ([hi:t])); whereas the second group, the *gelet*-dialects, are spoken by the Muslim population (sedentary and non-sedentary) of Lower Iraq and by the non-sedentary populations in the rest of the area (ibid: 5-6) [(3)] (see figure 2.2, p. 19).

According to Blanc (ibid: 6), the *qeltu* dialects are related to the Aleppo region dialects, while the *gelet* ones are related to the Bedouin dialects of the Shāmīya ([ʃa:mɪɛ:]) and those of Kuwait, Khūzistān ([xu:zɪsta:n])[(4)] and the Arabic Gulf (commonly known as the Persian Gulf) area. However, despite the vast variation of boundaries separating communities and the existence of non-Arabic communities on the land, Blanc (1964: 5, 181) considered the area as sharing one Mesopotamian Dialect, denoting that it covers "all the Tigris and Euphrates valleys and the areas between them, from the sources on the Anatolian plateau down to the Persian Gulf". A detailed account of the phonological features of IA in general and of each of the two dialectal types will be presented in section 2.6.

In comparing two of the *qeltu* dialectal groups, that of the city of Mosul and that of Baghdadi Christians, Blanc (ibid: 164) states that the dialect of Mosul has "unusual features peculiar to itself". Although there are many similarities between Mosul and Christian dialects, Blanc (ibid) believes there are "enough differences" to consider the Christian dialect as being a related but separate dialect. For Blanc (ibid), similarities between Christian and Mosul dialects may suggest that immigration of Christians from the north (from such cities as Mosul itself) to Baghdad (and other parts of Lower Iraq) reflect the influence of those northern dialects on the Christian accent in Baghdad.

In the study of Southern Iraq and Khūzistān, Ingham (1997: 13-14) offers what he considers as a more detailed classification of the *gelet* dialects, dividing them into two types: *Southern gelet*, which refers to characteristics of speakers of Basra, Nasiriya and ʻAmara; and *Central Mesopotamia*, which includes characteristics of speakers of Baghdad, Mussayab, Hilla and Karbala (also referred to in Bellem, 2007: 229). From an early stage of investigation when Ingham (1969) studied the dialects of Khūzistān, he found links between these dialects and the

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[(3)]Although Blanc's (1964: 183) also mentions a third community of non-Muslims, the Mandaeans, who speak the dialect of surrounding Muslim speakers.
[(4)] Khūzistān is politically part of Iran but linguistically "forms a unit with the southern Mesopotamian area" (Ingham, 1997: 14).

one across the Shaṭṭ al-ʻArab ([ʃatˤalʕaɾab]) [5] towards Arabia. Ingham (1997: 31) found phonological, morphological and lexical patterns which correlated with regional and occupational (nomadic vs. sedentary) factors.

2.5.3.1 *Sub-dialectal divisions: Bedouin vs. sedentary*

Generally speaking, outside of Arabia the *gelet*-dialects are spoken by Bedouin and Bedouinized populations of: fully nomadic camel herders, semi-nomadic sheep and goat herders, recently sedentarized nomads and semi-nomads, groups in different intermediate stages of sedentarization (Blanc, 1964: 167). Blanc (ibid) also refers to the Bedouinization of Muslims of Baghdad (a *gelet*-dialectal group) by stating that although these speakers are a representative of old urban dialectal forms, their dialect has been affected by the phonology and morphology of other areas of Lower Iraq, which in turn has been affected by Bedouinism. Such features as the realisation of /q/ as [ʒ] and /k/ as [tʃ] are used by full nomads; the realisation of /q/ as [j][6] ([dʒ]) and /k/ as [č] ([tʃ]) by semi-nomads and speakers from villages of Lower Iraq with recent sedentarization has been strongly influenced by recently sedentarized and semi-sedentarized groups; the realisation of /q/ as [g] and less frequently of /k/ as [č] ([tʃ]) is influenced by fully sedentary groups which on their part have gained non-sedentary influences (ibid: 168) (see section 2.6 for further details). The Baghdadi Muslim dialect belongs to the last type.

Blanc (1964: 168) offers another possible explanation for the *gelet* influence on the Baghdadi Muslim dialect, which he considers might be the result of immigration of sedentary populations from Arabia. This possibility is supported by the fact that the *gelet*-dialectal types are only Bedouin or Bedouinized outside of Arabia whereas in Northern and Eastern Arabia sedentary populations speak similar dialects (ibid). Blanc (ibid) speculates that populations of townsmen from these areas could have migrated to the towns of Lower Iraq bringing their dialects with them; and that populations from surrounding countryside immigrated to Baghdad where its Muslims started to absorb Bedouin or semi-Bedouin features. Blanc (ibid) adds that this process is historical but is still happening in the present-day[7] where some of the population is of rural origin in as far as speech and history; and that although these populations are mostly from the lower classes they still were able to influence the speech of Muslims of Baghdad.

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[5] Shatt al-Arab is a river in Southwest Asia of some 200 km in length, formed by the confluence of the Euphrates and the Tigris in the town of al-Qurnah in the Basra Governorate of southern Iraq.
[6] the sound [dʒ] is often transcribed as [j] in the literature due to transliteration conventions.
[7] Although Blanc (1964: 168) here refers to the time he carried out his work, to the best knowledge of the author of the present study, the process of immigration is still continuing till the present day.

Ingham (1997: 35) establishes another contrast, one between *nomadic* (Bedouin) dialects, which represent "the speech of nomads of the desert to the south and west of the Euphrates", and *sedentary* dialects, which relate to town dwellers and palm cultivators of Southern Mesopotamia. For *sedentary* dialects, Ingham (ibid) only included varieties within the Mesopotamian dialect (see section 2.6). Nomads of the desert, or what are commonly known as Bedouins, influenced the speech of Central and Southern Iraq by their immigration from the desert towards the river banks, and integrating with the original populations of the area. As a result, only the *gelet*-dialectal group was influenced by their speech where it was most influential in rural areas (see figure 2.2, p. 19). Christians and Jews later immigrated to those same areas from cities of Upper Iraq, like Mosul, mostly due to taking up job positions, but despite settling among *gelet* speakers they were able to preserve their *qeltu* speech variety. Furthermore, their population was not as large as that of the Bedouin groups, so they were not able to influence other speech varieties and lived within their own communities forming what Blanc (1964) calls communal dialects.

2.5.3.2 *Sub-dialectal divisions: ḥaḍar vs. ʻArab*

In a study of a variety of Arabian dialects among which is that of Southern Iraq, Ingham (1997: x, 29) differentiated between what is commonly known as an urban and rural distinction, and what the Arabic distinction calls as *ḥaḍar* [ħaðˤar] and *ʻarab* [ʕarab] in Iraq. He (ibid) found that the distinction was not what an 'Englishman' would consider as being simply between urban (towns) and rural (countryside) but that *ḥaḍar* refers to the "riverine-palm-cultivating Arabs of mixed tribal descend" and *ʻarab* refers to the "larger territorially organized tribes living away from the river in the plain or *bādiya* [ba:dija]" who are engaged in a number of occupations such as cereal, rice and date cultivation, nomadic sheep herding and water-buffalo breeding. In other words, the *ḥaḍar* refers to what have been established as settled populations along the river or what would be called *sedentary population* where the main towns lie and people of such areas are considered as *ḥaḍar* by rural populations; and the *ʻarab* refers to the less stable population living away from the river banks where many are either nomadic or semi-nomadic. He (ibid) also found the same distinction between the areas divided by the Euphrates, which sets the beginning of the desert, with Mesopotamian cultivators as being *ḥaḍar*, on one side, and the Arabian Bedouin camel herders (shepherd nomads) as being the *ʻarab*, on the other. He even noted non-uniformity in the dialects of Bedouin where one group spoke a dialect that was 'transitional' between Najdi and Mesopotamia.

2.5.3.3 *Sub-dialectal divisions: xašš vs. ṭabb*

Another urban/rural classification of the *gelet* Muslim Baghdadi Arabic is made by Abu-Haidar (1988: 77), who differentiates between two varieties: a *xašš*-type [xɛʃʃ], which she considers as "the well-established Baghdadi term" representing urban speech and a *ṭabb*-type [tˤʌbb] representing rural speech. The words *xašš* and *ṭabb* mean 'he entered'. The *xašš*-type of vocabulary is used by the older generation of Muslim Baghdadi speakers and the younger generation who aim at preserving the more urban variety of speech. The *ṭabb*-type vocabulary, on the other hand, is of rural origin that "found its way" to the speech of urban Muslim Baghdadi dialect by populations immigrating to the city from rural areas of Central Iraq. Furthermore, some Baghdadi speakers using *xašš* might be heard using the word *dixal*, which is the standard version of the words *xašš and ṭabb*, but never *ṭabb*; whereas people living in rural areas would never use the word *xašš* (Abu-Haidar, ibid: 77). Although Abu-Haidar's classification might apply to urban and rural areas of Baghdad, the present author found that many of what applies to the *ṭabb*-group applies to the speakers of urban cities of Lower Iraq like Basra, being a native of Basra herself (see section 2.6).

2.5.4 Dialectal divisions: summary and rationale for the choice of dialects

The above dialectal and area distinctions are interrelated as follows (figure 2.2): the urban/rural distinction is based upon whether populations live in towns or countryside. In this respect, Baghdadi Muslim and Christian and Jewish dialects investigated by Blanc (1964) are all urban representatives and main cities of Lower Iraq are also urban. The sedentary/non-sedentary distinction is based upon whether these populations are settlers or in-migrants from other areas. In this respect, Baghdadi and Mosul Muslims are sedentary, while Christians and Jews are sedentary in Northern cities of Iraq but non-sedentary in Baghdad and other main cities like Basra and 'Amara of Lower Iraq due their immigration from the northern areas to the central and southern ones. The Bedouin/sedentary distinction is based upon whether the populations are of nomadic origin (camel herders) or settlers who are palm-cultivators near river-banks. In this respect, populations of the *gelet* Muslims of Central and Southern Iraq are sedentary but have been influenced by Bedouinism of the nomadic populations who migrated to these areas. The Bedouin influence on Muslims of the above areas led to a secondary Bedouinization while minority groups of Baghdad, Christians and Jews, speak the sedentary type of Arabic (see also: Versteegh, 2001: 150). In present day speech, more Bedouin aspects are noted in rural areas of the *gelet* dialects than they are in the urban areas, although many phonological and morphological aspects of the *gelet* dialects still show that impact as will be shown in section 2.6.

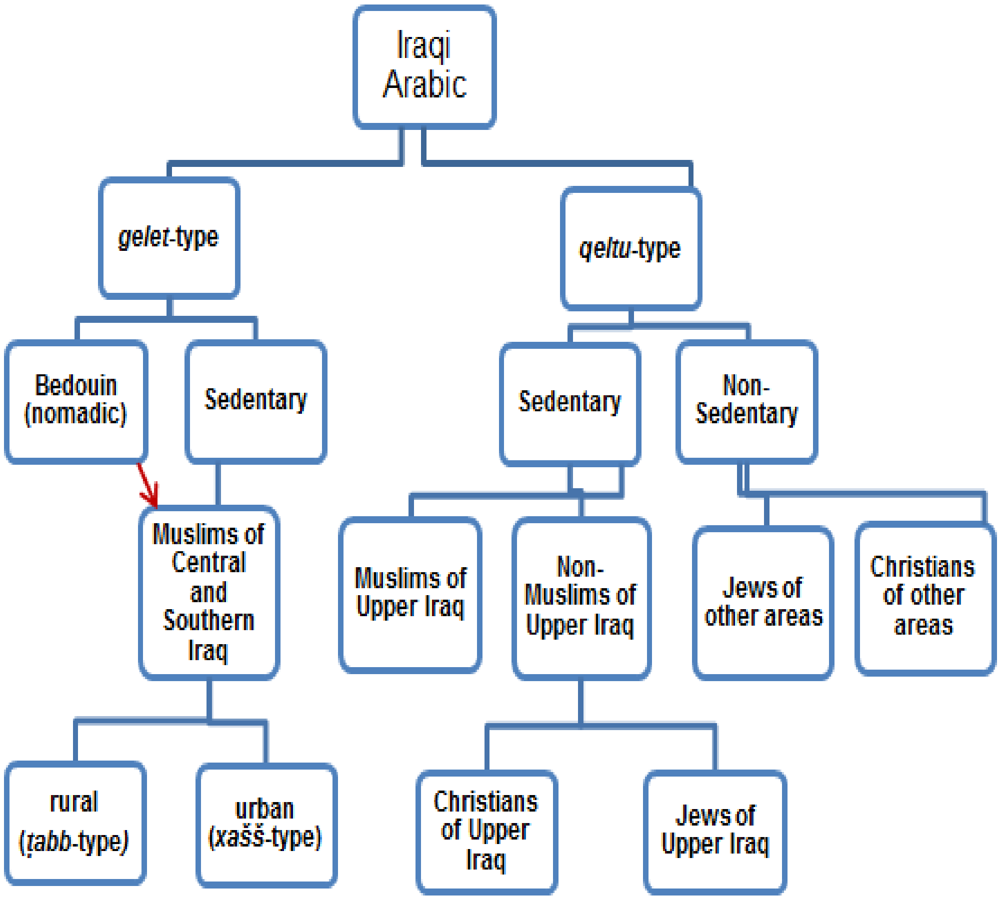

Figure 2.2: the main divisions into the gelet and qeltu dialectal types and their subdivisions: gelet into Bedouin / Sedentary, urban (xašš) / rural (ṭabb); and qeltu into Sedentary / Non-Sedentary.

Since the work of Blanc (1964), many researchers have adopted the two dialectal types suggested for Iraqi/Mesopotamian Arabic (see Jastrow, 1994; Ingham, 1997; Versteegh, 2001; Bellem, 2007). Jastrow (1994: 119) situates the *qeltu* dialects not only in Iraq, but also in two other Middle Eastern countries: Turkey and Syria. However, their existence in these countries is found in three forms: the first is in the form of small language areas, such as several villages, as in Anatolia and North Eastern Syria; the second is in the form of a single location, like a village or town, as in Northern Iraq and along the Euphrates; and the third is in the form of communal dialects, as in Central and Southern Iraq.

Following from Blanc's classification of IA into *qeltu* and *gelet* dialectal types and that of Ingham's *gelet* dialects into Southern and Central, speech samples for the present study were obtained from the following dialects: Mosul representing the *qeltu* (Northern) dialects, Baghdad representing the *Central Mesopotamian gelet* dialects, and Basra representing the *Southern gelet dialects*.

2.6 The Phonology of IA and its Dialectal Types

The following section provides a general overview of the phonology of IA and relevant dialectal variation, with a main emphasis on consonant and vowel inventories and realisations. Information from a small body of knowledge available on Iraqi in general (Al-Ani, 1970; Ghalib, 1984) and then on the Baghdadi and Basri dialects (Blanc, 1964; Mahdi, 1985; Abu-Haidar; 1991; Ingham, 1997) will be reviewed with a focus on religious as well as regional variation.

2.6.1 Consonants

Researchers differ in classifying IA consonants in as far as their number, manner and places of articulations. Table 2.1 provides an inventory of IA consonants as identified by the studies mentioned above, with disputed, dialectal, or rarely used ones in brackets. It classifies the consonants into: stops /b, (p), d, t, g, k, q, (ʕ)/, fricatives /(v), f, ð, θ, z, s, (ʒ), ʃ, ɣ, x, h, (ʕ), ħ/, affricates /dʒ, tʃ/, approximants /w, j/, nasals /m, n/, flap /ɾ/, lateral /l/ and pharyngealised /bˤ, mˤ, fˤ, ðˤ, (dˤ), tˤ, (zˤ), sˤ, lˤ/. Researchers of IA agree on classifying the manner of articulation of these consonants except for one, the pharyngeal /ʕ/. This controversial consonant has been the centre of debate by researchers on different languages classifying it as a fricative, an approximant or a stop (see chapter 5 for more details). In IA, the consonant is identified as a stop (Al-Ani, 1970, Mahdi, 1985), a fricative (Blanc, 1964; Ghalib, 1984; Abu-Haidar, 1988) and an approximant (Ingham, 1982; Butcher and Ahmad, 1987). Differences in classification of place of articulation only include the consonants /d, t, s, z, n/ which Blanc (1964: 17) considers as alveolars, Ghalib (1984: xii-xiii) as denti-alveolar, and Mahdi (1985: 1) as dental (though his description of their place of articulation suggests a dental-alveolar place as well). The remaining sounds between brackets are consonants used by speakers of some dialectal groups, by some regions within one dialectal group, or within a very narrow scope in few words. These differences are discussed in more detail below.

Table 2.1: Classification of the consonants of Iraqi Arabic [(8)]

	Bilabial	Labiodental	Dental	Interdental	Denti-alveolar	Alveolar	Palato-Alveolar	Palatal	Velar	Uvular	Pharyngeal	Glottal
Stop	b (p)				d t				g k	q	(ʕ)	ʔ
Fricative		(v) f		ð θ	z s		(ʒ) ʃ			ɣ x	(ʕ) (ħ)	h
Affricate							dʒ tʃ					
Approximant	w							j			(ʕ)	
Nasal	m					n						
Flap						ɾ						
Lateral						l						
Pharyngealised	bˤ mˤ	fˤ		ðˤ	(dˤ) tˤ	(zˤ) sˤ lˤ						

(8) This study takes the view that emphatic consonants in IA are pharyngealised (Al-Ani, 1970; Hassan and Esling, 2007; Hassan et al, 2011).

- The phoneme /q/ is one of the most studied phonological variables in Arabic due to its important phonetic distinguishing feature between many Arabic dialects. As was mentioned in section 2.5, it is preserved in *qeltu* Christian (Abu-Haidar, 1991) and Jewish dialects in almost all cases, while in the *gelet* Muslim dialects it is mainly realised as [g], and sometimes [k] and [dʒ], though it is also common to preserve the Standard Arabic /q/ in standard or religious words; e.g. Christian and Jewish [qāl] [qa:l]) 'he said' and Muslim [gāl] ([ga:l]); Christian [qaleb] 'heart', Jewish [qalb] and Muslim [gaḷuḅ] ([galˤubˤ]) (Blanc, 1964: 26). This distinction reflects the Bedouin influence on the *gelet*-dialectal groups earlier mentioned in section 2.5. Examples of words with the realisation [k] in the *gelet* Muslim dialects are: [waket] 'time' for /waqet/ and [ketal] 'he killed' for /qetal/. Generally, all *qeltu*-dialects are similar to Christian and Jewish dialects in preserving Standard Arabic /q/ except for a few areas as in 'Ana (Also commonly known as Anah, see map in figure 2.1) where [q] is used in most cases but also [g] in others, e.g. [qāl] ([qa:l]) 'he said' and [qām] ([qa:m]) 'he stood' but [gahwa] 'coffee' and [grayyeb] ([gɾajjeb]) 'near' (Blanc, 1964: 27).
- In relation to the *gelet* use of [g] as a realisation of /q/, Blanc (1964: 166) compares the syllable structure of the urban Baghdadi Muslim dialect and rural dialects of Lower Iraq where the latter have the "typical Bedouin syllabic reshuffling and alternation" which is absent from the former, e.g. Muslim [gahwa] and rural [ghawa] 'coffee'; Muslim [guṣaḅ] ([gusˤabˤ]) 'reeds' and [guṣḅa] ([gusˤbˤa]) 'a reed', rural [geṣaḅ] ([gesˤabˤ]) and [gṣeḅa] ([gsˤebˤa]). This feature is what Versteegh (2001: 149) refers to as the *gahāwa* [gaha:wa] *syndrome*, which is "a process of resyllabification in the neighbourhood of gutturals". For example, [kitab] 'to write' would become the imperfect [yaktib] ([jaktib]), and [ḥafar] ([ħafar]) would become [yḥafir] ([jħafir]); the latter has evolved from [yaḥfir] ([jaħfir]) to [yaḥafir] ([jaħafir]) then to [yḥafir] ([jħafir]). The syndrome is found in North-east Arabian dialects and dialects influenced by the immigration of Bedouins as in Egyptian dialects south of Asyut (ibid).
- The stop /k/ is realised as [k] in Christian (Abu-Haidar, 1991) and Jewish dialects, while it alternates in its realisation between [tʃ] and [k] in Muslim dialects, e.g. [kān] ([ka:n]) 'he was' for Christian and Jewish and [čān] ([tʃa:n]) for Muslim but [ykūn] ([jku:n]) for all three dialects; Christian [kaleb] 'dog', Jewish [kalb] and Muslim [čaleb] ([tʃaleb]) (Blanc, 1964: 25). However, [tʃ] also occurs in Christian and Jewish dialects in loanwords of Persian and Turkish origin, e.g. [čāy] ([tʃa:j]) 'tea' (of Persian [čɑy] ([tʃɑj])), [ṣūč] ([sˤu:tʃ]) 'fault, guilt' (of Turkish [suç] ([sutʃ])), are produced by Muslim, Christian and Jewish (Abu-Haidar, 1991: 13). The use of [tʃ] in the *gelet* Muslim Baghdadi dialect is the same as that of rural *gelet*-dialects of Iraq and some nomadic dialects in the area; while its use in Christian and Jewish dialects is similar to that of Mosul and Anatolian dialects (ibid: 26). From personal

observation and confirmation of speakers of the present study, the present author finds that [tʃ] is not only used by rural and nomadic dialects of the *gelet*-group but is in fact a feature of urban cities such as Basra. The fact that [tʃ] is a Bedouin feature has also been emphasised by Versteegh (2001: 149), which he states is found in Bedouins of Syria and Mesopotamia. Another feature that is related to the use of [tʃ] is in the pronominal suffix of the second person singular leading to distinction between masculine –(a)k and feminine –(i)č, e.g. [bētak] ([bɛ:tak]) vs. [bētič] ([bɛ:titʃ]) 'your house' (ibid: 157).

- Interdentals /θ, ð, ðˤ/ in Christian speech are realised as stops [t, d, dˤ] respectively (Blanc, 1964: 19). Blanc (ibid) notes that this change in interdentals only occurs in Christian speech and not in Jewish or even Muslim speakers of Mosul although all three dialects belong to the *qeltu* dialectal types. Muslim speakers in general also tend to realise the interdental /ð/ as the stop [d] in a few words where the interdental is originally found in Classical Arabic e.g. [jrēdī] ([dʒɾɛ:di:]) 'rat' for Standard Arabic /jurð/ (/dʒurð/).
- The pharyngealised [ðˤ] for /ðˤ/ is used by all speakers except Christians outside Baghdad, who realise it as [dˤ] instead (Blanc, 1964: 17; Al-Ani, 1970; Abu-Haidar, 1991: 7). However, the present author has noticed that people working in the media have recently been using the dental stop [dˤ] instead, perhaps as a convergence towards the realisation of this sound in other Arabic dialects and an avoidance of the less prestigious rural/Bedouin variant.
- Pharyngealised versus plain sounds: some plain consonants /z, f, b, m, l/ tend to have secondary pharyngealisation [zˤ, fˤ, bˤ, mˤ, lˤ][9] in such examples as: [bˤ] for Muslim, Christian and Jewish [ḅāḅa] ([bˤa:bˤa]) 'father' vs. [bāba] ([ba:ba]) 'his/her door'; [zˤ] for all three dialects as in [jaẓẓ] ([dʒazˤzˤ]); [fˤ] in Muslim [fˤakk] 'he opened' vs. Christian and Jewish [fakk]; and [mˤ] in a such words as [mˤajj] and [mˤa:j] 'water' (Blanc, 1964: 18). The pharyngealised sound [lˤ], on its part, is found in all three dialectal groups when the word God is present, except in [fīmāllā] ([fi:ma:lla:]) 'good bye' (Blanc, 1964: 19-20).
- A notable variable for IA is that of the phoneme /ɾ/. In Baghdadi Muslim, [ɾ] is used, but in Christian and Jewish dialects this phoneme is realised as [ɣ] in many contexts. Abu-Haidar (1991: 9) also reports this phenomenon as being a feature of Christian speech. Blanc (1964: 21) also noticed that some produce it infrequently but others tend to produce it consistently. The [ɣ] feature is similarly used by some individuals in the Syrian and Egyptian area but is considered as a phonetic feature of some dialects as those of North Africa and "less clearly" of

[9] The *gelet* dialectal group has other pharyngealised sounds due to the Bedouin influence, for e.g. /x/ which tends to be produced with secondary pharyngealisation [xˤ] due to emphatic spread from such consonants as pharyngealised [lˤ] as it is noted in the examples above which would accurately be produced as: Muslim [xāḷ] ([xˤa:lˤ]) 'mother's brother', Christian and Jewish /xāl/ ([xa:l]), (Blanc, 1964: 19-20).

Arabic dialects of Central Asia (ibid: 23). However, as confirmed by Blanc (ibid: 20), Iraqi Christian, Jewish and Mosul speakers tend to also retain [ɾ] stating that this happens with no sufficient justification, e.g. [ġrab] ([ɣɾa:b]) 'craw' as opposed to [ġeġbīl] ([ɣeɣbi:l]) 'sieve' which is originally [ġerbīl] ([ɣeɾbi:l]). Christian speakers also tend to retain [ɾ] in loanwords from Turkish, Persian, and Modern literary Arabic, e.g. [qōndara] ([qɔ:ndaɾa]) 'shoe'. Similar to Christian and Jewish, Mosul speakers tend to use [ɾ] in loanwords and some words of Classical Arabic origin, e.g. [qara] 'he read' for Standard Arabic [qaraʔa]. Blanc (ibid: 22) also found the same [ɾ] to [ɣ] shift in Mosul among all of the communities but not for all speakers. The feature is not found in the *gelet* dialects and therefore cannot be considered as a hallmark of sedentary dialects of Iraq (ibid).

- A feature that is related to preserving Classical Arabic consonants clusters –CC at the end of the word is found in the *qeltu* dialects, while speakers of the *gelet* dialect insert an epenthetic vowel [i] or [u], e.g. [kalb] vs. [čalib] ([tʃalib]) 'dog', [qalb] vs. [galub] 'heart' (Versteegh, 2001: 157). In triple consonant clusters –CCC-, the epenthetic vowel is inserted after the first consonant, e.g. [yuḏrubūn] ([juðˤɾubu:n]) → [yuḏrbūn] ([juðˤɾbu:n]) → [yuḏurbūn] ([juðˤuɾbu:n]) (ibid).
- A feature that is unique to Mosul is the occurrence of the vowel [ō] ([ɔ:]), in such words as [ōbaʕa] ([ɔ:baʕa]) 'four' where Baghdadi Muslim is [arbaʕa]; and [ōbʕā] ([ɔ:bʕa:]) 'Wednesday' where Baghdadi Muslim is [arbiʕāʔ] ([aɾbiʕa:ʔ]) which Blanc (ibid: 22) explains as undertaking the following 'chronological sequence': [arb] → [aġb] → [awb] → [ōb] ([æɾb] → [æɣb], → [aʊb] → [ɔ:b]) (Blanc, 1964: 22).
- The consonants /p, v/, which do not belong to the Arabic inventory of phonemes and are only common in loanwords from Persian, Turkish and European origin, are realised as [p, v] by some speakers of urban areas and educated speakers, and as [b, f] by others, mostly rural speakers (Blanc, 1964: 18; Abu-Haidar, 1991: 13) e.g. [pūši] ([pu:ʃi]) 'veil' and [parda] ([paɾda]) 'curtain' vs [bu:ʃi] and [baɾda] respectively). Notable exceptions to the urban/rural difference in the /p, v/ realisation apply to frequent words that have acquired Arabic phonetic features, e.g. [tilfizyōn] ([tilfizjɔ:n]) 'television'.

2.6.2 Vowels

Researchers investigating IA have come up with different sets of short and long vowels using different symbols to represent them (Blanc, 1964; Al-Ani, 1970; Ghalib, 1984; Mahdi, 1985; Abu-Haidar, 1991). In terms of their number and description, figure 2.3 provides an inventory of IA vowels.

Short Vowels		Long Vowels	
ɪ	**ʊ**	**i:**	**u:**
		ɛ:	**ɔ:**
a		**a:**	

Figure 2.3: Inventory of IA vowels

The classification consists of three short vowels /ɪ, a, ʊ/ and five long vowels /i:, ɛ:, a:, u:, ɔ:/. In more detail, these vowels are described as follows:

Short Vowels

/**ɪ**/: e.g. [mɪn] 'from', is a close, front and unrounded short vowel. It represents [(10)] the Standard Arabic diacritic *kasra*.

/**a**/: open, front and unrounded short vowel. It represents the Standard Arabic diacritic *fatħa*. It is realised as **[ɛ]**, an open-mid, front and unrounded short vowel, e.g. [sɛdd] 'he closed', or as **[ʌ]**, an open-mid, back and unrounded, e.g. [dʒʌɾ] 'he pulled'.

/**ʊ**/: e.g. [nʊsˤ] 'half', is close, back and rounded short vowel. It represents the Standard Arabic diacritic *dˤamma* (or *ðˤamma* as pronounced by most IA speakers).

Long Vowels

/**i:**/: close, front unrounded long vowel. It represents the Standard Arabic letter *jaa'* [ja:ʔ]. It is realised as [i], e.g. [ɪnti] 'you (fem.)', when in final position and as [i:], e.g. [ʕi:d] 'repeat (masc.)', everywhere else.

/**ɛ:**/: e.g. [ɣɛ:m] 'clouds', mid, front and unrounded long vowel. It is another realisation of the Standard Arabic letter *jaa'* [ja:ʔ] but when produced as [ej], i.e. Standard Arabic [ej] is produced as [ɛ:][(11)] in IA, e.g. [bejt] 'house' is realised as [bɛ:t].

/**a:**/: e.g. [da:x] 'he became dizzy', is open, front unrounded long vowel. It represents the Standard Arabic letter *'alif* [ʔalif].

/**u:**/: close, back rounded long vowel. It is one of two realisations of the Standard Arabic letter *waaw* [wa:w]. It is realised as [u:], e.g. [ɾu:ħ] 'go', in all cases but as a close back rounded [u], e.g. [aku] 'there is', when in final position.

[(10)] Short vowels in Standard Arabic are not represented by vowels in writing but instead by diacritics above or under the consonants.

[(11)] This is also found in other Arabic dialects and applies to vowel /ɔ:/. In all three Baghdadi dialects, the two vowels are realised as [ē] ([ɛ:]) and [ō] ([ɔ:]) respectively, unless preceding /y/ (/j/) and /w/ where /aj/ and /aw/ would be found; e.g. Muslim, Christian and Jewish [bēt] ([bɛ:t]) 'house' and /mōt/ ([mɔ:t]) 'death' but [awwal] ([awwal]) 'first' and /mayyet/ ([majjet]) 'dead' (Blanc, 1964: 50). The diphthongs are also kept in particular morphological patterns; e.g. the comparative [awsaʕ] ([awsaʕ]) 'broader', [aybas] ([ajbas]) 'drier' (ibid).

/ɔ:/: e.g. [ʕɔ:n] 'a helping hand', is mid, back rounded long vowel. This is another realisation of the Standard Arabic letter *waaw* [wa:w] but when produced as [aw], i.e. Standard Arabic [aw] is produced as [ɔ:] in IA, e.g. [mawt] 'death' is realised as [mɔ:t].

While the above list is the most commonly referred to vowel inventory for IA, studies differ in the number and quality of vowels referred to and the following is a number of these studies. Al-Ani[(12)] (1970: 23-24) classifies the IA vowels into three /i, a, u/ short and three long /ii, aa, uu/ vowels, each vowel with two or three allophones and as follows: short /i/ has three allophones [ɨ, ɪ, i], short /u/ has two allophones [ʊ, u], short /a/ has four allophones [ə, ɑ, ʌ, a], long /ii/ has three allophones [ɨɨ, ɪ, ii], long /uu/ has two allophones [ʊʊ, uu], and long /aa/ has three allophones [ɑɑ, ʌʌ, aa]. In Ghalib's (1984: xiii) description of Iraqi Colloquial Arabic, vowels are classified into three short /i, a, u/, and five long /ii, ee, aa, uu, oo/. For Blanc (1964: 30), despite noting that there are numerous distributional and historical patterning among vowels in the three Baghdadi dialectal communities (Muslim, Christian and Jew), the general Baghdadi vowel system consists of four short vowels /i, e, a, u/, and five long vowels / ī, ē, ā, ū, ō/ (/i:, e:, a:, u:, ɔ:/). Blanc (ibid) states that his use of the symbol for the short vowel /e/ is for mere convenience when in fact it would have been better represented by /ə/ since its allophones all lie within the mid central area of the vowel space. Abu-Haidar's (1991: 16, 17) classification of the vowels of Baghdadi Christian has five short vowels /i, ə, ɑ, u, o/ and five long vowels / ī, ē, ɑ̄, ū, ō/ (/i:, e:, a:, u:, ɔ:/). In classifying the vowels of the dialect of Basra, Mahdi (1985: 2) presents four short /i, a, u, o/ and five long ones /ii, ee, aa, uu, oo/.

An overall view of these vowels with differences of use between the *qeltu* and *gelet* dialectal types with particular reference to those among the three Muslim, Christian and Jewish dialects will be presented below.

- Short vowels show great differences in number of occurrence and distribution between Muslim and Christian/Jewish (Blanc, 1964: 30). /i/ occurs in all three dialects when the word used is of Classical Arabic origin as in the examples: /liʔan/ 'because' and /kitāb/ ([kita:b]) 'book'. The Muslim dialect has a contrast between /u/ and /e/ in such examples as: [ħebb] 'water jar' vs. /ħubb/ 'love'. Blanc (ibid: 166) also referred to the distribution of /u/ and /e/ as being a distinguishing factor between the Baghdadi Muslim dialect and the rural dialects of Iraq, e.g. Muslim [kull] and rural [kell] 'all', Muslim [guṣaḅ] ([gusˤabˤ]) and rural [geṣaḅ] ([gesˤabˤ]). Christian and Jewish dialects do not have that contrast and /u/ usually occurs in

[(12)] Al-Ani (1970) is the only one saying that IA vowels are phonologically identical to Standard Arabic. This is because in his study, he asked speakers to produce standard Arabic forms.

loanwords from Muslim and Classical Arabic, e.g. Muslim, Christian and Jewish [mudīr] ([mudi:ɾ]) ‘director’, and Muslim, Christian and Jewish [mumken] ‘possible’.

- The short vowels of the *qeltu* dialects have undergone “a wide-spread merger” of old /i/ and /u/ to [ə], e.g. [uxt] ‘sister’ and [bint] ‘daughter’ → [əxt] and [bətt] (Jastraw, 1994: 120). This feature is also noticed in the *gelet* dialects but as a merger of [ɪ], e.g. [ɪxɪt] ‘sister’ and [bɪtt] ‘daughter’.
- Another distinction is in the distribution of /a/ between that of the Jewish dialect on one hand and that of Muslim and Christian dialects on the other. All three dialects are similar in having allophones going from mid front [ɛ] to low front [ä] ([æ]) low central [a] and low back [ᴀ] ([ɑ]) (Blanc, 1964: 32). But the Jewish dialect differs from the other two in being more like most Arabic dialects where there is: [ɛ] or [*ā*] ([a:]) near front consonants, e.g. [jɛ́mɛl] ([dʒɛmɛl]), [jǎ́mäl] ([dʒæmal])‘camel’; [a] or [ᴀ] ([ɑ]) near back consonants, e.g. [ax] ‘brother’, [āku] ([a:ku]) or [Áku] (['ɑku]) ‘there is’; [ᴀ] ([ɑ]) near emphatics and /q/, e.g. [waqqᴀ] ([waqqɑ]) ‘leaf’, [ᴀḷḷᴀ] ([ɑlˤlˤɑ]) ‘God’. These cases differ from those of Muslim and Christian dialects when the allophones of /a/ occur in final unstressed syllables, when in absolute final position [ɛ] and [ä] ([æ]) but not when preceded by [ħ] and [ʕ] where [a] would occur, e.g. Jewish [əħnä] ([əħnæ]), Muslim and Christian [əħnɛ] (ibid).
- Long vowels, on the other hand, have less variability in as far as allophones are concerned. What is most noticeable is that long vowels in Jewish dialects tend to be shorter when in unstressed syllables than those of Muslim and Christian dialects (Blanc, 964: 33). In the case of /ē/ (/ɛ:/) and /ō/ (/ɔ:/) in the Jewish dialect, they either stay the same as in [sēmeʕ] ([sɛ:meʕ]) ‘having heard’ and /sēméʕa/ ([sɛ:m'eʕa]) ‘having heard her’; or are replaced by /i/ and /u/, e.g. [bēt] ([bɛ:t]) ‘house’ and [bitēn] ([bitɛ:n]) ‘two houses (ibid). Long vowels /ā, ī, ū/ (/a:, i:, u:/) of the Jewish dialect are realised as [a, i, u] in unstressed syllables as in [ʕāyan] ([ʕa:jan]) ‘he saw’ in contrast to [ʕayantu] ‘I saw’, while they remain long in Muslim and Christian dialects e.g. [čākūč] ([tʃa:ku:tʃ]) ‘hammer’ *vs.* Jewish [čakūč] ([tʃaku:tʃ]).
- /aa/ in the *qeltu* dialects has undergone ʔimāla (ʔima:la) “a historical raising of *ā* ([a:]) to *ē* ([ɛ:]) or even *ī* ([i:]) which was conditioned by an *i* vowel in the preceding or following syllable”, e.g [klāb] ([kla:b]) → [klēb] ([klɛ:b]) or [klīb] ([kli:b]) ‘dogs’ (Jastraw, 1994: 119) Blanc (1964: 165) refers to this process as being different (higher up towards /i:/) in the Mosul dialect from that of the Christian one, e.g. Christian [sakēkīn] ([sakɛ:ki:n]) ‘knives’, Mosul [sakīkīn] ([saki:ki:n]). This feature is absent from the *gelet* dialects.
- In the *qeltu* dialectal group there is a lowering of /ī, ū/ ([i:, u:]) to [ē, ō] ([ɛ:, ɔ:]) in the vicinity of emphatic, uvular and pharyngeal consonants, e.g. [ṣṭūḥ] ([sˤtˤu:ħ]) → [ṣṭōḥ] ([sˤtˤɔ:ħ]) ‘roof,

[daqīq] ([daqi:q]) → [daqēq] (daqɛ:q]) 'flour' (Jastraw, 1994: 120). In the *gelet* dialectal group there would be a preservation of /i:, u:/.

2.6.3 Phonological Differences among Other Sociolinguistic Groups

This section will deal with an overview of the phonological differences between sociolinguistic groups mentioned earlier, mainly between the urban (*xašš*) / rural (*ṭabb*) classification of *gelet* Baghdadi Muslim speech following Abu-Haidar (1988and between nomadic and sedentary dialects also following Ingham (1997) (see section 2.5). Examples given below for the *xašš*-group represent those of the urban Muslim dialect of Baghdad and those for the *ṭabb*-group represent those of the rural Muslim dialect of Baghdad and also refer to that of the urban Muslim dialect of Basra.

- Stress placement: in trisyllabic forms, stress falls on the initial syllable in the *xašš*-group, and on the medial syllable in the *ṭabb*-groups; e.g. *xašš* ['madrasa] 'school', *ṭabb* [mad'rasa] (Abu-Haidar, 1988: 77-78).
- Vowel length of the negative particles [*mā*] ([*ma:*]) and [*lā*] ([*la:*]): the standard Arabic long vowel is preserved in the *ṭabb* groups but shortened in the *xašš*-group; e.g. *xašš* **[**ma yākul] ([ma ja:kul]) 'he does not eat', *ṭabb* [mā yākil] ([ma: ja:kil]) (Abu-Haidar, 1988: 78).
- Initial consonant clusters resulting from the elision of the vowel in syllable initial position are only found in the *xašš*-group in the following cases (Abu-Haidar, 1988: 78). These cases are also related to the 'gahawa' syndrome earlier discussed:
  - **(i)** Third person singular imperfect of the verb form *faʕala* **(13)** + the object pronoun suffix; e.g. *xašš* [y'libsa] ([j'libsa]) 'he wears it', *ṭabb* ['yilib'sa] (['jilib'sa]). This feature is shared between the *gelet* dialects of Iraq and the dialects of Syro-Mesopotamia sheep-rearing tribes, e.g. [yi'gūl] ([ji'gu:l]) 'he says' and [ṯi'gīl] ([θi'gi:l]) 'heavy' (Palva,1984:16).
  - **(ii)** "Verbs of the *faʕala* form expressing defects"; e.g. *xašš* [ṭrašš] ([tˤraʃʃ]) 'he became deaf', *ṭabb* [ṭiraš] ([tˤiraʃ]).
  - **(iii)** "The plural of nominal forms of the faʕa:li:l pattern"; e.g. xašš [mja:ri:r] ([mdʒa:ɾi:ɾ]) 'drawers (pl.)', ṭabb [mija:ri:r] ([mɪdʒa:ɾi:ɾ]).
- Some imperfect tense verb forms differ in the type of vowel used where the *xašš*-group is characterised by the vowel /u/ and the *ṭabb*-group are characterised by the vowel /i/; e.g. *xašš* [nħuṭṭa] ([nħutˤtˤa]), 'we put it', *ṭabb* [nħiṭṭa] ([nħitˤtˤa]) (Abu-Haidar, 1988: 78). This again is a feature of Bedouin dialects affecting those of the *gelet* dialectal group.

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(13) The third person singular imperfect of the verb form *faʕala* is used along with its derivations in Arabic as a base for all other verb derivations.

- Nominal forms of the pattern *faʕʕaal* / *faʕʕaala* have their first syllable characterised by /i/ in the *xašš*-group and by /a/ in *ṭabb*-group; e.g. *xašš* [rijjāl] ([rɪdʒdʒa:l]) 'man', *ṭabb* [rajjāl] ([radʒdʒa:l]) (Abu-Haidar, 1988: 79). The Bedouin effect is also present in this /i/ vs. /a/ feature.
- In some disyllabic forms of the pattern $C_1VC_2C_3V$ where C_3 is /d/ or /t/, C_2 is frequently assimilated to C_3 in the *ṭabb*-group; e.g. *xašš* [ʕinda] 'he has', *ṭabb* [ʕidda] (Abu-Haidar, 1988: 79).
- First person singular subject 'I' (Standard Arabic ʔana) is pronounced with a final [i] by the *xašš*-group, and with a final [a] by the *ṭabb*–group (Abu-Haidar, 1988: 79), e.g. [ʔa:ni] vs. [ʔa:na].

The following are the phonological differences between the two Muslim *gelet*-dialectal groups, nomadic (Bedouin) and sedentary (Ingham, 1997). Again, in order to compare examples of these two dialectal groups with those of urban *gelet* groups, examples from urban Muslim Baghdad and urban Muslim Basra dialects are included below.

- Imperfective forms of measure in strong and final weak verbs which have one of the guttural sounds /h, ʕ, ħ, x/ or /ġ/ (/ɣ/): this feature involves two types of syllable structure with the 'nomadic' dialect having the stem of the structure /-faʕɪl-/ and the 'sedentary' having the stem /-fʕɪl-/ or /-fɪʕl-/ when they are followed by a suffix with a V-beginning; e.g. Nomadic [y'ħafır] ([j'ħafɪɾ]) 'he digs', Sedentary ['yɪħfır] (['jɪħfɪɾ]) (Ingham, 1997: 36). Based on this distinction, Basri Muslim is ['jɪħfɪɾ] and Baghdadi Muslim is ['juħfuɾ]. This is similar to the syllable structure referred to by Palva (1984: 11) where –aXC- is in contrast with –XaC- if X is one of the consonants [x, ġ, ḥ, ʕ, h] ([x, ɣ, ħ, ʕ, h]), e.g. [ħɪnna] vs. [ɪħnna] 'we, us'. These two sets of syllable structures are also related to the *gahāwa* syndrome earlier mentioned, which is of Bedouin origin.
- Certain verbal forms with a non-final open syllable: this feature involves the use of /a/ in the 'nomadic' form and the use of /ɪ/ in the 'sedentary' form within syllables where one of the vowels is one of /a, a-, e-, o-/ and the following consonant is either one of the apical liquids /l, r/ or the preceding or following consonant is one of … /h, ħ, ʕ, x, ġ/" (/ɣ/ for /ġ/); e.g. Nomadic ['xarab] (['xaɾab]) 'it spoilt' and Sedentary ['xɪrab] (['xɪɾab]) (Ingham, 1997: 38). The Basri Muslim form is ['xɪɾab] while the Baghdadi one is ['xuɾab].

2.7 Summary of Chapter 2

This chapter provided an overview on Iraq and aspects of its geography, history, population make-up and language varieties. Arabic is the main language of the country spoken by the majority of the population. Arabic varieties are divided on the basis of the occurrence of the Classical [q] variant or its realisation as [g] in two main dialectal groups: the *qeltu*-group and the *gelet*-group respectively. The qeltu group includes Muslim sedentary speakers of Upper Iraq and non-Muslims, Christian and Jew, of all of Iraq; the gelet-group includes Muslim sedentary and non-sedentary speakers of Lower (Central and Southern) Iraq. Muslim sedentary dialects of Lower Iraq are divided into two sub-groups: urban (*xašš*-group) and rural (*ṭabb*-group). Another *gelet*-group division is that of sedentary and nomadic (Bedouin) populations. The chapter also includes an inventory of speech sounds and a phonological overview of all dialectal groups but the most distinctive feature is the one that divides them into two main groups, the realisation of the Standard Arabic /q/ as [q] or [g].

Chapter 3 : Voice Quality

3.1 Introduction

Research on Voice Quality (henceforth VQ) has been carried out on many languages and for various objectives. The term Voice Quality, as will be defined in detail in section 3.2, refers to the colouring of the voice and not solely what occurs in the larynx. Very few attempts have been made to examine aspects of VQ in Arabic (e.g. Zeroual et al, 2008). Little is therefore known about basic VQ characteristics of typical speakers of the various Arabic dialects, whether in regard to age, sex, gender or geographical background.

Speakers of IA are generally thought to have a distinctive voice quality described anecdotally by some as involving an over-usage of the pharyngeal cavity and by others as involving an over-usage of the nasal cavity. This study will show that the two phenomena might actually be interrelated. Regarding the use of the pharyngeal cavity, Bellem (2007: 270) states that dialects of Bedouin origin which have the Arabic /q/ realised as [g], among which is the *gelet*-dialectal group (see section 2.5), have a 'stronger' (creakier) pharyngeal ʕ" adding that these dialects are believed to have more 'emphaticness' or are at least more 'guttural'. On the other hand, the interaction between strong pharyngeal realisation and nasalisation has been highlighted in studies which found the presence of nasalisation in IA pharyngeals in particular (more on these in Chapter 4). Hetzron (1969), for instance, notes that the production of Arabic /ħ/ and /ʕ/ may be accompanied by nasalisation. His (ibid) comment was made after observing that nasal consonants of South-Ethiopic languages occur in a position previously occupied by pharyngeals, which he explains as being the result of those speakers' realisation of pharyngeals with some nasalisation. Therefore, the present study intends to investigate VQ characteristics of pharyngeals in IA with particular reference to nasalisation. The aim is to find out whether nasality is a VQ feature of the speakers of IA or merely related to the production of some speech segments such as pharyngeals. It is vital to begin with an overview of the definition, types and other related subjects of VQ before investigating nasalisation in Iraqi speakers.

3.2 Definition and Historical Background

Research on VQ dates back to the 19th century when scientists, such as Quintilian (1899: c.III, Book XI, referred to by Laver, 1980: 1), began to notice differences between people's voices.

However, practical (i.e. perceptual and instrumental) investigations were not carried out in linguistics until the 1960s.

Sweet (1906: 74, cited by Esling, 2000: 25), used the term *organic basis* when explaining how languages have particular trends that control organic movements, to mean that languages are differentiated by a 'long-term quality'. Esling (ibid) interpreted this as referring to differences in physiological behaviour, whereby languages impose particular phonetic learned components that alter the operation of articulators in a training-like process. Sapir (1921: 48), on the other hand, used the term 'quality,' but distinguished between two meanings, one referring to "the inherent nature and resonance of the sound," and the other being the "general 'quality' of the individual's voice", which he counted as being "chiefly determined by the individual anatomical characteristics of the larynx and … of no linguistic interest whatsoever". Therefore, traditionally, linguists have not neglected the existence of the aspect of VQ, but in most cases they did not attempt to investigate it because the old belief was, as simply explained by Laver (1980: 1), that the analysis of voice quality was not part of language study. In fact, phoneticians have only recently started to demonstrate awareness of VQ, although such disciplines as speech pathology, psychology and psychiatry have already recognized its significance (Laver, 1991: 147).

It was not until the 1960s when Abercrombie's works and beliefs in the importance of paralinguistic aspects of language inspired other researchers. It was his student's book, Laver (1980), which became the first reliable, and most cited, reference of all. The book was the first comprehensive detailed description attempted on VQ. This work has triggered researchers of different backgrounds to notice the vitality of studies on VQ and motivated future research. It equipped researchers with the confidence to tackle research in a topic that was hardly considered an important aspect of speech. However, and despite it becoming part of the general knowledge, VQ is the least paralinguistic aspect of speech investigated throughout the world. Nevertheless, advances in studying exotic languages have shown that VQ is also an important linguistic feature since such languages use it contrastively.

In defining VQ, Abercrombie (1967: 91) states that it refers to "those characteristics which are present more or less all the time that a person is talking: it is a quasi-permanent quality running through all the sound that issues from his mouth." Following Abercrombie, Laver (1980:1) confirms that he also conceives of VQ in a broad sense, by considering it as "the characteristic auditory colouring of an individual speaker's voice", and not in its narrow sense "deriving solely from laryngeal activity". Many researchers have since used the phrase *colouring of the voice* as a straightforward reference to the term VQ.

Researchers across different sciences therefore share basic understandings of VQ, but might vary in particular details shaped by their different scientific backgrounds and approaches. Differences in ways of approaching VQ are also evident in what labels are used in representing it. Labels such as *phonation*, *voice set*, *glottal phonation*, *laryngeal phonation*, *timber*, *tone-of-voice* or even *vocal quality* are common and either mean VQ or one of its components. The present study will adopt the term *voice quality* and the definitions of Abercrombie and Laver, but refer to any of the mentioned terms where necessary.

Researchers also vary in categorizing VQ as a paralinguistic, a supralinguistic or a linguistic aspect of speech. Zeroual et al. (2008: 3) state that all three functions are actually served by the VQs and lie within the range studied by phoneticians: one is *linguistic*, reflecting phonetic segmental contrasts and/or prosodic patterns; the second is *sociolinguistic*, reflecting linguistic variations of social or geographical backgrounds; the third is *paralinguistic*, reflecting emotional statuses of speakers. A further function of VQ, which is recognized in relation to anatomical variation, is an 'extralinguistic' or 'idiosyncratic' function, reflecting such aspects as age, sex, etc. which contribute to speaker recognition (ibid).

3.3 Settings and Types

Researchers vary in classifying the types of VQ that exist. Zeroual et al. (2008) and Epstein (2002) note that a number of VQs could perceptually be recognized in speech. Each person could articulate a string of words with a particular VQ which might be the same or different from the VQ used in articulating another string of words by another, or even the same speaker (Zeroual et al., 2008: 3). Even each produced vowel could have a different VQ or acquire a VQ as a result of being influenced by a neighbouring consonant (Epstein, 2002). However, Zeroual et al. (2008: 3) add that not every VQ is relevant to phonetic studies but only those that are characterized as perceptually different or could be deliberately or non-deliberately reproduced and which are not restricted to anatomical features of a speaker. The majority of researchers, therefore, follow the categorization of VQ types and settings offered by Laver (1980, 1991, 1994), as he presents a thorough description of each type produced by the human voice.

Laver (1980: 13) defines a *setting* as "the aspect of the performance of a segment that it shares with other susceptible segments", where there is a capability of extracting these settings from segmental articulation. The term *segments*, here, refers to the smallest units constituting speech, i.e. sounds, whether consonants or vowels. Another definition is by two of his associates Wirz and Beck (1995:46) who consider *settings* "as long-term-average configurations of the vocal apparatus, around which the short-term movements necessary for the articulation of phonetic segments are made." And a third definition of a *setting* is offered by Beck (2007) regarding it as "a long-term tendency for some part of the vocal apparatus to adopt a particular configuration or pattern of behaviour." Beck (ibid) considers settings as 'strands' or 'components' working together in different ways. The present work will offer a brief account of Laver's classification of *laryngeal* and *supralaryngeal* types of settings**.**

In order to describe VQs, models are devised in a way that they rely on particular parameters (Zeroual et al., 2008: 3). Despite the fact that the parameters can only be auditory because there is no equal matching between auditory and articulatory VQ cues, the models only presume that every VQ is associated with a certain vocal tract 'configuration' called *articulatory setting*, which is what speakers continuously aim at keeping during an utterance (ibid), and is decided by an "independent control" in a certain area of the vocal tract (ibid: 4).

3.3.1 Neutral Setting

In a classification of the types of VQ, such terms as *phonation types, phonation settings*, and *laryngeal settings*, would be used to refer to settings of the larynx, and the term *supralaryngeal settings* to mean settings above the larynx. Laver's (1980, 1994) description was based on "a standard reference" type he calls *neutral*. But when referring to the laryngeal phonation types, he uses the term *modal voice* to refer to the neutral laryngeal setting. Laver (1980: 14) emphasizes that the neutral setting "only has the status of a descriptive datum-point … by reference to which other settings can be conveniently described". According to Laver (ibid) the following are specifications of the neutral setting against which the other settings could be described: no lip protrusion, no raising or lowering of larynx, equal width of supralaryngeal vocal tract, oral-front articulations made by tongue-blade, the tongue-root is neither advanced nor retracted, no vocal tract constriction by faucal pillars or pharyngeal constrictor muscles, no closing or overly opening of jaw, true vocal folds are competent in using air, have frequent cycles of vibration, no perceptible friction, full glottal vibration when facing moderate longitudinal tension, moderate adductive tension and moderate medial compression, general muscular tension of vocal apparatus is neither high nor low, only for linguistic reasons does nasality become audible in the velopharyngeal area.

3.3.2 Laryngeal (Phonatory) Settings

Phonation, according to Laver (1994: 184), "is the use of the laryngeal system, with the help of an airstream provided by the respiratory system, to generate an audible source of acoustic energy which can then be modified by the articulatory actions of the rest of the vocal apparatus". This group of settings deals with the variety of sounds the larynx can produce (ibid) and a person with a normal vocal apparatus can control (ibid: 93) including: voicelessness (nil phonation), voiced phonation (modal voice), voicelessness (breath phonation), whisper phonation, creak (laryngealisation), harshness and falsetto. Ladefoged proposed a continuum of phonation types depending on the space between the arytenoid cartilages ranging from the most open or furthest apart (voiceless) to the most closed or closest together (glottal stop) (Ladefoged, 1971: 8; Ladefoged and Maddieson, 1996: 49; Gordon and Ladefoged, 2001: 383; Keating and Esposito, 2007: 85).

	Most open	⟵		⟶	Most closed
Phonation type	Voiceless	Breathy	Modal	Creaky	Glottal closure

Figure 3.1: Continuum of phonation types (after Ladefoged, 1971, replicated from Gordon and Ladefoged (2001: 383) and Keating and Esposito (2007: 85).

Gordon and Ladefoged (2001: 1), on their part, distinguish between two sets of phonation types one associated with controllable actions of the glottis while the other with "personal idiosyncratic possibilities or involuntary pathological actions"; adding that what might be an uncontrollable pathological voice quality for one person could be a phonological contrast for another. This section will review phonation types related to findings of the present study.

3.3.2.1 *Voicelessness: nil phonation*

This refers to two states of the larynx: one is when the glottis has a wide opening but a silent "smooth, laminar flow" with no audible hissing and a zero acoustic effect; the second is when the glottis is fully closed with zero acoustic input during the closure (Laver, 1994: 187). Accordingly, in the first state the vocal folds are widely abducted, and in the second they are fully adducted blocking any flow of air from the lungs.

3.3.2.2 *Voiced phonation*: *modal voice*

This type is considered as "the neutral mode of phonation" (Laver, 1980: 110), where Laver emphasizes that it should not be confused with the 'normal' setting or the 'rest' position of the vocal organs (ibid: 14). It is also not preferable to use the term 'normal' when referring to the neutral type as it will only imply that the other settings are abnormal (Hollien, 1974; as cited by Laver, 1980: 109). In this type of phonation, the vibration of the vocal folds is "regularly periodic, efficient in producing vibration, and without audible friction brought on by incomplete closure of the glottis" (Laver, 1980: 111) (figures 3.1 and 3.2). Muscular and aerodynamic features work together to produce this pulsing. The pitch of the voice is the audible result of the frequent vibration of the vocal folds (Laver, 1994: 194).

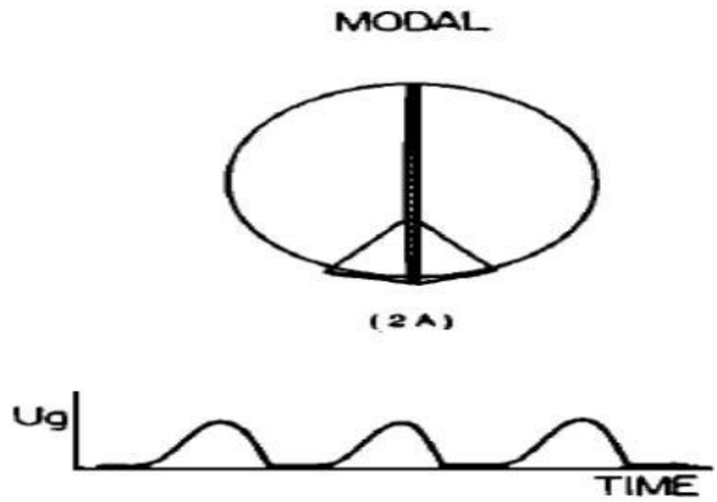

Figure 3.2: A modal voice with the vocal folds in a neutral state where they have a pulsed input (cited from: Klatt and Klatt, 1990: 822).

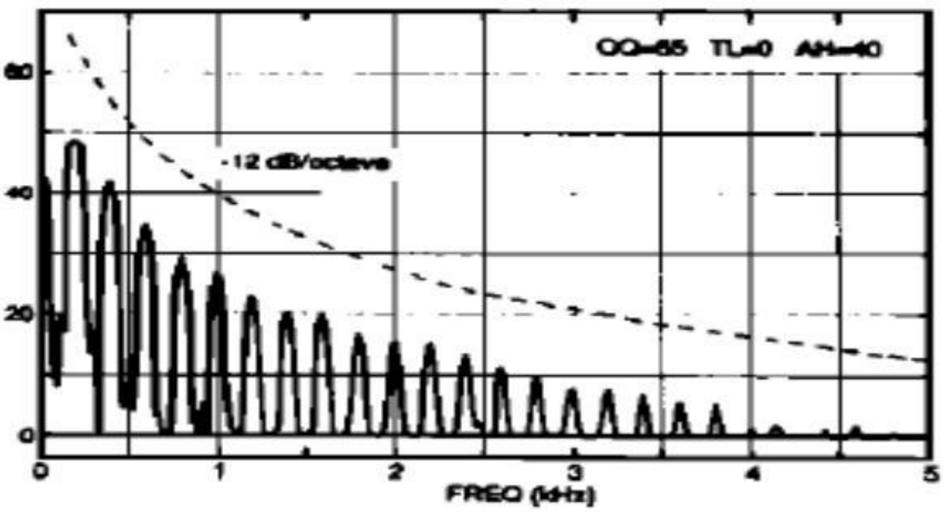

Figure 3.3: A spectrum showing a modal voice with neutral pulsing (cited from: Klatt and Klatt, 1990: 822).

3.3.2.3 *Breathiness*

Laver (1980: 132) states that this quality is "often heard as amodification of modal voice" leading to *breathy voice* (figures 3.3 and 3.4). There is inefficient vocal fold vibration accompanied by slight audible friction and low muscular effort; resulting in an open glottis along most of its length where the middle part of the folds never meet (ibid). The unsuccessful closing movement of the folds, leading to a lower glottal resistance, results in a higher rate of airflow than that in modal voice. In breathy phonation, the vocal folds are moderately abducted (in comparison to modal and creaky voice) and have slight longitudinal tension (Gordon and Ladefoged, 2001: 384; Ladefoged, 1971; Laver, 1980).

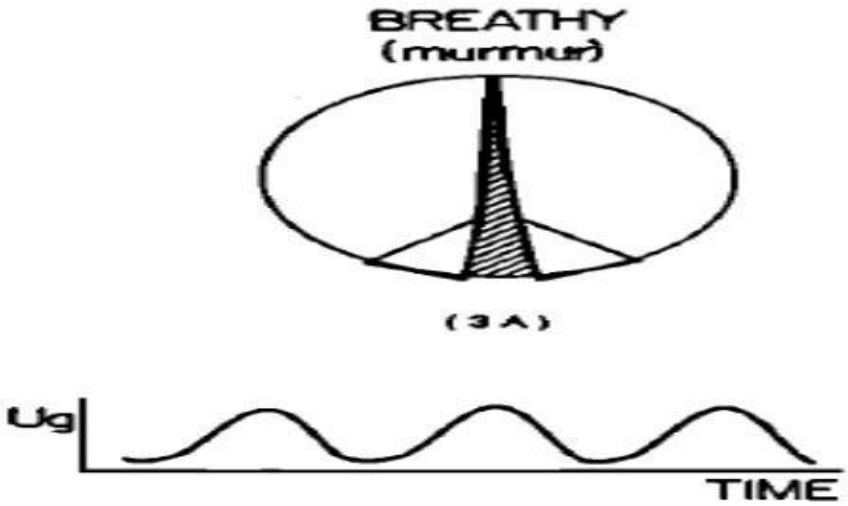

Figure 3.4: A breathy phonation with the vocal folds open (cited from: Klatt and Klatt, 1990: 822)

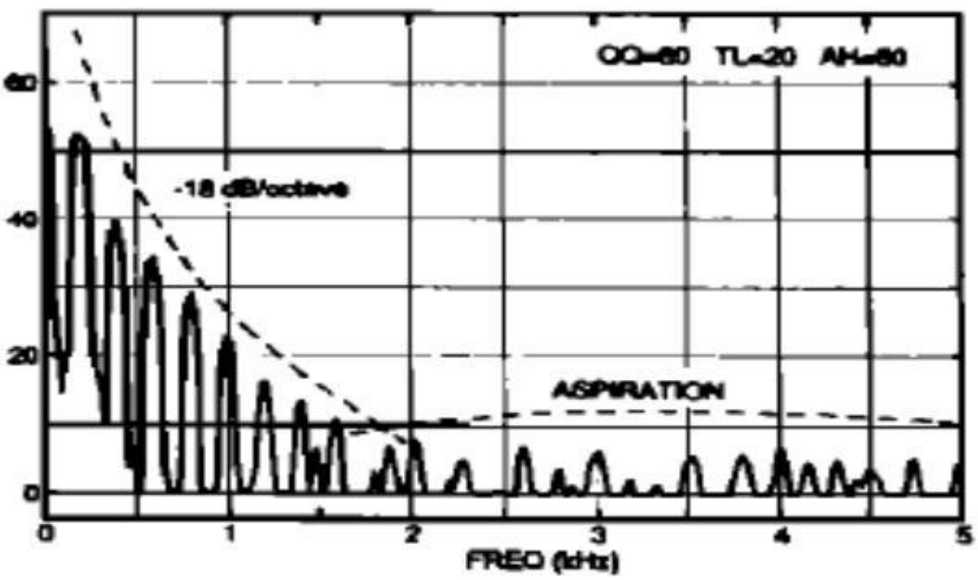

Figure 3.5: A spectrum of a breathy phonation showing weaker high-frequency harmonics replaced by aspiration noise (cited from: Klatt and Klatt, 1990: 822).

3.3.2.4 *Creak phonation*

This is also called 'vocal fry' or 'glottal fry' by American phoneticians (Laver, 1980: 122; 1994: 194-5). It is "associated with vocal folds that are tightly adducted but open enough along a portion of their length to allow for voicing" (Gordon and Ladefoged, 2001: 385; also found in Ladefoged, 1971; Laver, 1980). The acoustic result of this setting is a series of irregularly spaced vocal pulses (Gordon and Ladefoged, 2001: 385). Laver (1980: 125) also refers to the term ‘laryngealisation’ stating that it is used in the literature as a synonym for creak and creaky voice; the latter being a compound phonation of modal voice and creak. Creak is also referred to as ‘laryngealised’ or ‘pressed’ phonation by Klatt and Klatt (1999). This type also produces pulsed air-flow into the vocal tract, but this time the pulsing is slower and less frequent. What distinguishes creak phonation from harsh voice is the low fundamental frequency or else they would be quite alike. This low frequency is achieved by a pulsed action of the vocal folds with no equal time intervals between pulses (figures 3.5 and 3.6). The terms creaky voice and laryngealisation will be used in the present study.

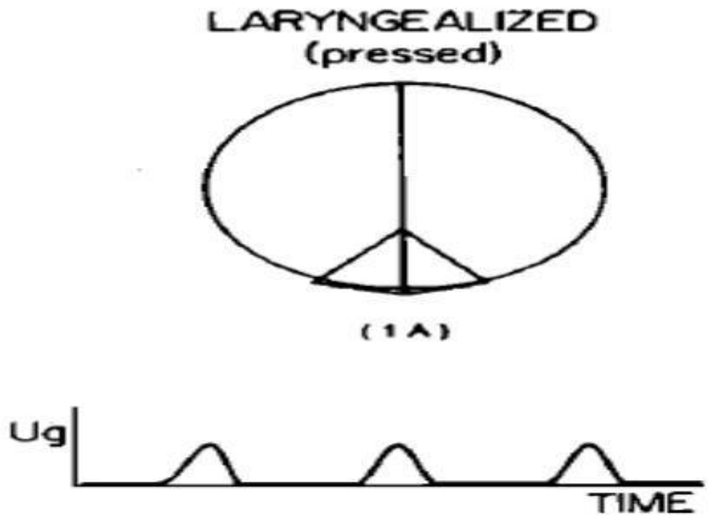

Figure 3.6: A laryngealised (pressed) or creaky phonation where the vocal folds are seen pressed together tightly and air forcing its way through them (Figure cited from: Klatt and Klatt, 1990: 822).

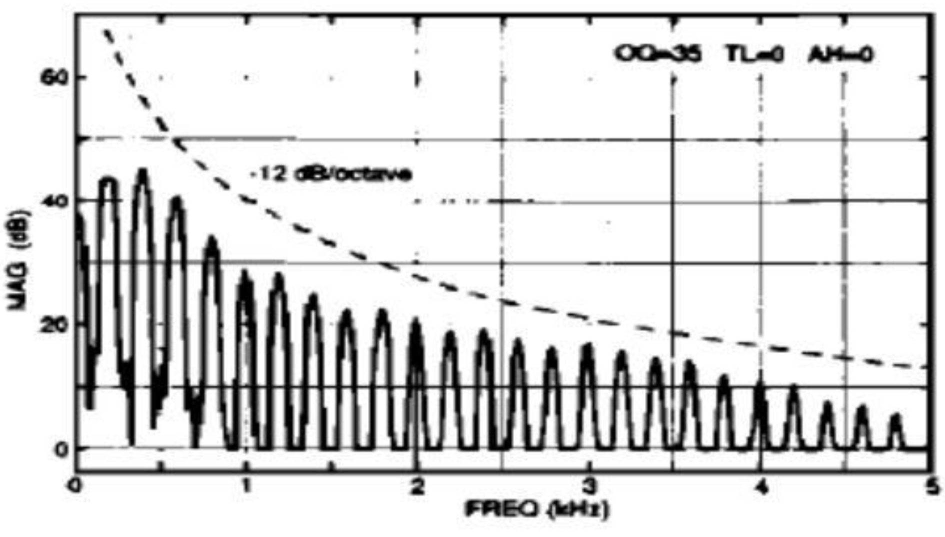

Figure 3.7: A spectrum of a creaky phonation with the pulsing showing the most intense fundamental component of all spectra (cited from: Klatt and Klatt, 1990: 822).

3.3.3 Supralaryngeal Settings

The neutral supralaryngeal settings mentioned earlier (section 3.2.1) could be altered by three types of settings: alterations of the longitudinal axis of the vocal tract, alterations of the longitudinal, cross-sectional axis, and velopharyngeal alterations.

3.3.3.1 *Longitudinal settings*

These types of alterations of the vocal tract axis are caused by the vocal organs being shifted from their neutral location. The first and second are shifts of the larynx from its neutral position resulting in two settings: *raised larynx voice* and *lowered larynx* voice (Laver, 1980: 23; 1991: 150). The third is *labial protrusion* caused by the lips being protruded, and the fourth is *labiodentalized voice* caused by raising and retracting the lower lip (ibid, 1980: 24).

3.3.3.2 *Latitudinal settings*

Laver (1980: 34) defines these settings as being "quasi-permanent tendencies to maintain a particular constrictive (or expansive) effect on the cross-sectional area at some given location along the length of the tract, relative to the cross-sectional area appropriate to the neutral vocal tract". Each of these tendencies is mainly caused by the movement of a vocal organ, i.e. lips, tongue, faucal pillars, pharynx and jaw, and accordingly grouped into five types of settings: labial settings, lingual settings, faucal settings, pharyngeal settings, mandibular settings (ibid).

3.3.3.3 *Velopharyngeal settings*

Laver (1980: 69) considers the neutral setting to involve producing all segments with a closure at the velopharyngeal area, except segments with phonologically nasalized characteristics or ones that precede them in a context. This category of settings includes two groups: nasal settings and denasal settings. Because the present study is concerned with investigating whether nasalisation co-occurs when pharyngeal consonants are produced and whether nasality is a VQ feature of some speakers of Iraqi Arabic coupled with geographical origin, the features of nasality and nasalisation will be dealt with in more details in Chapter 4.

3.4 Approaches to Investigating Voice Quality

Laver (1991: 148) states that a speaker's anatomy and physiology "determine the width of the potential range of operation of any voice quality feature, and the long-term habitual settings of the larynx and the vocal tract restrict this feature to a more limited range of operation". Speakers cannot control their anatomy and physiology, but have some control over the habitual settings.

Laver (ibid: 154) also divides the anatomy and physiology, which he calls biological information, into the following categories (for further explanations on the physiology and anatomy of speech see: Greene, 1980; Lieberman and Blumstein, 1988; Aronson, 1990; Boone and McFarlane, 2000): **1-** size and physique, **2-** sex and age, **3-** medical state.

Voice Quality is therefore differently approached depending on researchers' varying scientific backgrounds and objectives. Approaches can be *auditory-perceptual* **[14]**, *acoustic*, *articulatory* (*physiological*) or a set of two or all combined. These vary depending on the researcher's approach as well as the availability of instruments. Developments in technology have also influenced their application. Despite the fact that some researchers acknowledge that VQ could not be studied without applying a perceptual investigation since it is "fundamentally perceptual in nature" (Kreiman et al. 2007), others see that VQ investigations would be aided with acoustic methods (Hammarberg et al. 1980).

Objective or instrumental approaches also have their disadvantages. Articulatory methods, on one hand, are not always feasible because of their expenditure and availability. Such instruments as MRI, nasendoscopy and electroglottography **[15]** are not wide-spread, most are invasive, and are usually found in a handful of research departments, hospital clinics or voice-health research centres, and need considerable funding to access and use them.

Acoustic measurements, on the other hand, have the following advantages and disadvantages (Frohlich et al., 2000: 706). The advantages are: 1- the measurements provide more objective descriptions of voice characteristics and can in principle be replicated, 2- the procedure is ″noninvasive”, and 3- they offer the possibilities of allowing the evaluation of daily conversations and voice variety. Problems, however, could occur due to acoustic signal corruption. Uncontrolled factors such as background noise or a possible replication effect, specific vocal tract resonances, or heartbeat cycle may affect the values of the acoustic measures.

However, acoustic investigations are the most applied approach due to the availability and relatively low cost of instruments, since they only require a computer and free downloadable software. They do not offer the straight-forward imaging which results from applying articulatory instruments; nonetheless, they are not less reliable in providing solid findings. For these reasons,

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[14] The most popular approaches auditory-perceptual approaches are: the GRBAS scales (see: Sakata et al., 1994; Bodt et al., 1997; Carding et al., 2000; Batalla et al., 2004) and the VPA scheme (see: Laver, 1991; Stuart-Smith, 1999; Carding et al., 2000; Beck, 2005, 2007).

[15] Other articulatory techniques are Laryngoscopy, EMA, EGG, and Ultra-sound (see: Lieberman and Blumstein, 1988; Carlson and Miller, 1998; Frohlich et al., 2000; Story et al., 2001; Titze and Story, 2002; Edmondson and Esling, 2006; Zeroual et al., 2006).

the present study will apply acoustic examinations and correlate their results with those obtained from auditory analysis. Accordingly, the following sections will deal with the main acoustic measurements and methods applied in the literature, with particular focus on those that will be used in the present study (see Chapter 6 for more specific details). The measurements will be categorized into two groups according to the part of the vocal apparatus the cues tend to signal: laryngeal (phonatory) cues and supralaryngeal (vocal tract) cues.

3.4.1 Laryngeal (Phonatory) Cues

In acoustically investigating phonation types and settings, a number of acoustic cues and signals, among others [(16)], are considered (see:; Fry, 1979; Laver, 1980; Kuwabara and Ohgushi, 1984; Klatt and Klatt, 1990; Laver, 1994; Trittin and Lleo, 1995; Gordon and Ladefoged, 2001; Epstein, 2002; Ladefoged, 2003; Keating and Esposito, 2007; Simpson, 2012), the following are the ones applied in the present study:

1- *Amplitudes of the first and second harmonics (H*1-*H*2*)*: Since the frequencies of the harmonics but not their amplitudes are fixed due to the influence of f_0, it is those changeable amplitudes that characterize the voice leading to different phonation types; a process of comparison is carried out by comparing amplitudes of the first and second harmonics of the fundamental frequency. Keating and Esposito (2007: 86) consider the *H*1-*H*2 measure as being 'well-suited' to characterising differences along the phonation types (which they refer to as the glottal constriction) continuum, adding that it has been applied to many languages. This measure leads to the following interpretations (see: Fry, 1979; Laver, 1980, 1994; Klatt and Klatt, 1990; Trittin and Lleo, 1995; Epstein, 2002, among others):

a- If the first harmonic has the highest amplitude, the resulting voice is believed to be breathy (figure 3.7).

[(16)] Other signals include: appearance of pulses, *ratio of open quotient*, *inharmonics (or noise)* at higher frequencies, mostly above *F*3, f_0, *H*1-*A*2, *H*1-*A*3.

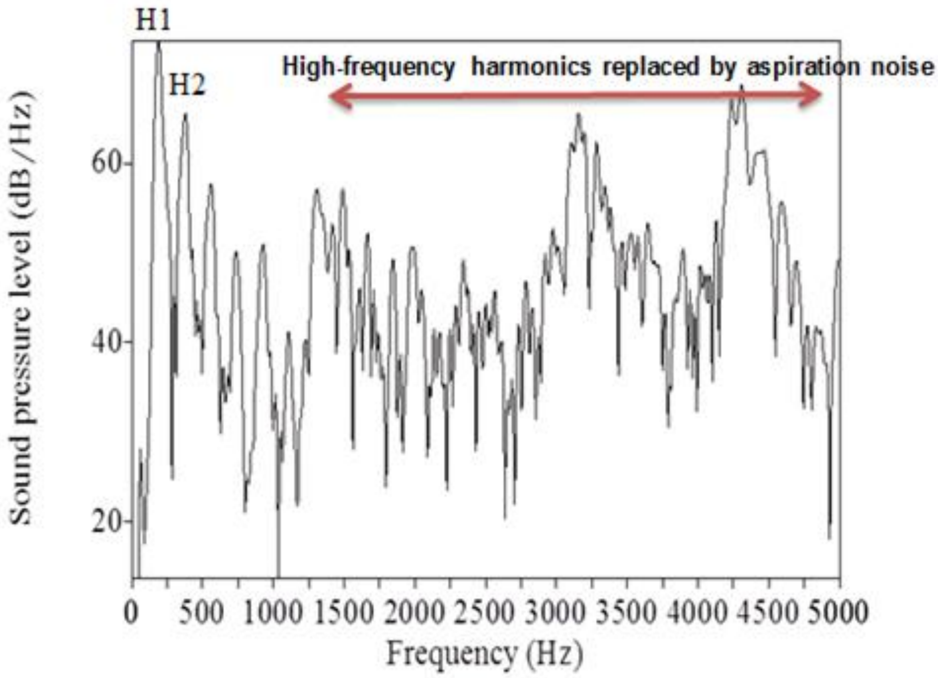


Figure 3.8: A spectrum of the vowel [ɪ] at onset in the word *min* [mɪn] 'from' produced by an adult male speaker of IA showing *H*1 higher than *H*2 and high-frequency harmonics replaced by aspiration, which suggests a breathy phonation.

b- If the higher frequency harmonics have higher amplitudes, the resulting voice is believed to be creaky (figure 3.8).

In other words, the higher the *H*1-*H*2 value the breathier the phonation (Keating and Esposito, 2007: 87).

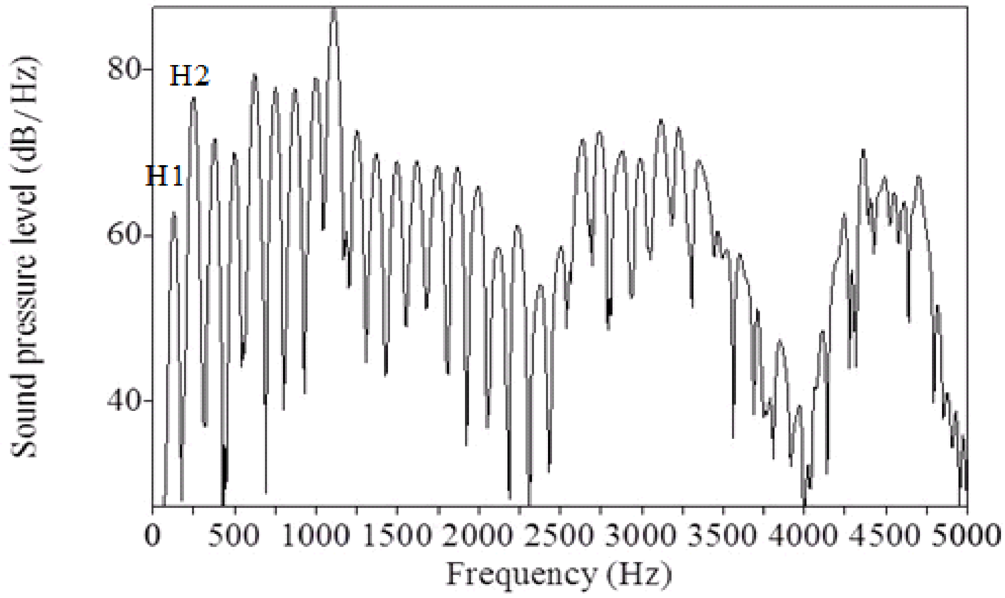


Figure 3.9: a spectrum of the vowel [ɔ:] at midpoint in the word *noo3* [nɔ:ʕ] 'type' produced by an adult male speaker of IA showing *H*1 lower than *H*2, which suggests a creaky phonation.

c- An increase in open quotient would lead to an increase in *H*1, which is measured to investigate the degree of breathiness.

d- *H*2 is measured as a reference for comparison with *H*1.

The degree of difference between the amplitude of the first two harmonics *H*1-*H*2 is also used by some researchers (e.g. Ladefoged, 2003) when deciding the type of phonation. Ladefoged (ibid: 180) showed spectra of three vowels in San Locas Quiavini Zapotec, one of the languages of Zapotec spoken in Mexico where *H*1 was either almost equal or higher than *H*2 and the resulting phonation type (see figure 3.9): if *H*1 is almost the same as *H*2, then the phonation is believed to be creaky; if *H*1 is higher than *H*2 and the difference is about 4dB, then the phonation is believed to be breathy; when *H*1 is also higher than *H*2 but the difference is smaller (about 2.5dB), the phonation is believed to be modal. Ladefoged (ibid: 178-179) also showed spectrograms and spectra of nasal consonants of Newar, another Language in Mexico, with modal and breathy voice (see figures 3.10 and 3.11). In the modal voice nasal, *H*1 does not have great energy and is lower in amplitude than *H*2. In the breathy voice nasal, the fundamental frequency has more energy and *H*1 is much higher in amplitude than *H*2.

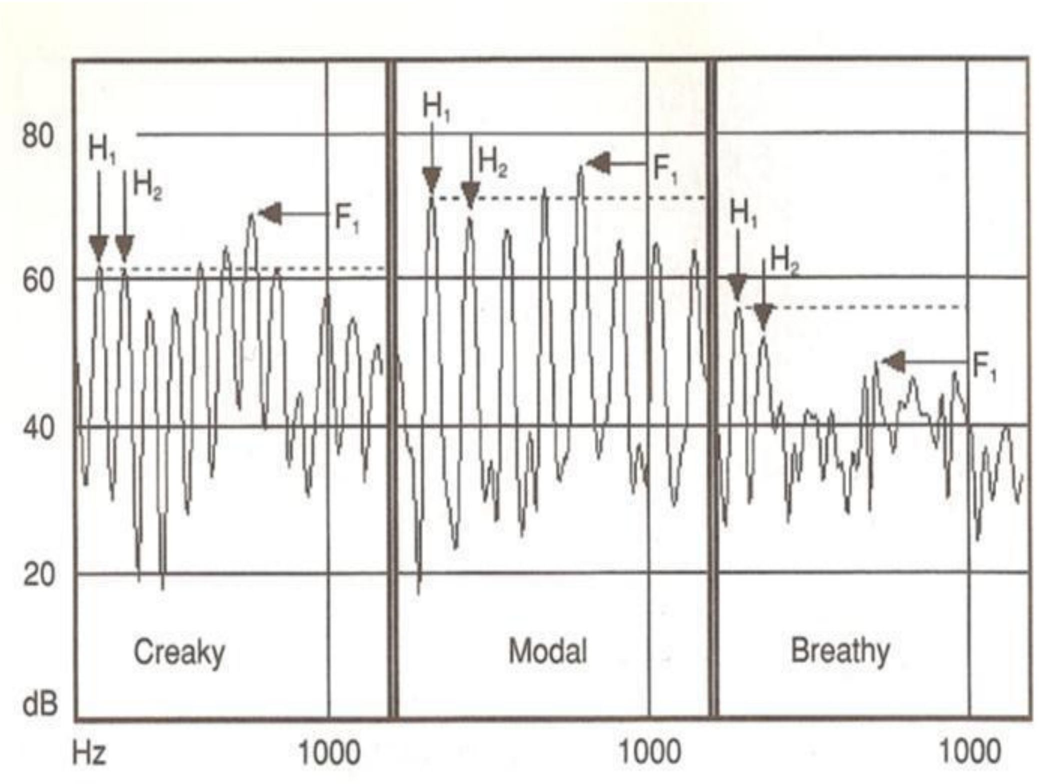


Figure 3.10: Spectra of creaky, modal and breathy [a] vowel in San Lucas Quiavini Zapotec, a language spoken in Mexico. The dashed line marks the intensity of H1 in each spectrum. The relation between *H*1 and *H*2 decides the type of phonation: creaky when *H*1 is almost equal to *H*2, modal when *H*1 is about 2dB higher than *H*2 and breathy when *H*1 is about 4dB higher than *H*2 (Figure cited from: Ladefoged, 2003: 180).

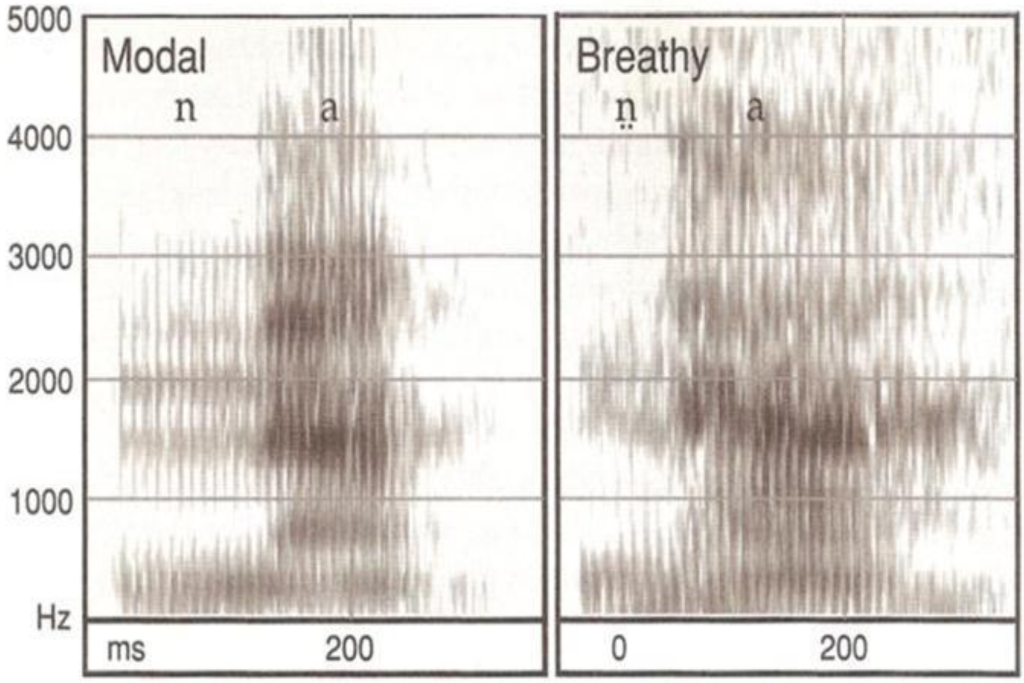


Figure 3.11: Spectrograms of nasal consonants of Newar, a Language in Mexico, with modal and breathy voices (Figure cited from: Ladefoged, 2003: 178).

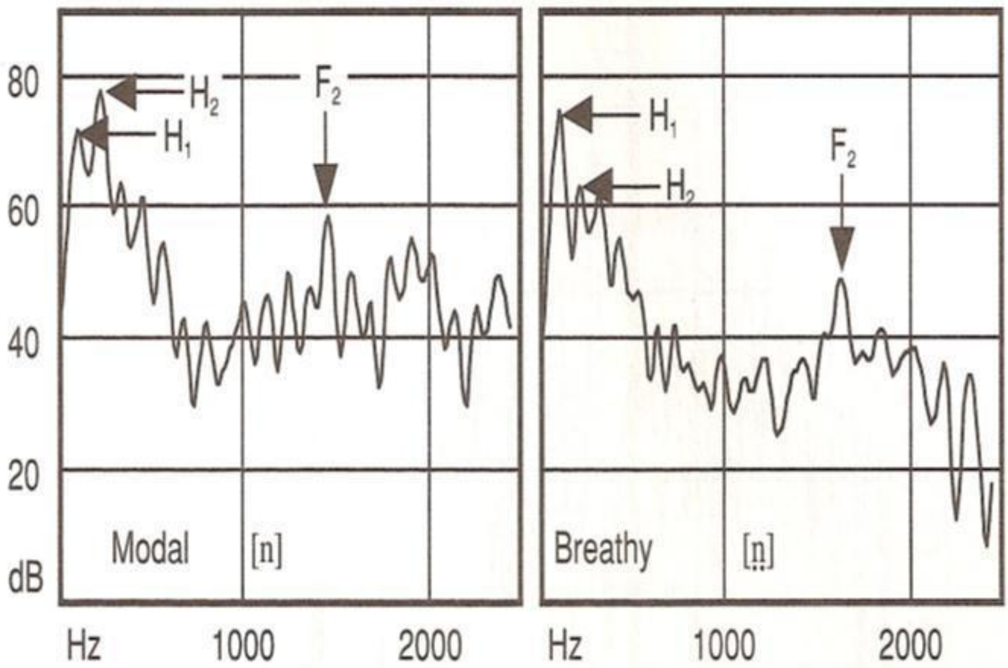


Figure 3.12: Spectra of nasal consonants of Newar, a Language in Mexico, with modal and breathy voice showing a lower *H*1 for the modal voice nasal and a higher *H*1 for the breathy voice nasal (Figure cited from: Ladefoged, 2003: 179).

Another study that tackled *H*1-*H*2 and its implications is by Simpson (2012) who set out to prove that the *H*1-*H*2 reference is not an appropriate measure for sex-specific differences. Sex-specific differences of *H*1-*H*2 and nasalisation were investigated in the vowel /ɑː/ within nasal and non-nasal contexts. The researcher found that although *H*1-*H*2 show a significant difference between male and female speakers it also shows that the value of the reference becomes larger within nasal contexts and for both sexes, with the value becoming positive for females and negative for males. Findings also showed that for males, *H*1 was consistently weaker than *H*2 while for females *H*2 was weaker. Simpson (ibid: 481) also states that nasal coupling increases within nasal contexts and helps predict which harmonic would be enhanced for each sex, which would be *H*1 for females and *H*2 for males, as a result of an enhanced FN1 (first nasal formant). Having the same harmonic being enhanced for each sex makes these harmonics sex-specific and not a measure of breathiness but rather a measure of nasalisation (see figure 3.12).

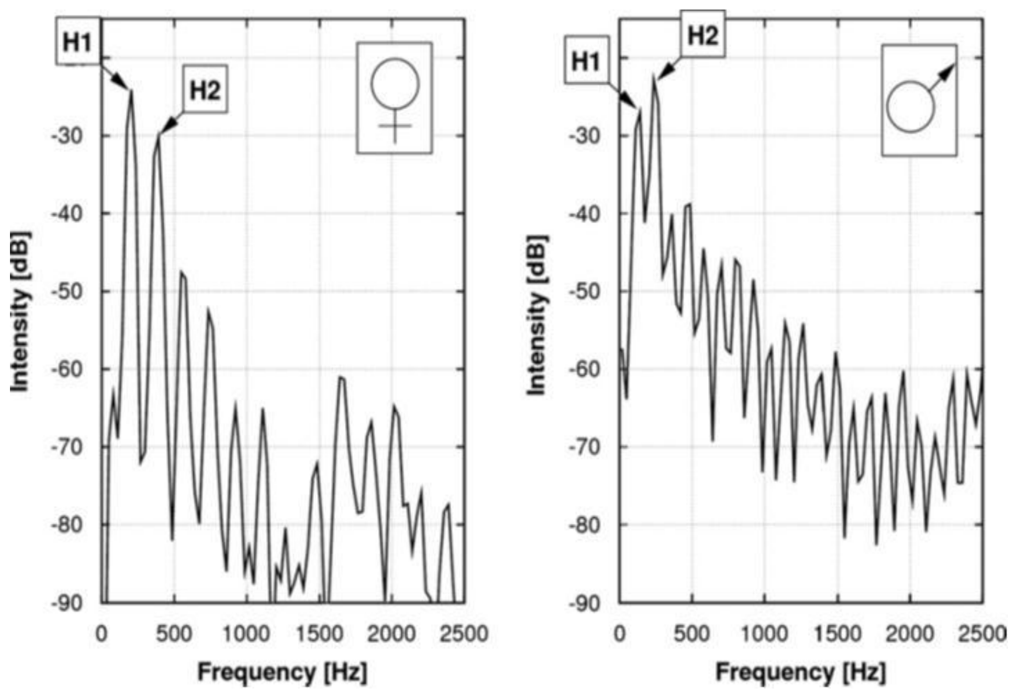


Figure 3.13: DFT spectra of female (left) and male (right) [n] from the word *mahne* 'warn' showing the positions of the first (*H*1) and second (*H*2) harmonics (Figure cited from Simpson, 2012: 483).

However, none of the above studies provide a scale of difference of *H*1-*H*2 between breathy and creaky (laryngealised) phonation types, except from Klatt and Klatt (1990: 829) who provide such a scale. To do so they (ibid) measured *H*1 at vowel midpoint in syllables uttered by 10 females and 6 males. Then they scaled up all values of differences between *H*1 and *H*2 by 10dB so that almost all numbers would be positive. The resulting average value of *H*1-*H*2 for female speakers was found to be 11.9dB, i.e. 1.9dB without the 10dB scaling up, and for male speakers 6.2dB, i.e. -4dB without the scaling up. The latter result shows male speakers having a weaker *H*1. Their results show an average difference of 5.7dB between sexes. Therefore, using *H*1 as an acoustic measure of breathiness would indicate that female speakers are more breathy than male speakers (ibid). Accordingly, and without the 10dB scaling up, any value that is below -4dB would indicate laryngealisation, i.e. creaky voice.

2- *Amplitudes of the first harmonic (H*1*) and strongest harmonic of the first formant (A*1*)*: Similar to *H*1-*H*2 above, since it is the changeable amplitudes that characterize the voice leading to different phonation types, a process of comparison is carried out by comparing amplitudes of the first harmonic (*H*1) to the strongest harmonics of the first (*A*1) formant; this measurement lead to the same interpretations as in point (2) (see: Fry, 1979; Laver, 1980, 1994; Klatt and Klatt, 1990; Trittin and Lleo, 1995; Epstein, 2002).

According to Kuang (2011: 14), the normalised *H*1*-*A*1 has proved to be a successful measure of phonation types in many languages. This measure is directly related to the first formant bandwidth (*B*1) which is in turn related to the posterior glottal opening (ibid). Accordingly, if a speaker has a posterior glottal opening, then first formant bandwidth will be increased (ibid: 15). Hanson and Chuang (1999: 1064) found that this glottal opening "persists throughout a vibratory cycle". However, observations suggest that its persistence is common in female speakers but is much less frequent among male speakers (ibid). They add that that glottal opening, which is also called a 'glottal chink', causes modifications to the spectrum such as the increase of *B*1 which is caused by "additional energy loss at the glottis" (ibid: 1065). Therefore, *H*1-*A*1 is a measure of glottal chink whereby its values are interpreted as follows (ibid: 1067): **1-** speakers with low *H*1-*A*1 values, showing strong high frequency, prominent *F*1 spectral peaks and little aspiration, would be assumed to have "abrupt glottal closure" with varying sized posterior *glottal chinks* starting from zero; **2-** speakers with high *H*1-*A*1 values, showing less high frequency energy, weaker *F*1 peaks and more aspiration noise, would be assumed to have "relatively large posterior glottal chinks extending beyond the vocal processes, with non simultaneous glottal closure".

According to Hanson (1996: 471), as *B*1 increases, *H*1-*A*1 increases, variation of *H*1 across speakers will also cause some "uncertainty" to the *H*1-*A*1 value; also, variation of *A*1 will depend on whether or not *F*1 is centred on a harmonic. Hanson (ibid) estimates that the range of *H*1-*A*1 is 16 dB ranging from a minimum of about -11 dB to a maximum of 5 dB for female speakers. This range of values suggests that *F*1 peaks vary from being very prominent for some speakers to being highly damped for others, although this range can also be due to the variation in *H*1 and how well *F*1 is centred on a harmonic across speakers.

Researchers have reported pharyngeals to be associated with creaky voice; therefore, the present study aims at investigating phonation types in relation to the production of these consonants. In addition, this work aims at finding which phonation types dominate the speech of male Iraqi speakers.

3.4.2 Supralaryngeal (Vocal Tract) Cues

As was mentioned in section 3.3.3, vocal tract or supralaryngeal settings include raised larynx voice and lowered larynx voice, labial protrusion, labiodentalized voice, labial settings, lingual settings, faucal settings, pharyngeal settings, mandibular settings, nasal settings and denasal settings. These settings signal a number of cues related to the effect they have on sound segments. These cues are examined in relation to the effect the above settings have on: formants ($F1$, $F2$, $F3$, etc.) of vowel segments and how changes in frequencies, amplitudes ($A1$, $A2$, $A3$, etc.), bandwidths ($B1$, $B2$, $B3$, etc.) and overall intensity of a particular vowel are influenced; consonantal features related to manner of articulation, place of articulation and voicing; the occurrence of such cues as extra peaks and zeros (antiformants) due to the emergence of side-chambers (or branches). These cues would be compared to the neutral setting in which these segments are produced investigating what changes these settings have caused.

In the present study nasalisation is investigated in relation to the production of pharyngeals (see Chapter 5 for more details) and more generally if nasality is a VQ feature of IA. To investigate a nasal setting, the above cues are measured within the form of relations: differences between $A1$-$P1$ (amplitude of the first formant and that of the extra peak above $F1$), $A1$-$P0$ (amplitude of the first formant and that of the extra peak below $F1$) (see Chapter 4 for more details). Therefore, Chapter 4 will deal with vocal tract cues in as far as the nasal setting is concerned and how that might have influenced the speech of IA speakers, with focus on acoustic characteristics of nasalisation.

3.5 Summary of Chapter 3

This chapter tackled the subject of voice quality and the controversy surrounding its types and vocabulary used to represent them. The present study adopts Laver's (1980) approach in terms of considering VQ as the perceived colouring of the speaker's speech which includes what happens along the entire speech apparatus rather than being restricted to the laryngeal activity. Aspects relating to the larynx or laryngeal settings are referred to as phonation types. VQ is divided into settings and types. Two types of settings will be investigated in the present study, supra-laryngeal (above the larynx) settings and laryngeal (phonatory) settings. The first type will deal with velopharyngeal settings to find out whether nasalisation is associated with the production of certain segments such as pharyngeals as proposed by the literature, and whether VQ is dialect–specific, or is a feature of IA speakers in general. The second type will decide if the voice of IA speakers is breathy or creaky in certain contexts, is dialect-specific or a general characteristic of

IA. The study will also investigate which phonation type plays a role in the perception of nasalisation, if any.

Chapter 4 : Nasality and Nasalisation

4.1 Introduction

This chapter explores the notions of *nasality* and *nasalisation* in relation to other co-occurring events in the velopharyngeal area of the vocal tract. The terms *nasals*, *nasal consonants*, *nasal vowels*, *nasalised vowels* and *nasal quality w*ill be defined. Nasal sounds share many spectral features with oral and nasalised vowels; therefore, measuring nasality in speech requires an understanding of how these three types of segments are produced.

The literature also suggests that some segments other than nasal consonants, for instance pharyngeal consonants, tend to cause nasalisation in neighbouring vowels in some dialects of a language rather than others. For instance x-rays, xeroradiograms and phonological investigations of speakers of some South Ethiopic languages as well as Iraqi and Libyan Arabic speakers show an open velum during the production of the pharyngeals /ħ/ and /ʕ/ (Hetzron, 1969; MacCurtain, 1981; Laradi, 1983; see Chapter 5 for more details). The possibility that the production of pharyngeal consonants in IA is accompanied by nasalisation will be investigated in the present study.

4.2 An Overview of Nasality

The term *nasal* or *nasalised* is given to all sounds produced with the velum lowered and the air flowing from the pharynx into the nose, with the difference being that nasalised sounds result from the effect of nasal sounds on neighbouring oral vowels. In nasal consonants the mouth is completely closed so the air only passes through the nose, while in nasalised sounds there is no complete closure in the mouth and the air passes through both the mouth and nose where a coupling of the two cavities is formed (Catford, 1977: 136-137; Kent and Read, 1992: 36; Ohala and Ohala, 1993: 225; Feng and Castelli, 1996: 3694). From an acoustic point of view what characterises nasal and nasalised sounds is a resulting ‘nasal resonance’, which is due to the coupling of the nasal cavity with the vocal tract as a result of the lowered velum and the formation of a resonance chamber (Catford, 1977: 136-137). This results in new low frequency formants, a shift in formant frequencies and other acoustic events which will be discussed in this chapter.

Nasality is a term that encompasses phonologically nasal segments (nasal consonants and nasal vowels), nasalised segments, phonological and non phonological VQ settings (Laver, 1980: 3, 4). As a phonological quality of vowels (i.e. nasal vowels), it is used to deliver lexical contrast in such languages as French, Portuguese and Yoruba (Laver, 1980: 4). As a phonological setting, nasality is used to mark verb forms in Sundanese, a Language of Java (ibid: 4). Nasality is also a "setting component" of VQ either of certain individuals or as a characteristic of being a member of a certain sociolinguistic group as in the case of speakers of Received Pronunciation in England and many accents of the United States (ibid).

4.3 Oral Vowels

Vowels are segments produced with no constriction to the air-flow such as that found in the production of consonants. According to Stevens (2000: 303) manipulations of the different articulators, tongue body, pharynx and lips, lead to variation in the shape of the supraglottal passage. The latter leads to a number of glottal source filterings, which are recognizable in the form of formant frequencies and bandwidths. This is maintained on the condition that no side branches are formed along the acoustic passage and that sound spreads in the vocal tract "approximately one-dimensional, with no cross-modes", and the resulting transfer function between the glottis and the lips being an all-pole function (ibid). Theoretically, the only spectral peaks that appear in oral vowels are those forming the main formants. Figure 4.1 shows an isolated long vowel [a:] produced by an Iraqi male speaker within the carrier sentence *quulu ... sit marrat* 'say … six times'. Vowels usually have very clearly defined formant bars. Figure 4.2 shows a spectrum of an oral isolated vowel with high frequency $F1$ and all harmonics very clearly defined.

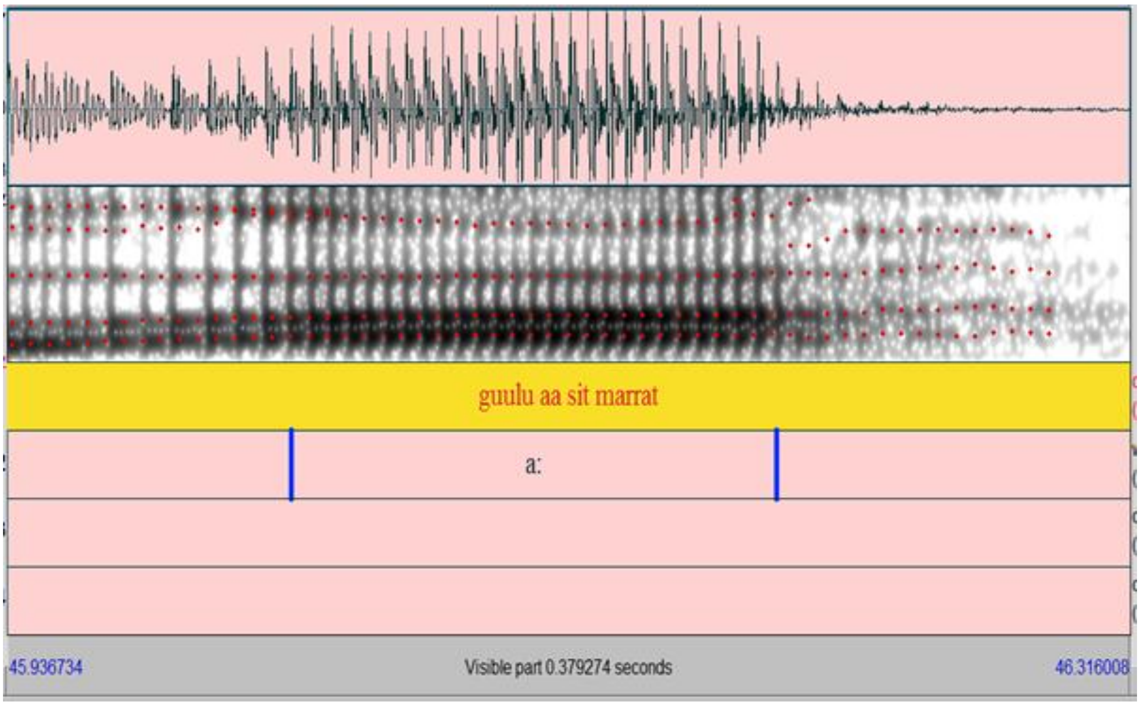


Figure 4.1: A spectrogram and spectrum showing how all formants are clearly defined in the isolated vowel [a:] as produced by an adult male speaker of IA.

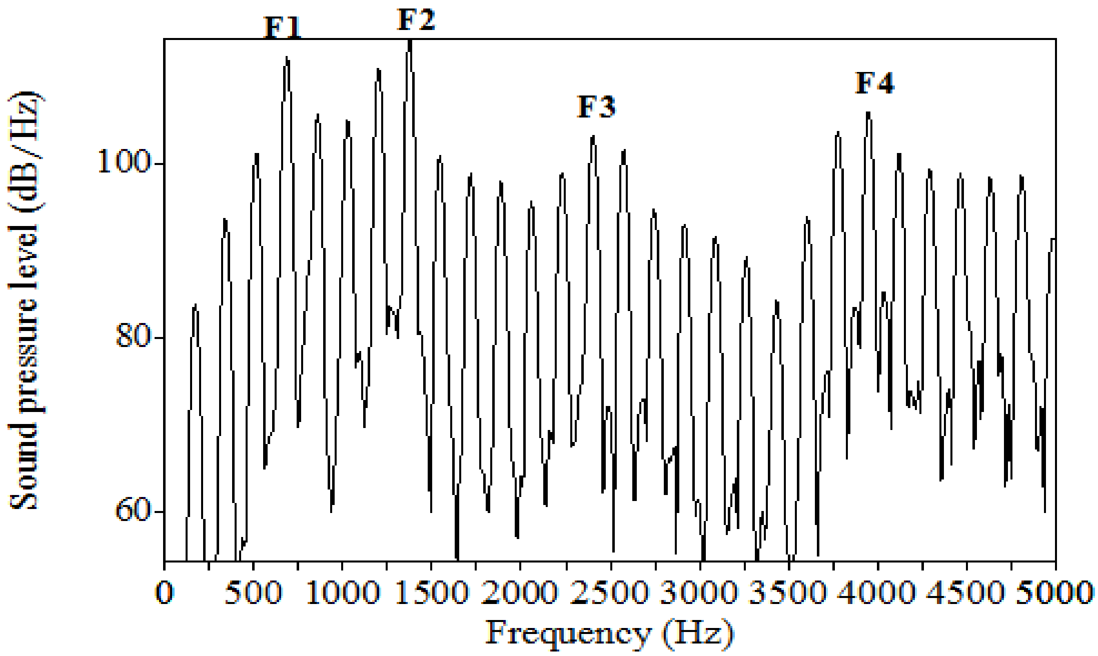


Figure 4.2: A spectrum showing how all harmonics are clearly defined in the isolated vowel [a:] as produced by an adult male speaker of IA.

4.4 Nasal Consonants

A *nasal consonant* is a sound produced with a velopharyngeal opening but with a complete closure at some point within the oral cavity (Stevens, 2000: 304). Nasal consonants are similar to vowels rather than consonants in the way they are produced with no constriction other than that leading to a closure in the oral cavity. That constriction decides the place of articulation of the nasal, e.g. bilabial, alveolar, velar or uvular. As was mentioned in section 4.2, a nasal consonant is produced by lowering the velum causing an acoustic coupling between the oral and nasal cavities. A *nasal murmur*, another term for a nasal consonant, is defined as being the sound produced by having the phonation action of the glottis spread through the velar passage, the nasal passage and then through the nose (Pickett, 1999: 113).

After air passes through the pharynx, it moves through both the oral and nasal cavities. As a result, the nasal cavity would have a resonating effect, leading to the appearance of nasal formants. A nasal formant is a resonance with low frequency associated with the nasal tract, which has a frequency of less than 500Hz for male's speech (Kent and Read, 1992: 231). The mouth would be closed at some point, so air going into it would resonate back towards the velopharyngeal cavity. The oral cavity acts as a side-branch to the main nasal one. The resonating effect of the oral cavity acts against some of the nasal resonances leading to the absorption of energy from the main tube. This effect creates anti-resonances, which are found in the form of *zeroes*, defined as drops in the amplitude of portions of the spectrum, and *poles*, defined as extra spectral peaks in comparison to an oral vowel spectrum (Beddor, 1983: 115). An antiformant, or zero, is a property of a transfer function but has an opposite effect to formants by preventing energy from passing effectively and acting similar to a "short circuit, trapping energy in the system" (Kent and Read, 1992: 227). Figure 4.3 shows a spectrogram of a word produced by an adult male Iraqi speaker. The word is a clear example of a comparison between the initial and final nasal consonant /m/ and a neighbouring vowel where the consonants are seen fainter than the vowel and formants are lower in the two nasals than they are in the vowel. Although the vowel in this case would be considered nasalised (see section 4.5) and the extra bar (pole) between $F1$ and $F2$ is seen present in the vowel and the initial consonant, the darkness of the vowel and decrease of formants in the nasals is a very apparent feature differentiating the two categories of sounds.

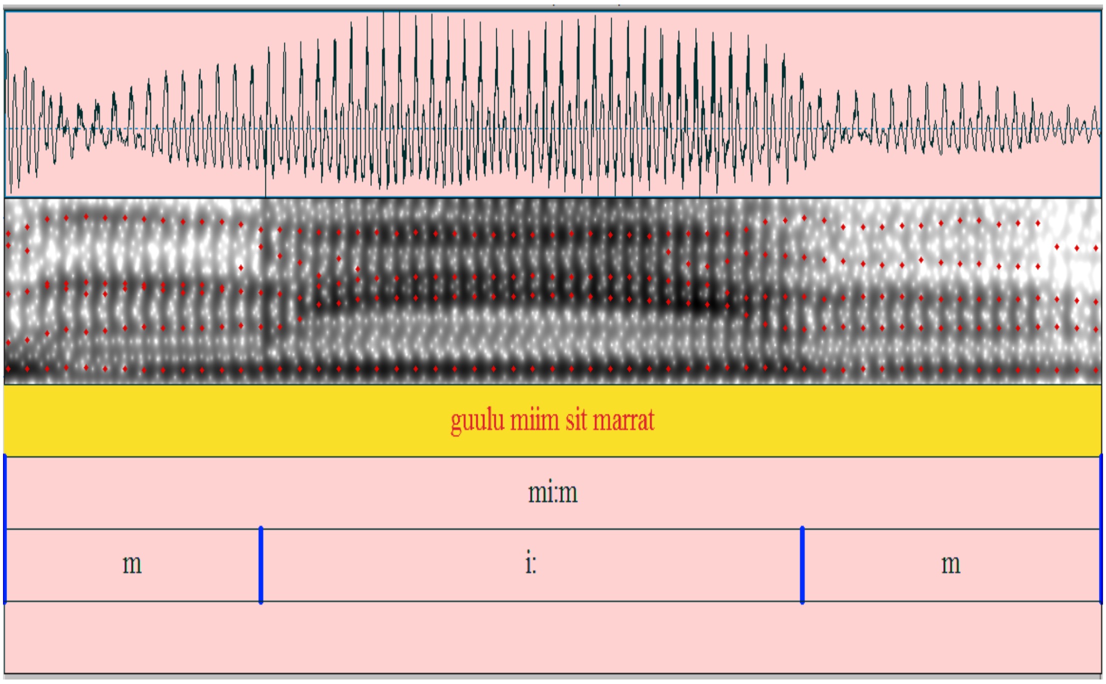


Figure 4.3: A Spectrogram comparing the formant patterns of a vowel surrounded by nasal consonants.

According to Fant (1973: 13), these zeroes, or what he calls 'a 0-pattern of anti-resonances' are "an additional determinant of formant levels" and could be found in a group of sound segments among which are nasal consonants. As a result, nasal sounds will have similar nasal formants where oral formants are usually found plus anti-formants appearing at different frequencies between *F*1 and *F*2 and above *F*3. Moreover, spectrograms of nasals show formants with low visibility due to their low amplitudes in comparison to those of vowels (Ladefoged, 2003: 143). In addition to zeros, spectral prominences (peaks) appear between oral formants in the vicinity of 200-300 Hz, another peak near 1000 Hz, and a zero that differs in frequency according to articulation or type of consonant: one at 1000Hz in /m/, one at 3500Hz in the post-dental, and one at 5000Hz in the velar (House, 1957: 198). Figure 4.4 shows a spectrogram and spectrum of the nasal consonant /m/ where a clear extra peak is present between *F*1 and *F*2 on the spectrogram seen as a dark bar at about 1000Hz, and the same pole on the sixth harmonic (*H6*) with a preceding zero on the fifth harmonic (*H*5) are clear on the spectrum.

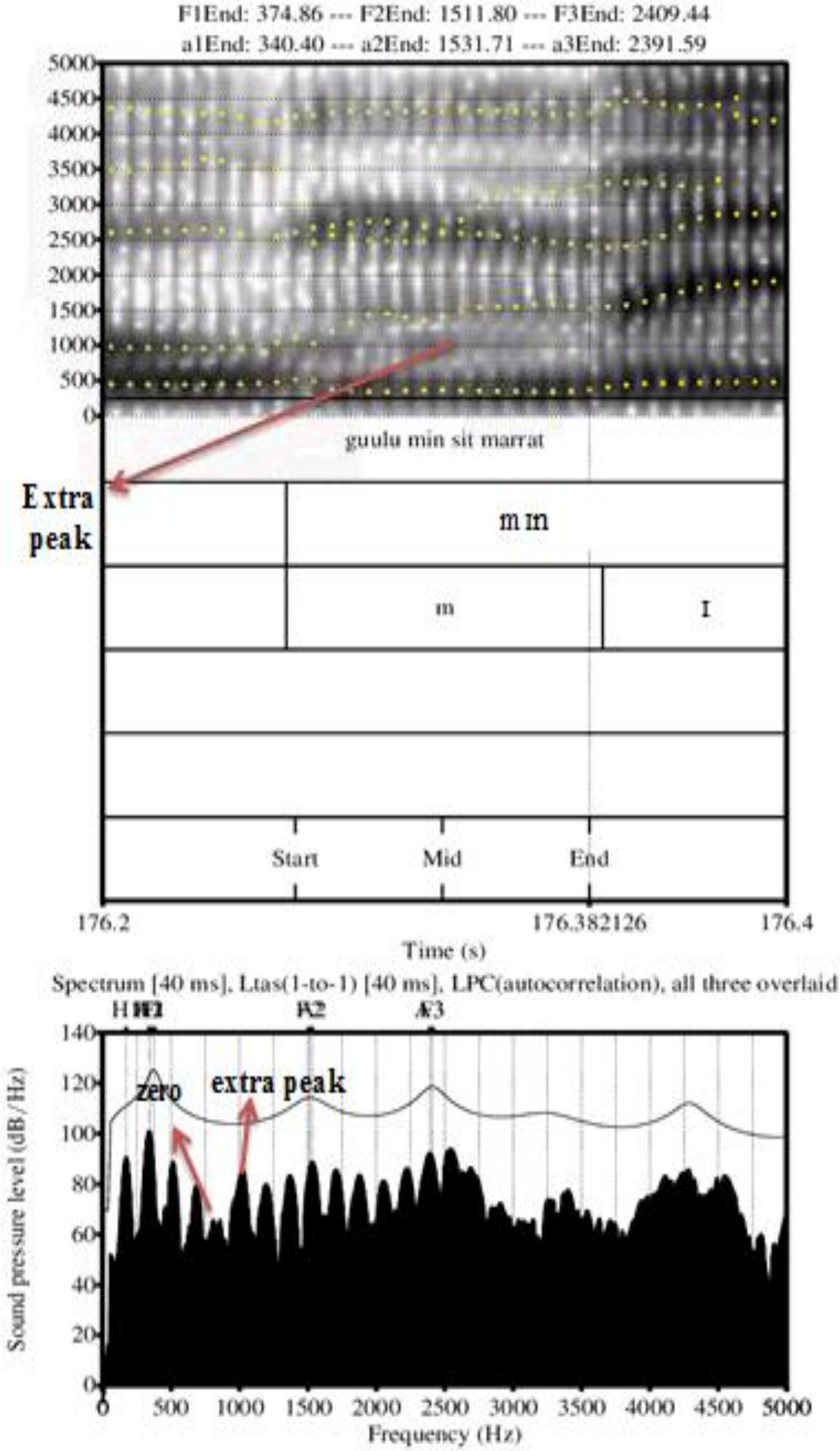


Figure 4.4: A spectrogram of the nasal consonant /m/ in the word min [mɪn] 'from' showing an extra peak (dark bar) between F1 and F2 at about 1000Hz; the same pole (on H6) and a zero (on H5) on the spectrum.

The occurrence of zeros and poles is one feature differentiating nasal consonants from oral vowels; other features include nasal consonants having lower frequency regions, particularly that of *F*1 in the vicinity of 300Hz (Fujimura, 1962: 1874) and a general reduction of amplitude (Dickson, 1962: 104) due to the larger area of damping created by the additional channel. The increase of damping leads to widening the bandwidths (Kakata, 1956: 662; Fujimura, 1962: 1874; Dickson, 1962: 104), especially that of *F*1, also leading to the flattening of its peak and therefore decreasing its amplitude. As mentioned above, there is a density of formants and anti-formants in the frequency domain (Fujimura, 1962: 1874; Dickson, 1962: 104), where anti- formants (zeros) occur between *F*1 and *F*2 leading to drop in the frequency of *F*1 and a rise in the frequency of *F*2 to reach the region of oral vowel *F*3 (Fry, 1979: 119). Anti-formants tend to absorb energy from the area in which they occur, so it would be seen as a white (no energy) area on the spectrogram. The length of the side branch decides the frequency and position of an anti-formant, where the longer the side branch the lower the frequency (House, 1957: 199). Figures 4.5 and 4.6 show spectra of the two nasal consonant /m, n/ produced by the same adult speaker of IA where a dip (zero) is seen between *F*1 and *F*2 for both consonants at their midpoint. Figure 4.6 of /n/ also shows an extra peak following the zero between *F*1 and *F*2 and on the eighth harmonic (H8), but that of Figure 4.5 does not show any extra peak which could indicate that it is not necessary to have both the pole and zero to have nasality.

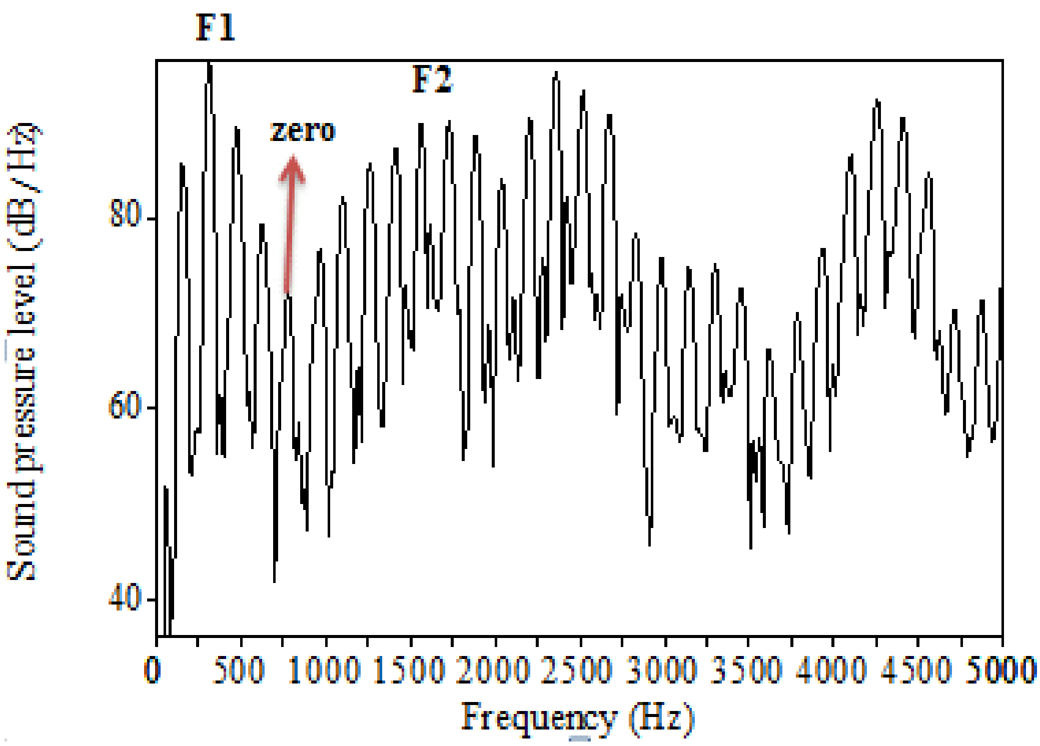


Figure 4.5: A spectrum of a mid portion of the consonant /m/ in the word *dem* [dɛm] 'blood' produced by an adult male speaker of IA.

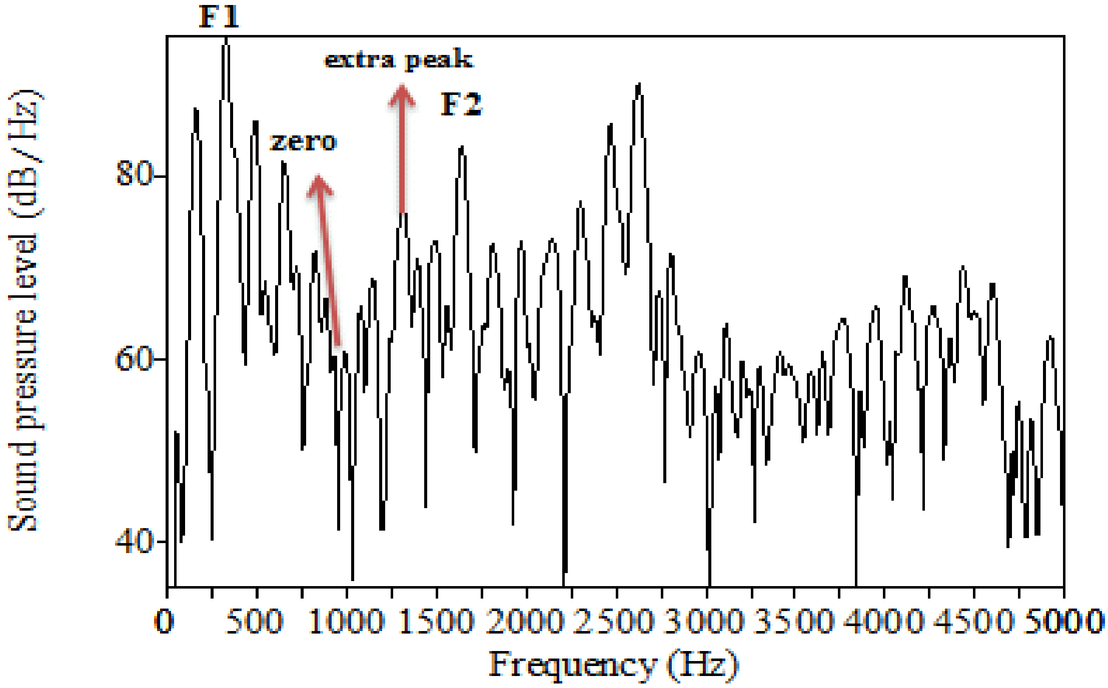


Figure 4.6: A spectrum of a mid portion of the consonant /n/ in the word *nuun [nu:n]* 'the letter n in Arabic' produced by an adult male speaker of IA.

4.5 Nasalised Vowels

Nasalised vowels share articulatory features with both oral vowels and nasal consonants, and are defined as vowels produced with a lowered velum so that the pulmonic, egressive air-stream passes out of both the mouth and the nose (Catford, 1977: 181). The lowering of the velum enables the opening of a side passage for air to flow through the nasal cavity (Hattori et al., 1958). Nasalised vowels differ in their nature in regard to what articulatory and acoustic effects they have on spectrograms and why. In most cases, vowels are nasalised due to the following: when neighbouring nasal consonants; because of the lowering of the velum due to a side-effect of the movement of another speech organ; or as part of their own nature in contrast with others which are oral (Berger, 2007: 9-10). However, the last case is more related to what would be labelled as 'nasal vowels' rather than nasalised ones. Although both are articulated in the same way, their occurrences and the circumstances of their nasalisation are different, bearing in mind that researchers use the two terms interchangeably to refer to one or both types (Beddor, 1983; Berger, 2007). For Stevens (2000: 304), when a nasal consonant is produced there is a velopharyngeal opening, and when that consonant is adjacent to a vowel that opening continues into the vowel thus causing nasalisation in at least the part nearer to the consonant. Such a vowel would be called nasalised but does not usually have any contrast with oral vowels. A nasal vowel, on the other hand, is produced regardless of the presence or absence of a nasal consonant and they tend to have a contrast with oral vowels (ibid) (see figures 4.7 and 4.8).

As was mentioned earlier, when the main vocal tract is coupled with other acoustic systems, zeros and poles are added to the transfer function (ibid: 303). Having a velopharyngeal opening creates a coupling between the main vocal tract and the nasal cavity which causes nasalisation of the vowel when there is a vowel-like configuration (Stevens, 2000: 304). According to Hawkins and Stevens (1985: 1560), when producing a nasal vowel, acoustic coupling of the two tracts occurs at a halfway point between the glottis and the lips. Figure 4.7 shows spectra of nasal and non-nasal vowels of the French word *engage*. The word contains two syllables with one of the vowels being nasal and the other non-nasal. The figure shows the nasal vowel having apparent differences of a widened $F1$ and an enhanced $H1$ due to the acoustic effect of the maxillary sinuses. In the non-nasal vowel, there is a clear prominent spectral peak for $F1$ and $F2$ and a weak $H1$. There is also an extra peak in the non-nasal vowel at 1500Hz, which Stevens (2000: 321) attributes to a potential subglottal resonance.

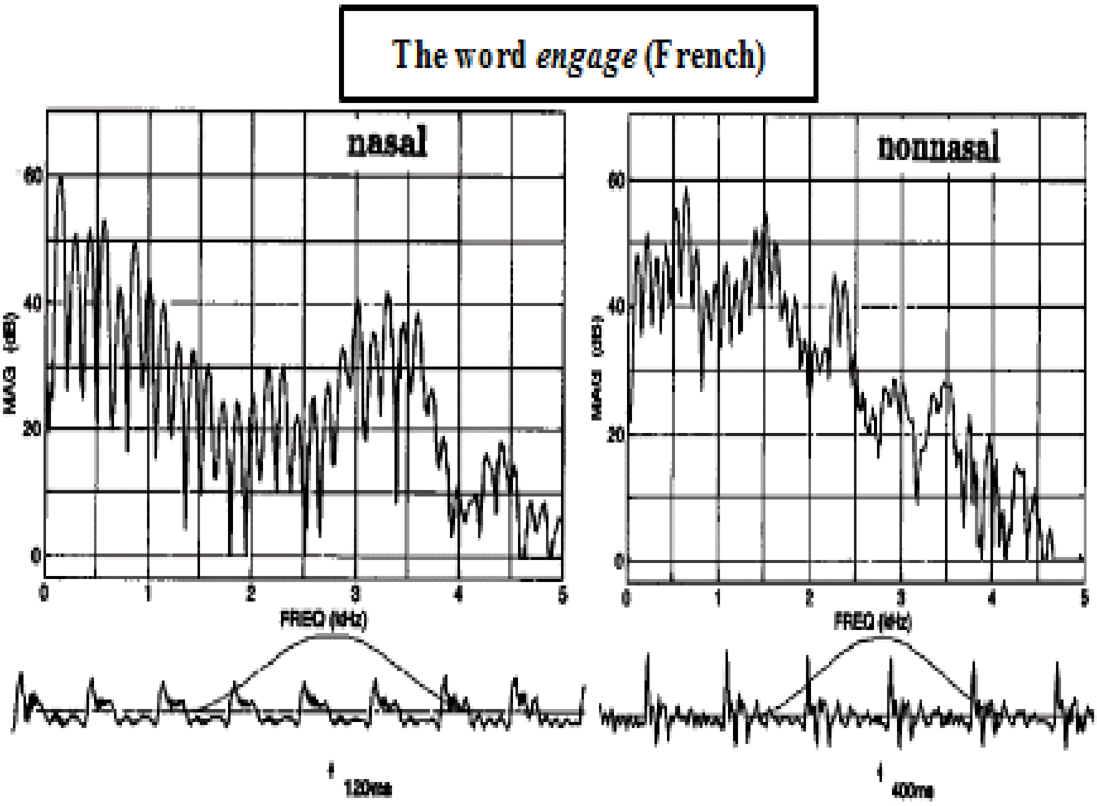


Figure 4.7: Spectra of a two syllable French utterance *engage*, showing the differences between a nasal and a non-nasal /*a*/. There is enhanced *H*1 and widened *F*1 in the nasal; there are prominent peaks of *F*1 and *F*2 (Figure from: Stevens, 2000: 319).

The present research aims at investigating whether nasalised vowels are predominant in Iraqi Arabic in general and in the production of pharyngeal consonants in particular. Figure 4.8 shows the same widened $F1$ and a lowering of formant frequencies in vowel [a:] within the word *maat* [ma:t] 'he died' produced by a male speaker of IA. Figure 4.9 compares the same vowel [a:] but in isolation as produced by the same adult male speaker of IA showing clear prominent formant spectral peaks.

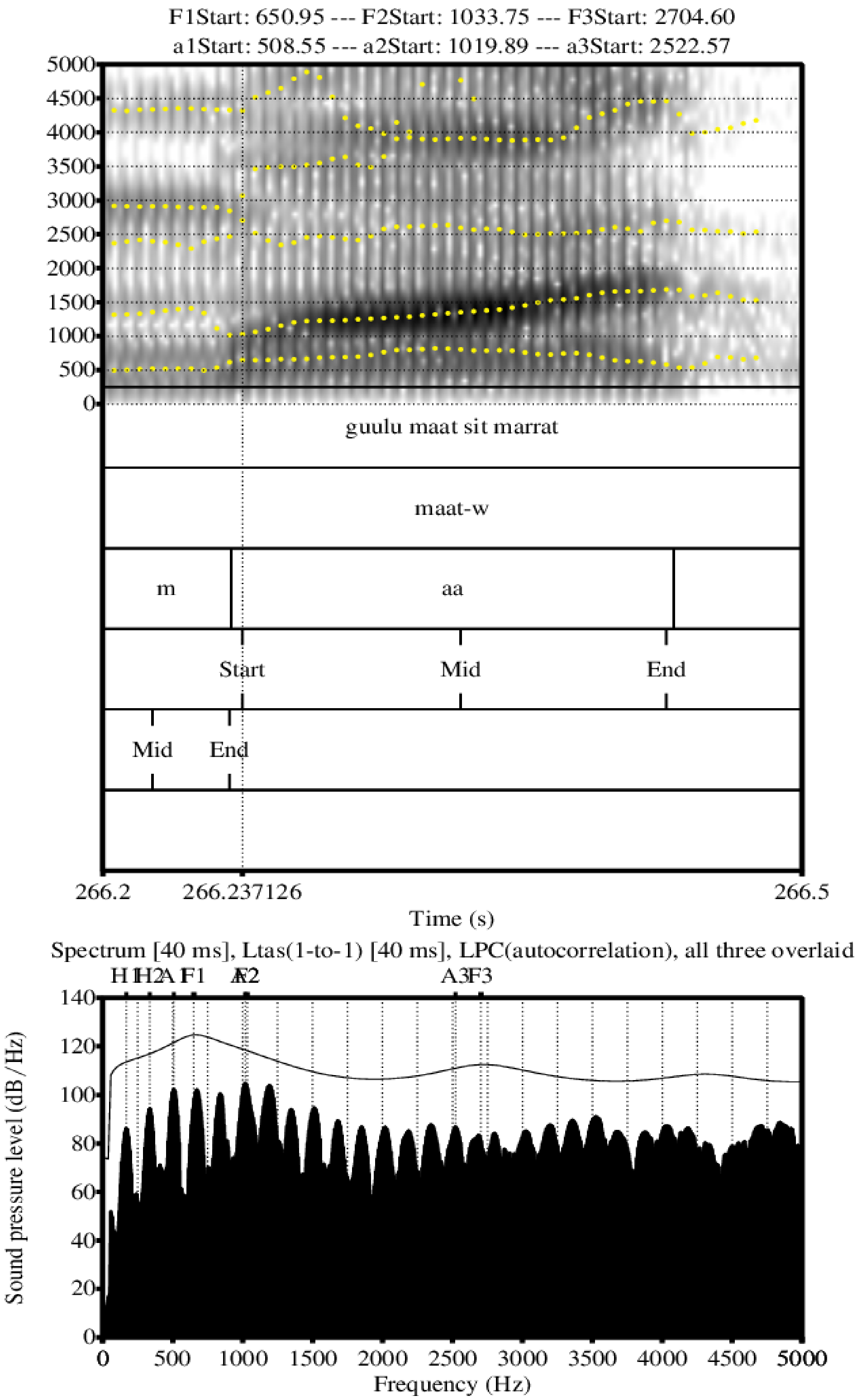


Figure 4.8: A spectrogram and spectrum showing widened formant peaks and a lowering of formant frequencies in vowel [a:] within the word maat [ma:t] 'he died' produced by a male speaker of IA.

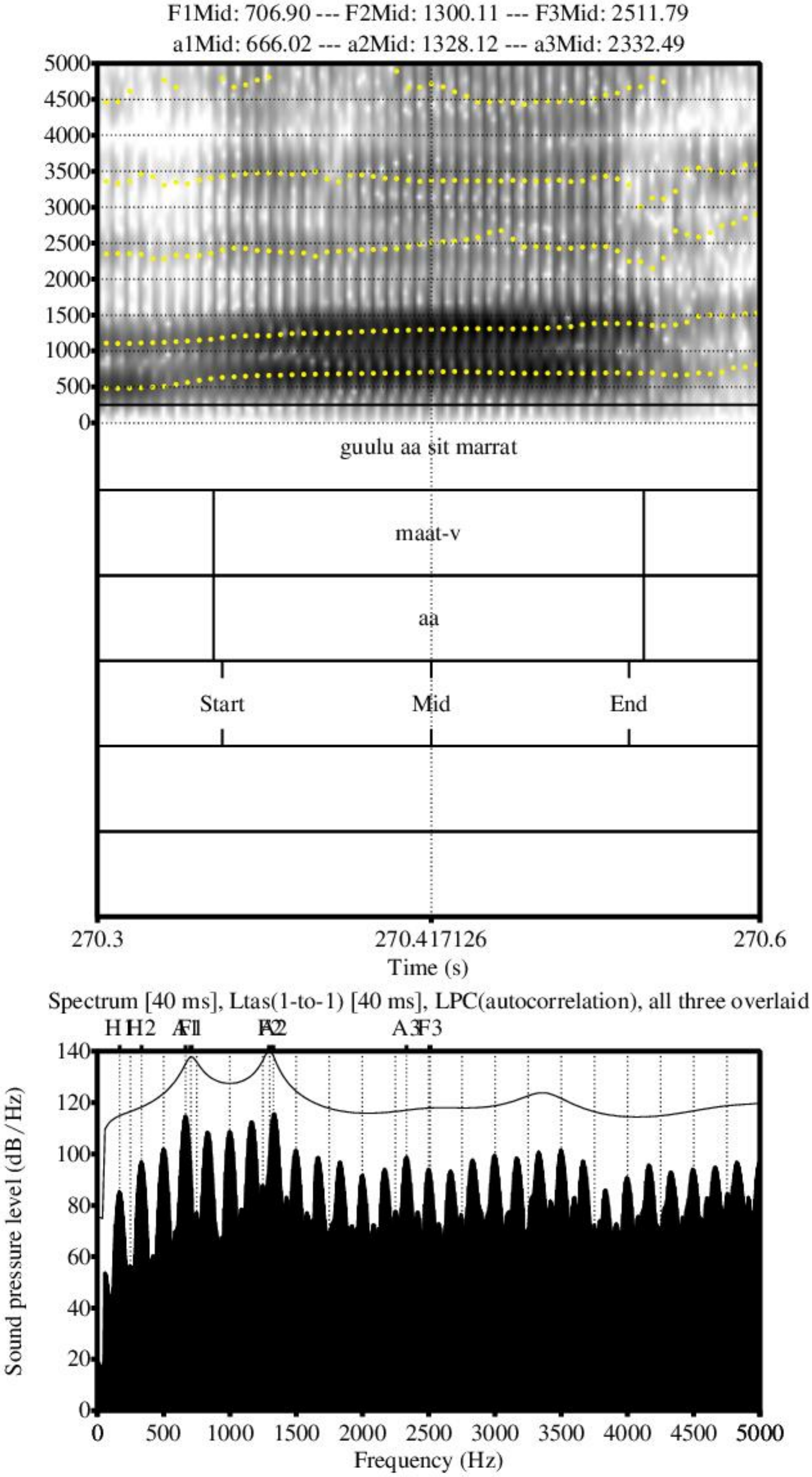


Figure 4.9: Comparing the same vowel aa [a:] but in isolation as produced by an adult males IA speaker showing clear prominent formant spectral peaks.

Most researchers consider nasalised vowels as being the most difficult type of segments to measure. The reason for that begins with the way they are articulated. Section 4.3 described that nasal consonants are produced with two tracts, one is the velopharyngeal (i.e. nasal tract) being the main tract, the second is the mouth cavity (i.e. oral tract) being the side-branch, where only the nasal cavity is open. Nasalised vowels, on their part, use the same branches but with an opposite function. Vowels are originally oral, but when they are influenced by a neighbouring nasal the velum is lowered and air passes through the nose. As a result, the oral tract remains the main tube with the nasal tract becoming the side-branch. The nose is also open at its end; therefore, in addition to the oral formants two other types of resonances are introduced: nasal formants and anti-formants, or what are known as additional pole-zero pairs (Beddor, 1983; Chen et al., 2007). The resulting signals are a collection of both the oral and nasal effects and as follows: oral formants (oral resonances) produced by the oral tract being open at the lips: *F*1, *F*2 … etc.; nasal formants (nasal resonances) produced by the nasal tract being open at the nostrils in the form of extra poles (peaks): referred to as *N*1, *N*2 or *P*1, *P*0 … etc.; anti-formants which are in the form of zeroes produced by the nasal tract usually along with the extra peaks forming pole-zero pairs within the vicinity of the natural formants. They are formed because some air resonances bounce back into the oral tract absorbing some of the energy of the latter.

Ohala (1975: 294) describes nasalised vowels as having a complicated spectrum and mentions that in these vowels both the oral and nasal cavities tend to produce all three types of formants: oral, nasal and anti-formant. Ohala (ibid) adds that the frequencies of the three types are determined by two factors: vowel configurations, and amount of velopharyngeal coupling of the two tracts. Beddor (1983) uses term 'nasal formants' with contempt because she believes that they are not only resonances of the nasal tract but the whole vocal tract. In comparing spectrograms of oral and nasal vowels, Ladefoged (2003: 135-137) points out that the most apparent feature of nasal vowels is the disappearance of the first formant. Ladefoged (ibid) refers to a fainter first formant in nasalised vowels stating that one needs to have "superimposed formant tracks" to be able to find it (figure 4.10).

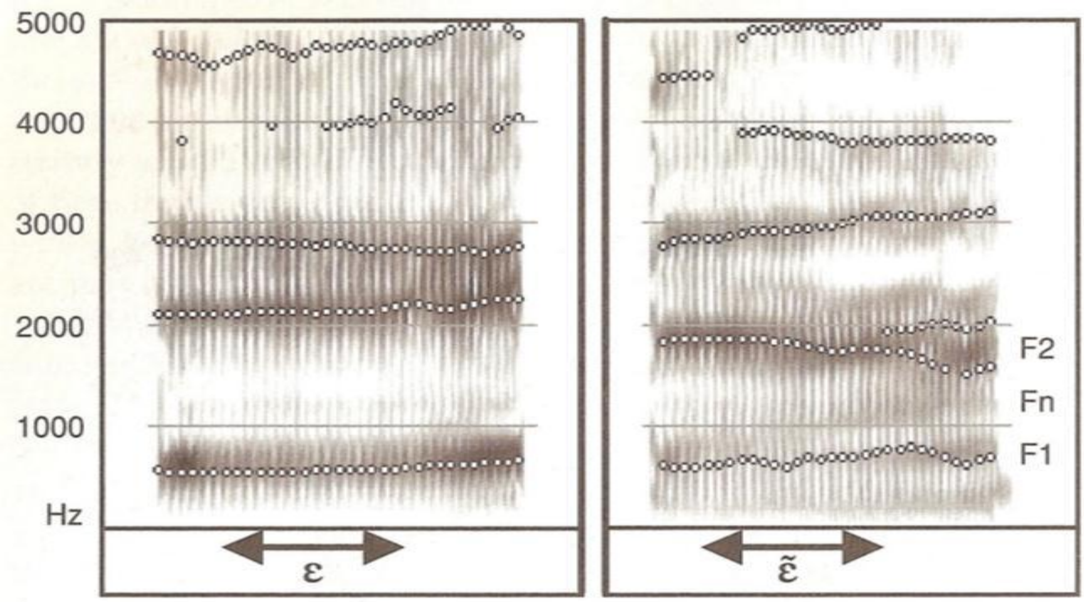


Figure 4.10: In comparing spectrograms of oral and nasalised (nasal) vowels where the most apparent feature of nasalised vowel is the disappearance of (or a fainter) first formant, in addition to a decrease in F2 and the appearance of an extra peak Fn (Figure from: Ladefoged, 2003: 136).

Ladefoged (ibid) refers to other differences between oral and nasal vowels: **1-** an extra energy between *F*1 and *F*2 that he labels as *F*n, which would mainly be seen near the end of a nasalised vowel; **2-** a significantly lower *F*2, which is interestingly opposite to findings of other researchers who found a rise in *F*2. Figure 4.11 is another example taken from data of the present study showing a spectrogram and spectrum of the vowel [a:] in the word *naam* [na:m] 'he slept' within the carrier sentence *quulu naam sit marrat*, where a clear extra peak is present between *F*1 and *F*2 on the spectrogram seen as a dark bar at about 1000Hz and the same pole on the fifth harmonic (*H*5) is clear on the spectrum. This is in comparison to figure 4.12 which shows a spectrogram and spectrum of the isolated vowel [a:] within the carrier sentence *quulu aa sit marrat*, where no extra peaks or zeros are present between *F*1 and *F*2, and the amplitude and frequency of *F*1 are higher than those of figure 4.13. The frequency of *F*1 in the isolated vowel is around 600-700Hz while in the embedded nasalised vowel it is about 500Hz.

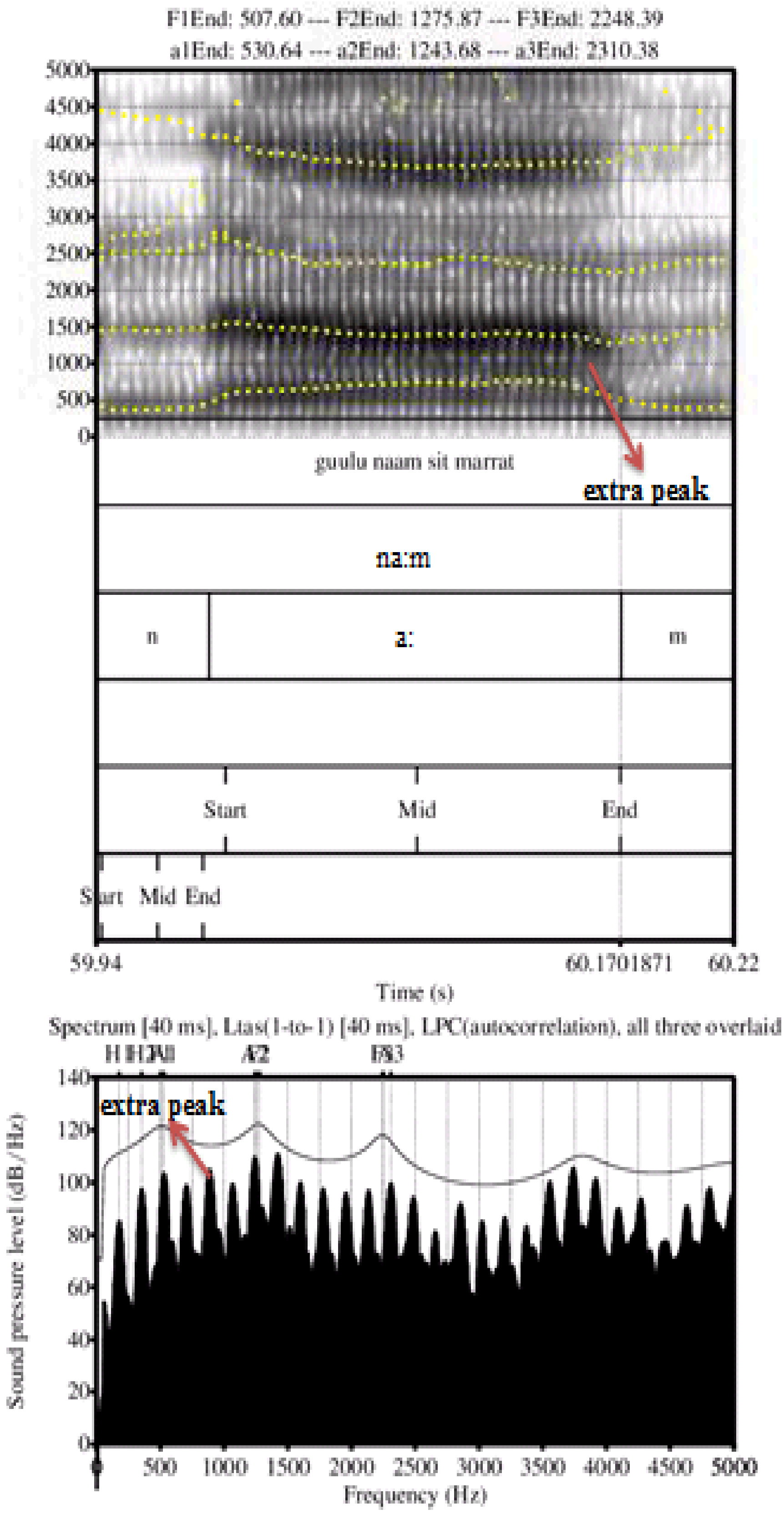


Figure 4.11: A spectrogram of the vowel [a:] in the word *naam* [na:m] 'he slept' with an extra peak (a dark bar) between F1 and F2 at about 1000Hz; the same pole (on H5) on the spectrum.

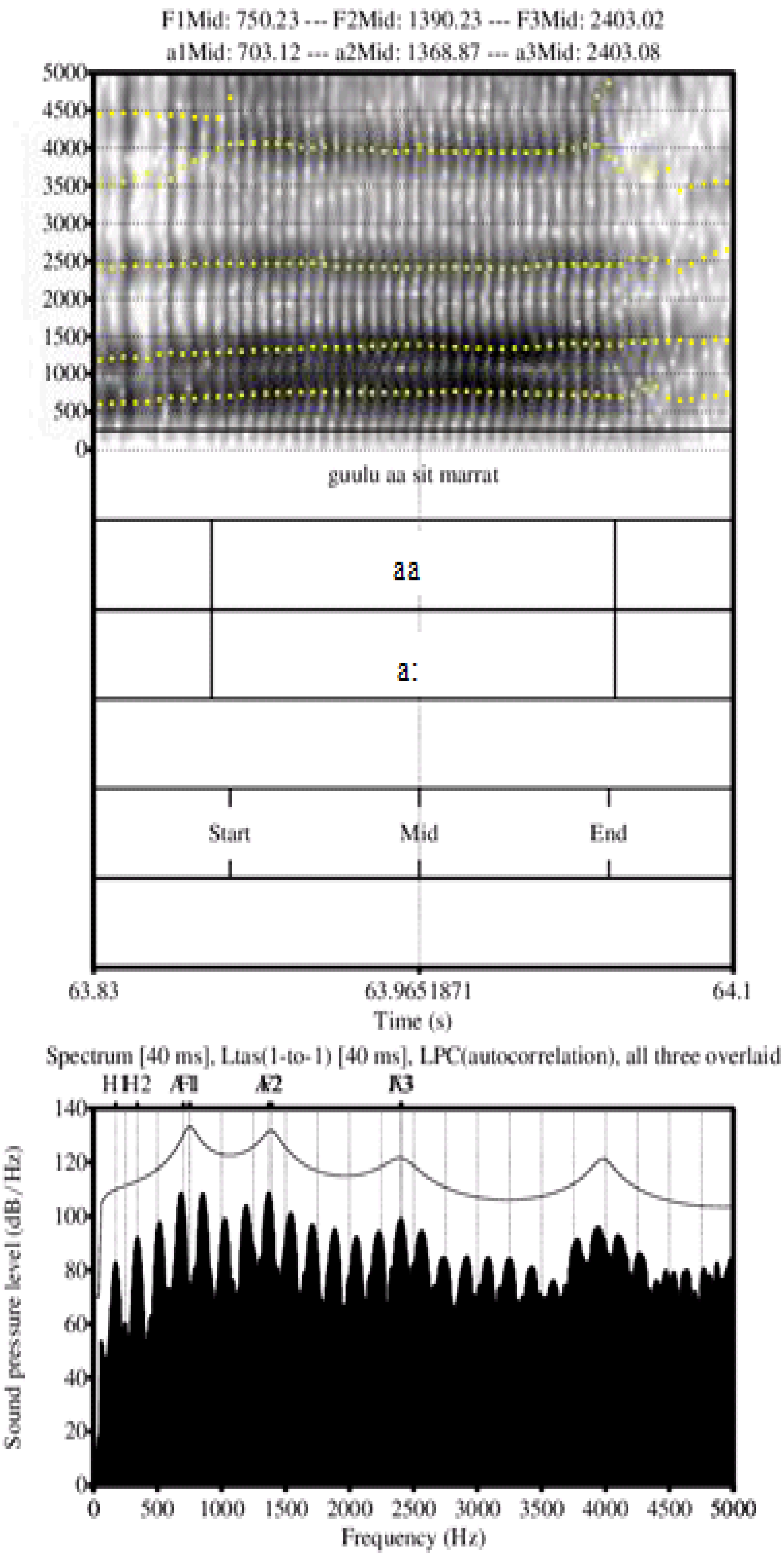


Figure 4.12: A spectrogram and spectrum of the isolated vowel aa [a:] where no extra peaks or zeros are present between F1 and F2; the amplitude and frequency of F1 are fairly high.

Beddor (1983) also mentions particular positions of nasal peaks which tend to occur at higher frequencies than $F1$ in high vowels where $F1$ is itself a nasal rather than an oral formant in low vowels and tends to have a high frequency.

The result of the coupling of the two tracts has other acoustical effects such as: decrease in $A1$ (amplitude of first formant $F1$) (House and Stevens, 1956; Beddor, 1983; Chen, 1995; Chen, 1997; Chen et al., 2000; Chen et al., 2007) or overall amplitudes (Ohala, 1962); increase of $B1$ (Bandwidth of $F1$) (Beddor, 1983; Hawkins and Stevens, 1985); decrease in overall vowel intensity (Beddor, 1983); general increase of all vowel bandwidths (Ohala, 1962); shift of $F1$ frequency upwards (rise) or downwards (drop) depending on type of vowel (high, mid, low) as follows: an upward shift for high vowels, a lesser raise for mid vowels, and a downward shift for low vowels (House and Stevens, 1956; House, 1957; Fry, 1979; Hawkins and Stevens, 1985; Chen et al., 2007); a spectral peak developing around 1kHz and a zero around 700-1800 Hz (House and Stevens, 1956; Hawkins and Stevens, 1985; Chen, 1995); another nasal peak introduced between 250 and 450 Hz (Hattori et al., 1958; Ohala, 1962; Fujimura and Lindqvist, 1971; Maeda, 1982, Chen, 1997; Chen et al., 2000). However, there are conflicting results found in the literature as to the direction of shift of $F1$ frequency. Although some would say upward or downward depending on vowel type as mentioned above, others like Fujimura and Lindqvist (1971) would predict a rise in $F1$ regardless of vowel type. Furthermore, some studies add another effect which is related to the shift of upper formant frequencies particularly that of $F2$. Beddor (1983: 118) also states that there are conflicting results as to the direction of shift. Some say it generally rises and becomes closer to $F3$ (Fry, 1979) others say it drops with a fading $F1$ in high vowels (Ladefoged, 2003).

In an investigation of 3 out of the 75 surveyed languages (English, Turkish, Hindi), Beddor (1983: 134) found more detailed downward and upward shift of $F1$ depending on vowel types and as follows: **1-** for high front unrounded vowels there is a consistency of rise in $F1$; **2-** for mid front unrounded vowels there was no consistency of results in the direction of shift of $F1$ frequency (ibid: 139); **3-** for low front unrounded vowels there were differences of results but she (ibid: 143) found the majority show a drop in $F1$; **4-** for low central unrounded vowels, Beddor (ibid: 149) found consistency of drop in $F1$; **5-** for mid back rounded vowels, a drop in $F1$ was also found (ibid: 153); **6-** for high back rounded vowels, results showed little consistency with $F1$ shifting downward in some and upward in others but with more instances of drop (ibid: 158).

Maeda (1982: 911), in a study of acoustic modelling of the vocal tract with appropriate nasal passages by using computer simulation, observed that such high vowels as [i, u] are heard as more nasalised and that nasalisation increases with the increase of coupling of the velopharyngeal ports; whereas in mid and low vowels such as [a, o, e] no matter how much their quality is modified, they were still not heard as nasalised. Berger (2007: 10) distinguishes between two types of nasalised vowels: contextual and contrastive, but adds that velar lowering during vowels could be the result of other reasons: a- passive velar movement, where the velum moves as the result of the movement of other articulators, the tongue body for example; b- background nasality, which happens as the result of the speaker's speech style or physiology; c- structural or functional defects, where there might be a problem in the mechanism of the velum that prevents it from closing as it normally should, as in the case of cleft palate; d- inadvertent nasalisation, which is caused by having an impaired hearing.

However, from a practical point of view, not all that is predicted or found by researchers is attested in all vowel systems. For example, figures 4.13 and 4.14 show a comparison between a low (open) vowel and a high (close) one, respectively, in as far as how they would appear in a nasal context. The low vowel [a:] has a slight zero-pole pair appearing on $H5$ and $H6$, respectively, between $F1$ and $F2$. However, the area below $F1$, which according to the literature should have an extra peak or/and zero, has clearly defined formant peaks. Figure 4.14, on the other hand, shows the high vowel [i:] at midpoint within the word *miim* [mi:m] 'the letter *m* in Arabic' produced by the same speaker. In the figure, both spectrogram and spectrum show two extra peaks between $F1$ and $F2$. The presence of these two peaks has led to a wrong auto-detection of the position of $F2$ in PRAAT, which should instead have been that of $F3$. There is also a slight dip around 1500Hz between the two peaks, which could be considered as a zero, but it does not show on any of the spectrograms.

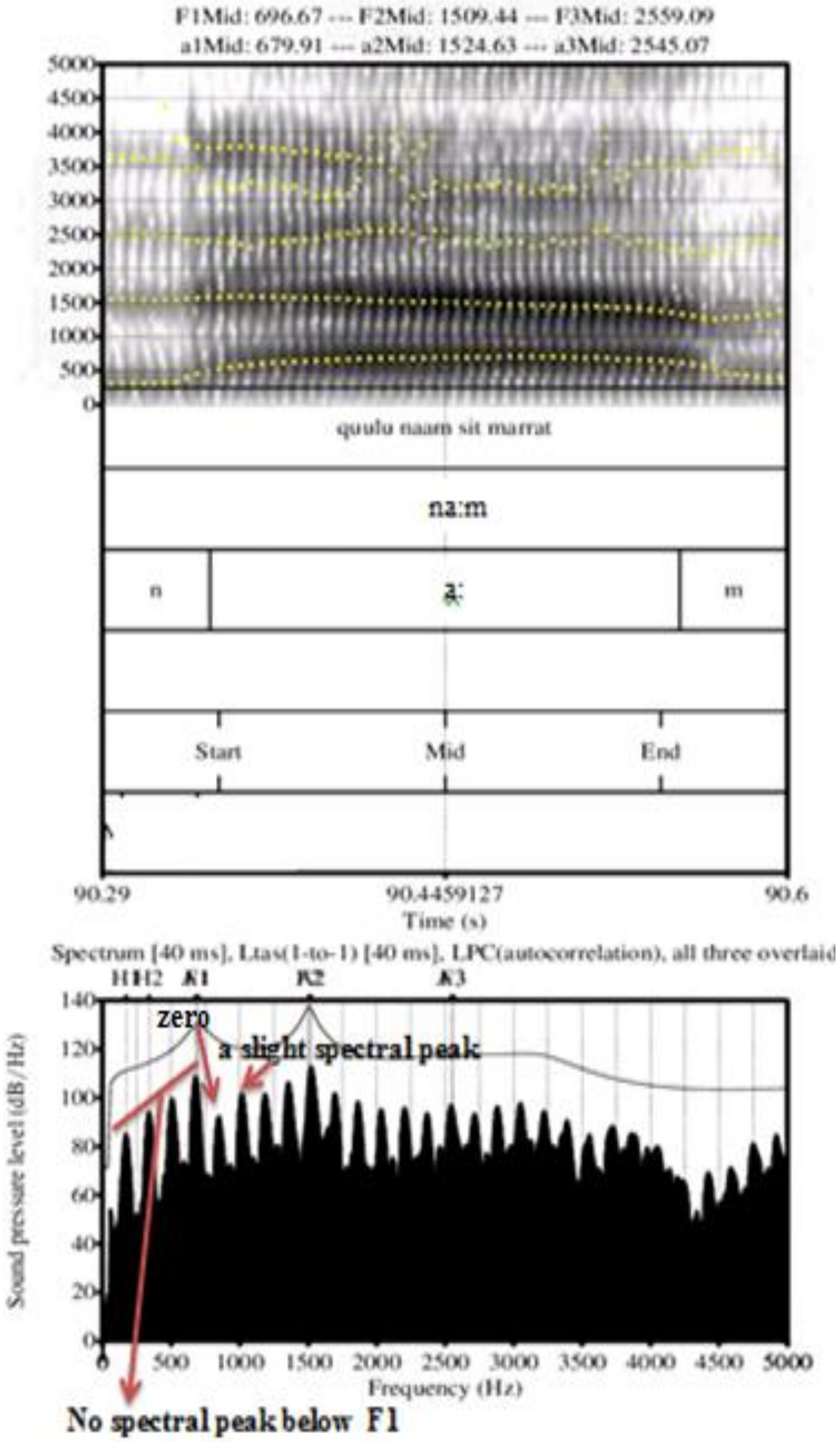


Figure 4.13: A spectrogram and spectrum of the low (open) vowel [a:] at midpoint within the word *naam* [na:m] 'he slept' where a slight zero-peak pair is noted between *F*1 and *F*2 but none below *F*1.

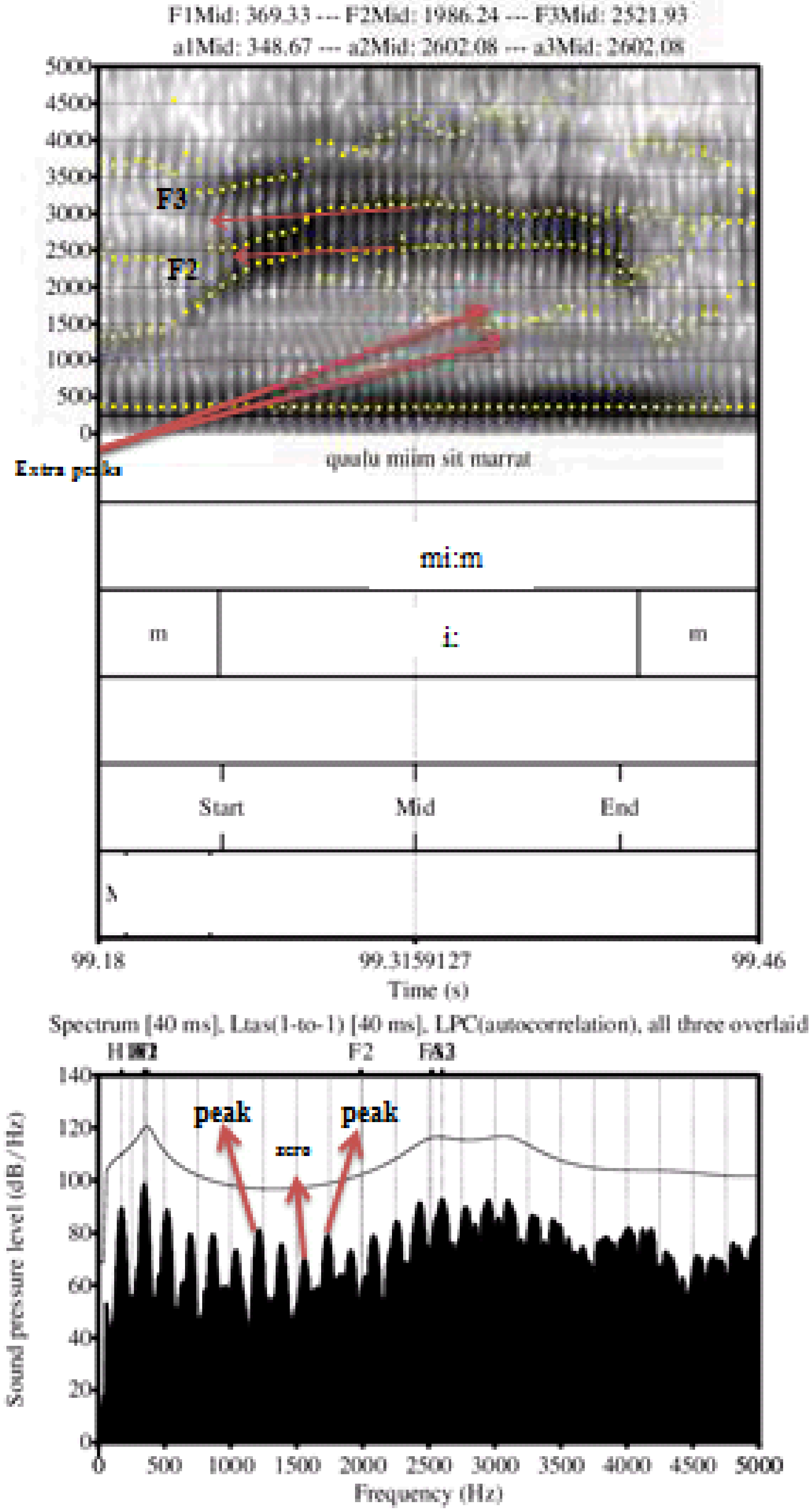


Figure 4.14: A spectrum of the high (close) vowel ii [i:] at midpoint within the word *miim* [mi:m] 'the m in Arabic' where two extra peaks and a slight dip (zero) between them are seen between F1 and F2.

4.6 Nasal Voice Quality

One more phenomenon related to *nasality* is that of *nasal voice quality*. Therefore, the following section is a brief account of the origins of sociolinguistic work on nasal VQ and how it has been perceived over the years with particular reference to Russell (1931) and Laver's (1980) work because both studies are dedicated to the study of VQ irrespective of the time-span between them.

Since the 18th C, observations were noted on *nasality* as a feature of VQ when Bayly (1758: 130; as cited by Laver, 1980: 68) stated that the most notable 'ill tones' are those referred to as speaking through the nose and in the throat. Reaching the first part of the 19th C, researchers used the label 'nasal' to refer to a quality of the voice without having to explain it; and by 1877 onwards, when writers started to write about voice quality, it became well recognized (Laver, 1980: 68-69).

In an illustration made by Prof. T. Earl Pardoe on the x-ray results of Russell's (1931: 240) experiments on speakers of different languages (English, French, Italian, Spanish, Tenor and Baritone), the former distinguishes between the effects of *nasality* compared to that of *nasal resonance* as being two different types of *nasal quality* by vowels. Pardoe (ibid) compares these two effects considering them as two types of VQ, both of which are produced by the nose; adding that one of these is 'disagreeable' whereas the other had "a tonal quality anybody would be proud to be able to produce". This comparison also distinguishes the two types of VQ with that of *nasal twang*, all being traceable functions of the nasal passage but with the latter being a 'detestable' type of function (Russell, 1931: 240). Russell (1931: 239) gives a simplified (impressionistic) definition of what is known as the *nasal twang* saying it is a "rather disagreeable quack-like quality in the voice". This quality is commonly known to be a feature of the speech of certain parts of New England where results of the laryngoperiskop show an apparent constriction in the interior larynx (ibid).

Laver (1980: 68) states that writings on the subject of *nasality* have exceeded those on any other aspect of VQ but remains to be an area of misconceptions and vagueness in phonetic writings due to the inability to distinguish between some terms used to refer to the phenomena of nasality. Only nasal twang has always been described as being a VQ setting in contrast to nasality occurring on individual segments, although nothing assures that it is also used to refer to different phenomena by the different writers. In connection to nasality is the phrase *velopharyngeal settings* which is used and favoured to the more informal phrase 'velic settings' because the physiology of nasality and denasality has much more to reflect than just the position of the velum

(Laver, 1980: 69). The term *velopharyngeal* would therefore be used to reflect the influence the velic activity has on activities of the pharynx, and accordingly of the tongue and larynx (ibid). Laver (ibid: 69) also adds that the misconceptions and vagueness about nasality could therefore be due to the fact that literature on phonetics tends to constantly over-simplify the velopharyngeal action as being restricted to the position of the velum.

The neutral velopharyngeal setting has velopharyngeal closure during all segments except those which in some languages have audible nasality as a necessity to phonologically identify them, and those segments which tend to be nasalised due to being immediately preceding them (Laver, 1980: 69). Laver (1980: 70), therefore, concludes that *nasality* is a concept that includes a number of VQs with auditory distinction that can be grouped into one main category of *nasal voice*. However, it is not enough to understand how the velopharyngeal system works in order to understand the phenomena of nasality and that this 'inadequacy' is due to three aspects of the concept of nasality (Laver, 1980: 77-78). Firstly, "*nasality is above all else an auditory concept"*, and not mainly an articulatory one and therefore would not be specific in identifying the position of the velum during speech. Secondly, "'*nasality' is a cover term for a number of auditorily similar but not identical phenomena*". Thirdly, "*nasality is a condition of resonance of a special kind*" meaning that it does not have to occur in the nasal cavity and could result at different other positions and forming what is known as the cul-de-sac resonance (see below) with its different positions in addition to its usual nasal cavity position. According to Laver (1980: 4), *nasality* is very common as a setting of voice quality characterizing people as being members of certain sociolinguistic groups. Laver (ibid) also refers to different languages and dialects which use *nasality* some way or another, such as in French, Portuguese and Yoruba where it is used for identifying lexical contrasts; in Sundanese, a language of Java, where it is phonologically used as a setting marking out verb forms; or characterizing such varieties of English as most speakers of Received Pronunciation in England and many accents of the United States and Australia.

And to produce a *nasal quality*, one of the cavities have to be closed at the end in order to "pen the sound in a sort of *cul de sac*" (Russell, 1931: 42). If for instance a person usually uses nasal resonance and gets a cold, which leads to a closed nose, then the sound entering the nose will not be able to escape from the nostrils. The result is an extreme constriction produced by the epiglottis, by the interior larynx, or between the tongue and the walls of the pharynx, causing the lower pharyngeal walls to form a *cul de sac*. On how a cul-de-sac is created, Russell (1931: 240) states:

> Where the tonal quality is distinctly nasal the cushion of the epiglottis … seen almost to close upon the cartilages of Wrisberg... This may be due not only to

> the pull exercised by the aryteno-epiglottideus muscle…, but also to a contraction of the arymembranaceus muscle…, and to a downward tipping of the arytenoid cartilages which would through [throw] their superior prongs forward. When this closure takes place, it will be seen that a sort of cul-de-sac might be created between the vocal lips themselves and this superior narrowing of the opening.

Russell (ibid: 42) adds that such a constriction at that position was considered by Paget (1923) as the cause of what is known as *nasal twang*. Russell believes that this type of constriction would partially take place in part of the quality of the French nasal vowels, for which many could judge as being not at all nasal.

Laver (1980: 78) refers to certain facts for having or not having *nasality*, particularly segmental, which he believes are usually used and presented in textbooks in a very simplified way but not always clearly recognized. The first of those simplifications says *"when the velum is closed speech is free from nasality*, and conversely*, that when speech is free from nasality, the velum is closed"* (ibid: 78) which Rousselot (1901; as cited by Laver, 1980: 79) had proven otherwise when he observed a slight opening of the velum during most of a sequence of normal speech with no audible nasality. Other researchers (e.g. Russell, 1931: 42) also refer to *nasality* without a velar opening. This, Russell (ibid), explains is not a nasal tone or any quality of nasalisation and that producing this effect needs doing something else other than just opening the nasal passage. Russell (ibid) adds that during listening to phonograph recordings during carrying out X-rays of the vowel [e] produced twice one with a velar opening and the other with a velar closure (see figure 4.15), he failed to hear any difference in vowel qualities of either and no *nasalisation* quality when a velar opening is present. He (ibid) also notes coming across people who tend to use nasal resonance in their speech but not have any trace of *nasality* in their vowels, explaining that this happens because one has to distinguish between *nasality* and *nasal resonance*. Russell (1931: 42) further found x-ray results which show speakers who tend to have an open nasal passage during some vowels but not during others.

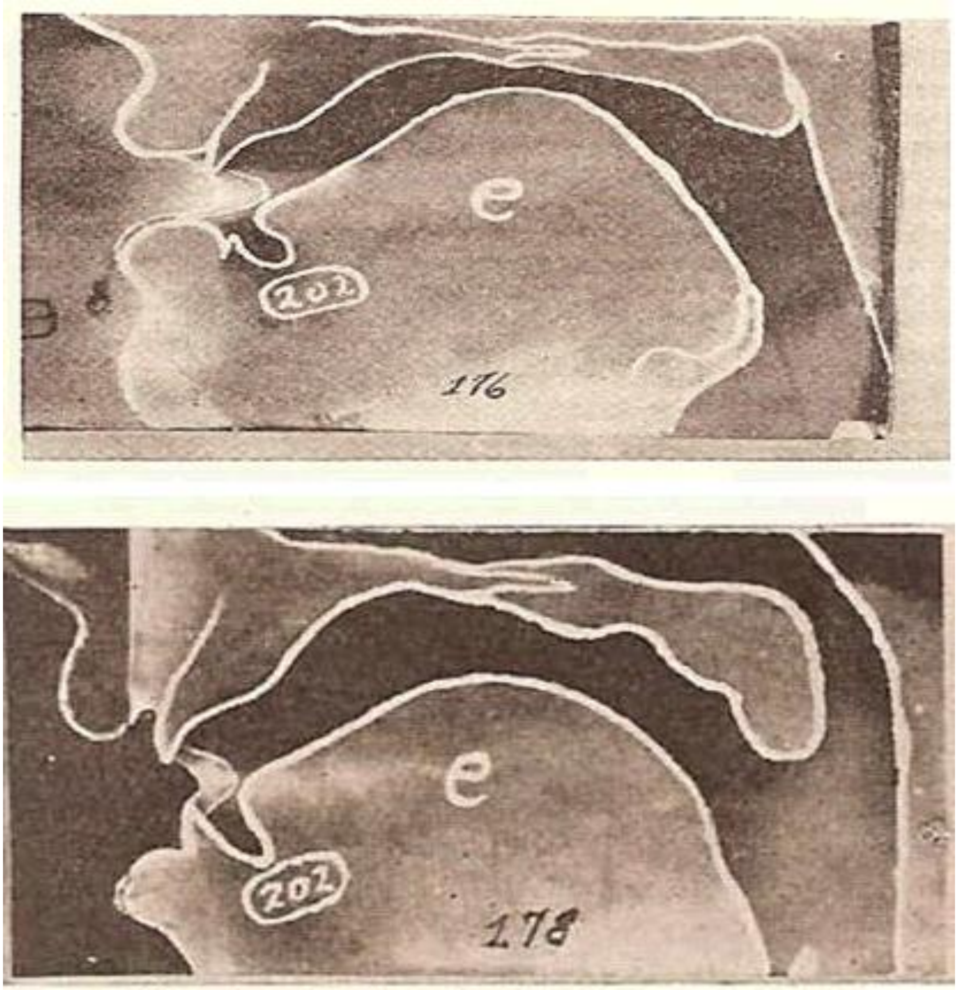


Figure 4.15: X-ray pictures of the vowel [e] produced twice one with a velar opening and the other with a velar closure (Figures from: Russell, 1931: 143, 144).

The second simplification goes to say that *"nasal airflow always gives rise to nasality*, and conversely that *nasality always requires nasal airflow"* where Laver (1980: 79) believes that having air passing through the nose does not have to be heard as nasality, nor is it necessary to have an air-flow to hear nasality. The third simplification says that *"resonance of the nasal cavity is the only resonance responsible for the production of nasality*, and conversely that *nasality always requires resonance of the nasal cavity"* for which Laver (ibid: 82) comments that resonance of the nasal cavity would be considered the most common and most important feature of acoustic and auditory correlates of nasality, but is not the only one. He (ibid: 79-80) also adds that although *nasality* is a result of resonance, air does not have to pass through the nasal cavity to produce that resonance as it could happen at other positions regarding the formation of a side-chamber or what Russell (1931: 18) calls the *cul-de-sac* (see above).

As a result of the above discussion, it is necessary to establish a relation between producing nasality as part of the performance of segments and its production in VQ (Laver, 1980: 83-85). In nasal stops, depending on the place of articulation the side chamber in the oral cavity (in bilabial and velar nasals), is formed by the back of the tongue moving towards the velar contact and reaching the under surface of the uvula (in velar nasals), or in the space between the two sets of faucal pillars (in uvula nasals). Velar and uvular nasals have resonances formed within the oral, pharyngeal and nasal cavities (Laver, 1980: 84). As for producing nasalised segments, the nasal cavity is the side chamber.

In *nasality* as a feature of VQ, the auditory effect has to be almost always present and having a side chamber other than the nasal cavity has to be regarded as a "distinct possibility" in at least a minimum number of cases. However, it should be noted that such cases are mostly noted in works in speech therapy and pathology due to the fact that these side-chambers are formed in speakers who have a certain speech disability (Laver, ibid: 85), for whom the most frequent position for the side chamber apart from the nasal cavity is the pharynx, i.e. in the lower pharynx or upper larynx (ibid).

Taking the previous discussion into account, the present study is set to investigate nasality accompanying segments, i.e. pharyngeals, and see if it is a velopharyngeal setting that is colouring the speech of IA speakers. The study is an auditory and acoustic one; therefore there is no possibility of investigating the movement of the velum or if the type of nasality, if any, is produced somewhere else in the speech apparatus by forming a cul de sac somewhere in the pharynx for example or somewhere near the larynx. However, it is hoped that if nasalisation was found to occur in vowels adjacent to pharyngeal consonants and/or colouring the speech of IA speakers in general or one of its dialects, then it will pave the path for future studies to conduct an articulatory investigation and reach a better understanding of how and why it happens.

4.7 Zeros and Poles

As mentioned in section 4.4, extra poles could be defined as being additional peaks and zeros as 0-energy instances (Kent and Read, 1992: 231), which appear as a result of divisions of passages or constrictions in the vocal tract (ibid: 227). In both nasal consonants and nasalised (or nasal) vowels, poles and zeros appear as the result of a transfer function, where zeros are introduced as a result of forming a junction or the division of the resonating system. Zeros and Poles interact differently with each other depending on their frequencies and bandwidths. When they have exactly the same frequency and bandwidth, they tend to cancel each other (Kent and Read, 1992: 36; Stevens, 2000: 135). When they have different frequencies, their combined effect can be noticed in a spectrum, where a spectral peak represents a pole and a deep valley represents a zero (Kent and Read, 1992: 36). It is also worth noting that zeros do not only occur in the transfer functions of a nasal sound but also of a sound produced with a constriction above the glottis (Stevens, 2000: 135). Before making any acoustic investigation, a criterion is needed to decide where and how many peaks and zeroes are found or expected to occur in a nasalised vowel. The following are some of what the literature has about peaks and zeros. Figure 4.16 presents a spectrogram and spectrum of the consonant /n/ in the word *been* [bɛ:n] 'between' within the carrier sentence *quulu been sit marrat,* where the spectrogram shows it fainter than the preceding vowel. The spectrogram also shows a zero between *F*1 and *F*2 and at higher frequencies above *F*3. The zero is seen as a dip on the spectrum representing a zero within the vicinity of 1000Hz.

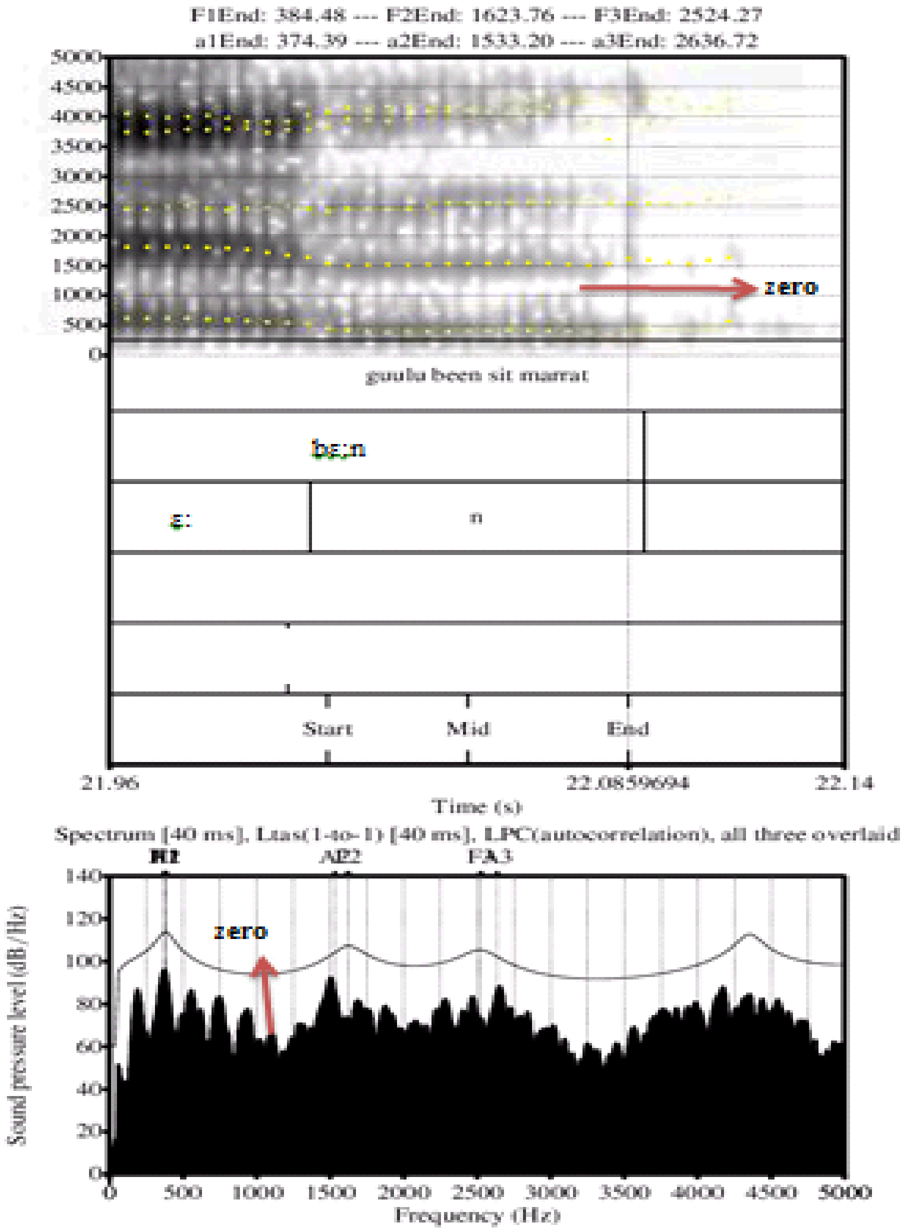


Figure 4.16: A spectrogram of the nasal consonant /n/ in the word been [bɛ:n] 'between' which is seen fainter than the neighbouring vowel and has a zero between F1 and F2; the spectrum shows a dip at the same position representing the same zero.

In a study of Sweep-Tone measurements of the characteristics of the vocal tract, Fujimura and Lindqvist (1971: 552) only describe what happens to formant frequencies in general and to $F1$ in particular with the addition of a paired nasal formant and an antiformant (antiresonance). When the vowel is low, this pair exists below $F1$. In this case, there is a nasal formant (Fn) followed by a zero then by the oral formant ($F1$). But when the vowel is high, the pair exists above $F1$. In this case, the oral formant ($F1$) would be first followed by a zero then by the nasal formant (Fn). In non-nasalised low vowels, $F1$ would usually be of high frequency, whereas in non-nasalised high vowels it would usually be of low frequency. However, the more the vowel is nasalised the more the antiformant occurs closer to one of the oral formants than to its own mate (i.e. the other half of the pair) (Fujimura and Lindqvist, 1971: 552). Contrary to all other works, Maeda (1982: 911) found that in low vowels the nasal pole-zero pair was located above the "shifted" first formant instead of below it. Interestingly, these observations are similar to those found in the present study where the frequency and amplitude of $F1$ tends to decrease, the gap between $F1$ and $F2$ increases, and a pole and/or zero appear between $F1$ and $F2$ within a low (open) vowel. This was particularly noticed in figure 4.13 where a slight spectral peak was noticed between $F1$ and $F2$; this was among many other similar cases which will be presented in Chapter 7. Figure 4.17 shows a spectrum of the mid portion of the vowel [a:] in the word *maat* [ma:t] 'he died' within the carrier sentence *quulu maat sit marrat* as produced by an Iraqi speaker. Figure 4.18 shows a spectrum of a mid portion of the same vowel in isolation also produced within the same carrier sentence by the same speaker. In comparing the two spectra, it is clear that when /a:/ is in the vicinity of a nasal consonant there is a decrease in the amplitude of the first formant ($A1$), a decrease in the frequency of $F1$, a pole on the fifth harmonic ($H5$) and a zero on the sixth harmonic ($H6$) between $F1$ (which shifted downward from $H4$ to $H3$) and $F2$.

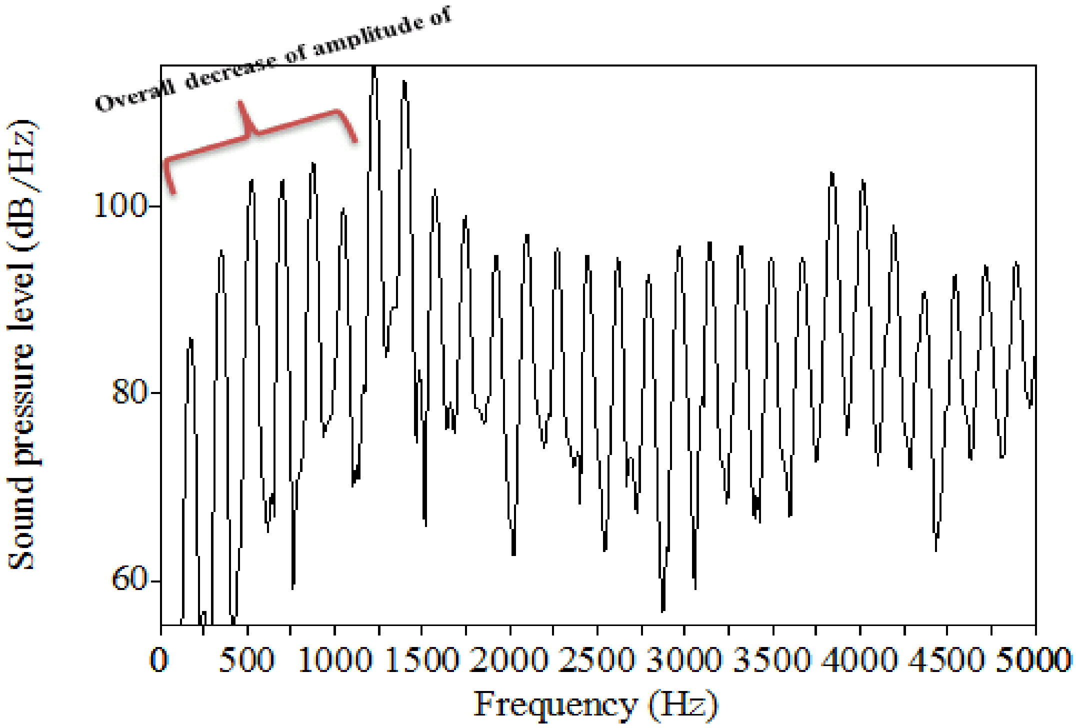


Figure 4.17: A spectrum showing a decreased amplitude and frequency of F1 at the mid portion of the vowel [a:] in the word maat [ma:t] 'he died'.

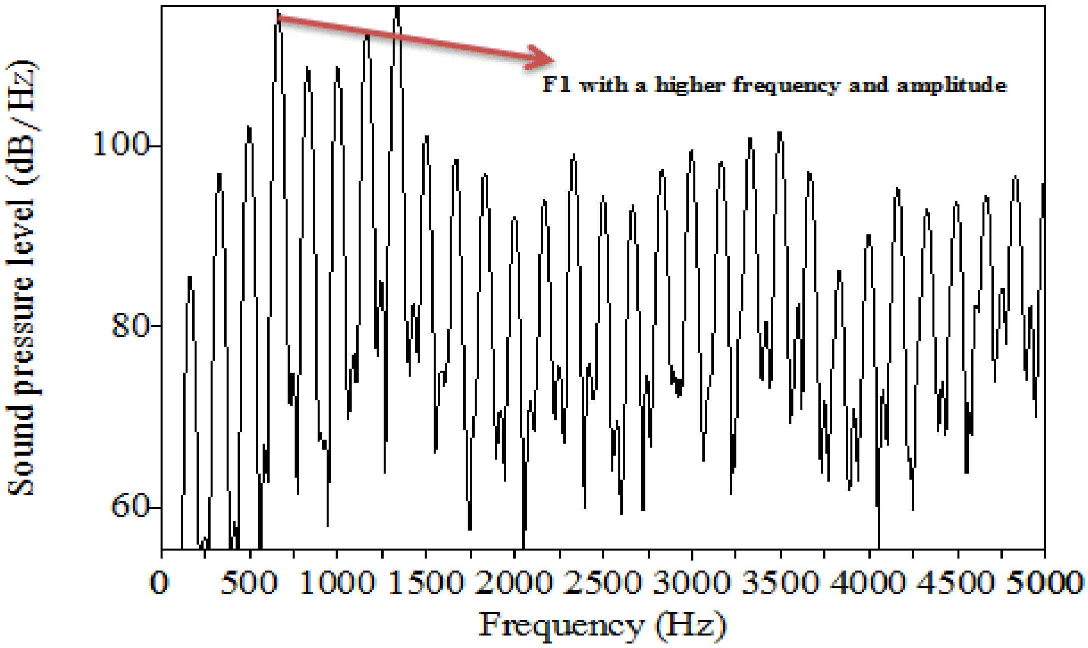


Figure 4.18: A spectrum showing a higher amplitude and frequency of F1 at mid portion of the isolated vowel [a:].

In a nasalised [i], House and Stevens (1956) refer to one peak in the vicinity of 300 Hz, a drop in magnitude (zero) near 1000Hz and a prominence (i.e. another peak) in the region of 2500Hz. Maeda (1982: 913), in referring to [a], shows the appearance of a nasal peak (*N*1) below the shifted formant peak (*F*1) and another nasal peak (*N*2) above the *F*1; also showing that when the coupling between the nasal and oral tracts increases, the peaks of *N*1 and *F*1 become of similar prominence and both move closer to $F2$ (see figures 4.19 and 4.20). Maeda (ibid: 914) concludes that the nasal pole-zero pair must occur in the region of $F1$ for mid and low vowels to have auditory nasalisation.

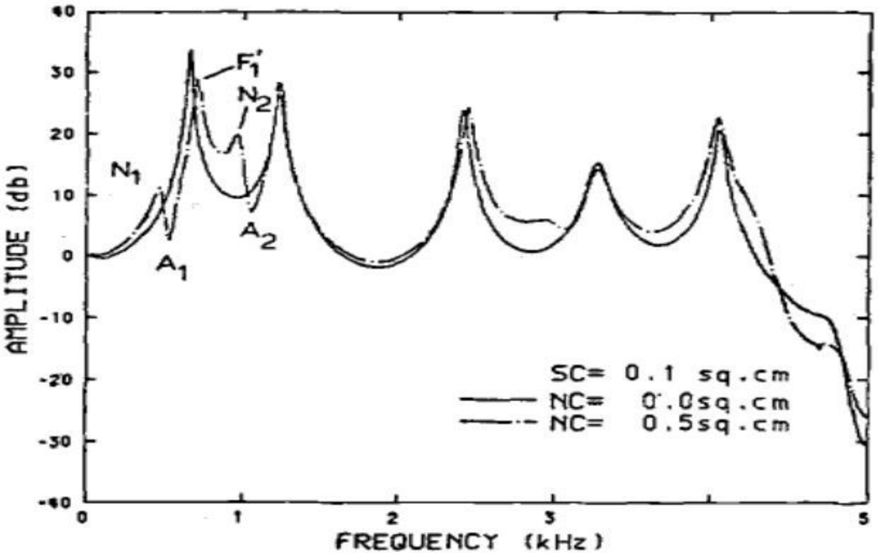


Figure 4.19: The transfer function, under the closed glottis condition, of the vowel [a] and with weak nasal coupling (caption and Figure from: Maeda, 1982: 913).

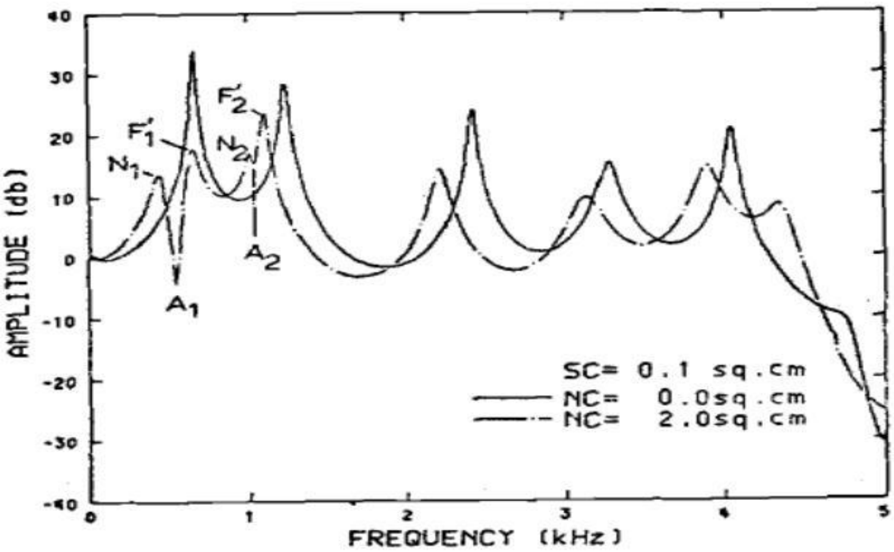


Figure 4.20: The transfer function, under the closed glottis condition, of the vowel [a] except with an increased nasal coupling (caption and Figure from: Maeda, 1982: 913).

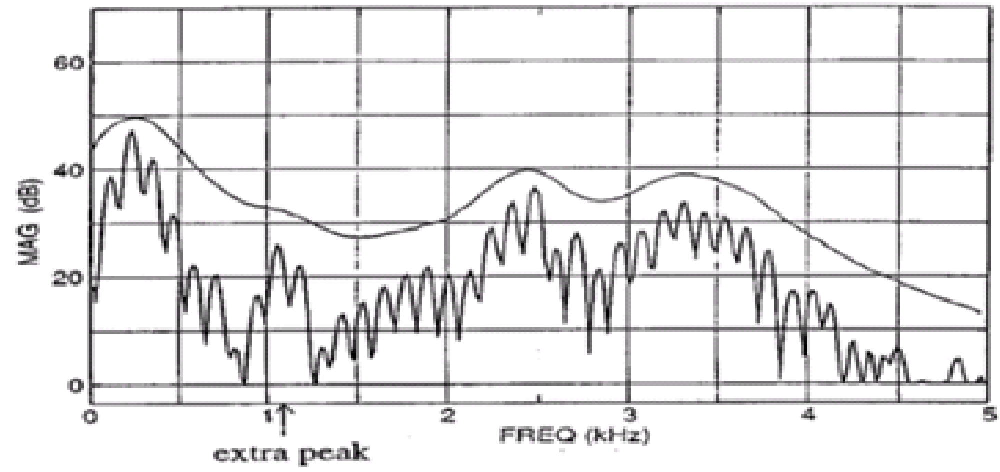
Glass and Zue (1985: 1571) compared nasalised and non-nasalised vowels of American English where they found only one extra resonance in non-nasalised vowels within the $F1$ region, but found two for nasalized vowels within the same region; yet, non-nasalised vowels also had extra resonances at the low frequency region (i.e. below $F1$). The extra resonance in nasalised vowels is 'distinct' because it has an increase in magnitude compared to $F1$ or/and there is a deepened valley between the extra resonance and $F1$. Glass and Zue (ibid: 1572) also show that sometimes a nasalised vowel does not have an extra peak so other measurements are applied. Furthermore, their study shows that extra resonances are more 'distinct' in low vowels than in high vowels and in males than in females. Their findings are very interesting bearing in mind that American English is seen as a nasalised dialect.

4.8 Review of Studies on Measuring *P*1 and *P*0 to Detect Nasalisation

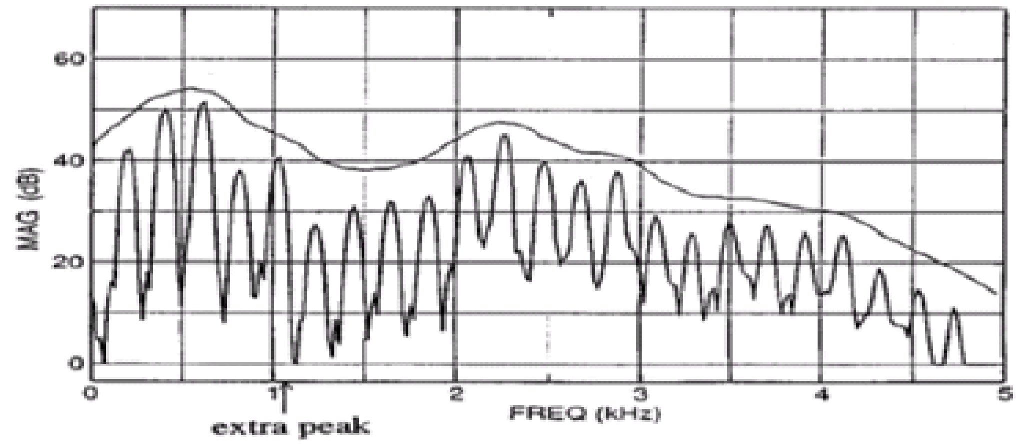
The following are a number of studies on nasalisation which measured poles (*P*0 below *F*1, and *P*1 above *F*1) and what procedures they followed. The review will tackle eight studies starting with one by Glass and Zue (1985) which was later followed by a number of studies by Chen and co-authors (Chen, 1995, 1997, 2000; Chen et al., 2000; Chen et al., 2007), a study by Berger (2007) and finally one by Amino and Osanai (2012). The work by Glass and Zue (1985) is concerned with investigating the position of extra peaks and their connection with having nasalisation. Works by Chen and co-authors are a set of studies to investigate which methods of acoustic investigations would be the most helpful in measuring extra peaks in nasalised contexts. The last two studies by Berger (2007) Amino and Osanai (2012) are both investigations of the different acoustic methods used to measure vowel nasalisation one of which is that applied in the studies of Chen and co-authors. Below is a detailed account of the methods and results of each of the seven studies.

In a study on detecting nasalised vowels in American English, Glass and Zue (1985: 1569) used data containing 200 words which include nasal consonants in many different contexts, singletons and clusters which appear in initial, medial and final positions. Many words were minimal pairs such as *cap*/*camp*; all words were embedded in a carrier phrase; six speakers (3 male and 3 female) were recorded. Nasalisation was investigated by applying pre-emphasis and smoothing, and spectra were computed from a windowed cepstrum. Although only nasalised vowels have an extra resonance above *F*1, according to the authors (ibid: 1570-1571), some non-nasalised vowels have an extra resonance below *F*1. Furthermore, the extra resonance was also more evident because it was either higher in amplitude (*P*1) than that of *F*1 (*A*1); or because *A*1 amplitude was lower than *P*1; or even both. The authors also stated that nasalised vowels might not have the extra resonance above *F*1; therefore another factor, which is smearing of *F*1, would signify nasalisation. Nevertheless, due to the differences in environments of nasalised vowels in their data, Glass and Zue (ibid) stated that "none of the observed acoustic characteristics were present at all times".

Chen (1995) investigated the vowels /æ, i, ɔ, ɑ, u, ʌ/ among others embedded in words and sentences produced by American normal-hearing adults and impaired hearing children. The method used was applying a DFT with low-pass filtering at 4.8 kHz and the signal was digitized at 10 kHz with 12-bit samples using Klatt's developed software package (KLSPEC). In cases of normal-hearing adults, the measurements were obtained at 20ms intervals throughout vowels between nasal consonants assuming they would be nasalised due to their environment; while in hearing-impaired children, measurements were obtained at 10ms intervals in vowels (ibid: 2446). Results showed that for adult speakers it was easier to detect the extra peak for front vowels but more difficult to detect it when $F2$ was at a low frequency. But by following spectral changes in time, the researcher was able to locate the frequency of that extra peak. As a result of the overall investigation, the peak was located between the ranges 790 and 1100 Hz, with an average of 950 Hz. And the averaged frequency of the overall results from both adults and hearing-impaired children speakers was 910 Hz. A nasalised vowel is characterized as having an extra pole-zero between $F1$ and $F2$ plus a widened $F1$ bandwidth (see figure 4.21). The latter would lead to the decrease of $F1$ amplitude (i.e. $A1$). Therefore, using the formula $A1$-$P1$ (where $P1$ is the amplitude of the extra peak) of the difference between the two amplitudes, a small difference (less than 10 dB) was considered as indicative of the vowel being nasal. If, however, $P1$ was not identified because it was close to that of $F1$, the extra peak would be located as being the second harmonic following the first formant peak (see figure 4.22).



(a)



(b)

Figure 4.21: Spectra of nasalised vowels produced in the context of nasal consonants by normal-hearing adult speakers. (a) Vowel [i] produced by a male speaker. (b) Vowel [æ] produced by a female speaker. There is an extra peak between F1 and F2 (caption and Figure from: Chen, 1995: 2446).

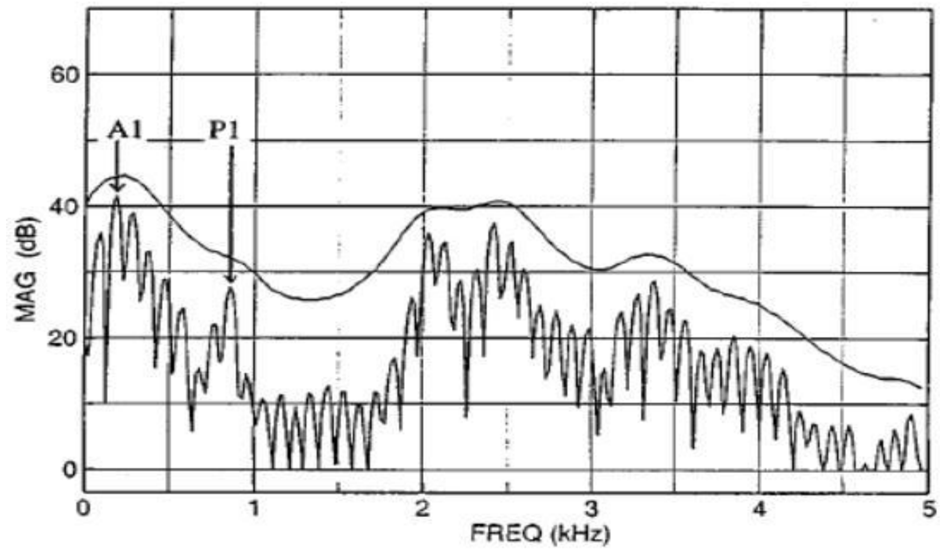


Figure 4.22: The bandwidth of the first formant can be quantified by the amplitude of that formant, A1, and the prominence of the extra peak can be quantified by its amplitude, P1 (caption and Figure from: Chen, 1995: 2447).

In a later study, on the other hand, Chen (1997) detected two extra peaks: one between $F1$ and $F2$ with the amplitude $P1$, the other lower than $F1$ with the amplitude $P0$. Therefore, in addition to the above $A1$-$P1$ formula, the formula $A1$-$P0$ was used with the second extra peak was below $F1$. Vowels investigated in that research were / i, ɛ, æ, u, ɑ, ʌ / in the neighbourhood of either nasal consonants or oral stops as produced by English speakers; these were also compared with nasal vowels following stop consonants as produced by French speakers. To carry out the investigation, the data was run through a low-pass passive seven-pole elliptical filter and digitized at 10 kHz with 12-bit samples. Using Klatt's KLSPEC93, the vowel frequency domain was analysed by utilizing the DFT from the package. In all cases, the measurements were obtained by generating spectra using a 30ms Hamming window and computing a 512-pt. DFT throughout the vowel. Results showed that for all vowels produced by the English speakers except /i/ ($F1$ was very low so Chen found it difficult to measure $P0$ in this vowel), the average frequency of $P0$ ranged between 206 and 223 Hz; while for all vowels $P1$ ranged between 924 and 1032 Hz, with an overall average of 966 Hz (for $P1$ frequency ranges and average see point no.2). In French speakers, and for all vowels, the average frequency range of $P0$ was between 216 and 256 Hz, with an average of 237 Hz across all vowels; while $P1$ ranged between 874 and 1029 Hz, with an overall average of 936 Hz. Another difference between English and French results is in the mean of $A1$-$P1$, ranging from 10 to 15dB for English and from 9 to 12dB for French; and the mean of $A1$-$P0$ ranging from 6 to 8dB for English and from 3 to 9 for French. In general, the lower the values resulting from both formulas, the more nasalised a vowel was found to be (see figure 4.23). General findings showed that nasalisation of the English vowels was caused by context and that of the French vowels was caused by contrast, which could indicate variation of the size of the velopharyngeal opening, which could have caused the means of $A1$-$P1$ and $A1$-$P0$ to be smaller within the most-nasalised portions in French than the nasal vowels in English. Chen also (ibid: 2369) notes that speaker differences or vowel environment influencing vowel breathiness could have affected the values of $A1$-$P0$ and suggests that a parameter to characterise breathiness, such as $H1$-$H2$, should be used to tease apart the effect of breathy voicing on $A1$-$P0$ from that of nasalisation.

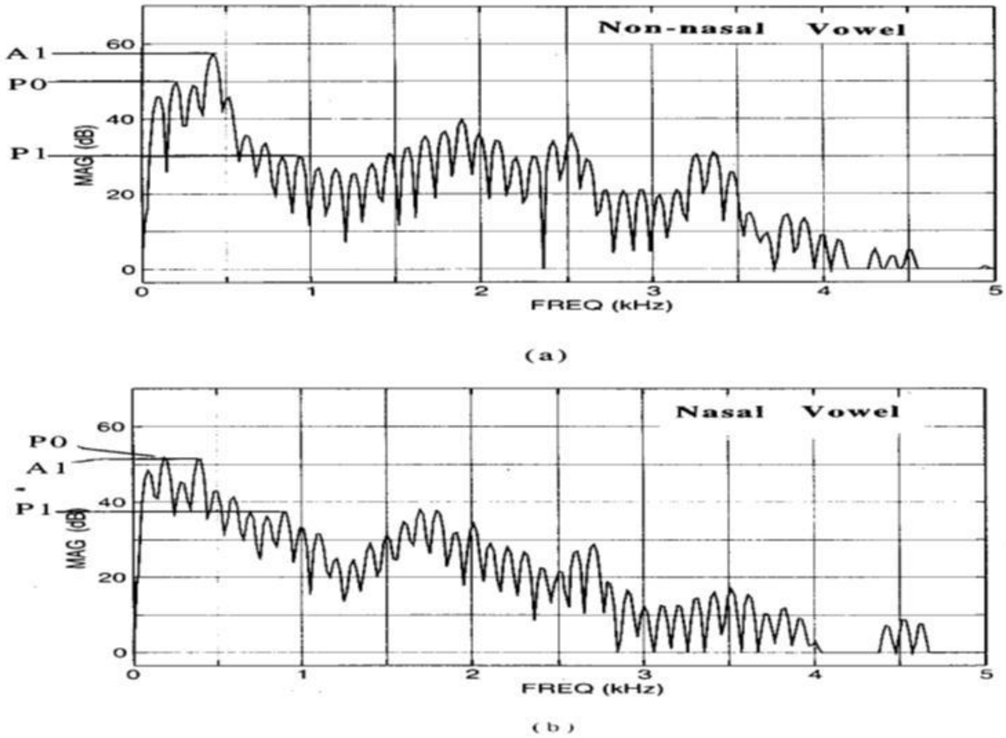


Figure 4.23: (a) spectrum of an oral vowel compared with (b) spectrum of a nasalised vowel from the same speaker. A1-P1 and A1-P0 are greater for the oral vowel than the nasal vowel (caption and Figure from: Chen, 1997: 2365).

Chen (2000) later conducted a study on Chinese by measuring maximum amplitudes of *A*1, *P*1, and *P*0 in simple vowels within words containing nasal codas followed by all phonetically possible syllable initial consonants as produced by one male Chinese speaker. In this study Chen (ibid) aimed at investigating if type of vowel affects the *A*1-*P*1 and *A*1-*P*0 values as it was noted in Chen (1997). Therefore, three vowels bellowing to three types were chose, low /a/, high /i/ and central /ə/. This was achieved by digitizing the signal at 10 kHz and generating spectra in vowels and nasal consonants, with no pre-emphasis, using a 25.6 Hamming window and 512-pt FFT (see figure 4.24). A nasalised vowel was expected to have a lowered *A*1 but a raised *P*1 and *P*0, while results of *A*1-*P*1 and *A*1-*P*0 were expected to be smaller than in an oral vowel. However, differences of frequency due to type of vowel, nasal coarticulation and speaker variation led to making adjustments (i.e. normalisation) to *A*1-*P*1 and *A*1-*P*0 by removing the effects of *F*1 and *F*2 on the amplitudes *P*0 and *P*1 to get *A*1-*P*0n and *A*1-*P*1n (ibid: 55). In the vowel [i], only the *A*1-*P*1n was measured because *F*1 would be at a low frequency so influences and is influenced by *P*0; the latter might even occur at the same position as *F*1 and would therefore enhance *A*1. However, if *P*0 has a different frequency than that of *F*1 and with higher amplitude, *P*0 could mistakenly be considered as *F*1. Chen (ibid: 55) stated that when the vowel is nasalised due to a neighbouring nasal consonant there would be: an increase in *F*1, a decrease in *A*1, and a constant *H*1. If that nasalised vowel was [i], *H*2 was used as *A*1. If [i] was not nasalised, either *H*1 or *H*2 having the highest amplitude was chosen as *A*1. If the vowel was [a], *A*1-*P*0n was measured because *P*1 is not usually distinct since this vowel has a high *F*1 and a low *F*2. Finally, if the vowel was [ə], both formulas would be used. Results (Chen, 2000: 65) showed that all three vowels had greater degree and faster rate of nasalisation than vowels which were in non-nasal contexts. When comparing vowels followed by a nasal coda with or without murmur, results showed that when vowels are followed by syllable-initial [n] anticipation of the nasal with murmur was weaker. This was noted by the smaller degree of nasal coupling, slower rate of nasalisation, and/or shorter duration of vowel nasalisation. Other results showed that *A*1-*P*1 and *A*1-*P*0 values differed according to vowel type. For the *A*1-*P*0 measured within a vowel in a nasal context, [ə] had a more negative slope than [a] indicating a slower rate of nasalisation for low vowels. As for the *A*1-*P*1 measure, [i] had more negative slopes than [ə] indicating a faster rate of nasalisation for high vowels. Chen (ibid) concluded that a nasalised low vowel has a longer period of nasal coupling than a high vowel.

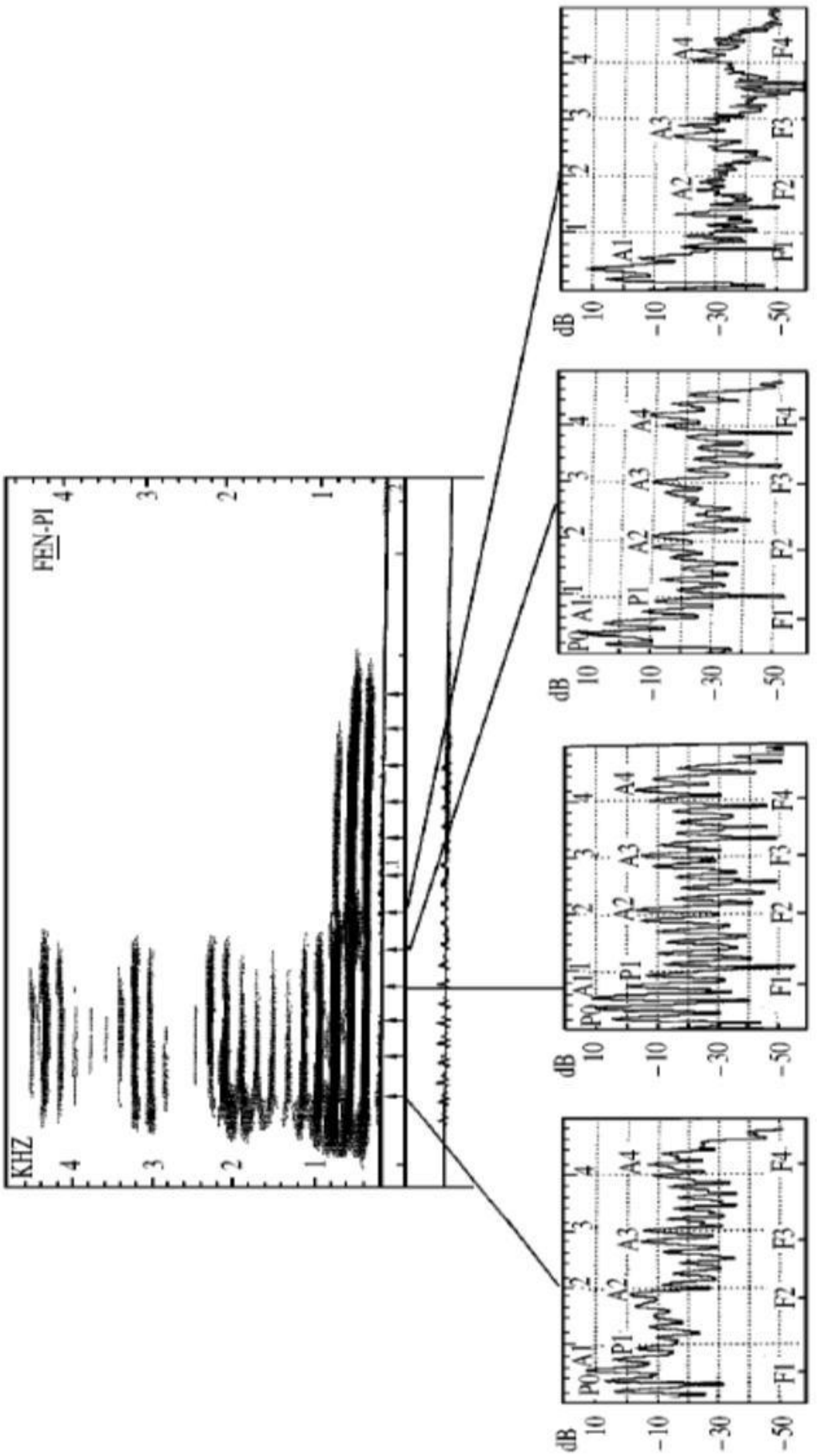


Figure 4.24: Spectrogram of [ən] in "fen-pi'' where four of the FFT spectra calculated 10ms apart from the beginning of the first glottal vibration of the vowel to the end of the nasal consonant are also shown (caption and Figure from: Chen, 2000: 49).

In a later study by Chen et al. (2000) investigated *A*1, *P*1, and *P*0 within the formulas *A*1-*P*1 and *A*1-*P*0 in vowels produced by native speakers of English who underwent endoscopic sinus surgery and were recorded three time, one week before, one week after and one month after surgery. In this study, the authors used the same vowels as in Chen (1997) / ɛ, æ. u, ɑ, ʌ/ and instead restricted the type of measures applied in each vowel type. For *A*1-*P*1, spectra were generated at every 10ms and averaged throughout the vowel, but only the beginning and end were used to quantify nasalisation in these vowels. The frequency of *P*1 was expected to be around 950 Hz, of *P*0 around 250 Hz. However, because the peak of *P*0 was close to that of *F*1 in high vowels, only *A*1-*P*1 was investigated; where only *A*1-*P*0 was investigated for non-high vowels because the peak of *P*1 would be close to those of *F*1 and *F*2. Spectral differences were also obtained in nasal consonants for the patients' utterances. Results of the spectra at midpoint for nasal consonants showed a raise in *A*1 and a lowered nasal peak Pl_n (around 1000Hz). The rise in *A*1 and lowering of $P1_n$ was used as an acoustic correlate to quantify nasalisation on nasal consonants. Two trained phoneticians were were asked to judge which member of each pair was more nasal in a forced-choice test. Results of all patients showed a significant increase in the average of *A*1-*P*1n after surgery. Figure 4.25 shows spectra from the midpoint of the nasal consonant /n/ for a patient before and after surgery. Generally, the results from *A*1-*P*1 were highly correlated with perceptually judged nasality, where for example in normal-hearing speakers the difference was 10dB or more and in hearing-impaired speakers the difference was much less than 10B. Accordingly after surgery, and for all speakers, /i/ was perceived as less nasal which corresponded to an increase in *A*1-*P*1; and for four of the speakers, /æ/ was perceived as more nasal corresponding to a decrease in *A*1-*P*0

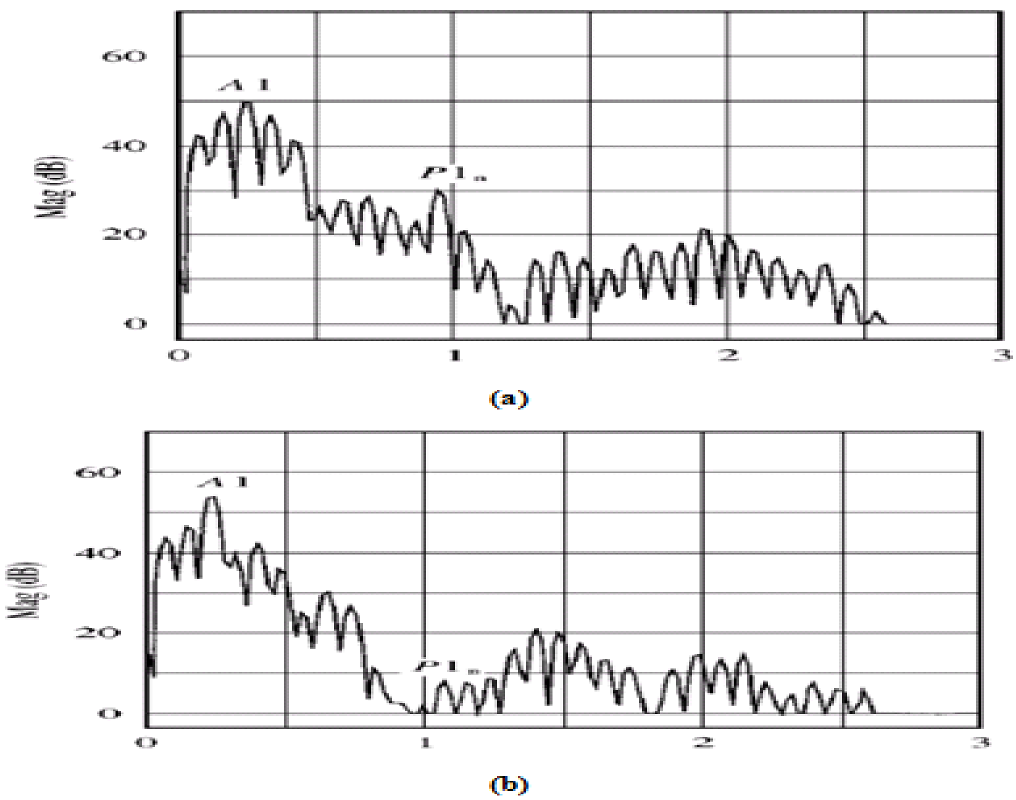


Figure 4.25: Spectra from the middle of /n/ spoken by a sinus surgery patient (a) before and (b) after surgery. A1 is amplitude of the F1; P1n is amplitude of the nasal peak at about 1000Hz (caption and Figure from: Chen et al, 2000: 308).

Following the above studies, Chen et al. (2007: 906) investigated vowel nasalisation in American English in only one vowel, /i/. This vowel was chosen aiming to demonstrate that: nasalisation can occur in a vowel with only one neighbouring nasal consonant even if that nasal is preceding it; having nasal consonants on both sides of the vowel does not increase nasalisation of the vowel. The high vowel /i/ was chosen for the following factors: **a-** acoustic velopharyngeal coupling is stronger for high compared to low vowels [this is opposite to the general view, see section 4.9]; **b-** when neighbouring a nasal consonant, nasalisation takes longer in high oral vowels compared to their low counterparts; **c-** there is no effect caused by *F*1 and *F*2 because *F*2 occurs further from the 1kHz making it easier to recognize a pole near that frequency particularly in a male speaker. This is accomplished by generating spectra of time waveforms via applying 20ms Hamming windows and computing 512-point FFT at 10, 20, 30, 40, and 50ms from the closures or releases of consonants adjacent to the target vowels. Data consisted of 150 words with the vowel in different phonetic contexts, resulting in 900 tokens in total produced by six male speakers. The procedure was to extract *A*1 and *P*1 from the spectrum by adopting the following criteria: *A*1 to be measured on the largest harmonic between 300-900Hz, while the nasal resonance amplitude *P*1 on the largest harmonic between 770-1500Hz. Their results from *A*1-*P*1 values showed statistical differences between vowels with and without neighbouring nasal consonants. Results also showed that *A*1-*P*1 values decrease in the following direction CVC > NVC > NVN, with words containing two nasals having more nasalisation. However, they also found that when having a final nasal in CVN the results were CVC > CVN = NVN, where nasalisation when a nasal is in final position would be equal to when there are two nasals in the word.

In a study to evaluate parameters detecting nasalisation, Berger (2007: 28) adopted Chen's above parameter detections of *A*1-*P*1 and *A*1-*P*0 and three others: *A*1-*H*1 (the difference between *A*1 and *H*1 is taken to obtain the relative amplitude of *F*1 instead of the absolute amplitude), COG (centre of gravity or centre of mass, is a mean of frequencies in the spectrum weighted by amplitude) and *B*1 (bandwidth of *F*1). Measuring the five formants was obtained using a 25ms window. Measuring *B*1 was through Praat's standard bandwidth command. The remaining measurements were investigated by applying a narrow-band spectrum on a 30ms Gaussian window "centred at the sample time" and *A*1, *H*1, *P*0, and *P*1 were selected from the spectra, where *A*1, *P*0 and *P*1 were measured by finding the most prominent harmonic in a certain region (ibid: 29). Nasalisation was expected to lead to the following: a decrease of *A*1-*H*1 due to flattening of F1 which increases *B*1, and a decrease in *A*1-*P*1 and *A*1-*P*0, and a drop in COG. Results showed that *A*1-*H*1 had the best discrimination of nasalisation, second was *A*1-*P*0, third were both *B*1 and COG (within 1000Hz), while *A*1-*P*1 and COG (within 1500Hz) were the poorest.

In a study designed to evaluate whether or not proposed acoustic measures of vowel nasality are applicable for speaker comparison in a forensic context, Amino and Osanai (2012) investigated amplitude difference of *A*1-*P*1 caused by nasalisation and frequency differences of $F1\text{-}F_{P1}$ (first formant frequency-frequency of extra peak) (ibid: 96). Their data consisted of 18 monosyllables and 6 isolated words produced by 50 male speakers. Recordings were conducted twice for each speaker at an interval of 2 to 3 months, making a total of 200 tokens. Recordings were conducted through four ways: through a microphone and a telephone, through air-conduction and bone conduction (ibid: 98). The air-conducted tokens were used as the test-targets. Data was sampled at 44.1 kHz with 16-bit resolution and down sampled at 11.025 kHz before the analysis. Nasality measures were directly obtained from vowel spectra of 512-point FFT with a 30 ms hamming window and averaged over the whole portion of the vowel. *A*1, *P*1, *F*1 and F_{P1} were all manually determined from the spectra. Peaks of the first and second formants were detected which made it easier to locate the extra peak in the vicinity of *F*1. Results showed that *A*1-*P*1 had larger values with an onset oral than with an onset nasal; the nasal-oral difference of *A*1-*P*1 was significant for all vowels ($p < 0.01$); *A*1-*P*1 had larger values for high and front vowels /i, e, ɯ/ than low back vowels /a, o/. The authors stated that the latter result was caused by the two formants becoming close to each other and enhancing the amplitude of the extra peak *P*1, leading to a lowering of the value of *A*1-*P*1 (ibid: 99).

4.9 Review of All Acoustic Patterns of Nasalisation Applied in the Literature

Previous sections in this chapter have included various types of acoustic measurements and patterns of nasalisation. This section is a summary of those and other acoustic patterns of nasalisation applied in the literature, among others, and the rationale behind them.

1. *Overall Vowel Intensity: nasalised vowels have a decrease in intensity in comparison with their non-nasalised counterparts*. Spectrographic and waveform information would be checked to see the overall vowel amplitude at the onset of nasalisation where a decrease in the waveform confirms its existence (see: Beddor, 2007: 250).
2. *Vowel height:* This is in regard to what is suggested by some of the literature, e.g. Ohala (1975: 300-301) suggests that low (open) vowels tend to be more nasalised in comparison to high (close) vowels.
3. *Shift in F1* frequency*:* conflicting results in the literature indicate two approaches: **a-** a rising for high vowels, a lesser raise for mid vowels, and a lowering for low vowels (House and Stevens, 1956; House, 1957; Ohala, 1962; Hawkins and Stevens, 1985; Chen et al., 2007); **b-** predicting a raise regardless of vowel type (Fujimura and Lindqvist, 1971.
4. *Shift in F2 frequency*: some studies also consider changes in frequency of *F*2 as indications of nasalisation. They also have conflicting results whereby some say it generally raises and becomes closer to *F*3 (Fry, 1979: 119) or it lowers (Ladefoged, 2003).
5. *B1 bandwidth of F1: This tends to increase to about 300Hz in nasalised vowels* (Chen et al., 2007; Beddor, 2007: 250) in comparison to it being about 100-200Hz in oral ones. The bandwidth of *F*1 is usually broadened, decreased in amplitude and less peaked because of the damping of the oral cavity when affected by nasalisation (Pickett, 1999: 70). In other words, *B*1 plus the relative strength of *F*1 decides the resonance peak (see: Klatt and Klatt, 1990: 835; Trittin and Lleo, 1995). However, it should also be noted that an increase in *B*1 could also indicate breathiness due to having a glottal chink which leads to an increase in the *H*1-*A*1 values (see Chapter 3). Therefore, it will be necessary to distinguish what affects the increase in *B*1, i.e. breathiness or nasalisation.
6. *A1 amplitude of F1: This tends to decrease in nasalised vowels* (Chen et al., 2007; Beddor, 2007: 250).

In relation to the above three cues in 4-6 and according to Beddor (2007: 250) the onset of nasalisation, which is inspected by applying FFT spectra every 10ms portions of the vowel, would be recognized as being the first spectrum with a low-frequency nasal formant and/or a broadening of $F1$ bandwidth and lowering of $F1$ amplitude.

7. *P1 and N0:* In addition to the above parameters of nasalisation, the two most obvious acoustic cues to be measured are the extra poles-zeroes introduced by having a side-branch cavity (which is the mouth in nasal consonants; the nose in nasalised vowels). These poles and zeroes are usually present before $F1$, between $F1$ and $F2$, and above $F2$. Most of the literature focuses on the one(s) between $F1$ and $F2$ believing them to be the most indicative of vowel nasalisation (see sections 4.4 and 4.5).
8. *A1-P1*, where $A1$ is the amplitude of the highest peak of $F1$, and $P1$ is the amplitude of the highest peak harmonic in the vicinity of $F1$. The different value resulting from $A1$-$P1$ would reveal if there is any acoustic nasalisation or not and as follows: the lower the value the more nasalised the vowel (Chen, 1995, 1997, 2000; Chen et al., 2000; Chen et al., 2007). These studies have applied this measure on non-high vowels which have a distance between $F1$ and $F2$ long enough to allow extra peaks to appear.
9. $A1$-$P0$, where $P0$ is the amplitude of the of the harmonic that has the highest amplitude below $F1$ and following the same threshold as in *A1-P1* whereby the lower the value the more nasalised the vowel (Chen, 1995, 1997, 2000; Chen et al., 2000). These studies have applied this measure on non-low vowels which have a distance below $F1$ to allow for an extra peak to appear.

4.10 Summary of Chapter 4

Tackling the topic of nasality and nasalisation is of vast difficulty. The first matter to consider is to distinguish between the different types of segments that carry nasality: nasal consonants, nasal and nasalised vowels. All these segments are produced by having the air flowing through two coupled chambers, the oral cavity and the nasal cavity, with the velum lowered. However, the difference between the consonants on one hand and the two types of vowels on the other is that the former have the nasal cavity as their main chamber and the oral as a side-chamber, while the latter have the oral cavity as the main and the nasal as the side-chamber. Nasal and nasalised vowels are produced similarly but differ in what causes them to have nasalisation. Nasalised vowels have nasalisation due to the influence of contexts containing nasal consonants. Nasal vowels are phonologically nasalised segments produced with nasalisation even if no nasal consonant are neighbouring them. In all three nasal segments, the side chamber causes the occurrence of inharmonics, pole-zeros, which tend to absorb energy at certain frequencies, mostly in the vicinity of $F1$.

Another term that needs to be distinguished when working in the field of VQ is that of nasality. Nasality is an auditory concept of VQ which is the result of the occurrence of nasal resonance but not necessarily in the nose. A side-chamber, also referred to as a cul-de-sac, has to be formed either by lowering the velum and having a velopharyngeal opening where the oral and nasal cavities are coupled, or the velum is raised so no velopharyngeal opening is present but the chamber is formed somewhere down the pharynx. This latter type of side-chamber is the cause of a type of VQ commonly known as the nasal twang. This nasal VQ could be the explanation of nasalisation accompanying non-phonological nasal segments, such as pharyngeals, where some of the literature suggests them having auditory nasalisation despite the fact that no velopharyngeal opening is present (see Chapter 5 on Pharyngeals). This, however, differs from cases of pharyngeals being produced with a velopharyngeal opening but without any audible nasalisation (see Chapter 5 for more details).

Chapter 5 : Pharyngeals

5.1 Introduction

This chapter will provide a brief overview of the articulatory and acoustic features of the two pharyngeal consonants /ħ/ and /ʕ/ in Arabic with particular focus on those of Iraqi Arabic. Researchers differ in their description of the place and manner of articulation of these consonants, and of which articulators are involved, and accordingly differ in the types of realisations associated with these consonants. This chapter will tackle these places and manners of articulations associated with Arabic pharyngeal consonants and with IA in particular. In addition to the different realisations of pharyngeal consonants, and as mentioned in Chapter 4, some studies suggest that the production of one or both of the consonants in some Arabic dialects is accompanied by nasalisation and creaky voice; therefore, this chapter will provide an account of these two phenomena.

5.2 Early Descriptions

A *pharyngeal consonant* is a sound articulated somewhere in the pharynx such as the Arabic /ħ, ʕ/. Researchers have given different impressionistic and experimental accounts of these sounds depending on the techniques available at the time of their investigation. Going back to the beginning of the 20th C., Van Ess (1918: 1-2; 1938: 1-2) investigated the spoken Arabic of Mesopotamia and described /ħ/ as a 'dry, sharp /h/', and /ʕ/ as a 'choking sound'. In a later investigation of the Colloquial Arabic of Egypt, Syria and Mesopotamia, O'Leary (1925: 12) described /ʕ/'s production as being similar to that of an emphatic glottal /ʔ/, with a 'contraction' made by the throat and seeming like "a catch in the throat". Moving into the second half of the 20th C., Hockett (1958: 66) differentiated between two types of productions made in the pharynx: one is described similarly to O'Leary's account of /ʕ/ above, 'a pharyngeal catch' which is produced with a complete closure in the lower pharyngeal region made by moving the back of the tongue towards the back wall of the pharynx; the second he called 'a pharyngeal spirant' (/ħ/), whereby a small passageway is formed instead of a complete closure and the air stream passes in a voiced or voiceless turbulence. Hockett (1958) added that both voiced and voiceless spirants are found in some Arabic dialects within phonemic contrasts with each other and with other consonants.

5.3 Manner and Place of Articulation of Pharyngeals

The following section will focus on the amount of variation associated with the manner of articulation of pharyngeal consonants and the different views and findings regarding which articulators are involved in their production. These sounds are usually described as being pharyngeal fricatives whereby /ʕ/ is voiced and /ħ/ voiceless (McCarthy and Raffouli, 1964: 6-7; Blanc, 1964: 17; Ghazeli, 1977: 43; Laradi, 1983: 11; Abu-Haidar, 1991: 7; Holes, 2004: 58; Alotaibi and Muhammad, 2010: 227). Some researchers, however, consider them as voiceless and voiced approximants (Catford, 1977: 163; Shahin, 2002: 57; Heselwood, 2007) with /ʕ/ thought to be followed by a stop articulation in final position (Butcher and Ahmad, 1987: 170-71), or as aryepiglottic trills (Hassan et al, 2011). Other researchers have also described /ħ/ as a voiceless fricative but differed in their description of /ʕ/ as being: a voiced approximant (Obrecht, 1968: 26; Ingham, 1982: xxi; Esling, 1999; Esling, 2005: 27); a tight approximant (Heselwood, 2007); a voiceless stop (Al-Ani, 1970: 62; MacCurtain, 1981: 140); or an epiglottal stop [ʡ] (Esling, 1999; Esling, 2005; Edmondson et al, 2005; Edmondson et al, 2007). Variation in the description of this category of sounds can even be found within one dialect of Arabic. The examples that follow tackle different Arabic dialects while those on IA will be dealt with in section 5.5.

A review of the huge literature on pharyngeals within and outside Arabic confirms the existence of a closure within /ʕ/ or accompanying it. In a study of the Arabic dialect of Khūzistān ([xu:zɪsta:n]), Ingham (1974: 104-5) describes /ħ/ as a voiceless pharyngeal fricative but /ʕ/ as a voiced frictionless continuant, which would have a full closure when doubled. On the phonological features of the Fes/Meknes Moroccan Arabic dialects, Heath (1987: 13) considers /ħ/ as a voiceless pharyngeal fricative produced with "heavy expulsion of breath through a light constriction", and /ʕ/ as the voiced counterpart of /ħ/, though it lacks a true fricative constriction and has some features of a stop. Erwin (1963: 9) notes that when articulating /ʕ/ air passes through the constriction in the pharynx with less force and less audible friction than in /ħ/; but when /ʕ/ is in final position a glottal stop is heard following it because the constriction is released after the vibration of the vocal folds have stopped and it occurs shortly with some aspiration. In a study of over 15 languages, Esling (2005: 29) found that languages of the Northwest Pacific contain a glottal fricative and glottal stop in addition to either a pharyngeal fricative or an approximant with an epiglottal place of articulation, adding that the phoneme /ʕ/ is actually an epiglottal stop [ʡ] having a full closure at the aryepiglottic sphincter and that /ħ/ is a voiceless pharyngeal fricative (figure 5.1).

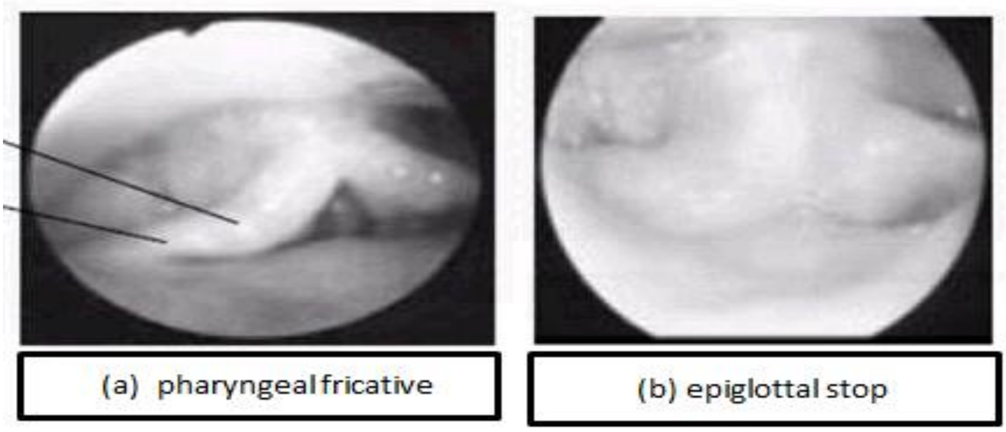


Figure 5.1: Two postures of the laryngeal articulator: (a) /ħ/ as a pharyngeal fricative, (b) /ʕ/ as an epiglottal stop (Figures from: Esling, 2005: 28).

A more detailed account of occurrence of a stop in the so-called pharyngeal fricative is that of Laufer and Condax (1979: 51; 1981: 39) in a fiberscopic and acoustic analysis of Hebrew pharyngeals. The epiglottis was found to be moving backwards separately from the root of the tongue during the articulation of both pharyngeals. The epiglottis either formed a narrow closure with the pharyngeal wall or a complete closure with it (ibid). This led the authors (1979: 50) to conclude that the epiglottis is "an active and independent articulator" in producing pharyngeal consonants. In terms of /ħ/, they (1979: 51) reached the same finding regarding it being a voiceless fricative but with a varying range of opening between the epiglottis and the pharyngeal wall. Their later results (ibid, 1981: 47) clearly showed that the epiglottis is the place of articulation of both pharyngeals with /ħ/ being a fully voiceless fricative. They (ibid) also show that there are two strictures in the production of /ħ/, one between the epiglottis and pharynx with no involvement of the tongue, and the other between the base of the epiglottis and the apex of the arytenoids (ibid: 49). If the epiglottis makes a stricture with both pharynx and arytenoids, the passage will be in an **S** shape (figure 5.2).

Although /ʕ/ was found to have the same place of articulation of /ħ/, its range of opening was found to be much more variable than that of /ħ/ and may be responsible for changing its manner of articulation (Laufer and Condax, 1979). In careful speech, the "entire width of the epiglottis touches the entire width of the pharynx, forming a complete closure" (ibid) (figure 5.3). Such an articulation was found to be completely voiceless (Laufer and Condax, 1981: 52). In rapid casual speech, the epiglottis goes back to the posterior wall of the pharynx causing a narrowing which is somehow wide; the resulting sound is a fully voiced glide-like continuant (figure 5.4). In these findings the authors (ibid) show that /ʕ/ realisation can range from a voiceless stop as shown by Al-Ani's (1970) results to a glide or continuant in some occurrences of /ʕ/ (see section 5.5). The third intermediate state is where there is no complete closure but rather a creaky (glottalised) voice. Heselwood (2007: 4) considers Egyptian and IA to be the least and most likely to have stop realisations of /ʕ/ respectively. He (ibid) explains it being related to the nature of these dialects whereby IA is a more conservative dialect and Egypt an innovative one.

Laufer and Condax (1979: 52) suggest that voicelessness in /ʕ/ when it is realised as a stop is due to the size of the space between the glottis and the place of articulating of the stop being very small, leaving little room for air to produce voicing during the closure.

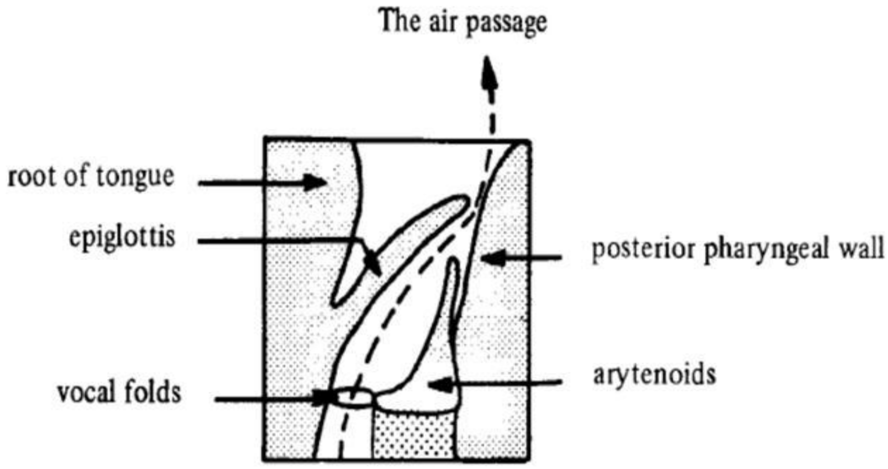


Figure 5.2: Lateral view of the larynx and pharynx during /ħ/. The air passage is S-shaped (caption and Figure from Laufer and Condax, 1981: 49).

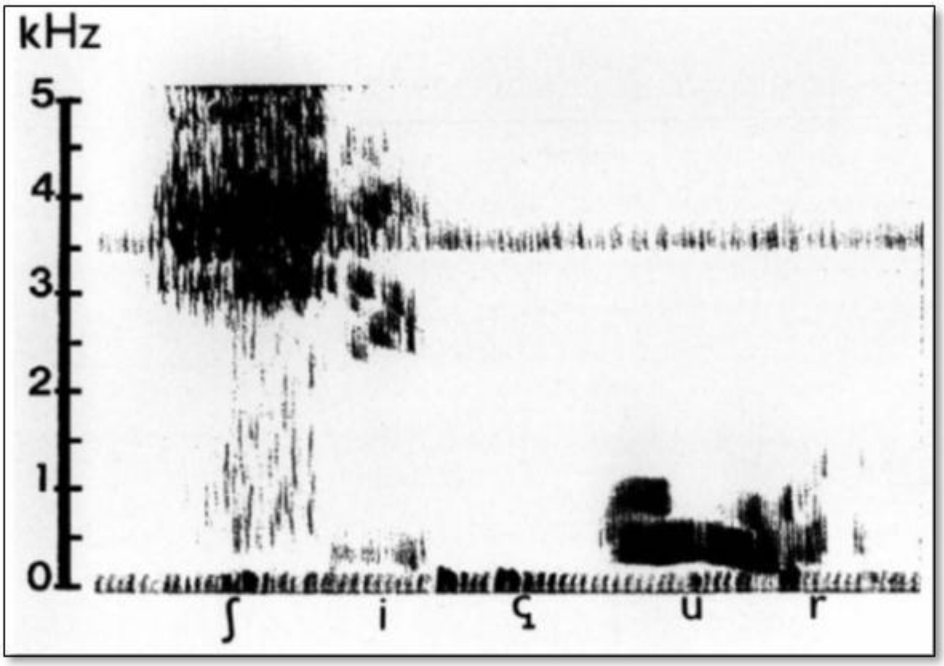


Figure 5.3: A phonemically voiced /ʕ/ which is phonetically voiceless, as revealed by the absence of a voice bar. Here it is a stop. (The horizontal line at approximately 3.5 kHz is caused by noise from the fiberoptic light source (caption and Figure from: Laufer and Condax, 1981: 50).

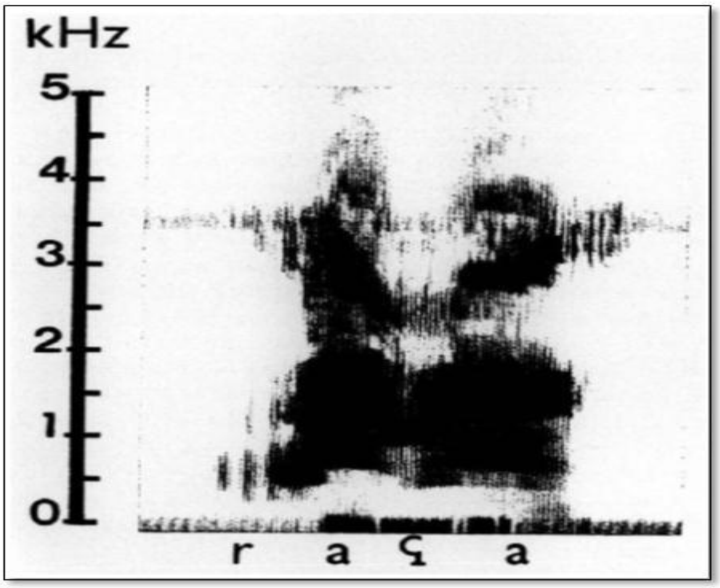


Figure 5.4: Rapid-speech variant of [ʕ], realised as a glide resembling the adjacent [a] to each side, particularly in the structure of the first two formants (caption and Figure from: Laufer and Condax, 1981: 52).

Ladefoged and Maddieson (1996: 37) state that no language can make a stop at the upper part of the pharynx and that although pharyngeal fricatives tend to occur they are not very common and what are mostly considered as pharyngeal stops and fricatives in such languages as Arabic and Hebrew are in fact epiglottal. They (ibid) believe that differentiating between the two places of articulation really matters because in the Burkikhan dialect of Agul the two places tend to contrast. Dahalo is another language which has phonologically voiced epiglottal stops as seen in the spectrograms of medial single and geminate /ʡ/, for example in the words /nd'o:ʡo/ 'floor' and /p’'uʡʡu/ 'pierce' (ibid: 38) (figure 5.5).

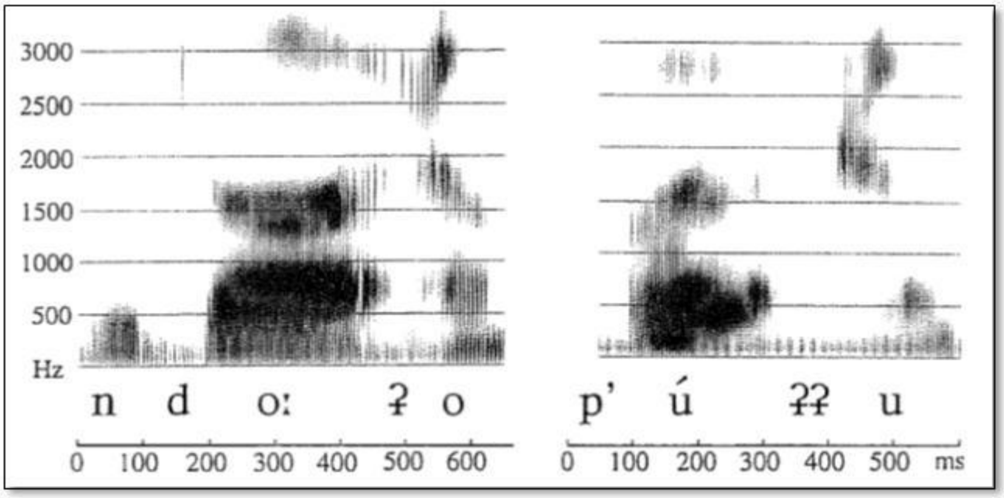


Figure 5.5: Spectrograms of intervocalic single and geminate /ʡ/ in the Dahalo words /nd'o:ʡo/ 'floor' and /p’'uʡʡu/ 'pierce' (caption and Figure from: Ladefoged and Maddieson, 1996: 37).

According to O'Connor (1973: 42), the voiced and voiceless pharyngeal sounds are produced by moving the back of the tongue towards the wall of the pharynx, leading the passing air to cause friction. O'Connor (ibid) also states that instead of merely calling them pharyngeal sounds they should be called linguo-pharyngeal to highlight the involvement of the tongue in their production, but the linguo- part is usually omitted. According to Catford (1977: 163), on the other hand, it is the faucal pillars that play the main part in producing the pharyngeal sounds by laterally compressing "the part of the pharynx immediately behind the mouth" resulting in moving the faucal pillars towards each other while raising the larynx. Catford (ibid) therefore considers both /ħ/ and /ʕ/ as pharyngeal approximants where it is "largely a sphincteric semi-closure of the oro-pharynx" that takes place.

In a spectrographic analysis to investigate the role of *F*2 transition in cueing discrimination of velarized and non-velarized consonant pairs in Lebanese Arabic, including pharyngeals, Obrecht (1968: 7, 26-27) found that during the production of /ħ/ spectrograms showed it generally having high intensity, and its constriction and friction noise were glottal and had an articulatory apparatus similar to a vowel. /ʕ/, on the other hand, was composed of 'voiced noise' and scatter and blurring associated with the noise (for more details on Obrecht's acoustic analysis and findings see section 5.5).

Esling (2005: 28) describes what happens at the laryngeal constrictor when the pharyngeals /ħ, ʕ/ are produced (see figure 5.1). Producing /ħ/ starts with the glottis open and the arytenoids move upward and forward, leading "the cuneiform tubercles of the aryepiglottic folds" to reach the epiglottis' surface. The aryepiglottic folds are therefore the active articulator and the epiglottis the passive one leading Esling to label the place of articulation as *epiglottal*. Esling (ibid) adds that the same happens to the voiced pharyngeal (epiglottal) approximant /ʕ/, but in order to distinguish between pharyngeal /ħ, ʕ/ and epiglottal /H, ʢ/ adding aryepiglottic trilling to the two pharyngeals could enhance them. The constriction is further accompanied by the raising of the larynx and the closing off of the airway. Esling's findings are confirmed by Zeroual et al. (2008: 5) who used a nasendoscope inserted in the nostrils of 35 Morrocan Arabic speakers and placing it at three levels to observe the movement of: 1- oropharyngeal level: the tongue, pharyngeal walls and the epiglottis; 2- laryngopharyngeal level: the basis of the epiglottis, aryepiglottic folds, ventricular bands, glottis and the arytenoids; 3- laryngeal level: the glottis, ventricular bands and the arytenoids. Speakers produced three sustained vowels [a, i, u] with modal neighbouring the voiceless /ħ/ and voiced /ʕ/ pharyngeal consonants. Their results showed that these sounds are produced with two constrictions: one between the tip of the epiglottis and the posterior pharyngeal wall (epiglotto-pharyngeal), and the other between the base of the epiglottis, the aryepiglottic folds, and the tip of the arytenoids (aryepiglottic sphincter or epilaryngeal). Zeroual et al. (ibid: 10) conclude that /ħ/ has auditory features of whisper and /ʕ/ those of creaky voice. Laufer and Condax (1979, 1981) and Laufer and Baer (1988) also found the epiglottis as the place of articulation of /ħ/ and /ʕ/ in Hebrew and Arabic. On the recognized profiles of pharyngeal categories of articulation, Esling (2005: 26-27) draws a number of conclusions among which are the following:

- **a-** The arytenoid cartilages move forward and up under the epiglottis and the tongue. They act as the main articulator instead of the epiglottis, which on its part does not cover the airway. The arytenoid cartilages themselves work in reverse to the tongue by blocking the air flow.
- **b-** The pharyngeal articulator that produces [ħ] and [ʕ] and pharyngealised sounds is essentially aryepiglottic.
- **c-** Pharyngeal sounds involve retraction of the tongue and raising of the larynx for efficient laryngeal sphinctering.

5.4 Acoustic Manifestations of Arabic Pharyngeal Consonants

The following section will give a brief and general account of the acoustic description of the two pharyngeals.

On describing the production of /ħ/ for his Lebanese subjects using spectrographic analysis, Obrecht (1968: 26) stated that the speaker's spectrograms of /ħ/ show noise ranging from the top of the frequency range down to 1750Hz. The strongest noise area is usually between 2100Hz and 3600Hz. /ħ/ generally has high intensity, its constriction and friction noise are glottal with an articulatory apparatus which is similar to a vowel. There is also pharyngealisation accompanying its production. It nevertheless contains clearly defined formant structure throughout. /ʕ/, on the other hand, is composed of 'voiced noise', harmonic structure, plus scatter and blurring associated with the noise; this is mostly noticed at medial position. At initial position, it consists of irregular and abnormally wide spacing between striations.

On the acoustic properties of the voiceless pharyngeal fricative [ħ], Ghazeli (1977: 45-49) states that the sound is "characterized by strong non-periodic noise but with visible formant structure" adding that the stricture is narrower for [ħ] than for [ʕ] and sustained for longer. Ghazeli (ibid) also states that when producing [ħ], the shape of the vocal tract becomes similar to the neighbouring vowel; [ħ] and [ʕ] were also found to have similar formant patterns when occurring in the same vocalic environment. On the acoustic properties of the voiced pharyngeal fricative [ʕ], Ghazeli (ibid: 43) states that the sound's formant frequencies are similar to those of vowels, however the ‘vertical spikes’ representing glottal pulses are further apart in [ʕ] than in vowels, indicating that the vibration of the vocal cords occurs at a slower rate leading to a lower fundamental frequency than those of vowels.

From a survey of the *gelet*-dialectal group discussed in Chapter 2, Bellem (2007: 270) concludes that Bedouin and many rural Levantine dialects of that group have “a ‘stronger’ (creakier and more stop-like, rather than approximant-like) pharyngeal ʕ”. These dialects also have the [g] realisation of Classical Arabic /q/, occasional [č] (IPA [tʃ]) realisation of /k/, and preserve the interdentals of Classical Arabic. Bellem (ibid) adds that these dialects are believed to generally have more ‘emphaticness’ or are at least of a more ‘guttural’ quality. This would also apply to the *gelet* dialects of Lower (Central and Southern) Iraq discussed in Chapter 2. In fact, creaky voice (laryngealisation) has been associated with pharyngeals in a number of studies on Arabic dialects like Ghazeli (1977) on Tunisian, Butcher and Ahmad (1987) on IA, Zeroual et al. (2008) on Moroccan, and Heselwood (2007) on a number of dialects. Laryngealisation was also reported in other languages like Hebrew (Laufer and Condax, 1979) where either stop realisations of /ʕ/ or creaky voice were noted but not together. These studies have reported that creaky voice mostly accompanied stop realisations or those realisations which are short of a full closure when producing /ʕ/; in such a way that having more constriction in the pharynx leads to having a less modal-like phonation (Heselwood, 2007: 6). However, Ladefoged (2001: 146) believes that many cannot make stops in the pharynx. He (ibid) adds that the voiced pharyngeal fricative /ʕ/ is produced with “a great deal” of laryngealisation saying “perhapse because the necessary constriction in the pharynx also causes a constriction in the larynx” (Ladefoged, 2001: 146), commenting that pharyngeal consonants are produced by many with no friction and instead they are more like approximants. However, Heselwood (2007: 6) believes that it would be more accurate to say that a laryngeal constriction is what leads to a pharyngeal constriction.

Another study of the pharyngeal /ʕ/ is that of Heselwood (2007) who mentions yet another variant, that of the tight approximant. His (ibid) study investigated the production of /ʕ/ by 21 speakers from eleven countries of the Arab region: Morocco, Algeria, Tunisia, Egypt, Palestine, Jordan, Syria, Iraq, Saudi Arabia, Kuwait, Qatar. Heselwood (ibid: 1) describes this tight approximant as being acoustically characterised by a pattern of filtering where the first six or so harmonics, including the fundamental, have a noticeably decreased amplitude. He (ibid) states that this variant is cross-dialectally widespread and phonologically is “in free variation” when occurring with variants that show other manners of articulation. Acoustically, there is a low f_0 which causes the harmonics to be pressed close together under the influence of a bandpass filter that is linked to a laryngopharyngeal compression of the ventricles leaving a narrow band of resonance positioned in the vicinity of 1 kHz (ibid: 2). Heselwood showed spectrograms and spectra of the tight approximant variant occurring in the case of a geminate in such words as /waʕʕad/ ‘a promise’ and /ʃaʕʕa/ ‘it glowed’ by male and female speakers from: Morocco, Palestine, Jordan, Saudi Arabia, Qatar and Egypt (figure 5.6). The tight approximant variant was mostly common in initial prevocalic position (ibid: 26). Tokens with the pharyngeal occurring in utterance-initial position begin with a stop release (figure 5.7), for which Heselwood (ibid) did not provide any proper classification due to the study’s different focus.

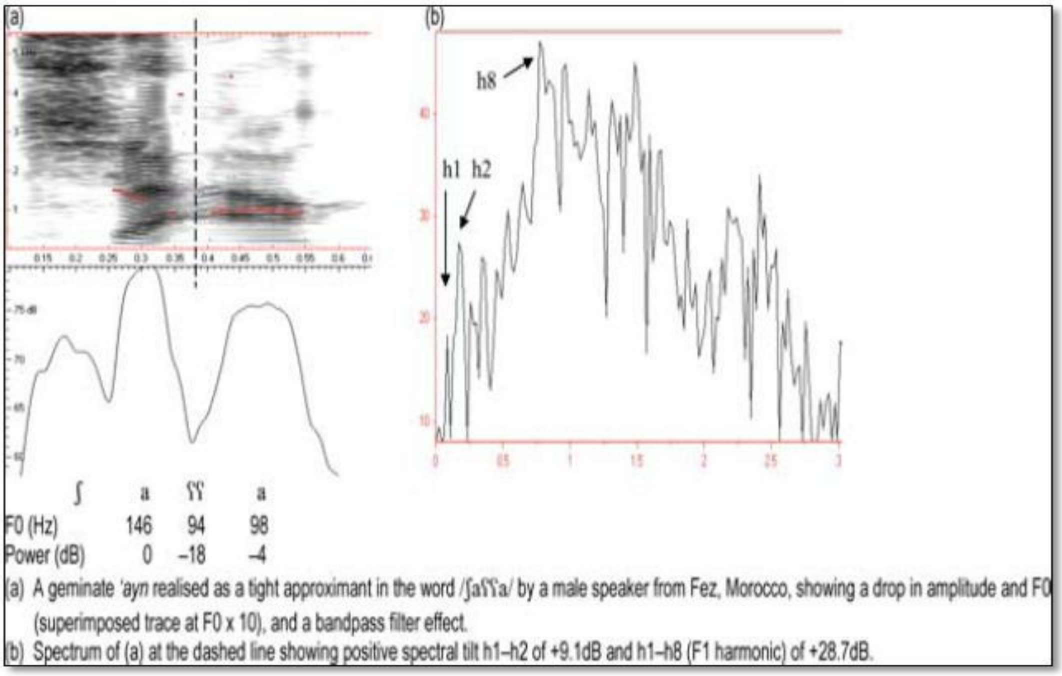


Figure 5.6: Tight approximant realisation of geminate *‘ayn* by a speaker from Fez, Morocco, showing a reduction in amplitude and F0, and a bandpass filter effect; narrowband spectrogram (512-sample window size), Hamming window spectrum (caption and Figure from: Heselwood, 2007: 10).

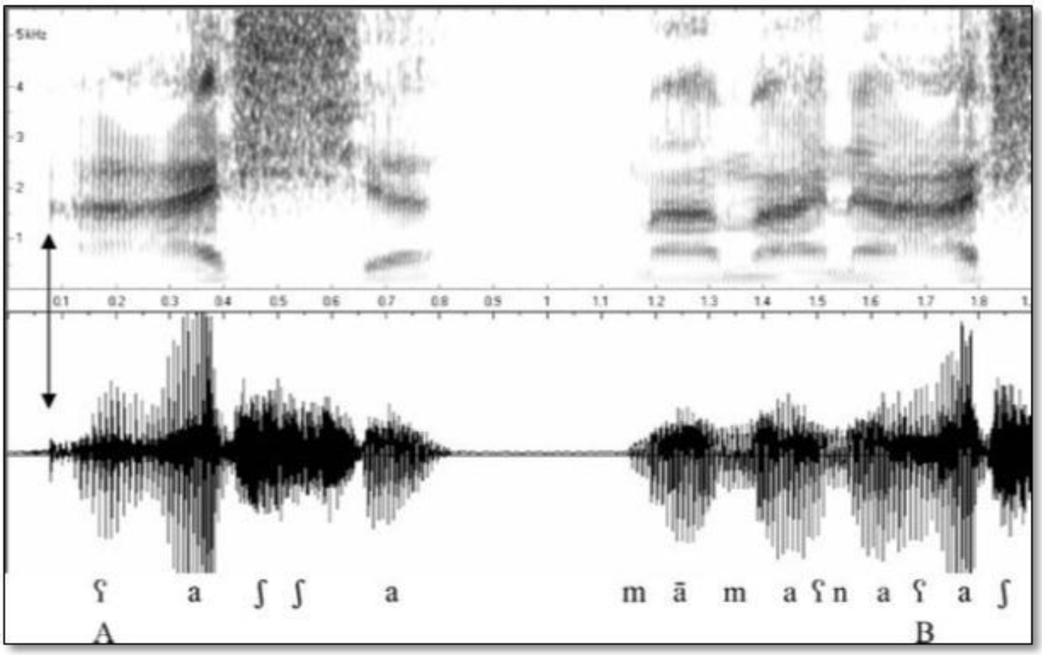


Figure 5.7: Utterance initial (A) and utterance-medial (B) realisations of word-form initial 'ayn in /ʕaʃʃa/ by a male speaker from Kuwait. The utterance-initial realisation has a stop release (indicated by the arrow) while the utterance-medial realisation does not (caption and Figure from: Heselwood, 2007: 27).

5.5 Description of Iraqi Arabic Pharyngeal consonants

The following section will give a brief account of the physiological and acoustic description of the two pharyngeals of IA and how they are usually realised by IA speakers.

5.5.1 General Description

In their investigation of the Spoken Arabic of Baghdad, McCarthy and Raffouli (1964: 6-7) consider /ħ/ as a voiceless pharyngeal fricative, describing it as a "breathy, almost panting h"; and /ʕ/ as a voiced pharyngeal fricative, describing it as being similar to a "sheep's Ba:a:!" Al-Ani's (1970:62) acoustic analysis of the two pharyngeal consonants in IA concluded that /ħ/ is mostly realised as a voiceless pharyngeal constricted fricative, which becomes voiced in intervocalic position; the duration range of its constriction is 100-500ms. /ħ/ is produced by forming a constriction between the dorsum of the tongue and the posterior of the pharyngeal wall (Al-Ani, 1970: 60). Butcher and Ahmad (1987: 170), using acoustic and aerodynamic techniques in investigating the speech of three Iraqi speakers, found the constriction in /ħ/ in the environments of short vowels is wider and has more variation than in environments of long vowels. Their results also showed high rates of airflow accompanying the production of /ħ/. Oral airflow rates of /ħ/ showed a mean maximum flow of 595 cm^3 at initial position and 640 cm^3 at final position, which Butcher and Ahmad (ibid: 166-7) believe to be mid-way between the ranges of a fricative and those of an approximant. They (ibid: 170) describe /ħ/ as “a voiceless continuant sound with high rates of airflow, high intensity noise and marked formant structure”.

The most common allophone for /ʕ/, on the other hand, is found to be a voiceless stop and not a voiced fricative as has been described in other studies (see section 5.3), especially at initial and final positions, while it is realised as a glide inter-vocalically. MacCurtain (1981: 140, 205) confirms Al-Ani’s (1970) description of /ʕ/ as being a pharyngeal stop after investigating the productions of an adult male IA speaker using electrolaryngographic tracings. In investigating the production of the pharyngeal /ʕ/ by an Iraqi speaker, MacCurtain (1981: 140) used electrolaryngographic tracings and observed the epiglottis tip blocking the pharyngeal passage and having no direct contact with the tongue root, therefore providing evidence that the epiglottis is used as an articulator in producing the pharyngeal stop. MacCurtain (ibid) adds that those electrolaryngo-graphic tracings show that in producing the pharyngeal stop the larynx and arytenoid folds vibrate similarly to the vibration that is found for other Arabic stops. MacCurtain (ibid) concludes from that evidence that the pharyngeal stop is produced by muscle groups which are supraglottic and is accompanied by shortening of the vestibular folds and raising of the larynx.

Butcher and Ahmad (1987: 167) believe that the amount of oral airflow in /ʕ/ at initial position is very low for it to be a fricative. They (ibid: 167) also did not find any peak of airflow that would usually be linked to releases of a stop or a fricative. They (ibid: 171) believe that the only place to form a constriction would be the epiglottis and even that needs a “degree of fine control”; therefore trying to produce a voiced fricative at this position would result in failure of producing turbulence particularly when glottal and articulatory constrictions are occurring. They (ibid: 156) add that it is difficult to produce fricatives at the region of the vocal tract where the two pharyngeals are produced and therefore consider both sounds as approximants. However, in their analysis, Butcher and Ahmad (ibid) state that both pharyngeals are produced by a constriction in the pharynx with the epiglottis possibly being involved but with the laryngeal tension playing a vital role. These conclusions are also reinforced by the fact that there was no evidence of any friction when producing /ʕ/ (ibid: 171). They (ibid) also add that since the pharyngeal area is not suitable for producing a fricative, the sound is: either an approximant with a general constriction of the pharynx, a raised larynx and a lowered velum as in the case of /ħ/; or a stop with a constriction formed at the epiglottis or “more likely” at the glottis. For /ʕ/, any additional constriction of the pharynx would be accompanied by one at the larynx leading to the air being completely interrupted at one or both positions (ibid).

Another study in which Iraqi Arabic, among other languages, is investigated is that of Edmondson et al. (2007: 2065), who state that the reason behind choosing IA was due to "its extreme and phonologically challenging pharyngeal reflexes" because of the extremely varying results on IA they reviewed in works of Butcher and Ahmad (1987), Laufer and Baer (1988) and Heselwood (2007). By using transnasal laryngoscopy, Edmondson et al. (2007: 2066) analysed a number of video recordings of reflexes of the two pharyngeals. They found /ħ/ glottally voiceless with an extreme laryngeal constriction of the aryepiglottic folds at the top of the epilaryngeal tube. These folds tended to sometimes trill especially when occurs as a medial geminate as in the word /saħħar/ 'made magic'. Pharyngeal /ʕ/, on the other hand, was mostly realised as a voiced approximant, with some instances of slight trilling. In such examples as /saʕiːd/ 'happy' it appears as a tap due to the approximation of the aryepiglottic folds towards the tubercle of the epiglottis with a rapid burst. But when this consonant is a medial geminate /-ʕʕ-/, it is produced as a full epiglottal stop [ʡː] with a complete closure of the airway as in the word /faʕʕal/ 'made active'. From the video recording of this production, the authors found evidence that /ʕ/ can be an epiglottal stop, but that this needs to be treated with caution because these findings are based on the productions of one speaker. They conclude that in IA, the constriction of the laryngeal articulator tends to generate two types of stop closure /ʔ, ʡ/ (i.e. laryngeal and epiglottal, respectively) and two types of sound source generation, glottal vibration and aryepiglottic fold vibration.

Another finding of a trill is that by Hassan et al (2011: 831), who used acoustic, EGG, kymographic, high-speed laryngoscopic and aperture estimate techniques. They (ibid) carried out high-speed laryngoscopy on productions of IA voiced and voiceless aryepiglottic trills by an adult male speaker from Basra, Iraq (the first author). The subject produced four IA words containing the trilled consonant variants of /ʕ, ħ/ within an intervocalic context /aCi/ and grouped into two pairs according to vowel length: /raħiːl/ 'travel' vs. /raħħiːl/ 'travel a lot' and /saʕiːd/ 'happy' vs. /saʕʕiːd/ 'make people happy' (ibid: 832). Their results showed that aryepiglottic trilling was present in all trills but the geminates displayed the highest degree of arepiglottic fold movement because these folds had more time to "overcome their resting inertia" (see figures 5.8 and 5.9).

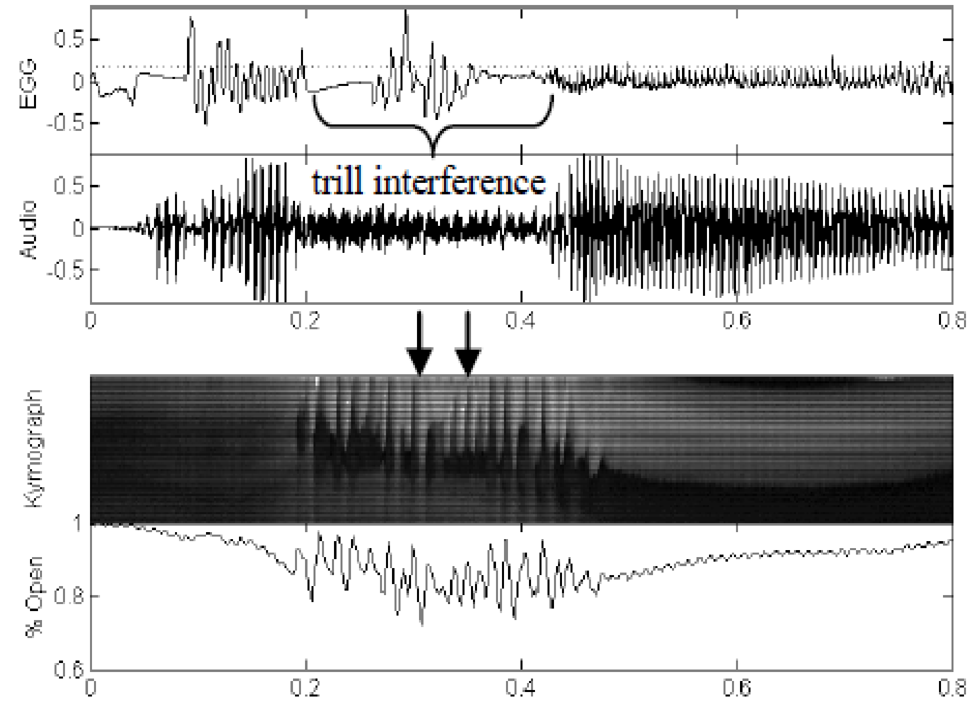


Figure 5.8: An example of the trilled variant /ħ/ in an intervocalic geminate position within the word /raħħiːl/. Arrows mark start and end points for the contiguous frames of the voiceless trill (Figure from: Hassan et al, 2011: 833).

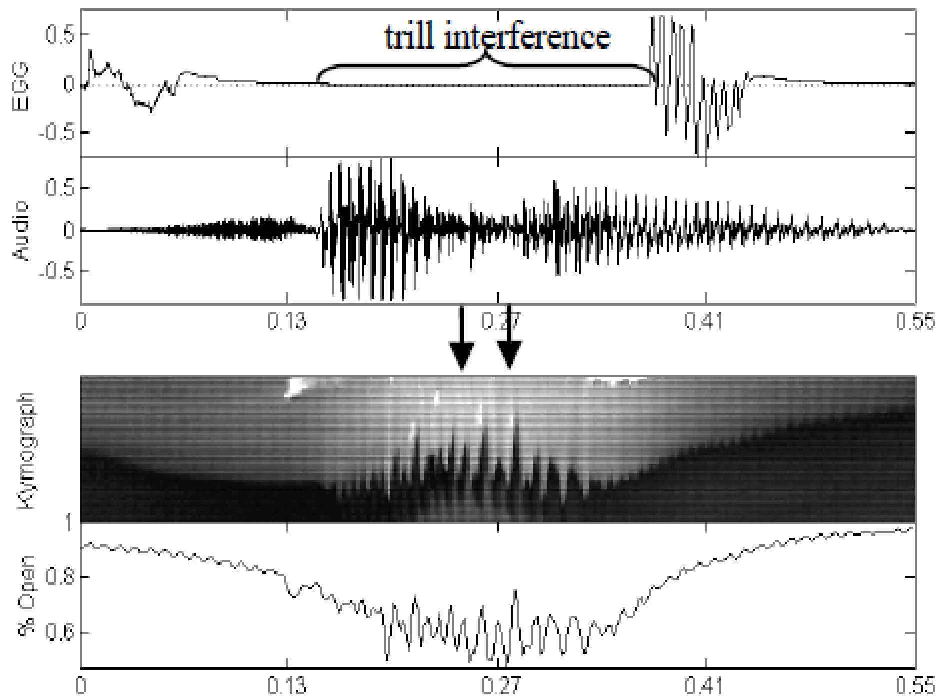


Figure 5.9: An example of the trilled variant /ʕ/ in an intervocalic geminate position within the word /saʕʕiːd/. Arrows mark start and end points for the contiguous frames of the voiced trill (Figure from: Hassan et al, 2011: 833).

5.5.2 Acoustic Description of Pharyngeal Consonants

The following is an acoustic description of the pharyngeal consonants of IA.

/ħ/

In Al-Ani's (1970: 60) acoustic and articulatory (x-ray) investigation of the speech production of eight IA speakers the author found that there was always a period of voiceless friction representing the production of /ħ/. It is produced as a noise similar to but stronger than /h/, where in /ħ/ it is sometimes seen as a "shadow of weak formant structures which are a continuation of the neighbouring vowel formants" (ibid). In their acoustic and aerodynamic investigation of pharyngeal consonants in IA, Butcher and Ahmad (1987: 170) state that from the behaviour of the formant transition in /ħ/ they "do not find any reason to doubt the presence of a constriction in the pharynx, in addition to indications that the larynx is both constricted and raised". The authors (1987: 164) found the total duration of /ħ/ to be constant in all productions. The main frequency range they identified is between 500 and 1500Hz representing friction in /ħ/ in addition to the presence of bands of higher intensity which are similar to formants (ibid: 168). These bands do not differ according to consonant position or vowel length and are found in the regions of 700-900, 1600-2200, 2200-3000 and 3100-4500Hz. Figures 5.10 and 5.11 show two productions of pharyngeal /ħ/, taken from the present study, one in initial position produced by an IA male speaker from Baghdad and the other in final position produced by a male speaker from Mosul. Both productions show a voiceless pharyngeal fricative in both positions.

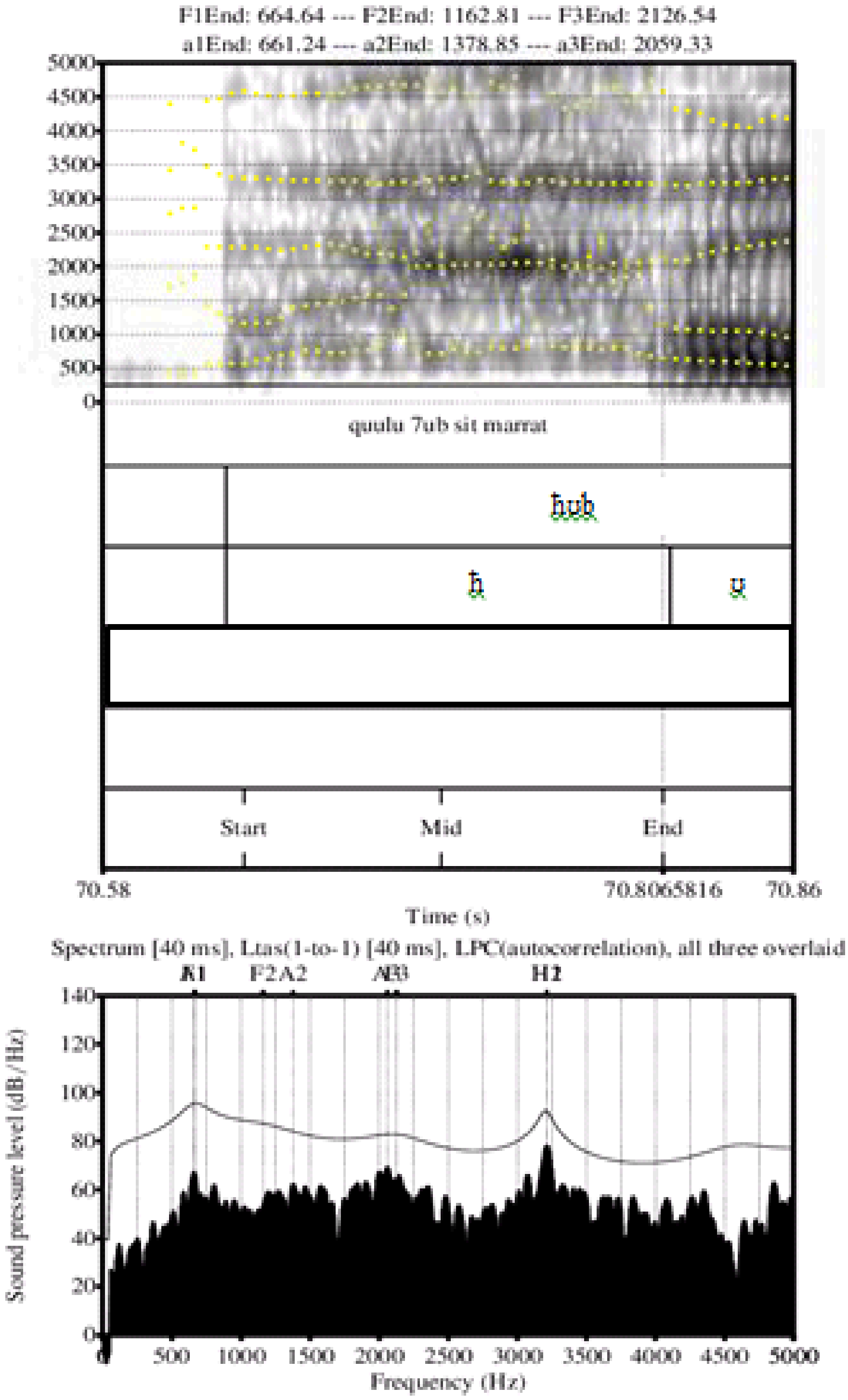


Figure 5.10: a spectrogram and spectrum of an initial pharyngeal /ħ/ in the word 7ub [ħʊb] 'love' as produced as a voiceless fricative by an IA male speaker from Baghdad.

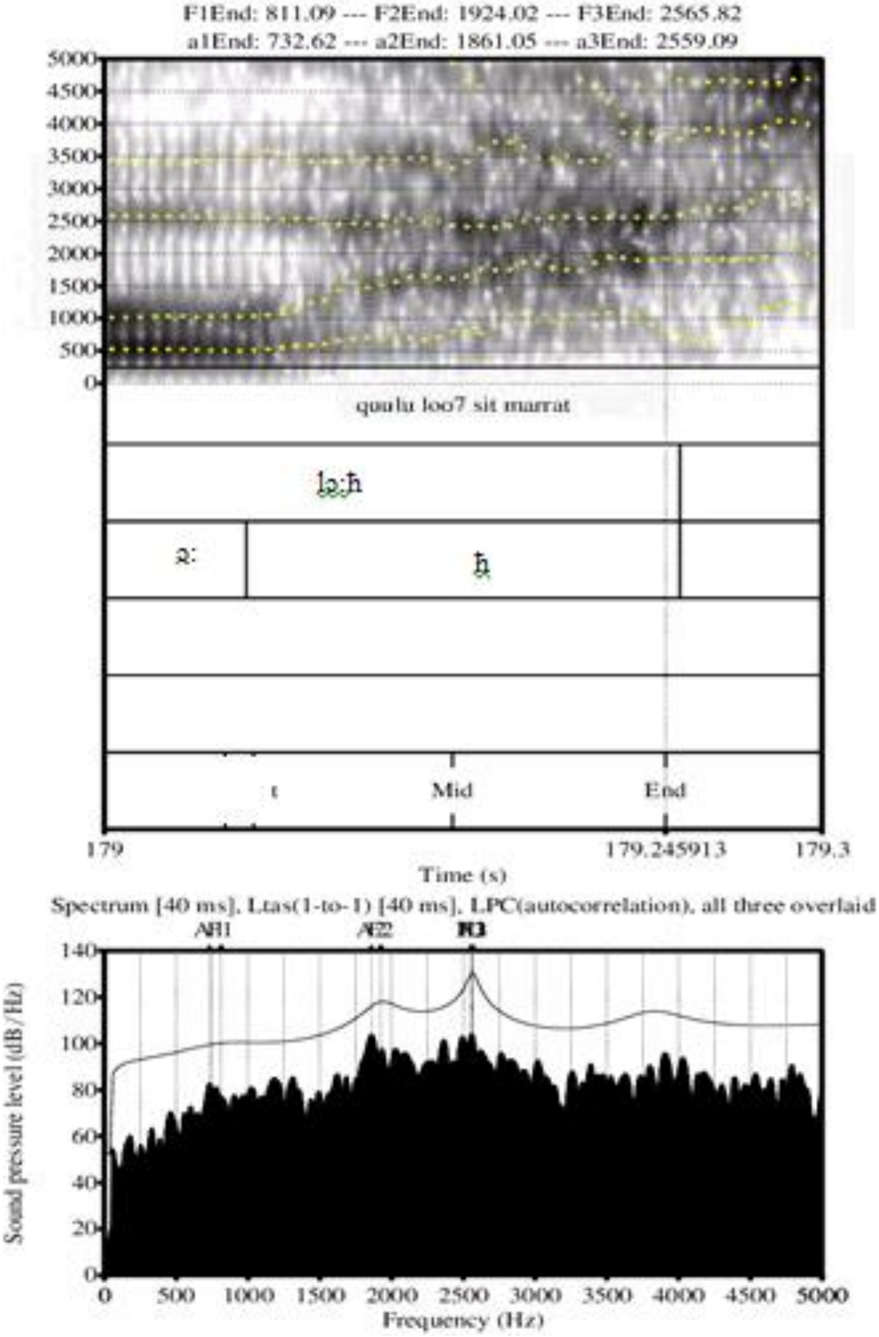


Figure 5.11: A spectrogram and spectrum showing how a final pharyngeal /ħ/ would be produced in comparison to that in Figure (5.14); the /ħ/ in this case is in the word loo7 [lɔ:ħ] 'a piece of wood' also produced as a voiceless fricative by an IA male speaker from Mosul.

/ʕ/

Butcher and Ahmad (1987: 170-71) found that /ʕ/ is accompanied by creaky voice, which would be followed by a stop when in final position without any sign of friction. The general duration of /ʕ/ varies depending on its position in monosyllabic (real and nonsense Iraqi Arabic) words: 56.0% of the whole word in initial position and 81.0% in final position; e.g. /ʕ/ in initial position was 185ms in /ʕi:f/ 'leave it', 100ms in /ʕe:b/ 'that's rude' and 65ms in /ʕa:b/ 'ruined'; while in final position, it was 185ms in /bi:ʕ/ 'sell', 135ms in /be:ʕ/ 'selling' and 165ms in /ba:ʕ/ 'he sold' (Butcher and Ahmad, 1978: 160, 164). No visible friction is ever seen in connection with /ʕ/.

However, in most cases where /ʕ/ precedes /u:, u, o:/ there was evidence of a period of ‘creak’ represented by a wide irregular spacing between voicing striations (ibid: 166). This creakiness was also found by Zeroual et al. (2008: 3) whose study showed that the voiced and voiceless Arabic pharyngeal consonants have auditory features of whisper and creaky voice, respectively. Where /ʕ/ is realised as a stop, hardly any energy is seen at higher frequencies except in some cases where the vowels /u:, u, o:/ are present, and *F*1 and *F*2 have equal intensity (ibid: 168). In an investigation to identify a new tight approximant variant of the Arabic pharyngeal *‘ayn* in the speech of 21 male and female speakers, Heselwood (2007: 4) showed a spectrogram of a “stopped realisation” by his male speaker of the Muslim dialect of Baghdad, Iraq, which from an auditory point of view has a ‘strong’ or ‘massive’ glottal stop which has a clear release burst seen at around 1 kHz (see figure 5.12).

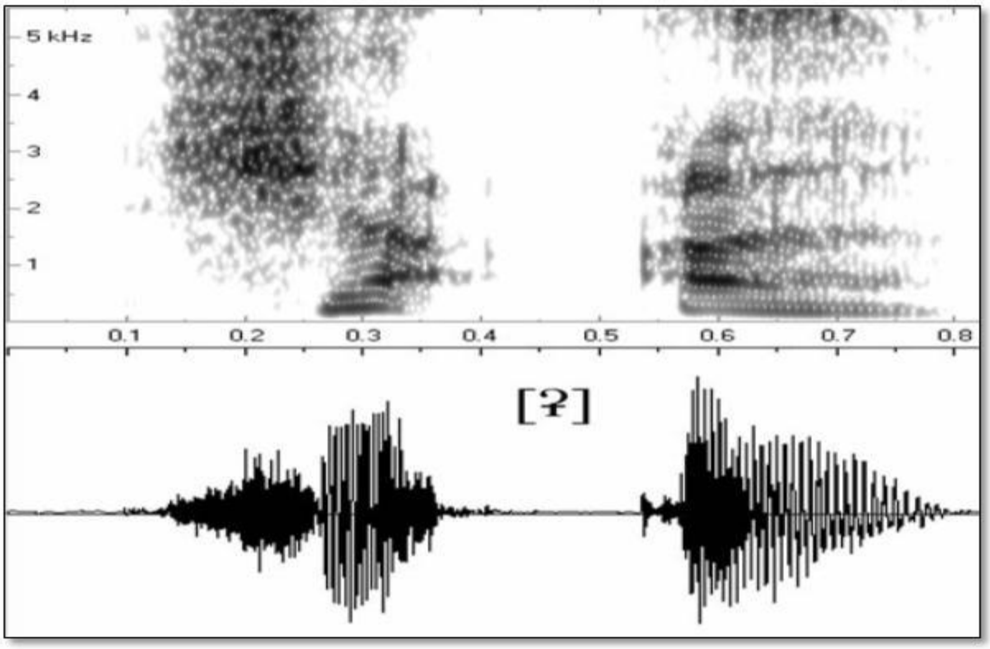


Figure 5.12: Spectrogram of a stopped geminate ‘ayn in the word /ʃaʕʕa/ produced by a male speaker from Baghdad, Iraq. The auditory impression is of a ‘massive’ glottal stop involving glottal, ventricular, aryepiglottic and possibly epiglotto-pharyngeal occlusion (citation and Figure from: Heselwood, 2007: 5).

Initial position

At this position, Butcher and Ahmad (1987: 164) report a release burst that is 15ms long in about 60% of the cases, and that consists of “creaky glottal pulses”. Al-Ani’s (1970: 62) spectrograms, on the other hand, show /ʕ/ as a burst with a duration of 40-50ms followed by a “random noise” which is in most cases voiced. Al-Ani (ibid)’s results also show mutual influence between pharyngeal /ʕ/ and the following vowel. When /ʕ/ is followed by /i/ or /i:/, e.g. /ʕi/ and /ʕi:/ (nonsense words), vowel formants are affected according to the following: a rise in *F*1 from around 275-300 Hz up to 400Hz or even higher; a drop in *F*2 is from around 2000-2200Hz down to 1500Hz and sometimes lower; *F*3 shows minimal influence. When /ʕ/ is followed by /a/, e.g. /ʕalam/ 'flag', the *F*2 onset in this position rises from 1300-1350Hz; when followed by /a:/, e.g. /ʕa:lam/ 'world', it rises from 1250-1300Hz, because *F*2 of /a:/ is lower than that of /a/. In fact, the whole of the *F*2 and not only the onset is influenced by /ʕ/ in both /a/ and /a:/. Figures (5.13, 5.14) show productions of initial pharyngeal /ʕ/ by two IA male speakers from Baghdad and Mosul, respectively, taken from the present study. In the first figure /ʕ/ is realised as a voiced pharyngeal approximant and in the second as a voiceless stop. It is apparent that IA speakers tend to vary in their realisation of the consonant /ʕ/ (for more details see Chapter 7). In comparing the vowel formants at onset of vowel /ɔ:/ in both productions, *F*1 is slightly higher in the case of the approximant, around 600Hz, than it is in the stop, around 500Hz; *F*2 shows the opposite trend as it tends to drop in the approximant, around 1000Hz, while it is around 1300Hz in the stop.

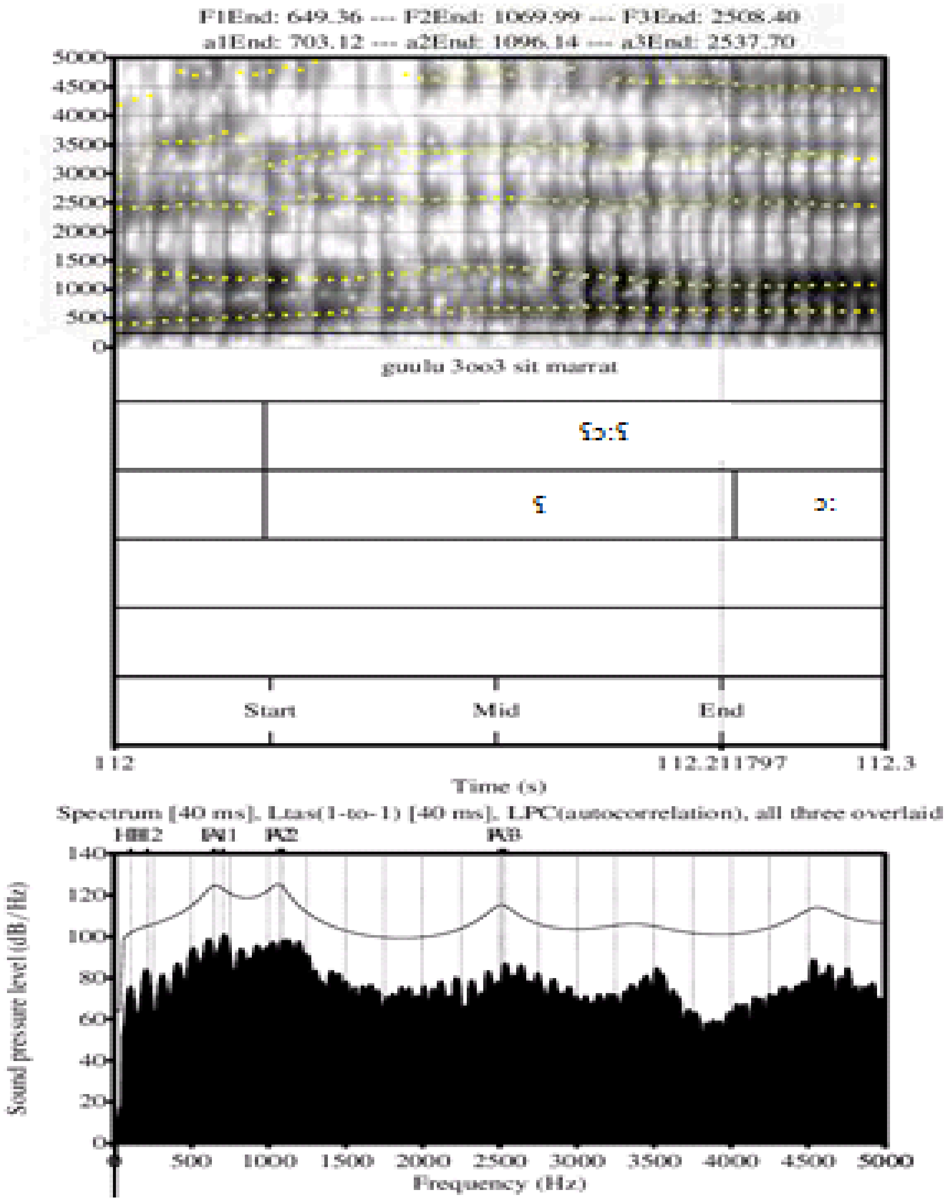


Figure 5.13: A spectrogram and spectrum of an initial pharyngeal /ʕ/ in the word 3oo3 [ʕɔ:ʕ] 'yuk!' realised as a voiced approximant by an IA male speaker from Baghdad.

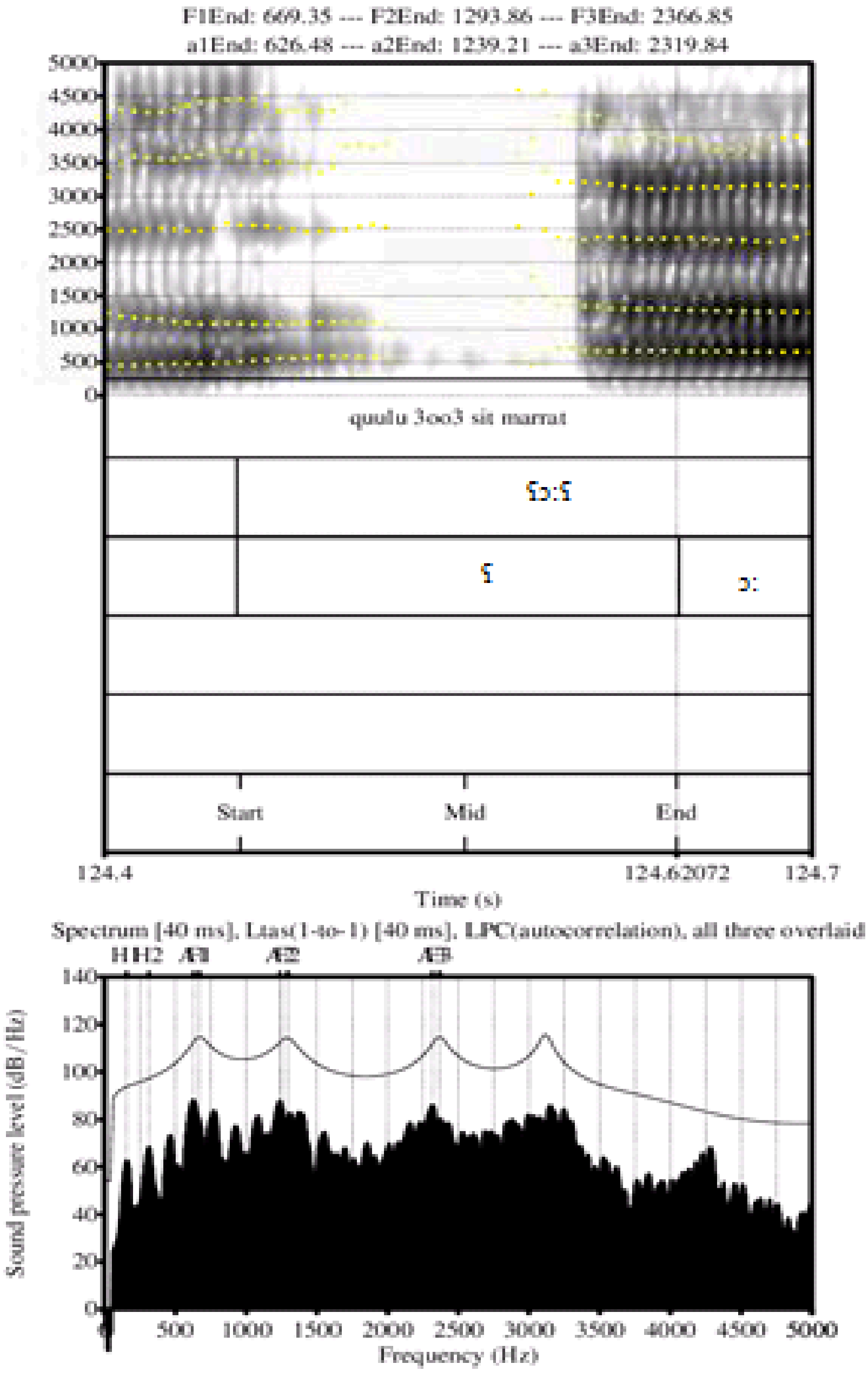


Figure 5.14: A spectrogram and spectrum of an initial pharyngeal /ʕ/ in the same word as Figure (5.3), 3oo3 [ʕɔːʕ] 'yuk!, but realised as a stop by another IA male speaker from Mosul.

Medial position

In this position, how /ʕ/ is realised depends on its environment and whether it is single or geminate. In the case of being geminated, /ʕ/ is always seen as a silence gap (300-330ms long), preceded by "some sort of a glide" (30-40ms long) in *F*1 and *F*2 of the preceding vowel, and followed by a burst (around 50-70ms long) with frequencies of up to 1450Hz (Al-Ani, 1970: 63).

The geminated consonant /ʕʕ/ also affects *F*2 of the following vowel with similar measurements to those of initial /ʕ/, e.g. /waʕʕada/ ‘he threatened’. In the case of a single /ʕ/ in an intervocalic position, the consonant is either seen as a stop or a glide continuation of formants of preceding and following vowels, e.g. /waʕada/ ‘he promised’. These formants are usually accompanied by voiced noise with “irregular random striations” and no formant tracings particularly at the centre. Frequencies of *F*1 and *F*2 are similar to those of initial /ʕ/; while no frequencies are seen above 2000Hz. Also in medial position, when /ʕ/ is preceded by a consonant, no effect can be seen because they each belong to a different syllable (ibid). When, on the other hand, /ʕ/ is followed by a consonant it would be seen as a gap of silence (80-100ms long) followed by a burst (30-40ms long). However, when ending a syllable, /ʕ/ is produced as a stop with vowel frequencies similar to those at initial position.

Final position

Pharyngeal /ʕ/ in this position is realised as an approximant followed by a stop accompanied by creaky voice (Butcher and Ahmad, 1987: 170). The stop is typically found to have a 15ms period of noise burst following a period of silence which varies in duration (95ms - 145ms. The authors (ibid) report this to be a glottal rather than a pharyngeal release. Waveforms of the larynx show that creak occurs in many cases of /ʕ/ particularly at this final position. Al-Ani (1987: 63), on the other hand, found that /ʕ/ in final position has two articulations: released and unreleased. When it is released, /ʕ/ is aspirated and seen as a silence gap (170-200ms long) on the spectrograms. The effect of /ʕ/ on preceding vowels is seen as an off-glide continuation of the preceding vowel in *F*1 and *F*2 (ibid: 64). The off-glide is also sometimes seen at the end of vowel frequencies as a random voiced noise 40-60ms long. The gap, on its part, could also have a breathy release which is seen as noise, or is seen as a ‘weak spike’ 40-75ms long (ibid). Figures 5.15 and 5.16 show productions of a final pharyngeal /ʕ/ by two IA male speakers from Mosul taken from the present study. However, each speaker tends to produce the sound differently. The first produces it as a voiced approximant but the second starts producing it as a voiced approximant followed by a voiceless stop.

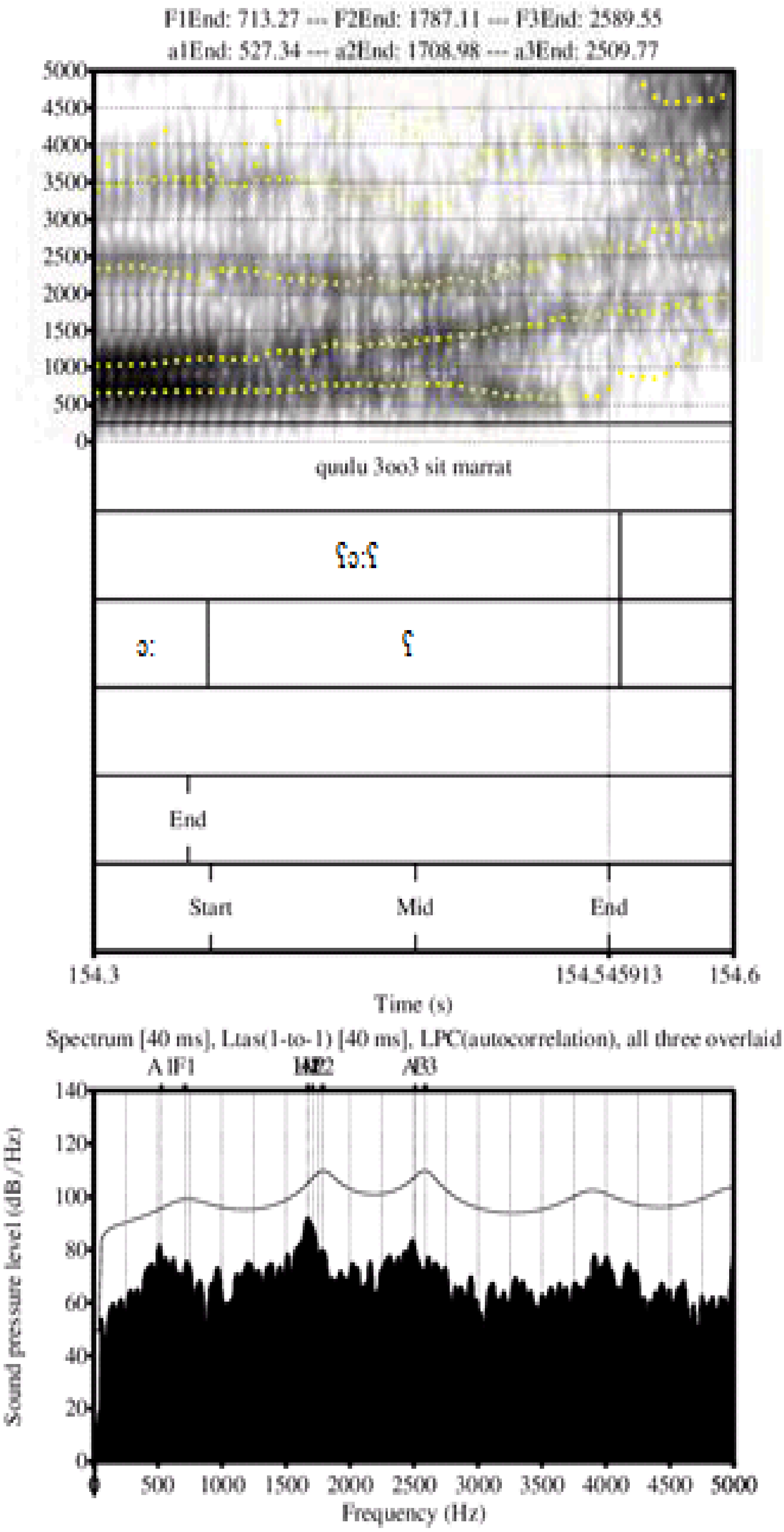


Figure 5.15: A spectrogram and spectrum of a final pharyngeal /ʕ/ in the same word 3oo3 [ʕɔːʕ] 'yuk! of Figures (5.3, 5.4) as produced by an IA male speaker from Mosul and realised as a voiced approximant. The spectrum has undergone pre-emphasis.

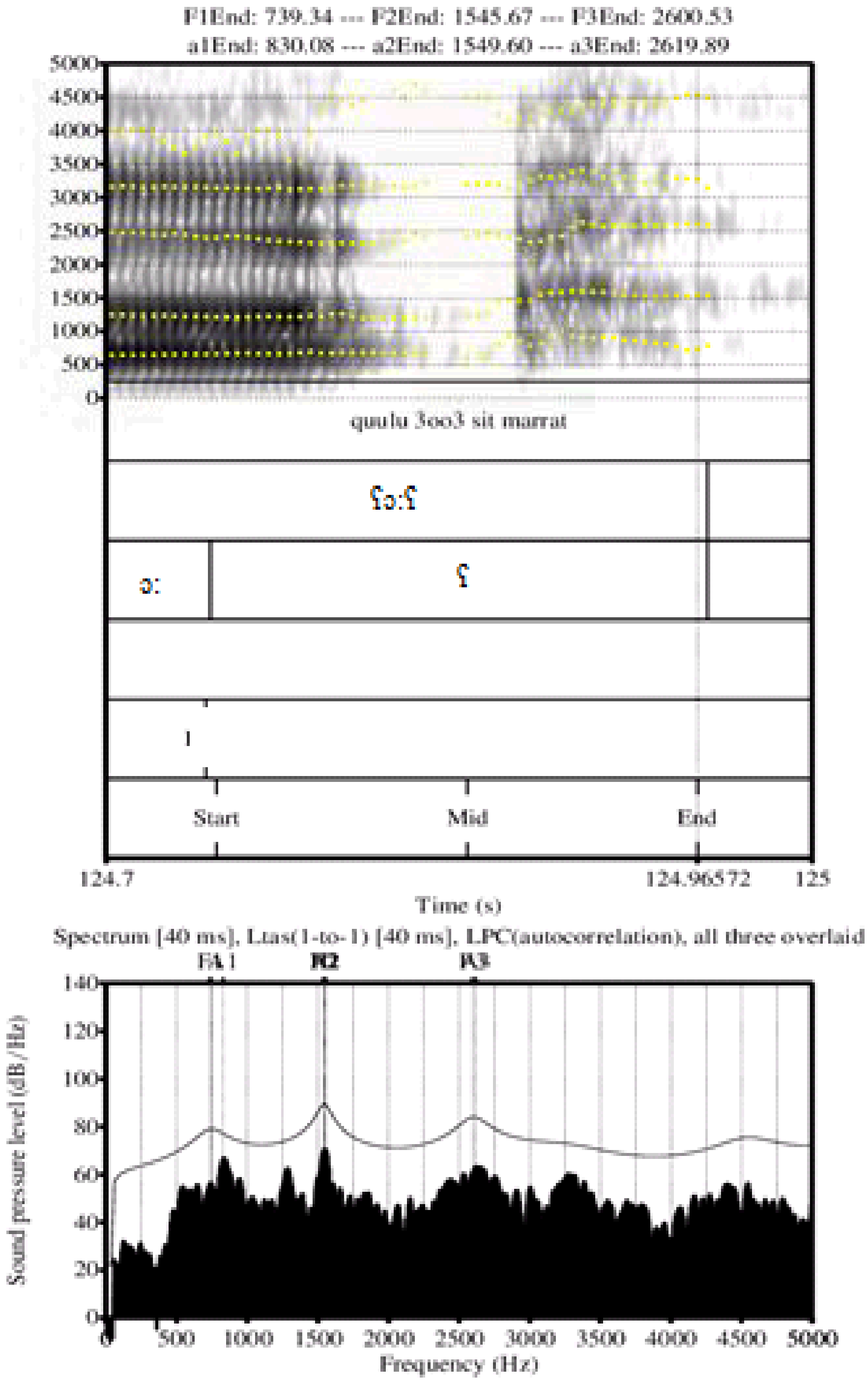


Figure 5.16: A spectrogram and spectrum of a final pharyngeal /ʕ/ in the same word 3oo3 [ʕɔ:ʕ] 'yuk!' of Figures (5.3, 5.4, 5.5) as produced by an IA male speaker from Mosul. The sound is a voiceless stop. The spectrum has undergone pre-emphasis.

In comparing results of pharyngeal consonants /ħ, ʕ/ with glottal consonants /h, ʔ/ within the same environments, Butcher and Ahmad (1987: 168) found that no change is shown for the glottals while for pharyngeals there is: a rise in *F*1 of all vowels, a rise of *F*2 in back vowels particularly /u:, u, o:/, and a drop in *F*2 of front vowels particularly short ones /i, a/, which tend to have values of *F*2 lower than those in glottal environments.

5.6 Nasalisation in Pharyngeal consonants

Research on various languages suggests that pharyngeal consonants tend to be accompanied by nasalisation of the adjacent vowel. The effect seems to be strongest in the production of Iraqi speakers.

One of the first studies associating pharyngeal consonants with nasalisation of the following vowel is by Hetzron (1969: 70), who investigated South-Ethiopic languages and sometimes found non-etymological *n* s at the end of an initial syllable as in the following examples: in Amharic [*and*] 'one' (originating from /*a ħad*/), [*ənqəfat*] 'obstacle' (old root /*ʕqf*/), Western Gurage [*änqʸäfä-*] 'he embraced' (old root /*ħqf*/), [*anqʸä*] 'after' (from /*ħaq*$^{(w)}$/). Hetzron (ibid: 71) went on to investigate why this *n* appears in certain places and not in others. He found that in most of these cases the *n*'s occurred in LVC contexts (Laryngeal + Vowel + Consonant) that used to contain one of /ħ ʕ/ followed by a vowel and then a consonant (other than m, n, r, and l). The pharyngeals /ħ/ and /ʕ/, which Hetzron calls L1 (Laryngeal 1), were "reduced" to the laryngeals /h/ and /ʔ/, which he calls L2 (Laryngeal 2), respectively **(*ħ*→ *h* and *ʕ* → *ʔ* ($L_1 \rightarrow L_2$)).** Following that process an *n* appeared between the vowel and the following consonant as in:

$$\# L_1VC \rightarrow \# L_2V\textit{n}C$$

Hetzron (ibid) believed that the insertion of these *n* s between the vowel and the following consonant has some connection with the reduction of pharyngeals; however, he also believed that in reality no *n* has been inserted but a homorganic nasal which in some cases tends to be m before b and f, suggesting that there must be a relation between the pharyngeals *ħ* and *ʕ* and nasality. By exploring the potential reason for the nasals in these contexts, Hetzron found a connection with Semitic languages, particularly that of Arabic, through a correspondence with Delattre (ibid: 71-72). In his reply to Hetzron (1969: 72), Delattre stated that in order to find out if there is a physiological explanation behind vowels being nasalised after /ʕ/ and /ħ/ but not after /ɣ/ and /x/, he used motion x-ray pictures of all these consonants in intervocalic position between /i/, /a/ and /u/ vowels produced by a native Iraqi Arabic speaker. After studying the motion film and each frame for /ʕ/ and /ħ/ separately, Delattre found that all articulations of /ʕ/ and /ħ/ shared three motions irrespective of the preceding or following vowel: (a) a sharp movement of the root of the tongue backwards toward the lower part of the pharyngeal wall; (b) a significant raising of the larynx (by about 8 mm after /i/, 13 mm after /a/ and 15 mm after /u/); (c) a lowering of the uvula "far down along the root of the tongue and curled up its tip as if to vibrate".

On the above lowering of the uvula, Delattre (Hetzron, 1969: 72-73) gives a speculative reason relying on motion-picture x-rays of French /R/, which is produced with a pharyngeal constriction, where the tip of the uvula lowers towards the tongue just above the constriction. However, in producing the French /R/, the constriction is high in the pharyngeal passage so the uvula tip easily reaches the tongue without causing a velic opening. But in the case of /ʕ/, the tip of the uvula lowers in an effort to reach the point which is best for vibration which lies along the tongue root and is just above the constriction. This would mean the uvula needing to lower very far down to reach the pharyngeal constriction of /ʕ/ and therefore forcing the velum to "leave the rhino-pharyngeal wall" creating a velic opening similar to that of nasal vowels in such languages as French. Delattre (ibid: 73) presumes that if no velic opening is found in the Arabic /ɣ/, it is due to the high position of the pharyngeal constriction; therefore, similar to French /R/, the uvula reaches the tongue just above the constriction without forcing the velum to leave the rhino-pharyngeal wall thus no velic opening is caused.

Based on Delattre's description above, Hetzron (1969: 73) concluded that the production of ħ and ʕ has "something in common with nasality" and that when the Cushites learned Semitic, they tried to pronounce these consonants, which were unfamiliar to them, by relying on their acoustic impression and interpreting them as being nasalised then shifting nasality to the following vowel. This vowel was later "decomposed" into 'vowel + nasal consonant' as follows:

 # *ħ/ʕ* + V + C → # *h/ʔ* + Ṽ + C → # *h/ʔ* + V + *n* + C

In another interesting connection between /ʕ/ and /n/ is that made by Mahdi (1985: 74) which he calls "the occurrence of /n/ as a reflex of /ʕ/" giving it the Arabic term Al-'istinṭa:' [ʔalistintˤaʔ] derived from the word *'anṭa* [ʔantˤa] 'he gave'. In Mahdi's (1985) descriptive study of the spoken Arabic of Basra, he states that this is a phonological feature that occurs in Basri Iraqi Arabic in one word [ʔantˤa] (Classical Arabic [ʔaʕtˤa]) and its derivations, thinking from first sight that it happened due to the influence of /tˤ/ when /ʕ/ is voiceless. Not all researchers agree with this sequence of events though, with Rabin (1951: 32) stating that the condition in Arabic suggests that *'anṭa* [ʔantˤa] (the causative of *naṭa* [natˤa]) was the older word later replaced in the East by *'aṭa* [ʕatˤa] (the synonym of *naṭā* [natˤa:]) possibly after the meaning *naṭa* [natˤa] "had become too specialised". In his investigation of the dialect of Yemen, Rabin (ibid: 31) suggests that the change from *'aʕṭa* to *'anṭa* has turned [ʕ] into [n] or emphatic [ṇ] influenced by [ṭ] due to that fact that [ʕ] normally has a nasal element associated with its articulation and that under the influence of some neighbouring consonants the nasal is what remains of [ʕ]. He calls this nasal element a nasal twang which is heard in the speech of Palestinian Arabic (ibid: 32). Rabin (ibid) lists some

Arabic dialect regions where the word *'anṭa* is common such as Baghdad, Southern Iraq, Nablus in Palestine and the ʻAneze in the Syrian desert. In fact, Rabin believes that the change from *'anṭa* to *'aʕṭa* has come full circle with the original word being *'anṭa* which turned into *'aʕṭa* then later changed back into *'anṭa* in the dialects stated above, but where *'aʕṭa* was kept by others such as the Yemeni dialect which only uses [ʕ].

Laver (1980: 46) draws a connection between pharyngealisation or pharyngeal constriction and nasalisation. In his view, pharyngalisation is attained by two lingual settings: pharyngalised voice, which covers constrictions of the middle of the pharynx, versus laryngo-pharyngalised voice, which covers constrictions of the lower pharynx and upper larynx. In both cases there is a backward and slightly downward movement of the "centre of mass" of the tongue. He (ibid: 46-47) adds that there is yet an existing auditory difficulty in distinguishing between the two because other physiological and acoustical occurrences tend to accompany any constriction in the pharynx such as a lowering of the larynx leading to a breathy-like phonatory setting, and because the velum is attached to the tongue by the palatoglossus muscle, the velum tends to be pulled downwards resulting in some nasalisation. Ohala (1975: 300-301) provides two reasons for having nasalised glottal and pharyngeal obstruents:

> an open velopharyngeal port would not prevent the build-up of air pressure behind the glottal or pharyngeal constrictions since it is in front of those constrictions, and the noise produced by voiceless glottal and pharyngeal obstruents is so diffuse, so low in intensity, and with higher frequencies dominating in the spectrum that oral-nasal coupling would have little acoustic effect on it…

In a study of Back Consonants and the Backing Coarticulation in Arabic, Ghazeli (1977) investigated the productions of 12 adult males speaking a variety of Arabic dialects but studied one speaker for the articulatory (cinefluorographc film) and oral and nasal airflow (Electro Aerometer) experiments, and the rest of speakers for the acoustic spectrographic analysis. On the movement of the velum during the production of pharyngeal consonants, Ghazeli (1977: 39) notes that "one of the most elusive tasks is to delineate" this aspect. He (ibid) adds that in addition to its normal raising and lowering movement, the velum stretches in a way as if there is a pulling downward of its lower tip, leading him to believe that it could not stay closed with so much stretching. After further investigation of the velum's movement, it became clear to Ghazeli (ibid: 39) that the upper posterior tip of the velum moves down the pharyngeal wall but remains in contact with it. Ghazeli (ibid: 41) also measured nasal airflow during the articulation of pharyngeals and found no nasal leak. He (ibid: 41) found that the average nasal airflow for [ʕ] and [ħ] was 0.002 litres/min, which was similar to that of the voiceless fricative [s] where no velic opening was present. In comparison, nasal airflow in the nasals [m] and [n] was between 8 and 15litres/min and in vowels adjacent to nasal consonants between 5 and 12 litres/min. Ghazeli (ibid) confirms that despite having a small area of contact between the velum and the pharyngeal wall, there was a complete closure. However, these conclusions are only based on investigating nasal air-flow within the production of one of his Tunisian speakers (himself) although one of his speakers was an Iraqi. Ghazeli (1977: 41-42) concluded that Delattre's subjects may have had the same velum movements as his but led Delattre to believe the presence of a nasal leak.

In a physiological and articulatory investigation of pharyngealisation in the spoken Arabic of Tripoli (Libya) in comparison with other dialects, Laradi (1983) used different instrumental techniques (video-endoscopic and video-fluorographic recordings, spectrographic analysis, palatographic and airflow measurements) and speakers from different backgrounds (three speakers from Tripoli in Libya, one speaker from Basra in Iraq and one from Hadramaut in Yemen). According to Laradi (ibid: v), pharyngealisation "refers to all sounds whose main articulatory requisite is a constriction in the pharyngeal cavity". Her (ibid) main focus was on the two pharyngeals /ħ, ʕ/ where her study was mainly concerned with their articulation, controversies surrounding the manner and place of articulationof /ʕ/, and the connection with nasalisation during /ħ, ʕ/ production.

On producing /ħ/ in Libyan Arabic, Laradi (1983: 123) found that the tongue was slightly lowered, the root of the tongue retracted towards the back of the pharynx causing a narrowing at the oropharyngeal cavity and creating a constriction between the epiglottis and the pharyngeal wall. There was also a rise in the larynx, a lowering of the jaw, and raising of the velum. However, only a small part of the velum was partially in contact with the nasopharynx while the rest of it seemed to be away from it. When comparing /ʕ/ with /ħ/, Laradi (ibid: 123) did not find much difference between them in as far as the shape of the tongue. The jaw was lowered. The root of the tongue was horizontally displaced. The constriction between the root of the tongue and the back wall of the pharynx was greater at the level of the epiglottis, but not as great as that for /ħ/ (ibid: 126). The larynx was raised higher in /ʕ/ than in /ħ/, creating a narrower laryngo-pharyngeal cavity. The velum was raised with a partial closure but with a firmer contact for /ʕ/ than that for /ħ/ (ibid: 126).

Xeroradiogram results of /ʕ/ in intervocalic position as in the word [maʕʕana] 'with us' for the Yemeni speaker showed a lowering of the velum due to the presence of the nasal sound (Laradi, 1983: 129, 306). However, there was no lowering of the velum during the production of /ħ/ in the word [naħħa] 'he moved' for the same speaker despite the presence of a nasal consonant. Laradi (ibid: 306) justified the difference of movement of the velum in the two pharyngeals within these two utterances as being due to the presence of the following rather than the preceding nasal consonant. Investigations of /ħ/ for the same Yemeni speaker showed nasal airflow occurring only within nasal contexts and only when /ħ/ was in initial and final positions (ibid). One of the Libyan subjects, on the other hand, had variable amounts of nasal airflow in all productions of /ħ/ whether within nasal or non-nasal contexts. For this speaker, however, there was less nasal airflow for /ʕ/ than for /ħ/. These results might well indicate dialectal differences since variation occurs in one dialect and not the other. However, there is also the possibility of individual variability because these results have been obtained from one subject from each dialect and cannot be generalised on other speakers of the same dialects. Laradi's (1983: 132) results from videofluorographic investigations showed the following:

1- For both pharyngeals in initial position within nasal contexts (e.g. [ħilim] 'dream' and [ʕilim] 'reality') the velum is lowered but with more lowering for /ʕ/ than for /ħ/, while it is raised for /i/ in the same words (see figures 5.17 and 5.18).

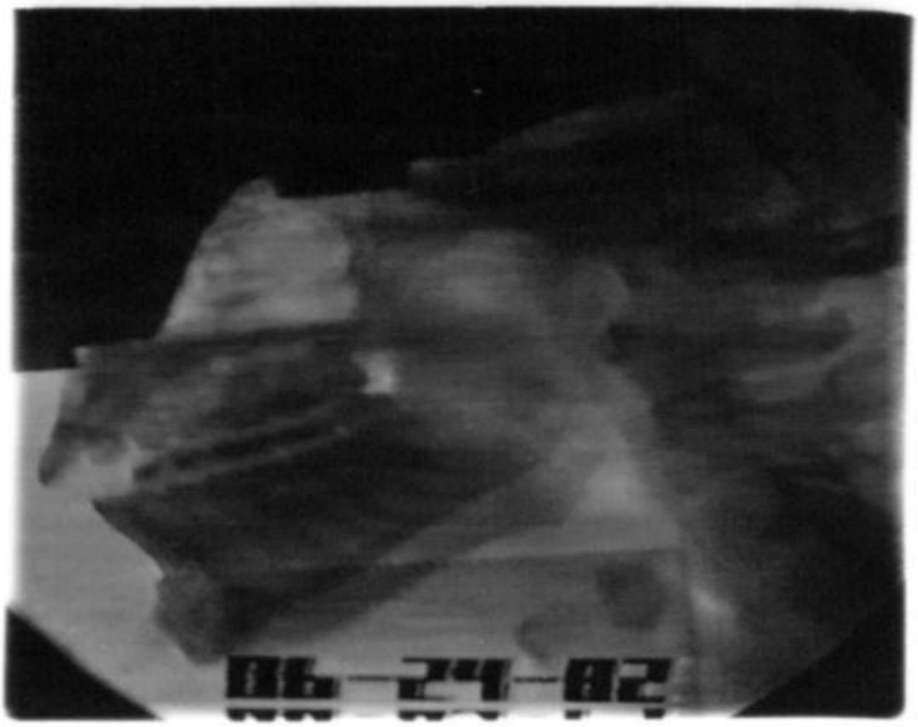


Figure 5.17: X-ray of the vowel /i/ in the word /ħilim/ 'dream' where the velum is lowered (Figure from: Laradi, 1983: 134).

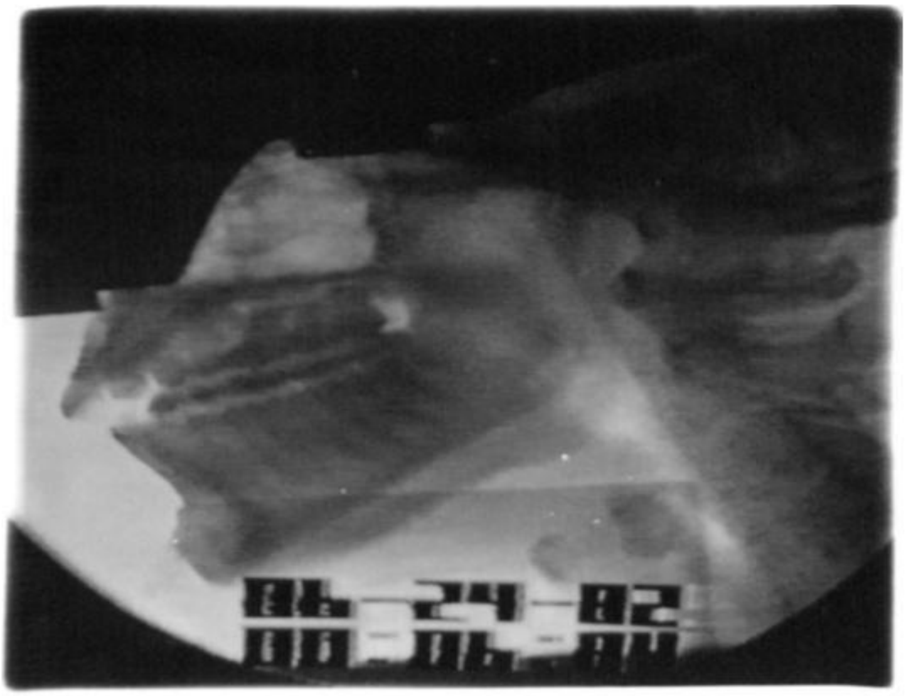


Figure 5.18: X-ray of the vowel /i/ in the word /ʕilim/ ‘reality’ where the velum is lowered (Figure from: Laradi, 1983: 134).

2- In non-nasal contexts produced by the Libyan speaker, e.g. [ʕi:d] ‘repeat’ and [ʕu:d] ‘stick’, /ʕ/ seems to have a lowered velum in both cases in spite of the absence of a nasal consonant (ibid: 130). Laradi (ibid) explains this by stating that pharyngeals are generally produced with a lowered velum and because the consonant was initial and produced following a pause where the velum was already in a lowered state, so during the consonant the velum maintained its lowered position (figures 5.19 and 5.20).

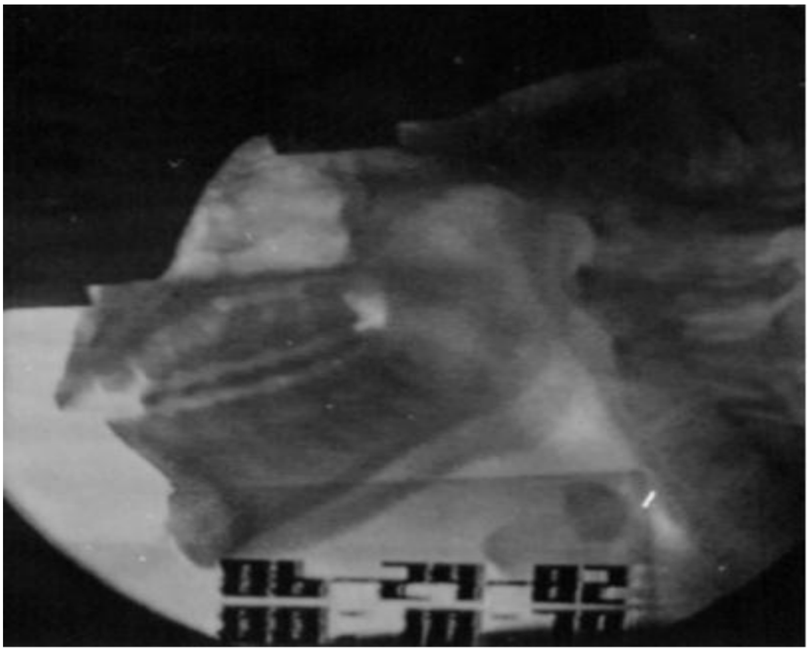


Figure 5.19: x-ray of the word [ʕi:d] ‘repeat’ produced with a lowered velum (Figure from: Laradi, 1983: 131).

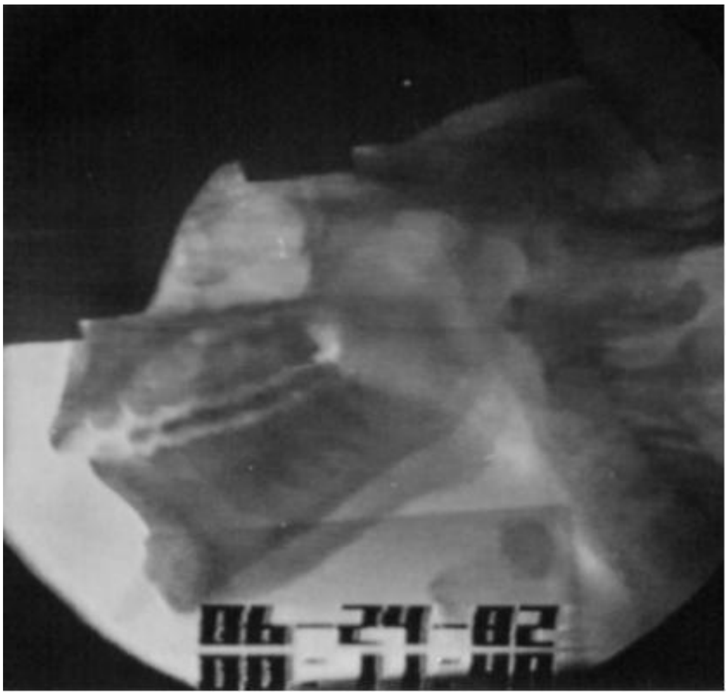


Figure 5.20: x-ray of the word [ʕu:d] 'stick' produced with a lowered velum (Figure from: Laradi, 1983: 131).

3- Also in non-nasal contexts, e.g. [ħadd] 'limit' and [ʕadd] 'counted', the velum seems to be in a more raised position in /ħ/ than it is in /ʕ/ (ibid: 136) (figures 5.21 and 5.22).

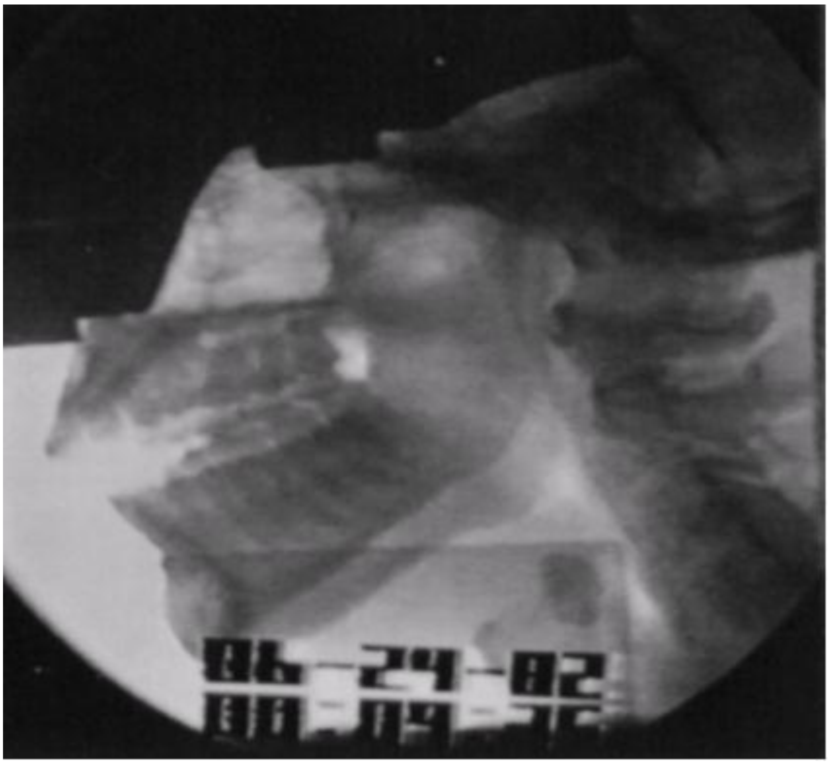


Figure 5.21: X-ray of the vowel /a/ in the word /ħadd/ 'limit' where the velum is raised (Figure from: Laradi, 1983: 139).

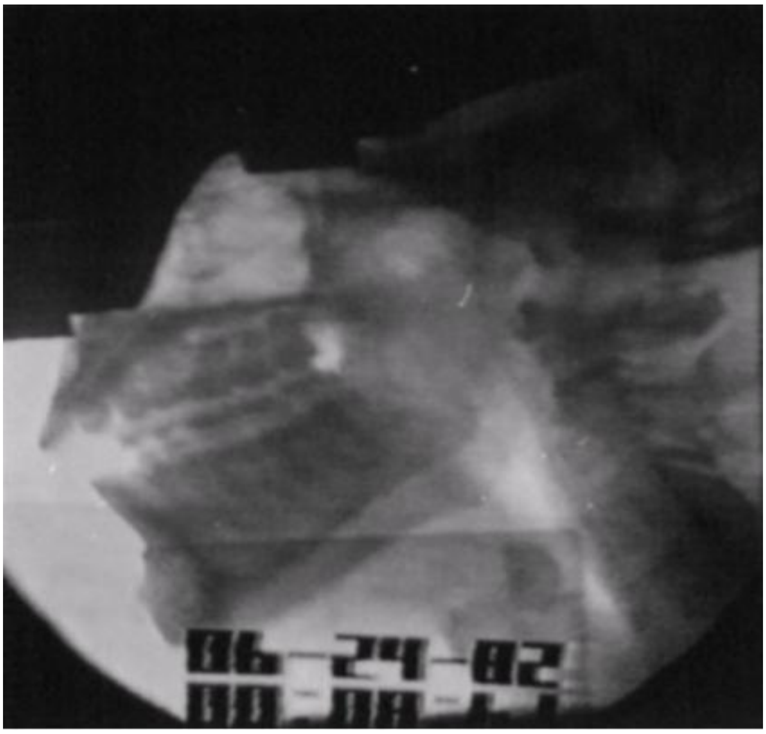


Figure 5.22: X-ray of the vowel /a/ in the word /ʕadd/ 'counted' where the velum is less raised than in /ħ/ in Figure (5.14) (Figure from: Laradi, 1983: 139).

4- Aerogram results of the nasal airflow for /ħ/ showed that one Libyan speaker had nasal airflow in all word positions and within nasal and non-nasal contexts, but that airflow did vary in the Yemeni speakers and was mostly present when /ħ/ was medial and geminated, e.g. /waħħada/ 'he united' (ibid: 161).

5- Although Laradi's (ibid: 306) results showed nasal airflow she confirms that there was no actual perceived nasalisation when pharyngeals were produced.

In a study of acoustic and aerodynamic characteristics of pharyngeal consonants in IA, Butcher and Ahmad (1987: 161) recruited three male subjects to read a list of mainly nonsense words in which /ħ/ and /ʕ/ occur at initial and final positions. In investigating nasal airflow, only one out of the three speakers had airflow during the production of /ħ/ where his mean peak value for nasal airflow in initial position was 240cm^3/s, but he had rare or minimal nasal airflow in final position. In syllable-initial position the speaker's production exhibited an amount of velopharyngeal opening where the faucal muscles were involved in the pharyngeal constriction and lowering of the velum (ibid: 167). The authors (ibid: 167-168) interpreted this result as being due to physiological events, mainly the involvement of the faucal muscles – the palatoglossi and the palatopharyngei - in the constriction of the pharynx and lowering of the soft palate.

It seems that despite all the suggestions above regarding velum lowering potentially taking place in the process of pharyngeal articulation, this process may be language, dialect or even speaker specific. The cross-dialectal comparisons conducted in the present research will investigate if one dialect has more nasalisation than the others. It will also compare dialects to find if a certain realisation of pharyngeals is dialect-specific. A connection between type of realisation and nasalisation will also investigate if a particular realisation is more nasalised than others.

5.7 Summary of Chapter 5

Chapter 5 dealt with an overview of how the two pharyngeals /ħ/ and /ʕ/ are described in the literature and how much controversy lies within the area of deciding the place and manner of articulation of the two sounds. There is not much disagreement on the part of /ħ/ which is mostly considered as a voiceless fricative except for a few researchers who consider it as an approximant. /ʕ/, on the other hand, has been labelled as a voiced fricative, a voiced approximant, a tight approximant, a voiceless stop or an approximant followed by a stop. Researchers also differ in deciding whether /ʕ/ is actually a pharyngeal or an epiglottal. In IA, most recent studies tend to regard it as epiglottal. Figures taken from the present study seem to confirm the fact that there is variation in producing pharyngeal /ʕ/ even within speakers of the same dialect or sub-dialects. The variation may even be speaker specific. A number of studies have also found the pharyngeals, especially those of different Arabic dialects, to be produced with accompanying nasal airflow suggesting nasalisation. Some of these studies have confirmed the presence of nasal airflow but say that no audible nasalisation was heard. Some of these findings have included speakers of IA among others but do not show consistency within all speakers. This might also suggest speaker specific patterns.

Chapter 6 : Methodology

6.1 Introduction

This chapter will deal with the methods adopted in this study. It will tackle each part of the investigation starting from selecting the speakers, constructing the stimuli, carrying out the recording sessions, processing and segmenting the recordings, and analysing the data using auditory and acoustic measures.

6.2 Purpose and Rationale of Study

As was mentioned in Chapter 1, the present study aims to investigate two voice quality settings, velopharyngeal (nasalisation) and laryngeal (phonation types), in the speech of IA speakers. This was driven by suggestions in the literature that associate the production of pharyngeal consonants, particularly stops, with features of nasalisation and creaky voice. There are also reports of different realisations of pharyngeal /ʕ/ in IA, with a stop being most common. Therefore, this study will offer a detailed account of the different realisations and properties of pharyngeal fricatives and establish a connection, if any, between certain realisations and the above two VQ settings. Finally, the study aims to examine if these features and realisations are dialect-specific or even more generally a peculiarity of IA. To investigate these matters, the present study is set to answer the following questions:

1- *What are the auditory and acoustic properties of pharyngeal consonants in Iraqi Arabic and are they coupled with nasalisation and laryngealisation as is suggested in the literature?*

2- *Are nasality and laryngealisation quality features of Iraqi speakers?*

3- *Does degree of nasalisation and laryngealisation vary between the three linguistic areas of Iraq, i.e. northern, central, and southern?*

6.3 Methods

The following is a brief account of the methods conducted to answer each research question.

1- Conducting a review of the literature on Iraqi Arabic and on the description of pharyngeal consonants as produced by Iraqi speakers as well as speakers of other Arabic dialects and languages. The review is followed by an acoustic and auditory investigation aimed at obtaining a description of the two pharyngeals, creating a profile of their different realisations, and finding out if nasalisation and laryngealisation are features accompanying their production.

2- Conducting a review of the literature on nasalisation and phonation types as described by the literature. The review is followed by an auditory and acoustic investigation of nasalisation and laryngealisation cues to find out if these vocal settings are merely associated with pharyngeal consonants, are a feature of a particular dialect, or are VQ features of IA speakers in general.

3- Investigating cross-dialectal differences due to the fact that studies that have investigated nasalisation in pharyngeals were applied on different Arabic dialects, including Iraqi Arabic. Results showed variation among speakers of these dialects with some showing a lowering in the velum denoting nasalisation. In addition, Iraqi speakers participating in these dialects were from different Iraqi dialects and not all of them showed the same results. Due to major variation between dialectal groups of IA as was discussed in Chapter 2, it is essential to investigate how speakers of the three dialects chosen in the present study produce pharyngeal sounds, whether these sounds are accompanied by vocal settings of nasalisation and laryngealisation, and if so whether these settings are dialect- or speaker- specific. This will be obtained by conducting an auditory and acoustic investigation of cues of both features in the productions of speakers of the three dialects under investigation to find if they are specific of one or more of these dialects.

6.4 Speakers

For the purpose of this study, 35 Iraqi participants (13 females and 22 males) were chosen as speakers from a population of Postgraduate students and their spouses living in the UK for not more than two years in order to minimise the influence of English on their phonology/speech patterns. However, due to a number of reasons not all recordings were alaysed: 1- some speakers were unable to produce the written form in their dialect because they are used to seeing Arabic written in its Standard form; 2- others struggled to produce the vowel in its isolated form; 3- many of the recordings which were produced in the speakers' homes had background noise; 4- some of the Mosuli speakers did not speak the *qeltu* dialect. Therefore, recordings of only *nine* male speakers were used, with each three representing an IA dialect. There were three speakers from the Northern (Upper Iraq) *qeltu* dialect of Mosul, three from the Central *gelet* dialect of Baghdad, and three from the Southern *gelet* dialect of Basra. All nine speakers were Muslims, aged between 30 and 50 years old, had been living in their home-towns all their lives except for the time they studied in the UK, and used to work as university lecturers before the start of their study. The speakers had no known voice disorders or vocal-nasal apparatus problems.

It should also be noted that although speaker specific variation is not within the focus of the present study, any variability will be referred to and discussed in relation to the overall results with recommendations for future work.

6.5 Target Segments and Contexts

All stimuli consisted of monosyllabic real words with a CVC context, where V is either a long vowel, one of /iː, ɛː, aː, ɔː, uː/, or a short vowel, one of /ɪ, ɛ, ʌ, ʊ/ (see Chapter 2), and C is one of three: a nasal stop /m, n/, a pharyngeal /ʕ, ħ/, any other consonant (table 6.1). Words with a nasal environment were needed to investigate the effect of true/target nasals on surrounding vowels. They will also be considered as control environments. The degree of nasalisation was also investigated in nasal contexts to measure whether nasalisation effect was progressive or regressive. Words with a pharyngeal consonant in either position were included to investigate whether these consonants in IA have accompanying nasalisation as was suggested in the literature (see Chapter 5), and if so, whether its effect was similar to that of nasal contexts both in terms of degree and direction of influence. As with the nasal context, the effect of pharyngeals was investigated in an environment with pharyngeals in one position of the word, with the other consonant being an oral (i.e. pharyngeal-oral or oral-pharyngeal). Another pharyngeal environment was investigated whereby target words have both a nasal and a pharyngeal (i.e. nasal-pharyngeal and pharyngeal-nasal) in order to investigate whether nasalisation increases in such an environment compared with a nasal-nasal, a nasal-oral or oral-nasal environment. The fourth environment consists of two oral consonants (oral-oral) in order to investigate whether nasalisation and/or other VQ features (e.g. breathy or creaky phonations) still occur in such cases where no nasal consonant was present and if so, whether it was due to individual (speaker specific) or linguistic (dialect specific) reasons. For similar reasons, the last environment included was one investigating long vowels in isolation though still produced within the carrier sentence frame. These last two environments, oral-oral and isolation, will be considered as control environments similar to nasal ones.

The process of deciding on the environments, the consonants to be included, and the number of test-words and vowels required running a pilot study. These are detailed below.

Table 6.1: CVC contexts, their abreviations and examples.

Context	Abbreviation	Example1	Example2
nasal-vowel-nasal	NVN	*naam* /naam/ 'he slept'	*miim* /mi:m/ 'the letter *m* in Arabic'
nasal-vowel-oral	NVC	*maas* /ma:s/ 'diamond'	*mel* /mɛl/ 'he got bored'
oral-vowel-nasal	CVN	*xaam* /xa:m/ 'raw material'	*been* /bɛ:n/ 'between'
nasal-vowel-pharyngeal	NV(ħ/ʕ)	*noo3* /nɔ:ʕ/ 'type'	*naa7* /na:ħ/ 'he wept'
pharyngeal-vowel-nasal	(ħ/ʕ)VN	*3oon* /ʕɔ:n/ 'a helpful hand'	*7oom* /ħɔ:m/ 'a group of prey birds'
pharyngeal-vowel-oral	(ħ/ʕ)VC	*7aal* /ħa:l/ 'situation'	*3iid* /ʕi:d/ 'bring back'
oral-vowel-pharyngeal	CV(ħ/ʕ)	*laa7* /la:ħ/ 'was able to reach'	*baa3* /ba:ʕ/ 'he sold'
oral-vowel-oral	CVC	*baab* /ba:b/ 'door'	*beet* /bɛ:t/ 'house'

6.6 Piloting the Word List

The original list of potential target words consisted of 702 real words. Standard Arabic script was used with no diacritics or vocalisations. However, due to differences of use and familiarity with certain words by speakers from different parts of Iraq, the words were piloted in order to keep the most familiar ones to all three dialect speakers; this helped decrease the list while keeping the range of consonants and contexts needed for investigation. This was carried out by asking one speaker from each dialect to go through the test items and record them, each in a separate session. Words that were identified by either speakers as unfamiliar or not used in their dialect were excluded. As a result, the list consisted of 232 words. It contained monosyllabic words of CVC structure with V being one of the five long vowels /i:, ɛ:, a:, u:, ɔ:/ or one of the four short vowels /ɪ, ɛ, ʌ, ʊ/. For the analysis, some words were later left out because when the list was first compiled the intention was to include as many words with the target consonants as was possible, so there had to be a balance of included contexts although the number of examples from each vowel context was still uneven. Therefore, the final analysed list consisted of 122 words (see Appendix A), with five long vowel contexts containing /i:, ɛ:, a:, u:, ɔ:/ where each long vowel was repeated twice, once in the word context and once in the isolated-vowel context (as mentioned above), and four short vowels /ɪ, ɛ, ʌ, ʊ/ only produced once (tables 6.1 and 6.2), making a total of 206 utterances. However, the number of tokens for each vowel remained uneven due to a combination of reasons, including differences in the frequency of each vowel in this particular environment (CVC) and the need to discard tokens which were rejected by participants, but most of all due to the fact that all words were real because it proved very difficult for speakers to produce nonsense words.

Table 6.2: Number of tokens produced by each speaker and all speakers divided into categories.

Type of segment	Length of Vowel	Vowel	Total for each speaker	Total for all speakers
vowel	long	a:	33	297
		ɔ:	11	100
		ɛ:	11	99
		i:	14	126
		u:	15	134
	short	ɛ	20	180
		ɪ	6	54
		ʊ	4	36
		ʌ	8	72
isolation	long	a:	33	297
		ɔ:	11	100
		ɛ:	11	99
		i:	14	126
		u:	15	134
Total			206	1854

6.7 Stimuli Slides

Targets were presented without any diacritics to encourage both a dialectal and natural production since having diacritics would suggest a standard version of Arabic. Therefore, to gain consistency in the realisation of vowels in words which may have more than one possible vowel realisation, most words (which had an English equivalent) were provided with English translations when presented to the speakers on screen. Each word was presented within a carrier sentence '*quulu ... sit marrat*' (Say …. six times); sentences with target long vowels were repeated three times: first with the full CVC, second with only the CV part, and third only the V. This was done in order to help the speakers gradually isolate the vowels instead of suddenly asking them to produce a vowel in isolation. They were asked to produce the vowel as it was produced in the CVC word and not as an Arabic letter. Sentences with target short vowels were produced once (in the CVC form). The resulting recorded list of each speaker was 702 utterances.

Since Arabic speakers are not familiar with vowels in isolation or might produce them in an Arabic standard pronunciation, the researcher adopted another technique following Al-Tamimi (2007a, 2007b). This consisted of asking the speakers to repeat the word within the carrier sentence three times. The first repetition included the target-word (CVC) written fully in red, the second only the first syllable (CV), and the third only the vowel (V). The speakers were asked to read the carrier sentence and then only the sections of the word that were highlighted in red. That procedure aimed to help the speakers produce the 'same' vowel in isolation as they had attempted in a word context. For example, the speakers saw the target vowel *aa* [a:] in the following contexts in figures 6.1-6.3:

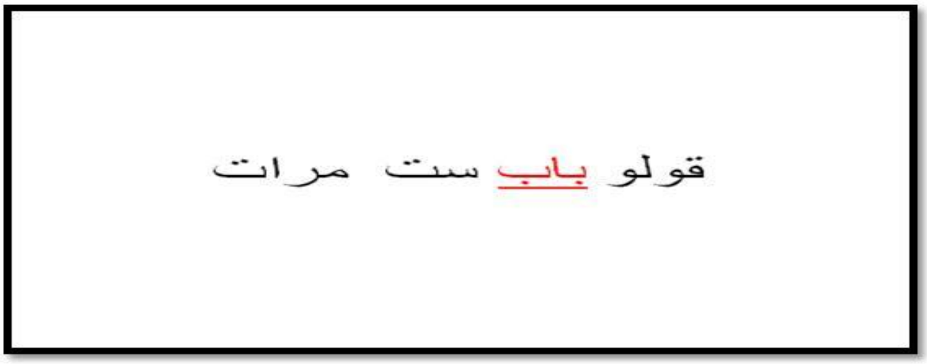


Figure 6.1: The sentence *quulu baab sit marrat* 'say door six times', with the whole target word highlighted in red.

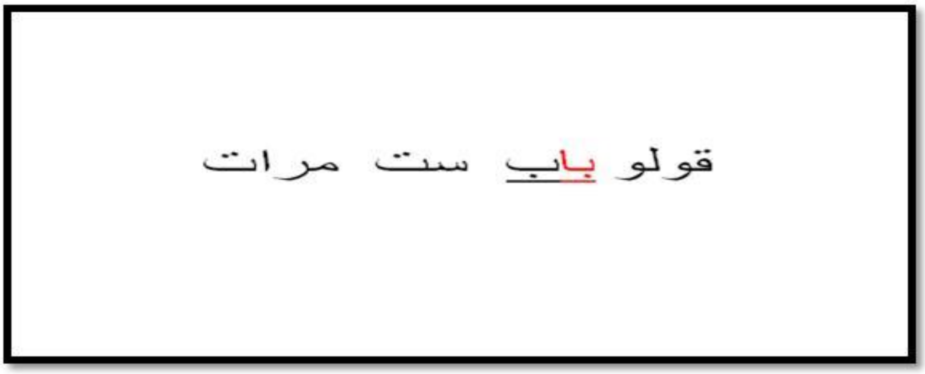


Figure 6.2: The sentence *quulu baab sit marrat* 'say door six times', with only CV highlighted in red.

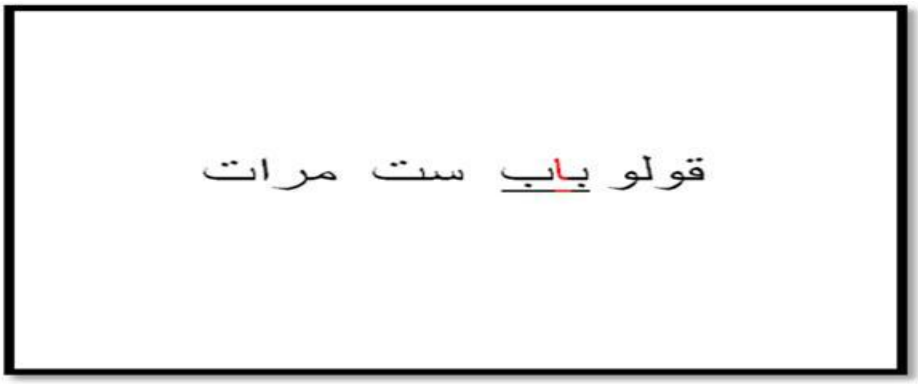


Figure 6.3: The sentence *quulu baab sit marrat* 'say door six times', with only the vowel highlighted in red.

The above procedure was applied to words with long vowels, with the aim to only use the first (figure 6.1) and third (figure 6.3) productions of the long vowels in the analysis. Words with short vowels were presented once, since diacritics were not included and therefore could not be highlighted in red as for long vowels (figure 6.4). The target words were randomised and presented in power-point slides with one sentence each. The slides were presented in two groups to provide a short break for the speakers during the recording sessions.

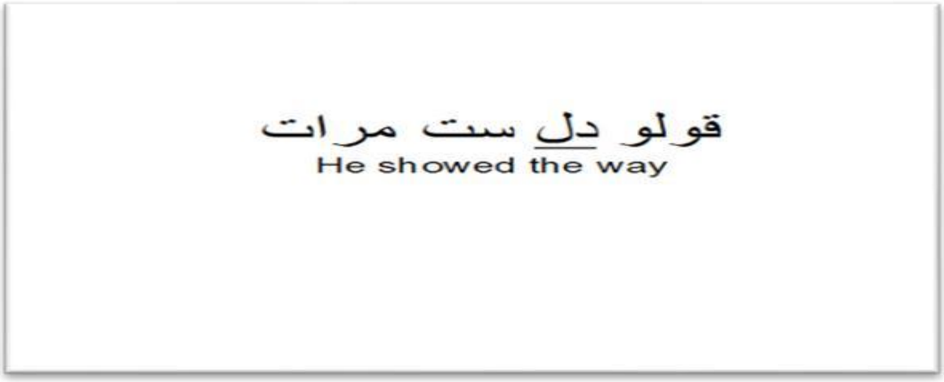


Figure 6.4: The sentence *quulu del sit marrat* 'say guide six times'.

6.8 Recording Techniques

The following section will deal with the procedures that took place during the recording sessions and what tasks the participants were asked to do.

Recording sessions were made in two different contexts depending on the city of residence of the speakers in the UK. Most speakers based in Newcastle upon Tyne were recorded at an audio-visual laboratory at Newcastle University. Due to shortage of speakers from Basra, subjects had to be located in another UK city, Swansea/Wales, where no accessible lab facility was available and speakers were located in their homes; therefore, for these speakers a high quality digital voice-recorder (Type: Edirol R09) with an external microphone (Type: Sony Electret Condenser, Model: ECM-MS907) was used to carry out the recordings.

In the lab and at the subjects' homes, recordings were carried out where the speaker was seated in front of a high-quality microphone attached to the recorder. In front of the speaker was a computer screen showing the power-point slides. The researcher explained the task and the differences between test-words and how many times they will be seen on screen. The speakers were asked to read a few sample-words chosen arbitrarily from the test-items in order to demonstrate their understanding of the task.

Because each slide only contains one sentence, the researcher was in control of moving on to the next slide after making sure that the speaker had produced the target words in the proposed manner. The recordings were later saved on a Portable Hard Drive as well as a CD for back-up. Finally, the recordings were subject to acoustical analysis using PRAAT (version 5.1.22) (15 December 2009: http://www.fon.hum.uva.nl/praat/).

6.9 Segmentation

Recordings were manually segmented before applying any acoustical analysis. In the process, both auditory and visual information were taken into consideration when deciding segmental boundaries, and as follows.

Because vowels and pharyngeal consonants were the main target in this investigation, a more detailed account of their segmentation will be presented here. In a vowel following a consonant, the transitional portions were considered to belong to the vowel and not the consonant, but the vowel did not include any aspiration or friction of that consonant. Therefore, the beginning of a vowel was taken from the first pulse of vibration indicating the start of voicing. The beginning of the vowel was also based on the change of intensity where at the beginning of a vowel intensity tends to ascend to a certain level and stays stable until the end of the vowel. The end of the vowel was based on the decrease in intensity and the end of voicing; no voiceless portions following the vowel were included, which applied to cases where a vowel was in isolation (figure 6.5).

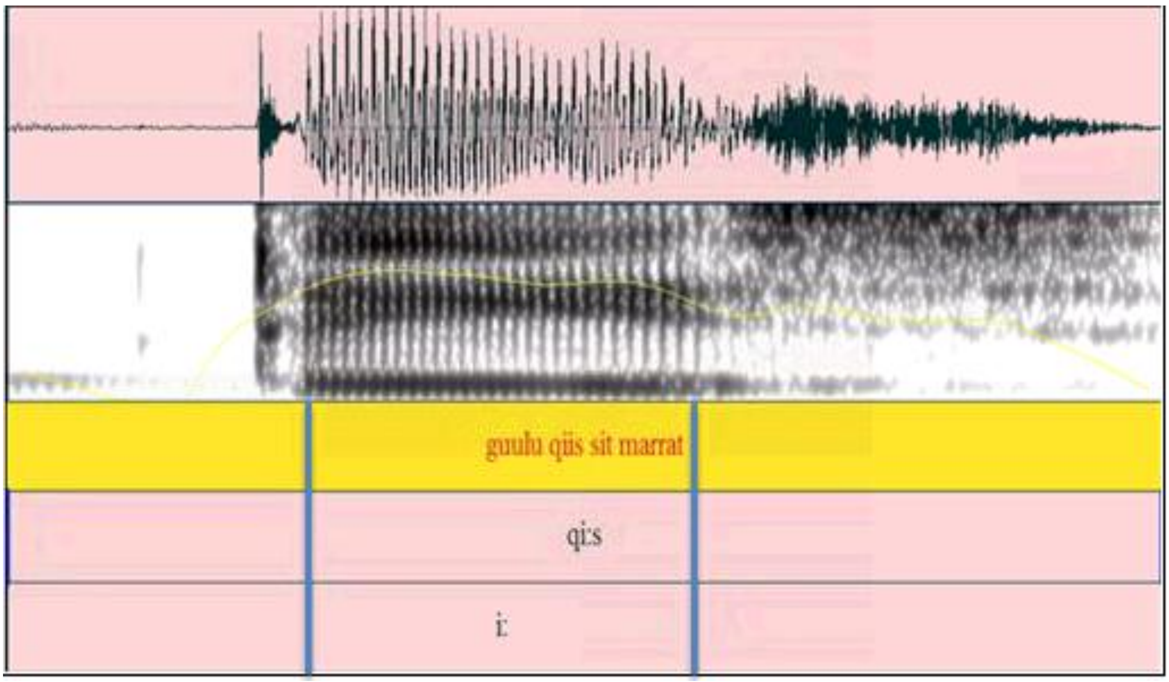


Figure 6.5: a spectrogram with a segmented long vowel between a stop and a fricative.

Only one type of consonant was needed for analysis and therefore for segmentation, the two pharyngeals /ħ, ʕ/. The variability in the realisation of the voiced pharyngeal fricative (see Chapter 5) required different criteria depending on whether it was realised as an approximant, a fricative or a stop. When visually inspecting the spectrogram, the following criteria were used to segment the pharyngeal at initial position: a- if the segment started with a burst preceded by a pause, the burst was considered as being part of /ʕ/ (figure 6.6); b- if the segment was not preceded by a pause or burst and had creaky-like instances, auditory information was used to decide the start of the pharyngeal (figure 6.7). In both cases the end of the pharyngeal was decided by the beginning of the pulses of the vowels and change in intensity. In final position, and in addition to auditory information, the pharyngeal started with the end of cycles of the vowels and change in intensity. The end of the consonant at this position coincided with the end of the creaky-like instances if the sound was realised as an approximant (figure 6.7) or the end of aspiration if the sound was realised as a stop (figure 6.6).

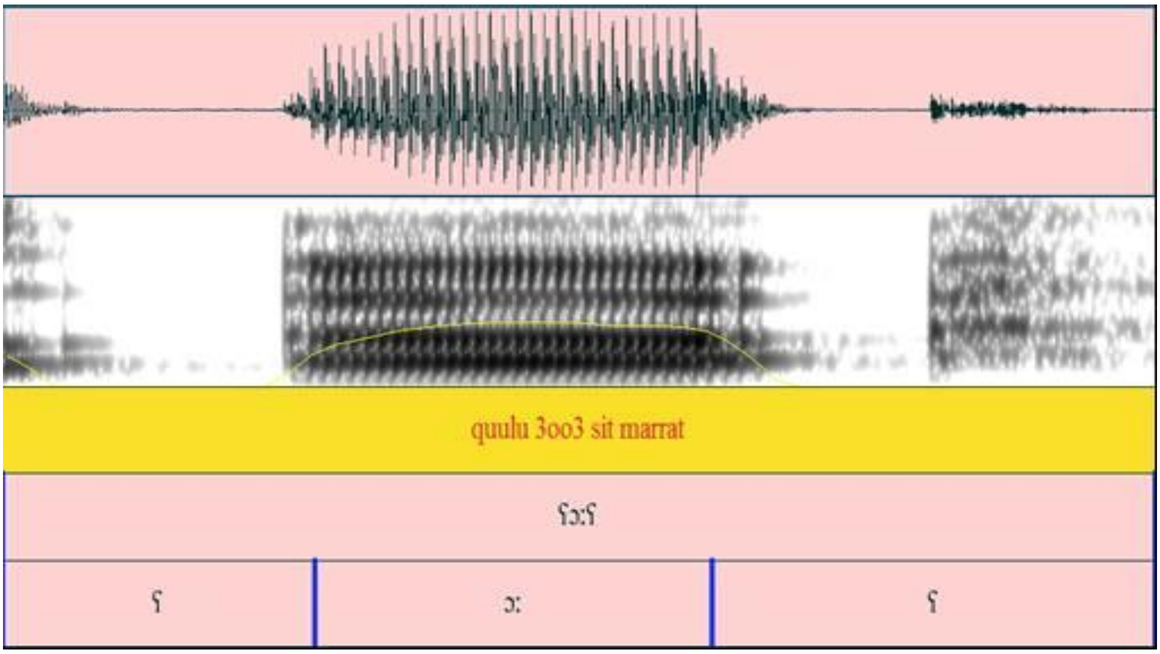


Figure 6.6: A spectrogram with a segmented CVC word containing two pharyngeals. It shows how the first pharyngeal is a stop so the pause and following burst and release are part of it and the second one is also a stop, showing a pause, burst and aspiration.

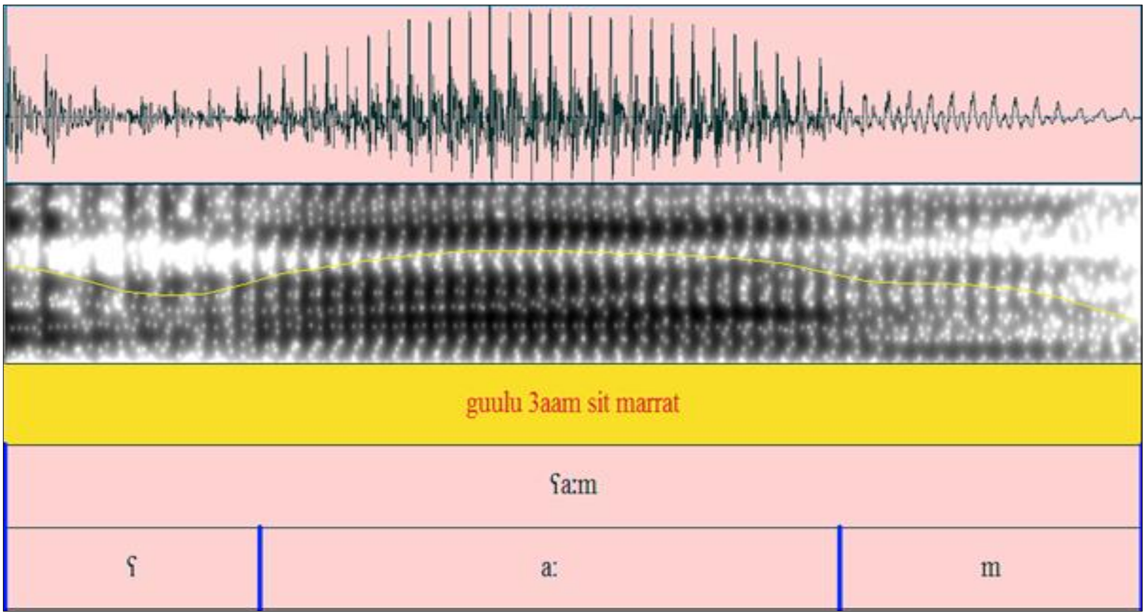


Figure 6.7: A spectrogram with a segmented CVC word containing an initial pharyngeal which is produced as an approximant with creak which extends into the vowel.

6.10 Auditory Analysis

Auditory analysis was carried out on three aspects of the data: the first was to determine how the pharyngeal /ʕ/ is realised within and across dialects due to the variation in realisation that this consonant has; the second was to determine if nasalisation occurs in non-nasal contexts, i.e. where no nasal is present, and if so how it compares to nasal-nasal, nasal-oral and oral-nasal contexts; the third was to determine what phonation types accompany the contexts above and whether there is any correlation between particular phonation types and certain linguistic contexts or speakers of a particular dialect. The first task resulted in a variety of scaled judgments where realisations of /ʕ/ were categories into: approximant, fricative, stop. The second task resulted in another variety of scaled judgments in which what was heard was categorised into the following three: *very nasalised*, *little nasalisation*, *no nasalisation*. The third task resulted in the following scaled judgments: creaky, breathy, modal.

All three tasks were repeated by the present researcher on 10% of the data in order to test the reliability of results. Results of the first task showed almost 100% agreement judgment on realisations of pharyngeal /ʕ/ (Appendix B). Only one token was judged as an approximant in test2 while it was judged as a fricative in test1. It was thought to have slight friction the first time. However, different results emerged for data judged on perceived nasalisation and phonation types. 44.45% of the re-tested data showed changes in perceived nasalisation, though the change was always from one category along the graded continuum to a neighbouring one (i.e. no token that was first heard as 'very nasalised' was later scored as having 'no nasalisation' and vice versa). Instead, some target vowels originally perceived (in test1) as 'very' nasalised were later perceived (in test2) as having 'little' nasalisation and the vice versa; and some judged as having 'little' nasalisation were later judged as having no nasalisation and vice versa (Appendix C). Auditory judgement of nasalisation generally proved difficult to perform, and the small scale used (with three categories only) did not allow for a more graded response, which left the 'little' category open to subjective interpretation.

Similarly, data judged on perceived phonation types showed 37.04% different results from the original test. What was first perceived as creaky voice was later perceived as being more modal-like and vice versa (Appendix D). This could be due to the fact that male speakers generally have low pitched voices which made it challenging to distinguish creaky from modal phonation. Note, however, that no confusions took place between the breathy category and either modal or creaky voice.

The relationship between pharyngeal realisation, word position, and nasalisation/phonation was also investigated. All auditory results were compared to the acoustic results.

6.11 Acoustic Analysis

Based on the definition adopted in this study (see Chapter 3), VQ can be measured by looking at acoustic consequences of laryngeal and supralaryngeal events carried out between the larynx and the end of the oral and nasal cavities. The following two sections will deal with the acoustic cues signalled by the two events and the form of relations combining them.

6.11.1 Methods of Measuring Acoustic Cues

A Praat script was used for the measurements detailed in this section. This was developed by Jalal Al-Tamimi (Al-Tamimi and Khattab, 2011; Al-Tamimi and Khattab, under review; partially adapted from Remijsen and Gilley, 2008; also found at: http://www.lel.ed.ac.uk/~bert/praatscripts.html). The script was applied on the segmented data, and results were generated in the form of Excel tables, manually checked for errors and later statistically analysed to meet the objectives of the study. Measurements of nasalisation and phonation types were carried out on the three vowel portions. First the data was down-sampled to 10 KHz, low-pass filtered (to 5 KHz) and pre-emphasised. Pre-emphasis was used to control for spectral tilt (Berger, 2007: 29). Accordingly, several 40ms Kaiser 2 (Gaussian-like) windows were generated in the three positions, from which several long term average spectra (LTAS) were generated from FFT spectra.

Acoustic measurements were applied at three vowel portions (onset, midpoint, offset) for the following reasons: a) in order to track changes at different positions; b) at midpoint, in order to reduce consonant influence (Trittin and Lleo, 1995) during what is presumably the most steady-state portion of the vowel where measurements would be less influenced by the voicing feature of neighbouring consonants (Klatt and Klatt, 1990: 829); the midpoint is also considered as the place at which the formants of vowels undergo “the least frequency shift between surrounding consonants” (Dickson, 1962: 105); c) at onset and offset, in order to investigate the amount and direction of influence of neighbouring consonants.

The following is a list of supralaryngeal (velopharyngeal) and laryngeal (phonatory) cues detected from the data:

- *P*1*:* this cue was measured in the vicinity of *F*1 by adopting a manual approach where a prominent peak was considered as the extra pole. The pole was measured between *F*1 and *F*2. In previous studies, detecting this cue was restricted to non-low vowels whereby the distance between *F*1 and *F*2 is long enough to allow for an extra peak to appear. In the present study all vowel types were investigated because this is the first time these measures have been applied to Arabic in general and contexts containing pharyngeal consonants in particular. Therefore, it is believed that in low vowels, where the distance between the two formants is too small no extra poles and zeros are expected to appear there, and therefore applying normalisation on results would take away the effect of formants on peaks (section 6.12.4). The highest peak detected would be the one with the highest amplitude within the range 700-1300. This range was applied following a number of studies reviewed in Chapter 4, in addition to cases where peaks had to be picked because of their prominence outside ranges suggested by the literature.
- *P*0*:* this cue was measured following the procedure applied in studies reviewed in Chapter 4, where the highest peak would be located within the frequency range 200-500Hz below *F*1. This range combines the ranges suggested in the literature and positions of prominent peaks observed in the present study. It suggests that the peak could be the second harmonic *H*2, which was also what Chen (2000) spectra showed, or a peak above *H*2 that has higher amplitude. Similarly to *P*1, previous studies restricted detecting *P*0 to non-high vowels whereby the distance below *F*1 is long enough to allow for an extra peak to appear; but for the same reasons above all vowels were investigated in the present study. Therefore, in high vowels, whereby this peak would be near to *F*1 and obscured by it, normalisation was applied and *H*2 was picked even if it occurred on *F*1.
- *F*1, *F*2 and *B*1: based on formant extraction algorithm used in Praat (Burg method, 25 ms Gaussian window, 5 ms step, and 5 formants were requested in the region from 0 to 5000 Hz), *F*1 *and F*2 formant frequencies and *B*1 bandwidth were measured at the three vowel portions.
- *Phonation measurements:* these were measured according to f_0 or formant frequencies. *H*1 was detected as being the highest peak in a range of frequencies with its lowest frequency defined as f_0 - (f_0/10) and its highest frequency as f_0 + (f_0/10) (Remijsen and Gilley, 2008). *H*2 was similarly detected but with f_0 multiplied by 2, i.e. 2*f_0-(f_0/10). The same applies to *A*1, i.e. *F*1-*B*1/2 and *F*1+*B*1/2 (Al-Tamimi and Khattab, 2011, under review).

- *Overall vowel intensity*: this was measured by taking the mean value of the intensity of the entire vowel.

6.11.2 Relations between Acoustic Cues

Differences of combinations of the above cues were used to measure: the presence of nasalisation in the speech of IA speakers, in general, and accompanying the realisations of pharyngeal fricatives, in particular; the measures were also used to examine which phonation types colour the speech of IA or any of its dialects. The following acoustic measurements were the most commonly applied in the literature:

1- *A*1-*P*0: nasalised environments were expected to show a decrease in this measure.

2- *A*1-*P*1: nasalised environments were expected to show a decrease in this measure.

3- *F*1 and *F*2 frequencies: *F*1 and *F*2 were expected to shift in frequency reflecting nasalisation depending on type of vowel (see Chapter 4).

4- *B*1 amplitude: this was expected to rise in nasal/nasalised environments.

5- Overall vowel intensity: this was expected to fall in nasal/nasalised environments.

6- The difference between the first two harmonics (*H*1-*H*2): this was expected to suggest creaky phonation if the difference is negative and *H*1 is < than *H*2; and breathy phonation if the difference is positive and *H*1 is > than *H*2.

7- The difference between the first harmonic and amplitude of the first formant (*H*1-*A*1): this was expected to suggest creaky phonation if the difference is negative and *H*1 is < than *A*1; and breathy phonation if the difference is positive and *H*1 is > than *A*1.

Normalisation was applied on these measures following Iseli et al. (2007).

6.11.3 Spectral Measurements

One cannot ignore the importance of the spectrogram and the information it provides, whether visually or when applying specific measurements. However, due to the more specific and detailed requirements of the present research, spectra were considered the main source of information. This is due to the fact that one of the main cues of nasalisation is the presence of poles in different positions as mentioned in Chapter 4. These poles were detected in order to investigate how consistent the appearance of peaks in the speech of speakers of IA is in indicating nasalisation compared with other languages and dialects already investigated; also the aim is to investigate if nasalisation actually occurs in pharyngeal contexts, and if so, if it is similar to what is found in nasal contexts.

To generate spectra of the three measurement points (onset, midpoint, offset) depending on the length (duration) of the vowel, the script mentioned in section 6.11.1 was applied. In relation to the length of the vowel, the script was made to apply the following measurements: if the vowel is less than 40ms long, the script was to only measure mean values of the whole vowel; if the vowel was between 40ms and 100ms long, the script was to generate three types of measurements (at onset, offset and mean values of the whole vowel); if the vowel was over 100ms long, the script was to generate four types of measurements (at onset, midpoint, offset and mean values of the whole vowel). In addition to the spectra, the script generated Esp. (Encapsulated Post Script) images which consisted of a spectrogram of the whole vowel segment with the position of three points where measurements had been carried out, referred to as Start, Mid and End (i.e. onset, midpoint and offset respectively), together with the spectrum generated at the particular point.

6.11.4 Normalisation of Nasalisation and Phonatory Measures

Normalisation of the results was carried out in order to remove the effects of $F1$ and $F2$. Three normalisation techniques were applied. The first technique was using an approximation formula recommended by Chen (1995: 2452):

$$T1_{\text{approx}} = \frac{F1^2}{(950-F1)(F1+950)}$$

And $T2$ can be approximated by:

$$T2_{\text{approx}} = \frac{F2^2}{(F2-950)(F2+950)}$$

As explained by Chen, the approximation gives a good indication of nasalisation without the effects of the higher formants and that the 950 is linked to the frequency location of the nasal peak. This normalisation was applied on both $P0$ and $P1$ by adapting the following:

$P0\text{norm} = P0 - T1 - T2$ $\quad$ $P1\text{norm} = P1 - T1 - T2$

The second technique was applied on the harmonics $H1$ and $H2$ using a formula recommended by Iseli et al. (2007: 2285):

$$H^*(\omega_0) = H(\omega_0) - \sum_{i=1}^{N} 10 \log_{10} \frac{(1-2r_i \cos(\omega_i)+r_i^2)^2}{(1-2r_i \cos(\omega_0+\omega_i)+r_i^2)(1-2r_i \cos(\omega_0-\omega_i)+r_i^2)}$$

$\omega_0 = 2\pi F_0$, where F_0 is the fundamental frequency $\quad$ $r_i = e^{-\pi B_i/F_s}$ $\quad$ $\omega_i = 2\pi F_i/F_s$

B_i = Babdwidth $\quad$ F_s = Sampling frequency $\quad$ F_i = Frequency of a formant

The third technique was applied on mean values of overall vowel intensity by dividing the value of the intensity of a segment by that of the mean of the word; therefore results will be around + or –1. Following this section, every time $P1$, $P0$, $H1$ and $H2$ are mentioned they will be preceded by an asterisk, *$P1$, *$P0$, *$H1$ and *$H2$, denoting being corrected from the effect of $F1$ and $F2$, i.e. normalisation.

6.12 Distribution of Data for Analysis

After applying all the above measurements, data were grouped in categories for comparison and statistical testing. These categories were divided according to: the presence or absence of the two pharyngeals, which type is present, their word position and dialectal differences. Within each category each acoustic measurement was presented and compared on the basis of the portion of the vowel near the pharyngeal: onset (where the pharyngeal is in initial position), midpoint (no matter where the position of the pharyngeal is) and offset (where the pharyngeal is in final position). The two categories are (all below comparisons were carried out between individual vowels):

1- *Contexts*: here word-environments were grouped into contexts of: n-n (or nasal-nasal, where an initial and final nasal is present), n-o (or nasal-oral, where an initial nasal is present with an oral consonant in the other position), o-n (or oral-nasal, where a final nasal is present and an oral in initial), ħ-n (where the pharyngeal ħ is found in initial and the other position occupied by a nasal), ʕ-n (where the pharyngeal ʕ is in initial position and a nasal in final), n-ħ (where the pharyngeal ħ is found in final and a nasal in initial), n-ʕ (where ʕ is in final position and a nasal in initial), ħ-o (where ħ is initial and an oral is final), o-ħ (where ħ is final and an oral is initial), ʕ-o (where ʕ is initial and an oral is final), o-ʕ (where ʕ is final and an oral is initial), o-o (where two oral consonants are present in both positions) and isolation (where vowels in isolation [(17)] were included).

2- *Dialects*: here the three dialects, Baghdad, Basra and Mosul, were compared.

6.13 Statistical Analysis

Statistical tests were applied on the acoustic and auditory data using the SPSS statistical programme, version 19. Several one-way ANOVAs (analysis of variance) with Bonferroni Post-Hoc and a p-value of < 0.001 analysis were applied on each of the acoustic measures. For these ANOVAs, the independent variables were: individual context, dialect; and the dependent

[(17)] isolation environments only include long vowels.

variables were: *A*1-**P*1, *A*1-**P*0, *B*1, *F*1, *F*2, *overall vowel intensity*, **H*1-**H*2, **H*1-*A*1. Several one-way MANOVA tests (multi-variance analysis) were also used for finding a connection between changes of *F*1 and *F*2 followed by separate ANOVAs for each formant change, which on their part are followed by post-hoc results. For the MANOVAs, the wilk's lambda MANOVA test value will be reported and evaluated with values close to 0 being very highly significant. For these MANOVAs, the same independent variables were compared on the basis of two dependent variables: *F*1 and *F*2 frequencies. Another statistical test used was an Independent-Samples *t*-test when comparing two independent variables: individual contexts, on the same above independent variables. The third type of statistical tests that are used to compare between the frequencies of occurrences of categorical (qualitative) data, i.e. results of the auditory impression of nasalisation, phonation types and realisation of pharyngeal /ʕ/, are three categorical *Chi*-square statistical tests. The first is a general *Pearson's Chi*-square test to reveal the auditory impression of nasalisation/phonation types for a combination of contexts containing one individual vowel. The other two tests are used to compare between individual contexts for auditory impression of nasalisation/phonation types, they are: the *chi*-square *for Independence Test* and the *Fisher's Exact Test*. These two were applied to find out if any two groups of contexts significantly differed.

Each of the independent variables has a number of sub-categories: dialect (3) and individual contexts (13). Data was divided and compared according to vowels (9). In order to verify the real weight of a significant difference, two effect size measures were computed, the eta-squared partial (η^2) for the factorial ANOVA (obtained directly from SPSS) with benchmarks: 'large' for more than 0.15, 'moderate' for between 0.06 and 0.15, and 'small' for below 0.06; and Cohen's *d* for post-hoc comparisons with benchmarks as 0.2, 0.5 and 0.8, corresponding to small, moderate and large effect size differences, respectively (Cohen, 1988).

Chapter 7 : Auditory and Acoustic Patterns of the Pharyngeal Consonants in Iraqi Arabic

7.1 Introduction

Following the debate around the realisation of the two pharyngeal fricatives in the literature as presented in Chapter 5, this chapter will reveal how the two sounds are realised by the 9 speakers from the present study. The description will provide an auditory and acoustic profiling of these two sounds, looking at their overall realisation and whether it patterns more with vowel-like, fricative-like and/or stop-like features. In terms of acoustic measurements, $F1$ and $F2$ frequency in vowels neighbouring the two pharyngeals are compared with $F1$ and $F2$ of the same vowels when produced in in oral context (for short vowels) and in oral and isolation contexts (for long vowels).

7.2 Realisation of the pharyngeal consonants

Auditory and spectrographic classification of the realisations of the two pharyngeal fricatives is carried out to determine the most common realisations according to their position in the word (initial, final) and dialect (Baghdad, Basra, Mosul). The realisation of /ħ/ as a voiceless fricative proved to be consistent in all speakers for all contexts in both word-positions. However, the realisation of /ʕ/ proved very diverse, concurring with the variation mentioned in the literature regarding IA. Realisations of /ʕ/ are grouped into three main categories: 1- approximant, 2- fricative and 3- stop, reflecting a continuum from the most open-like approximation to the most constricted (table 7.1). Within each category, further categorisation is done according to the degree and strength of constriction, which increases as the classification moves from 1a to 3d, while of course bearing in mind that some tokens show a combination of features. A general view of results shows approximants rather than stops to be the most frequently occurring realisation in IA (51%), and fricatives the least (table 7.2). A one-way nonparametric *Chi*-square test revealed that the relative frequencies of the three realisations of pharyngeal /ʕ/ by IA speakers differ significantly (χ^2 = 3378.36, df = 4, p<0.001).

Table 7.1: Realisations of /ʕ/ according to three main categories (approximant, fricative, and stop) and each into further detailed categories, within the three dialects.

Dialect	approximant								fricative						stop								Total
	a- pure approximant		b- approximant mixed with creak and friction		c- approximant mixed with creak		d- approximant with stop-like impression, showing only burst and no gap		a- voiced fricative		b- voiced fricative with formant-like shadows		c- voiced fricative mixed with creak		a-voiceless stop with formant-like shadows or friction		b- voiceless stop mixed with creak		c- voiceless stop with clear gap and burst		d- voiceless stop with clear gap, burst and aspiration		
	no.	%	no.	%	no.	%	no.	%	no.	%	no.	%	no.	%	no.	%	no.	%	no.	%	no.	%	
Baghdad	8	10 %			22	28%	1	1%					7	9%	8	10%	4	5%	18	23%	9	11%	77
Basra	37	48 %	3	3%	13	16%	4	5%	1	1%	9	11%			9	11%	1	1%					77
Mosul	15	19 %	2	2%	11	14%	1	1%	4	5%	7	9%	3	3%	10	12%	7	9%	7	9%	10	12%	77
Total	60	25 %	5	2%	46	19%	6	2%	5	2%	16	6%	10	4%	27	11%	12	5%	25	10%	19	8%	231

Table 7.2: percentage values of realisations of pharyngeal /ʕ/ in IA.

realisation of ʕ	Tokens	%
approximant	118	51.08%
fricative	31	13.42%
stop	82	35.50%
Total	231	100.00%

With regards to word-position effect (table 7.3), a one-way nonparametric *Chi*-square test revealed that the relative frequencies of the three realisations of pharyngeal /ʕ/ by IA speakers differ significantly in initial position ($\chi^2 = 67.06$, df = 2, $p<0.001$) with approximants prevailing in this position; while in final position, stop realisations prevailed ($\chi^2 = 44.34$, df =2, $p<0.001$). These results agree with that of Butcher and Ahmad (1987).

Table 7.3: percentage values of occurrences of each realisation of pharyngeal /ʕ/ in relation to word position.

position of pharyngeal	realisation of ʕ	Tokens	%
initial	approximant	107	63.31%
	fricative	26	15.38%
	stop	36	21.30%
initial Total		**169**	**76.13%**
final	approximant	8	15.09%
	fricative	5	9.43%
	stop	40	75.47%
final Total		**53**	**23.87%**
Grand Total		**222**	**100.00%**

After the previous general account of the different realisations of the pharyngeal /ʕ/ by IA speakers, the remainder of the section will offer a more detailed account of the description of each pharyngeal in relation to the way they are realised taking into consideration both auditory and spectrographic information, followed by a section on cross-dialectal differences of these realisations.

7.2.1 Voiceless Pharyngeal Fricative /ħ/

This pharyngeal is seen on spectrograms similar to fricatives, particularly /h/, with friction represented by noise and formant-like bands. Figure 7.1 shows a production of a voiceless fricative-like pharyngeal, apparent in its spectral shape, with friction at a wide range of frequencies and some formant-like shadows.

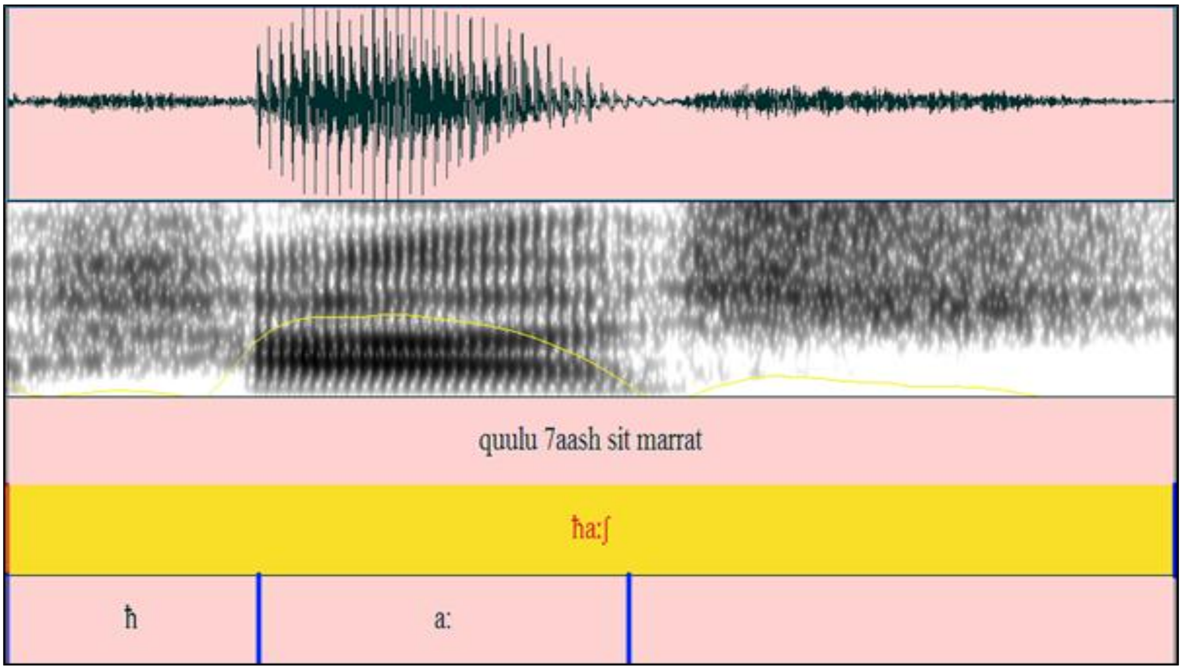


Figure 7.1: A spectrogram of an initial pharyngeal /ħ/ in the word 7aash [ħa:ʃ] 'he had cut the grass' produced as a voiceless fricative by an IA male speaker from Mosul.

7.2.2 Voice(less) Pharyngeal (Fricative?) [ʕ]

Unlike /ħ/, despite having three main realisations of pharyngeal /ʕ/, these categories are by no means exclusive and most realisations are labelled as approximant-, fricative-, and stop-like based on the main pattern that they showed, but had a mixture of patterns from the other categories. This section will describe each of these realisations.

7.2.2.1 *Approximant*

Although pharyngeal /ʕ/ has often been classed as a fricative in Arabic dialects, it is an approximant or glide-like that is been most common (Heselwood, 2007). The approximant is not always produced as a 'pure' voiced continuant. It is also produced mixed with creak, friction or a stop-like burst (visible and/or auditory). The following are the four realisations of an approximant.

'Pure' approximant

Figure 7.2 shows [ʕ] produced as a pure approximant with only slightly lower intensity than the neighbouring vowel, and loss of energy in the higher frequencies.

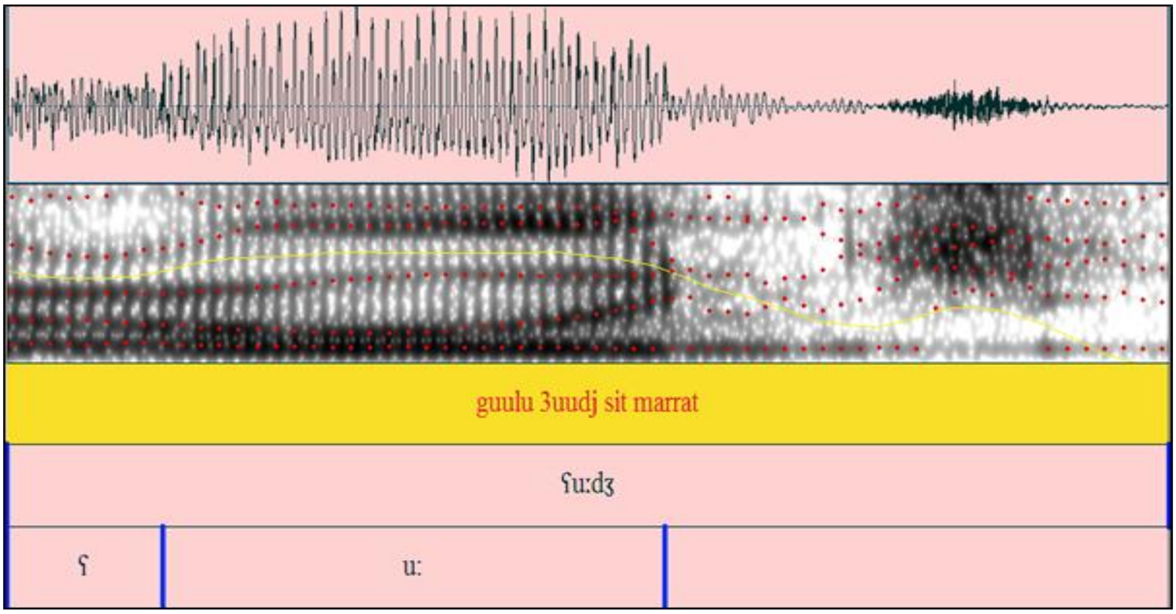


Figure 7.2: A spectrogram and waveform of an initial pharyngeal /ʕ/ in the word 3uudj [ʕu:dʒ] 'bent (pl.)' realised as a pure approximant by an IA male speaker from Baghdad.

Approximant mixed with creak and friction

Figure 7.3 shows the pharyngeal [ʕ] as an approximant dominated by creak and irregular intervals of voicing with instances of friction.

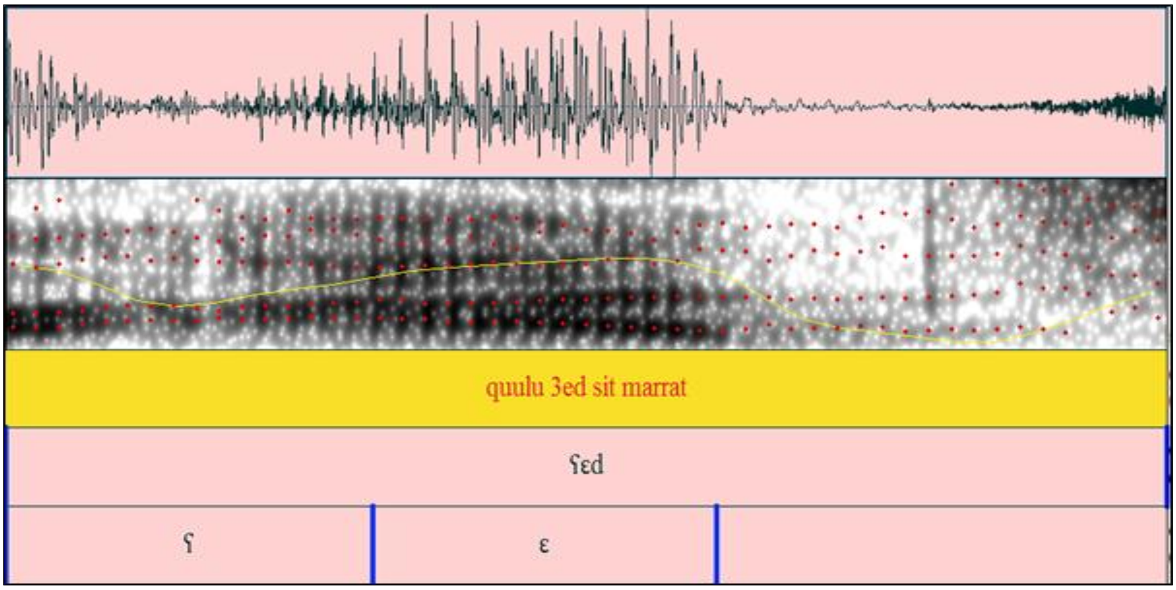


Figure 7.3: A spectrogram of an initial pharyngeal /ʕ/ in the word [ʕɛd] 'he counted' as produced by an IA male speaker from Mosul and realised as an approximant mixed with intervals of voicing and instances of friction.

Approximant mixed with creak

The speaker in figure 7.4 produces /ʕ/ as an approximant mixed with creak and very irregular voicing. What is also noted in this example is that the pharyngeal seems to combine approximant and creak, with the dominant pattern being creak.

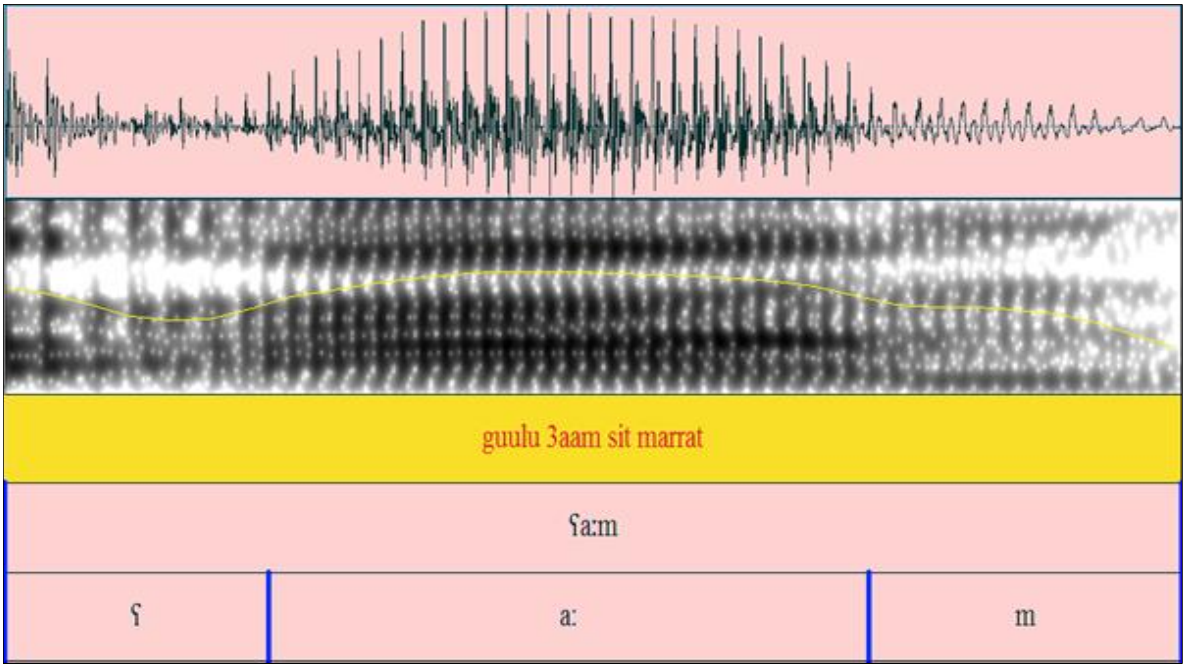


Figure 7.4: A spectrogram of an initial pharyngeal /ʕ/ in the word 3aam [ʕa:m] 'general' realised as an approximant mixed with creak by an IA male speaker from Mosul.

Approximant with auditory stop but no burst or gap

Figure 7.5 shows /ʕ/ realised as a voiced pharyngeal approximant with no visible gap or burst, although it is heard as having stop-like features in the first half of the consonant. This may be due to the creak and the lack of energy above 2.5K in the pharyngeal itself.

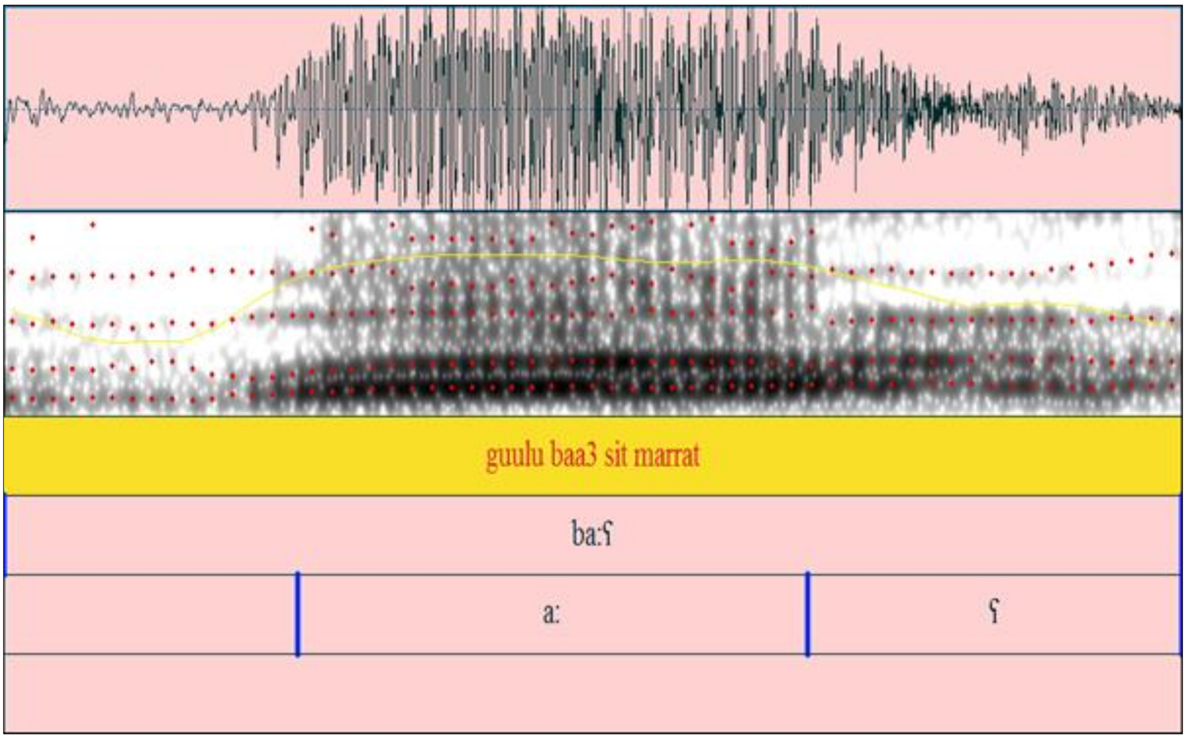


Figure 7.5: A spectrogram of a final pharyngeal /ʕ/ in the word baa3 [ba:ʕ] 'he sold' realised as a voiced approximant with no visible gap or burst but an auditory stop by an IA male speaker from Basra.

7.2.2.2 *Fricative*

Pharyngeal /ʕ/ has been classed as a fricative by many researchers investigating Arabic dialects, such as McCarthy and Raffouli (1964), Blanc (1964), Ghazeli (1977), Laradi (1983), Abu-Haidar (1991), Holes (2004), and Alotaibi and Muhammad (2010). However, IA speakers have very few fricative realisations of /ʕ/. The fricative is produced voiced but with voiceless intervals, again different to other Arabic dialects. The following are the three sub-category realisations where the baseline is a fricative but with other accompanying features.

'Pure' voiced fricative

Figure 7.6 shows a voiced fricative with irregular voicing.

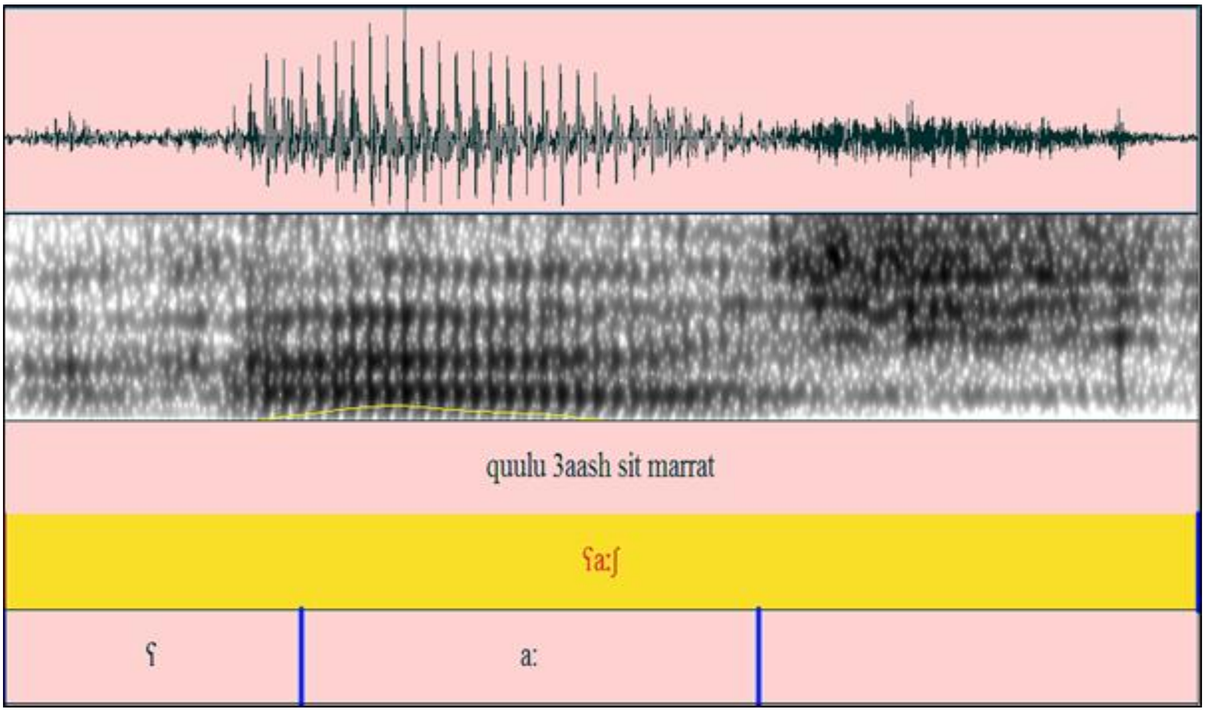


Figure 7.6: A spectrogram of initial /ʕ/ in the word 3aash [ʕa:ʃ] 'he lived' realised as a voiced fricative by an IA male speaker from Mosul.

Voiced fricative with formant-like shadows

Figure 7.7 shows a realisation of /ʕ/ realised as a fricative with irregular intervals of voicing and the strong appearance of formant-like shadows.

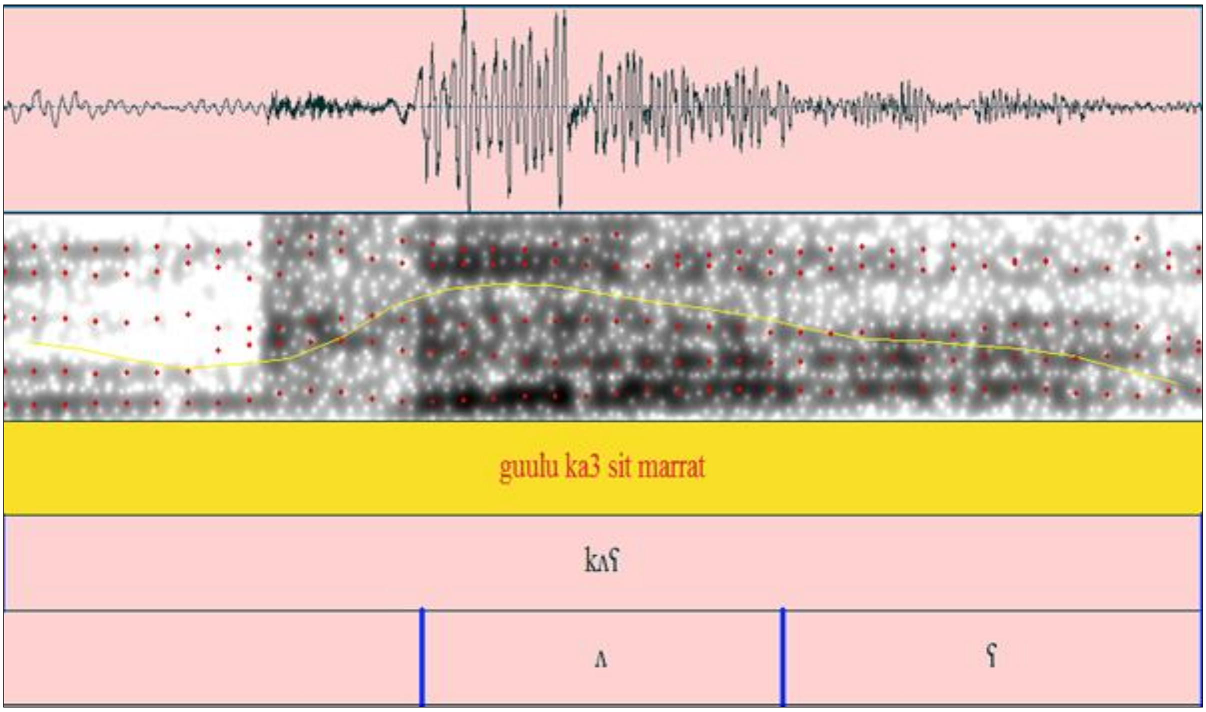


Figure 7.7: A spectrogram of final /ʕ/ in the word ka3 [kʌʕ] 'gave all up' realised as a voiced fricative with formant-like shadows by an IA male speaker from Basra.

Voiced fricative mixed with creak

Figure 7.8 shows /ʕ/ realised as a voiced fricative with instances of creak, which also extends into the first part of the vowel.

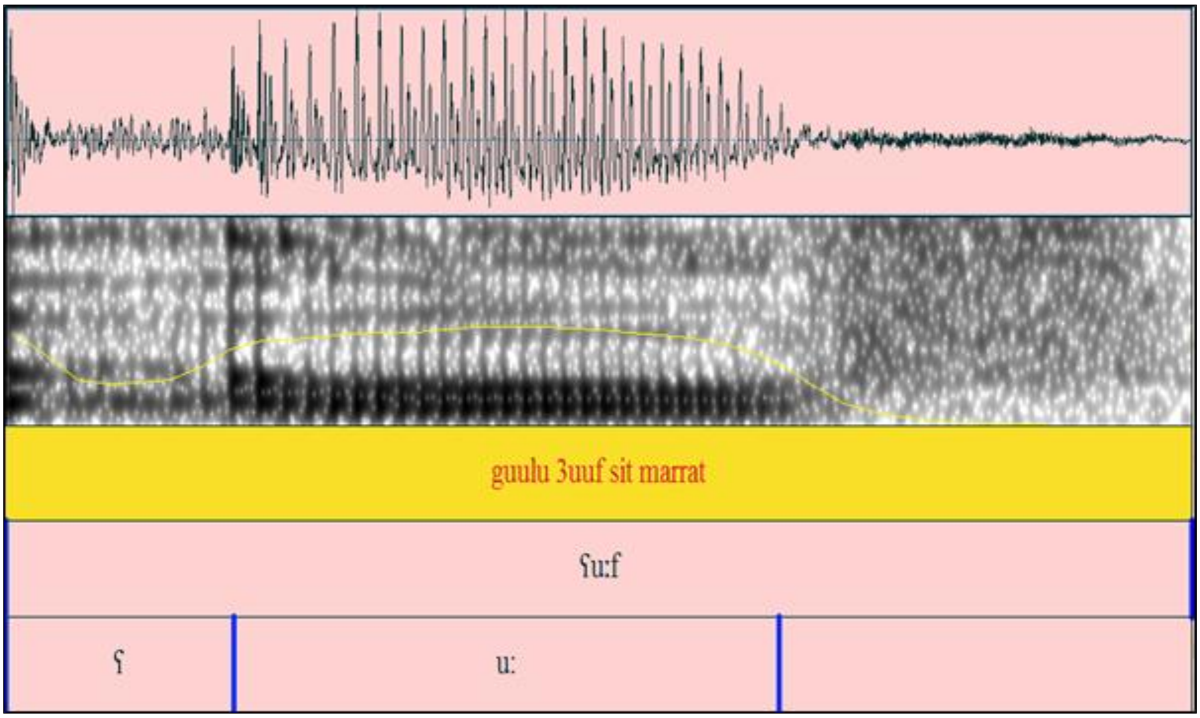


Figure 7.8: A spectrogram of initial /ʕ/ in the word 3uufj [ʕu:f] 'leave it' realised as a voiced fricative with mixed creak by an IA male speaker from Baghdad.

7.2.2.3 *Stop*

All cases of a stop realisation in the present study are noted to be voiceless. The following are the four realisations of the stop as noted in the present study.

Voiceless stop mixed with formant-like shadows and friction

Figure 7.9 shows /ʕ/ produced as a voiceless stop mixed with formant-like shadows and friction. Note again that the pharyngeal is not purely voiceless but also has voicing in its first and final quarters.

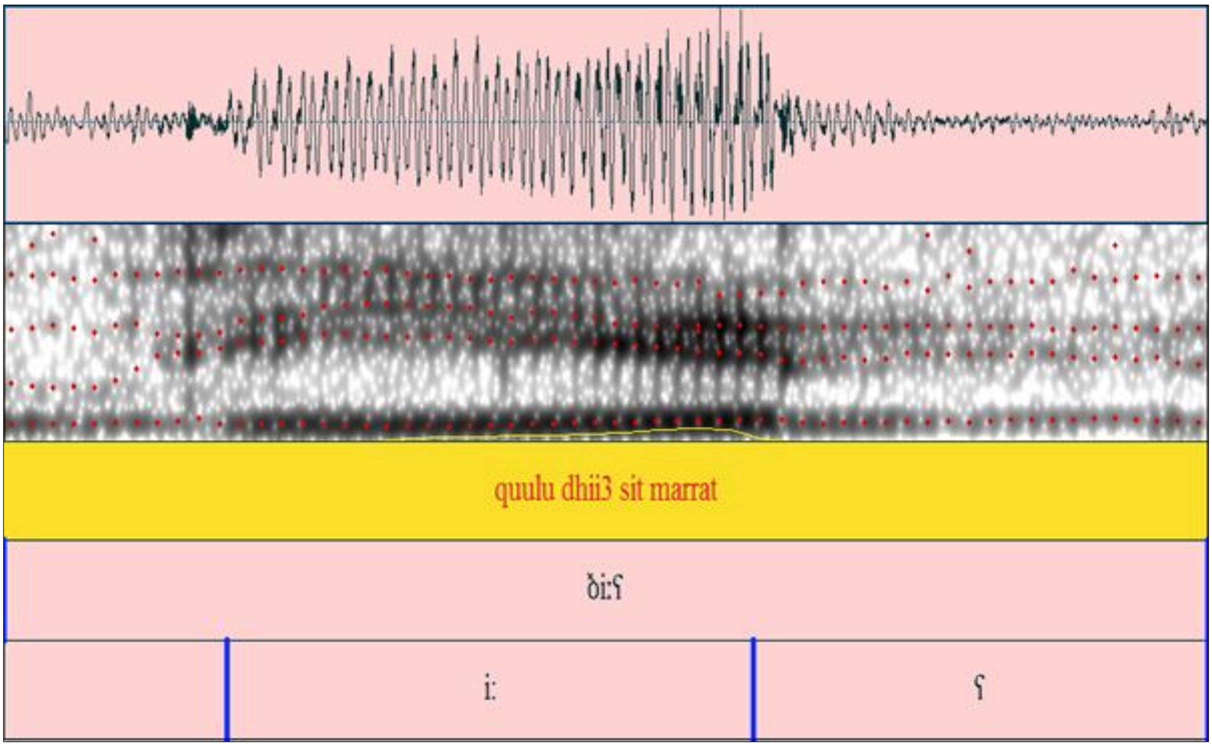


Figure 7.9: A spectrogram of a final pharyngeal /ʕ/ in the word dhii3 [ði:ʕ] 'do broadcast' as produced by an IA male speaker from Mosul. The sound is a voiceless stop mixed with formant-like shadows and friction, with voicing at its first and final quarters.

Voiceless stop mixed with creak

Figure 7.10 shows /ʕ/ realised as a stop with creak that ends with a gap and a burst.

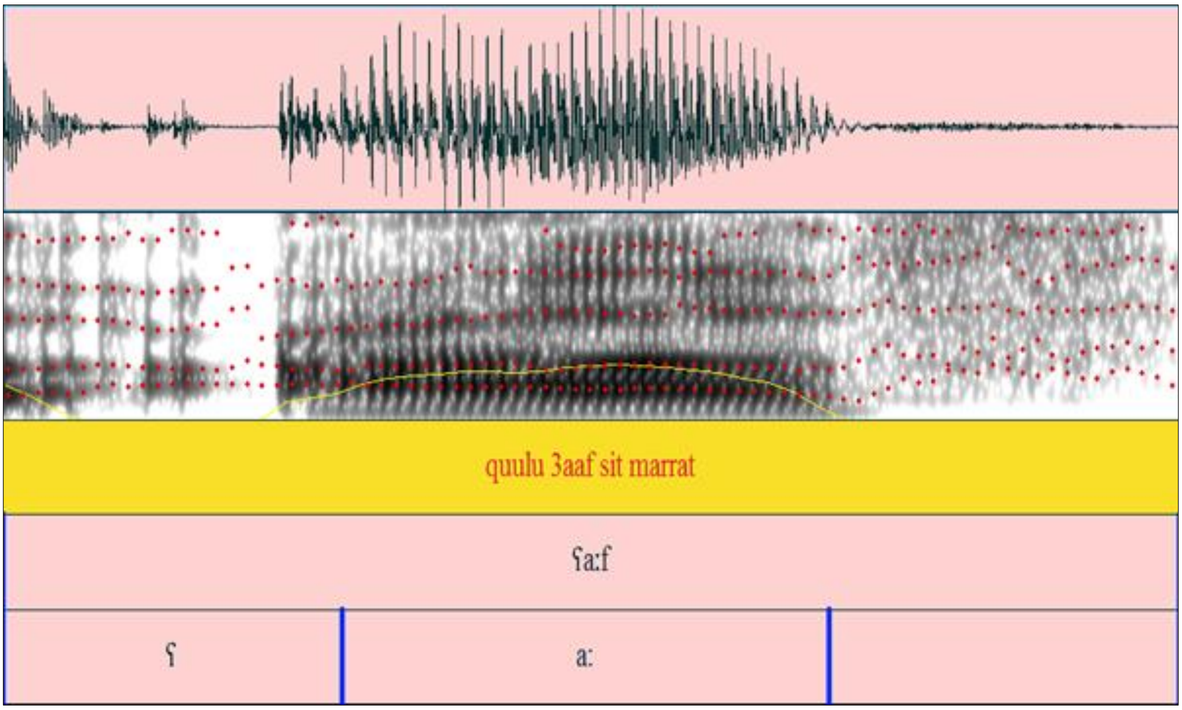


Figure 7.10: A spectrogram of initial /ʕ/ in the word 3aaf [ʕa:f] 'he left behind…' realised as a voiceless stop mixed with creak by an IA male speaker from Mosul.

Voiceless stop with clear gap and burst

Figure 7.11 shows /ʕ/ realised as a voiceless stop with a clear gap and burst in both word positions. Creak is also noted in the vowel both at onset and offset near each of the pharyngeals.

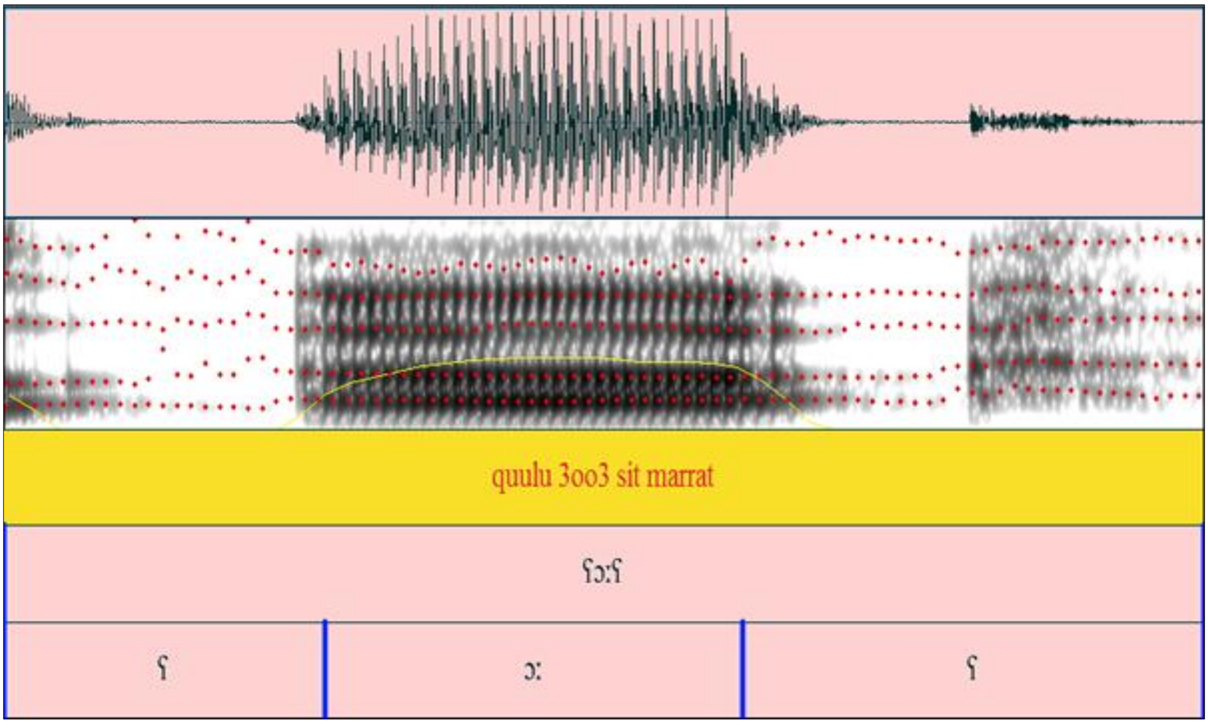


Figure 7.11: A spectrogram of an initial pharyngeal /ʕ/ in the word 3oo3 [ʕɔ:ʕ] 'yuk!, but realised as a voiceless stop with a clear gap and burst by an IA male speaker from Mosul.

Voiceless stop with clear gap, burst and aspiration

Figure 7.11 shows the same speaker producing the final pharyngeal as a voiceless stop with a clear gap and burst but with added aspiration.

7.2.3 Cross-dialectal Differences

Cross-dialectal comparisons between frequencies of occurrences of realisations of pharyngeal /ʕ/ were applied. Results in Table (7.4) show that Basra speakers produced the highest number of approximant realisations (74%) and the lowest number of stops (12%), while both Baghdad and Mosul speakers produced almost the same number of stops (50%, 42%) and approximants (40%, 38%). Fricatives are also produced in all three dialects but on a lesser scale. Interestingly, most fricatives are voiced with irregular voiceless instances but are never fully voiced as it is reported in other Arabic dialects (see tables 7.4 - 7.6).

Table 7.4: Realisations of /ʕ/ according to three main categories (approximant, fricative, and stop) within the three dialects.

dialect	approximant	%	fricative	%	stop	%
Baghdad	31	40%	7	9%	39	50%
Basra	57	74%	10	12%	10	12%
Mosul	30	38%	14	18%	33	42%
Grand Total	118	51%	31	13%	82	35%

Several *Chi*-square tests were applied to compare between frequencies of occurrences of realisations of pharyngeal /ʕ/ in all dialects and between each two dialects. A *Pearson Chi-square Test* showed significant differences between all dialects (χ^2 = 31.449, df = 4, p<0.001). This was followed by a *Chi*-square *Test of Independence* which showed that there are significant differences between Basra and each of Baghdad and Mosul but not between the latter two (table 7.5).

Table 7.5: Chi-square Test of Independence of comparing between dialects on the occurrences of realisations of pharyngeal /ʕ/.

Dialect1	Dialect2	Chi-square Test	df	Sig.
Baghdad	Basra	25.4	2	0.000
Basra	Mosul	2.85	2	0.241
Mosul	Mosul	21.3	2	0.000

To compare frequencies of occurrences of realisations of pharyngeal /ʕ/ in each dialect, *chi*-square was applied on the data. Results revealed that realisations of pharyngeal /ʕ/ were different by speakers of the three dialetcs, with Baghdad speakers producing more stops than approximants and fricatives (χ^2 = 20.16, df = 2, p<0.001); Basra speakers producing more approximants than stops and fricatives (χ^2 = 54, df = 2, p<0.001); and Mosul speakers were similar to Baghdad speakers in producing more stops than approximants and fricatives (χ^2 = 7.45, df = 2, p<0.001).

Results of sub-categories in approximant realisations (table 7.1) show Basra speakers have the *pure approximant* realisations as the most frequent (48%); while the *approximant mixed with creak* are the most frequent for Baghdad speakers (28%). Results of sub-categories in stop realisations show Baghdad speakers having the most occurrences of the *voiceless stops with a clear gap and burst* (with or without aspiration) which together equal 35% of the 77 tokens, followed by Mosul speakers with 22%, and the least are Basra with zero tokens. Mosul speakers had tokens within all 11 subcategories of realisations, showing similarities in realisations with both Baghdad and Basra speakers. The relative frequencies of sub-categories of pharyngeal /ʕ/ realisations produced by speakers of all three dialects differed significantly: for Baghdad speakers (χ^2 = 2872.18, df = 8, p<0.001) with the *approximant mixed with creak* and the *voiceless stops with a clear gap and burst* having the highest occurrences; for Basra speakers (χ^2 = 3002.23, df = 8, p<0.001) with the highest two occurrences being *pure approximant* and *approximant mixed with creak;* and for Mosul speakers (χ^2 = 3921.85, df = 11, p<0.001) with the highest two occurrences being *pure approximant* and *approximant mixed with creak.*

Several nonparametric *Chi*-square statistical tests were used to compare between the frequencies of occurrences of each realisation in each word position by speakers of each of the three dialects (table 7.6). The relative frequencies of the three realisations of pharyngeal /ʕ/ by Baghdad speakers differ significantly in initial position (χ^2 = 16.53, df = 2, p<0.001) and in final position (χ^2 = 14.23, df = 1, p<0.001) with these speakers producing more approximants in initial position and more stops in final position. In fact, Baghdad speakers produce no approximants in final position. The relative frequencies of the three realisations of pharyngeal /ʕ/ by Basra speakers differ significantly in initial position (χ^2 = 67.06, df = 2, p<0.001) with these speakers producing more approximants; but do not differ significantly in final position (χ^2 = 2.34, df = 2, p>0.001) with these speakers producing almost similar numbers of all realisations. The relative frequencies of the three realisations of pharyngeal /ʕ/ by Mosul speakers differ significantly in initial position (χ^2 = 6.64, df = 2, p<0.001) and in final position (χ^2 = 25, df = 2, p<0.001) with these speakers producing more approximants in initial position and more stops in final position similar to Baghdad speakers.

Table 7.6: Realisation of /ʕ/ combined with dialect and position of pharyngeal.

Dialect	position of pharyngeal	approximant	%	fricative	%	stop	%	Total
Baghdad	initial	31	54%	6	10%	20	35%	57
	final			1	5%	17	94%	18

Basra	initial	47	83%	7	12%	2	3%	56
	final	7	38%	3	16%	8	44%	18
Mosul	initial	28	49%	13	22%	16	28%	57
	final	1	5%	1	5%	15	88%	17
Grand Total		**117**	**50%**	**31**	**13%**	**82**	**35%**	**230**

Results showing a considerable number of stop realisations does coincide with what was mentioned in Chapter 5 whereby IA is more likely to have stop occurrences due to its conservative nature (Heselwood, 2007) adding to the 'emphatic' and 'guttural' quality by which IA is perceived (Bellem, 2007). Bellem (ibid) relates this quality more specifically to the *gelet* dialectal group to which Baghdad and Basra belong. However, while this is true of Baghdad, Basra speakers show considerably more approximant realisations than stops.

7.3 Formant Frequency of Neighbouring Vowels

This section will compare formant frequencies of vowels neighbouring the two pharyngeals with the same vowels in oral context (for short vowels) and in oral and isolation contexts (for long vowels). Comparisons are made at onset (near an initial pharyngeal), midpoint (irrespective of pharyngeal position), and offset (preceding a final pharyngeal). For statistical comparisons, a MANOVA will be applied for contexts containing each vowel. This is followed by a Bonferroni post-hoc analysis to investigate potential differences between the low level contexts.

7.3.1 Onset

In this section, onset portions of the vowel (long and short vowels separately) which are near an initial pharyngeal are compared with those in an oral context _for short vowels_ and in oral and isolation contexts _for long vowels_ (figures 7.12 – 7.16). Overall results at onset show that the direction of $F1$/$F2$ frequency changes depends on the quality of vowels neighbouring pharyngeal consonants. For the long front vowels /iː, ɛː/ $F1$ rises and $F2$ lowers, suggesting a more back and more open quality; for the long back vowels /uː, ɔː/ both $F1$ and $F2$ increase, suggesting a more front and more open quality; and near long central vowel /aː/, there is a significant increase in $F1$, denoting a more open quality, and a tendency for $F2$ to increase, suggesting a more front quality in comparison to isolation contexts, but to decrease in comparison to oral contexts, suggesting a more back quality. Short front vowels show similar results to long ones, but back /ʊ/ shows the same trend as front vowels, i.e. backing rather than fronting as was found for long back vowels. When comparing the two pharyngeals, results show that vowels following /ʕ/ have a more open quality than those following /ħ/.

An overview of results also shows that for some vowels, particularly central and back, the pharyngeal influence can be interpreted differently depending on whether the formants are compared with those of the same vowels as produced in isolation contexts or oral ones. This could be due to the varying influence of consonants that surround the oral contexts.

7.3.1.1 *Long Vowels*

Frequency changes of *F*1 and *F*2 measured at onset in long vowels neighbouring the two pharyngeal consonants in comparison to oral and pharyngeal contexts are presented in table 7.7 and figure 7.12. General results suggest: **1-** a more open and more back articulation of vowels /iː, ɛː/ triggered by a raised *F*1 and a lowered *F*2 in vowels when neighbouring both pharyngeals; **2-** a more open quality of vowel /aː/ triggered by a raised *F*1 with no change in *F*2; **3-** a more front and more open quality of /uː, ɔː/ triggered by a raise in both formants; **4-** a tendency for /ɛː/ following pharyngeal /ʕ/ to have a more open and more back quality than /ħ/, but only a more back quality for vowel /aː/. Below are the detailed results for each vowel.

Table 7.7: Effect size differences and Cohen *d* values for *F*1/*F*2 frequency changes within pharyngeal, oral and isolation contexts at onset of long vowels.

Vowel	Formant	Context1	Context2	Cohen *d*	effect size	Sig.
/iː/	*F*1	ʕ-o	o-o	1.42	large	$p<0.001$
			isolation	2.57	large	$p<0.001$
	*F*2	ʕ-o	o-o	0.89	large	$p<0.001$
			isolation	2.02	large	$p<0.001$
/ɛː/	*F*1	o-o	ħ-o	3.05	large	$p<0.001$
			ʕ-o	2.87	large	$p<0.001$
		isolation	ħ-o	1.71	large	$p<0.001$
			ʕ-o	2.11	large	$p<0.001$
	*F*2	isolation	ʕ-o	1.11	large	$p<0.001$
/aː/	*F*1	o-o	ħ-o	2.85	large	$p<0.001$
			ʕ-o	2.74	large	$p<0.001$
		isolation	ħ-o	2.15	large	$p<0.001$
			ʕ-o	2.03	large	$p<0.001$
	*F*2	o-o	ħ-o	0.50	moderate	$p<0.001$
			ʕ-o	0.78	moderate to large	$p<0.001$
/uː/	*F*1	ʕ-o	o-o	1.33	large	$p<0.001$
			isolation	1.66	large	$p<0.001$
	*F*2	ʕ-o	isolation	1.06	large	$p<0.001$
/ɔː/	*F*1	ħ-o	o-o	2.63	large	$p<0.001$
			isolation	1.89	large	$p<0.001$
	*F*2	ħ-o	o-o	2.51	large	$p<0.001$
			isolation	1.57	large	$p<0.001$

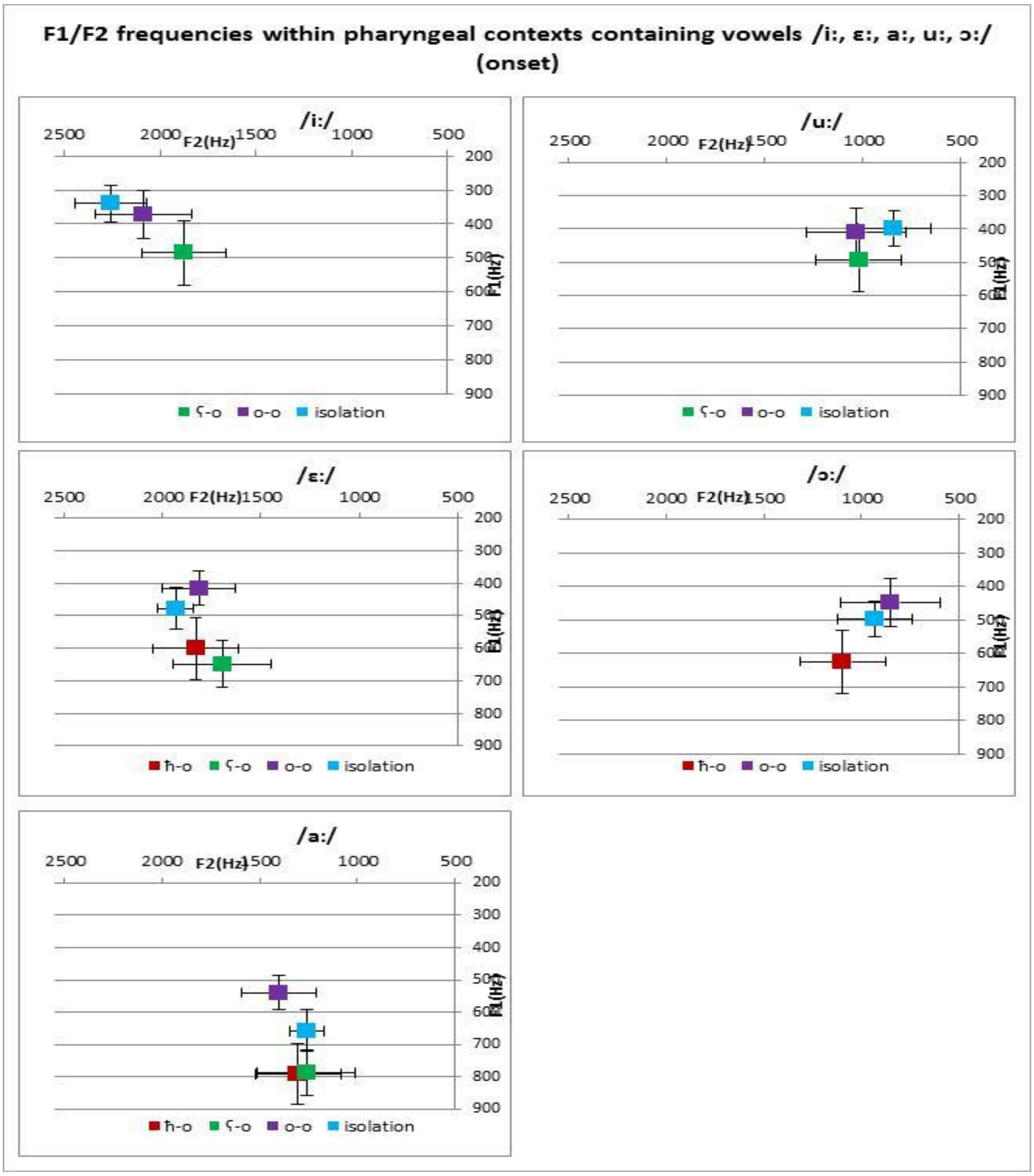


Figure 7.12: Plotted *F*1/*F*2 frequencies in vowels /i:, ɛ:, a:, u:, ɔ:/ within pharyngeal contexts in comparison to oral and isolation contexts measured at onset.

/i:/: A MANOVA test showed significant differences between *F*1 and *F*2 for contexts containing vowel /i:/ at onset (Wilks`s Λ = 0.578, F (4, 354) = 27.901, p<.0001, η_p^2 = 0.240). Statistical results on *F*1 frequencies obtained at the onset of vowel /i:/ revealed a significant effect with a large effect size (F (2, 180) = 47.248, p<0.001, η_p^2 = 0.347). Bonferroni post-hoc analysis revealed significant differences between ʕ-o context and each of o-o and isolation contexts. *F*2 frequencies obtained at the onset of vowel /i:/ revealed a significant effect with a large effect size (F (2, 180) = 33.436, p<0.001, η_p^2 = 0.273). Bonferroni post-hoc analysis revealed significant differences between ʕ-o context and each of o-o and isolation contexts.

/ɛ:/: A MANOVA test showed significant differences between *F*1 and *F*2 for contexts containing vowel /ɛ:/ at onset (Wilks`s Λ = 0.472, F (6, 294) = 22.318, p<.0001, η_p^2 = 0.313). Statistical results on *F*1 frequencies obtained at the onset of vowel /ɛ:/ revealed a significant effect with a large effect size (F (3, 151) = 39.576, p<0.001, η_p^2 = 0.445). Bonferroni post-hoc analysis revealed significant differences between o-o context and each of ħ-o and ʕ-o contexts; between isolation context and each of ħ-o and ʕ-o contexts; but not between ħ-o and ʕ-o contexts, instead showing a more open production in ʕ-o. *F*2 frequencies obtained at the onset of vowel /ɛ:/ revealed a significant effect with a moderate effect size (F (3, 151) = 4.220, p<0.001, η_p^2 = 0.079). Bonferroni post-hoc analysis revealed significant differences between isolation and ʕ-o contexts only.

/a:/: Results show a higher *F*1 in comparison to o-o and isolation contexts, suggesting a more open quality. However, unlike the results noted by Al-Ani (1970) within vowel /a:/ where results show both formants as higher, *F*2 in the present study shows a drop in comparison to o-o context and only a tendency to be higher in comparison to isolation context. Results also indicate a tendency for context /a:/ in ʕ-o to have a more back but not a more open quality than in ħ-o. A MANOVA test showed significant differences between *F*1 and *F*2 for contexts containing vowel /a:/ at onset (Wilks`s Λ = 0.458, F (6, 856) = 68.196, p<.0001, η_p^2 = 0.323). Statistical results on *F*1 frequencies obtained at the onset of vowel /a:/ revealed a significant effect with a large effect size (F (3, 432) = 140.303, p<0.001, η_p^2 = 0.495). Bonferroni post-hoc analysis revealed significant differences between o-o context and each of ħ-o and ʕ-o contexts; between isolation context and each of ħ-o and ʕ-o contexts; but not between ħ-o and ʕ-o contexts themselves. *F*2 frequencies obtained at the onset of vowel /a:/ revealed a significant effect with a moderate effect size (F (3, 432) = 17.497, p<0.001, η_p^2 = 0.109). Bonferroni post-hoc analysis revealed significant differences between o-o and each of ħ-o and ʕ-o; but not between ħ-o and ʕ-o contexts themselves, although ħ-o is showing a a more front production.

/u:/: Results show a more front and more open quality of /u:/ in ʕ-o context in comparison to isolation but only a more open quality in comparison to o-o context. These results coincide with results of Al-Ani (1970) where onsets of vowels /uu/ had a raised *F*1 and *F*2. A MANOVA test showed significant differences between *F*1 and *F*2 for contexts vowel /u:/ at onset (Wilks`s Λ = 0.697, F (4, 350) = 17.291, p<.0001, η_p^2 = 0.165). Statistical results on *F*1 frequencies obtained at the onset of vowel /u:/ revealed a significant effect with a large effect size (F (2, 178) = 21.334, p<0.001, η_p^2 = 0.195). Bonferroni post-hoc analysis revealed significant differences between ʕ-o context and each of o-o and isolation contexts. *F*2 frequencies obtained at the onset of vowel /u:/ revealed a significant effect with a moderate effect size (F (2, 178) = 13.618, p<0.001, η^2 =

0.134). Bonferroni post-hoc analysis revealed significant differences between ʕ-o and isolation contexts only.

/ɔ:/: Results show vowels in ħ-o context as having a more front and more open quality. A MANOVA test showed significant differences between *F*1 and *F*2 for contexts containing vowel /ɔ:/ at onset (Wilks`s $\Lambda = 0.740$, F (4, 248) = 10.083, $p<.0001$, $\eta_p^2 = 140$). Statistical results on *F*1 frequencies obtained at the onset of vowel /ɔ:/ revealed a significant effect with a large effect size (F (2, 127) = 18.909, $p<0.001$, $\eta_p^2 = 0.232$). Bonferroni post-hoc analysis revealed significant differences between ħ-o context and each of o-o and isolation contexts. *F*2 frequencies obtained at the onset of vowel /ɔ:/ revealed a significant effect with a large effect size (F (2, 127) = 14.540, $p<0.001$, $\eta_p^2 = 0.189$). Bonferroni post-hoc analysis revealed significant differences between ħ-o context and each of o-o and isolation contexts.

7.3.1.2 *Short Vowels*

Frequency changes of *F*1 and *F*2 measured at onset in short vowels neighbouring the two pharyngeal consonants are presented in table 7.8 and figure 7.13. General results suggest: **1-** a more back and more open quality for the three vowels /ɪ, ɛ, ʊ/ triggered by a raised *F*1 and a lowered *F*2; **2-** a more back quality for /ɛ/ in ʕ-o than ħ-o. Below are the detailed results for each vowel.

Table 7.8: Effect size differences and Cohen d values for *F*1/*F*2 frequency changes within pharyngeal and oral contexts at onset of short vowels.

Vowel	Formant	Context1	Context2	Cohen *d*	effect size	Sig.
/ɪ/	*F*1	ʕ-o	o-o	2.69	large	$p<0.001$
	*F*2	ʕ-o	o-o	1.39	large	$p<0.001$
/ɛ/	*F*1	o-o	ħ-o	2.81	large	$p<0.001$
			ʕ-o	3.29	large	$p<0.001$
	*F*2	ʕ-o	ħ-o	1.16	large	$p<0.001$
			o-o	1.46	large	$p<0.001$
/ʊ/	*F*1	ħ-o	o-o	6.29	large	$p<0.001$
	*F*2	ħ-o	o-o	2.54	large	$p<0.001$

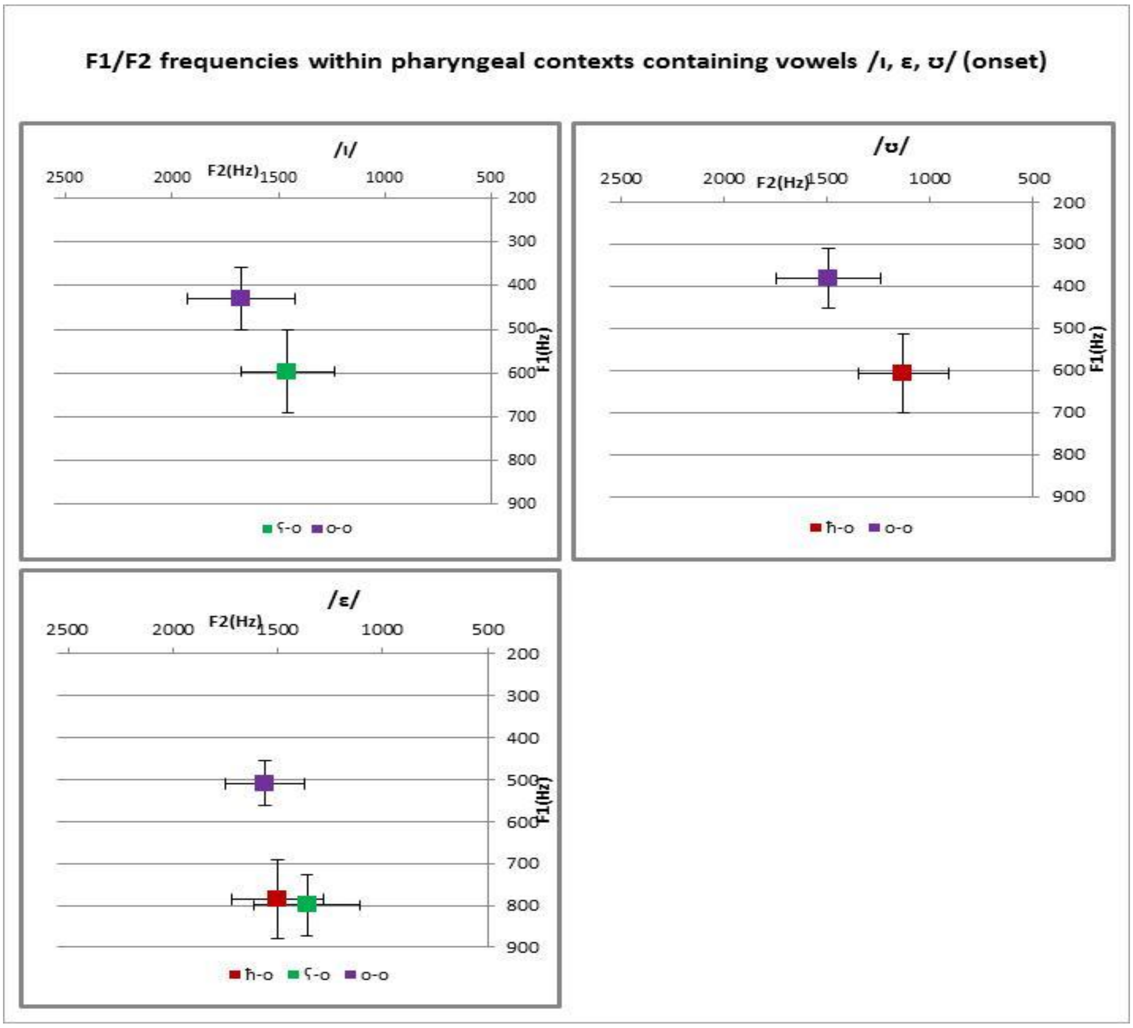


Figure 7.13: Plotted *F*1/*F*2 frequencies in vowels /ɪ, ɛ, ʊ/ within pharyngeal contexts in comparison to oral and isolation contexts measured at onset.

/ɪ/: A MANOVA test showed significant differences between *F*1 and *F*2 for contexts containing vowel /ɪ/ at onset (Wilks`s $\Lambda = 0.384$, $F\ (2, 24) = 19.236$, $p<.0001$, $\eta_p^2 = 0.616$). An independent-samples *t*-test was applied and revealed a significant difference ($t\ (25) = 6.233$, $p<0.001$) between ʕ-o and o-o on *F*1 values. Another independent-samples *t*-test was applied and revealed a significant difference ($t\ (25) = 3.165$, $p<0.001$) between ʕ-o and o-o on *F*2 values.

/ɛ/: A MANOVA test showed significant differences between *F*1 and *F*2 for contexts containing vowel /ɛ/ at onset (Wilks`s $\Lambda = 0.290$, $F\ (4, 244) = 52.228$, $p<.0001$, $\eta_p^2 = 0.461$). Statistical results on *F*1 frequencies obtained at the onset of vowel /ɛ/ revealed a significant effect with a large effect size ($F\ (2, 125) = 134.026$, $p<0.001$, $\eta_p^2 = 0.685$). Bonferroni post-hoc analysis revealed significant differences between o-o context and each of ħ-o and ʕ-o contexts; but not between ħ-o and ʕ-o contexts. *F*2 frequencies obtained at the onset of vowel /ɛ/ revealed a significant effect with a large effect size ($F\ (2, 125) = 11.682$, $p<0.001$, $\eta_p^2 = 0.160$). Bonferroni post-hoc analysis revealed significant differences between ʕ-o context and each of ħ-o and o-o contexts.

/ʊ/: A MANOVA test showed significant differences between *F*1 and *F*2 for contexts containing vowel /ʊ/ at onset (Wilks`s $\Lambda = 0.081$, $F(2, 14) = 78.925$, $p<.0001$, $\eta_p^2 = 0.919$). An independent-samples *t*-test was applied and revealed a significant difference ($t(15) = 12.915$, $p<0.001$) between ħ-o and o-o on *F*1 values. Another independent-samples *t*-test was applied and revealed a significant difference ($t(15) = 4.983$, $p<0.001$) between ħ-o and o-o on *F*2 values.

7.3.2 Midpoint

All measurements at mid-point are taken into account regardless of the position of the pharyngeal. This is to see if the effect of the pharyngeal on formant frequencies extends further into the vowel or is only restricted to the portion neighbouring it. Figures 7.14 and 7.15 show contexts being much closer than they are in figures 7.12 and 7.13, indicating less effect of pharyngeal consonants at midpoint than at onset. This is also noted by the fewer instances of significant differences between pharyngeal contexts and each of oral and isolation contexts. However, the overall statistical results show significant differences which follow the same trend as that noted at onset. When *F*1/*F*2 are measured at midpoint of long vowels, front vowels show a more open and more back quality, back vowels show a more open and more front quality, and central vowels show a more open quality but no significant changes in *F*2. In short vowels, on the other hand, only front vowels follow the same trend, while back vowel /ʊ/ shows two different formant changes: when formant changes are measured at midpoint within context ħ-o, *F*1 rises and *F*2 lowers, suggesting a more back and more open quality; but within context o-ħ, both *F*1 and *F*2 increase suggesting a more front and more open quality. This latter quality is what would be expected in a back vowel similar to vowels /u:, ɔ:/, but at onset formant changes in vowel /ʊ/ showed a different trend with a more open and more back quality. When comparing the effect each pharyngeal has on formant changes at midpoint, results showed no significant differences between them except for vowel /i:/, whereby pharyngeal /ħ/ (but not /ʕ/ as was noted at onset) showed more pharyngealisation. However, despite variation in changes of /ʊ/ formants, all other results are similar to results obtained in studies by Al-Ani (1970) and Butcher and Ahmad (1987), exhibiting similar changes at onset/offset as midpoint and showing a rise of *F*1 in all vowels, a rise in *F*2 of back vowels and a lowering of *F*2 in front vowels.

7.3.2.1 *Long Vowels*

Frequency changes of *F*1 and *F*2 measured at midpoint in long vowels neighbouring the two pharyngeal consonants are presented below (table 7.9, figure 7.14). General results show: **1-** a more back and more open quality for vowels /i:, ɛ:/; **2-** only a more open quality for vowel /a:/; **3-**

a more front and more open quality for vowel /ɔ:/; **4-** only a more front quality for vowel /u:/; **5-** no significant differences between the two pharyngeals in any of the long vowels. Below are the detailed results for each vowel.

Table 7.9: Effect size differences and Cohen *d* values for *F*1/*F*2 frequency changes within pharyngeal, oral and isolation contexts at midpoint of long vowels.

Vowel	Formant	Context1	Context2	Cohen *d*	effect size	Sig.
/i:/	*F*1	o-ħ	isolation	0.65	moderate to large	$p<0.001$
	*F*2	o-ħ	o-o	1.28	large	$p<0.001$
			isolation	1.26	large	$p<0.001$
		o-ʕ	isolation	0.73	moderate to large	$p<0.001$
/ɛ:/	*F*1	o-o	ħ-o	1.28	large	$p<0.001$
			ʕ-o	1.12	large	$p<0.001$
/a:/	*F*1	o-o	ħ-o	0.62	moderate to large	$p<0.001$
			ʕ-o	0.79	moderate to large	$p<0.001$
		isolation	ħ-o	0.80	large	$p<0.001$
			ʕ-o	0.85	large	$p<0.001$
/u:/	*F*2	o-ʕ	o-ħ	1.32	large	$p<0.001$
			ʕ-o	1.41	large	$p<0.001$
			o-o	1.97	large	$p<0.001$
			isolation	2.34	large	$p<0.001$
		o-ħ	isolation	0.95	large	$p<0.001$
/ɔ:/	*F*1	ħ-o	o-ħ	1.16	large	$p<0.001$
			o-o	1.51	large	$p<0.001$
			isolation	1.43	large	$p<0.001$

/i:/: Results show vowel formants in context o-ħ as having a more back and more open quality in comparison to o-o and isolation contexts. The other two pharyngeal contexts ʕ-o and o-ʕ show the same backing and opening tendencies. A MANOVA test showed significant differences between *F*1 and *F*2 for contexts containing vowel /i:/ at midpoint (Wilks`s $\Lambda = 0.794$, $F\,(10, 422) = 6.456$, $p<.0001$, $\eta_p^2 = 0.109$). Statistical results on *F*1 frequencies obtained at the midpoint of vowel /i:/ revealed a significant effect with a small effect size ($F\,(4, 216) = 3.074$, $p<0.001$, $\eta_p^2 = 0.055$). Bonferroni post-hoc analysis revealed significant differences between o-ħ and isolation contexts only. *F*2 frequencies obtained at the midpoint of vowel /i:/ revealed a significant effect with a moderate effect size ($F\,(4, 216) = 8.542$, $p<0.001$, $\eta_p^2 = 0.139$). Bonferroni post-hoc analysis revealed significant differences between o-ħ context and each of o-o and isolation contexts; and between o-ʕ and isolation contexts.

/ɛ:/: A MANOVA test showed significant differences between *F*1 and *F*2 for contexts containing vowel /ɛ:/ at midpoint (Wilks`s $\Lambda = 0.839$, $F\,(6, 294) = 4.501$, $p<.0001$, $\eta_p^2 = 0.084$). Statistical results on *F*1 frequencies obtained at the midpoint of vowel /ɛ:/ revealed a significant effect with a moderate effect size ($F\,(3, 151) = 6.790$, $p<0.001$, $\eta_p^2 = 0.121$). Bonferroni post-hoc analysis revealed significant differences between the o-o context and each of ħ-o and ʕ-o; but not between ħ-o and ʕ-o. *F*2 frequencies obtained at the midpoint of vowel /ɛ:/ revealed a significant effect with a small effect size (F (3, 151) = 2.987, p<0.001, η_p^2 = 0.057). Bonferroni post-hoc analysis revealed a significant rising of F2 in both pharyngeal contexts in comparison to the o-o context, denoting a more open quality. They also show tendencies for a more back quality.

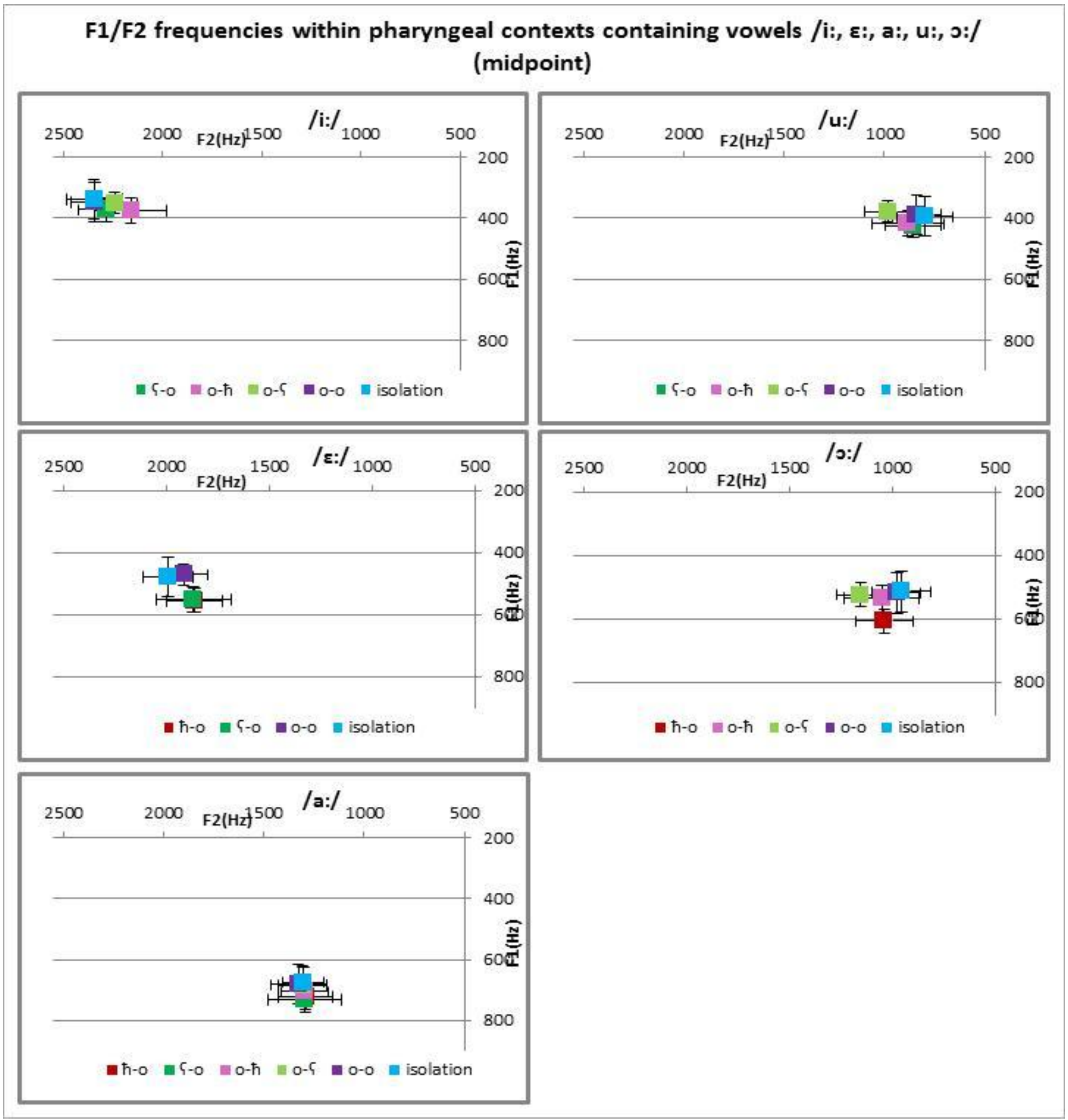


Figure 7.14: Plotted *F*1/*F*2 frequencies in vowels /i:, ɛ:, a:, u:, ɔ:/ within pharyngeal contexts in comparison to oral and isolation contexts measured at midpoint.

/a:/: Similar to onset, formant changes only show a more open quality imposed by pharyngeals. A MANOVA test showed significant differences between F1 and F2 for contexts containing vowel /a:/ at midpoint (Wilks`s Λ = 0.921, F (10, 960) = 4.043, p<.0001, η_p^2 = 0.040). Statistical results on F1 frequencies obtained at the midpoint of vowel /a:/ revealed a significant effect with a moderate effect size (F (5, 487) = 7.418, p<0.001, η_p^2 = 0.072). Bonferroni post-hoc analysis revealed significant differences between o-o context and each of ħ-o and ʕ-o; between isolation context and each of ħ-o and ʕ-o; but not between ħ-o and ʕ-o contexts themselves. *F*2 frequencies obtained at the midpoint of vowel /a:/ revealed a significant effect with a small effect size (F (5, 487) = 0.667, p>0.001, η_p^2 = 0.007). Bonferroni post-hoc analysis revealed a significant rise in *F*1, indicating a more open quality but not much change is noted in *F*2.

/u:/: Results only show a more front but not more open quality imposed by pharyngeals. A MANOVA test showed significant differences between *F*1 and *F*2 for contexts containing vowel /u:/ at midpoint (Wilks`s Λ = 0.735, F (8, 382) = 7.945, p<.0001, η_{p}^2 = 0.143). Statistical results on *F*1 frequencies obtained at the midpoint of vowel /u:/ revealed a significant effect with a small effect size (F (4, 196) = 2.903, p<0.001, η_p^2 = 0.057) but Bonferroni post-hoc analysis revealed no significant differences between contexts. *F*2 frequencies obtained at the midpoint of vowel /a:/ revealed a significant effect with a large effect size (F (4, 196) = 14.190, p<0.001, η_p^2 = 0.228). Bonferroni post-hoc analysis revealed significant differences between o-ʕ context and each of o-ħ, ʕ-o, o-o and isolation contexts; and between o-ħ and isolation contexts. These results show no significant changes of *F*1 for all contexts but a rise in *F*2 for o-ʕ and o-ħ contexts, denoting a more front quality.

/ɔ:/: A MANOVA test showed significant differences between *F*1 and *F*2 for contexts containing vowel /ɔ:/ at midpoint (Wilks`s Λ = 0.832, F (6, 262) = 4.198, p<.0001, η_{p}^2 = 0.088). Statistical results on *F*1 frequencies obtained at the midpoint of vowel /ɔ:/ revealed a significant effect with a moderate effect size (F (3, 135) = 5.779, p<0.001, η_p^2 = 0.116). Bonferroni post-hoc analysis revealed significant differences between ħ-o context and each of o-ħ, o-o and isolation contexts. *F*2 frequencies obtained at the midpoint of vowel /a:/ revealed a significant effect with a moderate effect size (F (3, 135) = 3.119, p<0.001, η_p^2 = 0.066). Bonferroni post-hoc analysis revealed a significant more front quality for ħ-o context. There are also tendencies for the other two pharyngeal contexts to show a more front quality and for all three contexts to show a more open quality.

7.3.2.2 *Short Vowels*

Frequency changes of *F*1 and *F*2 measured at midpoint in short vowels neighbouring the two pharyngeal consonants are presented below (table 7.10, figure 7.15). General results show: **1-** a more open and more back quality for vowel /ɪ, ɛ/; **2-** a varying effect of /ħ/ on /ʊ/ depending on word position, with an initial /ħ/ leading to a more open and more back quality and a final /ħ/ leading to a more open and more front /ʊ/ quality; **3-** no significant differences between the two pharyngeals. Below are the detailed results for each vowel.

Table 7.10: Effect size differences and Cohen d values for *F*1/*F*2 frequency changes within pharyngeal and oral contexts at midpoint of short vowels.

Vowel	Formant	Context1	Context2	Cohen *d*	effect size	Sig.
/ı/	*F*1	ʕ-o	o-o	1.65	large	*p*<0.001
	*F*2	ʕ-o	o-o	0.96	large	*p*<0.001
/ɛ/	*F*1	o-o	ħ-o	1.46	large	*p*<0.001
			ʕ-o	2.30	large	*p*<0.001
			o-ħ	1.84	large	*p*<0.001
		ħ-o	ʕ-o	0.69	moderate to large	*p*<0.001
	*F*2	o-ħ	ħ-o	2.25	large	*p*<0.001
			ʕ-o	1.79	large	*p*<0.001
			o-o	2.58	large	*p*<0.001
		ʕ-o	ħ-o	0.89	large	*p*<0.001
			o-o	0.80	large	*p*<0.001
/ʊ/	*F*1	ħ-o	o-ħ	1.85	large	*p*<0.001
			o-o	3.27	large	*p*<0.001
		o-ħ	o-o	3.79	large	*p*<0.001
	*F*2	ħ-o	o-ħ	2.32	large	*p*<0.001

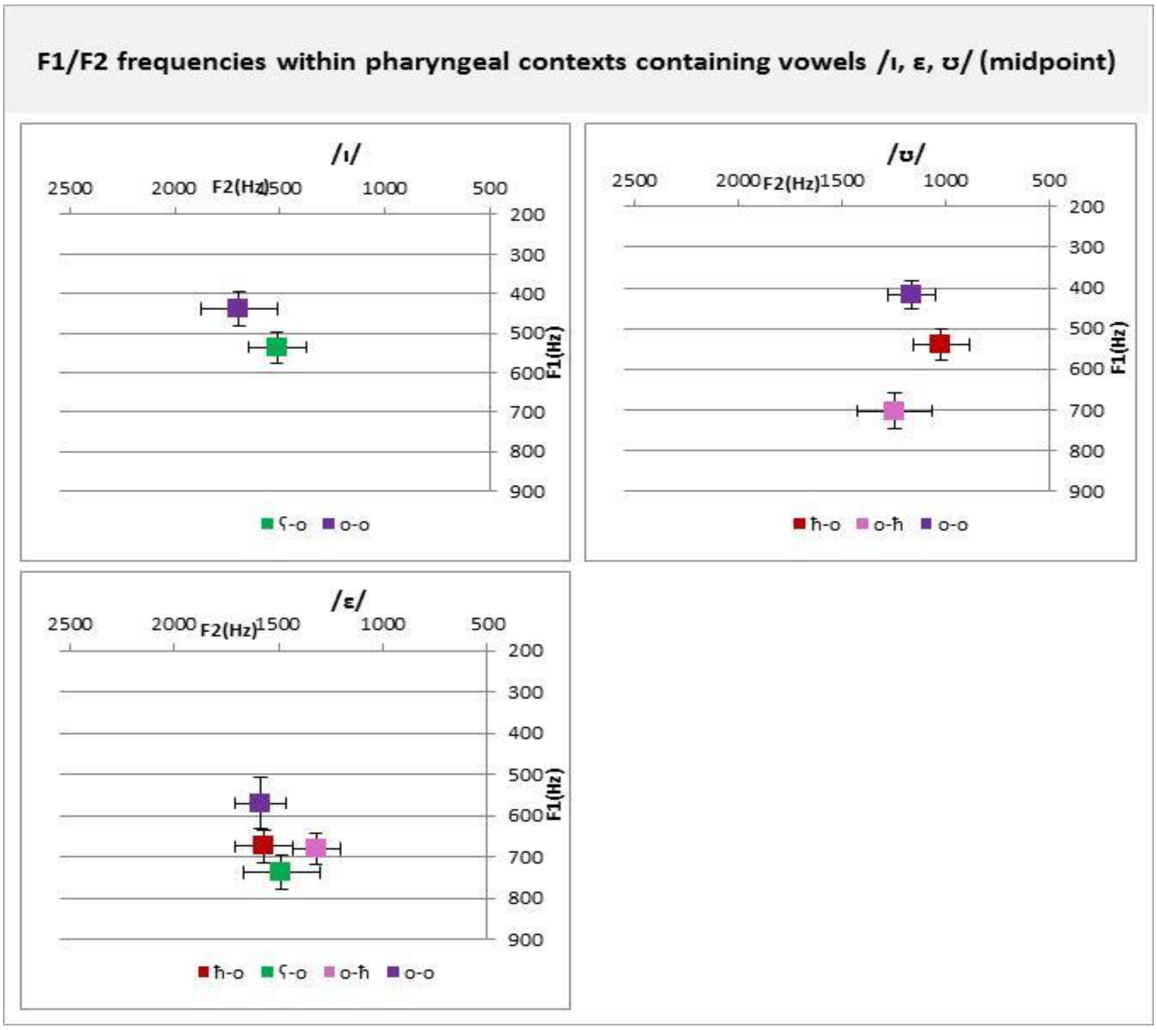


Figure 7.15: Plotted *F*1/*F*2 frequencies in vowels /ı, ɛ, ʊ/ within pharyngeal contexts in comparison to oral and isolation contexts measured at midpoint.

/ɪ/: A MANOVA test showed significant differences between *F*1 and *F*2 for contexts containing vowel /ɪ/ at midpoint (Wilks`s $\Lambda = 0.616$, $F\,(2, 24) = 7.467$, $p<.0001$, $\eta_p^2 = 0.384$). An independent-samples *t*-test was applied and revealed a significant difference ($t\,(25) = 3.941$,

p<0.001) between ʕ-o and o-o on $F1$ values. Another independent-samples t-test was applied and revealed a significant difference (t (25) = 2.147, p<0.001) between ʕ-o and o-o on $F2$ values.

/ɛ/: A MANOVA test showed significant differences between $F1$ and $F2$ for contexts containing vowel /ɛ/ at midpoint (Wilks`s Λ = 0.437, F (6, 260) = 22.217, p<.0001, η_p^2 = 0.339). Statistical results on $F1$ frequencies obtained at the midpoint of vowel /ɛ/ revealed a significant difference with a large effect size (F (3, 134) = 32.443, p<0.001, η_p^2 = 0.426). Bonferroni post-hoc analysis revealed significant differences between o-o contexts and each of ħ-o, ʕ-o and o-ħ contexts; and between ħ-o and ʕ-o contexts. $F2$ frequencies obtained at the midpoint of vowel /ɛ/ revealed a significant effect with a large effect size (F (3, 134) = 17.409, p<0.001, η_p^2 = 0.285). Bonferroni post-hoc analysis revealed significant differences between o-ħ context and each of ħ-o, ʕ-o and o-o contexts; and between ʕ-o context and each of ħ-o and o-o contexts. These results show contexts o-ħ and ʕ-o as having a rise in $F1$ and a drop in $F2$, indicating a more back and more open quality. Context o-ʕ only shows a rise in $F1$, indicating a more open quality.

/ʊ/: A MANOVA test showed significant differences between $F1$ and $F2$ for contexts containing vowel /ʊ/ at midpoint (Wilks`s Λ = 0.185, F (4, 44) = 14.552, p<.0001, η_p^2 = 0.570). Statistical results on $F1$ frequencies obtained at the midpoint of vowel /ʊ/ revealed a significant effect with a large effect size (F (2, 25) = 29.801, p<0.001, η_p^2 = 0.722). Bonferroni post-hoc analysis revealed significant differences between ħ-o and each of o-ħ and o-o contexts; and between o-ħ and o-o. $F2$ frequencies obtained at the midpoint of vowel /ʊ/ revealed a significant effect with a large effect size (F (2, 25) = 6.915, p<0.001, η_p^2 = 0.376). Bonferroni post-hoc analysis revealed significant differences between ħ-o and o-ħ contexts. These results show two different formant changes, one whereby the vowel in ħ-o context shows a more open and more back quality and the other whereby the vowel in o-ħ context shows a more open but more front quality. These results suggest that the position of the pharyngeal has a varying effect on formant frequencies extending into the middle part of the vowel.

7.3.3 Offset

As for the onset portion, the offset portion of the vowel near a pharyngeal is compared with that of the same vowel in oral and isolation contexts. As was found at onset, Figures 7.16 and 7.17 show that contexts are wider apart, showing that pharyngeal contexts have more effect on the edges of the vowel than at midpoint. However, results also show that the distance between contexts is not as wide at offset as it was at onset, indicating a progressive effect of pharyngealisation. Overall results of both long and short vowels show a similar trend of formant frequency changes whereby $F1$ rises in all vowels suggesting a more open quality, and $F1$ lowers in front vowels suggesting a more back quality but rises in back vowels suggesting a more front quality. However, vowel /ɔ:/ shows a more front and more open quality when compared to isolation context but a more back and more open quality when compared to an oral one. Furthermore, when comparing the effects of either pharyngeal at offset, no significance was found in the three vowels /i:, a:, u:/.

7.3.3.1 *Long Vowels*

Frequency changes of *F*1 and *F*2 measured at offset in long vowels neighbouring the two pharyngeal consonants are presented below (table 7.11, figure 7.16). General results show: **1-** and more open and more back quality for vowel /i:/; **2-** only a more open quality for vowel /a:/; **3-** for vowels /u:, ɔ:/ a more open and more front quality in relation to isolation contexts, and a more open and more back quality in relation to oral contexts. Below are the detailed results for each vowel.

Table 7.11: Effect size differences and Cohen d values for *F*1/*F*2 frequency changes within pharyngeal, oral and isolation contexts at offset of long vowels.

Vowel	Formant	Context1	Context2	Cohen *d*	effect size	Sig.
/i:/	*F*1	o-o	o-ħ	2.71	large	$p<0.001$
			o-ʕ	2.65	large	$p<0.001$
	*F*2	o-o	o-ħ	0.98	large	$p<0.001$
			o-ʕ	1.04	large	$p<0.001$
		isolation	o-ħ	1.48	large	$p<0.001$
			o-ʕ	1.51	large	$p<0.001$
/a:/	*F*1	o-o	o-ħ	1.96	large	$p<0.001$
			o-ʕ	2.06	large	$p<0.001$
		isolation	o-ħ	1.74	large	$p<0.001$
			o-ʕ	1.98	large	$p<0.001$
/u:/	*F*1	o-o	o-ħ	2.89	large	$p<0.001$
			o-ʕ	3.16	large	$p<0.001$
		isolation	o-ħ	2.26	large	$p<0.001$
			o-ʕ	2.36	large	$p<0.001$
	*F*2	o-o	o-ħ	1.02	large	$p<0.001$
			o-ʕ	1.47	large	$p<0.001$
		isolation	o-ħ	0.97	large	$p<0.001$
			o-ʕ	0.80	large	$p<0.001$
/ɔ:/	*F*1	o-ħ	o-o	2.40	large	$p<0.001$
			isolation	1.62	large	$p<0.001$
	*F*2	o-ħ	o-o	1.11	large	$p<0.001$

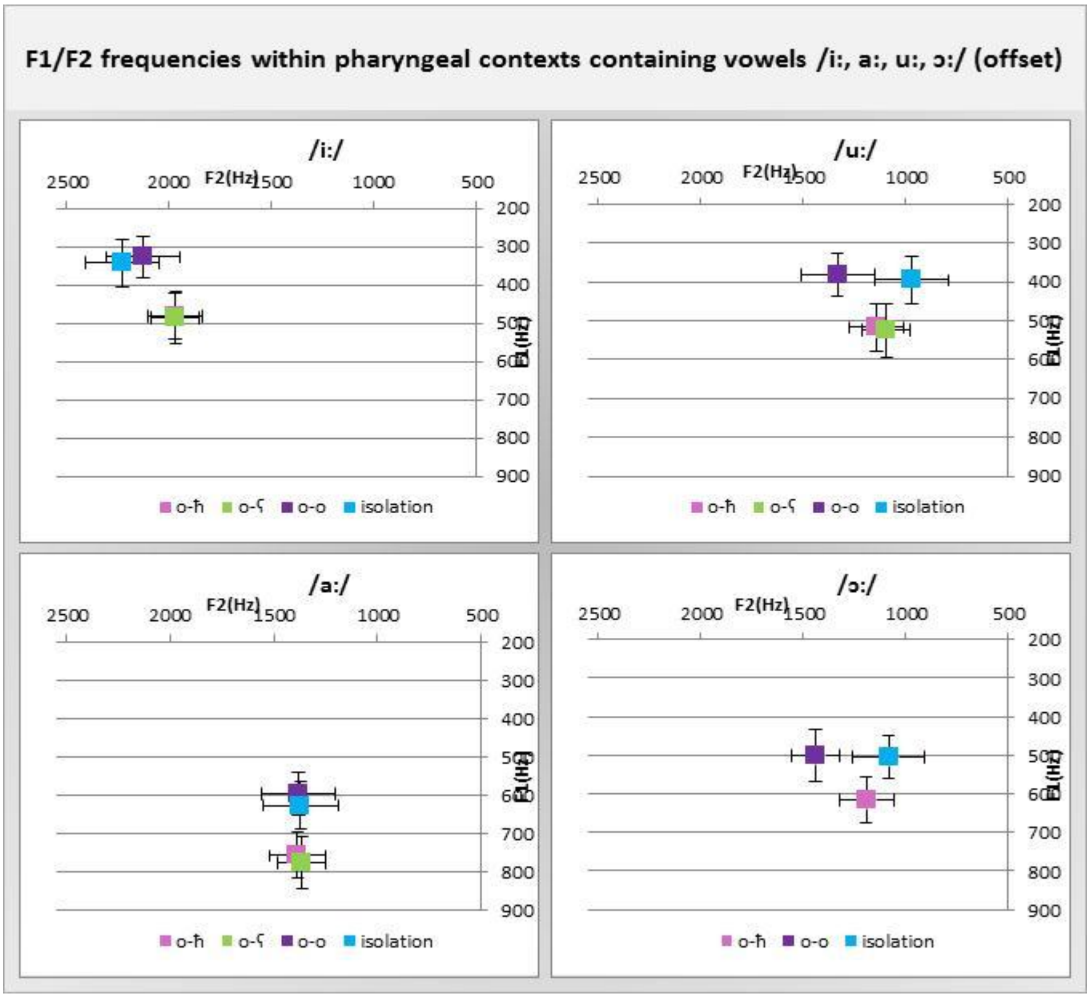


Figure 7.16: Plotted *F*1/*F*2 frequencies in vowels /i:, a:, u:, ɔ:/ within pharyngeal contexts in comparison to oral and isolation contexts measured at offset.

/i:/: A MANOVA test showed significant differences between *F*1 and *F*2 for contexts containing vowel /i:/ at offset (Wilks`s Λ = 0.431, *F* (6, 388) = 33.826, *p*<.0001, η_p^2 = 343). Statistical results on *F*1 frequencies obtained at the offset of vowel /i:/ revealed a significant effect with a large effect size (*F* (3, 198) = 57.425, *p*<0.001, η_p^2 = 0.469). Bonferroni post-hoc analysis revealed significant differences between o-o context and each of o-ħ and o-ʕ contexts; but not between o-ħ and o-ʕ contexts themselves. *F*2 frequencies obtained at the midpoint of vowel /i:/ revealed a significant effect with a large effect size (*F* (3, 198) = 22.161, *p*<0.001, η_p^2 = 0.254). Bonferroni post-hoc analysis revealed significant differences between o-o context and each of o-ħ and o-ʕ contexts; between isolation context and each of o-ħ and o-ʕ contexts; but not between o-ħ and o-ʕ contexts themselves.

/a:/: A MANOVA test showed significant differences between *F*1 and *F*2 for contexts containing vowel /a:/ at offset (Wilks`s Λ = 0.717, *F* (6, 820) = 24.703, *p*<.0001, η_p^2 = 0.153). Statistical results on *F*1 frequencies obtained at the offset of vowel /a:/ revealed a significant effect with a large effect size (*F* 3, 414) = 53.796, *p*<0.001, η_p^2 = 0.282). Bonferroni post-hoc analysis revealed significant differences between o-o context and each of o-ħ and o-ʕ contexts; between isolation context and each of o-ħ and o-ʕ contexts; but not between o-ħ and o-ʕ contexts themselves. *F*2 frequencies obtained at the offset of vowel /a:/ revealed a non-significant effect with a small effect size (F (3, 414) = 0.148, p>0.001, $\eta_p^2 = 0.001$).

/u:/: Results show both pharyngeal contexts lead to a raised *F*1, indicating a more open quality in relation to o-o and isolation contexts; but showing a more front quality with a raised *F*2 in relation to isolation context and a more back quality with a lowered *F*2 in relation to o-o context. A MANOVA test showed significant differences between *F*1 and *F*2 for contexts containing vowel /u:/ at offset (Wilks`s Λ = 0.405, F (6, 342) = 32.581, p<.0001, $\eta_p^2 = 0.364$). Statistical results on *F*1 frequencies obtained at the offset of vowel /u:/ revealed a significant effect with a large effect size (F (3, 175) = 32.695, p<0.001, $\eta_p^2 = 0.363$). Bonferroni post-hoc analysis revealed significant differences between o-o context and each of o-ħ and o-ʕ contexts; between isolation context and each of o-ħ and o-ʕ contexts; but not between o-ħ and o-ʕ contexts themselves. *F*2 frequencies obtained at the offset of vowel /u:/ revealed a significant effect with a large effect size (F (3, 175) = 31.062, p<0.001, $\eta_p^2 = 0.351$). Bonferroni post-hoc analysis revealed significant differences between o-o context and each of o-ħ and o-ʕ contexts; between isolation context and each of o-ħ and o-ʕ contexts; but not between o-ħ and o-ʕ contexts themselves although showing a more open more back quality for o-ʕ.

/ɔ:/: As was found for /u:/, results for /ɔ:/ show o-ħ context as leading to a raised *F*1, indicating a more open quality in relation to o-o and isolation contexts; but showing a more front quality with a raised *F*2 in relation to isolation context and a more back quality with a lowered *F*2 in relation to o-o context. A MANOVA test showed significant differences between *F*1 and *F*2 for contexts containing vowel /ɔ:/ at offset (Wilks`s Λ = 0.708, F (4, 248) = 11.668, p<.0001, η_p^2 = 0.158). Statistical results on *F*1 frequencies obtained at the offset of vowel /ɔ:/ revealed a significant effect with a moderate effect size (F (2, 127) = 11.343, p<0.001, $\eta_p^2 = 0.154$). Bonferroni post-hoc analysis revealed significant differences between o-ħ context and each of o-o and isolation contexts. *F*2 frequencies obtained at the offset of vowel /ɔ:/ revealed a significant effect with a moderate effect size (F (2, 127) = 12.264, p<0.001, $\eta_p^2 = 0.164$). Bonferroni post-hoc analysis revealed significant differences between o-ħ and o-o contexts.

7.3.3.2 *Short Vowels*

Frequency changes of *F*1 and *F*2 measured at offset in short vowels neighbouring the two pharyngeal consonants are presented below (table 7.12, figure 7.17). General results show a more open and more back quality for vowel /ɛ/ and a more open and more front quality for vowel /ʊ/. Below are the detailed results for each vowel.

Table 7.12: Effect size differences and Cohen d values for *F*1/*F*2 frequency changes within pharyngeal and oral contexts at offset of short vowels.

Vowel	Formant	Context1	Context2	Cohen *d*	effect size	Sig.
/ɛ/	*F*1	o-ħ	o-o	4.79	large	*p*<0.001
	*F*2	o-ħ	o-o	0.84	large	*p*<0.001
/ʊ/	*F*1	o-ħ	o-o	4.85	large	*p*<0.001
	*F*2	o-ħ	o-o	2.95	large	*p*<0.001

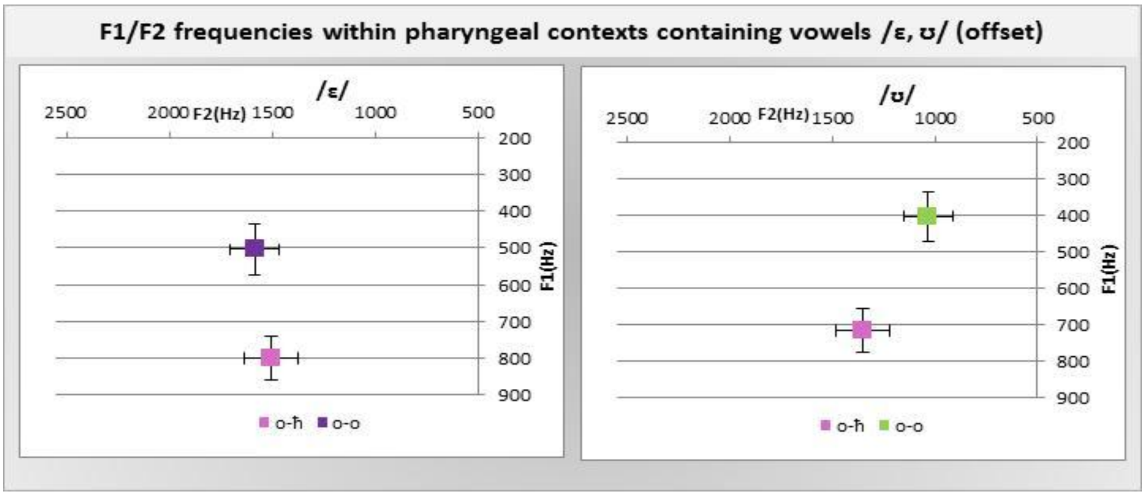


Figure 7.17: Plotted *F*1/*F*2 frequencies in vowels /ɛ, ʊ/ within pharyngeal contexts in comparison to oral and isolation contexts measured at offset.

/ɛ/: A MANOVA test showed significant differences between *F*1 and *F*2 for contexts containing vowel /ɛ/ at offset (Wilks`s $\Lambda = 0.274$, $F(2, 69) = 91.274$, $p<.0001$, $\eta_p^2 = 0.726$). An independent-samples *t*-test was applied and revealed a significant difference ($t(70) = 13.265$, $p<0.001$) between o-ħ and o-o on *F*1 values. Another independent-samples *t*-test was applied and revealed a significant difference ($t(70) = 2.341$, $p<0.001$) between o-ħ and o-o on *F*2 values.

/ʊ/: A MANOVA test showed significant differences between *F*1 and *F*2 for contexts containing vowel /ʊ/ at offset (Wilks`s $\Lambda = 0.117$, $F(2, 14) = 52.919$, $p<.0001$, $\eta_p^2 = 0.883$). An independent-samples *t*-test was applied and revealed a significant difference ($t(16) = 9.878$, $p<0.001$) between o-ħ and o-o on *F*1 values. Another independent-samples *t*-test was applied and revealed a significant difference ($t(15) = 5.736$, $p<0.001$) between o-ħ and o-o on *F*2 values.

Results from the three vowel portions showed that both pharyngeals had the same effect, with a general increase of *F*1 and a decrease of *F*2 in front vowels but an increase of *F*2 in central and back vowels. These formant frequency changes show pharyngeals as being articulated in a manner that changes the quality of neighbouring vowels towards that of open (low) central vowel /aː/.

This lowering effect of pharyngeals was also noted by Bellem (2007: 142) in connection to the Iraqi dialect of Muslim Baghdadi.

7.4 Summary of Chapter 7

Results from this chapter have shown that only the voiceless pharyngeal /ħ/ is realised as described in the literature, as a voiceless pharyngeal fricative. Pharyngeal /ʕ/, on the other hand, does not fit the same profile noted in the literature, showing a range of realisations including an approximant, a fricative and a stop. Although all three realisations are produced in initial and final positions, approximants showed more prevalence in initial position (63% of realisations), while stops were more common in final position (75% of realisations) (Table 7.1). Baghdad and Mosul speakers had the most stop realisations. The constricted stop-like realisation of /ʕ/ in Baghdad fits in with descriptions of the *gelet* dialectal group as having a more emphatic or guttural quality (Bellem, 2007). Realisations also showed instances of accompanying creak, which again agrees with findings in the literature that associate this feature with pharyngeals (Ghazeli, 1977; Butcher and Ahmad, 1987; Heselwood, 2007). However, Basra speakers, while also belonging to the *gelet* dialect, exhibited the most approximant realisation in their pharyngeal production, with very few instances of stop realisations. This is not the only difference between Baghdad and Basra as will be noted in Chapters 8, 9 and 10, but it primarily shows that there are major differences between sub-dialects of the same group, each representing a region, Central and Southern of Iraq, respectively (see Chapter 11 for possible interpretations).

Comparisons of formant frequencies in vowels neighbouring pharyngeals with those in isolation and oral contexts showed that both pharyngeals had the same effect, with a general rise in $F1$ in all vowels, and a drop in $F2$ in front vowels /iː, ɪ, ɛː, ɛ/ but an increase in $F2$ in back vowels /uː, ʊ, ɔː/. Central vowel /aː/ showed a rise in F1 but no significant changes in $F2$, suggesting a more open quality. Overall results show the same changes at all three vowel portions with minor differences for some vowels particularly /ʊ/. These changes coincide with those reported by Al-Ani (1970), Butcher and Ahmad (1987) and Bellem (2007) and suggest that pharyngeal consonants have a centring effect on vowels.

Chapter 8 : Auditory Impressions of Nasalisation and Phonation Types in the Speech of Iraqi Speakers

8.1 Introduction

The present chapter will deal with the auditory patterns of nasalisation and phonation types in Iraqi Arabic. These will be investigated in various nasal, pharyngeal and oral contexts; within pharyngeal contexts, any potential effect of particular realisations of /ʕ/ on the presence of nasalisation and certain phonation types will also be explored. The final part of the chapter will investigate the relationship between the perceived phonation types and the occurrence of nasalisation.

8.2 Auditory Results of Nasalisation in Pharyngeals

Results from the auditory analysis are presented below as a function of the linguistic and the social (locality) context. Nasalisation is categorised along a perceptual continuum with the following three contexts: ‘very nasalised’, ‘little nasalisation’ and ‘no nasalisation’ (henceforth ‘very’, ‘little’ and ‘none’).

Investigating auditory impression of nasalisation is conducted within pharyngeal environments in comparison to oral and nasal ones. Two other environments are also investigated: **1-** nasal and pharyngeal (in nasal-pharyngeal and pharyngeal-nasal combinations), e.g. /nɔ:ʕ/ ‘type’ and /ʕɛn/ ‘about’, to see if a combination of nasal and pharyngeal consonants in the same word would have an increased effect of nasalisation in comparison with having a nasal-only environment. **2-** isolated vowel context, in order to find out whether its production will also be accompanied by nasalisation even when no other consonant, nasal or pharyngeal, is present. **3**- *cross-dialectal differences*, where the comparison is based upon the three dialects (Baghdad, Basra and Mosul).

The investigation of the first two environments is carried out by presenting a detailed examination of all contexts with particular focus on pharyngeal ones (n-ħ , ħ-n, n-ʕ, ʕ-n, ħ-o, o-ħ, ʕ-o and o-ʕ), e.g. /nɔ:ħ/ ‘wailing as in crying’, /ħɛn/ ‘longed for’, /nɔ:ʕ/ ‘type’, /ʕa:m/ ‘general’, /ħɛl/ ‘solution’, /za:ħ/ ‘moved aside’, /ʕa:ʃ/ ‘he lived’ and /ba:ʕ/ ‘he sold’. In the three stages the pharyngeals are compared to a nasal context which consists of either two nasals (referred to as nasal-nasal or n-n) or one nasal in either position and an oral in the other (referred to as nasal-oral and oral-nasal or n-o and o-n); an oral context which consists of any two consonants other than the two pharyngeals or the two nasals (refered to as oral or o-o); and finally to isolation which is the long vowels produced with no neighbouring consonants.

All stages and comparisons will be carried out on individual long and short vowels /iː, ɪ, ɛː, ɛ, aː, ʌ, uː, ʊ, ɔː/. Percentage values of tokens are presented within the charts in relation to the above contexts/environments and the perceptual continuum contexts of *very*, *little* and *none*. Three *Chi*-square statistical tests are applied. The first is a general *Pearson's Chi*-square test to reveal the auditory impression of nasalisation for a combination of contexts on each vowel. The other two tests are used to compare individual contexts for auditory impression of nasalisation. They are the *chi*-square *for Independence Test* and the *Fisher's Exact Test*. These two were applied to find out if any two contexts differed significantly; i.e. if a distinction between nasal and non-nasal contexts exists. After establishing that distinction, it is the aim of this study to find out which of these two contexts pharyngeal ones pattern with.

8.2.1 Contexts

Analysis for contexts is carried out in two stages: one takes into consideration the different contexts only (figure 8.1); the second takes into consideration type of vowel and pharyngeal (nasal and non-nasal) contexts only (figure 8.2). For the first stage individual contexts are compared on the presence of auditory nasalisation irrespective of type and position of consonants or type of neighbouring vowels. Statistical results revealed that the auditory impression of nasalisation is significantly associated with individual contexts (*Pearson's* $\chi^2 = 1065.550$, df = 26, $p<0.001$).

In an overall examination of individual vowels, statistical tests show that nasal contexts have more prominent levels of nasalisation than non-nasal contexts, with all nasal contexts showing more perceived nasalisation than non-nasal contexts. In comparing between individual contexts, the *Chi*-square *Test for Independence* and the *Fisher's Exact Test* show the following general results: **1-** nasal contexts are significantly more nasalised than non-nasal ones; **2-** pharyngeal-nasal and nasal-pharyngeal contexts show similar degrees of nasalisation to nasal-nasal contexts and more nasalisation than nasal-oral and oral-nasal ones; **3-** there is a significant difference between nasal-oral and oral-nasal contexts, with nasal-oral ones show more nasalisation; **4-** there are significant differences between non-nasal pharyngeal contexts and each of nasal and other non-nasal contexts, whereby non-nasal pharyngeal ones have in-between levels of nasalisation; **5-** pharyngeal-oral contexts show more nasalisation than oral-pharyngeal contexts. These results therefore show that auditory impression of nasalisation increases when there are two nasals, when nasals are in initial position (progressive effect), when a nasal is combined with a pharyngeal (irrespective of position), and when pharyngeals are in initial position (also progressive effect) within non-nasal contexts. However, the main result is that auditory impression of nasalisation is present within contexts containing pharyngeals even if no nasal consonant is present but rarely present within oral or isolation ones.

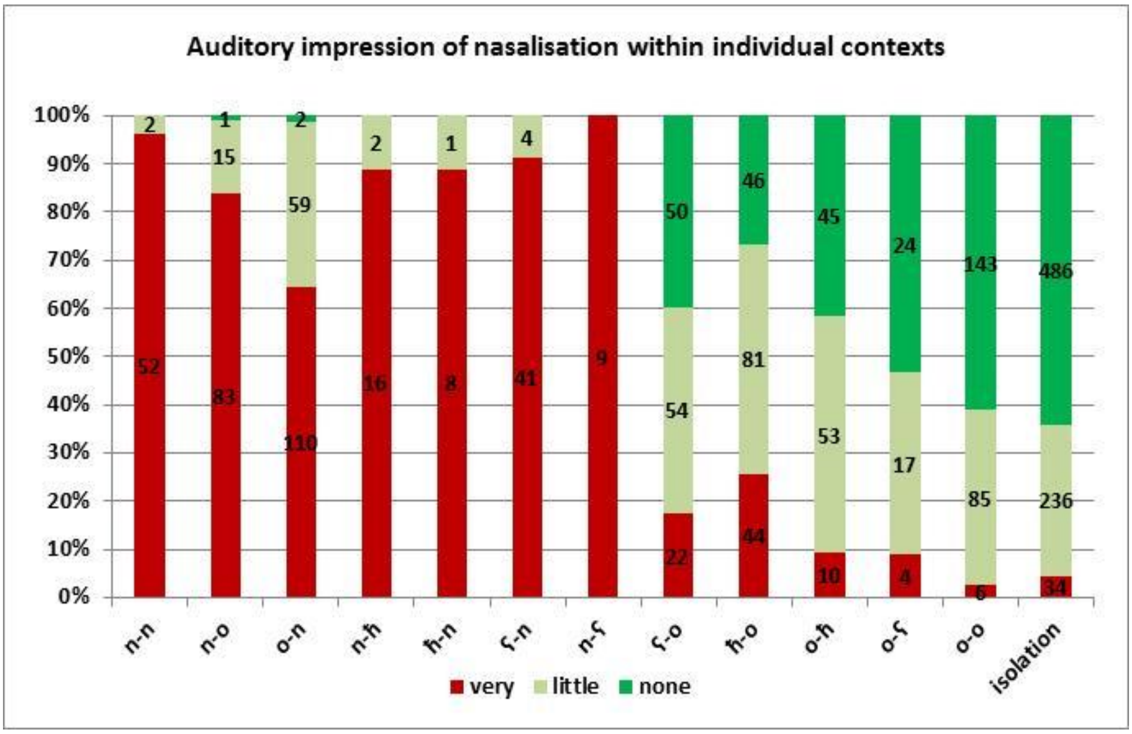


Figure 8.1: Auditory impression of nasalisation in relation to the different contexts irrespective of vowels.

For the second stage where individual contexts are compared on the presence of auditory nasalisation on the basis of individual vowels but irrespective of the position of the pharyngeal or nasal sounds, a general *Pearson's Chi*-square statistical test revealed that on a probability of $p<0.001$ there is a significant relationship between contexts containing vowels /ɛ:, ɛ, a:, u:, ɔ:/ for the auditory impression of nasalisation on a probability of $p<0.001$ (see Table 8.1 for all *Pearson's Chi*-square results).

Table 8.1: General *Pearson's Chi*-square test results of auditory impression of nasalisation on contexts containing each vowel.

Phoneme	Pearson *Chi*-Square	df	Sig.
i:	3.383	4	0.496
ɪ	--	--	--
ɛ:	33.157	4	0.000
ɛ	45.017	8	0.000
a:	52.249	10	0.000
ʌ	11.804	6	0.066
u:	39.620	6	0.000
ʊ	0.000	1	1.000
ɔ:	26.129	6	0.000

Not all results concluded from the overall comparison between contexts (figure 8.1) can be noted between contexts containing each vowel (figure 8.2). In comparing vowels, it is noted that most contexts containing vowels /iː, ɛː, ɛ, aː, ʌ, ɔː/ show high levels of nasalisation whereby more contexts containing vowels /ɪ, uː, ʊ/ show low levels of nasalisation. This indicates that vowel type also plays a role in the effect of auditory nasalisation. These results could explain some of the inconsistency of behaviour of some contexts, such as ħ-o, ʕ-o, o-ħ and o-ʕ contexts, for different vowels. On a probability of $p<0.001$, isolation contexts are similar to oral contexts in vowels /iː, ɛː, aː, uː/ but significantly different in vowel /ɔː/.

In order to compare individual contexts for auditory impression of nasalisation, two other *chi*-square tests were applied: a *chi*-square *Test for Independence* and *Fisher's Exact Test*. Results showed that contexts containing a combination of a pharyngeal and a nasal consonant are similar to each other but are significantly different from non-nasal pharyngeal contexts. There are differences caused by non-nasal pharyngeal contexts showing that: **1-** contexts containing pharyngeal /ħ/ exhibit more nasalisation than those containing /ʕ/ in initial position; **2-** contexts containing non-nasal pharyngeals show more nasalisation than oral and isolation contexts. In more detail: ħ-o context is significantly different from ʕ-o, o-ħ, o-ʕ, o-o and isolation contexts with ħ-o context showing more nasalisation; ʕ-o context is similar to o-ħ and o-ʕ contexts but significantly different from nasal contexts (in having less nasalisation) and from oral and isolation contexts (in having more nasalisation); o-ħ context is similar to o-ʕ and ʕ-o contexts but significantly different from all other contexts (again showing less nasalisation than all nasal contexts and ħ-o context, but having more nasalisation than o-o and isolation contexts); only o-ʕ context is similar to o-o and isolation contexts (which means that a pharyngeal in final position yields a reduced auditory impression of nasalisation especially if that pharyngeal is /ʕ/). However, overall results show that the main distinction between nasal and non-nasal contexts is similar in both stages one and two; therefore, only results of pharyngeal contexts will be tackled below (see table 8.2, figure 8.2).

Table 8.2: Significant results of *Chi*-square Test for Independence and Fisher's Exact Test results of auditory impression of nasalisation for individual contexts containing each vowel.

Vowel	Context1	Context2	*Chi*-square	df	Sig.
/ɛː/	ʕ-n	ʕ-o	14.4	2	$p<0.001$
		ħ-o	27.0	2	$p<0.001$
/ɛ/	ħ-n	ʕ-o	19.0	2	$p<0.001$
		ħ-o	16.6	2	$p<0.001$
		o-ħ	11.2	2	$p<0.001$
	ʕ-n	ʕ-o	23.2	2	$p<0.001$
		ħ-o	22.7	2	$p<0.001$
		o-ħ	15.1	2	$p<0.001$
/aː/	n-ħ	ħ-o	8.13	2	$p<0.001$

		o-ħ	16.6	2	$p<0.001$
		o-ʕ	15.3	2	$p<0.001$
	ʕ-n	ʕ-o	8.22	2	$p<0.001$
		ħ-o	11.8	2	$p<0.001$
		o-ħ	21.6	2	$p<0.001$
		o-ʕ	18.0	2	$p<0.001$
	o-ʕ	ʕ-o	14.0	2	$p<0.001$
		ħ-o	15.5	2	$p<0.001$
		o-ħ	9.87	2	$p<0.001$
/u:/	n-ħ	ʕ-o	23.0	2	$p<0.001$
		o-ħ	16.0	2	$p<0.001$
		o-ʕ	12.4	2	$p<0.001$
/ɔ:/	n-ʕ	ħ-o	7.94	2	$p<0.001$
		o-ħ	18.0	2	$p<0.001$
	ʕ-n	o-ħ	14.8	2	$p<0.001$

Results of vowels /ɛ:, ɛ, a:, u:, ɔ:/ show significant differences between the nasal and non-nasal pharyngeal contexts, with high degrees of nasalisation in the former; results of vowels /i:, ɛ:/ show no significant difference between contexts containing /ʕ/ and those containing /ħ/; nor does position of pharyngeal in vowels /ɛ:, ʊ/ have any impact on nasalisation. However, /a:/ shows variation between non-nasal pharyngeal contexts: **1-** contexts which have an initial pharyngeal are significantly different from those that have a final pharyngeal, with those in initial position showing more nasalisation: context ʕ-o is significantly different from both o-ʕ and o-ħ contexts; **2-** context ħ-o is significantly different from o-ʕ context; **3-** there is no significant difference between ħ-o and ʕ-o contexts; **4-** but there is a significant difference between o-ħ and o-ʕ contexts, with o-ħ context showing more nasalisation. For vowels /ʌ, ɔ:/, there is a significant difference between ħ-o and o-ħ, with ħ-o showing more nasalisation. For vowels /i:/, no significant differences are noted between any of the non-nasal pharyngeal contexts with all showing little nasalisation.

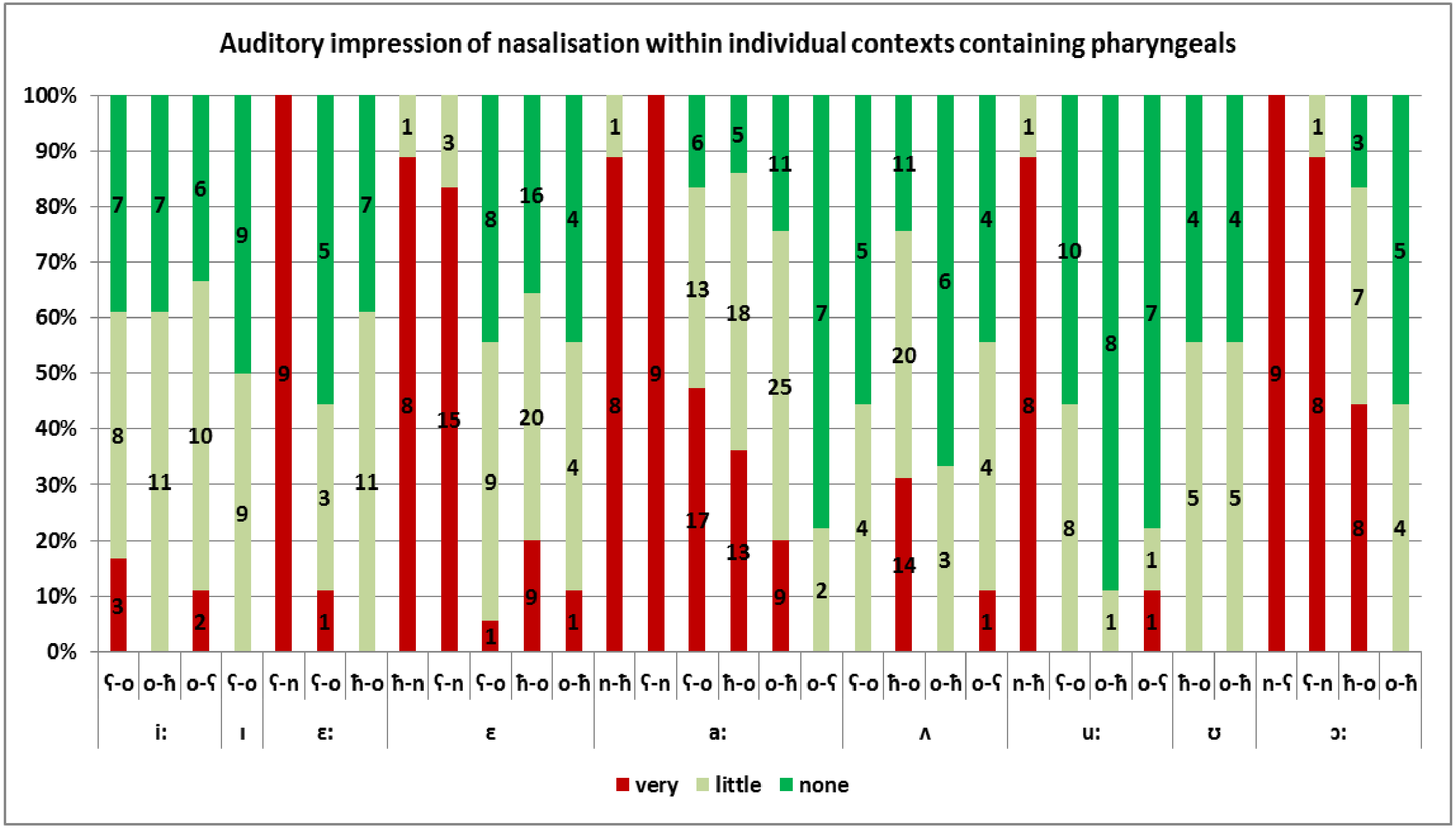


Figure 8.2: Auditory impression of nasalisation in relation to type and position of pharyngeal neighbouring each vowel.

8.2.2 Auditory impression of nasalisation in relation to the realisation and position of /ʕ/

As was previously mentioned, this section will only cover auditory impression of nasalisation in relation to the different realisations of the pharyngeal /ʕ/ within contexts containing that pharyngeal. A *Pearson's Chi*-square test revealed that the auditory impression of nasalisation is surprisingly not significantly associated with different realisations of the pharyngeal /ʕ/ within contexts containing that pharyngeal on a probability of $p<0.001$ (table 8.3).

Table 8.3: *Pearson's Chi*-square test results on different realisations of the pharyngeal /ʕ/ in relation to perceived nasalisation within contexts containing that pharyngeal.

Phoneme	Pearson *Chi*-Square	df	Sig.
i:	1.675	2	0.433
ɪ	4.667	2	0.097
ɛ:	1.620	4	0.805
ɛ	2.000	4	0.736
a:	8.631	4	0.071
ʌ	3.033	4	0.552
u:	5.536	4	0.237
ɔ:	0.782	4	0.941

Similar to section 8.2.1, this section compares between individual contexts for auditory impression of nasalisation in relation to the different realisations of the pharyngeal /ʕ/ within contexts containing that pharyngeal. The statistical tests applied show that the only significant difference is between approximants and stops neighbouring vowel /a:/ ($\chi^2 = 7.45$, df = 2, $p=0.024$) on a probability of $p<0.001$ with stops showing more nasalisation. Figure (8.3) shows that nasalisation is influencing some vowels and not others. It is also noted that nasalisation is either present in all contexts containing a particular vowel or is absent from all of them. Despite that, all those contexts are comparable. Accordingly, all contexts of vowels /i:, ɪ, ʌ, u:/ show low levels of nasalisation, while contexts of vowels /ɛ:, ɛ, a:, ɔ:/ show the highest levels of nasalisation. It is clearly noted that significant differences occur between vowels rather than as a direct relation to a specific realisation.

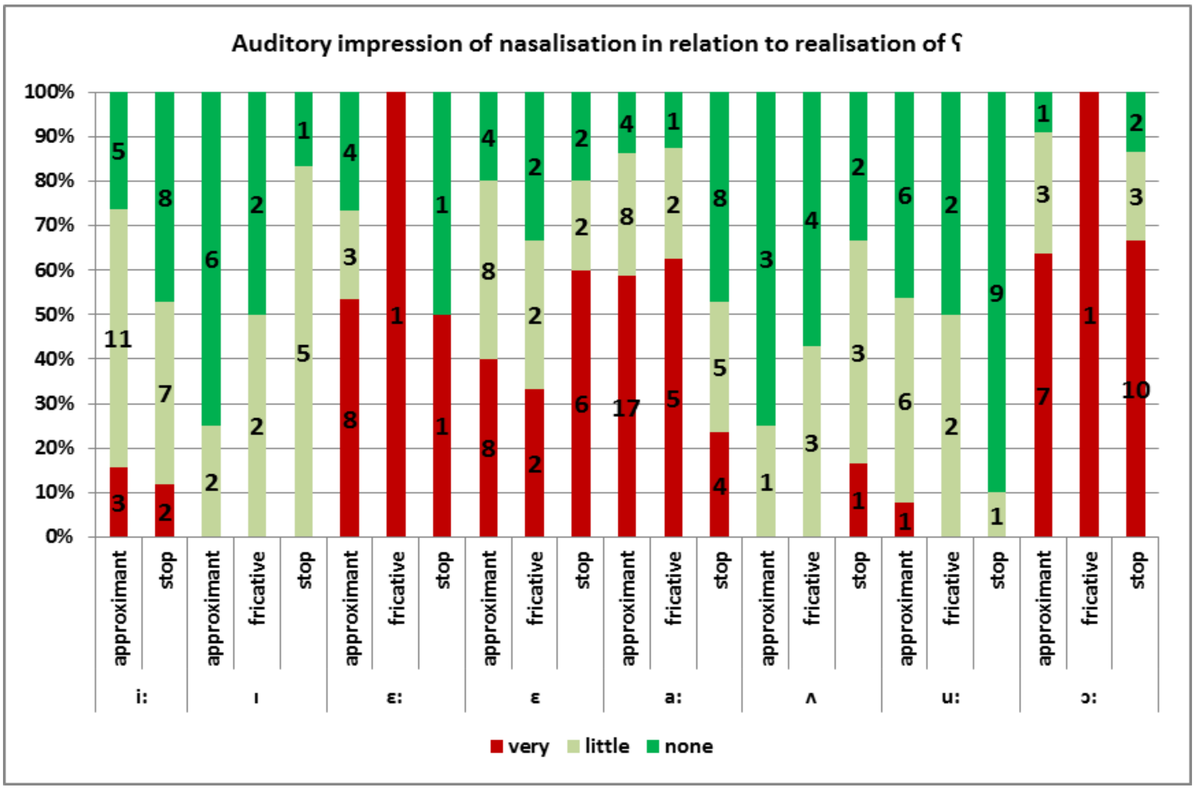


Figure 8.3: Auditory impression of nasalisation in relation to the position and realisation of /ʕ/ for each vowel.

8.2.3 Cross-dialectal differences in vowels

Percentages of all contexts for perceived nasalisation in the three dialects are shown in figure 8.4. A *Pearson's Chi*-square test revealed that the auditory impression of nasalisation is not significantly associated with cross-dialectal differences for vowels on a probability of $p<0.001$ although vowel /a:/ shows a tendency to have significant differences (table 8.4).

Table 8.4: *Pearson's Chi*-square test results on cross-dialectal differences in auditory impression of nasalisation within vowels.

phoneme	*Pearson Chi-Square*	df	Sig.
i:	6.617	4	0.158
ɪ	3.926	4	0.416
ɛ:	6.468	4	0.167
ɛ	3.448	4	0.486
a:	11.794	4	0.019
ʌ	0.541	4	0.969
u:	5.011	4	0.286
ɔ:	1.300	4	0.861
i:	3.871	4	0.424

Statistical tests showed no significance between dialects on the probability of $p<0.001$. These results show no distinction in auditory impression of nasalisation between dialects on the basis of vowels alone (i.e. when all contexts are combined).

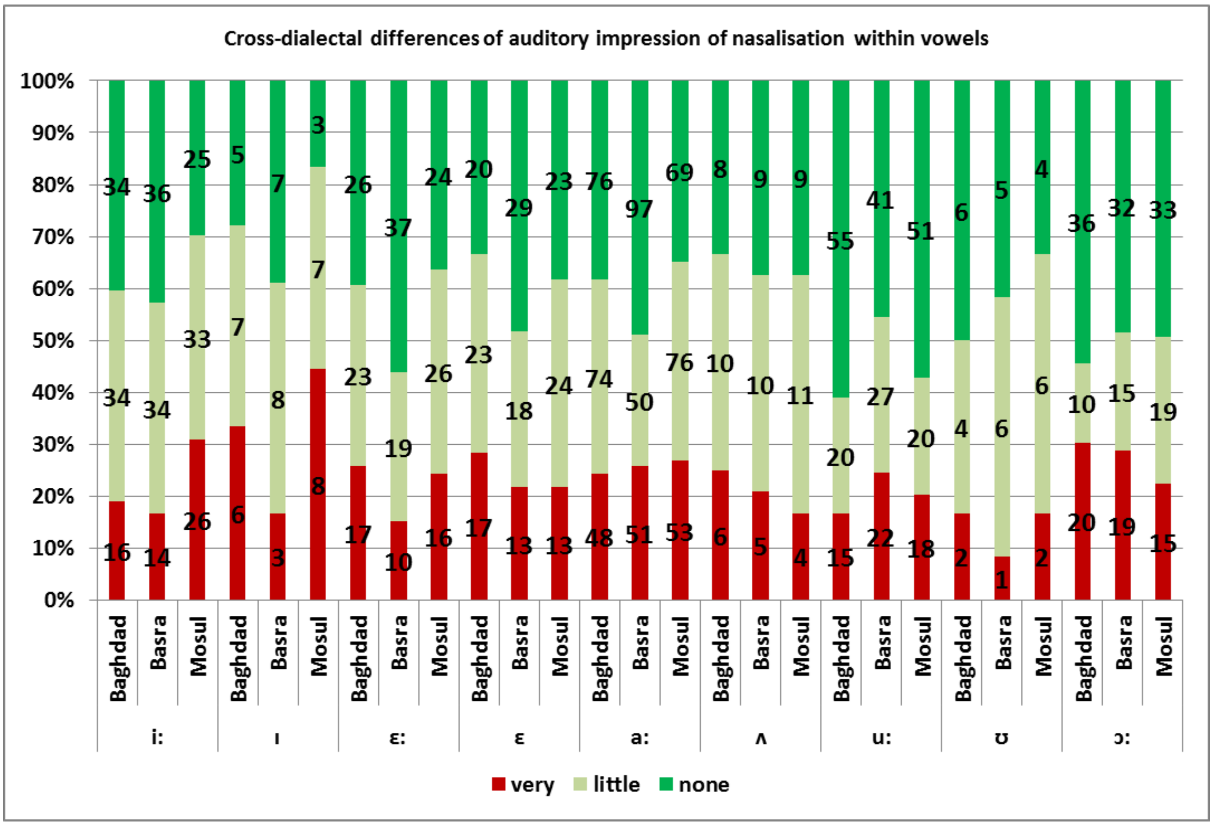


Figure 8.4: Cross-dialectal differences of auditory impression of nasalisation within vowels.

8.2.4 Cross-dialectal differences in individual contexts

Percentages of all contexts for perceived nasalisation in the three dialects are shown in figure 8.5. A *Pearson's Chi*-square test revealed that the auditory impression of nasalisation is not significantly associated with cross-dialectal differences for individual contexts on a probability of $p<0.001$ except for isolation (table 8.5).

Table 8.5: *Pearson's Chi*-square test results on cross-dialectal differences in auditory impression of nasalisation within individual contexts.

Context	*Pearson Chi*-Square	df	Sig.
n-n	4.154	2	0.125
n-o	3.369	4	0.498
o-n	1.310	4	0.860
n-ħ	1.125	2	0.570
ħ-n	2.250	2	0.325
n-ʕ	1.	2	1.000
ʕ-n	0.549	2	0.760
ħ-o	4.295	4	0.368
o-ħ	1.238	4	0.872
ʕ-o	4.301	4	0.367
o-ʕ	4.221	4	0.377
o-o	8.829	4	0.066
isolation	45.492	4	0.000

Statistical tests showed only three instances of significant differences between dialects on the probability of $p<0.001$. One significant difference is between Baghdad and Basra for oral contexts with Baghdad showing more nasalisation than Basra. The other two instances are between Mosul and each of Baghdad and Basra for isolation contexts with a $p<0.000$, whereby Mosul is showing the highest degree of auditory nasalisation. However, results showed no significant differences in connection to type and position of the pharyngeal. This denotes that the type and position of a pharyngeal has no effect on the auditory impression of nasalisation when comparing speakers of the three dialects under investigation. Despite having no significant differences between dialects, there are potential tendencies for Baghdad to show more nasalisation than the other two dialects. This is particularly noted in contexts ħ-o, ʕ-o and o-ʕ.

However, when comparing between contexts on the basis of dialect, a similar picture is noted to that in previous figures. The same pattern of results is noted whereby all nasal contexts have high levels of auditory nasalisation while oral and isolation contexts have the least; nasal-nasal and nasal-oral contexts show more nasalisation than oral-nasal context; non-nasal pharyngeal contexts show in-between levels of nasalisation, with pharyngeal-oral contexts showing higher levels of nasalisation than those of oral-pharyngeal ones. These results coincide with those previously noted whereby nasals and pharyngeals (in non-nasal contexts) have a progressive effect of auditory impression of nasalisation. Most importantly, irrespective of contexts and individual vowels, there does not seem to be many differences between speakers of the three dialects for auditory impression of nasalisation.

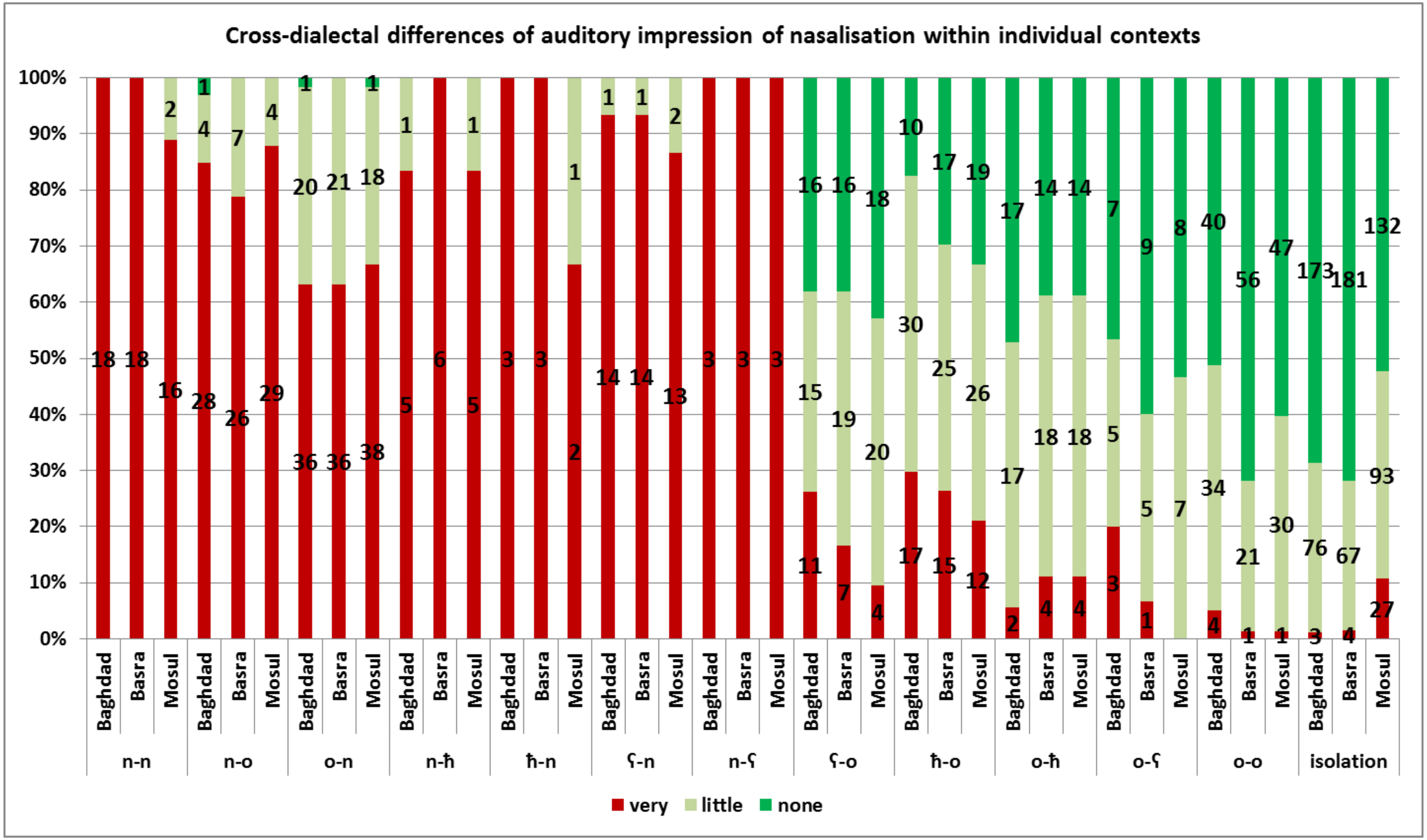


Figure 8.5: Cross-dialectal differences of auditory impression of nasalisation within individual contexts irrespective of vowels.

8.2.5 Cross-dialectal differences of auditory impression of nasalisation in relation to realisation of pharyngeal /ʕ/

A *Pearson's Chi*-square test revealed that the auditory impression of nasalisation is not significantly associated with cross-dialectal differences in relation to realisation of pharyngeal /ʕ/ (table 8.6, figure 8.6).

Table 8.6: *Pearson's Chi*-square test results on cross-dialectal differences of auditory impression of nasalisation in relation to realisation of pharyngeal /ʕ/.

Realisation of /ʕ/	*Pearson Chi-Square*	df	Sig.
approximant	3.463	4	0.483
fricative	2.362	4	0.670
stop	1.870	4	0.760

Statistical tests also showed non-significance between dialects. There is only one potentially significant tendency noted in figure 8.6 whereby Baghdad is showing more nasalisation than Basra and Mosul when producing approximants.

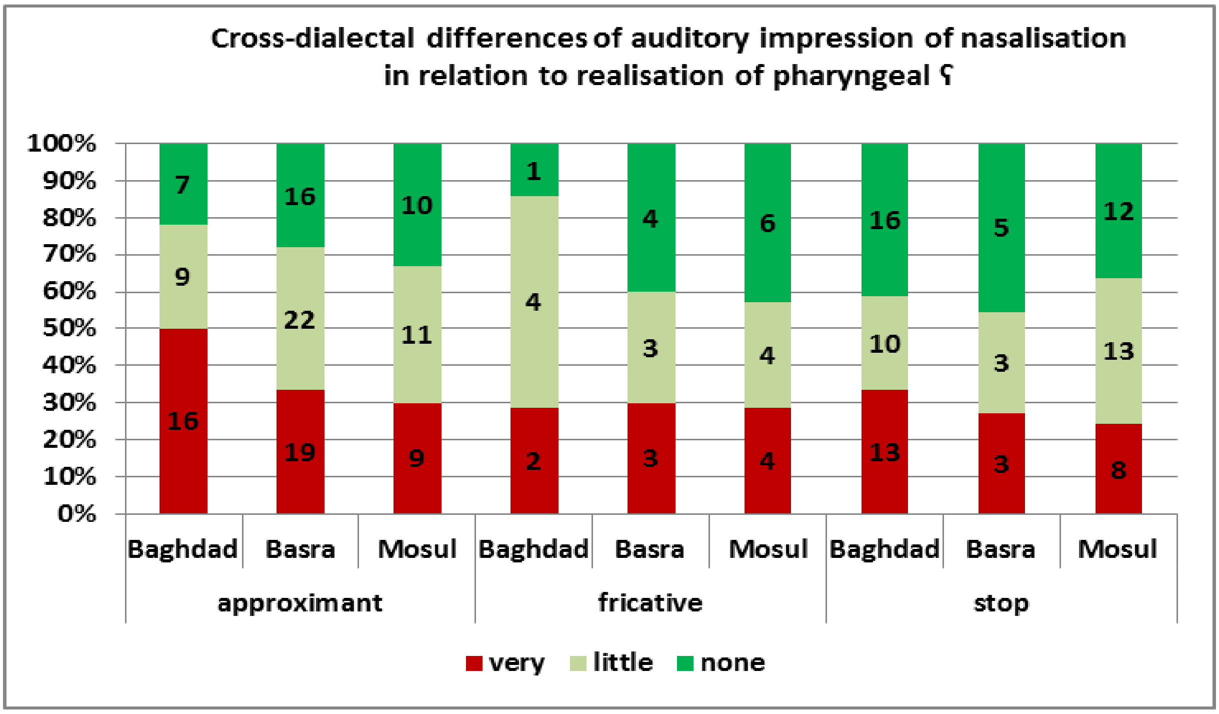


Figure 8.6: Cross-dialectal differences of auditory impression of nasalisation in relation to realisation of pharyngeal /ʕ/ irrespective of vowels.

8.3 Auditory impression of Phonation Types

Results from the auditory impression of phonation types are presented below as a function of the linguistic and the social (locality) context. The investigation of phonation types was focused on three categories: ‘creaky voice (laryngealised)’, ‘breathy voice’ and ‘modal voice’.

As for the auditory analysis of nasalisation, phonation types within pharyngeal environments are compared with oral and nasal ones; and in two other environments: **1-** a nasal pharyngeal one, to see if a combination of nasal and pharyngeal consonants in the same word would have an effect on the type of phonation perceived in comparison with having a nasal-only or a pharyngeal-only environment; **2-** isolated vowel context, in order to find out which phonation type will accompany their production even when no other consonant, nasal or pharyngeal, is present and if that phonation type is dialect-specific.

The investigation of the above-mentioned environments is carried out by presenting a general view of results within the same contexts and comparisons as in the analysis of nasalisation: between contexts and cross-dialectal. In the three stages the pharyngeal consonants are compared to nasal (which consists of two or one nasal consonants), oral and isolation environments.

All stages and comparisons will be carried out on individual long and short vowels /i:, ɪ, ɛ:, ɛ, a:, ʌ, u:, ʊ, ɔ:/. Percentages are presented within the charts in relation to the above contexts/environments and the three perceptual categories *creaky*, *breathy* and *modal*. These charts show the spread of phonation types according to the categories in question, one for auditory impression of phonation types in general and one in relation to the realisation of pharyngeal /ʕ/. Similar to section 8.2, three categorical *Chi*-square statistical tests are applied and for the same purposes, they are: 1- a *Pearson's Chi*-square test, 2- a *chi*-square *for Independence Test*, and 3- the *Fisher's Exact Test*.

8.3.1 Contexts

Analysis here is carried out in two stages: one takes into consideration the different contexts only (figure 8.7); the second takes into consideration type of vowel and pharyngeal (nasal and non-nasal) contexts (figure 8.8).

For the first stage contexts are compared on the presence of auditory phonation types in respect to the different individual contexts only, a *Pearson's Chi*-square test revealed that the auditory impression of different phonation types (creaky phonation in this case) is significantly associated with individual contexts (*Pearson's* $\chi 2 = 57.305$, df = 18, $p<0.001$).

Results show that: the lowest overall perceived laryngealisation is found in nasal contexts; while the highest is found in nasal pharyngeal contexts; oral contexts have low levels of laryngealisation and isolation have one of the highest levels; non-nasal pharyngeal contexts are interestingly showing lower levels of laryngealisation than their nasal counterparts, showing more instances of breathy phonation than nasal contexts; oral contexts also show more breathy instances than nasal ones. More importantly, results show a tendency for contexts n-ʕ and o-ʕ to have higher perceived laryngealisation than contexts n-ħ and o-ħ; and contexts with initial pharyngeals show more perceived laryngealisation than final ones.

In comparing between individual contexts, the *Chi*-square *Test for Independence* and the *Fisher's Exact Test* show: **1-** the general result is that contexts are either more creaky (more laryngealised) or less creaky because the traces of breathy phonation is very little and hardly noticeable even in contexts showing less laryngealisation; **2-** there seem to be more instances of breathy phonation in non-nasal contexts than there are in nasal ones; **3-** nasal contexts not containing pharyngeal consonants show the most pronounced auditory impression of laryngealisation (creaky) phonation; **4-** nasal contexts are significantly different from other contexts especially pharyngeal and isolation; **5-** pharyngeal contexts have most pronounced auditory impression of laryngealisation; **6-** initial pharyngeal contexts have more frequent auditory impression of laryngealisation than other contexts; **7-** oral-nasal context shows the least impression of laryngealisation; **8-** there are tendencies for the three nasal contexts (nasal-nasal, nasal-oral and oral-nasal) to show the least overall impression of laryngealisation than all the other contexts.

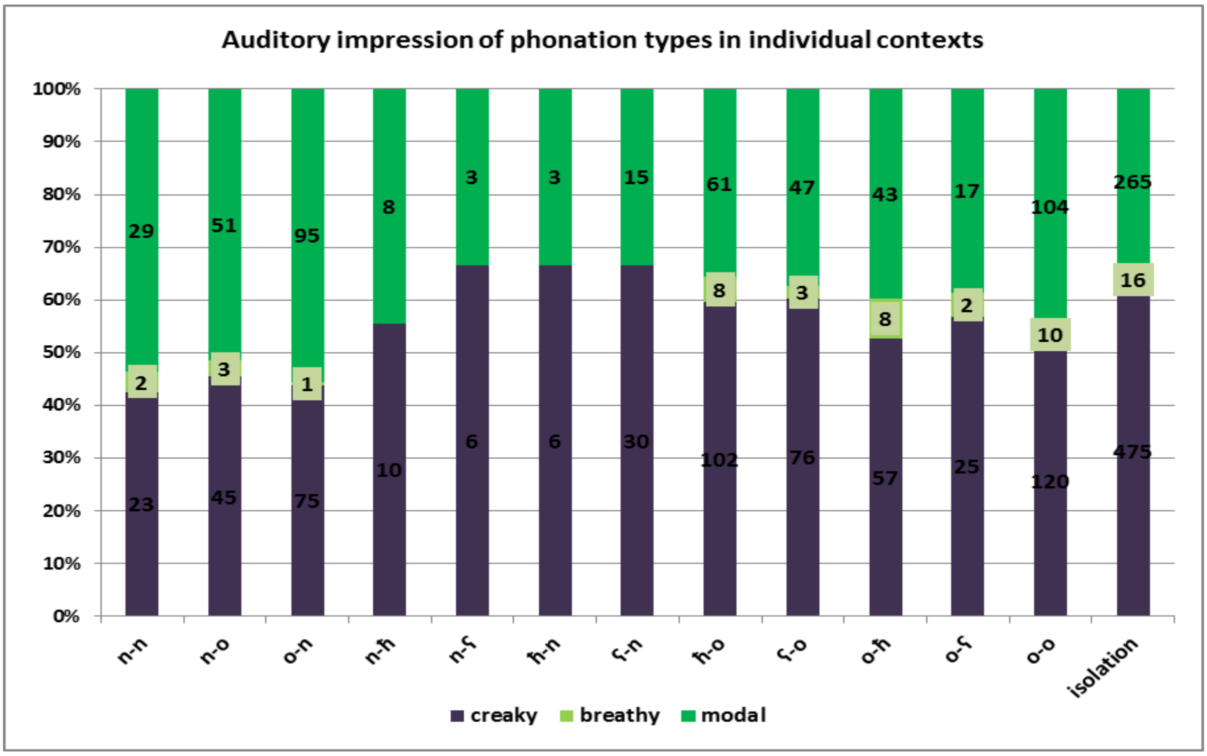


Figure 8.7: Auditory impression of phonation types in relation to the different contexts irrespective of vowels.

For the second stage contexts are compared on the presence of auditory laryngealisation on the basis of individual vowels (long and short) but irrespective of the position of the pharyngeal or nasal sounds. A *Pearson's Chi*-square test was applied and revealed that the auditory impression of nasalisation is only significantly associated with pharyngeal contexts containing vowel /a:/ on a probability of $p<0.001$ (table 8.7). This significance shows that this vowel has the most variation of results and significance between individual contexts as will be noted in table 8.8.

Table 8.7: *Pearson's Chi*-square test results of the auditory impression phonation types on pharyngeal contexts containing each vowel.

phoneme	*Pearson's Chi*-square	df	Sig.
i:	12.613	14	0.557
ɪ	3.842	6	0.698
ɛ:	18.796	12	0.094
ɛ	12.954	14	0.530
a:	77.334	20	0.000
ʌ	5.630	6	0.466
u:	16.327	16	0.430
ʊ	6.444	6	0.375
ɔ:	18.974	18	0.393

In comparing between individual contexts, the *Chi*-square *Test for Independence* and the *Fisher's Exact Test* were applied. Results show all contexts containing long vowels within nasal contexts as having the lowest auditory impression of laryngealisation, patterning with oral vowels in that respect, while the highest are those contexts that contain pharyngeal consonants, which pattern with isolation context (table 8.8). Initial pharyngeal consonants in non-nasal contexts show the most significant differences with other contexts. This shows a progressive effect of auditory impression of laryngealisation. In comparing nasal-oral with oral-nasal, an initial nasal shows less perceived laryngealisation than a final one. This coincides with the auditory impression of nasalisation whereby a final nasal consonant shows less perceived nasalisation than an initial one indicating a progressive effect of nasalisation.

Table 8.8: Chi-square Test for Independence and Fisher's Exact Test results of the auditory impression of phonation types in contexts containing vowels /ɛ:, ɛ, a:, u:, ɔ:/.

Vowel	Context1	Context2	*Chi*-square	df	Sig.
/ɛ:/	o-n	isolation	8.41	2	$p<0.001$
/ɛ/	n-o	o-o	12.1	2	$p<0.001$
	o-n	o-o	7.60	2	$p<0.001$
	ħ-n	o-o	7.60	2	$p<0.001$
	ħ-o	o-o	14.1	2	$p<0.001$
	o-ħ	o-o	12.1	2	$p<0.001$
/a:/	o-n	ħ-o	9.8	2	$p<0.001$
	o-n	ʕ-o	9.7	2	$p<0.001$
	o-n	o-ħ	7.72	2	$p<0.001$
	o-n	o-ʕ	8.79	2	$p<0.001$
	o-n	isolation	37.7	2	$p<0.001$
	n-ħ	isolation	7.65	2	$p<0.001$
	ʕ-o	o-ħ	7.60	2	$p<0.001$
	o-ħ	isolation	25.3	2	$p<0.001$
	o-o	isolation	19.8	2	$p<0.001$
/u:/	o-n	ʕ-o	8.2	2	$p<0.001$
	n-ħ	ʕ-o	9.7	2	$p<0.001$
/ɔ:/	ħ-o	isolation	11.1	2	$p<0.001$

Contexts containing short vowels, on the other hand, do not showing any significant differences and few tendencies that distinguish between contexts. Auditorily, all short vowels have high levels of perceived laryngealisation. Therefore, only long vowels will be tackled in some detail and as follows: **1-** no significant differences are noted between contexts containing vowel /i:/ but tendencies show pharyngeal and isolation contexts evoking the highest impression of laryngealisation in comparison with non-pharyngeal nasal and oral contexts; **2-** there are no significant differences between contexts containing vowel /u:/ nor are there any tendencies distinguishing them, but overall results of contexts containing this vowel show the lowest degree of laryngealisation; **3-** the only significant difference for contexts containing vowel /ɛ:/ show the isolation context having the highest level of laryngealisation and the oral-nasal one the lowest; **4-** all significant differences between contexts containing vowel /a:/ indicate two patterns: the first showing the highest levels of perceived laryngealisation in non-nasal pharyngeal and isolation contexts; the second showing low levels of perceived laryngealisation in nasal and oral contexts; **5-** the only significant difference for vowel /ɔ:/ is that between pharyngeal-oral and isolation contexts because for this vowel the pharyngeal-oral is not following the trend and has one of the lowest levels of perceived laryngealisation while isolation has one of the highest. Other comparisons for vowel /ɔ:/ show tendencies for non-pharyngeal nasal and oral contexts to show the lowest levels of auditory impressions of laryngealisation.

In order to compare differences between individual pharyngeal contexts in terms of the auditory impression of laryngealisation, two other *chi*-square tests were applied: a *chi*-square *Test for*

Independence and *Fisher's Exact Test*. Overall results show contexts containing pharyngeal /ʕ/ as triggering more frequent perceptions of laryngealisation than those containing /ħ/ (table 8.9, figure 8.8). Despite a few instances whereby this trend is not followed especially for vowels /ɛː, ʌ/, all other comparisons show this trend whether the consonants are initial, final, combined with a nasal or not. As was noted above contexts containing vowel /aː/ show the most significant distinctions. Furthermore, pharyngeal contexts ħ-o and o-ħ containing vowels /ʊ, ɔː/ do not show results that follow the progressive effect.

Table 8.9: Significant results of *Chi*-square Test for Independence and Fisher's Exact Test results of the auditory impression of phonation types for individual contexts containing vowels /ɛː, ɛ, aː, uː, ɔː/.

vowel	Context1	Context2	*Chi*-square	df	Sig.
/ɛ/	ħ-o	ʕ-o	6.48	2	$p<0.00$
/aː/	ħ-o	o-ħ	6.70	2	$p<0.00$
	ʕ-o	o-ħ	7.60	2	$p<0.00$
	o-ħ	isolation	25.3	2	$p<0.00$
/ɔː/	ħ-o	isolation	11.1	2	$p<0.00$

/iː/: There is no significant difference between contexts o-ħ and o-ʕ but there is a tendency for context o-ʕ to show more perceived laryngealisation than contexts o-ħ.

/ɛ/: There is a significant difference between contexts ħ-o and ʕ-o denoting the latter having more perceived laryngealisation. However, there is no significant difference between contexts ħ-n and ʕ-n, but they show a tendency to show more perceived laryngealisation in context ʕ-n.

/aː/: There are no significant differences between contexts ħ-o and ʕ-o or between contexts o-ħ and o-ʕ, but there is a tendency for contexts ʕ-o and o-ʕ to show higher levels of perceived laryngealisation than contexts ħ-o and o-ħ. Furthermore, results show a significant difference between ħ-o and o-ħ contexts indicating higher levels of perceived laryngealisation in context ħ-o denoting a progressive effect. There are no significant differences between contexts ʕ-o and o-ʕ but there is a tendency for context ʕ-o to show more perceived laryngealisation than context o-ʕ, also denoting a progressive effect.

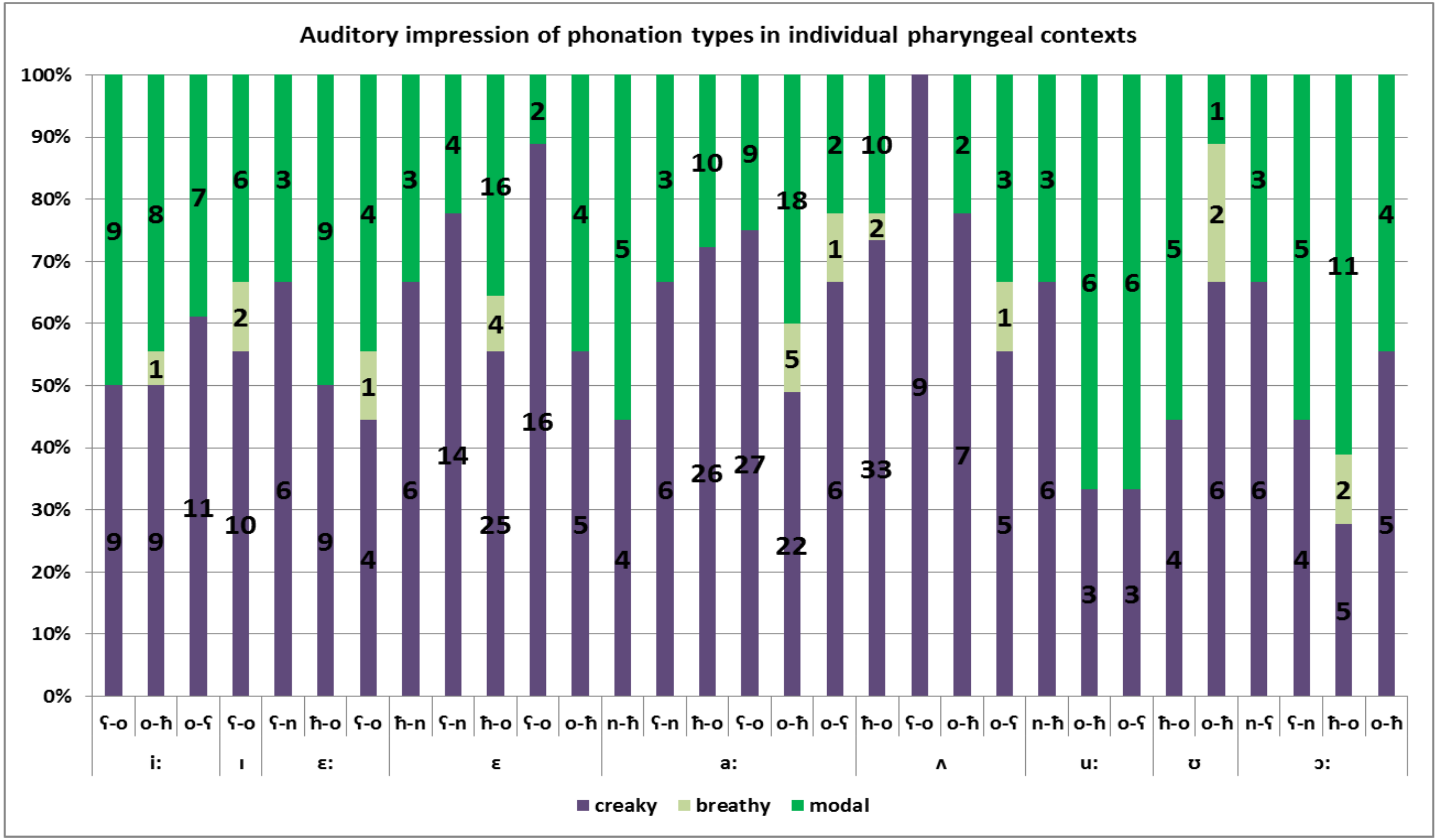


Figure 8.8: Auditory impression of phonation types in relation to type and position of pharyngeals for each vowel.

/ʌ/: For this vowel, individual pharyngeal contexts do not show any significant differences with each other. However, contexts ħ-o and ʕ-o show a tendency for context ʕ-o to have more perceived laryngealisation. On the other hand, and as noted above, contexts o-ħ and o-ʕ show the opposite trend with context o-ħ showing more perceived laryngealisation. Furthermore, the trend of the progressive direction of effect is also not present for contexts containing this vowel.

/uː/: Contexts o-ħ and o-ʕ show no significant differences or tendencies of effects by each pharyngeal consonant.

8.3.2 Auditory impression of phonation types in relation to the realisation of /ʕ/

A *Pearson's Chi*-square test revealed that there is no significant association between auditory impression of phonation types and different realisations of the pharyngeal /ʕ/ within contexts containing that pharyngeal on a probability of $p<0.001$ (table 8.10).

Table 8.10: *Pearson's Chi*-square test results on different realisations of the pharyngeal /ʕ/ in relation to perceived phonation types within contexts containing that pharyngeal for each vowel.

phoneme	*Pearson Chi-Square*	df	Sig.
iː	2.948	1	0.086
ɪ	2.750	4	0.600
ɛː	2.880	4	0.578
ɛ	0.480	2	0.787
aː	3.014	4	0.555
ʌ	2.313	4	0.678
uː	3.045	2	0.218
ɔː	0.835	2	0.659

This section compares between individual contexts for auditory impression of phonation types in relation to the different realisations of the pharyngeal /ʕ/ within contexts containing that pharyngeal. The same two *chi*-square tests were applied: the *chi*-square *Test for Independence* and the *Fisher's Exact Test*. Overall results show no significant differences between realisations of pharyngeal /ʕ/ and the auditory impression of phonation types. There is a tendency for stop realisations to show slightly higher levels of laryngealisation than approximants and fricatives (figure 8.9).

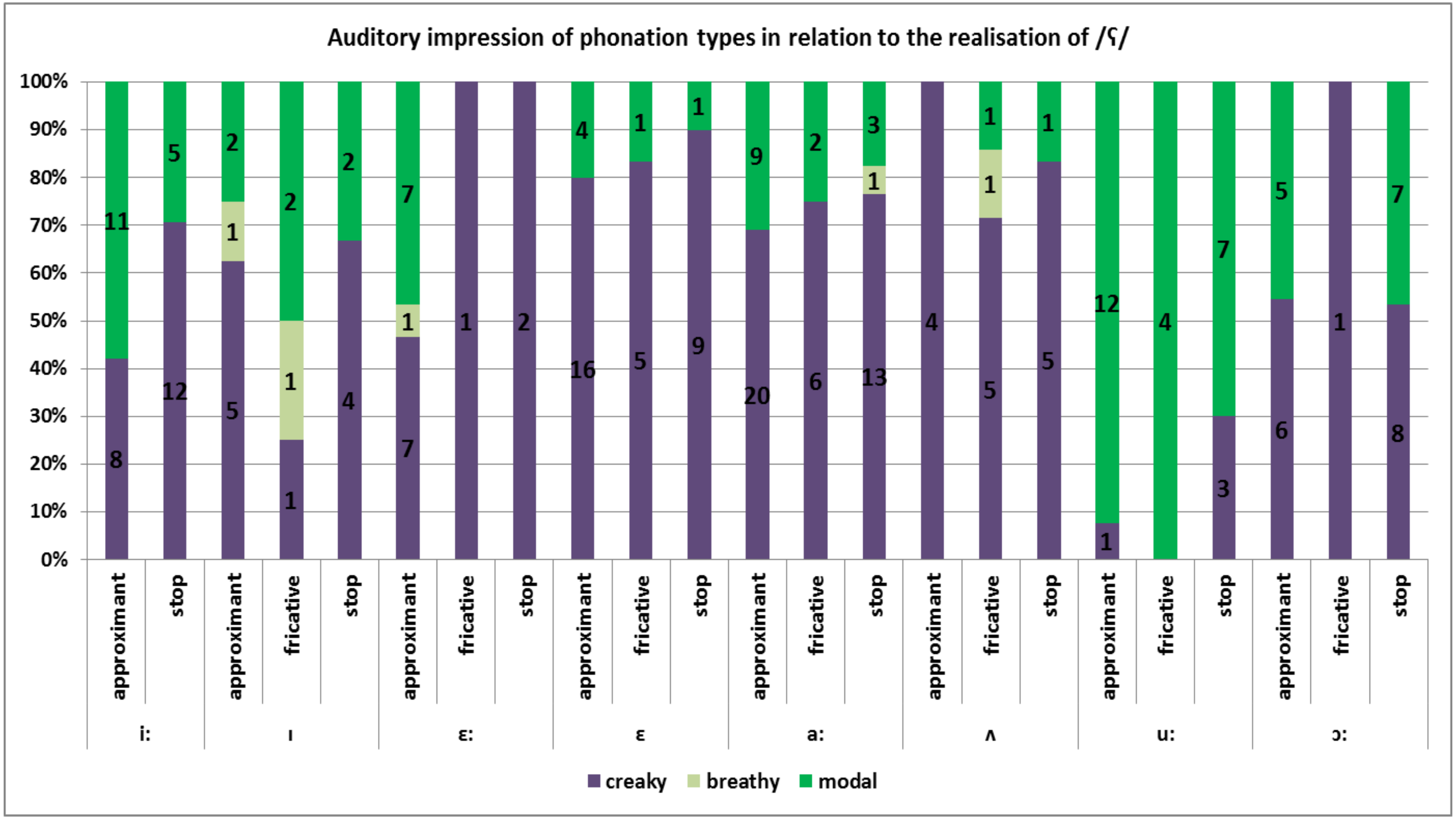


Figure 8.9: Auditory impression of phonation types in relation to the position and realisation of /ʕ/ for each individual vowel.

8.3.3 Cross-dialectal differences in vowels

Percentages of all contexts for perceived phonation types in the three dialects are shown in figure 8.10. A *Pearson's Chi*-square test revealed that the auditory impression of phonation types is significantly associated with cross-dialectal differences for vowels /i:, u:, ɔ:/ (table 8.11).

Table 8.11: *Pearson's Chi*-square test results of cross-dialectal differences on perceived phonation types within vowels.

phoneme	*Pearson Chi-Square*	df	Sig.
i:	40.250	4	0.000
ɪ	8.313	4	0.081
ɛ:	15.154	4	0.004
ɛ	8.159	4	0.086
a:	16.374	4	0.003
ʌ	6.133	4	0.189
u:	33.736	4	0.000
ʊ	9.833	4	0.043
ɔ:	29.882	4	0.000

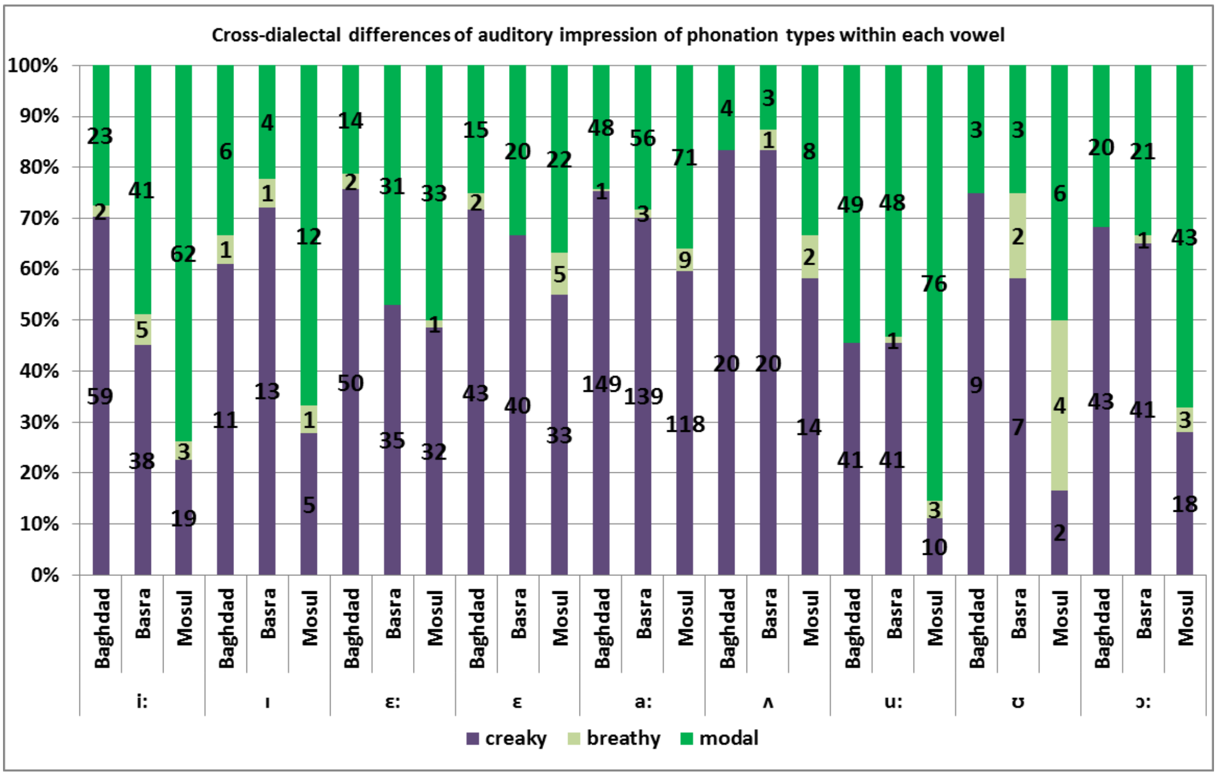


Figure 8.10: Cross-dialectal differences of auditory impression of phonation types within vowels.

Overall cross-dialectal results show Baghdad having the highest auditory impression of laryngealisation followed by Basra and Mosul showing the lowest (figure 8.10). Overall results show that: **1-** the overall lowest values are for vowel /u:/; **2-** there are significant differences between Mosul and each of Baghdad and Basra on vowels /a:, u:, ɔ:/ indicating Mosul having the least auditory impression of laryngealisation; **3-** there are no significant differences between dialects on vowels /ɛ, ʌ/, but there is a tendency for Mosul to show the least perceived laryngealisation; **4-** there are significant differences between all three dialects on vowel /iː/, between Baghdad and each of Basra and Mosul on vowel /ɛː/, and between Baghdad and Mosul on vowel /ʊ/ indicating that Baghdad has the highest auditory impression of laryngealisation for vowels /iː, ɛː, ʊ/ and Mosul the least for vowels /iː, ʊ/; **5-** there is a significant difference between Basra and Mosul for vowel /ɪ/ whereby it shows the only highest perceived laryngealisation for Basra but with Mosul also showing the least.

8.3.4 Cross-dialectal differences in individual contexts

This section tackles cross-dialectal differences of auditory impression of phonation types within individual contexts. Percentages of all contexts for perceived phonation types in the three dialects are shown in figure (8.11). A *Pearson's Chi*-square test revealed that the auditory impression of phonation types is significantly associated with cross-dialectal differences for individual contexts on a probability of p<0.001 within contexts o-n, o-ħ and o-o (table 8.12).

Table 8.12: *Pearson's Chi*-square test results on cross-dialectal differences in auditory impression of phonation types within individual contexts.

context	*Pearson Chi-Square*	df	Sig.
n-n	16.232	4	0.003
n-o	11.286	4	0.024
o-n	36.960	4	0.000
n-ħ	3.150	2	0.207
ħ-n	0.000	2	1.000
n-ʕ	3.000	2	0.223
ʕ-n	7.800	2	0.020
ħ-o	14.830	4	0.005
o-ħ	20.106	4	0.000
ʕ-o	3.849	4	0.427
o-ʕ	3.853	4	0.426
o-o	20.738	4	0.000
isolation	19.166	4	0.001

In applying the *chi*-square *Test for Independence* and the *Fisher's Exact Test*, results showed significant differences between Mosul and the other two dialects. Mosul shows the lowest auditory impression of laryngealisation and Baghdad the highest in most contexts except nasal-pharyngeal and pharyngeal-nasal whereby Basra shows the highest impression of laryngealisation. This result is noted in most contexts except n-ħ, n-ʕ and ʕ-n (figure 8.11).

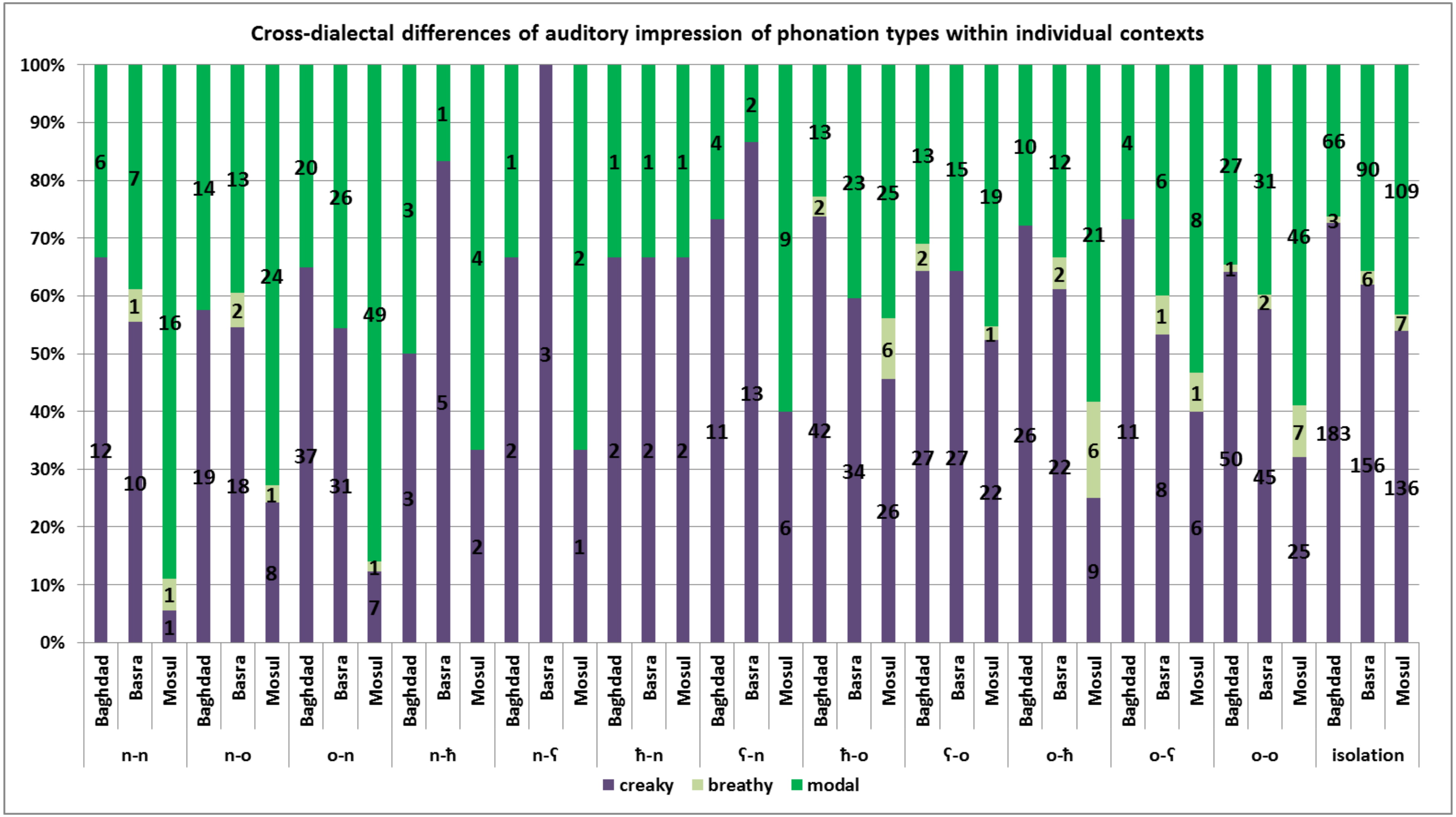


Figure 8.11: Cross-dialectal differences of auditory impression of phonation types within individual contexts.

8.3.5 Cross-dialectal differences in auditory impression of phonation types in relation to realisation of pharyngeal /ʕ/

A *Pearson's Chi*-square test revealed that the auditory impression of phonation types is significantly associated with cross-dialectal differences in relation to realisation of pharyngeal /ʕ/ for stop realisations (table 8.13, figure 8.12).

Table 8.13: *Pearson's Chi*-square test results on cross-dialectal differences of auditory impression of phonation types in relation to realisation of pharyngeal /ʕ/.

realisation of /ʕ/	*Pearson Chi-Square*	df	Sig.
approximant	10.225	4	0.037
fricative	1.601	4	0.809
stop	16.068	4	0.000

Results show that for the realisations of /ʕ/ as an approximant, there is a significant difference between Basra and Mosul approximants whereby Basra shows the most frequent laryngealisation and Mosul the least. For the realisations of a stop, there is a significant difference between Baghdad and Mosul stops whereby Baghdad shows the most frequent laryngealisation and Mosul the least. There are no significant differences between dialects in the relation between auditory laryngealisation and the realisations of /ʕ/ as a fricative. Overall, results show that stop realisations trigger the highest impression of laryngealisation.

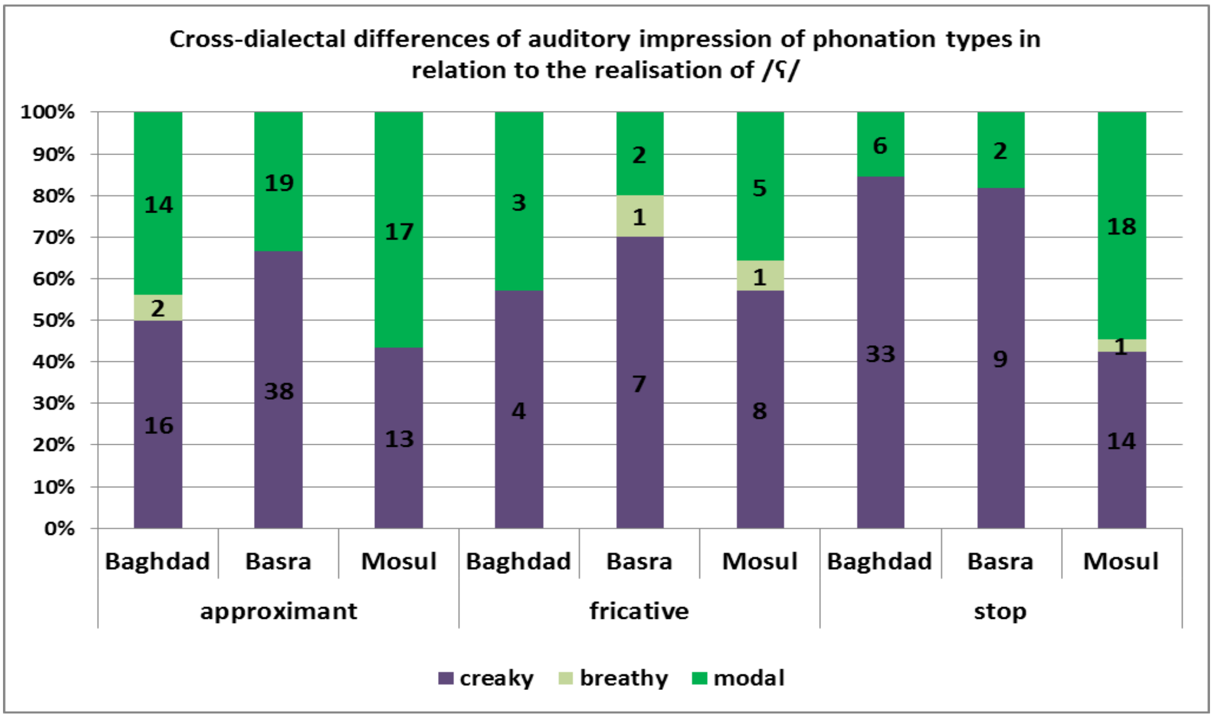


Figure 8.12: Cross-dialectal differences of auditory impression of phonation types in relation to realisation of pharyngeal /ʕ/ irrespective of vowels.

8.4 Summary of Chapter 8

This chapter presented results from two auditory investigations, one of nasalisation and the other of phonation types. Results of the auditory impression of nasalisation showed that there is a distinction between nasal and non-nasal contexts and that non-nasal pharyngeal context had more perceived nasalisation than oral and isolation contexts. Results also showed that nasalisation increases when there are two nasals, when a nasal is combined with a pharyngeal (irrespective of position or type of pharyngeal), when a nasal is initial and combined with a final oral, and when a pharyngeal is also initial and combined with a final oral. Nasal and pharyngeal consonants therefore have a progressive effect on nasalisation. Cross-dialectal comparisons show tendencies for Baghdad to show more nasalisation than the other two dialects. Finally, no significant differences were noted between realisations of pharyngeal /ʕ/ and nasalisation.

Results of the auditory impression of phonation types showed that there is a distinction between pharyngeal and non-pharyngeal contexts, with nasal contexts having the least perceived laryngealisation and pharyngeal ones the highest; isolation contexts had the most perceived laryngealisation whereas oral contexts had the least; contexts containing pharyngeal /ʕ/ showed more perceived laryngealisation than those containing /ħ/; and pharyngeal consonants had a progressive effect of laryngealisation. Cross-dialectal comparisons showed Baghdad speakers as having higher levels of laryngealisation and Mosul speakers the least. A few instances showed a connection between type of pharyngeal realisation and phonation types whereby stop realisations showed a tendency to trigger the highest perceived laryngealisation. Cross-dialectally, Basra approximants and Baghdad stops showed the highest levels of perceived laryngealisation but no distinction was noted for fricatives; for both approximants and stops Mosul showed the least perceived laryngealisation.

Chapter 9 : Acoustic Parameters of Nasalisation in Iraqi Arabic

9.1 Introduction

The present chapter will deal with the acoustic patterns of nasalisation in Iraqi Arabic. These acoustic measurements will be investigated in various nasal, pharyngeal and oral contexts and results of the acoustic measures of nasalisation compared with the auditory analyses in Chapter 8.

Sections will present results from the following acoustic normalised measurements: *A*1-**P*1 [(18)] (difference between amplitude of *F*1 and amplitude of the extra peak between *F*1 and *F*2), *A*1-**P*0 (difference between amplitude of *F*1 and amplitude of extra peak below *F*1), *B*1 (bandwidth of *F*1), *F*1/*F*2 frequency changes and *overall vowel intensity* (for more details see Chapter 6). These measurements are taken in each of the environments detailed in section 8.2. Three portions of the vowel are also investigated as follows: onset (at the start of the vowel near initial nasal and pharyngeal consonants), midpoint (irrespective of the position of nasals and pharyngeals), and offset (at the end of a vowel near final nasal and pharyngeal consonants). For statistical comparisons, a general one-way ANOVA will be applied for contexts containing each vowel and each context for cross-dialectal comparisons. This is followed by a Bonferroni post-hoc analysis to investigate potential differences between the low level contexts.

9.2 *A*1-**P*1

In this section, results of measuring *A*1-**P*1 will be tackled within contexts containing each individual vowel as well as cross-dialectally. Here and elsewhere the values resulting from the *A*1-**P*1 measurement are interpreted as follows (see Chen 1995, 1997, 2000; Chen et al. 2000, 2007; and Berger 2007): the lower the amplitude difference the more nasalisation the context exhibits, with phonological nasal contexts expected to have the lowest of all values, the oral and isolated vowel contexts the highest, and the pharyngeal and pharyngeal-nasal as the experimental ones. Following studies by Chen (1995 onwards, see Chapter 4, section 4.7) in which a difference of less than 10 dB was considered as indicative of the vowel being nasal, results from this study are evaluated with this figure in mind while being mindful of the different vowel contexts looked at in the present study.

[(18)] The star sign accompanying *P*1, *P*0, *H*1 and *H*2 denotes normalised measures.

The following sections will present results at onset and offset portions due to the fact that results at midpoint were similar but their figures can be found in Appendixes E and F. Each portion will be followed by a discussion of results in general and in connection with each type of comparisons (i.e. between individual contexts or cross-dialectal).

9.2.1 Onset

Results generally show a distinction between two types of vowels: those that have a low *F*1, i.e. high and high-mid vowels /iː, ɪ, ɛː, ʊ, uː/, and those that have a high *F*1, i.e. low and low-mid vowels /aː, ʌ, ɔː/. The contexts are: n-n (nasal-nasal) e.g. /naːm/ 'he slept', n-o (nasal-oral) e.g. /mɛl/ 'he is bored', o-n (oral-nasal) e.g. /dɛm/ 'blood', n-ħ and n-ʕ (both are part of the nasal-pharyngeal environment) e.g. /naːħ/ 'he wailed' and /nɔːʕ/ 'types' respectively, ħ-n and ʕ-n (both are part of pharyngeal-nasal environment) e.g. /ħɔːm/ 'he hovered' and /ʕɛm/ 'uncle' respectively, ħ-o and ʕ-o (previously part of pharyngeal-oral) e.g. /ħʊb/ 'love' and /ʕɛːb/ 'rude' respectively, o-ħ and o-ʕ (previously part of oral-pharyngeal) e.g. /lɔːħ/ 'a piece of wood' and /ðiːʕ/ 'broadcast' respectively, o-o (oral) e.g. /baːb/ 'door' and isolation. Main results reveal that low and low-mid vowels / aː, ʌ, ɔː/ show lower *A*1-**P*1 values than high and high-mid vowels /iː, ɪ, ɛː, ɛ, ʊ, uː/. Below are the detailed results for each vowel. A discussion of all results will be presented later (this applies to all results in this chapter).

9.2.1.1 *Contexts*

Results will be presented following the order in figure 9.1. Below are detailed results of each vowel and only significant differences are presented in table 9.1.

Table 9.1: Effect size differences and Cohen *d* values for *A*1-P*1 values within individual contexts at onset.**

Vowel	Context1	Context2	Cohen *d*	effect size	Sig.
/iː/	isolation	n-n	0.99	large	p<0.001
		n-o	0.79	moderate to large	p<0.001
		ʕ-o	0.78	moderate to large	p<0.001
/ɪ/	o-o	n-n	0.59	moderate	p<0.001
		ʕ-o	0.86	moderate to large	p<0.001
/ɛː/	o-o	ʕ-n	1.10	large	p<0.001
		ħ-o	0.68	moderate to large	p<0.001
	ħ-o	o-o	0.84	large	p<0.001
/ɛ/	o-o	n-o	0.53	moderate	p<0.001
		ʕ-n	1.01	large	p<0.001
/aː/	o-o	ħ-o	0.55	moderate	p<0.001
		ʕ-o	0.57	moderate	p<0.001

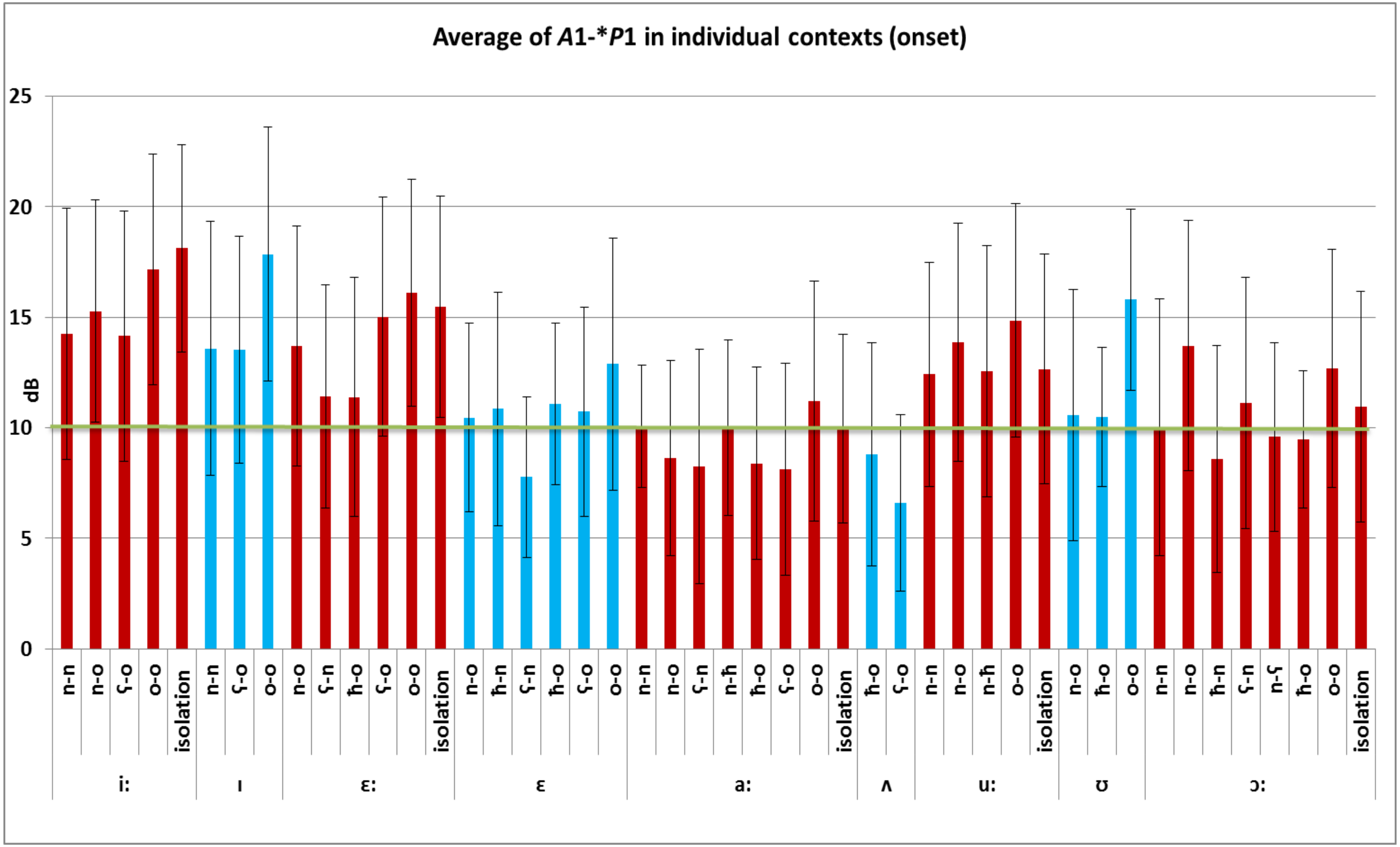


Figure 9.1: ***A*1-****P*1 **values within individual contexts at onset.**

/iː/: A one-way ANOVA reveals a significant effect of contexts containing vowel /iː/ on *A*1-**P*1 values at onset with a small effect size (F (4, 207) = 5.171, p<0.001, η_p^2 = 0.092). Bonferroni post-hoc analysis reveals isolation context as having significantly less nasalisation than each of n-n, n-o and ʕ-o contexts. No significant differences were observed between the o-o context and the remaining contexts, but the n-n, nasal-oral n-o and ʕ-o contexts show potential differences. There is non-significance between o-o and isolation contexts but they potentially belong to the same group of non-nasalised contexts with high average *A*1-**P*1 values. The above results indicate a distinction between nasal contexts and each of isolation and o-o contexts; the ʕ-o context patterns with nasal contexts, suggesting more nasalisation than other non-nasal contexts.

/ɪ/: A one-way ANOVA reveals a non-significant effect of contexts containing vowel /ɪ/ on *A*1-**P*1 values at onset; but Bonferroni post-hoc analysis reveals o-o context as having significantly less nasalisation than each of n-n and ʕ-o contexts. No significant differences are observed between the latter two contexts but their low average *A*1-**P*1 values show a tendency for both to have nasalisation.

/ɛː/: A one-way ANOVA reveals a significant effect contexts containing vowel /ɛː/ on *A*1-**P*1 values at onset with a moderate effect size (F (5, 169) = 2.646, p<0.001, η_p^2 = 0.075). Bonferroni post-hoc analysis reveals ħ-o context as having significantly more nasalisation than o-o context. No significant difference is observed between o-o and n-o contexts but show a tendency for n-o to suggest more nasalisation. Also n-o has a tendency to show less nasalisation than ʕ-n context, which indicates that a combination of nasal and pharyngeal consonants increases the effect of nasalisation on neighbouring vowels. No significant differences are noted between isolation context and the remaining contexts but show a tendency to pattern with the o-o context. No significant differences are observed between ħ-o and ʕ-o or between ʕ-o and other contexts due to the large SD values but the average *A*1-**P*1 values indicate a tendency for ʕ-o to have higher values than ħ-o suggesting more nasalisation. This is denoted by the moderate effect size difference between ħ-o and ʕ-o.

/ɛ/: A one-way ANOVA reveals a significant effect of contexts containing vowel /ɛ/ on *A*1-**P*1 values at onset with a moderate effect size (F (5, 161) = 2.862, p<0.001, η_p^2 = 0.084). Bonferroni post-hoc analysis reveals o-o context as having significantly less nasalisation than ʕ-n context, but not with ħ-n context. No significant differences are observed between o-o and ħ-n contexts, but they show a tendency for ħ-n to have lower *A*1-**P*1 values. These results indicate that the two pharyngeal consonants vary in their effect on *A*1-**P*1 values, with /ʕ/ showing more nasalisation than /ħ/. No significant differences are noted between contexts ħ-o and ʕ-o or with any other contexts. However, there is a tendency for ħ-o to show more nasalisation than ʕ-o.

/a:/: A one-way ANOVA reveals a significant effect of contexts containing vowel /a:/ on *A*1-*P1 values at onset with a small effect size (F (7, 486) = 2.447, p<0.001, η_p^2 = 0.035). Bonferroni post-hoc analysis reveals o-o context as having significantly less nasalisation than both ħ-o and ʕ-o contexts. No significant difference is noted between the two pharyngeal contexts. Despite having many tokens containing vowel /a:/, only the two mentioned contexts are significantly different showing the pharyngeal contexts as having the most nasalisation, even more than nasal contexts. This does follow the same pattern established in other vowels whereby pharyngeal contexts have high levels of nasalisation and oral contexts have the least. However, none of the four nasal contexts with or without pharyngeals have any significant differences with oral or with isolation due to the high peak found in all contexts irrespective of nasalisation.

/ʌ/: This vowel is found in two contexts only therefore an independent-samples *t*-test was applied and reveals a non-significant difference (t (51) = 1.222, p>0.001) between contexts ħ-o and ʕ-o on *A*1-**P*1 values at onset. However, there is still a tendency for context ʕ-o to have more nasalisation than ħ-o, denoting an opposite trend to that noted in other vowels.

/u:/: A one-way ANOVA reveals a significant effect of contexts containing vowel /u:/ on *A*1-*P1 values at onset with a moderate effect size (F (5, 223) = 2.914, p<0.001, η_p^2= 0.063). However, when investigating potential differences between the low level contexts, Bonferroni post-hoc analysis reveals non-significant differences. Generally, contexts containing /u:/ are similar to those containing /i:, ɪ, ɛ:, ɛ/ with most *A*1-**P*1 values above 10dB as was discussed earlier. However, unlike those vowels, /u:/ does not show a significant distinction between oral/isolation and nasal contexts and instead all these contexts have similar average values. There are tendencies for differences between o-o context and each of n-n and n-ħ contexts, and between isolation context and n-o context.

/ʊ/: A one-way ANOVA reveals a significant effect of contexts containing vowel /ʊ/ on *A*1-*P1 values at onset with a large effect size (F (2, 25) = 2.728, p<0.001, η_p^2 = 0.192). Despite a general significant result, the Bonferroni post-hoc analysis reveals no significant differences. However, there is a tendency for differences between o-o context and each of n-o and ħ-o contexts, grouping n-o and ħ-o with contexts showing nasalisation.

/ɔ:/: A one-way ANOVA reveals a non-significant effect of contexts containing vowel /ɔ:/ on *A*1-**P*1 values at onset. Despite this non-significant result, there is a tendency for context ħ-n to have a higher *A*1-**P*1 value than context ʕ-n indicating more nasalisation. This coincides with all previous significant or near-significant results.

9.2.1.2 *Cross-dialectal differences in vowels*

Nasalisation is investigated in relation to the three geographical areas, represented by the three dialects of Baghdad, Basra and Mosul, in order to establish if any of them shows more nasalisation than the other two. Measurements are applied at each portion of individual vowels irrespective of contexts _nasal, non-nasal, pharyngeal, non-pharyngeal, oral or isolation_ as the main comparison. Another comparison includes comparing dialectal differences of individual contexts irrespective of individual vowels and also irrespective of vowel types. Both comparisons will be applied similarly to previous results at onset and offset portions of the vowel. As was previously mentioned, low and low-mid vowels have the overall lowest values, which also applies to cross-dialectal comparisons; high and high-mid vowels also have overall high values (table 9.2, figure 9.2). Also vowels /ɛ, a:, ɔ:/ did not show significant differences between dialects and therefore will not be discussed below.

Table 9.2: Effect size differences and Cohen *d* values for Cross-dialectal comparisons of *A*1-P*1 values at onset.**

Vowel	Dialect1	Dialect2	Cohen *d*	effect size	Sig.
/i:/	Basra	Baghdad	0.58	moderate	$p<0.001$
		Mosul	0.52	moderate	$p<0.001$
/ɪ/	Baghdad	Basra	1.02	large	$p<0.001$
/ʊ/	Baghdad	Mosul	0.68	moderate to large	$p<0.001$

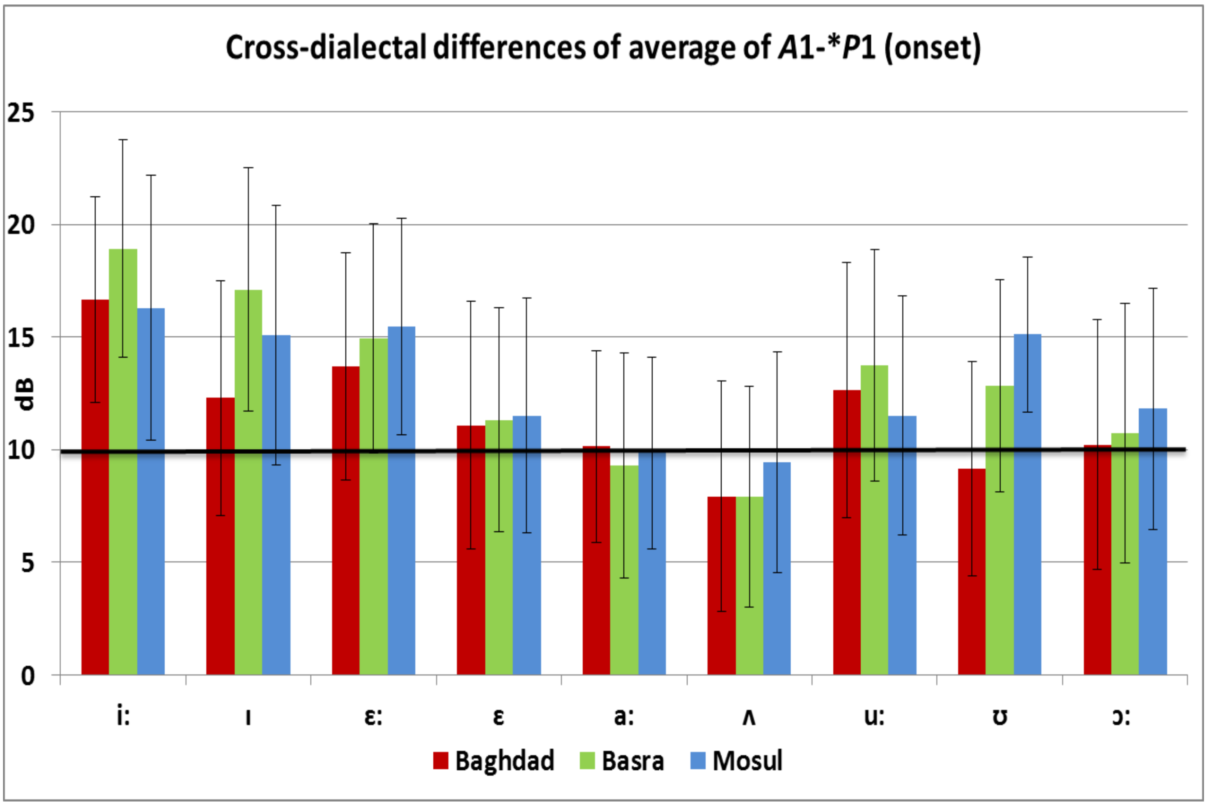


Figure 9.2: Cross-dialectal differences of *A*1-P*1 values for vowels at onset.**

/i:/: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *A*1-**P*1 values within vowel /i:/ at onset with a moderate effect size (F (2, 207) = 6.517, p<0.001, η_p^2 = 0.060). Bonferroni post-hoc analysis reveals Basra as having a significantly higher *A*1-**P*1 value than each of Baghdad and Mosul.

/ɪ/: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *A*1-**P*1 values within vowel /ɪ/ at onset with a large effect size (F (2, 35) = 3.086, p<0.001, η_p^2 = 0.158). Bonferroni post-hoc analysis reveals Baghdad as having a significantly lower *A*1-**P*1 value than Basra.

/ɛ:/: A one-way ANOVA reveals a non-significant effect of cross-dialectal differences on *A*1-**P*1 values within vowel /ɛ:/ at onset; but results show lower *A*1-**P*1 values in Baghdad compared with each of Basra and Mosul.

/ʌ/: A one-way ANOVA reveals a non-significant effect of cross-dialectal differences on *A*1-**P*1 values within vowel /ʌ/ at onset; but show a tendency for Mosul to show less nasalisation than each of Baghdad and Basra.

/u:/: A one-way ANOVA reveals a non-significant effect of cross-dialectal differences on *A*1-**P*1 values within vowel /u:/ at onset; but show a tendency for Basra to show less nasalisation than Mosul.

/ʊ/: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *A*1-**P*1 values within vowel /ʊ/ at onset with a large effect size (F (2, 25) = 4.201, p<0.001, η_p^2 = 0.268). Bonferroni post-hoc analysis reveals Baghdad as having a significantly lower *A*1-**P*1 value than Mosul. Despite non-significance, tendencies suggest that Mosul exhibits the least nasalisation.

In the auditory analysis there were no significant differences between dialects with respect to nasalisation, but there was a tendency for Baghdad dialect to show more nasalisation than the other two dialects. Therefore, the trend is the same but the non-significance of auditory results may be due to the fact that the *A*1-**P*1 acoustic measure is more subtle.

9.2.1.3 *Cross-dialectal differences in individual contexts*

Below are details of the statistical results for Cross-dialectal comparisons in individual contexts (table 9.3, figure 9.3). Below are the detailed results for each context.

Table 9.3: Effect size differences and Cohen *d* values for cross-dialectal comparisons of *A*1-P*1 values within individual contexts at onset.**

Context	Dialect1	Dialect2	Cohen *d*	effect size	Sig.
n-n	Basra	Baghdad	0.54	moderate	p<0.001
		Mosul	0.60	moderate to large	p<0.001
n-o	Baghdad	Mosul	0.70	moderate to large	p<0.001
n-ħ	Baghdad	Basra	0.64	moderate to large	p<0.001
n-ʕ	Basra	Baghdad	0.71	moderate to large	p<0.001
		Mosul	0.71	moderate to large	p<0.001
ħ-n	Basra	Mosul	0.57	moderate to large	p<0.001
ʕ-n	Basra	Mosul	0.65	a moderate to large	p<0.001
ʕ-o	Basra	Mosul	0.40	moderate	p<0.001

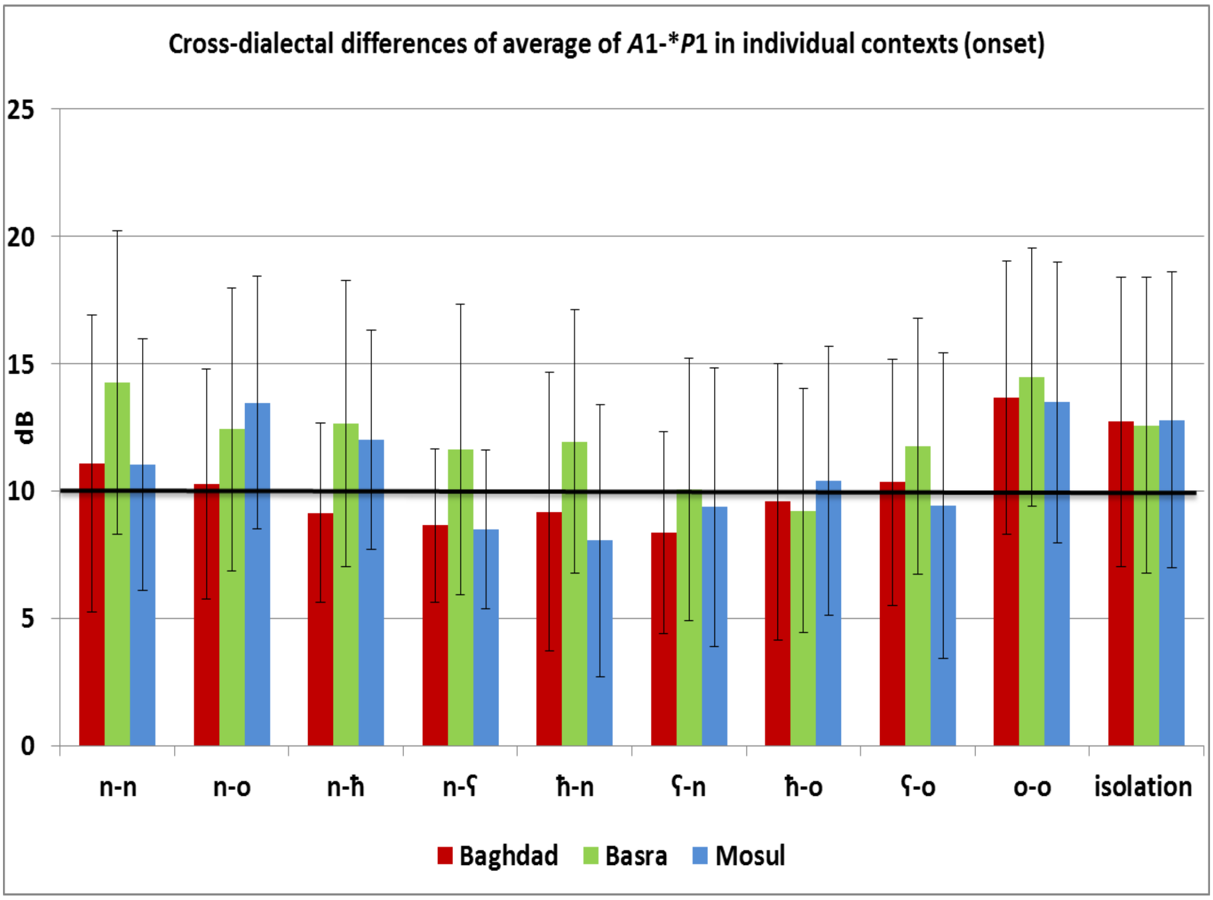


Figure 9.3: Cross-dialectal differences of *A*1-P*1 values within individual contexts at onset.**

n-n: A one-way ANOVA reveals a non-significant effect of cross-dialectal differences on *A*1-**P*1 values within the n-n context at onset with a moderate effect size (F (2, 53) = 1.988, p>0.001, η_p^2 = 0.072). Bonferroni post-hoc analysis reveals Basra as having a significantly higher *A*1-**P*1 value than each of Baghdad and Mosul.

n-o: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *A*1-**P*1 values within the n-o context at onset with a moderate effect size (F (2, 98) = 3.121, p<0.001, η_p^2 = 0.061). Bonferroni post-hoc analysis reveals Baghdad as having a significantly lower *A*1-**P*1 value than Mosul.

n-ħ: A one-way ANOVA reveals a non-significant effect of cross-dialectal differences on *A*1-**P*1 values within the n-ħ context at onset with a moderate effect size (F (2, 17) = 0.723, p>0.001, η_p^2 = 0.088). Bonferroni post-hoc analysis reveals Baghdad as having a significantly lower *A*1-**P*1 value than Basra. Despite non-significant differences between Baghdad and Mosul they have a moderate to large effect size showing Baghdad as having a lower *A*1-**P*1 value. Basra has a small effect size with Mosul with both having similar high values.

n-ʕ: A one-way ANOVA reveals a non-significant effect of cross-dialectal differences on *A*1-**P*1 values within the n-ʕ context at onset with a moderate effect size (F (2, 8) = 0.565, p>0.001, η_p^2= 0.158). Bonferroni post-hoc analysis reveals Basra as having a significantly higher *A*1-**P*1 value than each of Baghdad and Mosul. Baghdad and Mosul have zero effect size.

ħ-n: A one-way ANOVA reveals a non-significant effect of cross-dialectal differences on *A*1-**P*1 values within the ħ-n context at onset with a moderate effect size (F (2, 17) = 0.501, p>0.001, η_p^2= 0.063). Bonferroni post-hoc analysis reveals Basra as having a significantly higher *A*1-**P*1 value than Mosul. Basra also has a moderate but non-significant effect size with Baghdad.

ʕ-n: A one-way ANOVA reveals a non-significant effect of cross-dialectal differences on *A*1-**P*1 values within the ʕ-n context at onset with a small effect size (F (2, 44) = 0.489, p>0.001, η_p^2= 0.023). Bonferroni post-hoc analysis reveals non-significant differences between dialects, but shows a moderate effect size between Baghdad and Basra indicating a tendency for Baghdad to have the highest nasalisation.

ħ-o: A one-way ANOVA reveals a non-significant effect of cross-dialectal differences on *A*1-**P*1 values within the ħ-o context at onset with a small effect size (F (2, 157) = 0.563, p>0.001, η_p^2= 0.007). Bonferroni post-hoc analysis reveals non-significant differences between dialects on ħ-o contexts and only shows small effect size between them.

ʕ-o: A one-way ANOVA reveals a non-significant effect of cross-dialectal differences on *A*1-**P*1 values within the ʕ-o context at onset with a small effect size (F (2, 125) = 1.949, p>0.001, η_p^2= 0.031). Bonferroni post-hoc analysis reveals Basra as having a significantly higher *A*1-**P*1 value than Mosul. Basra also has a moderate but non-significant effect size with Baghdad.

o-o: A one-way ANOVA reveals a non-significant effect of cross-dialectal differences on *A*1-**P*1 values within the oral context at onset with a small effect size (F (2, 235) = 0.655, p>0.001, η_p^2= 0.006). Bonferroni post-hoc analysis also reveals a non-significant difference between dialects and showing a small effect size between all of them. The high *A*1-**P*1 values in all dialects are around 15dB suggesting all are similar in showing little nasalisation.

Isolation: A one-way ANOVA reveals a non-significant effect of cross-dialectal differences on *A*1-**P*1 values within the isolation context at onset Similar to the oral context, the high *A*1-**P*1 values in all dialects also around 15dB suggest them similar in showing little nasalisation.

9.2.1.4 *Discussion of the A1-*P1 measure results at onset*

A general view of results obtained at the three vowel portions for individual contexts as well as cross-dialectal ones show two main distinctions: one between nasal and non-nasal contexts, with pharyngeal contexts being grouped with nasal ones; the second is between two types of vowels, one which can be used for this measure and the other not. This first distinction follows findings in the literature which suggest that pharyngeals are accompanied by nasalisation or/and a lowering of the velum (see Chapter 5). The second distinction is between those that have a low *F*1, i.e. high and high-mid vowels /i:, ɪ, ɛ:, ʊ, u:/, and those that have a high *F*1, i.e. low and low-mid vowels /a:, ʌ, ɔ:/. The first set of vowels have overall high *A*1-**P*1 values, while the second set has overall low values, with some exceptions here and there. Overall values for contexts containing vowels /i:, ɪ, ɛ:, ɛ, u:/ are higher than 10dB with some being over 15dB. This is due to the position of *F*1 and its relation to *F*2. In the case of these vowels *F*1 is very low, lying on *H*1, *H*2 or *H*3, and *F*2 is high leading to a wide distance between the two formants. This distance leads to a downward spectral tilt which lowers amplitudes of harmonics and any additional peaks as they move away from *F*1 towards *F*2. And despite applying pre-emphasis to control the spectral tilt by enhancing peaks at higher frequencies, the amplitudes remain much lower than *A*1. Therefore no matter how prominent the extra peak is, it will still be lower than *A*1, leading to a high value of difference of *A*1-**P*1. However, the distinction between contexts with nasalisation and those with no nasalisation still exists but does not follow the same threshold of 10dB above. As a result, for these vowels, a significant difference would be the threshold for distinguishing between what exhibits nasalisation and what does not; taking into account any tendencies as reported by measures of effect size (see Cohen, 1988).

Overall values of contexts containing /a:, ʌ, ɔ:/ on the other hand are lower than 10dB, with some exceptions here and there. These results are again explained in relation to the position of the two formants. In these vowels, which are low and mid central, *F*1 is high and very close to *F*2 so the extra peak between them (*P*1) is enhanced by this closeness. Despite applying normalisation, whereby any effect of formants in terms of increasing amplitudes of neighbouring peaks is corrected, the amplitude of *P*1 remains prominent; therefore, a high *P*1 and a low *A*1 leads to a low *A*1-**P*1 (Chen, 2000; Chen et al. 2000; Chen et al., 2007; Amino and Osanai, 2012: 99).

Chen et al. (2007) restricted applying *A*1-*P*1 to high vowels after finding the same above results in Chen (1995, 1997, 2000). In addition to the overall low values, no nasal/non-nasal distinction is noted in these vowels because having a high peak is found in all contexts and not restricted to nasal or contexts with nasalisation. Pharyngeal contexts are also affected since pharyngealisation further raises *F*1, leading to further enhancement of *P*1. This explains why in contexts containing these vowels, pharyngeal contexts are the only contexts that show significant differences with oral contexts. Furthermore, vowel portions near a pharyngeal consonant are affected by pharyngealisation which tends to raise *F*1, causing an additional raise of *P*1. Also, a combination of nasal and pharyngeal consonants increases the effect of nasalisation on neighbouring vowels even if the pharyngeal is in initial position and not the nasal. This latter result indicates that pharyngeal consonants have a progressive effect of nasalisation.

The nasalisation effect of nasal and non-nasal pharyngeal contexts suggests that they could be produced with a lowering of the velum as noted by Laradi (1983) and Butcher and Ahmad (1987) (for more details see Chapter 5). This lowering could also explain why nasal pharyngeal contexts show more nasalisation than other nasal contexts, since both the nasal and the pharyngeal would be produced with a lowered velum increasing their effect of nasalisation on neighbouring vowels. It is, however, not clear why no significant differences exist between contexts containing vowel /u:/. One reason might be because some speakers produced this vowel with *F*1 and *F*2 being close to each other, leading to it behaving in a similar manner to /a:/ and /ɔ:/. This same vowel showed different behaviours to other vowels when auditory and acoustic measures of phonation types were applied (Chapters 8 and 10).

Cross-dialectal comparisons for each vowel shows Baghdad dialect having the lowest value, suggesting it has the most nasalisation in the contexts of two vowels /ɪ, ʊ/. Basra dialect, on the other hand has the highest values, suggesting it has the lowest nasalisation in contexts of two vowels /i:, ɪ/ alongside a tendency to have the lowest nasalisation in /u:/. One exception is the vowel /ʊ/, where Mosul dialect shows the highest value. Comparisons in general show that Baghdad dialect has the highest degree of nasalisation in three contexts: nasal-oral, nasal-pharyngeal and pharyngeal-nasal; Basra dialect has the lowest degree of nasalisation in three contexts: nasal-nasal, nasal-pharyngeal and pharyngeal-nasal, and is in-between in one context, nasal-oral; while Mosul dialect has the lowest nasalisation in one context, nasal-oral, and in-between in two contexts: nasal-pharyngeal and pharyngeal-nasal. In the nasal-nasal context both Baghdad and Mosul dialects show more nasalisation than Basra. Pharyngeal-oral, oral and isolation contexts show no significant differences between dialects; but similar to previous results, overall results show pharyngeal-oral having more nasalisation than oral and isolation due to its low *A*1-**P*1 compared to the high *A*1-**P*1 values in oral and isolation. These results match the tendency reported in the auditory analysis. There is also another consistency noted for the *A*1-**P*1 results within pharyngeal contexts whereby Basra dialect has the lowest nasalisation. In comparing acoustic results of contexts with the auditory analysis of nasalisation, we note that:

- A distinction between nasal context and each of oral and isolation contexts is established in both types of analysis;
- Nasal and non-nasal contexts containing pharyngeals have the highest levels of nasalisation according to the *A*1-**P*1 measure. However, in the auditory results only the nasal pharyngeal contexts pattern with other nasal contexts; while non-nasal pharyngeal ones have lower levels of nasalisation but are still significantly higher than those in oral and isolation contexts.

In comparing results of the acoustic and auditory impression of nasalisation in individual pharyngeal contexts, it was noted for both that non-nasal contexts with an initial pharyngeal consonant showed more nasalisation than those with a final pharyngeal consonant; also most vowels neighbouring /ħ/ in contexts ħ-n and ħ-o show more nasalisation than those neighbouring /ʕ/ in context ʕ-n and ʕ-o. The cross-dialectal acoustic results are also similar to the tendency reported in the auditory analysis whereby Baghdad exhibits more nasalisation despite the lack of significance in most cases.

9.2.2 Offset

As was previously mentioned for *A*1-**P*1 at onset, the general result that is repeated for this measure is that overall values for low and low-mid vowels /a:, ʌ, ɔ:/ are lower than those of high and high-mid vowels /i:, ɪ, ɛ:, ɛ, ʊ, u:/ (table 9.4, figure 9.4). In comparing results of individual contexts at offset with those at onset, we find that all ANOVA tests for each vowel yield the same significance or lack thereof; but comparisons between individual contexts show various differences which are later discussed. Also as was previously mentioned for *A*1-**P*1 at onset, the general result that is repeated for this measure is that overall values for low and low-mid vowels /a:, ʌ, ɔ:/ are lower than those of high and high-mid vowels /i:, ɪ, ɛ:, ɛ, ʊ, u:/. For vowel /ɔ:/ with a high *F*1 and overall low average *A*1-**P*1 values similar to vowel /a:/ confirming previous results. Accordingly, vowel /ɔ:/ will not be discussed below. However, below are the detailed results for all other vowels.

Table 9.4: Effect size differences and Cohen d values for of A1-*P1 values within individual contexts at offset.

Vowel	Context1	Context2	Cohen *d*	effect size	Sig.
/i:/	isolation	n-n	1.11	large	$p<0.001$

		o-n	0.79	moderate to large	*p*<0.001
		o-ħ	0.69	moderate to large	*p*<0.001
/ɪ/	n-n	o-o	1.18	large	*p*<0.001
/ɛ:/	o-o	o-n	0.86	large	*p*<0.001
		ʕ-n	0.95	large	*p*<0.001
/ɛ/	o-n	ħ-n	1.56	large	*p*<0.001
		o-ħ	1.06	large	*p*<0.001
		ʕ-n	1.33	large	*p*<0.001
/a:/	o-o	o-ħ	0.21	small	*p*<0.001
/u:/	o-o	n-n	1.00	large	*p*<0.001
		n-ħ	1.36	large	*p*<0.001
/ʊ/	o-o	oral-pharyngeal	2.03	large	*p*<0.001

/i:/: A one-way ANOVA reveals a significant effect of contexts containing vowel /i:/ on *A*1-**P*1 values at offset with a moderate effect size (F (5, 225) = 5.367, p<0.001, η_p^2 = 0.109). Bonferroni post-hoc analysis reveals isolation context as having significantly less nasalisation than each of n-n and o-n contexts. There are no significant differences between context- o-o and each of n-n and o-n but show a tendency for o-o to have less nasalisation. There are no significant differences between each of o-ħ and o-ʕ contexts and each of n-n and o-n contexts, , suggesting that for vowel /i:/ the non-nasal pharyngeal contexts do not pattern with nasalised contexts. It also suggests that a final pharyngeal consonant in the oral-pharyngeal contexts does not have an effect on nasalisation as it did at onset when measures were taken for the same vowel near an initial pharyngeal consonant in the pharyngeal-oral contexts. These two results agree with those of the auditory impression of nasalisation whereby final pharyngeal consonants had less effect on nasalisation than initial ones indicating a progressive effect. Other Bonferroni post-hoc analysis results reveal isolation context as having significantly less nasalisation than context o-ħ but not with context o-ʕ. This suggests that contexts containing final pharyngeal /ħ/ neighbouring vowel /i:/ show more nasalisation than those containing /ʕ/.

/ɪ/: A one-way ANOVA reveals a non-significant effect of contexts containing vowel /ɪ/on *A*1-**P*1 values at offset, but Bonferroni post-hoc analysis reveals n-n context as having significantly more nasalisation than o-o context. No significant difference is noted between the o-o and o-n contexts but show a tendency for o-o to have less nasalisation. This indicates that having two nasal consonants induces more nasalisation than one nasal consonant when that nasal is in final position combined with an initial oral. These results also coincide with results at onset whereby nasal-nasal showed lower *A*1-**P*1 values than nasal-oral; it also coincides with the auditory impression of nasalisation.

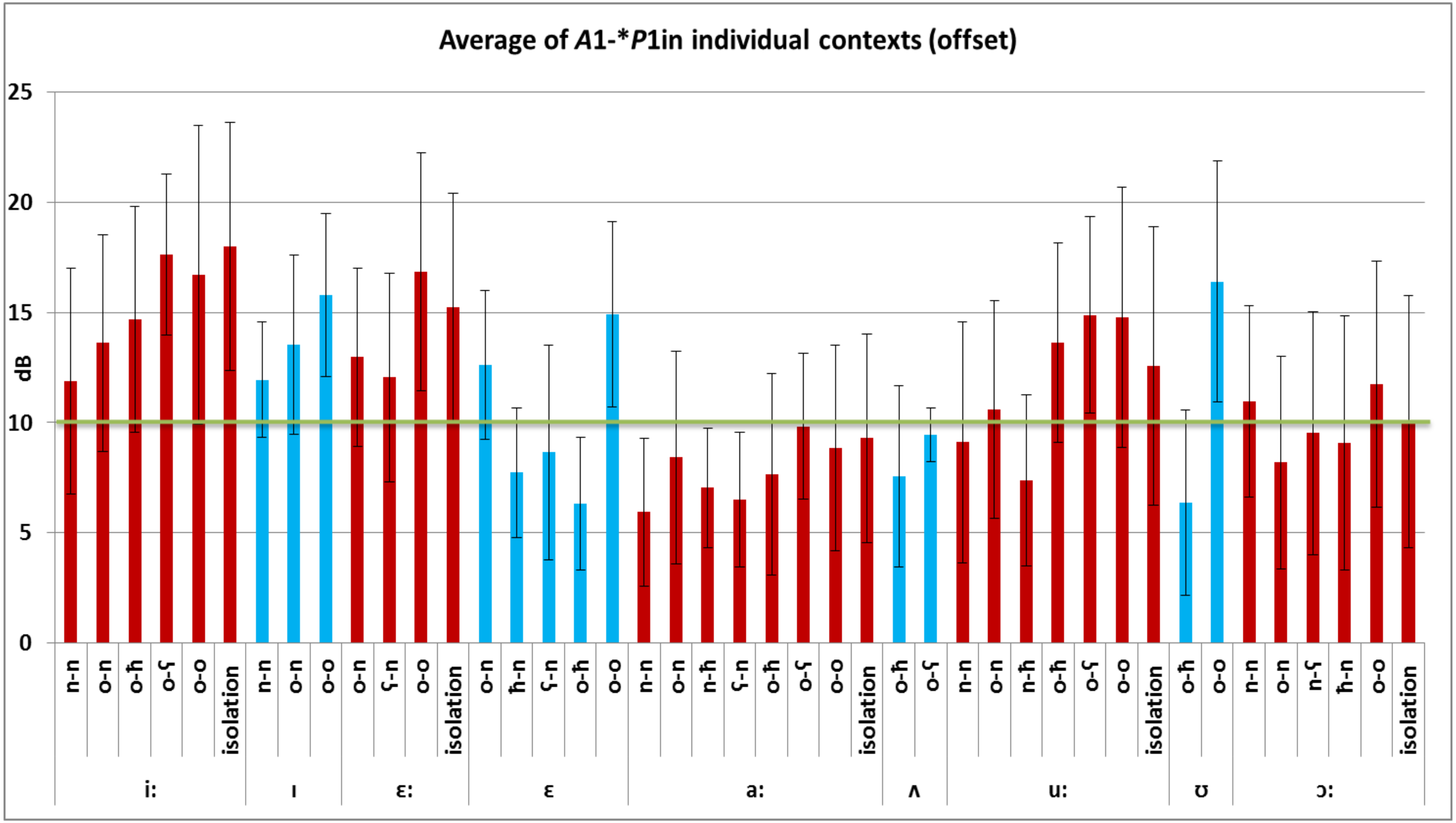


Figure 9.4: ***A*1-****P*1 **values within individual contexts at offset.**

/ɛ:/: A one-way ANOVA reveals a significant effect of contexts containing vowel /ɛ:/ on $A1$-$*P1$ values at offset with a moderate effect size (F (3, 160) = 4.318, p<0.001, η_p^2 = 0.076). Bonferroni post-hoc analysis reveals o-o context as having significantly less nasalisation than each of o-n and ʕ-n contexts. No other significance is noted but tendencies show a general trend for nasal contexts to have lower $A1$-$*P1$ values. Tendencies between context isolation and each of ʕ-n and o-n contexts indicate a distinction between nasal and non-nasal contexts. There is also a tendency for o-n context to show less nasalisation than ʕ-n indicating that the presence of the pharyngeal consonant has an effect of increasing nasalisation.

/ɛ/: A one-way ANOVA reveals a significant effect of contexts containing vowel /ɛ/ on $A1$-$*P1$ values at offset with a large effect size (F (4, 107) = 14.947, p<0.001, η_p^2 = 0.367). Bonferroni post-hoc analysis reveals the o-o context as having significantly less nasalisation than each of the ħ-n and ʕ-n contexts. However, post-hoc analysis also reveals context o-n as having significantly less nasalisation than context ħ-n but not ʕ-n, with a large effect size for both, showing more nasalisation in context ħ-n than in context ʕ-n. In comparing context o-o with the o-n context results show a tendency for the o-n context to have more nasalisation. But it is also noted that when the final nasal consonant is combined with an initial oral consonant, the nasal has less effect on nasalisation than in other contexts. This again is similar to auditory results.

/a:/: A one-way ANOVA reveals a significant effect of contexts containing vowel /a:/ on $A1$-$*P1$ values at offset with a small effect size (F (7, 495) = 2.094, p<0.05, η_p^2 = 0.029). Overall low average $A1$-$*P1$ values for contexts containing this vowel confirm previous results. Bonferroni post-hoc analysis reveals o-o context as having significantly less nasalisation than o-ħ context but not with o-ʕ context, once more showing more nasalisation in non-nasal contexts containing final pharyngeal /ħ/ than /ʕ/.

/ʌ/: For comparing the two contexts containing /ʌ/, an *independent*-samples t-test was applied and reveals no significant differences (t (24) = 0.172, p>0.001) between o-ħ and o-ʕ on $A1$-$*P1$ values for vowel /ʌ/ at offset. This result could be explained in relation to what was previously discussed about vowels with a low $F1$ with overall low $A1$-$*P1$ values having little or no significant differences among contexts containing them.

/u:/: A one-way ANOVA reveals a significant effect of contexts containing vowel /u:/ on $A1$-$*P1$ values at offset with a moderate effect size (F (6, 232) = 3.350, p<0.001, η_p^2 = 0.082). Bonferroni post-hoc analysis reveals o-o context as having significantly less nasalisation than each of n-n and n-ħ contexts. No significant differences are found between o-n context and any of the other contexts, but results suggest that the o-n context, while showing slight nasalisation compared with the o-o and isolation contexts, still has less nasalisation than the remaining nasal contexts. Other statistical analysis results reveal non-significant differences between contexts o-ħ and o-ʕ and other contexts or between each other, but showa tendency for o-ħ to have a lower *A*1-**P*1 value than o-ʕ potentially indicating more nasalisation. However, other differences between o-ħ and o-ʕ contexts and each of n-n, n-ħ, o-n and o-o contexts suggest that the oral-pharyngeal contexts pattern more closely with non-nasal contexts, and only when combined with an initial nasal do they show the impact of nasalisation.

/ʊ/: A one-way ANOVA reveals a significant effect of contexts containing vowel /ʊ/ on *A*1-**P*1 values at offset with a large effect size (F (1, 17) = 18.254, p<0.001, η_p^2 = 0.533). There are only two contexts to compare therefore an independent-samples *t*-test was applied and reveals o-o context as having significantly less nasalisation than o-ħ context on *A*1-**P*1 values for vowel /ʌ/ at offset (t (16) = 4.272, p<0.001) grouping o-ħ with contexts having nasalisation.

9.2.2.1 *Cross-dialectal differences in vowels*

Results of cross-dialectal comparisons at offset are presented below (table 9.5, figure 9.5). Below are the detailed results for each vowel.

Table 9.5: Effect size differences and Cohen *d* values for cross-dialectal comparisons of A1-*P1 values at offset

Vowel	Dialect1	Dialect2	Cohen *d*	effect size	Sig.
/ɪ/	Baghdad	Basra	1.00	large	*p*<0.001
/ɛ:/	Baghdad	Basra	0.81	large	*p*<0.001
		Mosul	0.75	moderate to large	*p*<0.001
/ɛ/	Baghdad	Mosul	0.54	moderate	*p*<0.001
/a:/	Baghdad	Basra	0.50	moderate	*p*<0.001
		Mosul	1.00	large	*p*<0.001
	Basra	Mosul	0.43	moderate	*p*<0.001
/ʌ/	Basra	Mosul	0.65	a moderate to large	*p*<0.001
/u:/	Basra	Baghdad	0.77	large	p<0.001
		Mosul	0.47	moderate	p<0.001
/ʊ/	Basra	Mosul	1.04	large	p<0.001
/ɔ:/	Baghdad	Basra	0.64	moderate to large	p<0.001

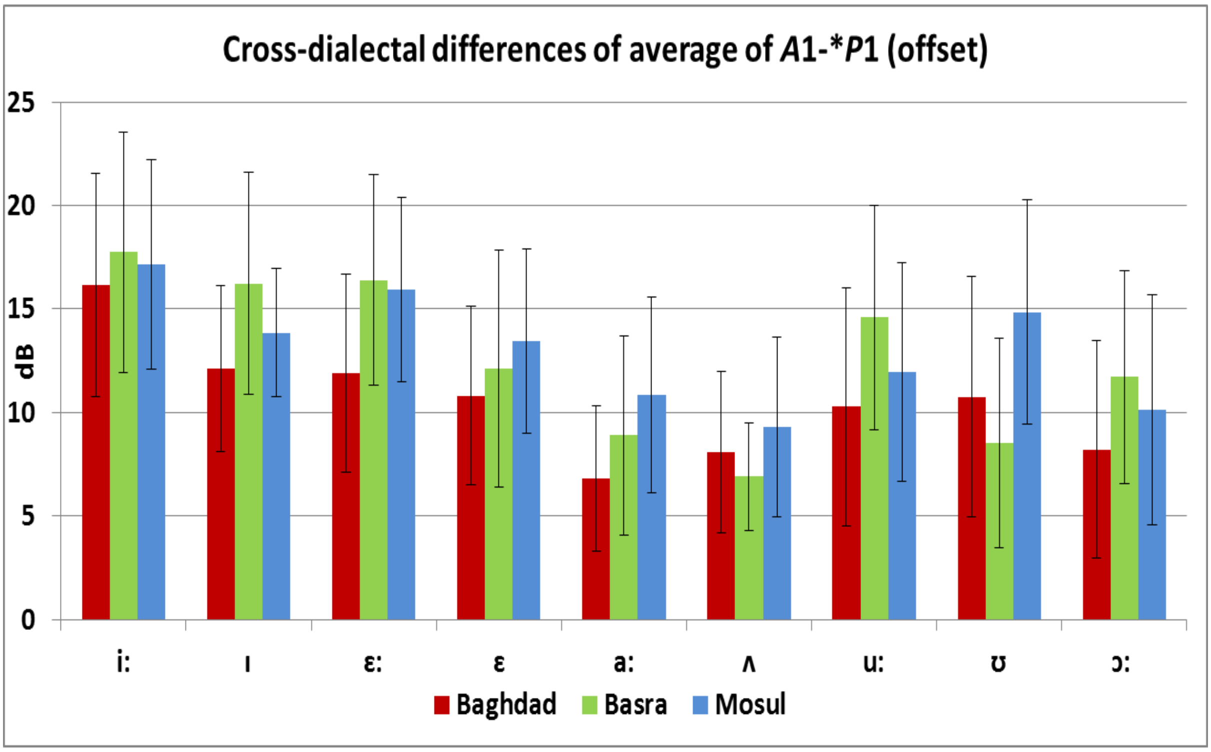


Figure 9.5: Cross-dialectal differences of *A*1-P*1 values for vowels at offset.**

/i:/: A one-way ANOVA reveals a non-significant effect of cross-dialectal differences on *A*1-**P*1 values within vowel /i:/ at offset, but show a tendency for Baghdad to show more nasalisation than each of Basra and Mosul, which on their part do not show much difference.

/ɪ/: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *A*1-**P*1 values within vowel /ɪ/ at offset with a large effect size (F (2, 35) = 3.283, p<0.001, η_p^2 = 0.166). Bonferroni post-hoc analysis reveals Baghdad as having a significantly lower *A*1-**P*1 value than Basra, with non-significance between Mosul and both Baghdad and Basra.

/ɛ:/: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *A*1-**P*1 values within vowel /ɛ:/ at offset with a moderate effect size (F (2, 160) = 10.646, p<0.001, η_p^2 = 0.119). Bonferroni post-hoc analysis reveals Baghdad as having a significantly lower *A*1-**P*1 value than each of Basra and Mosul. A non-significant difference exists between Basra and Mosul, with both showing less nasalisation values than Baghdad.

/ɛ/: A one-way ANOVA reveals a non-significant effect of cross-dialectal differences on *A*1-**P*1 values within vowel /ɛ/ at offset, but Bonferroni post-hoc analysis reveals Baghdad as having a significantly lower *A*1-**P*1 value than Mosul; and Basra has no significant differences with either.

/a:/: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *A*1-**P*1 values within vowel /a:/ at offset with a moderate effect size (F (2, 495) = 36.471, p<0.001,

η_p^2 = 0.129). Bonferroni post-hoc analysis reveals all dialects having significant differences showing Baghdad having the lowest *A*1-**P*1 values and Mosul the highest.

/ʌ/: A one-way ANOVA reveals a non-significant effect of cross-dialectal differences on *A*1-**P*1 values within vowel /ʌ/ at offset, but Bonferroni post-hoc analysis reveals Basra as having a significantly lower *A*1-**P*1 value than Mosul. This result again shows Mosul having the least nasalisation and Basra and not that of Baghdad- having the most nasalisation.

/u:/: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *A*1-**P*1 values within vowel /u:/ at offset with a moderate effect size (F (2, 232) = 11.071 p<0.001, η_p^2 = 0.088). Bonferroni post-hoc analysis reveals Basra as having a significantly lower *A*1-**P*1 value than each of Baghdad and Mosul. Baghdad and Mosul have a non-significant difference.

/ʊ/: A one-way ANOVA reveals a non-significant effect of cross-dialectal differences on *A*1-**P*1 values within vowel /ʊ/ at offset, but Bonferroni post-hoc analysis reveals Basra as having a significantly lower *A*1-**P*1 value than Mosul. No significant differences are revealed by Baghdad and the other dialects. This result is similar to that of vowel /ʌ/.

/ɔ:/: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *A*1-**P*1 values within vowel /ɔ:/ at offset with a moderate effect size (F (2, 190) = 6.233, p<0.001, η_p^2 = 0.062). Bonferroni post-hoc analysis reveals Baghdad as having a significantly lower *A*1-**P*1 value than Basra. No significant differences are revealed by Mosul and the other dialects.

9.2.2.2 *Cross-dialectal differences in individual contexts*

Only nasal-nasal, oral-nasal and isolation contexts showed significant differences between dialects, with Baghdad having the most nasalisation (table 9.6, figure 9.6). All contexts containing pharyngeals, whether nasal or non-nasal and irrespective of position showed no significant differences between dialects; the same was found for the oral context. However, there are tendencies of what potentially could be significant differences between dialects for some of the pharyngeal contexts as noted by the moderate and large effect size differences. There are only small effect size differences between all dialects for contexts ħ-n and o-ħ, showing comparable degrees of nasalisation in pharyngeal contexts across dialects. These results partly coincide with auditory impression of nasalisation whereby no significant differences were noted between dialects and for all individual contexts. However, irrespective of having significant of non-significant differences, all contexts show Baghdad having the lowest *A*1-**P*1 values. Below are the detailed results for each individual context.

Table 9.6: Effect size differences and Cohen d values for cross-dialectal comparisons of A1-*P1 values within individual contexts at offset.

Context	Dialect1	Dialect2	Cohen *d*	effect size	Sig.
n-n	Baghdad	Basra	0.78	moderate to large	p<0.001
o-n	Baghdad	Basra	0.91	large	p<0.001
		Mosul	0.72	moderate to large	p<0.001
n-ħ	Basra	Baghdad	0.93	large	p<0.001
		Mosul	0.83	large	p<0.001
n-ʕ	Mosul	Baghdad	1.61	large	p<0.001
		Basra	1.86	large	p<0.001
ʕ-n	Mosul	Baghdad	0.69	moderate to large	p<0.001
		Basra	0.38	moderate	p<0.001
o-ʕ	Baghdad	Basra	0.53	moderate	p<0.001
		Mosul	0.73	moderate to large	p<0.001
isolation	Baghdad	Basra	0.50	moderate	p<0.001
		Mosul	0.52	moderate	p<0.001

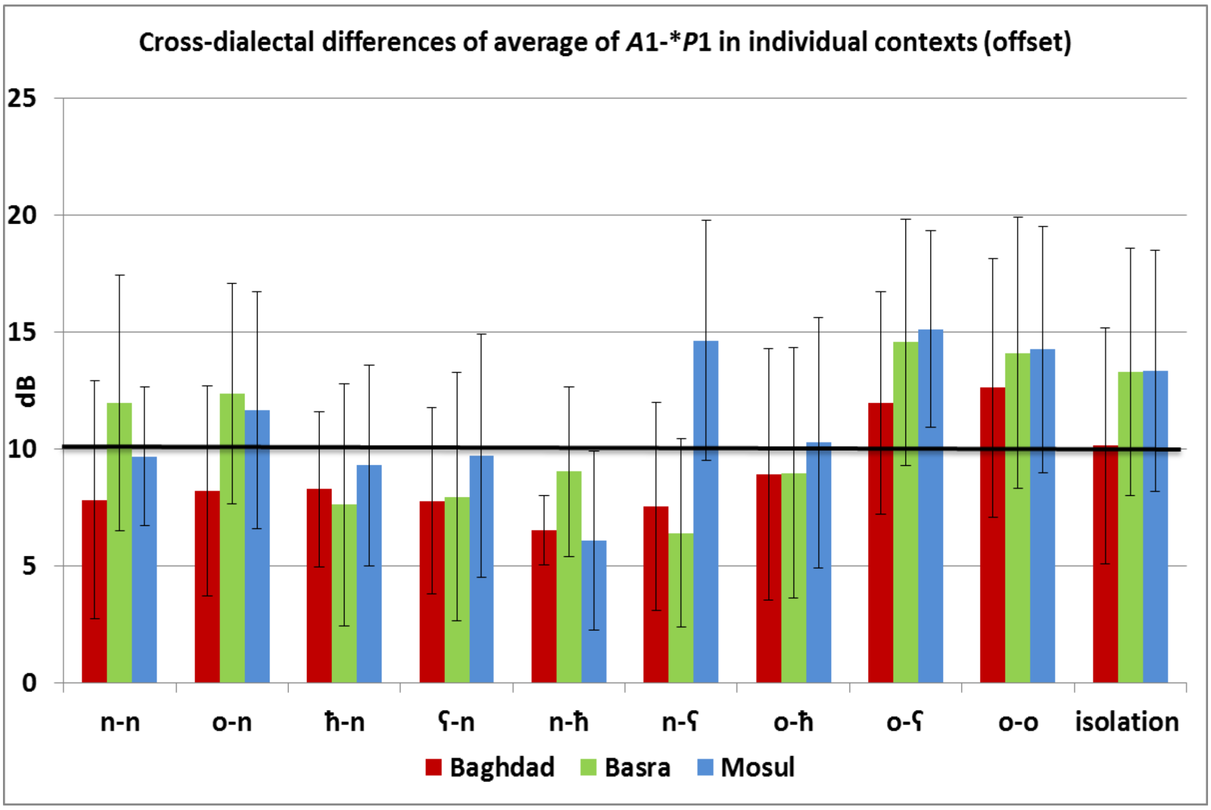


Figure 9.6: Cross-dialectal differences of *A*1-*P1 values within individual contexts at offset.

n-n: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *A*1-**P*1 values within the nasal-nasal context at offset with a small effect size (F (2, 53) = 3.574, p<0.001, η_p^2 = 0.123). Bonferroni post-hoc analysis reveals Baghdad as having a significantly lower *A*1-**P*1 value than Basra.

o-n: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *A*1-**P*1 values within the oral-nasal context at offset with a small effect size (F (2, 170) = 12.465,

p<0.001, η_p^2 = 0.129). Bonferroni post-hoc analysis reveals Baghdad as having a significantly lower $A1$-*$P1$ value than each of Basra and Mosul.

n-ħ: A one-way ANOVA reveals a significant effect of cross-dialectal differences on $A1$-*$P1$ values within the context n-ħ at offset with a large effect size (F (2, 17) = 1.558, p<0.001, η_p^2 = 0.172). Bonferroni post-hoc analysis reveals Basra as having a significantly higher $A1$-*$P1$ value than each of Baghdad and Mosul.

n-ʕ: A one-way ANOVA reveals a significant effect of cross-dialectal differences on $A1$-*$P1$ values within the context n-ʕ at offset with a large effect size (F (2, 8) = 3.213, p<0.001, η_p^2 = 0.517). Bonferroni post-hoc analysis reveals Mosul as having a significantly higher $A1$-*$P1$ value than each of Baghdad and Basra.

ʕ-n: A one-way ANOVA reveals a significant effect of cross-dialectal differences on $A1$-*$P1$ values within the context ʕ-n at offset with a small effect size (F (2, 44) = 0.589, p<0.001, η_p^2 = 0.027). Bonferroni post-hoc analysis reveals Mosul as having a significantly higher $A1$-*$P1$ value than each of Baghdad and Basra; with no significant differences between Baghdad and Basra.

o-ʕ: A one-way ANOVA reveals a significant effect of cross-dialectal differences on $A1$-*$P1$ values within the context o-ʕ at offset with a moderate effect size (F (2, 43) = 1.963, p<0.001, η_p^2 = 0.087). Bonferroni post-hoc analysis reveals Baghdad as having a significantly lower $A1$-*$P1$ value than each of Basra and Mosul.

o-o: A one-way ANOVA reveals a non-significant effect of cross-dialectal differences on $A1$-*$P1$ values within the o-o context at offset, but with Baghdad showing potential tendencies for to have the most nasalisation.

Isolation: A one-way ANOVA reveals a significant effect of cross-dialectal differences on $A1$-*$P1$ values within the isolation context at offset with a small effect size (F (2, 773) = 22.470, p<0.001, η_p^2 = 0.055). Bonferroni post-hoc analysis reveals Baghdad as having a significantly lower $A1$-*$P1$ value than each of Basra and Mosul.

9.2.2.3 *Discussion of the A1-*P1 measure results at offset*

Overall results of individual contexts at offset reveal a number of findings which are summarised as follows: **1-** vowels with low $F1$ have fewer significant differences among contexts due to reasons previously mentioned; **2-** generally, the measure distinguishes between nasal and non-nasal contexts; **3-** contexts containing pharyngeals showed more nasalisation, even if the context was non-nasal and the pharyngeal was final; **4-** having two nasals increases nasalisation the most; **5-** having one nasal in final position combined with an initial oral sometimes shows the least nasalisation among nasal contexts; **6-** but when final nasals are combined with initial pharyngeals they show regressive effect on nasalisation of neighbouring vowels; and **7-** a final pharyngeal combined with an initial nasal is more likely to have nasalisation than one with an initial oral. More specifically, results showed that: **1-** final pharyngeal /ħ/ has more effect of nasalisation on neighbouring vowels than /ʕ/; **2-** even if measures are taken near a final nasal, the type of pharyngeal at initial position changes the degree of nasalisation, with a context with an initial /ħ/ in ħ-n showing more nasalisation than one with an initial /ʕ/ in ʕ-n. Interestingly, many of these results coincide with those resulting from the auditory impression of nasalisation particularly with regards to the oral-nasal context showing the least nasalisation amongst nasal contexts.

Results of cross-dialectal comparisons show findings similar to those at onset and could be summarised as follows: **1-** irrespective of whether the results showed significance or tendencies, Baghdad dialect is noted as the variety with the most nasalisation for most vowel contexts; **2-** Basra and Mosul dialects have the lowest nasalisation for most vowels, with Basra showing the least nasalisation in many contexts; **3-** These results coincide with those of the auditory impression of nasalisation.

9.2.3 Summary of the *A*1-**P*1 measure

Results of the *A*1-**P*1 measure has shown that it distinguishes between nasal and non-nasal contexts in vowels /i:, ɪ, ɛ:, ɛ, u:, ʊ/ but not in /a:, ʌ, ɔ:/ for reasons explained in the introduction and discussion sections. Pharyngeal and nasal contexts show two types of behaviour depending on type and position of consonants, type of vowel and dialect: contexts having two nasal consonants have more nasalisation than those containing one; pharyngeal consonants combined with nasal consonants also show nasalisation the most regardless of the position of each consonant; when nasal consonants are combined with oral consonants, nasalisation is not as prominent as in other nasal or pharyngeal contexts; nasal and pharyngeal consonants show an overall progressive effect of nasalisation; pharyngeal consonants combined with orals vary in the amount of nasalisation but tend to pattern more closely with nasal contexts; the highest overall values are those found in oral (o-o) and isolation contexts which indicate the least degree of nasalisation; pharyngeal /ħ/ shows more nasalisation than pharyngeal /ʕ/ in initial and final positions and for both nasal and non-nasal contexts; dialectal comparisons show Baghdad as having the most nasalisation and Basra the least in most contexts.

9.3 *A*1-**P*0

Similar to *A*1-**P*1, here and elsewhere the evaluation of values resulting from the *A*1-**P*0 measurement is informed by findings from Chen (1995, 1997, 2000), Chen et al. (2000, 2007) and Berger (2007), which indicate that the threshold value for nasalisation is below 10dB; the present study will apply the same criteria while bearing in mind effect of vowel context, individual speaker and dialectal differences. While *A*1-**P*1 represents the difference of value between the amplitude of *F*1 and that of the extra peak between *F*1 and *F*2, *A*1-**P*0 represents the difference of value between the amplitude of *F*1 and that of the extra peak below that formant.

Here the overall values of all vowels are very low, below 10dB, and particularly low, below 5dB, in vowels /iː, ɪ, ɛː, uː, ʊ/. Furthermore, the only distinction noted is that between non-pharyngeal nasal contexts and isolation but not with oral context and only for vowels /ɛː, aː, ɔː/. The only consistent result noted in all vowels is that contexts containing pharyngeals, whether nasal or non-nasal, have the highest of all values and even exceed 15dB in vowels /ɛ, aː, ʌ, ɔː/. This result contradicts results obtained from the *A*1-**P*1 measure where these contexts showed the lowest values indicating the highest levels of nasalisation. These results do not coincide with results obtained in the literature where *A*1-**P*0 was found to discriminate well between contexts with nasalisation and those that are otherwise. Nevertheless, the measure was still used in this study and reported on here because it highlights this contradiction with the literature and allows us to relate that to the type of data analysed in the present study.

The results reported here could be explained by looking at the position of the extra peak in relation to the position of the first two formants. In measuring *P*0, which is measured below *F*1, vowels /iː, ɪ, ɛː, uː, ʊ/ have a very low *F*1, which could lie on the same harmonic as *P*0 or the one close to it. This enhances the amplitude of *P*0 despite data having undergone normalisation in order to remove the effect of formants, leading to a lower *A*1-**P*0 value for these vowels (Osanai, 2012). In pharyngeal contexts, there is an increase in *F*1 and a decrease in *F*2 at vowel portions near pharyngeal consonants in effect of pharyngealisation. This increase in *F*1 would have it located on harmonics as high as *H*6 or even higher, therefore allowing the presence of an extra peak below *F*1. However, that extra peak would not have enough amplitude to reflect a decrease in *A*1-**P*0 because having a high *F*1 would cause an upward tilt that leads to an increase in amplitude for higher harmonics. Therefore, even in vowels with high *F*1 as in /ɛ, aː, ʌ/, contexts that contain pharyngeals act in further enhancement of *F*1 due to pharyngealisation. Even though these vowels do show some discrimination between non-pharyngeal nasal contexts and isolation, they fail to show the same discrimination with oral contexts. This could also be explained following the above patterns but taking into consideration that the oral contexts consist of a variety of consonants that might lower *F*1 in vowels /ɛː, aː,ɔː/. Due to the above discussion and similarities of results between the three vowel portions, only results obtained at onset will be presented below and those applied at midpoint and offset are found in Appendixes G and H.

9.3.1 Contexts

Results will be presented following the order in figure 9.7. Effect size differences and Cohen *d* values are presented in table 9.7. Results of all pharyngeal contexts show them having the highest of all *A*1-**P*0 values suggesting pharyngealisation rather than nasalisation. Furthermore, only vowels /ɛː, ɛ, aː, ʌ, ɔː/ have more than one pharyngeal context. Therefore, only a summary will be provided of some of the results. In long vowels, isolation context also has one of the highest values but not o-o context, whereby for all vowels o-o context has one of the lowest values, similar to non-pharyngeal nasal contexts and even lower in vowel /ɔː/. It is noted that when a pharyngeal is present in initial position, as in ħ-n and ʕ-n, it tends to increase the *A*1-**P*0 values whereas when a nasal is initial it tends to decrease the value, as in n-ħ and n-ʕ. This explains the different results obtained from this measure as opposed to the *A*1-**P*1 results. When a nasal is in initial position, nasalisation decreases the value, showing the effect of the measure in distinguishing nasal contexts. When an initial pharyngeal is present the values increase as a result of pharyngealisation. No significant differences are noted between contexts containing the two pharyngeals, but tendencies suggest those containing pharyngeal /ħ/ have lower *A*1-**P*0 values than those containing /ʕ/, which indicate /ʕ/ showing more pharyngealisation than /ħ/. Below are the detailed results for each vowel.

/iː/: A one-way ANOVA reveals a significant effect of contexts containing vowel /iː/ on *A*1-**P*0 values at onset with a large effect size (F (4, 207) = 14.184, p<0.001, $\eta_p^2 = 0.218$). Bonferroni post-hoc analysis reveals ʕ-o context as having a significantly higher *A*1-**P*0 value than each of n-n, n-o, isolation and o-o contexts. Pharyngeals therefore show the highest *A*1-**P*0 values due to pharyngealisation and not nasalisation (this applies to results of other vowels); moreover, there is no distinction between nasal and non-nasal contexts.

/ɪ/: A one-way ANOVA reveals a non-significant effect of contexts containing vowel /ɪ/ on *A*1-**P*0 values at onset, but showing a tendency for the ʕ-o context to show higher *A*1-**P*0 values than the other contexts, due to the effect of pharyngealisation.

/ɛː/: A one-way ANOVA reveals a significant effect of contexts containing vowel /ɛː/ on *A*1-**P*0 values at onset with a moderate effect size (F (4, 169) = 5.481, p<0.001, $\eta_p^2 = 0.117$). Bonferroni post-hoc analysis reveals ʕ-n, ħ-o and ʕ-o contexts as having significantly higher *A*1-

*P0 values than each of n-o and o-o contexts; and isolation context as having significantly higher value than o-o context. No significant differences are noted between pharyngeal contexts but tendencies show pharyngeal /ʕ/ having more pharyngealisation effect on the following vowel than pharyngeal /ħ/.

/ɛ/: A one-way ANOVA reveals a significant effect of contexts containing vowel /ɛ/ on A1-*P0 values at onset with a large effect size (F (3, 159) = 12.921, p<0.001, η_p^2 = 0.199). Bonferroni post-hoc analysis reveals ħ-o and ʕ-o contexts as having significantly higher A1-*P0 values than each of n-o and o-o contexts; and ħ-n and ʕ-n contexts as having significantly higher value than o-o context. However, no significant differences are noted between pharyngeal contexts.

Table 9.7: Effect size differences and Cohen d values for *A*1-P*0 values within individual contexts at onset**

Vowel	Context1	Context2	Cohen *d*	effect size	Sig.
/iː/	ʕ-o	n-n	1.35	large	*p*<0.001
		n-o	1.57	large	*p*<0.001
		isolation	2.01	large	*p*<0.001
		o-o	0.76	moderate to large	*p*<0.001
/ɛː/	ʕ-n	n-o	1.70	large	*p*<0.001
		o-o	1.33	large	*p*<0.001
	ħ-o	n-o	1.02	large	*p*<0.001
		o-o	0.90	large	*p*<0.001
	ʕ-o	n-o	2.15	large	*p*<0.001
		o-o	1.99	large	*p*<0.001
	isolation	o-o	0.66	moderate to large	*p*<0.001
/ɛ/	ħ-o	n-o	1.01	large	*p*<0.001
		o-o	1.07	large	*p*<0.001
	ʕ-o	n-o	1.20	large	*p*<0.001
		o-o	1.15	large	*p*<0.001
	ħ-n	o-o	0.82	large	*p*<0.001
	ʕ-n	o-o	0.80	large	*p*<0.001
/aː/	ħ-o	n-n	1.67	large	*p*<0.001
		n-o	1.27	large	*p*<0.001
		n-ħ	1.46	large	*p*<0.001
		o-o	1.12	large	*p*<0.001
		isolation	0.54	moderate	*p*<0.001
	ʕ-o	n-n	1.70	large	*p*<0.001
		n-o	1.31	large	*p*<0.001
		n-ħ	1.52	large	*p*<0.001
		o-o	1.19	large	*p*<0.001
		isolation	0.60	moderate to large	*p*<0.001
	isolation	n-n	0.98	large	*p*<0.001
		n-o	0.70	moderate to large	*p*<0.001
		o-o	0.57	moderate	*p*<0.001
/uː/	ʕ-o	o-o	1.10	large	*p*<0.001
		isolation	0.71	moderate to large	*p*<0.001
/ʊ/	ħ-o	n-o	1.51	large	*p*<0.001
		o-o	1.18	large	*p*<0.001
/ɔː/	o-o	ħ-n	2.01	large	*p*<0.001
		ʕ-n	2.34	large	*p*<0.001
		ħ-o	1.12	large	*p*<0.001
		isolation	2.02	large	*p*<0.001

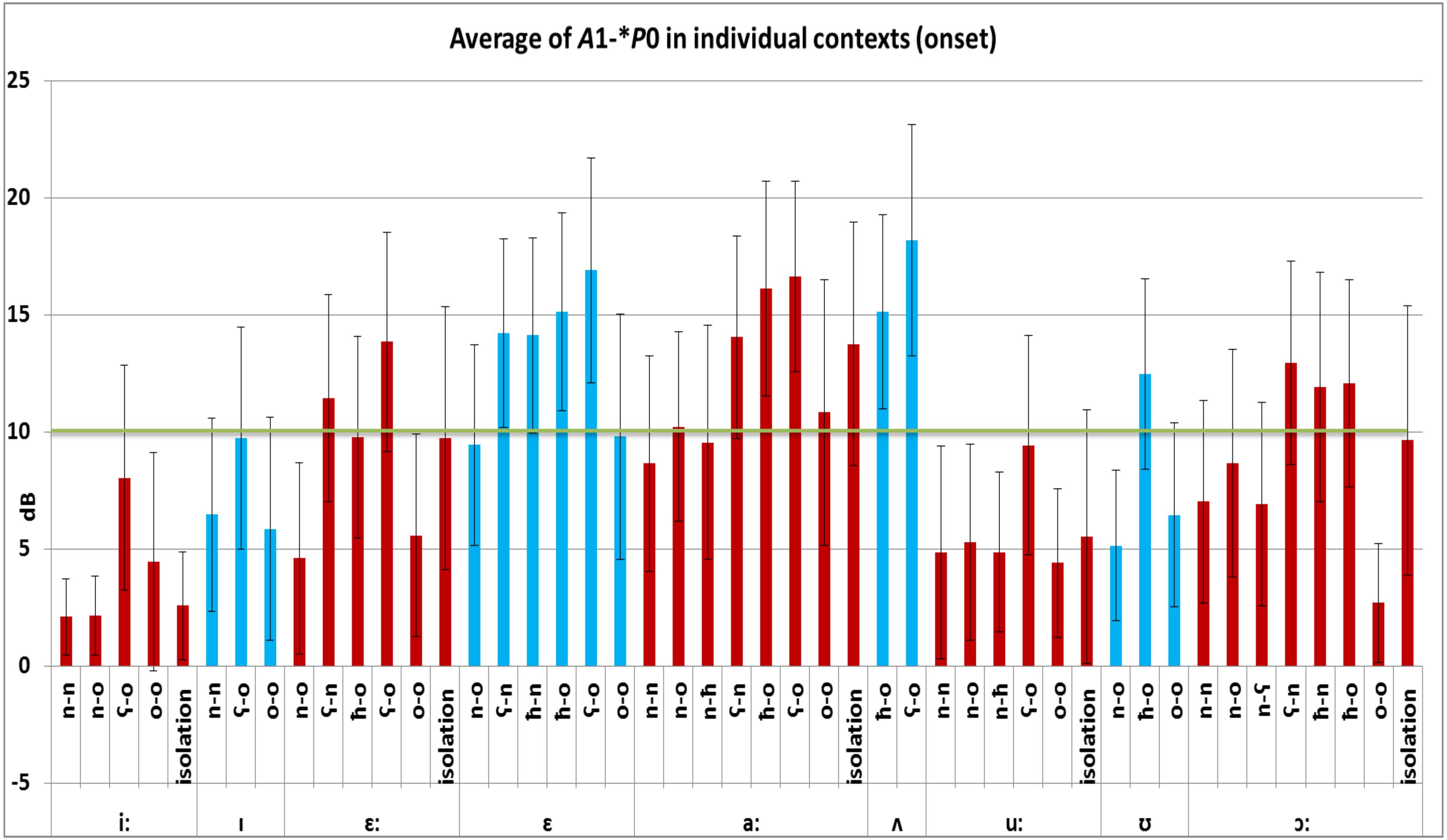


Figure 9.7: ***A*1-*P0 values within individual contexts at onset.**

/a:/: A one-way ANOVA reveals a significant effect of contexts containing vowel /a:/ on *A*1-**P*0 values at onset with a moderate effect size (F (6, 486) = 12.921, p<0.001, $\eta_p^2 = 0.120$). Bonferroni post-hoc analysis reveals ħ-o and ʕ-o contexts as having significantly higher *A*1-**P*0 values than each of n-n, n-o, n-ħ, o-o and isolation contexts; and isolation context as having a significantly higher value than each of n-n, n-o and o-o contexts. As for other vowels, the pharyngeal contexts show the highest *A*1-**P*0 values denoting pharyngealisation. However, for this vowel there is a distinction between nasal and non-nasal contexts with the former suggesting more nasalisation as shown by their lower *A*1-**P*0 values.

/ʌ/: Because there are only two contexts to compare, an *independent*-samples *t*-test was applied and revealed no significant differences (t (51) = 1.274, p>0.001) between contexts ħ-o and ʕ-o on *A*1-**P*0 values for vowel /ʌ/ at onset, but showing a tendency for ħ-o context to have less pharyngealisation effect than ʕ-o context.

/u:/: A one-way ANOVA reveals a significant effect of contexts containing vowel /u:/ on *A*1-**P*0 values at onset with a small effect size (F (5, 223) = 2.463, p<0.05, $\eta_p^2 = 0.053$). Bonferroni post-hoc analysis reveals ʕ-o context as having a significantly higher *A*1-**P*0 value than each of o-o and isolation contexts.

/ʊ/: A one-way ANOVA reveals a significant effect of contexts containing vowel /ʊ/ on *A*1-**P*0 values at onset with a large effect size (F (2, 25) = 5.680, p<0.05, $\eta_p^2 = 0.331$). Bonferroni post-hoc analysis reveals ħ-o context as having a significantly higher *A*1-**P*0 value than each of n-o and o-o contexts.

/ɔ:/: A one-way ANOVA reveals a significant effect of contexts containing vowel /ɔ:/ on *A*1-**P*0 values within vowel at onset with a moderate effect size (F (7, 181) = 3.642, p<0.001, $\eta_p^2 = 0.128$). Bonferroni post-hoc analysis reveals o-o context as having a significantly lower *A*1-**P*0 value than each of ħ-n, ʕ-n, ħ-o and isolation contexts. However, no significant differences are noted between the two pharyngeal or between nasal and non-nasal contexts.

9.3.2 Cross-dialectal differences in vowels

Results here are similar to those of *A*1-**P*0 for the first criteria where the highest values would be for vowels /ɛ, a:, ʌ/ and the lowest for vowels /i:, ɪ, ɛ:, u:, ʊ/, except for vowel /ɔ:/ which shows low values here (figure 9.8). It is also generally noted that contexts which have the lowest *A*1-**P*1 values have the highest *A*1-**P*0 values. This also applies to the first criteria as was previously discussed. Due to the fact that the overall results are similar to previous ones, this section will only focus on vowels which show significant differences between dialects. ANOVA results show no significant differences between dialects for vowels /iː, ɪ, ʌ, uː, ʊ/ (table 9.8). Below are the detailed results for vowels /ɛː, ɛ, aː, ɔː/.

Table 9.8: Effect size differences and Cohen d values for cross-dialectal comparisons of *A*1-P*0 values at onset.**

Vowel	Dialect1	Dialect2	Cohen *d*	effect size	Sig.
/ɛː/	Basra	Bagdad	0.69	moderate to large	*p*<0.001
		Mosul	0.68	moderate to large	*p*<0.001
/ɛ/	Baghdad	Basra	0.48	moderate	*p*<0.001
		Mosul	0.57	moderate	*p*<0.001
/aː/	Baghdad	Basra	0.89	large	*p*<0.001
		Mosul	0.85	large	*p*<0.001
/ɔː/	Basra	Mosul	0.68	moderate to large	*p*<0.001

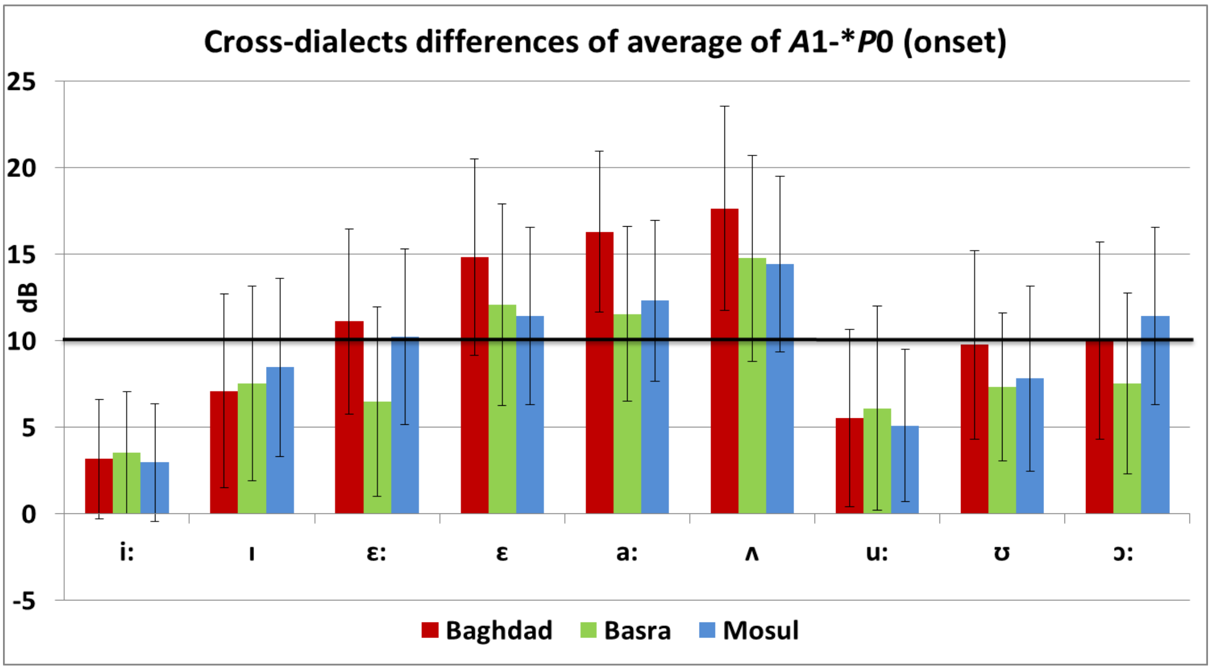


Figure 9.8: Cross-dialectal differences of average values of *A*1-P*0 for vowels at onset.**

/ɛː/: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *A*1-**P*0 values within vowel /ɛː/ at onset with a moderate effect size (F (2, 169) = 8.958, p<0.001, η_p^2 = 0.097). Bonferroni post-hoc analysis reveals Basra as having a significantly lower *A*1-**P*0 value than each of Bagdad and Mosul. This result shows Basra as having the least pharyngealisation.

/ɛ/: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *A*1-**P*0 values within vowel /ɛ/ at onset with a small effect size (F (2, 159) = 4.708, p<0.001, η_p^2 = 0.057). Bonferroni post-hoc analysis reveals Baghdad as having a significantly higher *A*1-**P*0 value than each of Basra and Mosul. This result shows the Baghdad as having the most pharyngealisation.

/a:/: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *A*1-**P*0 values within vowel /a:/ at onset with a moderate effect size (F (2, 486) = 39.338, p<0.001, η_p^2 = 0.140). Bonferroni post-hoc analysis reveals Baghdad as having a significantly higher *A*1-**P*0 value than each of Basra and Mosul. This result shows Baghdad as having the most pharyngealisation.

/ɔ:/: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *A*1-**P*0 values within vowel /ɔ:/ at onset with a moderate effect size (F (2, 181) = 6.981, p<0.001, η_p^2 = 0.072). Bonferroni post-hoc analysis reveals Basra as having a significantly lower *A*1-**P*0 value than Mosul. This result shows Basra as having the least pharyngealisation and that of Mosul the most although there is not much difference between Mosul and Baghdad vowels.

9.3.3 Cross-dialectal differences in individual contexts

ANOVA results of each context for the three dialects show no significant differences for contexts nasal-nasal, nasal-pharyngeal and oral (table 9.9, figure 9.9). It is also very noticeable that overall values decrease in contexts containing initial nasals as a result of nasalisation; whereas they increase in contexts containing initial pharyngeals as a result of pharyngealisation. This increase is also irrespective of which pharyngeal is present at initial position suggesting no significant differences between the two pharyngeals in their effect on pharyngealisation. Below are results of individual contexts showing significant differences between the three dialects.

Table 9.9: Effect size differences and Cohen d values for cross-dialectal comparisons of *A*1-P*0 values within contexts at onset.**

Context	Dialect1	Dialect2	Cohen *d*	effect size	Sig.
n-o	Basra	Baghdad	0.55	moderate	p<0.001
		Mosul	0.68	moderate to large	p<0.001
n-ħ	Basra	Baghdad	0.52	moderate	p<0.001
		Mosul	0.64	moderate to large	p<0.001
n-ʕ	Mosul	Baghdad	2.10	large	p<0.001
		Basra	2.00	large	p<0.001
ʕ-n	Baghdad	Basra	1.90	large	p<0.001
		Mosul	1.82	large	p<0.001
ħ-o	Baghdad	Basra	0.59	moderate	p<0.001
		Mosul	0.52	moderate	p<0.001
ʕ-o	Baghdad	Basra	0.49	moderate	p<0.001
		Mosul	2.01	large	p<0.001
	Basra	Mosul	0.40	moderate	p<0.001
isolation	Baghdad	Basra	0.30	moderate	p<0.001

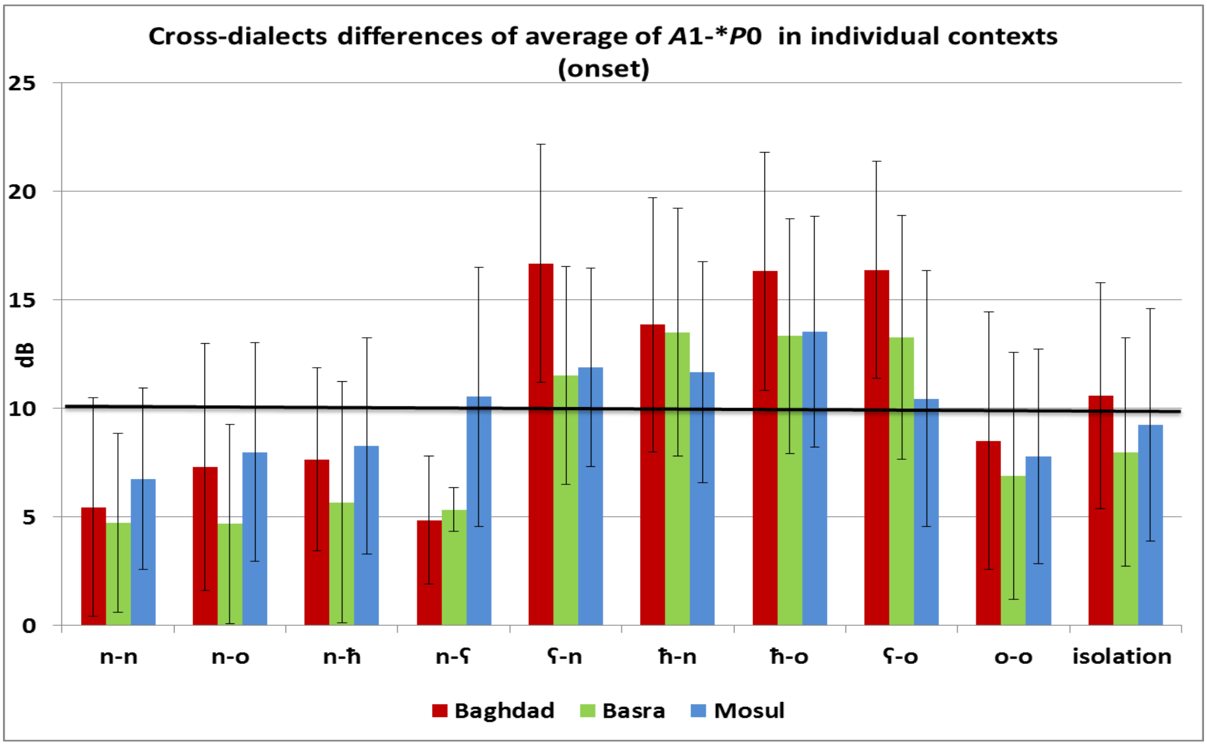


Figure 9.9: Cross-dialectal differences of *A*1-P*0 values within individual contexts at onset.**

n-n: A one-way ANOVA reveals a non-significant effect of cross-dialectal differences on *A*1-**P*0 values within n-n context at onset, but show a tendency for Basra to have the lowest *A*1-**P*0 value and Mosul the highest.

n-o: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *A*1-**P*0 values within the n-o context at onset with a moderate effect size (F (2, 98) = 3.343, p<0.001, η_p^2 = 0.065). Bonferroni post-hoc analysis reveals Basra as having a significantly lower *A*1-**P*0 value than both Baghdad and Mosul.

n-ħ: A one-way ANOVA reveals a non-significant effect of cross-dialectal differences on *A*1-**P*0 values within n-ħ context at onset, but Bonferroni post-hoc analysis reveals Basra as having a significantly lower *A*1-**P*0 value than both Baghdad and Mosul.

n-ʕ: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *A*1-**P*0 values within the n-ʕ context at onset with a large effect size (F (2, 8) = 2.374, p<0.001, η_p^2 = 0.442). Bonferroni post-hoc analysis reveals Mosul as having a significantly higher *A*1-**P*0 value than each of Baghdad and Basra.

ħ-n: A one-way ANOVA reveals a non-significant effect of cross-dialectal differences on *A*1-**P*0 values within ħ-n context at onset, but show a tendency for Mosul to have a lower *A*1-**P*0 value than each of Baghdad and Basra.

ʕ-n: A general one-way ANOVA reveals a significant effect of cross-dialectal differences on *A*1-**P*0 values within ʕ-n context at onset with a moderate effect size (F (2, 44) = 4.383,

p<0.001, $\eta_p^2 = 0.173$). Bonferroni post-hoc analysis reveals Baghdad as having a significantly higher *A*1-**P*0 value than each of Basra and Mosul.

ħ-o: A general one-way ANOVA reveals a significant effect of cross-dialectal differences on *A*1-**P*0 values within ħ-o context at onset with a moderate effect size (F (2, 157) = 3.686, p<0.001, $\eta_p^2 = 0.045$). Bonferroni post-hoc analysis reveals Baghdad as having a significantly higher *A*1-**P*0 value than each of Basra and Mosul.

ʕ-o: A general one-way ANOVA revealed a significant effect of cross-dialectal differences on *A*1-**P*0 values within ʕ-o context at onset with a moderate effect size (F (2, 125) = 8.079, p<0.001, $\eta_p^2 = 0.116$). Bonferroni post-hoc analysis reveals significant differences between all dialects with Baghdad showing the highest *A*1-**P*0 value and Mosul the lowest.

o-o: A one-way ANOVA reveals a non-significant effect of cross-dialectal differences on *A*1-**P*0 values within o-o context at onset, but show a tendency for Baghdad to show a higher *A*1-**P*0 value than each of Basra and Mosul.

Isolation: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *A*1-**P*0 values within the isolation context at onset with a moderate effect size (F (2, 775) = 10.316, p<0.001, $\eta_p^2 = 0.072$). Bonferroni post-hoc analysis reveals Baghdad as having a significantly higher *A*1-**P*0 value than Basra.

9.3.4 Discussion of the *A*1-**P*0 measure results

*A*1-*P*0 is a measure of nasalisation which has been used in the literature to distinguish between contexts with nasalisation and those with no nasalisation. However, there has been restrictions on the type of vowels in which the measure should be applied, favouring vowels with a high *F*1 allowing a space below it for an extra peak to appear. Therefore, the measure was assumed to work on low and low-mid vowels which have high *F*1. In the present study, all vowels were used in order to examine this result and if it applies to Arabic. Interestingly, we have found that not only the type of vowel hinders how this measure performs, but also the type of consonants neighbouring those vowels. It has been noted that when such consonants as pharyngeals are present, the measure does not distinguish between contexts with nasalisation and those with no nasalisation and instead it tends to distinguish between ones with pharyngealisation and those with no pharyngealisation, except in vowel /a:/ where it does both; although low-mid and mid vowels /ɛ:, ɛ, a:, ʌ, ɔ:/ showed tendencies to have that distinction. Results of individual contexts show a consistency whereby contexts containing pharyngeal consonants have the highest values although the same ones had the lowest values when measuring *A*1-**P*1; this is due to the effect of pharyngealisation and not lack of nasalisation. Furthermore, no significant differences are noted between nasal and non-nasal contexts. Only vowel /a:/ shows the nasal/non-nasal distinction irrespective of the overall *A*1-**P*0 high values within pharyngeal contexts. Apart from showing the same results as in other vowels in terms of the pharyngeal context showing the highest *A*1-**P*0 values, there are two main results: one relates to the oral context having the lowest overall *A*1-**P*0 value, and the other is that isolation context has an overall high *A*1-**P*0 value. Furthermore, contexts containing initial nasals tend to decrease values as a result of nasalisation whereas contexts containing initial pharyngeals tend to increase values as the result of pharyngealisation. Also, contexts containing pharyngeal /ʕ/ show higher *A*1-**P*0 values indicating more pharyngealisation than those containing pharyngeal /ħ/.

From observing cross-dialectal comparison results it can be noted that they are in contradiction with what has been established for *A*1-**P*1 whereby the Baghdad dialect showed the most nasalisation; here, if the measure is to be taken as a nasalisation measure, then the Baghdad dialect seems to show the least nasalisation. Instead, *A*1-**P*0 seems to be reflecting the degree of pharyngealisation with Baghdad dialect showing the most pharyngealisation. Furthermore, in most contexts Basra dialect is showing the least values indicating the least pharyngealisation. Results of cross-dialectal comparisons within individual contexts show that whether there is significance or mere tendency, Baghdad vowels have the highest values indicating the highest degree of pharyngealisation; Basra is showing the lowest values in non-pharyngeal contexts indicating the lowest degree of pharyngealisation. Furthermore, it is noted that overall values of contexts containing an initial pharyngeal (whether nasal or non-nasal) are higher than those containing an initial nasal. This again is caused by pharyngealisation rather than nasalisation.

Therefore, *A*1-**P*0 did not prove to be a good measure of nasalisation in this study but interesting results emerged. For instance, it is mainly effective in differentiating between high and low *F*1 and *A*1. It is very sensitive to the frequency of *F*1 and therefore requires more experimentation and control over what should be investigated in terms of types of consonants and their influence over neighbouring vowels. Moreover, the measure does not seem to be good for Arabic contexts due to the variety of Arabic consonants that are not found in the languages that were previously investigated, particularly pharyngeal consonants. The measure is very sensitive and needs more restrictions in what and when it should be used. Therefore, results in the present study do not show it as a ‘bad’ measure but one that has to be used with caution.

9.4 First formant Bandwidth (*B*1)

As was mentioned in Chapter 4, *B*1 (Bandwidth of *F*1) is expected to be wider for two reasons: **1-** when a vowel is affected by nasalisation (Ohala, 1962; Beddor, 1983; Hawkins and Stevens, 1985; Klatt and Klatt, 1990; Trittin and Lleo, 1995; Pickett, 1999; Chen et al., 2007; Beddor, 2007; Berger, 2007); **2-** when a vowel is affected by breathiness (Hanson, 1996; Hanson and Chuang, 1999; Kuang, 2011). The criteria used in the literature to differentiate vowels with nasalisation and those with no nasalisation when measuring *B*1 is: **a-** when the value of *B*1 is between 200Hz and 300Hz, the context is considered to have nasalisation; **b-** if it falls below 200Hz then the vowel would not be considered having nasalisation. The criterion used to differentiate vowels which have high *B*1 values due to nasalisation and those due to breathiness is **H*1-*A*1, an acoustic measure of phonation types. This measure is directly related to *B*1 which is in turn related to the posterior glottal opening whereby: if a speaker has a posterior glottal opening, then *B*1 will be increased leading to the increase of **H*1-*A*1 values.

However, similar to other measures, this measure is applied on Iraqi Arabic speakers producing a variety of consonants not found in the other investigated languages and dialects; therefore, depending on surrounding consonants, *B*1 values could increase for other different reasons working together. Furthermore, only measures at midpoint will be presented here because onset shows the same results and offset shows less distinction between nasal and non-nasal contexts; midpoint also has more contexts to show (see Appendixes I and J for figures at onset and offset).

9.4.1 Contexts

Results will be presented following the order in figure 9.10. Effect size differences and Cohen *d* values are presented in table 9.10. Below are the detailed results for each vowel.

Table 9.10: Effect size differences and Cohen *d* values of *B*1 values within individual contexts at midpoint.

Vowel	Context1	Context2	Cohen *d*	effect size	Sig.
/ɛː/	ʕ-n	o-n	1.55	large	p<0.001
		ħ-o	1.60	large	p<0.001
		ʕ-o	1.58	large	p<0.001
		o-o	2.71	large	p<0.001
		isolation	1.66	large	p<0.001
/ɛ/	ħ-n	n-o	1.48	large	p<0.001
		o-n	1.61	large	p<0.001
		o-ħ	1.62	large	p<0.001
		o-o	1.65	large	p<0.001
	ʕ-n	n-o	1.30	large	p<0.001
		o-n	1.50	large	p<0.001
		o-ħ	1.52	large	p<0.001

		o-o	1.53	large	*p*<0.001
	ħ-o	ħ-n	0.93	large	*p*<0.001
		ʕ-n	0.13	large	*p*<0.001
/a:/	o-ħ	n-o	1.21	large	*p*<0.001
		o-n	0.81	large	*p*<0.001
		ʕ-n	1.72	large	*p*<0.001
		ħ-o	0.86	large	*p*<0.001
	o-ʕ	n-o	1.30	large	*p*<0.001
		ʕ-n	1.67	large	*p*<0.001
	o-o	n-o	1.42	large	*p*<0.001
		o-n	1.01	large	*p*<0.001
		ʕ-n	1.93	large	*p*<0.001
	isolation	n-o	1.12	large	*p*<0.001
		o-n	0.77	moderate to large	*p*<0.001
		ʕ-n	1.56	large	*p*<0.001
/u:/	n-n	ʕ-o	1.43	large	*p*<0.001
		o-ħ	1.53	large	*p*<0.001
		o-ʕ	1.40	large	*p*<0.001
		o-o	1.31	large	*p*<0.001
		isolation	1.26	large	*p*<0.001
	o-n	o-ħ	1.18	large	*p*<0.001
		o-ʕ	1.06	large	*p*<0.001
		o-o	0.98	large	*p*<0.001
		isolation	0.89	large	*p*<0.001
	n-ħ	ʕ-o	1.51	large	*p*<0.001
		o-ħ	1.61	large	*p*<0.001
		o-ʕ	1.50	large	*p*<0.001
		o-o	1.36	large	*p*<0.001
		isolation	1.31	large	*p*<0.001
/ʊ/	n-o	ħ-o	2.11	large	*p*<0.001
		o-o	1.73	large	*p*<0.001
/ɔ:/	o-ħ	n-o	2.37	large	*p*<0.001
		o-n	1.72	large	*p*<0.001
		ħ-n	2.03	large	*p*<0.001
		ʕ-n	2.15	large	*p*<0.001
		n-ʕ	2.76	large	*p*<0.001
	o-o	n-o	2.37	large	*p*<0.001
		o-n	1.79	large	*p*<0.001
		ħ-n	2.08	large	*p*<0.001
		ʕ-n	2.20	large	*p*<0.001
		n-ʕ	2.78	large	*p*<0.001

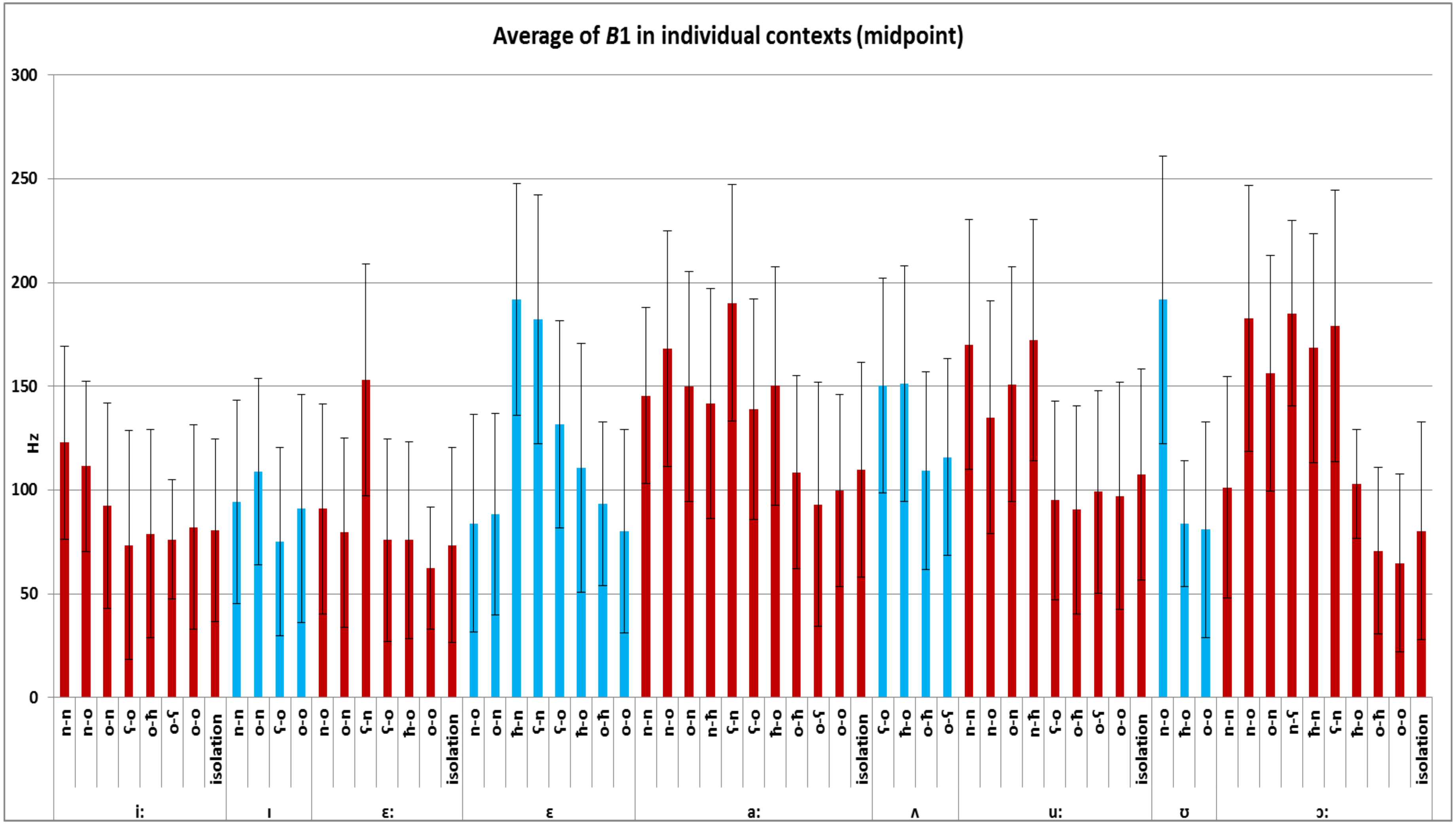


Figure 9.10: ***B*1 values within individual contexts at midpoint.**

/iː/: A one-way ANOVA reveals a significant effect of contexts containing vowel /iː/on *B*1 values at midpoint with a small effect size (F (6, 206) = 2.036, p<0.001, η_p^2 = 0.058). However, Bonferroni post-hoc analysis reveals non-significant differences between contexts, but there is a tendency for nasal contexts to have higher *B*1 values than non-nasal contexts. This is noted by the differences between n-n context and each of ʕ-o, o-ħ, o-ʕ, o-o and isolation contexts; and between n-o context and each of o-n, o-ħ and o-ʕ, ʕ-o, o-o and isolation contexts. Context o-n on the other hand exhibits patterns that coincide with those found in the auditory analysis and *A*1-**P*1 results, whereby it was sometimes grouped with non-nasal contexts due to showing the least nasalisation out of all nasal contexts. Here o-n context has a tendency to show less nasalisation than each of n-n, ʕ-o, o-ħ and o-ʕ contexts, but is similar in value to those of o-o and isolation contexts.

/ɪ/: A one-way ANOVA reveals a non-significant effect of contexts containing vowel /ɪ/ on *B*1 values at midpoint. Even average values do not show a distinction between nasal and non-nasal contexts. They only show o-n as having the highest *B*1 values, suggesting that it has the most nasalisation, which is one of the rare examples showing a regressive rather than a progressive effect of nasalisation. **/ɛː/:** A one-way ANOVA reveals a significant effect of contexts containing vowel /ɛː/ on *B*1 values at midpoint with a moderate effect size (F (5, 177) = 4.177, p<0.001, η_p^2 = 0.108). Bonferroni post-hoc analysis reveals ʕ-n context as having a significantly higher *B*1 value than each of o-n, ħ-o, ʕ-o, o-o and isolation contexts. These significant differences for /ɛː/ at midpoint are similar to those at onset.

/ɛ/: A one-way ANOVA reveals a significant effect of contexts containing vowel /ɛ/ on *B*1 values at midpoint with a large effect size (F (7, 127) = 6.248, p<0.001, η_p^2 = 0.267). Bonferroni post-hoc analysis reveals context ħ-o as having a significantly lower *B*1 value than each of ħ-n and ʕ-n contexts. On the other hand, the three contexts ħ-n, ʕ-n and ʕ-o show the overall highest values for this vowel. However, high *B*1 values for contexts containing this vowel do not indicate a distinction between nasal and non-nasal contexts but between pharyngeal and non-pharyngeal contexts, although mostly nasal pharyngeal ones.

/aː/: A one-way ANOVA reveals a significant effect of contexts containing vowel /aː/ on *B*1 values at midpoint with a moderate effect size (F (10, 480) = 7.589, p<0.001, η_p^2 = 0.139). Bonferroni post-hoc analysis reveals context o-ħ as having a significantly higher *B*1 value than each of n-o, o-n, ʕ-n and ħ-o but not ʕ-o contexts; context o-ʕ as having a significantly higher *B*1 value than each of n-o and ʕ-n contexts. Results of this vowel show: a significant distinction between nasal and non-nasal contexts; contexts ħ-o and ʕ-o have high *B*1 values, grouping them with nasal contexts alongside ʕ-n and n-ħ; but contexts o-ħ and o-ʕ have low *B*1 values grouping them with non-nasal contexts. Only contexts containing this vowel show a distinction between directions of effect on nasalisation caused by pharyngeal consonants; those that are in initial position show higher *B*1 values, i.e. indicating a progressive effect.

/ʌ/: A one-way ANOVA reveals a significant effect of contexts containing vowel /ʌ/ on *B*1 values at midpoint with a moderate effect size (F (3, 63) = 2.506, p<0.001, η_p^2 = 0.111). However, Bonferroni post-hoc analysis reveals non-significant differences between contexts, but show tendencies of differences between contexts ħ-o and ʕ-o on one hand and contexts o-ħ and o-ʕ on the other indicating higher *B*1 values for the former contexts. These results show a progressive effect of pharyngeal consonants in their effect on nasalisation, which coincides with auditory impression of nasalisation and *A*1-**P*1 results.

/u:/: A one-way ANOVA reveals a significant effect of contexts containing vowel /u:/ on *B*1 values at midpoint with a large effect size (F (7, 189) = 5.185, p<0.001, η_p^2 = 0.166). Bonferroni post-hoc analysis reveals n-n and n-ħ contexts as having significantly higher *B*1 values than each of ʕ-o, o-ħ, o-ʕ, o-o and isolation contexts; and the o-n context as having a significantly higher *B*1 value than each of o-ħ, o-ʕ, o-o and isolation contexts. Similar to contexts containing vowels /a:/, results of those containing /u:/ show a distinction between nasal and non-nasal contexts whereby nasal contexts containing two nasals or a nasal and a pharyngeal show the highest *B*1 values indicating the most nasalisation.

/ʊ/: A one-way ANOVA reveals a significant effect of contexts containing vowel /ʊ/ on *B*1 values at midpoint with a large effect size (F (3, 22) = 6.583, p<0.001, η_p^2 = 0.510). Bonferroni post-hoc analysis reveals n-o context as having a significantly higher *B*1 value than each of ħ-o and o-o contexts. These results further show that for the *B*1 measure, non-nasal pharyngeal contexts are grouped with other non-nasal rather than nasal contexts, which differs from results of *A*1-**P*1.

/ɔ:/: A one-way ANOVA reveals a significant effect of contexts containing vowel /ɔ:/ on *B*1 values at midpoint with a large effect size (F (9, 160) = 8.510, p<0.001, η_p^2 = 0.337). Bonferroni post-hoc analysis reveals o-ħ and o-o contexts as having significantly lower *B*1 values than each of n-o, o-n, ħ-n, ʕ-n, and n-ʕ contexts. These results show: a distinction is found between nasal and non-nasal contexts; context ħ-o has a tendency of showing more nasalisation than context o-ħ indicating another instance of progressive effect of pharyngeal consonants on nasalisation; all nasal contexts except the n-n one have high *B*1 values. This last result differs from results of all other vowels as well as those obtained from the auditory and *A*1-**P*1 investigations, where the n-n context yielded the highest nasalisation values.

9.4.2 Cross-dialectal differences in vowels

In a general view of results of this measure, it is noticed that Baghdad has the overall highest *B*1 values (table 9.11, figure 9.11). Below are the detailed results for each vowel.

Table 9.11: Effect size differences and Cohen *d* values for cross-dialectal comparisons of *B*1 values for vowels at midpoint.

Vowel	Dialect1	Dialect2	Cohen *d*	Effect size	Sig.
/i:/	Baghdad	Basra	0.47	moderate	$p<0.001$
		Mosul	0.38	moderate	$p<0.001$
/ɪ/	Baghdad	Basra	1.58	large	$p<0.001$
		Mosul	1.59	large	$p<0.001$
/ɛ:/	Baghdad	Basra	0.57	moderate	$p<0.001$
		Mosul	1.20	large	$p<0.001$
/ɛ/	Mosul	Baghdad	1.07	large	$p<0.001$
		Basra	0.56	moderate	$p<0.001$
/a:/	Baghdad	Basra	0.62	moderate	$p<0.001$
		Mosul	1.10	large	$p<0.001$
	Basra	Mosul	0.32	moderate	$p<0.001$
/ʌ/	Mosul	Baghdad	1.33	large	$p<0.001$
		Basra	1.03	large	$p<0.001$
/u:/	Baghdad	Basra	1.46	large	$p<0.001$
		Mosul	1.21	large	$p<0.001$
/ʊ/	Basra	Baghdad	0.95	large	none
		Basra	0.85	large	none
/ɔ:/	Baghdad	Basra	0.59	moderate	$p<0.001$
		Mosul	1.18	large	$p<0.001$

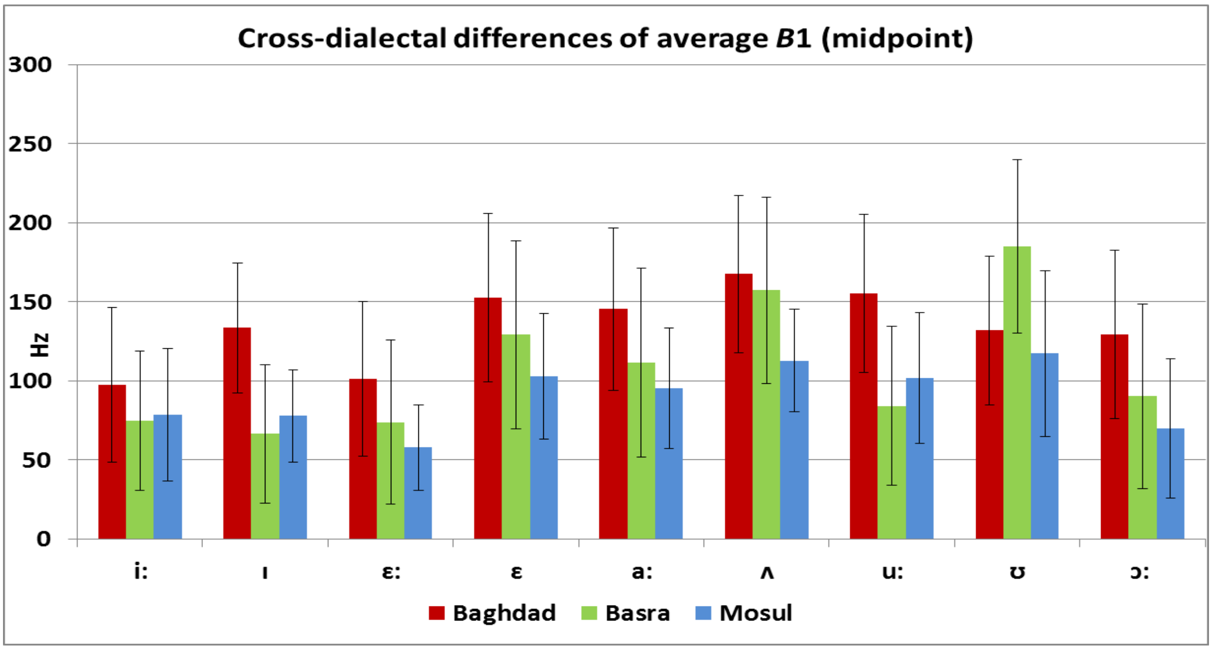


Figure 9.11: Cross-dialectal differences of *B*1 values for vowels at midpoint.

/i:/: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *B*1 values within vowel /i:/ at midpoint with a small effect size (F (2, 206) = 4.767, $p<0.001$, η_p^2 =

0.045). Bonferroni post-hoc analysis reveals Baghdad as having a significantly higher *B*1 value than each of the other two dialects.

/ɪ/: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *B*1 values within vowel /ɪ/ at midpoint with a large effect size (F (2, 45) = 13.110, p<0.001, η_p^2 = 0.379). Bonferroni post-hoc analysis reveals Baghdad as having a significantly higher *B*1 value than each of the other two dialects.

/ɛː/: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *B*1 values within vowel /ɛː/ at midpoint with a moderate effect size (F (2, 177) = 15.021, p<0.001, η_p^2 = 0.147). Bonferroni post-hoc analysis reveals Baghdad as having a significantly higher *B*1 value than each of the other two dialects.

/ɛ/: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *B*1 values within vowel /ɛ/ at midpoint with a moderate effect size (F (2, 127) = 11.856, p<0.001, η_p^2 = 0.159). Bonferroni post-hoc analysis reveals Mosul as having a significantly lower *B*1 value than the other two dialects.

/aː/: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *B*1 values within vowel /aː/ at midpoint with a moderate effect size (F (2, 480) = 40.859, p<0.001, η_p^2 = 0.146). Bonferroni post-hoc analysis reveals significant differences between all dialects, with effect size differences showing Baghdad having the highest *B*1 value and Mosul the lowest.

/ʌ/: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *B*1 values within vowel /ʌ/ at midpoint with a large effect size (F (2, 63) = 8.721, p<0.001, η_p^2 = 0.222). Bonferroni post-hoc analysis reveals Mosul as having a significantly lower *B*1 value than the other two dialects.

/uː/: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *B*1 values within vowel /uː/ at midpoint with a large effect size (F (2, 189) = 40.941, p<0.001, η_p^2 = 0.305). Bonferroni post-hoc analysis reveals Baghdad as having a significantly higher *B*1 value than each of the other two dialects.

/ʊ/: A one-way ANOVA reveals a non-significant effect of cross-dialectal differences on *B*1 values within vowel /ʊ/ at midpoint, but showing a tendency for Basra to have the most nasalisation with its highest *B*1 value.

/ɔː/: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *B*1 values within vowel /ɔː/ at midpoint with a moderate effect size (F (2, 160) = 13.885, p<0.001, η_p^2 = 0.149). Bonferroni post-hoc analysis reveals Baghdad as having a significantly higher *B*1 value than each of the other two dialects.

9.4.3 Cross-dialectal differences in individual contexts

Table 9.12 and figure 9.12 show results of the cross-dialectal comparisons of individual contexts whereby Baghdad again shows the highest *B*1 values. Below are the detailed results for each individual context.

Table 9.12: Effect size differences and Cohen d values for cross-dialectal comparisons of B1 values within individual contexts at midpoint.

Vowel	Dialect1	Dialect2	Cohen *d*	effect size	Sig.
n-n	Baghdad	Mosul	1.29	large	p<0.001
n-o	Baghdad	Mosul	0.89	large	p<0.001
o-n	Mosul	Baghdad	1.06	large	p<0.001
		Basra	0.56	moderate	p<0.001
n-ħ	Baghdad	Basra	2.92	large	p<0.001
n-ʕ	Mosul	Baghdad	2.17	large	p<0.001
		Basra	1.84	large	p<0.001
ħ-n	Mosul	Baghdad	1.14	large	p<0.001
		Basra	1.19	large	p<0.001
ʕ-n	Mosul	Basra	1.39	large	p<0.001
ħ-o	Baghdad	Basra	0.64	moderate to large	p<0.001
		Mosul	1.37	large	p<0.001
ʕ-o	Baghdad	Basra	1.14	large	p<0.001
o-ħ	Baghdad	Basra	0.57	moderate	p<0.001
o-ʕ	Baghdad	Basra	1.16	large	p<0.001
		Mosul	1.18	large	p<0.001
o-o	Baghdad	Basra	0.85	large	p<0.001
		Mosul	1.09	large	p<0.001
isolation	Baghdad	Basra	0.67	moderate to large	p<0.001
		Mosul	1.06	large	p<0.001

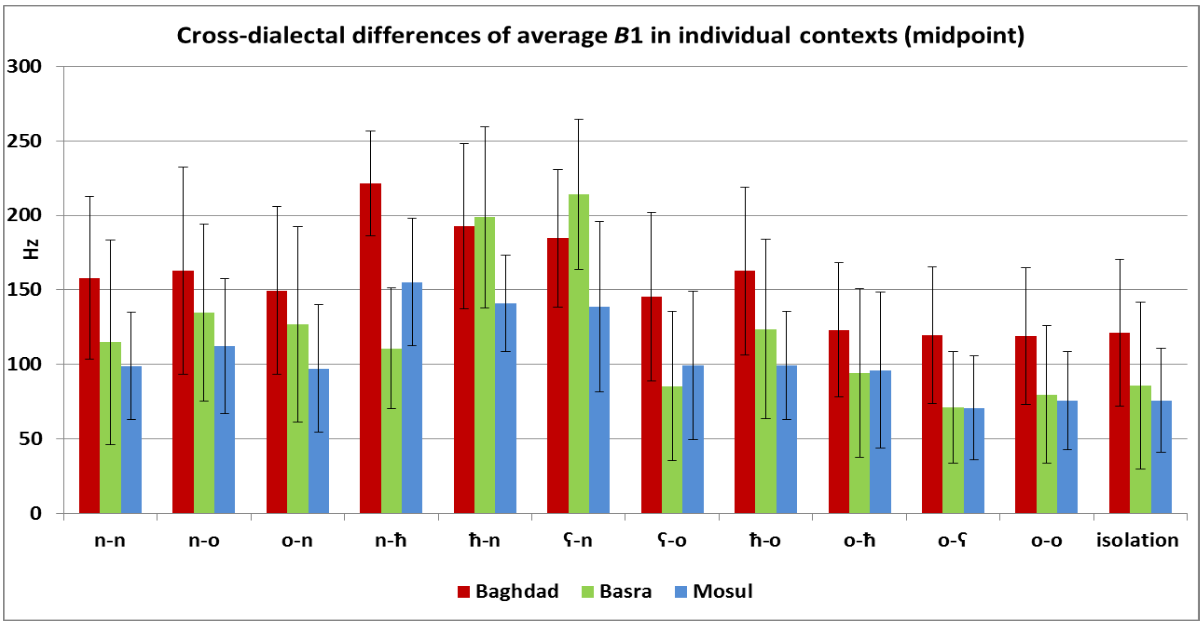


Figure 9.12: Cross-dialectal differences of *B*1 values for individual contexts at midpoint.

n-n: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *B*1 values within context n-n at midpoint with a large effect size (F (2, 31) = 4.221, p<0.001, η_p^2 = 0.225). Bonferroni post-hoc analysis reveals Baghdad as having a significantly higher *B*1 value and Mosul the lowest.

n-o: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *B*1 values within context n-o at midpoint with a moderate effect size (F (2, 63) = 3.912, p<0.001, η_p^2 = 0.114). Bonferroni post-hoc analysis reveals Baghdad as having a significantly higher *B*1 value and Mosul the lowest.

o-n: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *B*1 values within context o-n at midpoint with a moderate effect size (F (2, 117) = 9.827, p<0.001, η_p^2 = 0.146). Bonferroni post-hoc analysis reveals Mosul as having a significantly higher *B*1 value than each of the other two dialects.

n-ħ: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *B*1 values within context n-ħ at midpoint (F (2, 10) = 5.663, p<0.001, η_p^2 = 0.586). Bonferroni post-with a large effect size hoc analysis reveals Baghdad as having a significantly higher *B*1 value than Basra.

n-ʕ: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *B*1 values within context n-ʕ at midpoint with a large effect size (F (2, 13) = 1.642, p<0.001, η_p^2 = 0.767). Bonferroni post-hoc analysis reveals Mosul as having a significantly lower *B*1 value than each of the other two dialects.

ħ-n: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *B*1 values within context ħ-n at midpoint with a large effect size (F (2, 13) = 1.581, p<0.001, η_p^2 = 0.223). Bonferroni post-hoc analysis reveals Mosul as having a significantly lower *B*1 value than each of the other two dialects.

ʕ-n: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *B*1 values within context ʕ-n at midpoint with a large effect size (F (2, 29) = 5.082, p<0.001, η_p^2 = 0.273). Bonferroni post-hoc analysis reveals Mosul as having a significantly lower *B*1 value than Basra.

ħ-o: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *B*1 values within context ħ-o at midpoint with a large effect size (F (2, 128) = 18.561, p<0.001, η_p^2 = 0.228). Bonferroni post-hoc analysis reveals significant differences between all dialects, with Baghdad showing the highest *B*1 values and Mosul the lowest.

ʕ-o: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *B*1 values within context ʕ-o at midpoint with a large effect size (F (2, 107) = 13.959, p<0.001, η_p^2 = 0.210). Bonferroni post-hoc analysis reveals Baghdad as having a significantly higher *B*1 value than Basra.

o-ħ: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *B*1 values within context o-ħ at midpoint with a moderate effect size (F (2, 94) = 3.210, p<0.001, η_p^2

= 0.065). Bonferroni post-hoc analysis reveals Baghdad as having a significantly higher *B*1 value than Basra.

o-ʕ: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *B*1 values within context o-ʕ at midpoint with a large effect size (F (2, 34) = 6.120, p<0.001, η_p^2 = 0.277). Bonferroni post-hoc analysis reveals significant differences Baghdad as having a significantly higher *B*1 value than each of the other two dialects.

o-o: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *B*1 values within context o-o at midpoint with a large effect size (F (2, 184) = 20.215, p<0.001, η_p^2 = 0.182). Bonferroni post-hoc analysis reveals Baghdad as having a significantly higher *B*1 value than each of the other two dialects.

Isolation: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *B*1 values within context isolation at midpoint with a moderate effect size (F (2, 644) = 51.638, p<0.001, η_p^2 = 0.139). Bonferroni post-hoc analysis reveals Baghdad as having a significantly higher *B*1 value than each of the other two dialects.

9.4.4 Discussion of the *B*1 measure results

Results at midpoint show that there is a tendency for an overall distinction between nasal and non-nasal contexts whereby the former have higher *B*1 values. In vowels /iː, ɪ, ɛː, aː, uː, ʊ, ɔː/ the highest average values are those containing nasal consonants whether their *B*1 values are significantly higher than those in non-nasal contexts or only show tendencies. Vowels /ɛ, ʌ/ show different results from the other vowels whereby *B*1 values for vowel /ɛ/ show no distinction between nasal and non-nasal contexts and instead there is a distinction between pharyngeal and non-pharyngeal contexts, with the former having the highest values. However, the only vowels that showed significant differences to distinguish between nasal and non-nasal contexts are /aː, uː, ɔː/. While the results for the pharyngeals support those found for *A*1-**P*1, what is not clear for vowel /ɛ/ is why no nasal-non-nasal distinction is present. As for vowel /ʌ/, which only contains two non-nasal pharyngeal contexts, it is noted that *B*1 values for both contexts are high but with a higher value when the pharyngeal is initial in pharyngeal-oral; isolation context has one of the lowest *B*1 values, which is what would be expected; and oral context mostly shows low values but occasionally patterns with nasal contexts. This could be due to the types of consonants which vary in the way they influence neighbouring vowels. The remaining vowels had significant differences distinguishing between pharyngeal and non-pharyngeal contexts and tendencies of nasal/non-nasal distinctions as mentioned above.

In vowels /i:, ɪ, ɛ:, a:, u:, ʊ, ɔ:/ having a pharyngeal consonant combined with a nasal consonant increases *B*1 to the extent that it becomes higher than in nasal-nasal, nasal-oral and oral-nasal contexts, whether this pharyngeal is initial or final. This result is similar to that of *A*1-**P*1 with regards to pharyngeal nasal showing nasalisation the most. Having a pharyngeal combined with an oral, on the other hand, tends to be similar to non-nasal contexts in the above vowels in having low *B*1 whether the pharyngeal is initial or final. In fact, these contexts sometimes show the lowest overall *B*1 values. This was not found in results of the *A*1-**P*1 measure where these non-nasal pharyngeal contexts showed more nasalisation.

Furthermore, acoustic results of phonation types (Chapter 10) show that whether a nasal consonant is present or not the **H*1-**H*2 and **H*1-*A*1 values are very low indicating laryngealisation. These results rule out any existence of breathiness indicating that any high *B*1 values in these contexts are related to nasalisation. As for nasal (non-pharyngeal) contexts, these have breathy phonation as noted by the two phonation measures and also have a tendency to have high *B*1 values. This indicates that nasal contexts show both breathy phonation and nasalisation because if no other contexts show nasalisation these are bound to have nasalisation.

For more detailed results, individual contexts show that although the nasal-nasal context has no significant differences with any other context for all vowels, they still show one of the highest *B*1 values. Furthermore, nasal consonants combined with oral consonants in contexts n-o and o-n show a progressive effect of increasing *B*1 values because values in context n-o are higher than those in o-n whether these differences are significant or showing tendencies reflected by the effect size differences and the average *B*1 values observed. Results of contexts containing a pharyngeal consonant combined with a nasal consonant for vowels /ɛ:, ɛ, a:, u:, ɔ:/ show higher *B*1 values than other contexts. Furthermore, in all vowels no distinction is noted between the two pharyngeal consonants with regards to which one increases the value of *B*1. Generally, the *B*1 measure results was able to significantly differentiate between nasal and non-nasal contexts in three vowels /a:, u:, ɔ:/; while vowels /i:, ɪ, ɛ:, a:, u:, ʊ, ɔ:/ only showed high average *B*1 values within nasal contexts with significant differences being between pharyngeal and non-pharyngeal contexts.

In a general view of cross-dialectal results of this measure, it is noticed that Baghdad has the overall highest values. Results are consistent with previous results of both *A*1-**P*1 and the auditory impression of nasalisation suggesting that Baghdad vowels /i:, ɪ, ɛ:, a:, u:, ɔ:/ have higher *B*1 values than the same vowels of the other two dialects; Mosul has the lowest *B*1 values in five vowels /ɛ:, ɛ, a:, ʌ, ʊ, ɔ:/; and Basra shows variable results. In all cross-dialectal comparisons within individual contexts except pharyngeal-nasal ones, Baghdad has the highest *B*1 value. In the pharyngeal-nasal contexts, Basra has the highest *B*1 value, but patterns with Mosul in the other contexts, showing lower values. In pharyngeal contexts except ħ-n and ʕ-n, Baghdad shows more nasalisation than the other two dialects, whether or not these differences between dialects are significant or tendencies. In eight contexts Mosul has the lowest values. In two contexts, n-ħ and ʕ-o, Basra has the lowest *B*1 values and in another two contexts, ħ-n and ʕ-n, Basra has the highest *B*1 value. These results indicate a consistency with the vowel contexts whereby Baghdad has the highest *B*1 values, Mosul the lowest and Basra fluctuating in between. It is also noted from observing figures 9.11 and 9.12 that the overall average value results, irrespective of individual dialects, show that nasal contexts containing pharyngeal consonants have the highest *B*1 values, followed by other nasal contexts and non-nasal contexts containing initial pharyngeal consonants, and the lowest *B*1 values are in non-nasal contexts with final pharyngeal consonants as well as oral and isolation ones.

9.5 *F*1/*F*2 frequencies

Potential frequency changes of *F*1 and *F*2 in relation to nasalisation were investigated in vowels occurring in the environment of nasal and/or pharyngeal consonants. These environments were compared to oral and isolation ones, which are on their part used as the base for how these measures behave. As was previously mentioned in Chapter 7 on pharyngeal production and in this chapter on the *A*1-**P*0 measure, pharyngeal consonants lead to a rise in *F*1 in all vowels, a rise in *F*2 in back vowels and a drop in front vowels. Nasalisation effect, on the other hand, shows a different trend which mainly depends on the position of *F*1 in the neighbouring vowel and to a lesser extent on *F*2 (Chapter 4). This makes the interpretation of formant measures in environments with nasals and pharyngeals difficult due to potentially opposing effects. In looking at nasalisation effects, the discussion will adopt the approach mentioned in Chapter 4, which takes into consideration the type of vowel in deciding the direction of change of formant frequencies and its relation to nasalisation (House and Stevens, 1956; House, 1957; Fry, 1979; Hawkins and Stevens, 1985; Chen et al., 2007) and adopting that outlined by Beddor (1983: 134; see Chapter 4) which depend on vowel types: **1-** for high front unrounded vowels there is a consistency of *F*1 raising; **2-** for mid front unrounded vowels there is no consistency of results in terms of the direction of shift of *F*1; **3-** for low front unrounded vowels there are differences of results but the majority show a drop in *F*1; **4-** for low central unrounded vowels, there is consistency of *F*1 lowering; **5-** for mid back rounded vowels, there is a drop in *F*1; **6-** for high back rounded vowels, there is little consistency, with some showing lowering and others raising of *F*1 but with more instances of lowering.

There will be no detailed statistical analysis for the presentation of results because even if formant frequency changes in pharyngeal contexts pattern with changes in nasalised contexts, it will be difficult to tease apart the respective influence of nasalisation and pharyngealisation. Accordingly, there will only be a comparison between nasalised and non-nasalised contexts depending on the direction of change of formants. Furthermore, only results measured at onset will be presented in this chapter due to two main reasons (see Appendix K for results at other portions): **1-** there are more significant differences noted between contexts at onset than at the other two contexts, **2-** the overall results are repeated in the other two portions. Finally, cross-dialectal differences will not be tackled for this measure because results are a replica of those in the previous comparisons.

9.5.1 Contexts

Results in this section will be presented within long and short vowels each separately.

9.5.1.1 *Long vowels*

This section tackles results of formant frequency changes in long vowels within individual contexts (table 9.13, figure 9.13). Results here are compared to oral and isolation contexts.

/iː/: This is a front high unrounded vowel, so to show nasalisation, we would expect a rise in *F*1 and a drop in *F*2. Formant frequency results in n-n and n-o contexts exhibit these changes, indicating nasalisation. Context pharyngeal-oral exhibits the same formant changes which suggest pharyngealisation as was noted in Chapter 7. This may be one of the few instances whereby the direction of formant frequency changes is similar for both nasalisation and pharyngealisation. It could also be that the pharyngeal-oral contexts exhibit both effects given that they also showed nasalisation in this chapter.

/ɛː/: This is a front mid unrounded vowel, so is expected to have a drop in *F*1 and a rise in *F*2 to show nasalisation, similar to low central unrounded vowels. This would be supported by the fact that mid vowels have shown results which group them with vowel /aː/ especially with regards to the *A*1-**P*1 and *A*1-**P*0 measures, which rely on the position of *F*1 and *F*2. Results of n-o context show a drop in *F*1 and a rise in *F*2 as would be expected in a nasal context; while pharyngeal-nasal and pharyngeal-oral contexts show a raised *F*1 and a lowered *F*2, indicating pharyngealisation. For this vowel it is clear that pharyngealisation effects override nasalisation.

Table 9.13: Results of formant frequency changes in long vowels within individual contexts.

Vowel phoneme	Vowel type	context	Formant	Direction of change	feature
/iː/	Front high unrounded	n-n	F1	rise	nasalisation
			F2	drop	
		n-o	F1	rise	nasalisation
			F2	rise	
		ʕ-o	F1	rise	pharyngealisation
			F2	drop	
/ɛː/	Front mid unrounded	n-o	F1	drop	nasalisation
			F2	rise	
		ʕ-n	F1	rise	pharyngealisation
			F2	drop	
		ħ-o	F1	rise	pharyngealisation
			F2	drop	
		ʕ-o	F1	rise	pharyngealisation
			F2	drop	pharyngealisation
/aː/	Low central unrounded	n-n	F1	drop	nasalisation
			F2	rise	
		n-o	F1	drop	nasalisation
			F2	drop	
		n-ħ	F1	drop	nasalisation
			F2	rise	
		ʕ-n	F1	rise	pharyngealisation
			F2	rise	
		ħ-o	F1	rise	pharyngealisation
			F2	drop	
		ʕ-o	F1	rise	pharyngealisation
			F2	drop	
/uː/	Back high rounded	n-n	F1	no change	nasalisation
			F2	rise	
		n-o	F1	no change	nasalisation
			F2	rise	
		n-ħ	F1	drop	nasalisation
			F2	rise	
		ʕ-o	F1	rise	pharyngealisation
			F2	rise	
/ɔː/	Back mid rounded	n-n	F1	drop	nasalisation
			F2	rise	
		n-o	F1	no change	nasalisation
			F2	rise	
		n-ʕ	F1	drop	nasalisation
			F2	rise	
		ħ-n	F1	rise	pharyngealisation
			F2	rise	
		ʕ-n	F1	rise	pharyngealisation
			F2	rise	
		ħ-o	F1	rise	pharyngealisation
			F2	rise	

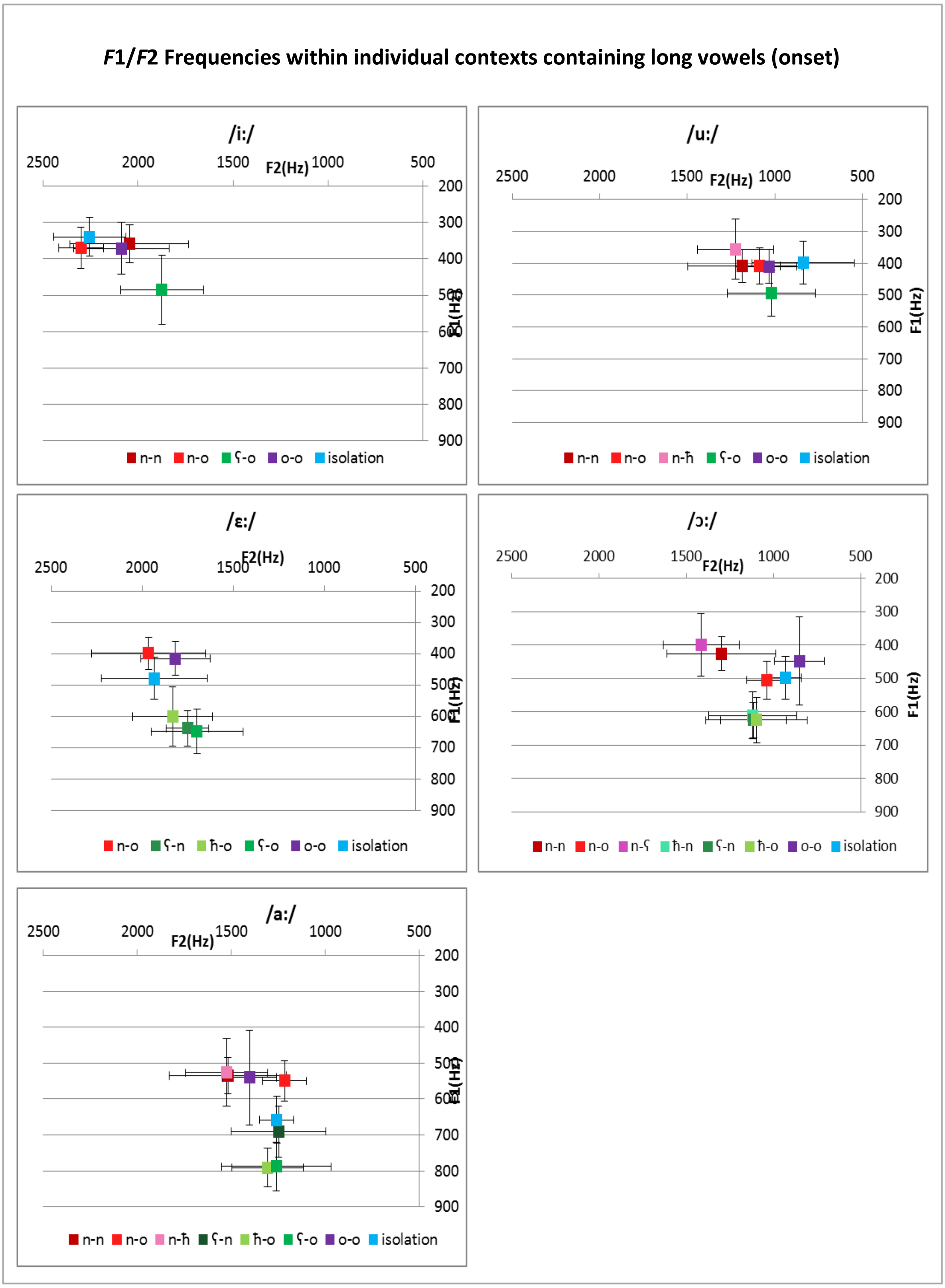


Figure 9.13: Plotted F1/F2 frequencies within individual contexts containing long vowels /iː, ɛː, aː, uː, ɔː/ at onset.

/aː/: This is a low central unrounded vowel which is expected to show a lowering of *F*1 and a potential rise in *F*2 as indications of nasalisation. In contexts n-n and nasal-pharyngeal *F*1 drops and *F*2 rises indicating nasalisation; In pharyngeal-nasal and pharyngeal-oral contexts both

$F1$ and $F2$ rise indicating pharyngealisation. However, in context n-o shows $F1$ drops, similar to other nasal contexts, but $F2$ also drops, which differs from what is expected in nasalised contexts. However, as was mentioned in Chapter 4, most of the literature considers shifts in $F1$ as the main decider of the effect of nasalisation.

/u:/: This is a back high rounded vowel, which, similar to Beddor's (1983) findings, did not show consistency of results. However, results of other nasalisation measures have indicated that formant frequency changes of this vowel behave similar to those of /a:/. In n-n and n-o contexts, $F2$ rises and $F1$ remains constant. They are also noted grouping together away from pharyngeal contexts indicating nasalisation. Nasal-pharyngeal contexts, on the other hand, show the clearest formant changes indicating nasalisation, with a drop in $F1$ and a rise in $F2$. Pharyngeal-oral contexts show a raise in both $F1$ and $F2$ indicating pharyngealisation for this vowel.

/ɔ:/: This is a back mid rounded vowel which is expected to show a drop in $F1$ and a potential rise in $F2$. In n-n and nasal-pharyngeal contexts, $F1$ for /ɔ:/ drops and $F2$ rises; in context n-o, $F2$ rises while $F1$ remains constant. In pharyngeal-nasal and pharyngeal-oral contexts, both formants rise indicating pharyngealisation. Measuring formant changes near the pharyngeal in pharyngeal-nasal contexts show patterning with other non-nasal pharyngeal contexts, while results near the nasal in nasal-pharyngeal contexts show patterning with the n-n context. However, context n-o does not pattern with any of these groups and shows the least formant frequency changes related to nasalisation than other nasal contexts. These results are similar to those in vowel /a:/.

9.5.1.2 *Short vowels*

Results of formant frequency changes in short vowels within individual contexts are shown in table 9.14 and figure 9.14. Here results are compared to those in oral contexts.

Table 9.14: Results of formant frequency changes in short vowels within individual contexts.

Vowel phoneme	Vowel type	context	Formant	Direction of change	feature
/ɪ/	Front high unrounded	n-n	F1	rise	nasalisation
			F2	no change	
		ʕ-o	F1	rise	pharyngealisation
			F2	drop	
/ɛ/	Front mid unrounded	n-o	F1	drop	nasalisation
			F2	no change	
		ħ-n	F1	rise	pharyngealisation
			F2	drop	
		ʕ-n	F1	rise	pharyngealisation
			F2	drop	
		ħ-o	F1	rise	pharyngealisation
			F2	drop	

		ʕ-o	F1	rise	pharyngealisation
			F2	drop	
/ʊ/	back high unrounded	n-n	F1	rise	?
			F2	drop	
		ħ-o	F1	rise	pharyngealisation
			F2	drop	pharyngealisation

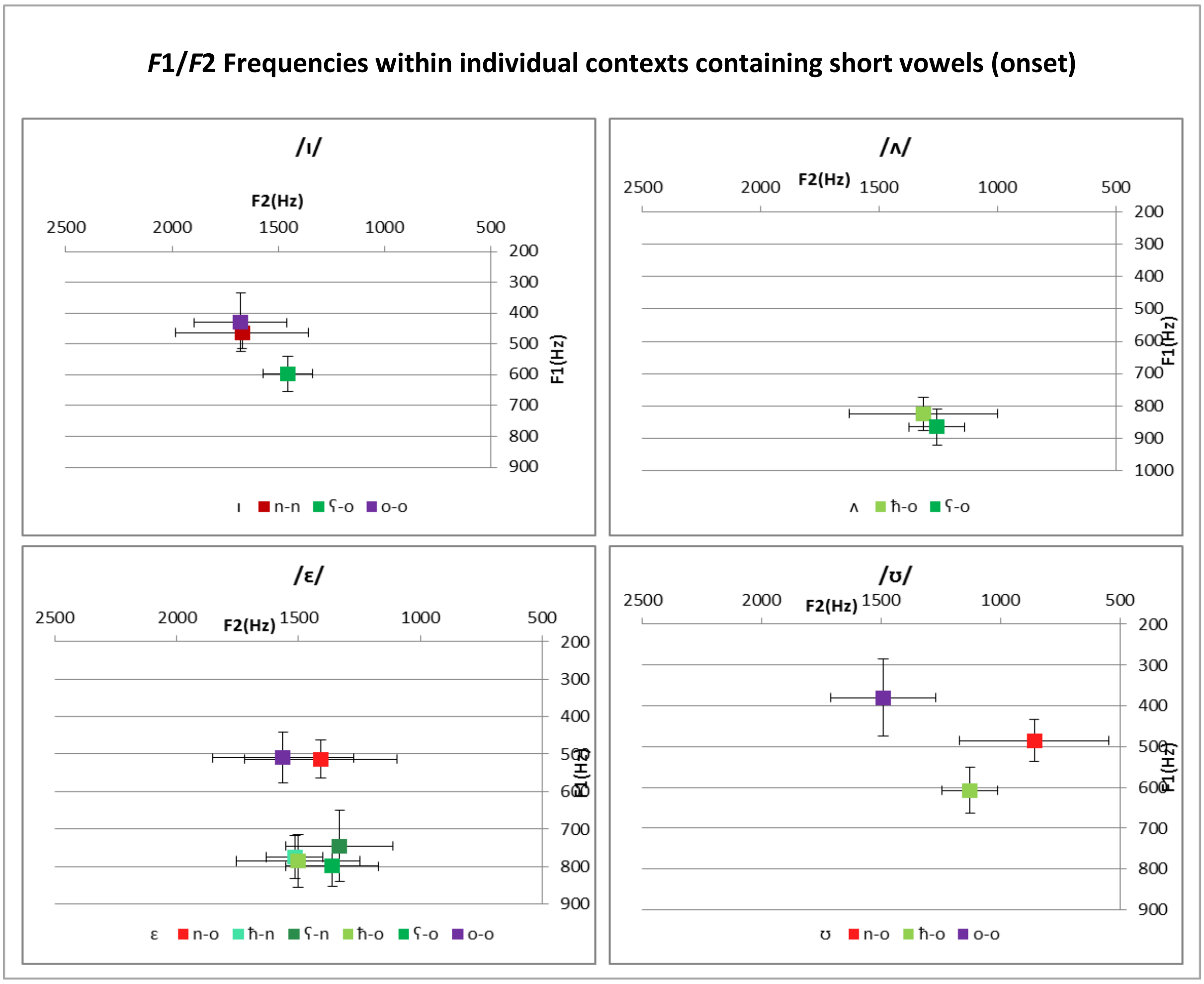


Figure 9.14: Plotted *F*1/*F*2 frequencies within individual contexts containing short vowels /ɪ, ɛ, ʌ, ʊ/ at onset.

/ɪ/: This is a front high unrounded vowel which is expected to show a rise in *F*1 and a potential drop in *F*2 as a result of nasalisation. In the n-n context, *F*1 for /ɪ/ drops, indicating nasalisation, while *F*2 remains constant. Also in ʕ-o context, *F*1 rises and *F*2 drops, which could indicate the presence of nasalisation; but the more open and more back quality noted for this context indicates pharyngealisation.

/ɛ/: This is a front mid unrounded vowel, expected to show similar formant frequency changes to low vowels as a result of nasalisation. In context n-o *F*1 drops indicating the presence of nasalisation, while *F*2 remains constant. In contexts ħ-n, ʕ-n, ħ-o, ʕ-o, *F*1 rises and *F*2 drops indicating pharyngealisation.

/ʌ/: This is a low central unrounded vowel, expected to show similar formant frequency changes to low vowels as a result of nasalisation. The vowel in only embeddied in two pharyngeal contexts with no oral context to compare with; but plots of contexts ħ-o and ʕ-o show a similar trend to those containing other vowel.

/ʊ/: This is a back high rounded vowel where a drop in *F*1 and a rise in *F*2 are expected in nasalised environments, similar to low vowels. Results indicate that /ʊ/ formants in the n-o context do not show the expected nasalisation effect, instead showing a rise in *F*1 and a drop in *F*2, suggesting a more back/more open vowel instead of a more front and more close articulation. In fact, the changes in n-o are similar to those in the ħ-o contexts, which on their part show pharyngealisation.

Other results for *F*1 and *F*2 frequencies in long and shrot vowels are interpreted while taking into consideration the position of the pharyngeal and not the nasal as was previously adopted for other measures (figures 9.13, 9.14). No detailed statistical results are presented because overall results of pharyngeal contexts show that there are no significant differences between the two pharyngeal consonants in terms of changes to formant frequencies except for *F*2 in vowels /ɛː, ɛ/. Contexts containing the two vowels /ɛː, ɛ/ neighbouring /ʕ/ showed tendencies for more *F*1 raising and *F*2 lowering than those neighbouring /ħ/, indicating more pharyngealisation for /ʕ/. This result coincides with those found for *A*1-**P*0. Furthermore, results in pharyngeal contexts only show the effect of pharyngealisation and not nasalisation, which are similar to results concluded in Chapter 7, and therefore do not need further discussion. It is also noted that nasal-pharyngeal contexts showed the most nasalisation effect.

9.5.2 Discussion of the *F*1/*F*2 measure results

A number of general findings are: **1-** there is a distinction between nasal and pharyngeal contexts; **2-** context nasal-pharyngeal shows the most nasalisation in vowels /aː, uː, ɔː/ due having the most front/close articulation with a lowered *F*1 and a raised *F*2, which fits the profile of contexts having nasalisation as indicated in the literature (see Chapter 4); **3-** context nasal-oral shows the most contradictory of all results because it is the least consistent of all nasal contexts in showing the profile changes that indicate nasalisation and groups it with nasal contexts; these differences are similar to those of the oral-nasal context at offset (see Appendix K). This could explain why auditory and other acoustic analyses occasionally showed these contexts as having the least nasalisation, particularly for oral-nasal contexts.

Results of vowel /aː, uː, ɔː/ show that not only does the nasal-pharyngeal context pattern with contexts showing nasalisation, but it also exhibits more extreme formant changes than other nasal contexts. This agrees with findings from the *A*1-**P*1 measure for these contexts. The overall results for contexts containing /a:, u:, ɔ:/ show that measuring *F*1/*F*2 near a pharyngeal consonant has the effect of pharyngealisation and near a nasal consonant has the effect of nasalisation. This difference of effect could explain why in some instances these contexts showed less nasalisation than other nasal ones from an auditory and acoustic point of view. This also applies to context oral-nasal at offset as can be noted in Appendix K.

As for pharyngeal contexts, no significant differences were noted between the two pharyngeals in showing pharyngealisation. Furthermore, due to the prevalence of pharyngealisation, it was not possible to measure nasalisation.

9.6 Overall Vowel Intensity

A decrease in overall vowel intensity is a measure of nasalisation (Beddor, 1983, 2007; see Chapter 4). The following sections will tackle this measure by investigating it in the same contexts and for the same vowels as in other measures. What is expected is that nasal contexts would show low values of intensity and non-nasal ones high values. Pharyngeal contexts are expected to also have high values of intensity following findings in the literature connecting high intensity with pharyngeal consonants (see Chapter 5).

9.6.1 Contexts

This section will tackle results of overall vowel intensity in individual contexts (table 9.15, figure 9.15). Below are detailed results of each vowel.

/i:/: A one-way ANOVA reveals a significant effect of individual contexts on *overall vowel intensity* values within vowel /i:/ with a large effect size (F (7, 265) = 16.253, p<0.001, η_p^2 = 0.306). Bonferroni post-hoc analysis reveals isolation context as having a significantly lower *intensity* value than each of n-n, n-o, and o-n, ʕ-o, o-ħ, o-ʕ and o-o contexts. However, there are tendencies for nasal contexts to have lower *intensity* values than pharyngeal and oral contexts. These results do not show significant differences between nasal and non-nasal contexts but tendencies show a potential difference between them. One explanation for the low intensity for context isolation could be related to speaker specific features rather than related to nasalisation. No significant differences are noted between the two contexts o-ħ and o-ʕ but show a tendency for context o-ħ to have lower *intensity*. This indicates that a final pharyngeal /ħ/ has an effect of lowering the value of *vowel intensity*.

Table 9.15: *Overall vowel intensity* within individual contexts.

Vowel	Context1	Context2	Cohen *d*	effect size	Sig.
/iː/	isolation	n-n	1.16	large	*p*<0.001
		n-o	1.14	large	*p*<0.001
		o-n	0.98	large	*p*<0.001
		ʕ-o	1.34	large	*p*<0.001
		o-ħ	1.68	large	*p*<0.001
		o-ʕ	1.80	large	*p*<0.001
		o-o	1.42	large	*p*<0.001
/ɛː/	isolation	o-n	0.74	moderate to large	*p*<0.001
		ħ-o	1.36	large	*p*<0.001
		ʕ-o	0.79	moderate to large	*p*<0.001
		o-o	0.95	large	*p*<0.001
/aː/	n-o	ħ-o	0.61	moderate to large	*p*<0.001
		ʕ-o	0.52	moderate	*p*<0.001
		o-ħ	0.90	large	*p*<0.001
		o-ʕ	1.99	large	*p*<0.001
		o-o	0.77	moderate to large	*p*<0.001
	isolation	ħ-o	0.99	large	*p*<0.001
		ʕ-o	0.80	large	*p*<0.001
		o-ħ	1.11	large	*p*<0.001
		o-ʕ	2.15	large	*p*<0.001
		o-o	0.93	large	*p*<0.001
	o-n	o-ħ	0.57	moderate	*p*<0.001
		o-ʕ	2.10	large	*p*<0.001
/uː/	ʕ-o	n-n	1.15	large	*p*<0.001
		n-o	1.01	large	*p*<0.001
		o-n	1.17	large	*p*<0.001
		n-ħ	1.17	large	*p*<0.001
		o-ħ	1.10	large	*p*<0.001
		o-o	1.12	large	*p*<0.001
		isolation	1.94	large	*p*<0.001
	o-o	isolation	0.75	moderate to large	*p*<0.001
/ʊ/	n-o	o-ħ	1.42	large	*p*<0.001
/ɔː/	n-ʕ	o-n	1.32	large	*p*<0.001
		ħ-n	1.11	large	*p*<0.001
		ʕ-n	1.01	large	*p*<0.001
		ħ-o	1.94	large	*p*<0.001
		o-ħ	2.23	large	*p*<0.001

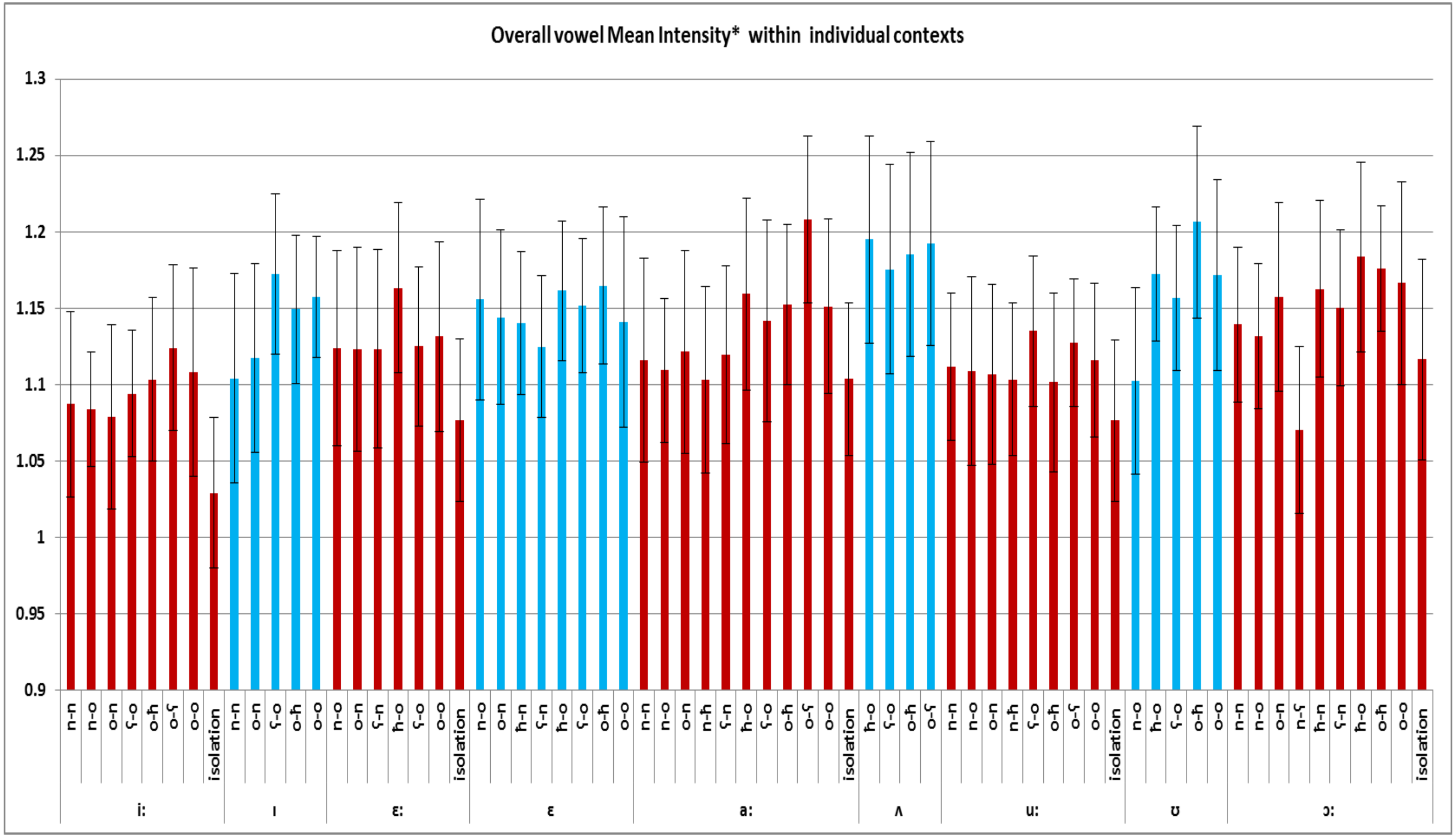


Figure 9.15: ***Overall vowel intensity*** **within individual contexts.**

/ɪ/: A one-way ANOVA reveals a non-significant effect of individual contexts on *overall vowel intensity* values within vowel /ɪ/. No significant differences were noted between contexts, but show tendencies for n-n context to have a lower *intensity* value than each of ʕ-o, o-ħ and o-o; and also o-n context shows a tendency to have lower *intensity* values than each of ʕ-o, o-ħ and o-o contexts. These results do not show a nasal/non-nasal distinction for *intensity*.

/ɛ:/: A one-way ANOVA reveals a significant effect of individual contexts on *overall vowel intensity* values within vowel /ɛ:/ with a large effect size (F (6, 192) = 6.875, p<0.001, η_p^2 = 0.182). Bonferroni post-hoc analysis reveals isolation context as having a significantly lower *intensity* value than each of o-n, ħ-o, ʕ-o and o-o contexts. These results are similar to those of vowel /i:/ whereby no significant differences are found to distinguish between nasal and non-nasal contexts but a significant distinction between isolation and other contexts. However, there are tendencies of distinctions between nasal contexts (n-o, o-n and ʕ-n) and each of ħ-o and ʕ-o. No significant difference is found between contexts ħ-o and ʕ-o but they show a tendency for ʕ-o to have lower *intensity*. Therefore, pharyngeal /ʕ/ when in initial position leads to lower *vowel intensity* than /ħ/.

/ɛ/: A one-way ANOVA reveals a non-significant effect of individual contexts on *overall vowel intensity* values within vowel /ɛ/, but there are tendencies for o-n to show a lower *intensity* value than o-ħ context. Other results show context ʕ-o with a tendency to have higher *intensity* than contexts ħ-n, ʕ-n and ħ-o.

/a:/: A one-way ANOVA reveals a significant effect of individual contexts on *overall vowel intensity* values within vowel /a:/ with a moderate effect size (F (10, 593) = 9.803, p<0.001, η_p^2 = 0.144). Bonferroni post-hoc analysis reveals n-o context as having a significantly lower *intensity* value than each of ħ-o, ʕ-o, o-ħ, o-ʕ and o-o contexts; isolation context having a significantly lower value than each of ħ-o, ʕ-o, o-ħ, o-ʕ and o-o contexts; and o-n context having a significantly lower value than each of o-ħ and o-ʕ contexts. These results indicate a distinction between pharyngeal and oral contexts, on the one hand showing high *intensity* values, and nasal and isolation contexts, on the other showing low values. No significant differences are noted between the two contexts ħ-o and ʕ-o but they show a tendency for ħ-o to have a higher *intensity* value. Results are the opposite for contexts o-ħ and o-ʕ because it is context o-ʕ that has a tendency to have a higher *intensity* value than that of o-ħ. These two opposite results indicate that not only the type but also the position of the pharyngeal has an effect on the value of *vowel intensity*. An initial /ʕ/ and a final /ħ/ lower vowel intensity.

/ʌ/: A one-way ANOVA reveals a non-significant effect of individual contexts on *overall vowel intensity* values within vowel /ʌ/; but context ʕ-o shows a tendency to have less *intensity* than context ħ-o. This result coincides with previous results whereby an initial pharyngeal /ʕ/

leads to a lowering of intensity. Contexts o-ħ and o-ʕ show the opposite effect with context o-ħ having a lower *intensity*. This is another indication that a final pharyngeal /ħ/ has an effect of lowering *vowel intensity*.

/u:/: A one-way ANOVA reveals a significant effect of individual contexts on *overall vowel intensity* values within vowel /u:/ with a large effect size (F (9, 268) = 8.003, p<0.001, η_p^2 = 0.218). Bonferroni post-hoc analysis reveals ʕ-o context as having a significantly higher *intensity* value than each of n-n, n-o, o-n, n-ħ, o-ħ, o-o and isolation contexts; and o-o context as having a significantly higher *intensity* value than isolation context. These results partially show what has been noted in other vowels whereby isolation has the lowest overall *intensity* value and non-nasal pharyngeal contexts show the highest values. Context o-ʕ has no significant differences with o-ħ context but shows a tendency for o-ħ to have a lower *intensity* value. These results are similar to those in previous vowels whereby a final pharyngeal /ħ/ shows an effect of lowering *vowel intensity*.

/ʊ/: A one-way ANOVA reveals a significant effect of individual contexts on *overall vowel intensity* values within vowel /ʊ/ with a large effect size (F (3, 34) = 2.946, p<0.001, η_p^2 = 0.222). Bonferroni post-hoc analysis reveals n-o context as having a significantly lower *intensity* value than o-ħ context. There are also non-significant differences between n-o and each of ħ-o, ʕ-o and o-o contexts but denoting a tendency to show a distinction between nasal and oral contexts. Also context ʕ-o shows a tendency to have a lower *intensity* value than context ħ-o. This result coincides with above results whereby an initial pharyngeal /ʕ/ lowers *vowel intensity*.

/ɔ:/: A one-way ANOVA reveals a significant effect of individual contexts on *overall vowel intensity* values within vowel /ɔ:/ with a moderate effect size (F (10, 209) = 3.373, p<0.001, η_p^2 = 0.145). Bonferroni post-hoc analysis reveals n-ʕ context as having a significantly lower *intensity* value than each of o-n, ħ-n, ʕ-n, ħ-o and o-ħ contexts. There are also non-significant differences between n-ʕ and the remaining contexts but showing a tendency to have the lowest overall *intensity* value for this vowel. Results also show that non-nasal pharyngeal contexts have the highest *overall vowel intensity* values. Other results also show a tendency for context ʕ-n to have lower *intensity* value than context ħ-n. This result suggests an initial pharyngeal /ʕ/ has an effect of lowering *intensity* in neighbouring vowels.

9.6.2 Cross-dialectal differences in vowels

This section will tackle cross-dialectal differences (table 9.16, figure 9.16). Below are detailed results of each vowel.

Table 9.16: Cross-dialectal comparisons of *overall vowel intensity* within vowels.

Vowel	Dialect1	Dialect2	Cohen *d*	effect size	Sig.
/ɪ/	Basra	Baghdad	0.57	moderate	*p*<0.001
		Mosul	0.54	moderate	*p*<0.001
/ɛ/	Baghdad	Basra	0.87	large	*p*<0.001
		Mosul	0.43	moderate	*p*<0.001
/a:/	Basra	Baghdad	0.90	large	*p*<0.001
		Mosul	0.80	large	*p*<0.001
	Baghdad	Mosul	0.25	moderate	*p*<0.001
/ʌ/	Basra	Baghdad	0.95	large	*p*<0.001
		Mosul	0.98	large	*p*<0.001
/u:/	Basra	Mosul	0.41	moderate	*p*<0.001
/ʊ/	Baghdad	Basra	0.73	moderate to large	*p*<0.001
		Mosul	0.66	moderate to large	*p*<0.001
/ɔ:/	Basra	Baghdad	0.47	moderate	*p*<0.001
		Mosul	0.62	moderate to large	*p*<0.001

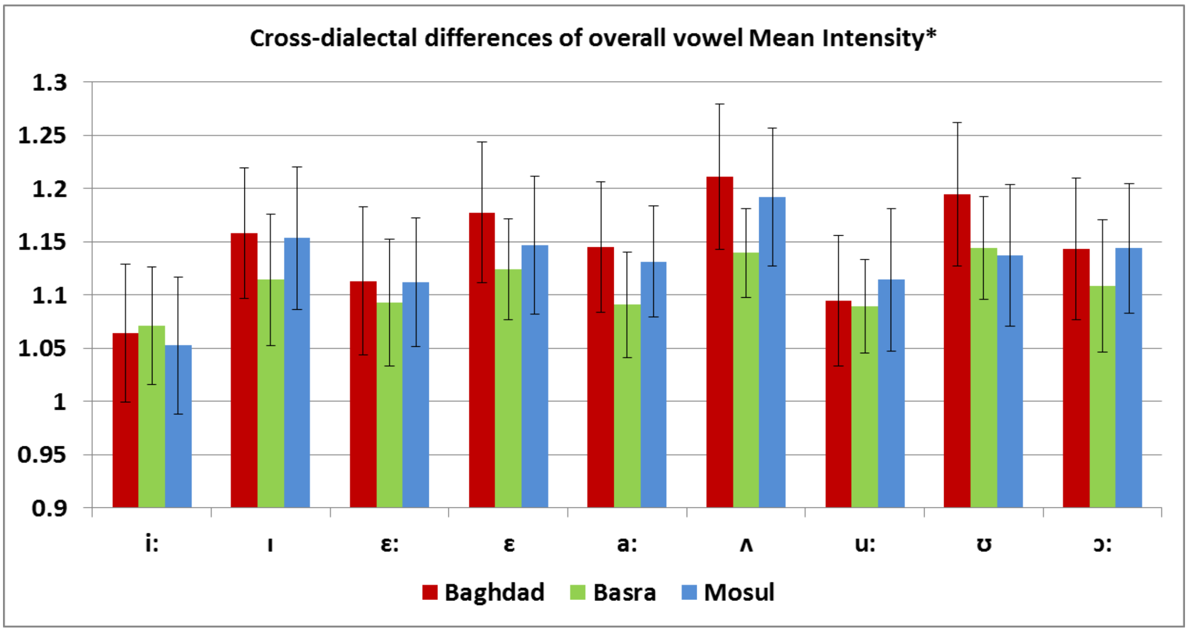


Figure 9.16: Cross-dialectal differences of *overall vowel intensity* within vowels.

/i:/: A one-way ANOVA reveals a non-significant effect of cross-dialectal differences on *overall vowel intensity* values within vowel /i:/, but show a tendency for mosul to show the lowest *intensity*.

/ɪ/: A one-way ANOVA reveals a non-significant effect of cross-dialectal differences on *overall vowel intensity* values within vowel /ɪ/, but Bonferroni post-hoc analysis reveals Basra as having a significantly lower *intensity* value than each of Baghdad and Mosul. But this result contradicts with all previous acoustic and auditory findings whereby Baghdad dialect had the most nasalisation. However, results of *A*1-**P*0 showed Baghdad dialect having the most pharyngealisation. With pharyngeal contexts showing high *intensity* for all vowels, and suggesting that pharyngealisation is accompanied by high *intensity*, explains why Baghdad is showing high *intensity* values.

/ɛ:/: A one-way ANOVA reveals a non-significant effect of cross-dialectal differences on *overall vowel intensity* values within vowel /ɛ:/, but showing a tendency for Basra to have the lowest *intensity*.

/ɛ/: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *overall vowel intensity* values within vowel /ɛ/ with a moderate effect size (F (2, 175) = 10.343, p<0.001, η_p^2 = 0.107). Bonferroni post-hoc analysis reveals Baghdad as having a significantly higher *intensity* value than each of Basra and Mosul, and Basra the lowest.

/a:/: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *overall vowel intensity* values within vowel /a:/ with a moderate effect size (F (2, 593) = 46.790, p<0.001, η_p^2 = 0.137). Bonferroni post-hoc analysis reveals significant differences between all dialects. The same result is replicated here with Basra showing the lowest *vowel intensity* value and Baghdad the highest as noted by the effect size differences.

/ʌ/: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *overall vowel intensity* values within vowel /ʌ/ with a moderate effect size (F (2, 80) = 6.198, p<0.001, η_p^2 = 0.137). Bonferroni post-hoc analysis reveals Basra as having a significantly lower *intensity* value than each of Baghdad and Mosul. This is another similar result with Basra showing the lowest *intensity* value and both Baghdad and Mosul the highest.

/u:/: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *overall vowel intensity* values within vowel /u:/ with a small effect size (F (2, 268) = 3.586, p<0.001, η_p^2 = 0.026). Bonferroni post-hoc analysis reveals Basra as having a significantly lower *intensity* value than Mosul. This result again shows Basra having the lowest *intensity* value.

/ʊ/: A one-way ANOVA reveals a non-significant effect of cross-dialectal differences on *overall vowel intensity* values within vowel /ʊ/, but Bonferroni post-hoc analysis reveals Baghdad as having a significantly higher *intensity* value than each of Basra and Mosul.

/ɔ:/: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *overall vowel intensity* values within vowel /ɔ:/ with a small effect size (F (2, 209) = 6.461, p<0.001, η_p^2 = 0.059). Bonferroni post-hoc analysis reveals Basra as having a significantly lower *intensity* value than each of Baghdad and Mosul.

9.6.3 Cross-dialectal differences in individual contexts

This section will tackle results of cross-dialectal comparisons of overall vowel intensity in individual contexts (table 9.17, figure 9.17). Contexts n-ħ, n-ʕ show no significant differences but tendencies between dialects indicating potential differences for Baghdad to have the highest intensity value and Basra the lowest; context o-ʕ also shows no significant differences between dialects but tendencies indicate potential differences between Baghdad and the other other two dialetcs. Below is a detailed discussion of all other contexts.

Table 9.17: Cross-dialectal comparisons of *overall vowel intensity* within individual contexts.

Context	Dialect1	Dialect2	Cohen *d*	effect size	Sig.
n-n	Baghdad	Basra	0.51	moderate	*p*<0.001
		Mosul	0.38	moderate	*p*<0.001
n-o	Baghdad	Basra	0.62	moderate to large	*p*<0.001
		Mosul	0.48	moderate	*p*<0.001
o-n	Basra	Baghdad	0.53	moderate	*p*<0.001
		Mosul	0.50	moderate	*p*<0.001
ħ-n	Baghdad	Basra	1.21	large	*p*<0.001
		Mosul	2.51	large	*p*<0.001
	Basra	Mosul	1.55	large	*p*<0.001
ʕ-n	Baghdad	Basra	0.60	moderate to large	*p*<0.001
ħ-o	Basra	Baghdad	0.65	moderate to large	*p*<0.001
		Mosul	0.84	large	*p*<0.001
ʕ-o	Basra	Baghdad	0.30	moderate	*p*<0.001
		Mosul	0.41	moderate	*p*<0.001
o-ħ	Baghdad	Basra	0.67	moderate to large	*p*<0.001
		Mosul	0.56	moderate	*p*<0.001
o-o	Basra	Baghdad	0.68	moderate to large	*p*<0.001
		Mosul	0.41	moderate	*p*<0.001
isolation	Basra	Baghdad	0.34	moderate	*p*<0.001
		Mosul	0.40	moderate	*p*<0.001

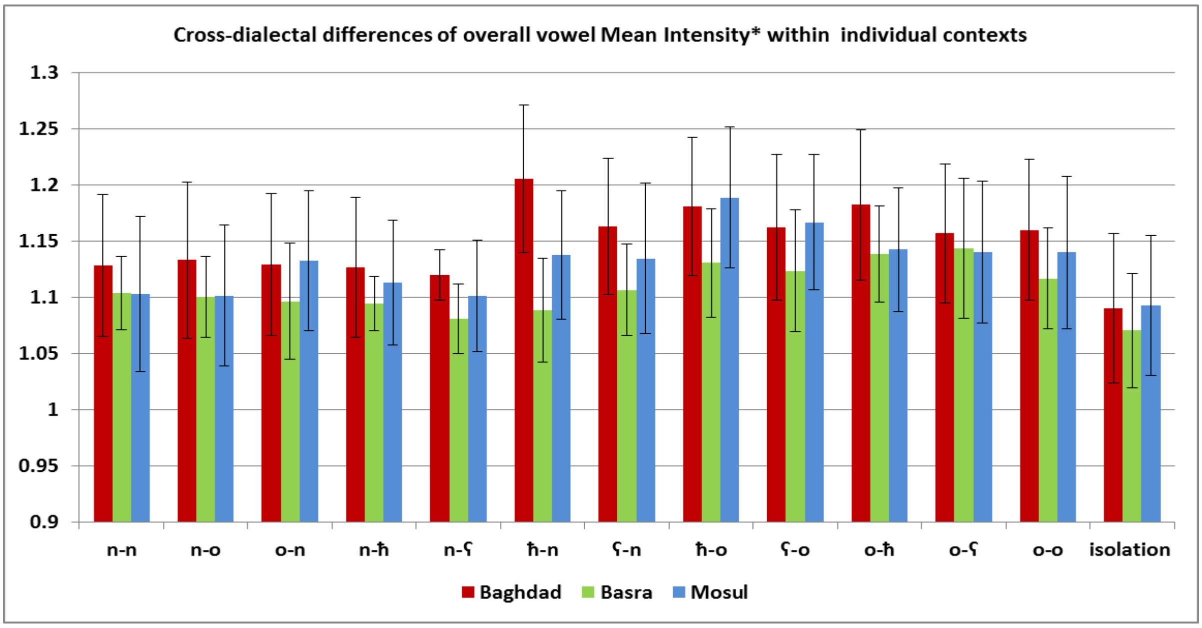


Figure 9.17: Cross-dialectal differences of *overall vowel intensity* within individual contexts.

n-n: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *overall vowel intensity* values within context n-n with a small effect size (F (2, 53) = 1.133, p<0.001, $\eta_p{}^2$ = 0.043). Bonferroni post-hoc analysis reveals Baghdad as having a significantly higher *intensity* value than each of Basra and Mosul.

n-o: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *overall vowel intensity* values within context n-o with a moderate effect size (F 2, 98) = 3.403,

$p<0.001$, $\eta_p^2 = 0.066$). Bonferroni post-hoc analysis reveals Baghdad as having a significantly higher *intensity* value than each of Basra and Mosul.

o-n: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *overall vowel intensity* values within context o-n with a small effect size (F (2, 170) = 4.150, $p<0.001$, $\eta_p^2 = 0.047$). Bonferroni post-hoc analysis reveals Basra as having a significantly lower *intensity* value than each of Baghdad and Mosul.

ħ-n: A general one-way ANOVA revealed a significant effect of cross-dialectal differences on *overall vowel intensity* values within context ħ-n with a moderate effect size (F 2, 26) = 1.522, $p<0.001$, $\eta_p^2 = 0.113$). Bonferroni post-hoc analysis reveals significant differences between all dialects, with Baghdad shoing the highest *intensity* value and Basra the lowest.

ʕ-n: A general one-way ANOVA revealed a significant effect of cross-dialectal differences on *overall vowel intensity* values within context ʕ-n with a moderate effect size (F 2, 44) = 3.616, $p<0.001$, $\eta_p^2 = 0.147$). Bonferroni post-hoc analysis reveals Baghdad as having a significantly higher *intensity* value than Basra.

ħ-o: A general one-way ANOVA revealed a significant effect of cross-dialectal differences on *overall vowel intensity* values within context ħ-o with a moderate effect size (F 2, 161) = 12.330, $p<0.001$, $\eta_p^2 = 0.134$). Bonferroni post-hoc analysis reveals Basra as having a significantly lower *intensity* value than each of Baghdad and Mosul.

ʕ-o: A general one-way ANOVA revealed a significant effect of cross-dialectal differences on *overall vowel intensity* values within context ʕ-o with a moderate effect size (F 2, 125) = 3.862, $p<0.001$, $\eta_p^2 = 0.059$). Bonferroni post-hoc analysis reveals Basra as having a significantly lower *intensity* value than each of Baghdad and Mosul.

o-ħ: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *overall vowel intensity* values within context o-ħ with a moderate effect size (F (2, 116) = 5.435, $p<0.001$, $\eta_p^2 = 0.087$). Bonferroni post-hoc analysis reveals Baghdad as having a significantly higher *intensity* value than each of Basra and Mosul.

o-o: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *overall vowel intensity* values within context o-o with a moderate effect size (F (2, 235) = 8.301, $p<0.001$, $\eta_p^2 = 0.067$). Bonferroni post-hoc analysis reveals Basra as having a significantly lower *intensity* value than each of Baghdad and Mosul. These results again show the same trend whereby Baghdad has the highest *vowel intensity* value and Basra the lowest.

Isolation: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *overall vowel intensity* values within context isolation with a small effect size (F (2,772) =

10.791, p<0.001, η_p^2 = 0.027). Bonferroni post-hoc analysis reveals Basra as having a significantly lower *intensity* value than each of Baghdad and Mosul.

9.6.4 Discussion of the overall vowel intensity measure results

Overall results have shown that nasal contexts exhibit low *overall vowel intensity* values; contexts containing pharyngeal consonants have high *intensity* values; non-nasal pharyngeal contexts show high *intensity* values while nasal pharyngeal ones show low values similar to other nasal contexts. A general view of results of individual contexts shows that type and position of pharyngeal consonants have an effect of lowering *overall vowel intensity*, with initial /ʕ/ and final /ħ/ having an effect of lowering that value. However, isolation contexts show the lowest overall *intensity* values. These low values in isolation context could be due to the effect of laryngealisation (as will be noted in Chapter 10), which lowers intensity in these vowels. There is no consonantal influence present in these isolated vowels where uninterrupted voicing happens. Cross-dialectal comparisons show Baghdad having the highest *intensity* values indicating pharyngealisation and Basra in many instances shows the lowest. However, these results do not coincide with the auditory impression of nasalisation and *A*1-**P*1 measures for which Baghdad was noted as having the most nasalisation. Rather, they coincide with *A*1-**P*0 results which show Baghdad having the highest pharyngealisation values among the three. This could be explained by drawing a connection between pharyngeal contexts and high *intensity* whereby all non-nasal and some nasal pharyngeal contexts showed high *intensity* values. Therefore, high *intensity* is showing to be a feature of pharyngealisation.

9.7 Summary of Chapter 9

Overall investigations of acoustic measures of nasalisation in IA have shown a number of results. The first measure of nasalisation *A*1-**P*1 has distinguished between nasal and non-nasal contexts and shown that: nasal contexts containing pharyngeal consonants have the most nasalisation; in non-nasal contexts, pharyngeal consonants showed nasalisation that is mostly similar to nasal contexts; both nasal and pharyngeal consonants have a progressive effect on nasalisation; pharyngeal /ħ/ has more impact on increasing nasalisation than /ʕ/; and cross-dialectally, Baghdad speakers showed the most nasalisation and Basra speakers the least.

The second measure of nasalisation *A*1-**P*0 has proved to be very sensitive to the position of *F*1 and should be used with caution as a nasalisation measure especially for contexts containing pharyngeal consonants. It distinguishes between nasal and non-nasal contexts providing they do not contain pharyngeal consonants. When a pharyngeal is present, the measure instead distinguished between pharyngealised and non-pharyngealised contexts; in nasal pharyngeal contexts containing initial nasals values tend to decrease as a result of nasalisation whereas in contexts containing initial pharyngeals values tend to increase as the result of pharyngealisation; contexts containing pharyngeal /ʕ/ show higher $A1$-*$P0$ values indicating more pharyngealisation than those containing pharyngeal /ħ/; and cross-dialectally, Baghdad has shown to be the most pharyngealised and Basra the least.

The third measure of nasalisation $B1$ showed tendencies of distinguishing between nasalised and non-nasalised contexts; nasal and pharyngeal consonants showed a progressive effect of nasalisation; no difference of effect was noted between the two pharyngeal consonants; cross-dialectal comparisons show the same consistency as was noted in the $A1$-*$P1$ measure whereby Baghdad shows the most nasalisation and Mosul the least.

The fourth nasalisation measure frequency changes of $F1$/$F2$ depended on type of vowel; most studies preferred to using changes in $F1$ as the main cue and with a lesser extent those in $F2$. Results showed a distinction between nasal and pharyngeal contexts. Nasal contexts showed a drop in $F1$ in low vowels and a rise in high vowels; while $F2$ had a rise in low vowels and drop in high ones. Pharyngeal contexts showed a rise in $F1$ in all vowels indicating a more open quality; a drop in $F2$ in front vowels indicating a more back quality; a rise in $F2$ in back vowels indicating a more front quality; and a rise in $F1$ in central vowels suggesting a more open quality but $F2$ remained constant. These results indicated the presence of pharyngealisation. Nasal-pharyngeal contexts showed the most nasalisation exhibited by the most close and most front articulation. In some vowels, contexts containing pharyngeal /ʕ/ showed more rise in $F2$ than those containing /ħ/ indicating more pharyngealisation.

Finally, the fifth nasalisation measure *overall vowel intensity* distinguished between nasal and non-nasal contexts. However, all pharyngeal contexts showed high values of *intensity* due to pharyngealisation. Overall vowel *intensity* is affected by type and position of neighbouring pharyngeal consonants with initial pharyngeal /ʕ/ having a progressive lowering effect and /ħ/ a regressive one. Cross-dialectal results showed Baghdad having the highest *intensity* values and Basra the lowest indicating Baghdad the most pharyngealised and Basra the least.

Chapter 10 : Acoustic Measurements of Phonation Types in the Speech of Iraqi Arabic Speakers

10.1 Introduction

This study aims at investigating phonation types associated with the production of IA speakers, especially those found to have accompanying nasalisation. There are two reasons for this: 1- to investigate creak or creaky voice accompanying the production of pharyngeal consonants as is reported in the literature, 2- to rule out any masking of breathy phonation as nasalisation. The latter aim emerged from recommendations by Chen (2007) who found extreme differences in values resulting from some of the acoustic measures whom she thought might be due to the effect of breathy phonation.

The present chapter will deal with the acoustic patterns of phonation types in IA. These acoustic measurements will be investigated in various nasal, pharyngeal and oral contexts similar to the auditory impression of phonation types in Chapter 8. This chapter will present and explore whether the results of the acoustic measures of phonation types support the auditory analyses.

The chapter will present results from the following acoustic normalised measurements: *H1-*H2 _difference between amplitudes of the first and second harmonics_ and *H1-A1 _difference between amplitude of the first harmonic and amplitude of the first formant F1_ (for more details see Chapters 3 and 6). These measurements are taken in each of the environments and vowel portions detailed in section 8.2. For statistical comparisons, a one-way ANOVA will be applied for contexts containing each vowel and each context for cross-dialectal comparisons. This is followed by a Bonferroni post-hoc analysis to investigate potential differences between the low level contexts.

10.2 *H1-*H2

In this section, results of measuring *H1-*H2 will be tackled within individual contexts containing each individual vowel as well as cross-dialectally. Following the literature, this measure is able to distinguish between phonation types. The threshold for this measure, following Klatt and Klatt (1990), is an average of -4dB for male speakers whereby *H1-*H2 values lower than that suggest a creaky phonation, i.e. laryngealisation, and values above -4dB a breathy phonation. Results from this study are evaluated with this figure into consideration while being mindful of the different vowel contexts looked at. The following sections will present results at onset and offset portions due to the fact that results at midpoint were similar (Appendixes L and M).

10.2.1 Onset

A general view of results obtained at vowel portions for individual contexts as well as cross-dialectal ones show a distinction between pharyngeal and non-pharyngeal contexts, with isolation contexts being grouped with pharyngeal ones in many instances.

10.2.1.1 *Contexts*

Results will be presented following the way they are presented in table 10.1 and figure 10.1 with contexts being compared for each individual vowel.

Table 10.1: Effect size differences and Cohen *d* values for *$H1$-*$H2$ values within individual contexts at onset.

Vowel	Context1	Context2	Cohen *d*	effect size	Sig.
/iː/	ʕ-o	n-n	1.45	large	p<0.001
		n-o	1.04	large	p<0.001
		o-o	1.16	large	p<0.001
		isolation	0.86	large	p<0.001
/ɪ/	ʕ-o	n-n	1.36	large	p<0.001
/ɛː/	n-o	ʕ-n	1.19	large	p<0.001
		ħ-o	1.32	large	p<0.001
		ʕ-o	1.64	large	p<0.001
		isolation	1.37	large	p<0.001
	ʕ-o	o-o	0.76	moderate to large	p<0.001
/ɛ/	o-o	ʕ-n	1.08	large	p<0.001
		ħ-o	0.62	large	p<0.001
		ʕ-o	1.07	moderate to large	p<0.001
/aː/	n-n	ʕ-n	1.69	large	p<0.001
		ħ-o	1.32	large	p<0.001
		ʕ-o	1.59	large	p<0.001
		isolation	1.09	large	p<0.001
	n-o	ħ-o	0.96	large	p<0.001
		ʕ-o	1.30	large	p<0.001
		isolation	0.83	large	p<0.001
	ʕ-o	n-ħ	1.26	large	p<0.001
		o-o	1.23	large	p<0.001
	o-o	ʕ-n	1.21	large	p<0.001
		ħ-o	0.89	large	p<0.001
		isolation	0.81	large	p<0.001
/uː/	n-n	ʕ-o	1.19	large	p<0.001
		isolation	0.80	large	p<0.001
	n-o	ʕ-o	1.68	large	p<0.001
		isolation	1.10	large	p<0.001
/ʊ/	ħ-o	o-o	1.62	large	p<0.001
/ɔː/	isolation	n-n	1.08	large	p<0.001
		n-o	1.02	large	p<0.001

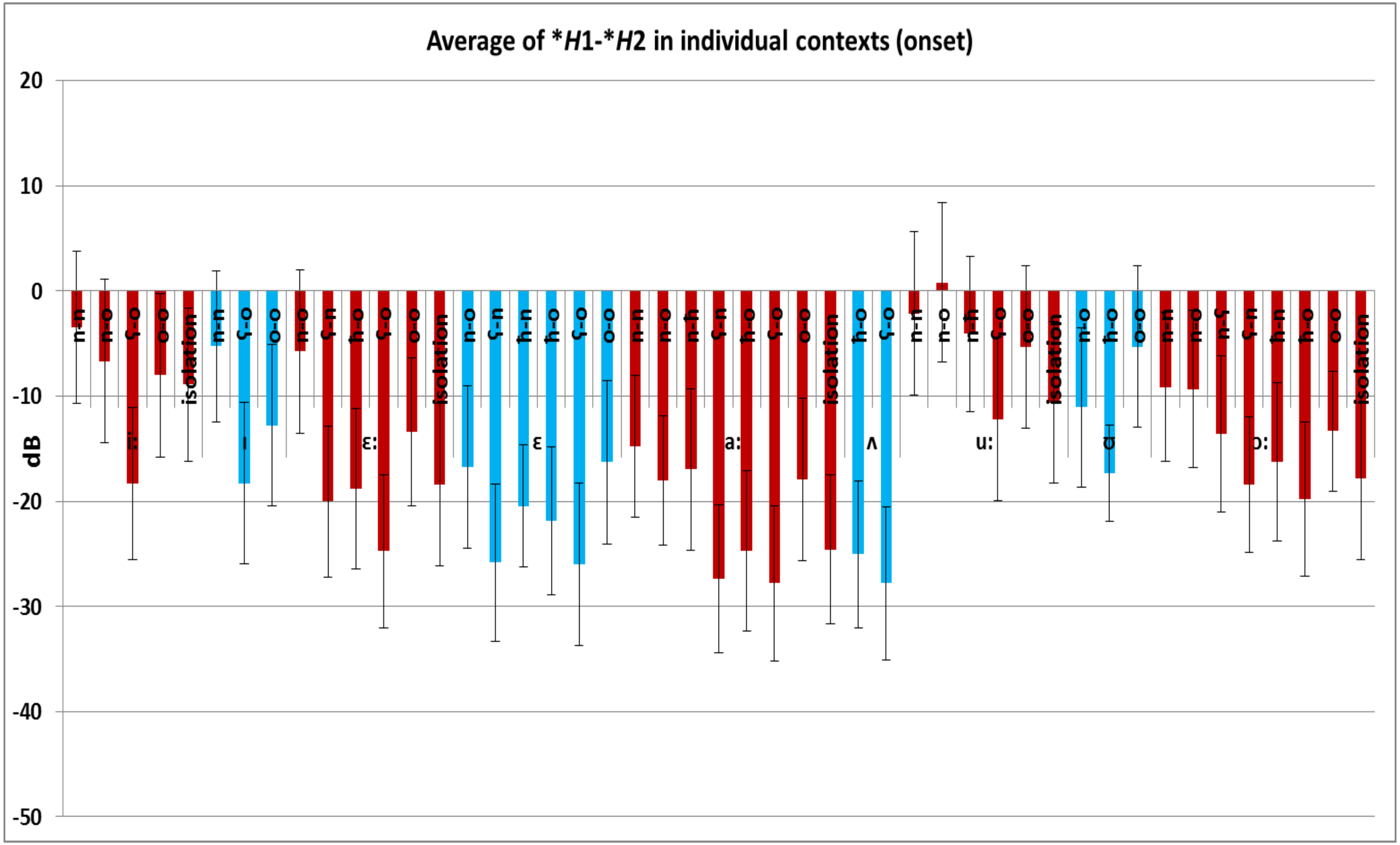


Figure 10.1: *H1-*H2 values within individual contexts at onset.

/iː/: A one-way ANOVA reveals a significant effect of individual contexts on **H*1-**H*2 values containing vowel /iː/ at onset with a moderate effect size (F (4, 207) = 4.943, p<0.001, η_p^2 = 0.089). Bonferroni post-hoc analysis reveals ʕ-o context as having a significantly lower **H*1-**H*2 value than each of n-n, n-o, o-o and isolation contexts.

/ɪ/: A one-way ANOVA reveals a significant effect of individual contexts on **H*1-**H*2 values containing vowel /ɪ/ at onset with a large effect size (F (2, 35) = 5.912, p<0.001, η_p^2 = 0.264). Bonferroni post-hoc analysis reveals ʕ-o context as having a significantly lower **H*1-**H*2 value than n-n context.

/ɛː/: A one-way ANOVA reveals a significant effect of individual contexts on **H*1-**H*2 values containing vowel /ɛː/ at onset with a moderate effect size (F (5, 169) = 5.050, p<0.001, η_p^2 = 0.133). Bonferroni post-hoc analysis reveals ʕ-o context as having a significantly lower **H*1-**H*2 value than each of n-o and o-o contexts; ħ-o context having a significantly lower value than n-o context; and n-o context as having a significantly higher **H*1-**H*2 value than each of ʕ-n and isolation contexts. There is no significant difference between ħ-o and ʕ-o contexts but they show a tendency for ʕ-o to have a lower **H*1-**H*2 value than ħ-o.

/ɛ/: A one-way ANOVA reveals a significant effect of individual contexts on **H*1-**H*2 values containing vowel /ɛ/ at onset with a large effect size (F (5, 161) = 5.910, p<0.001, η_p^2 = 0.159). Bonferroni post-hoc analysis reveals o-o context as having a significantly higher **H*1-**H*2 value than each of ʕ-n, ħ-o and ʕ-o contexts. There is no significant difference between ħ-o and ʕ-o contexts but they show a tendency for ʕ-o to have a lower **H*1-**H*2 value.

/aː/: A one-way ANOVA reveals a significant effect of individual contexts on **H*1-**H*2 values containing vowel /aː/ at onset with a moderate effect size (F (7, 486) = 9.792, p<0.001, η_p^2 = 0.125). Bonferroni post-hoc analysis reveals ʕ-o context as having a significantly lower **H*1-**H*2 value than each of n-n, n-o, n-ħ and o-o contexts; ħ-o context as having a significantly lower value than each of n-n, n-o and o-o contexts; n-n context as having a significantly higher **H*1-**H*2 value than each of ʕ-n and isolation contexts; n-o context as having a significantly higher value than isolation context; and o-o context having a significantly higher value than each of ʕ-n and isolation contexts. There is no significant difference between ħ-o and ʕ-o contexts but they show a tendency for ʕ-o to have a lower **H*1-**H*2 value.

/ʌ/: An independent-samples *t*-test was applied and reveals non-significant differences between ħ-o and ʕ-o on **H*1-**H*2 values for vowel /ʌ/ at onset but showing a tendency for ʕ-o context to have a lower value.

/uː/: A one-way ANOVA reveals a significant effect of individual contexts on **H*1-**H*2 values containing vowel /uː/ at onset with a moderate effect size (F (5, 223) = 7.301, p<0.001, η_p^2

= 0.143). Bonferroni post-hoc analysis reveals n-n and n-o contexts as having significantly higher *H1-*H2 values than each of ʕ-o and isolation contexts.

/ʊ/: A one-way ANOVA reveals a significant effect of individual contexts on *H1-*H2 values containing vowel /ʊ/ at onset with a large effect size (F (2, 25) = 5.039, p<0.001, η_p^2 = 0.305). Bonferroni post-hoc analysis reveals ħ-o context as having a significantly lower *H1-*H2 value than o-o context.

/ɔ:/: A one-way ANOVA reveals a significant effect of individual contexts on *H1-*H2 values containing vowel /ɔ:/ at onset with a moderate effect size (F (8, 181) = 2.959, p<0.001, η_p^2 = 0.120). Bonferroni post-hoc analysis reveals isolation context as having a significantly lower *H1-*H2 value than each of n-n and n-o contexts. No significant differences are noted between ħ-n/ʕ-n and any other contexts or themselves, but there is a tendency for context ʕ-n to have a lower *H1-*H2 value than context ħ-n.

10.2.1.2 *Cross-dialectal differences in vowels*

Results of cross-dialectal differences within vowels are presented below (table 10.2, figure 10.2).

Table 10.2: Effect size differences and Cohen *d* values for Cross-dialectal comparisons of **H*1-H*2values at onset.**

Vowel	Dialect1	Dialect2	Cohen *d*	effect size	Sig.
/i:/	Baghdad	Basra	1.39	large	p<0.001
		Mosul	0.93	large	p<0.001
	Basra	Mosul	0.73	moderate to large	p<0.001
/ɪ/	Baghdad	Basra	1.58	large	p<0.001
		Mosul	1.04	large	p<0.001
/ɛ:/	Baghdad	Basra	1.15	large	p<0.001
		Mosul	0.70	moderate to large	p<0.001
	Basra	Mosul	0.61	moderate to large	p<0.001
/ɛ/	Baghdad	Basra	2.13	large	p<0.001
		Mosul	1.60	large	p<0.001
	Basra	Mosul	0.83	large	p<0.001
/a:/	Baghdad	Basra	1.80	large	p<0.001
		Mosul	1.34	large	p<0.001
	Basra	Mosul	0.49	moderate	p<0.001
/ʌ/	Baghdad	Basra	1.61	large	p<0.001
		Mosul	1.45	large	p<0.001
	Basra	Mosul	0.54	moderate	none
/u:/	Baghdad	Basra	1.28	large	p<0.001
		Mosul	1.18	large	p<0.001
	Basra	Mosul	0.35	moderate	p<0.001
/ʊ/	Baghdad	Basra	2.18	large	p<0.001
		Mosul	1.86	large	p<0.001
/ɔ:/	Baghdad	Basra	1.38	large	p<0.001
		Mosul	1.03	large	p<0.001
	Basra	Mosul	0.68	moderate to large	p<0.001

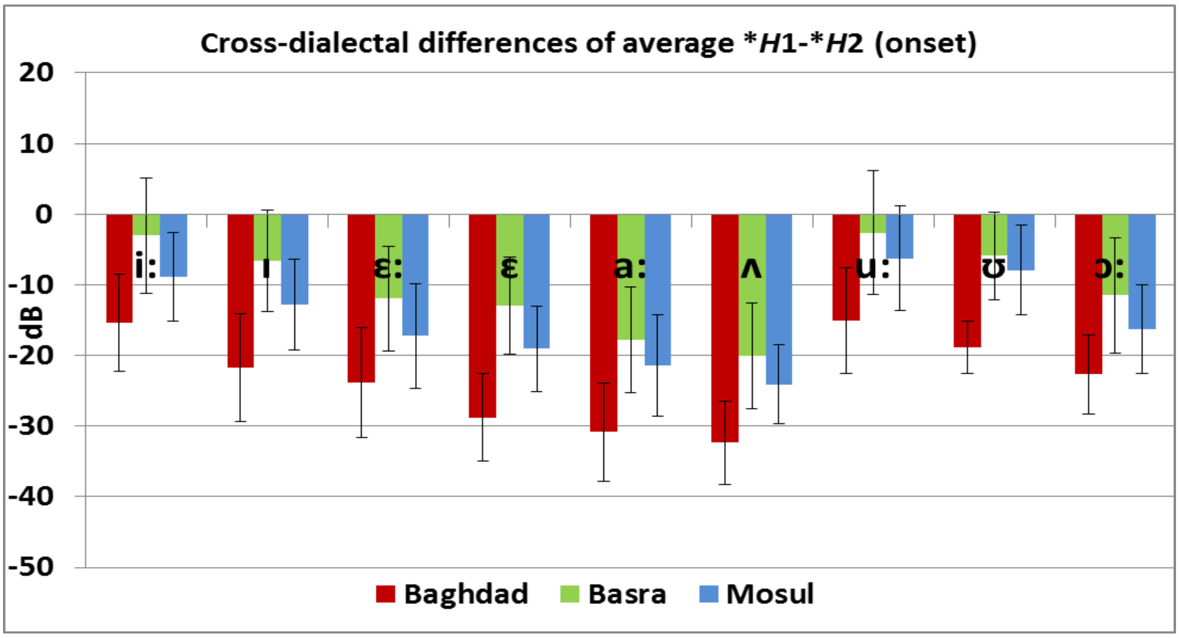


Figure 10.2: Cross-dialectal differences of *H1-*H2 values for vowels at onset.

/i:/: A one-way ANOVA reveals a significant effect of cross-dialectal differences on **H*1-**H*2 values within vowel /i:/ at onset with a large effect size (F (2, 207) = 41.407, p<0.001, η_p^2 = 0.288). Bonferroni post-hoc analysis reveals significant differences between all dialects. These results indicate Baghdad as having the lowest **H*1-**H*2 value and Basra the highest.

/ɪ/: A one-way ANOVA reveals a significant effect of cross-dialectal differences on **H*1-**H*2 values within vowel /ɪ/ at onset with a large effect size (F (2, 35) = 9.309, p<0.001, η_p^2 = 0.361). Bonferroni post-hoc analysis reveals Baghdad as having a significantly lower **H*1-**H*2 value than each of Basra and Mosul. Despite the non-significant differences between Basra and Mosul they show a tendency for Basra to have a higher value.

/ɛ:/: A one-way ANOVA reveals a significant effect of cross-dialectal differences on **H*1-**H*2 values within vowel /ɛ:/ at onset with a large effect size (F (2, 169) = 21.435, p<0.001, η_p^2 = 0.204). Bonferroni post-hoc analysis reveals significant differences between all dialects. These results indicate Baghdad as having the lowest **H*1-**H*2 value and Basra the highest.

/ɛ/: A one-way ANOVA reveals a significant effect of cross-dialectal differences on **H*1-**H*2 values within vowel /ɛ/ at onset with a large effect size (F (2, 161) = 68.814, p<0.001, η_p^2 = 0.464). Bonferroni post-hoc analysis reveals significant differences between all dialects. These results indicate Baghdad as having the lowest **H*1-**H*2 value and Basra the highest.

/a:/: A one-way ANOVA reveals a significant effect of cross-dialectal differences on **H*1-**H*2 values within vowel /a:/ at onset with a large effect size (F (2, 486) = 142.133, p<0.001, η_p^2 = 0.370). Bonferroni post-hoc analysis reveals significant differences between all dialects. These results indicate Baghdad as having the lowest **H*1-**H*2 value and Basra the highest.

/ʌ/: A one-way ANOVA reveals a significant effect of cross-dialectal differences on **H*1-**H*2 values within vowel /ʌ/ at onset with a large effect size (F (2, 53) = 13.715, p<0.001, η_p^2 = 0.350). Bonferroni post-hoc analysis reveals Baghdad as having a significantly lower **H*1-**H*2 value than each of Basra and Mosul. Despite the non-significant differences between Basra and Mosul they show a tendency for Basra to have a higher value.

/u:/: A one-way ANOVA reveals a significant effect of cross-dialectal differences on **H*1-**H*2 values within vowel /u:/ at onset with a large effect size (F (2, 223) = 36.337, p<0.001, η_p^2 = 0.247). Bonferroni post-hoc analysis reveals significant differences between all dialects. These results indicate Baghdad as having the lowest **H*1-**H*2 value and Basra the highest.

/ʊ/: A one-way ANOVA reveals a significant effect of cross-dialectal differences on **H*1-**H*2 values within vowel /ʊ/ at onset with a large effect size (F (2, 25) = 8.750, p<0.001, η_p^2 = 0.432). Bonferroni post-hoc analysis reveals Baghdad as having a significantly lower **H*1-**H*2 value than each of Basra and Mosul. Despite the non-significant differences between Basra and Mosul they show a tendency for Basra to have a higher value.

/ɔ:/: A one-way ANOVA reveals a significant effect of cross-dialectal differences on **H*1-**H*2 values within vowel /ɔ:/ at onset with a large effect size (F (2, 181) = 32.606, p<0.001, η_p^2 = 0.267). Bonferroni post-hoc analysis reveals significant differences between all dialects. These results indicate Baghdad as having the lowest **H*1-**H*2 value and Basra the highest.

10.2.1.3 *Cross-dialectal differences in individual contexts*

Results of cross-dialectal differences within individual contexts are presented below (table 10.3, figure 10.3).

Table 10.3: : Effect size differences and Cohen *d* values for Cross-dialectal comparisons of **H1-*H2* values within individual contexts at onset.

Context	Dialect1	Dialect2	Cohen *d*	effect size	Sig.
n-n	Baghdad	Basra	1.68	large	p<0.001
		Mosul	0.93	large	p<0.001
	Basra	Mosul	0.80	large	p<0.001
n-o	Baghdad	Basra	1.63	large	p<0.001
		Mosul	0.85	large	p<0.001
	Basra	Mosul	0.81	large	p<0.001
n-ħ	Basra	Baghdad	1.76	large	p<0.001
		Mosul	1.51	large	p<0.001
n-ʕ	Basra	Baghdad	1.71	large	p<0.001
		Mosul	2.10	large	p<0.001
ħ-n	Baghdad	Basra	1.99	large	p<0.001
ʕ-n	Baghdad	Basra	1.75	large	p<0.001
		Mosul	2.07	large	p<0.001
ħ-o	Baghdad	Basra	1.62	large	p<0.001
		Mosul	0.93	large	p<0.001

	Basra	Mosul	1.06	moderate	*p*<0.001
ʕ-o	Baghdad	Basra	1.38	large	*p*<0.001
		Mosul	1.54	large	*p*<0.001
o-o	Baghdad	Basra	1.59	large	*p*<0.001
		Mosul	0.99	large	*p*<0.001
	Basra	Mosul	0.61	moderate to large	*p*<0.001
isolation	Baghdad	Basra	1.16	large	*p*<0.001
		Mosul	0.90	large	*p*<0.001
	Basra	Mosul	0.38	moderate to large	*p*<0.001

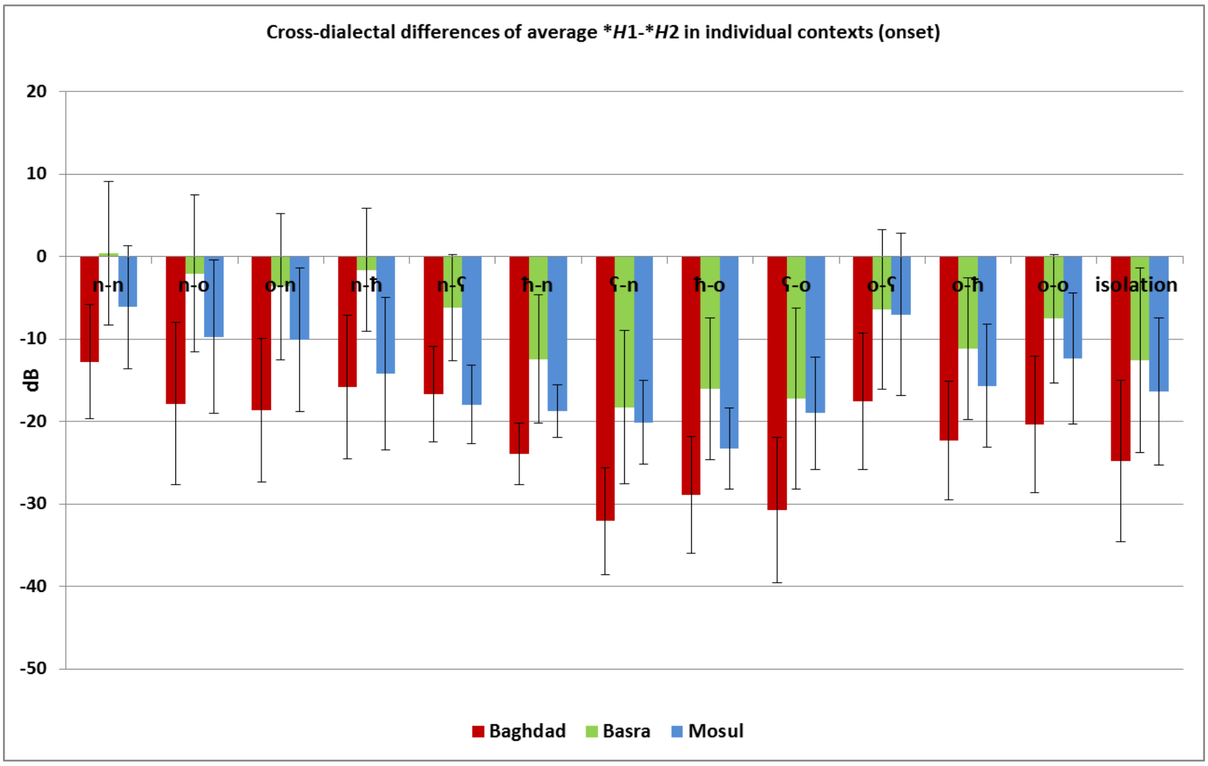


Figure 10.3: Cross-dialectal differences of *$H1$-*$H2$ values for individual contexts at onset.

n-n: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *H1-*H2 values within context n-n at onset with a large effect size (F (2, 53) = 12.970, p<0.001, η_p^2 = 0.337). Bonferroni post-hoc analysis reveals significant differences between all dialects. These results indicate Baghdad as having the lowest *H1-*H2 value and Basra the highest.

n-o: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *H1-*H2 values within context n-o at onset with a large effect size (F (2, 98) = 22.520, p<0.001, η_p^2 = 0.319). Bonferroni post-hoc analysis reveals significant differences between all dialects. These results indicate Baghdad as having the lowest *H1-*H2 value and Basra the highest.

n-ħ: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *H1-*H2 values within context n-ħ at onset with a large effect size (F (2, 17) = 5.009, p<0.001, η_p^2 = 0.400). Bonferroni post-hoc analysis reveals Basra as having a significantly higher *H1-*H2 value than each of Baghdad and Mosul. Despite the non-significant difference between Baghdad and Mosul they show a tendency for Baghdad to have the most laryngealisation.

n-ʕ: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *$H1$-*$H2$ values within context n-ʕ at onset with a large effect size (F (2, 8) = 3.841, p<0.001, η_p^2 = 0.561). Bonferroni post-hoc analysis reveals Basra as having a significantly higher *$H1$-*$H2$ value than each of Baghdad and Mosul. Despite the non-significant difference between Baghdad and Mosul they show a tendency for Baghdad to have the most laryngealisation.

ħ-n: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *$H1$-*$H2$ values within context ħ-n at onset with a large effect size (F (2, 17) = 6.986, p<0.001, η_p^2 = 0.482). Bonferroni post-hoc analysis reveals Baghdad having a significantly lower *$H1$-*$H2$ value than Basra.

ʕ-n: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *$H1$-*$H2$ values within context ʕ-n at onset with a large effect size (F (2, 44) = 16.417, p<0.001, η_p^2 = 0.439). Bonferroni post-hoc analysis reveals Baghdad having a significantly lower *$H1$-*$H2$ value than each of Basra and Mosul. Despite the non-significant difference between Basra and Mosul they show a tendency for Basra to have the least laryngealisation.

ħ-o: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *$H1$-*$H2$ values within context ħ-o at onset with a large effect size (F (2, 160) = 44.267, p<0.001, η_p^2 = 0.359). Bonferroni post-hoc analysis reveals significant differences between all dialects. These results show significant differences denoting Baghdad the most laryngealised and Basra the least.

ʕ-o: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *$H1$-*$H2$ values within context ʕ-o at onset with a large effect size (F (2, 125) = 28.781, p<0.001, η_p^2 = 0.319). Bonferroni post-hoc analysis reveals Baghdad having a significantly lower *$H1$-*$H2$ value than each of Basra and Mosul. Despite the non-significant difference between Basra and Mosul they show a tendency for Basra to have the least laryngealisation.

o-o: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *$H1$-*$H2$ values within context o-o at onset with a large effect size (F (2, 235) = 52.078, p<0.001, η_p^2 = 0.309). Bonferroni post-hoc analysis reveals significant differences between all dialects. These results indicate Baghdad as having the lowest *$H1$-*$H2$ value and Basra the highest.

Isolation: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *$H1$-*$H2$ values within context isolation at onset with a large effect size (F (2, 775) = 100.221, p<0.001, η_p^2 = 0.206). Bonferroni post-hoc analysis reveals significant differences between all dialects. These results indicate Baghdad as having the lowest *$H1$-*$H2$ value and Basra the highest.

10.2.1.4 *Discussion of the *H1-*H2 measure results at onset*

Results of the **H*1-**H*2 measure show all nasal and non-nasal pharyngeal contexts have low **H*1-**H*2 values when measures are taken near the pharyngeal at onset and offset positions of the vowel. At onset all **H*1-**H*2 values are lower than -10dB and some even lower than -20dB, showing high values of laryngealisation. The same is said for context isolation in vowels /ɛː, aː, uː, ɔː/. These results coincide with findings in Chapter 7 whereby realisations of pharyngeal consonants contained glottal reinforcements; with results in Chapter 8 whereby pharyngeal contexts showed high levels of auditory impression of laryngealisation. These results therefore show that pharyngealisation is accompanied by laryngealisation. It should also be noted that contexts containing vowel /uː/ showed the overall highest **H*1-**H*2 values indicating the least laryngealisation. This result coincides with results of the auditory impression of laryngealisation whereby contexts of the same vowel showed the lowest overall levels. It can also be noted for cross-dialectal comparisons.

As for results of the isolation contexts **H*1-**H*2 values are noted to be low showing the lowest values in vowels /ɛː, aː, uː, ɔː/ and patterning with pharyngeal contexts. Isolation contexts represent the production of sounds with no consonant effect and therefore the normal state of the larynx of speakers, which in our study show them having a laryngeal (creaky) phonation. This phonation would be masked by the presence of consonants when vowels are embedded in words unless there are consonants like pharyngeal consonants which enhance their laryngealisation. These results coincide with those in Chapter 8 whereby isolation contexts were perceived as having high levels of auditory impression of laryngealisation. Other findings in Chapter 9 showed that these same isolation contexts had the lowest *overall intensity* values amongst all contexts and for all vowels which agree with results of having high levels of laryngealisation.

Other results show some contexts, mainly non-pharyngeal nasal and two oral (in /uː, ʊ/) contexts, are the least accompanied by laryngealisation as noted by their high SD values. Oral contexts generally show less laryngealisation than pharyngeal and isolation contexts, similar to nasal ones for most vowels. The type of pharyngeal has an effect on increasing or decreasing laryngealisation although both are showing high levels of laryngealisation (table 10.2, figure 10.2). Contexts containing pharyngeal /ʕ/ show lower **H*1-**H*2 values than those containing pharyngeal /ħ/ whether the context is nasal or not, indicating more laryngealisation in /ʕ/. It is also noted that meassures taken near a nasal in contexts n-ħ and n-ʕ showed high **H*1-**H*2 values similar to other nasal contexts whereas meassures taken near a pharyngeal in contexts ħ-n and ʕ-n showed low values similar to other pharyngeal contexts. These results indicate that when nasalisation is present, laryngealisation decreases.

Cross-dialectally, whether the difference was significant or a tendency, for all vowels and individual contexts Baghdad shows the lowest *H1-*H2 values indicating the highest degree of laryngealisation (tables 10.3, 10.4, 10.5; figures 10.3, 10.4, 10.5). This coincides with previous results by Baghdad speakers showing high levels of pharyngealisation and *intensity*. Basra speakers on the other hand are showing the lowest values of *H1-*H2, of *intensity* and in many contexts of A1-*P0 measures, indicating the lowest degree of laryngealisation and pharyngealisation. In fact, Basra is showing SD values above 0 dB which lie in the positive values, but this is only found in contexts nasal-nasal, nasal-oral and nasal-pharyngeal. Mosul mostly shows inconsistent results except in the case of B1 values. Cross-dialectal comparisons within individual contexts showed pharyngeal-nasal and oral-pharyngeal contexts exhibit the lowest overall values. When comparing nasal-pharyngeal and pharyngeal-nasal contexts the effect of the nasal and pharyngeal is very apparent whereby nasalisation decreases laryngealisation but pharyngealisation increases it.

10.2.2 Offset

10.2.2.1 *Contexts*

For individual contexts, there is a distinction between pharyngeal and non-pharyngeal contexts (table 10.4, figure 10.4). In all contexts containing vowels /i:, u:/ except pharyngeal ones, there are high *H1-*H2 values reaching above 0 dB as is noted by the SD values. Also, the same significant differences and tendencies noted for onset are also noted at offset whereby pharyngeal /ʕ/ has a more pronounced laryngealisation effect than /ħ/ (table 10.7, figure 10.7).

/i:/: A one-way ANOVA reveals a significant effect of individual contexts on *H1-*H2 values containing vowel /i:/ at offset with a moderate effect size (F (5, 225) = 6.204, p<0.001, η_p^2 = 0.124). Bonferroni post-hoc analysis reveals o-ʕ context as having a significantly lower *H1-*H2 value than each of n-n, o-n, o-o and isolation contexts; and context o-ħ having a significantly lower value than o-n context. There are no significant differences between o-ħ and o-ʕ contexts but a moderate effect size indicating a tendency for more laryngealisation in o-ʕ.

/ɪ/: A one-way ANOVA reveals a non-significant effect of individual contexts on *H1-*H2 values containing vowel /ɪ/ at offset, but Bonferroni post-hoc analysis reveals o-n context having a significantly higher *H1-*H2 value than and n-n and o-o contexts.

/ɛː/: A one-way ANOVA reveals a non-significant effect of individual contexts on **H*1-**H*2 values containing vowel /ɛː/ at offset; but context o-o shows a tendency to have more larygealisation than nasal and isolation contexts.

/ɛ/: A one-way ANOVA reveals a non-significant effect of individual contexts on **H*1-**H*2 values containing vowel /ɛ/ at offset, but showing a tendency for contexts ħ-n, ʕ-n and o-ħ to have the most laryngealisation than each of o-n and o-o. Despite non-significant differences between ħ-n and ʕ-n contexts, they show a tendency for more laryngealisation in ʕ-n.

/aː/: A one-way ANOVA reveals a significant effect of individual contexts on **H*1-**H*2 values containing vowel /aː/ at offset with a small effect size (F (7, 495) = 3.095, p<0.001, η_p^2 = 0.043). Bonferroni post-hoc analysis reveals significant differences between isolation context and each of o-ħ and o-ʕ contexts. Despite non-significant differences between o-ħ and o-ʕ contexts, they show a tendency for more laryngealisation in o-ʕ.

/ʌ/: An independent-samples *t*-test was applied and reveals context o-ħ as having a significantly (t (24) = 2.272, p<0.001) higher **H*1-**H*2 value than context o-ʕ for vowel /ʌ/ at offset.

Table 10.4: Effect size differences and Cohen d values for of **H*1-H*2 values within individual contexts at offset.**

Vowel	Context1	Context2	Cohen *d*	effect size	Sig.
/iː/	o-ʕ	n-n	1.69	large	*p*<0.001
		o-n	1.56	large	*p*<0.001
		o-o	1.38	large	*p*<0.001
		isolation	1.08	large	*p*<0.001
	o-ħ	o-n	1.03	large	*p*<0.001
/ɪ/	o-n	n-n	0.47	moderate	*p*<0.001
		o-o	0.52	moderate	*p*<0.001
/aː/	isolation	o-ħ	1.08	large	*p*<0.001
		o-ʕ	0.56	moderate	*p*<0.001
/ʌ/	o-ħ	o-ʕ	0.97	large	*p*<0.001
/uː/	o-ʕ	n-n	1.73	large	*p*<0.001
		o-n	1.47	large	*p*<0.001
		o-o	1.95	large	*p*<0.001
		isolation	1.66	large	*p*<0.001
/ʊ/	o-ħ	o-o	0.88	large	*p*<0.001

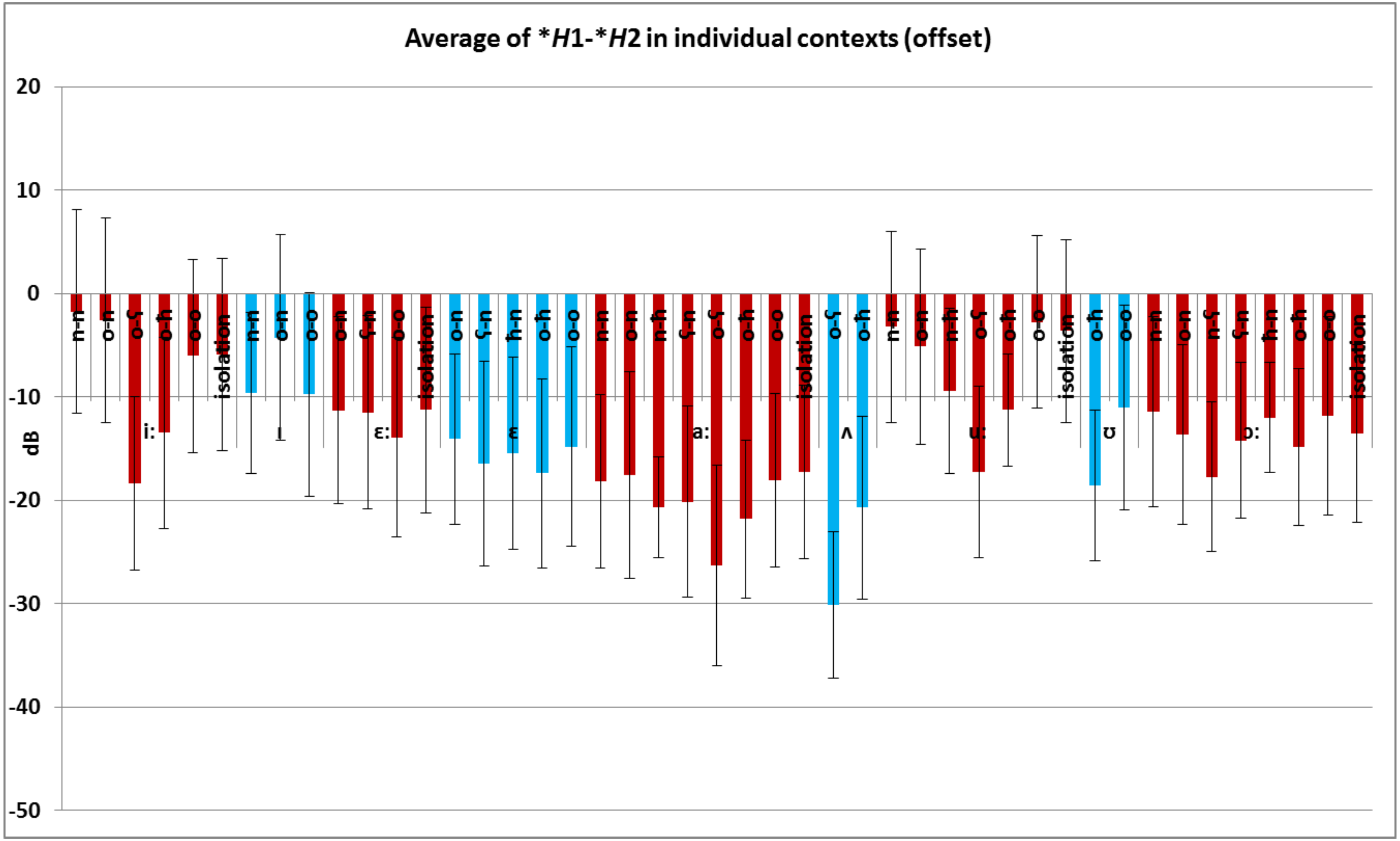


Figure 10.4: Average *H1-*H2 values within individual contexts at offset.

/uː/: A one-way ANOVA reveals a significant effect of individual contexts on *H1-*H2 values containing vowel /uː/ at offset with a moderate effect size (F (6, 232) = 5.661, p<0.001, η_p^2 = 0.131). Bonferroni post-hoc analysis reveals context o-ʕ as having a significantly lower *H1-*H2 value than each of n-n, o-n, o-o and isolation contexts. Despite non-significant differences between o-ħ and o-ʕ contexts, they show a tendency for more laryngealisation in o-ʕ.

/ʊ/: An independent-samples t-test was applied and reveals a significant difference (t (16) = 1.848, p<0.001) between o-ħ and o-o contexts on *H1-*H2 values.

/ɔː/: A one-way ANOVA reveals a non-significant effect of individual contexts on *H1-*H2 values containing vowel /ɔː/ at offset**,** but showing a a tendency for context n-ʕ to show more laryngealisation than all other contexts; and context o-ħ to also show more laryngealisation than each of n-n, ħ-n, ʕ-n and o-o contexts. These tendencies show contexts with final pharyngeals having more laryngealisation than others. Despite non-significant differences between ħ-n and ʕ-n contexts, they show a tendency for more laryngealisation in ʕ-n.

10.2.2.2 *Cross-dialectal differences in vowels*

Similar to other vowel portions and contexts, Baghdad shows the lowest *H1-*H2 values and Basra the highest, indicating Baghdad speakers as having the highest levels of laryngealisation and Basra the least (table 10.5, figure 10.5).

/iː/: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *H1-*H2 values within vowel /iː/ at offset with a large effect size (F (2, 225) = 95.827, p<0.001, η_p^2 = 0.462). Bonferroni post-hoc analysis reveals significant differences between all dialects with Baghdad showing the lowest *H1-*H2 value and Basra the highest.

/ɪ/: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *H1-*H2 values within vowel /ɪ/ at offset with a large effect size (F (2, 35) = 14.138, p<0.001, η_p^2 = 0.461). Bonferroni post-hoc analysis reveals Baghdad as having a significantly lower *H1-*H2 value than each of Basra and Mosul. Despite the non-significant differences between Basra and Mosul, they show a tendency for Basra to be the least laryngealised.

/ɛː/: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *H1-*H2 values within vowel /ɛː/ at offset with a large effect size (F (2, 160) = 43.028, p<0.001, η_p^2 = 0.353). Bonferroni post-hoc analysis reveals significant differences between all dialects with Baghdad showing the most laryngealised and Basra the least.

Table 10.5: Effect size differences and Cohen *d* values for cross-dialectal comparisons of **H*1-H*2 values at offset.**

Vowel	Dialect1	Dialect2	Cohen *d*	effect size	Sig.
/iː/	Baghdad	Basra	2.16	large	$p<0.001$
		Mosul	0.90	large	$p<0.001$
	Basra	Mosul	1.35	large	$p<0.001$
/ɪ/	Baghdad	Basra	1.89	large	$p<0.001$
		Mosul	2.37	large	$p<0.001$
/ɛː/	Baghdad	Basra	1.73	large	$p<0.001$
		Mosul	0.81	large	$p<0.001$
	Basra	Mosul	1.01	large	$p<0.001$
/ɛ/	Baghdad	Basra	2.37	large	$p<0.001$
		Mosul	2.11	large	$p<0.001$
	Basra	Mosul	0.80	large	$p<0.001$
/aː/	Baghdad	Basra	1.49	large	$p<0.001$
		Mosul	0.92	large	$p<0.001$
	Basra	Mosul	0.82	large	$p<0.001$
/ʌ/	Baghdad	Basra	1.19	large	$p<0.001$
/uː/	Baghdad	Basra	1.74	large	$p<0.001$
		Mosul	0.90	large	$p<0.001$
	Basra	Mosul	0.99	large	$p<0.001$
/ʊ/	Baghdad	Basra	0.64	moderate to large	$p<0.001$
/ɔː/	Baghdad	Basra	1.94	large	$p<0.001$
		Mosul	1.28	large	$p<0.001$
	Basra	Mosul	1.12	large	$p<0.001$

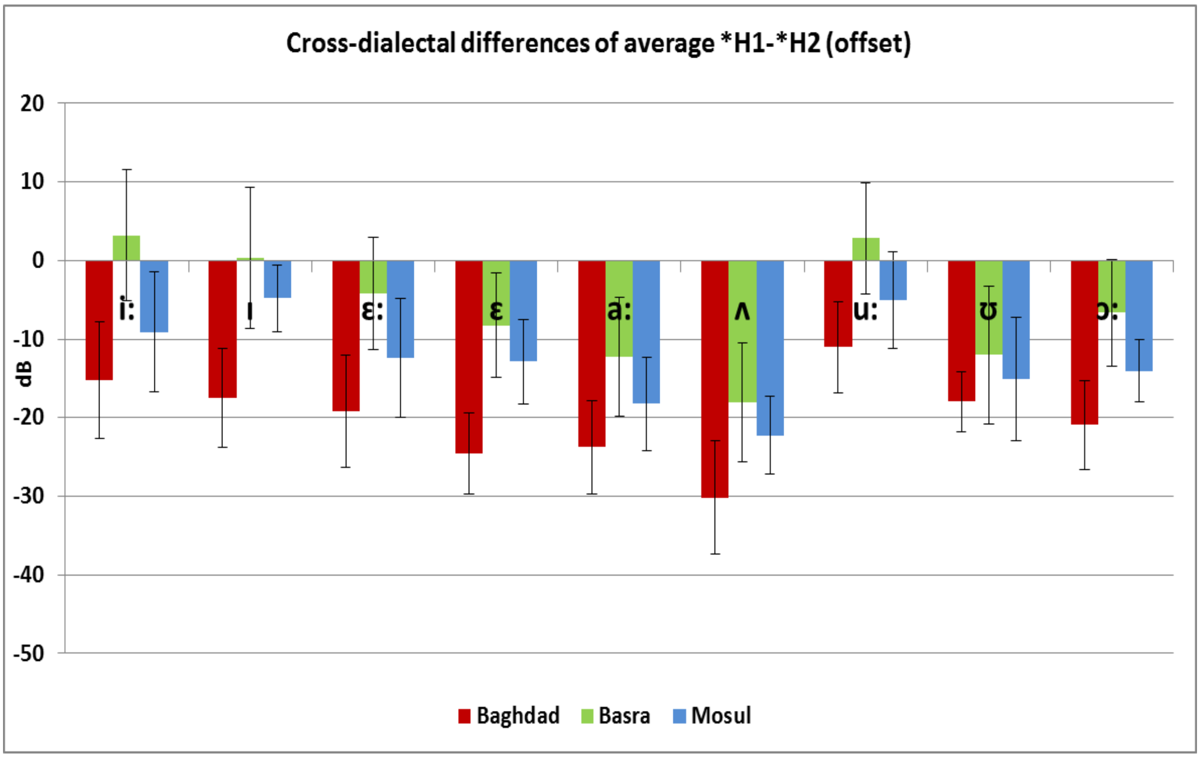


Figure 10.5: Cross-dialectal differences of **H*1-H*2 values for vowels at offset.**

/ɛ/: A one-way ANOVA reveals a significant effect of cross-dialectal differences on **H*1-**H*2 values within vowel /ɛ/ at offset with a large effect size (F (2, 107) = 58.129, $p<0.001$, η_p^2 =

0.525). Bonferroni post-hoc analysis reveals significant differences between all dialects with Baghdad showing the most laryngealised and Basra the least.

/a:/: A one-way ANOVA reveals a significant effect of cross-dialectal differences on **H*1-**H*2 values within vowel /a:/ at offset with a large effect size (F (2, 495) = 101.273, p<0.001, η_p^2 = 0.291). Bonferroni post-hoc analysis reveals significant differences between all dialects with Baghdad showing the most laryngealised and Basra the least.

/ʌ/: A one-way ANOVA reveals a significant effect of cross-dialectal differences on **H*1-**H*2 values within vowel /ʌ/ at offset with a large effect size (F (2, 25) = 4.095, p<0.001, η_p^2 = 0.263). Bonferroni post-hoc analysis reveals Baghdad as having a significantly lower **H*1-**H*2 value than Basra.

/u:/: A one-way ANOVA reveals a significant effect of cross-dialectal differences on **H*1-**H*2 values within vowel /u:/ at offset with a large effect size (F (2, 232) = 63.760, p<0.001, η_p^2 = 0.357). Bonferroni post-hoc analysis reveals significant differences between all dialects with Baghdad showing the most laryngealised and Basra the least.

/ʊ/: A one-way ANOVA reveals a significant effect of cross-dialectal differences on **H*1-**H*2 values within vowel /ʊ/ at offset with a small effect size (F (2, 17) = 0.470, p<0.001, η_p^2 = 0.059). Bonferroni post-hoc analysis reveals Baghdad as having a significantly lower **H*1-**H*2 value than Basra.

/ɔ:/: A one-way ANOVA reveals a significant effect of cross-dialectal differences on **H*1-**H*2 values within vowel /ɔ:/ at offset with a large effect size (F (2, 190) = 73.990, p<0.001, η_p^2 = 0.440). Bonferroni post-hoc analysis reveals significant differences between all dialects with Baghdad showing the most laryngealised and Basra the least.

10.2.2.3 *Cross-dialectal differences in individual contexts*

The same trend is noted here with Baghdad showing the lowest **H*1-**H*2 values even in pharyngeal-nasal contexts (table 10.6, figure 10.6). The same trend is noted here whereby nasal and non-nasal contexts containing pharyngeal /ʕ/ show the highest degrees of laryngealisation for all dialects. Overall Baghdad and pharyngeal contexts have the lowest values indicating the highest effects of laryngealisation.

Table 10.6: Effect size differences and Cohen *d* values for cross-dialectal comparisons of **H*1-H*2 values within individual contexts at offset.**

Context	Dialect1	Dialect2	Cohen *d*	effect size	Sig.
n-n	Baghdad	Basra	1.94	large	p<0.001
		Mosul	1.28	large	p<0.001
	Basra	Mosul	1.12	large	p<0.001
o-n	Baghdad	Basra	1.90	large	p<0.001

		Mosul	1.14	large	$p<0.001$
	Basra	Mosul	0.98	large	$p<0.001$
n-ħ	Baghdad	Basra	1.00	large	$p<0.001$
n-ʕ	Baghdad	Basra	7.41	large	$p<0.001$
		Mosul	3.40	large	$p<0.001$
ħ-n	Baghdad	Basra	1.68	large	$p<0.001$
		Mosul	1.78	large	$p<0.001$
ʕ-n	Baghdad	Basra	1.63	large	$p<0.001$
		Mosul	1.38	large	$p<0.001$
	Basra	Mosul	0.70	moderate to large	$p<0.001$
o-ħ	Baghdad	Basra	1.16	large	$p<0.001$
		Mosul	0.68	moderate to large	$p<0.001$
	Basra	Mosul	0.49	moderate	$p<0.001$
o-ʕ	Baghdad	Basra	1.08	large	$p<0.001$
o-o	Baghdad	Basra	1.83	large	$p<0.001$
		Mosul	1.19	large	$p<0.001$
	Basra	Mosul	0.70	moderate to large	$p<0.001$
isolation	Baghdad	Basra	1.36	large	$p<0.001$
		Mosul	0.68	moderate to large	$p<0.001$
	Basra	Mosul	0.87	large	$p<0.001$

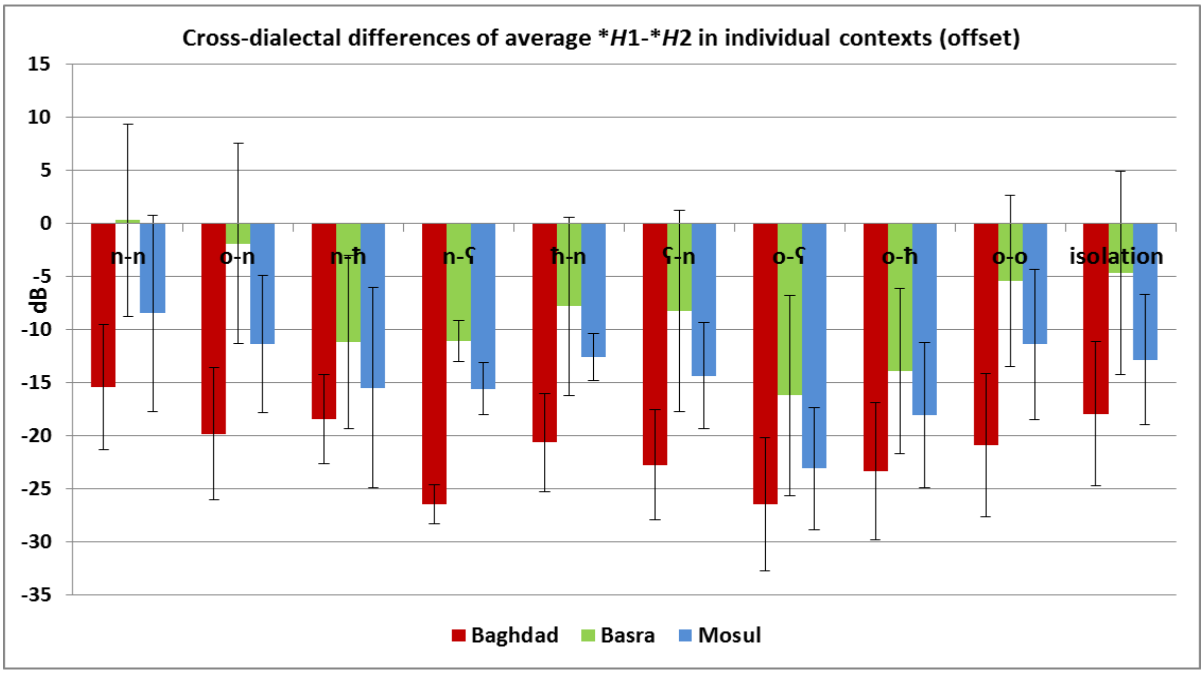


Figure 10.6: Cross-dialectal differences of *H1-*H2 values within individual contexts at offset.

n-n: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *H1-*H2 values within context n-n at offset with a large effect size (F (2, 53) = 13.007, p<0.001, η_p^2 = 0.338). Bonferroni post-hoc analysis reveals significant differences between all dialects with Baghdad showing the most laryngealisation and Basra the least.

o-n: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *H1-*H2 values within context o-n at offset with a large effect size (F (2, 170) = 56.120,

$p<0.001$, $\eta_p^2 = 0.401$). Bonferroni post-hoc analysis reveals significant differences between all dialects with Baghdad showing the most laryngealisation and Basra the least.

n-ħ: A one-way ANOVA reveals a non-significant effect of cross-dialectal differences on **H*1-**H*2 values within context n-ħ at offset, but Bonferroni post-hoc analysis reveals Baghdad as having a significantly lower **H*1-**H*2 value than Basra.

n-ʕ: A one-way ANOVA reveals a significant effect of cross-dialectal differences on **H*1-**H*2 values within context n-ʕ at offset with a large effect size (F (2, 8) = 25.391, $p<0.001$, $\eta_p^2 = 0.894$). Bonferroni post-hoc analysis reveals Baghdad as having a significantly lower **H*1-**H*2 value than each of Basra and Mosul. Despite the non-non-significant differences between Basra and Mosul they show a tendency for Basra to have the least laryngealisation.

ħ-n: A one-way ANOVA reveals a significant effect of cross-dialectal differences on **H*1-**H*2 values within context ħ-n at offset with a large effect size (F (2, 17) = 5.625, $p<0.001$, $\eta_p^2 = 0.429$). Bonferroni post-hoc analysis reveals Baghdad as having a significantly lower **H*1-**H*2 value than each of Basra and Mosul. Despite the non-significant differences between Basra and Mosul, they show a tendency for Basra to have the least laryngealisation.

ʕ-n: A one-way ANOVA reveals a significant effect of cross-dialectal differences on **H*1-**H*2 values within context ʕ-n at offset with a large effect size (F (2, 44) = 11.434, $p<0.001$, $\eta_p^2 = 0.353$). Bonferroni post-hoc analysis reveals significant differences between all dialects with Baghdad having the lowerst **H*1-**H*2 value and Basra the highest.

o-ħ: A one-way ANOVA reveals a significant effect of cross-dialectal differences on **H*1-**H*2 values within context o-ħ at offset with a moderate effect size (F (2, 116) = 13.257, $p<0.001$, $\eta_p^2 = 0.189$). Bonferroni post-hoc analysis reveals significant differences between all dialects with Baghdad having the lowest **H*1-**H*2 value and Basra the highest.

o-ʕ: A one-way ANOVA reveals a significant effect of cross-dialectal differences on **H*1-**H*2 values within context o-ʕ at offset with a large effect size (F (2, 43) = 5.157, $p<0.001$, $\eta_p^2 = 0.201$). Bonferroni post-hoc analysis reveals Baghdad as having a significantly lower **H*1-**H*2 value than Basra.

o-o: A one-way ANOVA reveals a significant effect of cross-dialectal differences on **H*1-**H*2 values within context o-o at offset with a large effect size (F (2, 235) = 69.742, $p<0.001$, $\eta_p^2 = 0.374$). Bonferroni post-hoc analysis reveals significant differences between all dialects with Baghdad showing the most laryngealisation and Basra the least.

Isolation: A one-way ANOVA reveals a significant effect of cross-dialectal differences on **H*1-**H*2 values within context isolation at offset with a large effect size (F (2, 773) =

140.048, $p<0.001$, $\eta_p^2 = 0.266$). Bonferroni post-hoc analysis reveals significant differences between all dialects with Baghdad showing the most laryngealisation and Basra the least.

10.2.2.4 *Discussion of the *H1-*H2 measure results at offset*

As was noted for results of **H*1-**H*2 at onset, pharyngeal contexts show the lowest values indicating the most laryngealisation; contexts containing pharyngeal /ʕ/ show more laryngealisation than those containing /ħ/; and cross-dialectally, Baghdad also shows laryngealisation the most and Basra the least. However, in comparison to onset there are less significant distinctions between individual contexts even within pharyngeal ones. Moreover, in comparison to onset, overall values of individual contexts are higher at offset indicating less effect of laryngealisation in final position. This indicates that laryngealisation effect from pharyngeal consonants is stronger when these consonants are in initial position indicating a progressive effect; this is similar to what was found for nasalisation and pharyngealisation. Cross-dialectally, and similar to results at onset, Baghdad shows the lowest **H*1-**H*2 values and Basra the highest, indicating Baghdad speakers as having the highest levels of laryngealisation and Basra the least.

10.2.3 Summary of **H*1-**H*2

Overall results of measuring **H*1-**H*2 show a number of findings which suggest a distinction between pharyngeal and non-pharyngeal contexts. Pharyngeal and isolation contexts showed the lowest overall values, indicating the highest degree of laryngealisation, while nasal and oral contexts showed the highest **H*1-**H*2 values. These results coincide with those of Chapter 7 showing pharyngeal consonants containing glottal reinforcements; with those of the auditory impression of laryngealisation whereby pharyngeal contexts showed more laryngealisation in comparison to non-pharyngeal nasal and oral contexts. These same results apply to cross-dialectal comparisons whereby Baghdad shows the overall lowest **H*1-**H*2 values indicating laryngealisation as well as pharyngealisation and overall high *intensity*, and Basra the highest for all three features. Furthermore, between the two pharyngeal consonants, contexts containing pharyngeal /ʕ/ showed more laryngealisation than those containing /ħ/. In comparing the vowel portions, results showed that pharyngeal consonants have a progressive effect of laryngealisation similar to effects of nasalisation and pharyngealisation.

10.3 *H1-A1

A relationship between the amplitudes of the first harmonics (*H*1) and strongest harmonic of the first formant (*A*1) lead to the following interpretations (see: Fry, 1979; Laver, 1980, 1994; Klatt and Klatt, 1990; Trittin and Lleo, 1995; Epstein, 2002): **1-** if the first harmonic has the highest amplitude, the resulting voice is believed to be breathy; **2-** if the higher frequency harmonics have higher amplitudes, the resulting voice is believed to be creaky (see Chapter 3 for more details). However, the **H*1-*A*1 measure has also been found to be related to the measure of *B*1 (bandwidth of *F*1) and accordingly to the posterior glottal chink (see Chapter 3 for more detail). According to Hanson (1996: 471), an increase in the chink increases *B*1, and as *B*1 increases **H*1-*A*1 increases. The increase of the chink means an increase of aspiration and therefore may suggest a breathy phonation. The following sections will present results at onset and offset portions due to the fact that results at midpoint were similar (Appendixes N and O).

10.3.1 Onset

10.3.1.1 *Contexts*

Overall **H*1-*A*1 values in vowels /iː, uː, ɔː/ are high. All pharyngeal contexts, except n-ħ and n-ʕ, have the lowest **H*1-*A*1 values suggesting a creaky phonation (laryngealisation) (table 10.7, figure 10.7).

/iː/: A one-way ANOVA reveals a significant effect of individual contexts on **H*1-*A*1 values containing vowel /iː/ at onset with a moderate effect size (F (4, 207) = 5.031, p<0.001, η_p^2 = 0.090). Bonferroni post-hoc analysis reveals context ʕ-o as having a significantly lower **H*1-*A*1 value than each of n-n, n-o, o-o and isolation contexts.

/ɪ/: A one-way ANOVA reveals a significant effect of individual contexts on **H*1-*A*1 values containing vowel /ɪ/ at onset with a large effect size (F (2, 35) = 5.169, p<0.001, η_p^2 = 0.239). Bonferroni post-hoc analysis reveals ʕ-o context as having a significantly lower **H*1-*A*1 value than each of n-n and o-o contexts.

Table 10.7: Effect size differences and Cohen *d* values for **H1-A1* values within individual contexts at onset.

Vowel	Context1	Context2	Cohen *d*	effect size	Sig.
/iː/	ʕ-o	n-n	1.23	large	*p*<0.001
		n-o	0.96	large	*p*<0.001
		o-o	0.87	large	*p*<0.001
		isolation	1.13	large	*p*<0.001
/ɪ/	ʕ-o	n-n	1.24	large	*p*<0.001
		o-o	0.85	large	*p*<0.001
/ɛː/	n-o	ʕ-n	1.73	large	*p*<0.001
		ħ-o	1.48	large	*p*<0.001
		ʕ-o	2.88	large	p<0.001
		isolation	1.13	large	*p*<0.001
	o-o	ʕ-n	1.35	large	*p*<0.001
		ħ-o	1.20	large	*p*<0.001
		ʕ-o	2.21	large	p<0.001
		isolation	0.80	large	*p*<0.001
	ʕ-o	isolation	1.18	large	p<0.001
/ɛ/	ħ-o	n-o	1.86	large	*p*<0.001
		o-o	1.53	large	*p*<0.001
	ʕ-o	n-o	1.79	large	p<0.001
		ħ-n	1.74	large	p<0.001
		o-o	1.11	large	p<0.001
	ħ-n	n-o	1.09	large	*p*<0.001
		o-o	0.89	large	*p*<0.001
	ʕ-n	n-o	1.05	large	p<0.001
		o-o	0.97	large	p<0.001
/aː/	ħ-o	n-n	2.06	large	*p*<0.001
		n-o	2.00	large	*p*<0.001
		n-ħ	1.78	large	*p*<0.001
		o-o	1.53	large	*p*<0.001
	ʕ-o	n-n	1.99	large	p<0.001
		n-o	1.89	large	p<0.001
		n-ħ	1.76	large	p<0.001
		o-o	1.56	large	p<0.001
		isolation	0.80	large	p<0.001
	isolation	n-n	1.10	large	*p*<0.001
		n-o	1.23	large	*p*<0.001
		o-o	0.83	large	*p*<0.001
	n-o	ʕ-n	0.94	large	*p*<0.001
/uː/	ʕ-o	n-n	1.01	large	*p*<0.001
		n-o	1.12	large	*p*<0.001
		o-o	1.05	large	*p*<0.001
		isolation	0.80	large	*p*<0.001
/ʊ/	n-o	ħ-o	1.98	large	*p*<0.001
		o-o	0.80	large	*p*<0.001
/ɔː/	ħ-o	n-n	1.19	large	*p*<0.001
		n-o	1.29	large	*p*<0.001
		n-ʕ	1.62	large	*p*<0.001
		o-o	1.67	large	*p*<0.001
	ħ-n	o-o	1.01	large	*p*<0.001
	ʕ-n	n-n	0.94	large	*p*<0.001
		n-o	0.89	large	*p*<0.001
		o-o	1.35	large	*p*<0.001

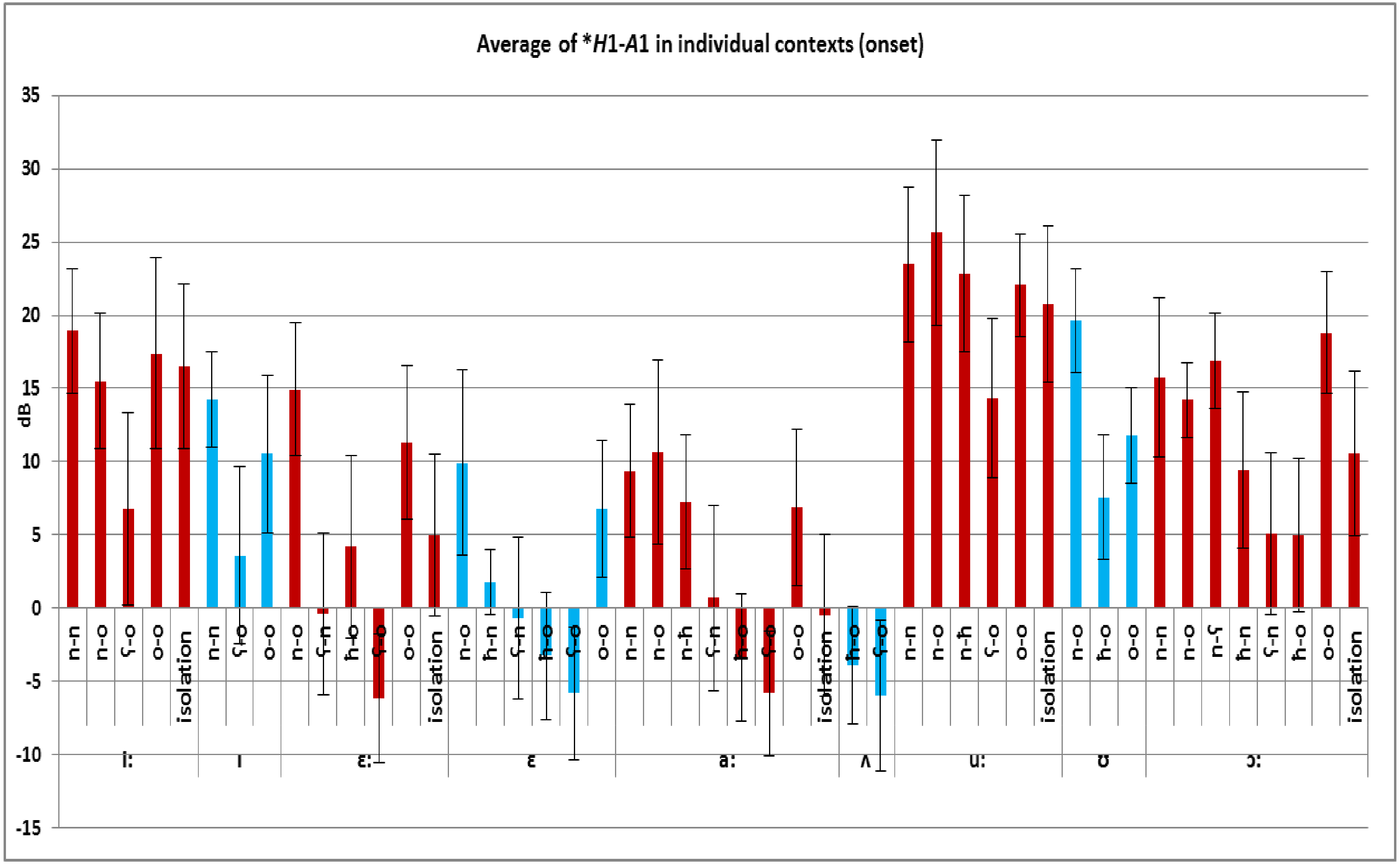


Figure 10.7: Average *H1-*A1 values within individual contexts at onset.

/ɛː/: A one-way ANOVA reveals a significant effect of individual contexts on *$H1$-$A1$ values containing vowel /ɛː/ at onset with a large effect size (F 5, 169) = 8.003, p<0.001, η_p^2 = 0.196). Bonferroni post-hoc analysis reveals n-o context as having a significantly higher *$H1$-$A1$ value than each of ʕ-n, ħ-o, ʕ-o and isolation contexts; and o-o context having a significantly higher value than each of ʕ-n, ħ-o, ʕ-o and isolation contexts; and ʕ-o context having a significantly lower value than isolation context. There are no significant differences between ħ-o and ʕ-o contexts, but they show a tendency for ʕ-o to have a lower *$H1$-$A1$ value than ħ-o.

/ɛ/: A one-way ANOVA reveals a significant effect of individual contexts on *$H1$-$A1$ values containing vowel /ɛ/ at onset with a large effect size (F (5, 159) = 15.567, p<0.001, η_p^2 = 0.336). Bonferroni post-hoc analysis reveals ħ-o context as having a significantly lower *$H1$-$A1$ value than each of n-o and o-o contexts; ʕ-o context having a significantly lower value than each of n-o, ħ-n and o-o contexts; ħ-n context having a significantly lower value than each of n-o and o-o contexts; and ʕ-n context having a significantly lower value than each of n-o and o-o contexts. There are no significant differences between ħ-n and ʕ-n contexts or between ħ-o and ʕ-o contexts, but the two pairs show a tendency for ʕ-n and ʕ-o to have lower *$H1$-$A1$ values indicating more laryngealisation than ħ-n and ħ-o.

/aː/: A one-way ANOVA reveals a significant effect of individual contexts on *$H1$-$A1$ values containing vowel /aː/ at onset with a large effect size (F (7, 486) = 16.701, p<0.001, η_p^2 = 0.196). Bonferroni post-hoc analysis reveals ħ-o context as having a significantly lower *$H1$-$A1$ value than each of n-n, n-o, n-ħ and o-o contexts; between ʕ-o and each of n-n, n-o, n-ħ, o-o and isolation contexts; and isolation context having a significantly lower value than each of n-n, n-o and o-o contexts; n-o context having a significantly higher value than ʕ-n context. There are no significant differences between ħ-o and ʕ-o contexts, but they show a tendency for ʕ-o to have a lower *$H1$-$A1$ value indicating more laryngealisation than ħ-o.

/ʌ/: An independent-samples t-test was applied and reveals a non-significant difference between ħ-o and ʕ-o contexts on *$H1$-$A1$ values for vowel /ʌ/ at onset, but showing a tendency for ʕ-o to have more laryngealisation.

/uː/: A one-way ANOVA reveals a significant effect of individual contexts on *$H1$-$A1$ values containing vowel /uː/ at onset with a moderate effect size (F (5, 223) = 3.792, p<0.001, η_p^2 = 0.80). Bonferroni post-hoc analysis reveals ʕ-o context as having a significantly lower *$H1$-$A1$ value than each of n-n, n-o, o-o and isolation contexts.

/ʊ/: A one-way ANOVA reveals a significant effect of individual contexts on *$H1$-$A1$ values containing vowel /ʊ/ at onset with a large effect size (F (2, 25) = 9.245, p<0.001, η_p^2 =

0.446). Bonferroni post-hoc analysis reveals n-o context as having a significantly higher *$H1$-$A1$ value than each of ħ-oand o-o contexts.

/ɔ:/: A one-way ANOVA reveals a significant effect of individual contexts on *$H1$-$A1$ values containing vowel /ɔ:/ at onset with a moderate effect size (F (7, 172) = 4.123, p<0.001, η_p^2 = 0.149). Bonferroni post-hoc analysis reveals ħ-o context as having a significantly lower *$H1$-$A1$ value than each of n-n, n-o, n-ʕ and o-o contexts; ħ-n context as having a significantly lower *$H1$-$A1$ value than o-o context; and ʕ-n context and each of n-n, n-o and o-o contexts. There are no significant differences between ħ-n and ʕ-n contexts, but they show a tendency for ʕ-n to have a lower *$H1$-$A1$ value than ħ-n.

10.3.1.2 *Cross-dialectal differences in vowels*

Results of cross-dialectal differences in vowels coincide with those of *$H1$-*$H2$ whereby Baghdad is noted as the most laryngealised and Basra the least (table 10.8, figure 10.8). These results are consistent for all vowels whether differences between dialects are significant or mere tendencies. Also, the same vowels /i:, i:, u:, ʊ, ɔ:/ have the overall highest values, especially for /u:/, and the same ones have the lowest.

Table 10.8: Effect size differences and Cohen *d* values for cross-dialectal comparisons of **H1-A1* values at onset.

Vowel	Dialect1	Dialect2	Cohen *d*	effect size	Sig.
/i:/	Baghdad	Basra	0.69	moderate to large	p<0.001
/ɪ/	Baghdad	Basra	0.71	moderate to large	p<0.001
/ɛ:/	Basra	Baghdad	0.79	moderate to large	p<0.001
		Mosul	0.49	moderate	p<0.001
/ɛ/	Baghdad	Basra	1.31	large	p<0.001
		Mosul	0.89	large	p<0.001
	Basra	Mosul	0.43	moderate	p<0.001
/a:/	Baghdad	Basra	1.39	large	p<0.001
		Mosul	1.03	large	p<0.001
	Basra	Mosul	0.48	moderate	p<0.001
/ʌ/	Baghdad	Basra	1.54	large	p<0.001
		Mosul	1.18	large	p<0.001
/u:/	Baghdad	Basra	0.59	moderate	p<0.001
		Mosul	0.55	moderate	p<0.001
/ʊ/	Baghdad	Basra	0.82	large	p<0.001
		Mosul	1.14	large	p<0.001
/ɔ:/	Baghdad	Basra	1.02	large	p<0.001
		Mosul	0.53	moderate	p<0.001
	Basra	Mosul	0.69	moderate to large	p<0.001

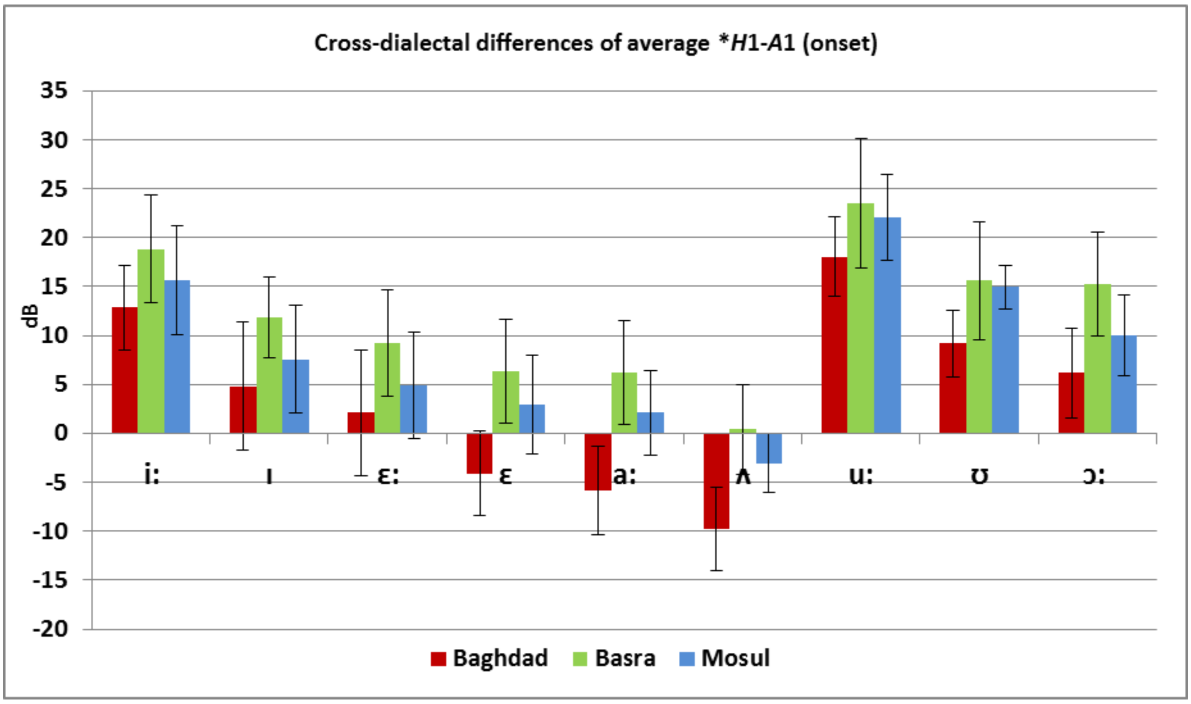


Figure 10.8: Cross-dialectal differences of *_H_1-_A_1 values for vowels at onset.

/i:/: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *_H_1-_A_1 values within vowel /i:/ at onset with a moderate effect size (F (2, 207) = 7.352, p<0.001, η_p^2 = 0.67). Bonferroni post-hoc analysis reveals Baghdad as having a significantly lower *_H_1-_A_1 value than Basra.

/ɪ/: A one-way ANOVA reveals a non-significant effect of cross-dialectal differences on *_H_1-_A_1 values within vowel /ɪ/ at onset, but Bonferroni post-hoc analysis reveals Baghdad as having a significantly lower *_H_1-_A_1 value than Basra.

/ɛ:/: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *_H_1-_A_1 values within vowel /ɛ:/ at onset with a moderate effect size (F (2, 169) = 9.862, p<0.001, η_p^2 = 0.106). Bonferroni post-hoc analysis reveals Basra as having a significantly higher *_H_1-_A_1 value than each of Baghdad and Mosul.

/ɛ/: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *_H_1-_A_1 values within vowel /ɛ/ at onset with a large effect size (F (2, 159) = 23.470, p<0.001, η_p^2 = 0.230). Bonferroni post-hoc analysis reveals significant differences between all three dialects with Baghdad showing the lowest *_H_1-_A_1 value and Basra the highest.

/a:/: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *_H_1-_A_1 values within vowel /a:/ at onset with a large effect size (F (2, 486) = 88.048, p<0.001, η_p^2 = 0.267). Bonferroni post-hoc analysis reveals significant differences between all three dialects with Baghdad showing the lowest *_H_1-_A_1 value and Basra the highest.

/ʌ/: A one-way ANOVA reveals a significant effect of cross-dialectal differences on **H*1-*A*1 values within vowel /ʌ/ at onset with a large effect size (F (2, 52) = 12.577, p<0.001, η_p^2 = 0.335). Bonferroni post-hoc analysis reveals Baghdad as having a significantly lower **H*1-*A*1 value than each of Basra and Mosul. Despite non-significant differences between Basra and Mosul they show a tendency for Basra to have the highest value.

/u:/: A one-way ANOVA reveals a significant effect of cross-dialectal differences on **H*1-*A*1 values within vowel /u:/ at onset with a moderate effect size (F (2, 223) = 7.804, p<0.001, η_p^2 = 0.066). Bonferroni post-hoc analysis reveals Baghdad as having a significantly lower **H*1-*A*1 value than each of Basra and Mosul. Despite non-significant differences between Basra and Mosul they show a tendency for Basra to have the highest value.

/ʊ/: A one-way ANOVA reveals a non-significant effect of cross-dialectal differences on **H*1-*A*1 values within vowel /ʊ/ at onset, but Bonferroni post-hoc analysis reveals Baghdad as having a significantly lower **H*1-*A*1 value than each of Basra and Mosul.

/ɔ:/: A one-way ANOVA reveals a significant effect of cross-dialectal differences on **H*1-*A*1 values within vowel /ɔ:/ at onset with a large effect size (F (2, 172) = 18.587, p<0.001, η_p^2 = 0.179). Bonferroni post-hoc analysis reveals significant differences between all three dialects with Baghdad showing the lowest **H*1-*A*1 value and Basra the highest.

10.3.1.3 *Cross-dialectal differences in individual contexts*

Here results are similar to cross-dialectal differences in vowels whereby Baghdad shows laryngealisation the most and Basra the least (table 10.9, figure 10.9). These results are consistent for all contexts whether differences between dialects are significant or tendencies. Moreover, **H*1-*A*1 values in the nasal-pharyngeal context are similar to other nasal contexts in having high values. More importantly, /ʕ/ is showing lower **H*1-*A*1 values in contexts ʕ-n and ʕ-o in comparison to contexts ħ-n and ħ-o. In contexts n-ħ and n-ʕ, it is nasalisation and not laryngealisation that is affecting **H*1-*A*1 values.

n-n: A one-way ANOVA reveals a significant effect of cross-dialectal differences on **H*1-*A*1 values within context n-n at onset with a moderate effect (F (2, 53) = 3.151, p<0.001, size η_p^2 = 0.109). Bonferroni post-hoc analysis reveals Baghdad as having a significantly lower **H*1-*A*1 value than Basra. Despite non-significant differences between Mosul and each of Baghdad and Basra they show a tendency for Baghdad to have the lowest value and Basra the highest.

Table 10.9: Effect size differences and Cohen *d* values for Cross-dialectal comparisons of **H1-A1* values within individual contexts at onset.

Context	Dialect1	Dialect2	Cohen *d*	effect size	Sig.
n-n	Baghdad	Basra	0.86	large	$p<0.001$
n-o	Basra	Baghdad	1.23	large	$p<0.001$
		Mosul	0.98	large	$p<0.001$
n-ħ	Baghdad	Basra	0.34	moderate	$p<0.001$
n-ʕ	Basra	Baghdad	2.61	large	$p<0.001$
		Mosul	3.33	large	$p<0.001$
ħ-n	Baghdad	Basra	1.31	large	$p<0.001$
		Mosul	1.21	large	$p<0.001$
ʕ-n	Baghdad	Basra	1.51	large	$p<0.001$
		Mosul	1.76	large	$p<0.001$
ħ-o	Baghdad	Basra	1.54	large	$p<0.001$
		Mosul	0.91	large	$p<0.001$
	Basra	Mosul	0.57	moderate	$p<0.001$
ʕ-o	Baghdad	Basra	0.94	large	$p<0.001$
		Mosul	1.04	large	$p<0.001$
o-o	Baghdad	Basra	0.92	large	$p<0.001$
		Mosul	0.54	moderate	$p<0.001$
isolation	Baghdad	Basra	0.67	moderate to large	$p<0.001$
		Mosul	0.39	moderate	$p<0.001$
	Basra	Mosul	0.34	moderate	$p<0.001$

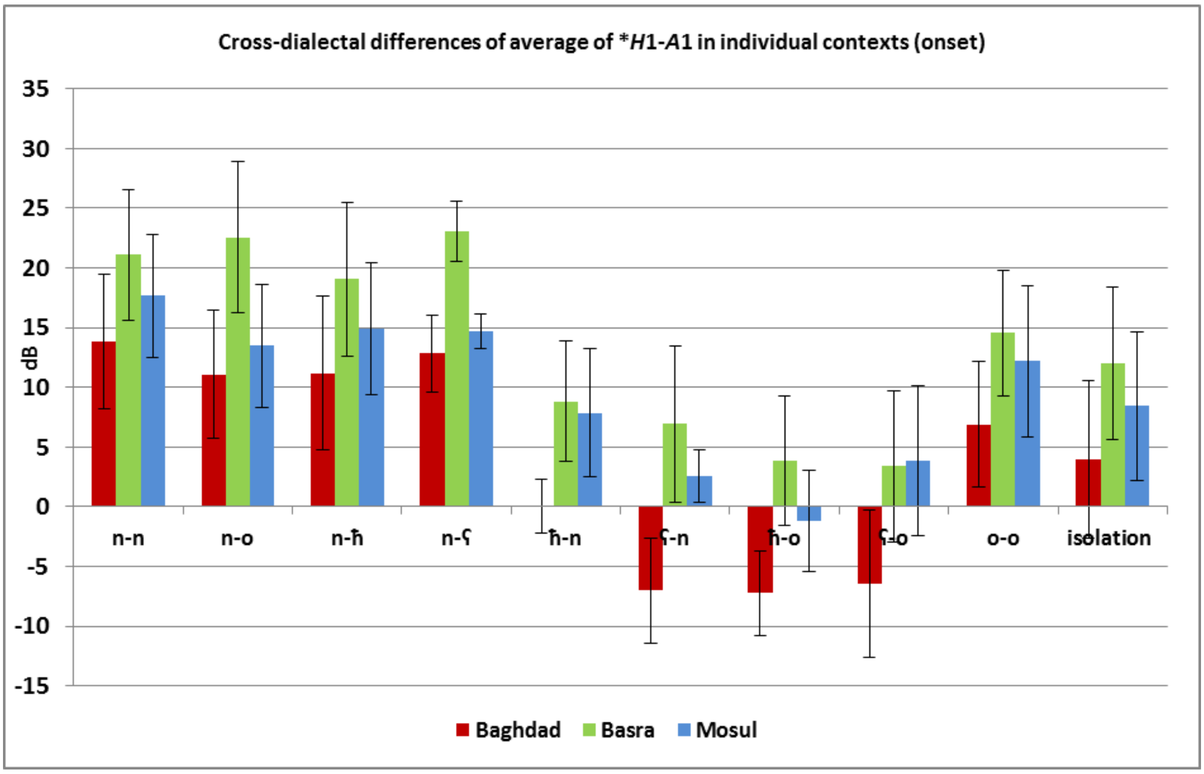


Figure 10.9: Cross-dialectal differences of **H1-A1* values within individual contexts at onset.

n-o: A one-way ANOVA reveals a significant effect of cross-dialectal differences on **H*1-*A*1 values within context n-o at onset with a large effect size (F (2, 98) = 14.894, $p<0.001$,

$\eta_p^2 = 0.237$). Bonferroni post-hoc analysis reveals Basra as having a significantly higher **H*1-*A*1 value than each of Baghdad and Mosul.

n-ħ: A one-way ANOVA reveals a significant effect of cross-dialectal differences on **H*1-*A*1 values within context n-ħ at onset with a moderate effect size (F (2, 17) = 0.709, p<0.001, $\eta_p^2 = 0.086$). Bonferroni post-hoc analysis reveals Baghdad as having a significantly lower **H*1-*A*1 value than Basra.

n-ʕ: A one-way ANOVA reveals a significant effect of cross-dialectal differences on **H*1-*A*1 values within context n-ʕ at onset with a large effect size (F (2, 8) = 11.246, p<0.001, $\eta_p^2 = 0.789$). Bonferroni post-hoc analysis reveals Basra as having a significantly higher **H*1-*A*1 value than each of Baghdad and Mosul. Despite non-significant differences between Baghdad and Mosul, Baghdad shows a tendency to have the lowest value.

ħ-n: A one-way ANOVA reveals a significant effect of cross-dialectal differences on **H*1-*A*1 values within context pharyngeal-nasal at onset with a large effect size (F (2, 62) = 12.901, p<0.001, $\eta_p^2 = 0.301$). Bonferroni post-hoc analysis reveals Baghdad as having a significantly lower **H*1-*A*1 value than each of Basra and Mosul. Despite non-significant differences between Basra and Mosul, they show a tendency for Basra to have the highest value.

ʕ-n: A one-way ANOVA reveals a significant effect of cross-dialectal differences on **H*1-*A*1 values within context ʕ-n at onset with a large effect size (F (2, 44) = 11.306, p<0.001, $\eta_p^2 = 0.350$). Bonferroni post-hoc analysis reveals Baghdad as having a significantly lower **H*1-*A*1 value than each of Basra and Mosul. Despite non-significant differences between Basra and Mosul, they show a tendency for Basra to have the highest value.

ħ-o: A one-way ANOVA reveals a significant effect of cross-dialectal differences on **H*1-*A*1 values within context ħ-o at onset with a large effect size (F (2, 157) = 29.002, p<0.001, $\eta_p^2 = 0.272$). Bonferroni post-hoc analysis reveals significant differences between all three dialects with Baghdad showing the lowest **H*1-*A*1 value and Basra the highest.

ʕ-o: A one-way ANOVA reveals a significant effect of cross-dialectal differences on **H*1-*A*1 values within context ʕ-o at onset with a large effect size (F (2, 125) = 13.463, p<0.001, $\eta_p^2 = 0.180$). Bonferroni post-hoc analysis reveals Baghdad as having a significantly lower **H*1-*A*1 value than each of Basra and Mosul.

o-o: A one-way ANOVA reveals a significant effect of cross-dialectal differences on **H*1-*A*1 values within context o-o at onset with a moderate effect size (F (2, 235) = 13.697, p<0.001, $\eta_p^2 = 0.105$). Bonferroni post-hoc analysis reveals Baghdad as having a significantly lower **H*1-*A*1 value than each of Basra and Mosul.

Isolation: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *H1-A1 values within context isolation at onset with a moderate effect size (F (2, 775) = 32.561, p<0.001, η_p^2 = 0.078). Bonferroni post-hoc analysis reveals significant differences between all three dialects with Baghdad showing the lowest *H1-A1 value and Basra the highest.

10.3.1.4 *Discussion of the H1*-A1 measure results at onset*

Results of the H1*-A1 measure are very much similar to those of the *H1-*H2 measure. All results of H1*-A1 at onset show pharyngeal contexts having low values, sometimes below 0 dB. This coincides with the low *H1-*H2 values, suggesting high levels of laryngealisation (creaky voice) in these contexts. At the same time, the nasal contexts are noted to show the highest *H1-A1 values. The latter result coincides with the high B1 values within nasal contexts. Contexts containing vowel /u:/ showed the overall highest *H1-A1 values indicating the least laryngealisation. This result coincides with results of the *H1-*H2 measure and auditory impression of laryngealisation whereby contexts of the same vowel showed the lowest overall levels. Nasal pharyngeal contexts that contain initial nasal consonants have high *H1-A1 values indicating that the effect of the nasal is stronger than the pharyngeal. When the pharyngeal consonant is initial, the *H1-A1 values in pharyngeal-nasal contexts are lowered by the influence of the pharyngeal, suggesting a creaky phonation. Isolation contexts show low *H1-A1 values in vowels /ɛ:, a:/ similar to pharyngeal contexts; whereas oral contexts show high *H1-A1 values similar to nasal contexts in all vowels. In all nasal and non-nasal pharyngeal contexts pharyngeal /ʕ/ has lower *H1-A1 values than /ħ/, indicating more laryngealisation. Cross-dialectal comparisons show similar results to those of the *H1-*H2 comparions whereby Baghdad shows the lowest overall *H1-A1 values and Basra the overall highest.

10.3.2 Offset

Results at offset show overall high values for all vowels and all contexts. This coincides with all previous results whereby nasalisation, pharyngealisation and laryngealisation are manifested at initial position and less in final position indicating a progressive effect.

10.3.2.1 *Contexts*

Non-nasal pharyngeal contexts have the overall lowest *H1-A1 values. Oral and isolation contexts do not behave in the same way they did at onset and instead are not following any trend or pattern and differ in being one of the highest (less laryngealisation) or one of the lowest (more laryngealisation) from one vowel to the other. Results in individual pharyngeal contexts show ones containing pharyngeal /ʕ/ as having lower values than those containing pharyngeal /ħ/, indicating more laryngealisation in /ʕ/ contexts (table 10.10, figure 10.10). Results of the *$H1$-$A1$ measure within individual contexts is presented below.

/iː/: A one-way ANOVA reveals a significant effect of individual contexts on *$H1$-$A1$ values containing vowel /iː/ at offset with a large effect size (F (5, 225) = 13.093, p<0.001, η_p^2 = 0.229). Bonferroni post-hoc analysis reveals o-ħ context as having a significantly lower *$H1$-$A1$ value than each of n-n, o-n, o-o and isolation contexts; and o-ʕ context and each of n-n, o-n, o-o and isolation contexts. There are no significant differences between contexts o-ħ and o-ʕ but they show a large effect size denoting a tendency for o-ʕ to show more laryngealisation.

/ɪ/: A one-way ANOVA reveals a non-significant effect of individual contexts on *$H1$-$A1$ values containing vowel /ɪ/ at offset, but o-n context shows a tendency to have a higher *$H1$-$A1$ value and each of n-n and o-o contexts.

/ɛː/: A one-way ANOVA reveals a significant effect of individual contexts on *$H1$-$A1$ values containing vowel /ɛː/ at offset with a small effect size (F (3, 160) = 2.655, p<0.001, η_p^2 = 0.048). Bonferroni post-hoc analysis reveals o-o context as having a significantly lower *$H1$-$A1$ value than each of o-n and isolation contexts.

/ɛ/: A one-way ANOVA reveals a significant effect of individual contexts on *$H1$-$A1$ values containing vowel /ɛ/ at offset with a moderate effect size (F (4, 107) = 4.404, p<0.001, η_p^2 = 0.146). Bonferroni post-hoc analysis reveals ħ-n context as having a significantly higher *$H1$-$A1$ value than o-ħ context; ʕ-n context having a significantly higher *$H1$-$A1$ value than each of o-ħ and o-o contexts; also o-ħ context having a significantly lower *$H1$-$A1$ value than each of o-n and o-o contexts. There are ano significant differences between contexts ħ-n and ʕ-n because it is the nasal in final position and not the pharyngeal that lowers the values.

Table 10.10: Effect size differences and Cohen d values for of *$H1$-$A1$ values within individual contexts at offset.

Vowel	Context1	Context2	Cohen *d*	effect size	Sig.
/iː/	o-ħ	n-n	1.16	large	$p<0.001$
		o-n	1.26	large	$p<0.001$
		o-o	1.11	large	$p<0.001$
		isolation	1.08	large	$p<0.001$
	o-ʕ	n-n	1.64	large	$p<0.001$
		o-n	1.86	large	$p<0.001$
		o-o	1.55	large	$p<0.001$
		isolation	1.83	large	$p<0.001$
/ɛː/	o-o	o-n	0.62	moderate to large	$p<0.001$
		isolation	0.58	moderate	$p<0.001$
/ɛ/	ħ-n	o-ħ	1.47	large	$p<0.001$
	ʕ-n	o-ħ	1.46	large	$p<0.001$
		o-o	0.71	moderate to large	$p<0.001$
	o-ħ	o-n	0.68	moderate to large	$p<0.001$
		o-o	0.45	moderate	$p<0.001$
/aː/	o-ħ	n-n	1.30	large	$p<0.001$
		o-n	1.01	large	$p<0.001$
		ʕ-n	1.42	large	$p<0.001$
		o-o	0.80	large	$p<0.001$
		isolation	0.82	large	$p<0.001$
	o-ʕ	n-n	1.66	large	$p<0.001$
		o-n	1.54	large	$p<0.001$
		n-ħ	1.35	large	$p<0.001$
		ʕ-n	1.77	large	$p<0.001$
		o-o	1.49	large	$p<0.001$
		isolation	1.76	large	$p<0.001$
	o-n	isolation	0.47	moderate	$p<0.001$
/ʌ/	o-ħ	o-ʕ	1.36	large	$p<0.001$
/uː/	o-ħ	n-n	1.23	large	$p<0.001$
		o-n	1.87	large	$p<0.001$
		o-o	0.96	large	$p<0.001$
		isolation	1.60	large	$p<0.001$
	o-ħ	n-n	1.70	large	$p<0.001$
		o-n	2.33	large	$p<0.001$
		n-ħ	1.80	large	$p<0.001$
		o-o	1.29	large	$p<0.001$
		isolation	1.93	large	$p<0.001$
/ʊ/	o-ħ	oral	2.48	large	$p<0.001$
/ɔː/	o-ħ	n-n	1.50	large	$p<0.001$
		ħ-n	1.09	large	$p<0.001$
		isolation	0.95	large	$p<0.001$

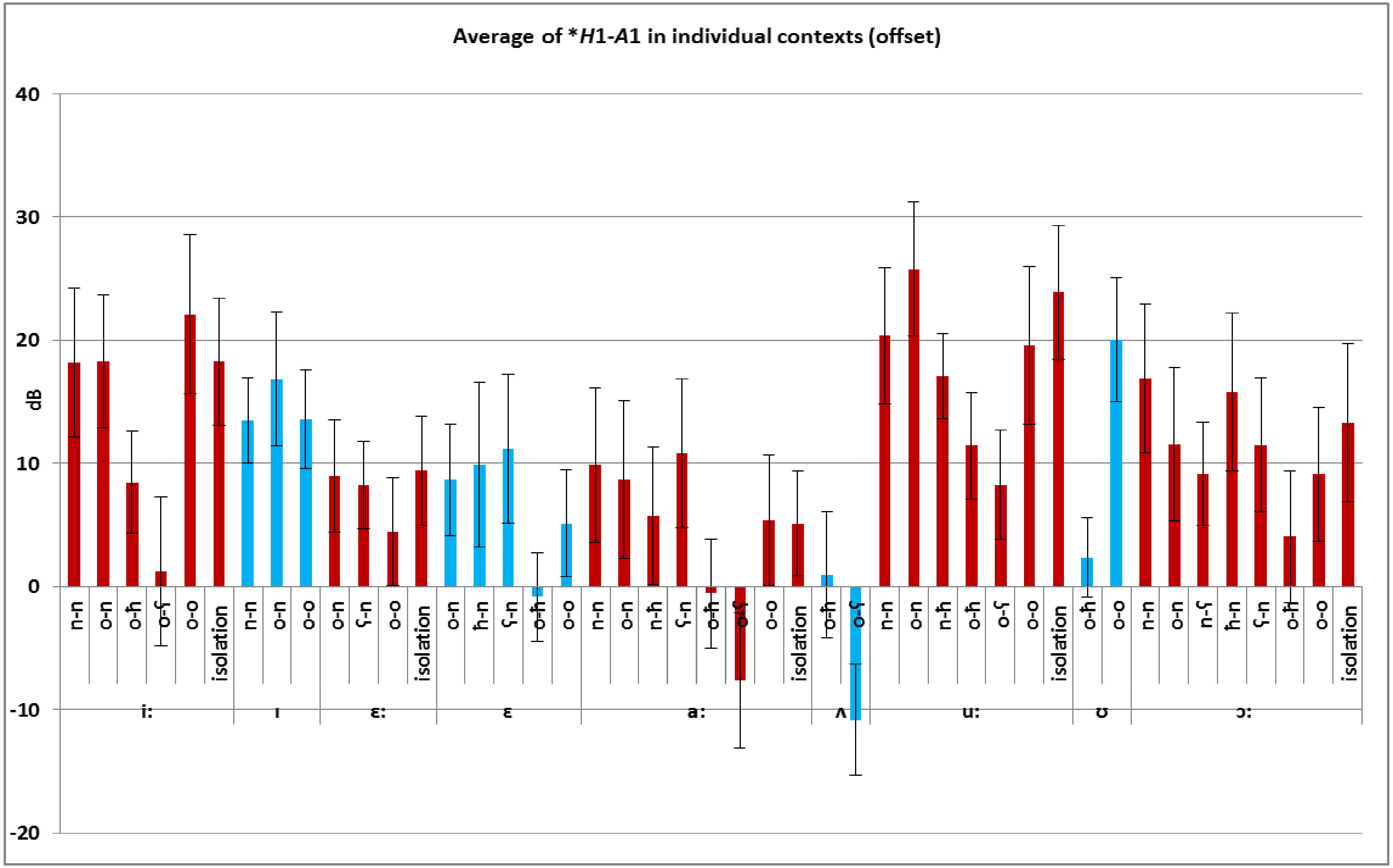


Figure 10.10: *H1-*A1 values within individual contexts at offset.

/a:/: A one-way ANOVA reveals a significant effect of individual contexts on *$H1$-$A1$ values containing vowel /a:/ at offset with a moderate effect size (F (7, 495) = 8.942, p<0.001, η_p^2 = 0.114). Bonferroni post-hoc analysis reveals o-ħ context as having a significantly lower *$H1$-$A1$ value than each of n-n, o-n, ʕ-n, o-o and isolation contexts; o-ʕ context and each of n-n, o-n, n-ħ, ʕ-n, o-o and isolation contexts; and o-n context having a significantly higher value than isolation context. There are no significant differences between contexts o-ħ and o-ʕ but they show a tendency for o-ʕ to show more laryngealisation.

/ʌ/: An independent-samples t-test was applied and reveals a significant difference (t (24) = 3.123, p<0.001) between o-ħ and o-ʕ contexts on *$H1$-$A1$ values for vowel /ʌ/ at offset with context o-ʕ showing more laryngealisation than o-ħ.

/u:/: A one-way ANOVA reveals a significant effect of individual contexts on *$H1$-$A1$ values containing vowel /u:/ at offset with a large effect size (F (6, 232) = 9.589, p<0.001, η_p^2 = 0.203). Bonferroni post-hoc analysis reveals o-ħ context as having a significantly lower *$H1$-$A1$ value than each of n-n, o-n, o-o and isolation contexts; and o-ʕ context having a significantly lower value than each of n-n, o-n, n-ħ, o-o and isolation contexts. There are no significant differences between contexts o-ħ and o-ʕ but they show a tendency for o-ʕ to have more laryngealisation.

/ʊ/: An independent-samples t-test was applied and reveals a significant difference (t (15) = 0.398, p<0.001) between o-ħ and o-o contexts on *$H1$-$A1$ values for vowel /ʊ/ at offset with the pharyngeal context showing a lower *$H1$-$A1$ value.

/ɔ:/: A one-way ANOVA reveals a significant effect of individual contexts on *$H1$-$A1$ values containing vowel /ɔ:/ at offset with a small effect size (F (7, 181) = 1.413, p<0.001, η_p^2 = 0.054). Bonferroni post-hoc analysis reveals o-ħ context as having a significantly lower *$H1$-$A1$ value than each of n-n, ħ-n and isolation contexts. Despite the lack of significant differences between ħ-n and ʕ-n contexts they show a a tendency for o-ʕ to have more laryngealisation.

10.3.2.2 *Cross-dialectal differences in vowels*

The same trend as at onset is noted whereby Baghdad shows the lowest *$H1$-$A1$ values indicating laryngealisation the most and Basra the highest *$H1$-$A1$ values (table 10.11, figure 10.11). As for results at onset, values of /u:/ are the overall highest, denoting the least laryngealisation while /ʌ/ shows the overall lowest values.

Table 10.11: Effect size differences and Cohen *d* values for cross-dialectal comparisons of **H1-A1* values at offset.

Vowel	Dialect1	Dialect2	Cohen *d*	effect size	Sig.
/i:/	Basra	Baghdad	1.02	large	*p*<0.001
		Mosul	0.74	moderate	*p*<0.001
/ɪ/	Baghdad	Basra	1.14	large	*p*<0.001
/ɛ:/	Basra	Baghdad	0.91	large	*p*<0.001
		Mosul	0.52	moderate	*p*<0.001
/ɛ/	Baghdad	Basra	1.17	large	*p*<0.001
		Mosul	0.96	large	*p*<0.001
	Basra	Mosul	0.53	moderate	*p*<0.001
/a:/	Baghdad	Basra	1.14	large	*p*<0.001
		Mosul	0.86	large	*p*<0.001
	Basra	Mosul	0.41	moderate	*p*<0.001
/ʌ/	Baghdad	Basra	0.72	moderate to large	*p*<0.001
/u:/	Basra	Baghdad	0.59	moderate	*p*<0.001
		Mosul	0.35	moderate	*p*<0.001
/ʊ/	Baghdad	Basra	0.79	moderate to large	*p*<0.001
/ɔ:/	Baghdad	Basra	1.06	large	*p*<0.001
		Mosul	0.75	moderate to large	*p*<0.001
	Basra	Mosul	0.50	moderate	*p*<0.001

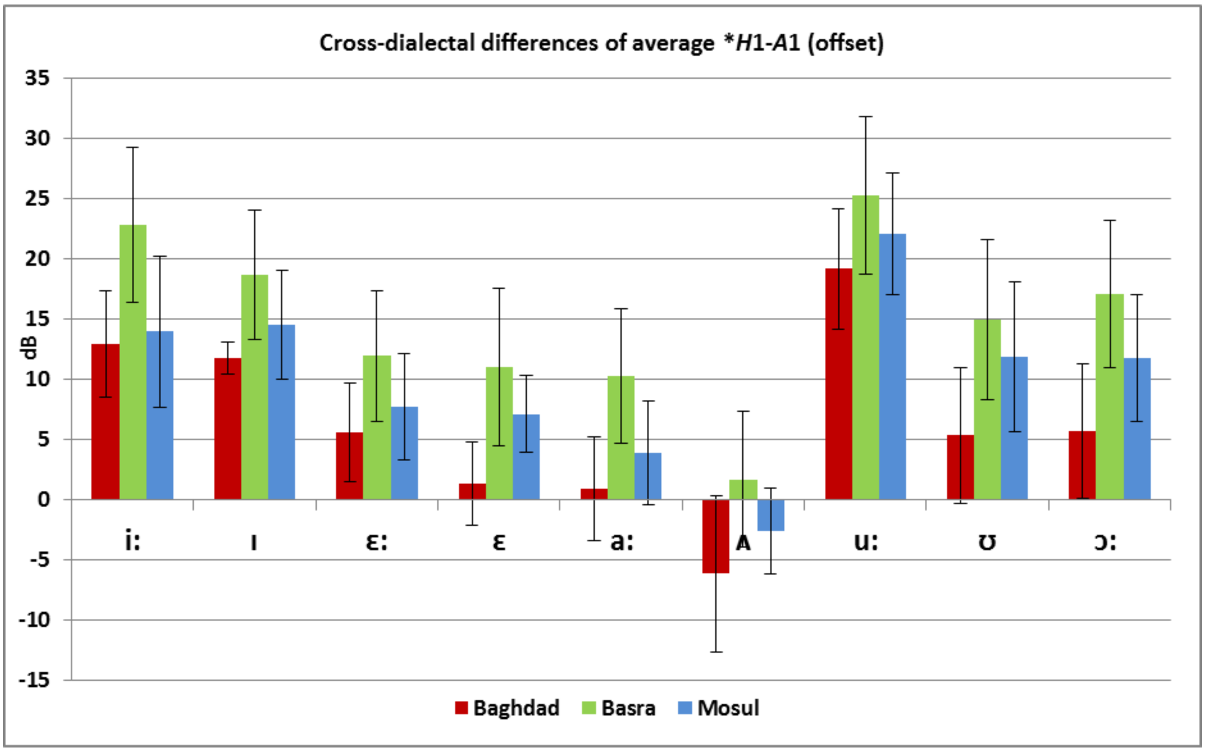


Figure 10.11: Cross-dialectal differences of *H1-A1 values for vowels at offset.

/i:/: A one-way ANOVA reveals a significant effect of cross-dialectal differences on **H*1-*A*1 values within vowel /i:/ at offset with a moderate effect size (F (2, 225) = 20.068, p<0.001, η_p^2 = 0.153). Bonferroni post-hoc analysis reveals Basra as having a significantly higher **H*1-*A*1 value than each of Baghdad and Mosul.

/ɪ/: A one-way ANOVA reveals a significant effect of cross-dialectal differences on **H*1-*A*1 values within vowel /ɪ/ at offset with a large effect size (F (2, 35) = 3.499, p<0.001, η_p^2 = 0.175). Bonferroni post-hoc analysis reveals Baghdad as having a significantly lower **H*1-*A*1 value than Basra.

/ɛ:/: A one-way ANOVA reveals a significant effect of cross-dialectal differences on **H*1-*A*1 values within vowel /ɛ:/ at offset with a moderate effect size (F (2, 160) = 11.628, p<0.001, η_p^2 = 0.128). Bonferroni post-hoc analysis reveals Basra as having a significantly higher **H*1-*A*1 value than each of Baghdad and Mosul.

/ɛ/: A one-way ANOVA reveals a significant effect of cross-dialectal differences on **H*1-*A*1 values within vowel /ɛ/ at offset with a large effect size (F (2, 107) = 14.035, p<0.001, η_p^2 = 0.211). Bonferroni post-hoc analysis reveals significant differences between all three dialects with Baghdad showing the lowest **H*1-*A*1 value and Basra the highest.

/a:/: A one-way ANOVA reveals a significant effect of cross-dialectal differences on **H*1-*A*1 values within vowel /a:/ at offset with a large effect size (F (2, 495) = 65.527, p<0.001, η_p^2 = 0.210). Bonferroni post-hoc analysis reveals significant differences between all three dialects with Baghdad showing the lowest **H*1-*A*1 value and Basra the highest.

/ʌ/: A one-way ANOVA reveals a significant effect of cross-dialectal differences on **H*1-*A*1 values within vowel /ʌ/ at offset with a moderate effect size (F (2, 25) = 1.428, p<0.001, η_p^2 = 0.110). Bonferroni post-hoc analysis reveals Baghdad as having a significantly lower **H*1-*A*1 value than Basra.

/u:/: A one-way ANOVA reveals a significant effect of cross-dialectal differences on **H*1-*A*1 values within vowel /u:/ at offset with a small effect size (F (2, 232) = 7.155, p<0.001, η_p^2 = 0.059). Bonferroni post-hoc analysis reveals Basra as having a significantly higher **H*1-*A*1 value than each of Baghdad and Mosul. Despite non-significant differences between Baghdad and Mosul they show a tendency for Baghdad to have the lowest **H*1-*A*1 value.

/ʊ/: A one-way ANOVA reveals a significant effect of cross-dialectal differences on **H*1-*A*1 values within vowel /ʊ/ at offset with a moderate effect size (F (2, 17) = 0.712, p<0.001, η_p^2 = 0.087). Bonferroni post-hoc analysis reveals Baghdad as having a significantly lower **H*1-*A*1 value than Basra.

/ɔ:/: A one-way ANOVA reveals a significant effect of cross-dialectal differences on **H*1-*A*1 values within vowel /ɔ:/ at offset with a large effect size (F (2, 181) = 19.936, p<0.001, η_p^2 = 0.182). Bonferroni post-hoc analysis reveals significant differences between all three dialects with Baghdad showing the lowest **H*1-*A*1 value and Basra the highest.

10.3.2.3 *Cross-dialectal differences in individual contexts*

Baghdad values are again the lowest and Basra ones the highest (table 10. 12, figure 10.12). Contexts o-ħ and o-ʕ have the lowest overall values denoting the most laryngealisation.

Table 10.12: Effect size differences and Cohen *d* values for cross-dialectal comparisons of **H*1-*A*1 values within individual contexts at offset.

Context	Dialect1	Dialect2	Cohen *d*	effect size	Sig.
n-n	Basra	Baghdad	1.30	large	p<0.001
		Mosul	1.00	large	p<0.001
o-n	Basra	Baghdad	1.27	large	p<0.001
		Mosul	0.96	large	p<0.001
n-ħ	Baghdad	Basra	0.54	moderate	p<0.001
		Mosul	0.55	moderate	p<0.001
n-ʕ	Baghdad	Basra	6.46	large	p<0.001
		Mosul	3.19	large	p<0.001
	Basra	Mosul	3.54	large	p<0.001
ħ-n	Baghdad	Basra	2.25	large	p<0.001
		Mosul	1.79	large	p<0.001
	Basra	Mosul	1.49	large	p<0.001
ʕ-n	Baghdad	Basra	1.91	large	p<0.001
		Mosul	1.27	large	p<0.001
	Basra	Mosul	0.89	large	p<0.001
o-ħ	Baghdad	Basra	0.87	large	p<0.001
		Mosul	0.41	moderate	p<0.001
	Basra	Mosul	0.59	moderate	p<0.001
o-ʕ	Baghdad	Basra	0.55	moderate	p<0.001
o-o	Baghdad	Basra	0.92	large	p<0.001
		Mosul	0.66	moderate to large	p<0.001
solation	Basra	Baghdad	0.61	moderate to large	p<0.001
		Mosul	0.57	moderate	p<0.001

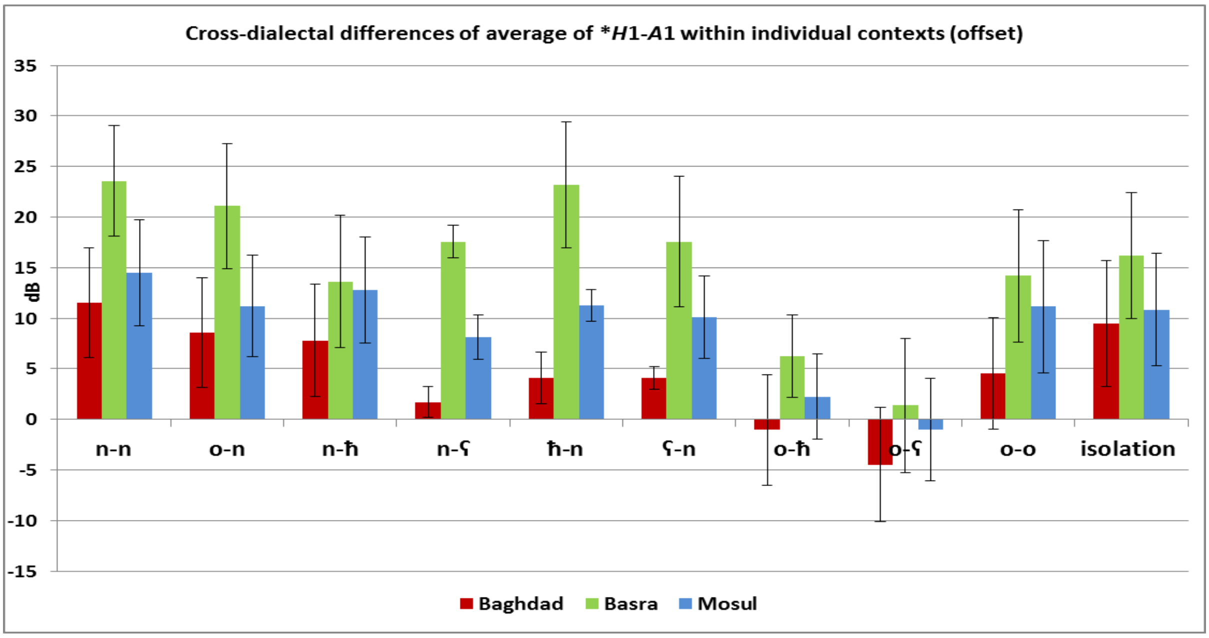


Figure 10.12: Cross-dialectal differences of **H*1-*A*1 values within individual contexts at offset.

n-n: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *$H1$-$A1$ values within context n-n at offset with a large effect size (F (2, 53) = 8.808, p<0.001, $\eta_p^2 = 0.257$). Bonferroni post-hoc analysis reveals Basra as having a significantly higher *$H1$-$A1$ value than each of Baghdad and Mosul. Despite non-significant differences between Baghdad and Mosul they show a tendency for Baghdad to have the lowest value.

o-n: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *$H1$-$A1$ values within context o-n at offset with a large effect size (F (2, 170) = 26.314, p<0.001, $\eta_p^2 = 0.239$). Bonferroni post-hoc analysis reveals Basra as having a significantly higher *$H1$-$A1$ value than each of Baghdad and Mosul. Despite non-significant differences between Baghdad and Mosul they show a tendency for Baghdad to have the lowest value.

n-ħ: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *$H1$-$A1$ values within context n-ħ at offset with a moderate effect size (F (2, 17) = 0.598, p<0.001, $\eta_p^2 = 0.074$). Bonferroni post-hoc analysis reveals Baghdad as having a significantly lower *$H1$-$A1$ value than each of Basra and Mosul. Despite non-significant differences between Basra and Mosul they show a tendency for Basra to have the highest value.

n-ʕ: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *$H1$-$A1$ values within context n-ʕ at offset with a large effect size (F (2, 8) = 32.088, p<0.001, $\eta_p^2 = 0.915$). Bonferroni post-hoc analysis reveals significant differences between all three dialects with Baghdad showing the lowest *$H1$-$A1$ value and Basra the highest.

ħ-n: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *$H1$-$A1$ values within context ħ-n at offset with a large effect size (F (2, 17) = 8.936, p<0.001, $\eta_p^2 = 0.544$). Bonferroni post-hoc analysis reveals significant differences between all three dialects with Baghdad showing the lowest *$H1$-$A1$ value and Basra the highest.

ʕ-n: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *$H1$-$A1$ values within context ʕ-n at offset with a large effect size (F (2, 44) = 12.575, p<0.001, $\eta_p^2 = 0.375$). Bonferroni post-hoc analysis reveals significant differences between all three dialects with Baghdad showing the lowest *$H1$-$A1$ value and Basra the highest.

o-ħ: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *$H1$-$A1$ values within context o-ħ at offset with a moderate effect size (F (2, 116) = 8.493, p<0.001, $\eta_p^2 = 0.130$). Bonferroni post-hoc analysis reveals significant differences between all three dialects with Baghdad showing the lowest *$H1$-$A1$ value and Basra the highest.

o-ʕ: A one-way ANOVA reveals a significant effect of cross-dialectal differences on *$H1$-$A1$ values within context o-ʕ at offset with a small effect size (F (2, 43) = 1.220, p<0.001, $\eta_p^2 =$

0.056). Bonferroni post-hoc analysis reveals Baghdad as having a significantly lower **H*1-*A*1 value than Basra.

o-o: A one-way ANOVA reveals a significant effect of cross-dialectal differences on **H*1-*A*1 values within context o-o at offset with a moderate effect size (F (2, 235) = 16.069, p<0.001, η_p^2 = 0.121). Bonferroni post-hoc analysis reveals Baghdad as having a significantly lower **H*1-*A*1 value than each of Basra and Mosul. Despite non-significant differences between Basra and Mosul they show a tendency for Basra to have the highest **H*1-*A*1 value.

Isolation: A one-way ANOVA reveals a significant effect of cross-dialectal differences on **H*1-*A*1 values within context isolation at offset with a moderate effect size (F (2, 773) = 29.184, p<0.001, η_p^2 = 0.070). Bonferroni post-hoc analysis reveals Basra as having a significantly higher **H*1-*A*1 value than each of Baghdad and Mosul. Despite non-significant differences between Baghdad and Mosul they show a tendency for Baghdad to have the lowest **H*1-*A*1 value.

10.3.2.4 *Discussion of the H1*-A1 measure results at offset*

Overall results of measuring **H*1-*A*1 at offset are similar to those at onset. Non-nasal pharyngeal contexts have the overall lowest **H*1-*A*1 values. In nasal pharyngeal contexts, on the other hand, there would be a lowering of values within nasal-pharyngeal contexts but none in pharyngeal-nasal ones, which on their part show high **H*1-*A*1 values. At offset, there is a change of results within oral and isolation contexts whereby they do not show the same behaviours as at onset, with isolation showing laryngealisation, and oral showing less or no laryngealisation; and instead they show no trend or pattern. In individual pharyngeal contexts, those containing pharyngeal /ʕ/ have lower values than those containing pharyngeal /ħ/ indicating more laryngealisation in /ʕ/ contexts (table 10.17, figure 10.17). Cross-dialectal comparisons show the same trend as at onset whereby Baghdad has the lowest **H*1-*A*1 values indicating laryngealisation and Basra the highest values. Also similar to results at onset, vowel /u:/ has the overall highest values denoting the least laryngealisation.

10.3.3 Summary of *H*1*-*A*1 measure

Similar to results of measuring **H*1-**H*2, overall results of measuring **H*1-*A*1 has shown a number of findings which mainly show it distinguishing between pharyngeal and non-pharyngeal contexts. Accordingly, pharyngeal contexts showed the lowest overall values indicating the most laryngealised while nasal contexts showed the highest. These results coincide with those of the auditory impression of laryngealisation and those of the **H*1-**H*2 low values also indicating laryngealisation. These same results apply to cross-dialectal comparisons whereby Baghdad showed the overall lowest *H1-A1 values similar to the low *H1-*H2 values indicating laryngealisation, and Basra the highest. Furthermore, contexts containing pharyngeal /ʕ/ showed more laryngealisation than those containing /ħ/. In comparing the vowel portions, results showed that pharyngeal consonants have a progressive effect of laryngealisation similar to other investigated effects. Other results showed that non-pharyngeal nasal contexts had the least laryngealisation; contexts containing pharyngeal /ħ/ which were noted as imposing more nasalisation and less pharyngealisation than those containing pharyngeal /ʕ/ have also shown less laryngealisation.

10.4 Summary of Chapter 10

All results thus far suggest that pharyngeal contexts have low H1*–A1 and *H1-*H2 values, denoting laryngealisation, and low A1-*P1 and high B1 values, denoting nasalisation. These results rule out the possibility that what is labelled as nasalised is in fact breathy phonation masked as nasalisation. Baghdad speakers show these results the most and their speech is generally accompanied by more laryngealisation and nasalisation than Basra and Mosul speakers, regardless of the context looked at. Other results showed that laryngealisation, like nasalisation and pharyngealisation, has a progressive effect on vowels; and that pharyngeal /ʕ/ triggers more laryngealisation in neighbouring vowels than pharyngeal /ħ/.

Chapter 11 : Summary and Discussion

11.1 Overview and significance of the study

This study has brought together areas of investigation that have never been explored within a single study before. It provided a detailed account of IA, its classifications into sub-dialects and sound inventory, with particular focus on the production of pharyngeal consonants as produced by nine speakers of three dialects, each representing a major dialect group: Mosul, representing Northern Iraqi, Baghdad, representing Central, and Basra, representing Southern. This was the first investigation to present a typology of realisations for the pharyngeal consonants which vary according to word position and dialect, and to look at accompanying voice quality features in their production. The aim was to shed light on potential links between pharyngeal production and nasalisation on the one hand, and sporadic suggestions that the Iraqi dialect is nasalised and that speakers of the *gelet* dialect group have a guttural quality on the other (Bellem, 2007).

Results showed that the presence of pharyngeals in a nasal context increases the nasalisation effect on neighbouring vowels, and that pharyngeal contexts do indeed show traces of nasalisation compared with oral contexts. Iraqi Arabic was not found to have a nasalised VQ; dialectal differences did, however show a tendency for Baghdadi to exhibit more nasalisation than the other two dialects examined here, providing a potential impetus for a future investigation. Baghdadi Arabic also exhibited more creaky phonation and more pharyngealisation than the other two dialects, providing the first set of evidence for potential VQ differences across dialects in Arabic.

11.2 Review of Aims and Purpose of Study

This study aimed to **a)** provide a comprehensive account of pharyngeal consonant realisation in IA, **b)** test whether the production of these consonants is accompanied with nasalisation and/or laryngealisation, **c)** find out if there are any correlations between certain realisations and accompanying voice quality features, and finally **d)** explore whether these voice quality features are restricted to pharyngeal contexts or are more general properties of voice quality within and across dialects of IA. These aims were motivated by sporadic findings in the literature suggesting more variability of pharyngeal consonant realisations in IA than in those produced by other Arabic dialects (Blanc, 1964; Al-Ani, 1970; Ghazeli, 1977; MacCurtain, 1981; Ingham, 1982; Laradi, 1983; Butcher and Ahmad, 1987; Abu-Haidar, 1991; Esling, 1999; Esling, 2005;

Heselwood, 2007; Bellem, 2007; Hassan et al, 2011) and connecting pharyngeals with nasalisation (Rabin, 1951; Hetzron, 1969; Laradi, 1983; Butcher and Ahmad, 1987) and laryngealisation (Ghazeli, 1977; Laufer and Condax, 1979; Butcher and Ahmad, 1987; Zeroual et al., 2008; Heselwood, 2007). These findings have led to anecdotal references to Iraqi Arabic as having an overall nasal and guttural quality, but to-date no study has investigated these claims.

In previous studies, pharyngeal /ʕ/ in IA was reported to be either realised as an approximant or a fricative, with sporadic occurrences of stop-like realisations; Al-Ani (1970)'s study is the only one to report stops as common allophones of /ʕ/. None of the mentioned studies here or in Chapter 5 have found the three realisations produced within the same dialect. Furthermore, nasalisation and laryngealisation are not known to be common features accompanying the articulation of pharyngeal consonants. However, early studies on nasalisation in connection to pharyngeal consonants (Rabin, 1951; Hetsron, 1969) have highlighted instances of language change whereby nasal consonants were found in positions which used to contain pharyngeal consonants (see Chapter 5). These findings were also supported by instrumental investigations suggesting a lowering of the velum during the production of these consonants by an IA speaker. A few following studies found a lowering of the velum but with no audible nasalisation (Laradi, 1983; Butcher and Ahmad, 1987) while others like Ghazeli (1977) failed to find that lowering. In fact, Ghazeli (1977) rejected the idea altogether, suggesting that even if producing a constriction in the pharynx requires a downward movement of the tongue, that movement will not be enough to pull the velum to the extent of forming a velopharyngeal opening. Ghazeli (ibid) further states that if there is audible nasalisation it would be due to a peculiar pattern of vibrations of the vocal folds and not due to a lowering of the velum. Laryngealisation has also been associated with the articulation of pharyngeal consonants but not all their realisations or in all word-positions. Some researchers found that laryngealisation is typical of stop or stop-like realisations of pharyngeals (Laufer and Condax, 1979; Heselwood, 2007; Bellem, 2007); others found laryngealisation in final word positions (Butcher and Ahmad, 1987), while others still report on laryngealisation when pharyngeals are in initial position and *not* realised as stops (Bellem, 2007).

11.3 Review of Research Questions

To investigate claims of different pharyngeal realisations in addition to accompanying nasalisation and laryngealisation, the present study set out to answer the following questions (Chapters 1 and 6):

1- *What are the auditory and acoustic properties of pharyngeal consonants in Iraqi Arabic and are they coupled with nasalisation and laryngealisation as is suggested in the literature?*

2- *Are nasalisation and laryngealisation voice quality features of Iraqi speakers?*

3- *Does degree of nasalisation and laryngealisation vary between the three linguistic areas of Iraq, i.e. northern, central, and southern?*

Q1) ***What are the auditory and acoustic properties of pharyngeal consonants in Iraqi Arabic and are they coupled with nasalisation and laryngealisation as is suggested in the literature?***

A detailed auditory and acoustic study of pharyngeal consonants in IA and of vowels in various nasal, pharyngeal and oral contexts was carried out. Data consisting of 206 monosyllabic words embedded within a carrier sentence were elicited from nine male speakers of three Iraqi dialects: Baghdad (representing Central *gelet*), Basra (representing Southern *gelet*) and Mosul (representing Northern *qeltu*). The target words were of a CVC structure with C being one of: a nasal /m, n/, a pharyngeal /ħ, ʕ/, or any other consonants referred to as oral; and V being one of: long vowels /i:, ɛ:, a:, u:, ɔ:/ and short vowels /ɪ, ɛ, ʌ, ʊ/. Vowels in isolation were also examined. Three portions of the vowel were investigated in order to trace changes near consonants (onset, offset) and within the steady-state (midpoint). Nasalisation and phonation measures were then applied in nasal, oral, pharyngeal and isolated vowel environments in order to unravel the source of nasalisation and creaky voice (laryngealisation) and to establish whether their manifestations are categorial or particular to certain contexts.

The auditory analysis was carried out first and offered an impressionistic profile of the pharyngeal consonants in IA indicating if a connection exists between their realisations and other VQ settings, mainly nasalisation and laryngealisation. The acoustic investigation involved a number of measures, the results of which were compared with the auditory results. To investigate nasalisation, five acoustic measures were applied: *A*1-**P*1, *A*1-**P*0, *B*1, *F*1/*F*2 and *overall vowel intensity*. To investigate phonation types, two acoustic measures were applied: **H*1-**H*2 and **H*1-*A*1The answer to this question required conducting a review of the literature on Iraqi Arabic (Chapter 2) and of the description of pharyngeal consonants as produced by Iraqi speakers as well as speakers of other Arabic dialects and languages (Chapter 5). The review was followed by an investigation to obtain a description of the two pharyngeals, to create a profile of their different realisations, and to find out if nasalisation and creaky phonation (laryngealisation) are features accompanying their production. this By doing so, this study is the first of its kind to contribute in offering such a detailed quantification of variation in the realisation of pharyngeal consonants as a function of phonological context. Results of the auditory and acoustic examinations of the pharyngeal consonants showed that they have three main realisations: approximant, fricative and stop, with overall prevalence of approximants (Chapter 7). The occurrence of a certain realisation was related to: **a)** word position, with approximant realisations mostly found in initial position and stop realisations in final position; and **b)** dialect, with Basra speakers producing the highest proportion of approximants and Baghdad and Mosul speakers producing the highest proportion of stops.

To investigate nasalisation, auditory analysis (Chapter 8) and five acoustic measures_ $A1\text{-}{*}P1$, $A1\text{-}{*}P0$, $B1$, $F1/F2$ and *overall vowel intensity* (Chapter 9) were applied. Results showed a strong connection between pharyngeal consonants and nasalisation, whereby nasalisation considerably increased when pharyngeals were combined with nasal consonants, exceeding nasalisation in other nasal contexts. Also, pharyngeals within non-nasal contexts showed more nasalisation than oral and isolation contexts. The results showed nasals and pharyngeals to have progressive effects of nasalisation on vowels, and vowels neighbouring /ħ/ to exhibit more nasalisation than those neighbouring /ʕ/. However, not all measures functioned equally well as nasalisation measures due to their sensitivity to the consonantal and vocalic environments under investigation and to the sometimes opposing effects of nasalisation and pharyngealisation on vowels. For instance, while $A1\text{-}{*}P1$ and $B1$ served as good indicators of nasalisation, the $A1\text{-}{*}P0$ measure was sensitive to changes in $F1/F2$ frequencies in the environment of pharyngeal consonants, which conflicted with expected changes from neighbouring nasals and led to results from both $A1\text{-}{*}P0$ and $F1/F2$ measures to reflect the effect of pharyngealisation rather than nasalisation. The same was true for *overall vowel intensity* measures, which are normally reflected by low values in nasal contexts but high values in pharyngeal contexts.

To investigate phonation types, two acoustic measures were used: ${*}H1\text{-}{*}H2$ and ${*}H1\text{-}A1$. Results showed consistency between auditory and acoustic findings and between individual and dialect-specific contexts whereby: a) pharyngeal contexts showed laryngealisation the most; b) laryngealisation was progressive, and c) pharyngeal /ʕ/ showed more laryngealisation than /ħ/. Isolation contexts exhibited low ${*}H1\text{-}{*}H2$ and ${*}H1\text{-}A1$ values similar to pharyngeal contexts, indicating laryngealisation.

Q2) ***Are nasalisation and laryngealisation voice quality features of Iraqi speakers?***

To answer this question an an investigation of nasalisation and laryngealisation was required to determine if they are merely associated with pharyngeal consonants or are voice quality features of IA speakers in general. The majority of results within oral and isolation contexts showed less nasalisation than other contexts. When comparing nasal, pharyngeal (nasal and non-nasal), oral and isolation contexts results showed that the nasal pharyngeal contexts had the most nasalisation followed by other nasal, pharyngeal (non-nasal) and the least were oral and isolation. These results coincide with expectations that oral and isolation contexts would be the least likely to show nasalisation. Therefore, results obtained within these contexts have shown nasalisation coinciding with certain speech segments and not a general feature of IA speakers. Vowels in isolation were accompanied with auditory creak and exhibited low *intensity* but no nasalisation.

Results of measuring phonation types showed isolation and pharyngeal contexts to have the highest degree of laryngealisation. Oral contexts, on the other hand showed similar results to nasal contexts in terms of lower levels of laryngealisation. These results coincide with those of Chapter 8, whereby isolation contexts were perceived as having high levels of laryngealisation and oral ones of the least; the results also coincide with those of Chapter 9 whereby isolation contexts also had low levels of *overall vowel intensity* also indicating high levels of laryngealisation. Results from the isolation and other contexts examined here suggest a general profile of VQ features of IA that is not nasalised but rather laryngealised. However, our speakers were all males so these results need to be interpreted with caution as they might be representing gender- or sex-specific phonation features as is noted in Klatt and Klatt (1990), Hanson and Chuang (1999) and Simpson (2012).

Accordingly, establishing an association between the production of pharyngeal consonants and the two mentioned voice quality features, nasalisation and laryngealisation, is a major contribution to knowledge in the area of phonetic realisations of pharyngeal consonants. Moreover, results of investigating nasalisation contribute to other studies of nasalisation in that they shed light on the fact that this feature may be dialect specific. The study helps to highlight how nasalisation functions in Iraqi Arabic, first in terms of it being progressive rather than regressive as many findings in the literature suggest, and then in terms of it being related to the production of two consonants that most researchers would not characterise as having additional features in their production. The study also sheds light on the fact that even if there is velum lowering during the production of pharyngeal consonants the result does not necessarily have to be perceived as nasalised. This suggests that the mechanism used when producing these consonants may have an impact on the lowering of the velum but not necessarily enough for the resulting production to be perceived as nasalised.

Q3) ***Does degree of nasalisation and laryngealisation vary between the three linguistic areas of Iraq, i.e. northern, central and southern?***

Nasalisation and laryngealisation were investigated in relation to the three geographical areas, represented by the three dialects of Baghdad, Basra and Mosul. Results showed that Baghdad speech exhibited nasalisation the most and Basra speech the least. Baghdad also had the highest *A*1-**P*0 and *intensity* values indicating pharyngealisation, the most and the highest levels of laryngealisation both from an auditory (Chapter 8) and acoustic point of view (Chapter 10). Therefore, laryngealisation, pharyngealisation and nasalisation are profile features of Baghdad speakers. Basra speakers exhibited the least nasalisation (high *A*1-**P*1 values), pharyngealisation (low *A*1-**P*0 and intensity), and laryngealisation (high **H*1-**H*2 and **H*1-*A*1 values). Only for the B1 measure did Mosul show the lowest values. These dialectal differences highlight the third contribution of the present study, which is that this is the first study to display cross-dialectal differences across speakers of three dialects of Iraqi Arabic in their realisation of the two pharyngeal consonants. Previous research has only made generalisations on results obtained in as far as how the pharyngeal consonants are realised by Iraqi speakers in general with no attempts to compare across speakers of different dialects or dialectal groups.

Therefore, overall results showed that nasalisation is found in nasal and pharyngeal contexts but not in isolation and oral contexts. These results indicate that nasalisation is context-specific (found within nasal and pharyngeal contexts) and local-dialect specific (a feature of Baghdad speakers) but not a feature of the general IA dialect. However, laryngealisation results showed to be context specific (found within pharyngeal contexts), dialect-specific (a feature of Baghdad speakers) and to some extent a general feature of the IA speakers participating in this study (indicated by isolated vowels).

11.4 Summary of results and evaluation of measures

11.4.1 Variation in the realisations of pharyngeal /ʕ/

Results from the acoustic and auditory analysis of pharyngeal consonants as produced by IA speakers showed that while /ħ/ is realised as a voiceless pharyngeal fricative, /ʕ/ has a range of realisations including an approximant, a fricative and a stop. The categories, however, were not mutually exclusive; rather a combination of features sometimes occurred within the same token, leading to a profile of realisations ranging from more approximant-like to more stop-like patterns, with a graded continuum rather than a categorical pattern. Although all three main realisation types were produced in both initial and final positions, approximants showed more prevalence in general and in initial position in particular (63% out of 118 tokens in total), while stops were more common in final position (75% of out 83 tokens in total) (table 7.1). It was also noted that irrespective of main realisation context, i.e. approximant, fricative, or stop, all three realisations are coupled with stop-like/creak-like features (Chapter 7). These results do not agree with Al-

Ani's (1970) findings, which showed that stop realisations for /ʕ/ prevail over other realisations in IA; but to some extent agree with those of Butcher and Ahmad's (1987) results (also on IA), who found that pharyngeal consonants were realised as approximants which had a stop release in final position. Our results also agree with other findings in the literature which suggest that IA /ʕ/ is mostly realised as an epiglottal stop in final word position, particularly in careful speech (Esling, 1999; Esling, 2005; Edmondson et al, 2005; Edmondson et al, 2007); when not realised as a stop /ʕ/ has been found to be "at least creaky" in initial word position (Bellem, 2007: 141). The auditory investigation of the present study showed more impressions of laryngealisation accompanying stop realisations although in many instances creaky voice was a feature of all three realisations. Comparisons of changes in frequencies of $F1$ and $F2$ on following vowels showed that both pharyngeals had the same effect, with a general rise in $F1$ in all vowels indicating a more open quality, a drop in $F2$ in front vowels /iː, ɪ, ɛː, ɛ/ indicating a more back quality, and a rise in $F2$ in back vowels /uː, ʊ, ɔː/ indicating a more front quality. Central vowel /aː/ showed a rise in $F1$, suggesting a more open quality but no significant changes in $F2$. These changes coincide with those suggested by Al-Ani (1970) and Butcher and Ahmad (1987).

11.4.2 Auditory and acoustic results of nasalisation

Before going into details of results of these auditory and acoustic results, there is a need for a reminder of all measures applied and how they were assessed. The auditory analysis was based on categorising perceived nasalisation along the following continuum: very nasalised (very), little nasalisation (little), no nasalisation (none). The acoustic investigation applied five measures. The values resulting from the $A1$-$*P1$ and $A1$-$*P0$ measures were interpreted as follows (see Chen 1995, 1997, 2000; Chen et al. 2000, 2007; and Berger 2007): the lower the resulting values the more nasalisation the context was considered to be, with phonological nasal contexts expected to have the lowest of all values, the oral and isolated vowel contexts the highest, and the pharyngeal and pharyngeal-nasal as the experimental ones. Following Chen et al. (2000), a difference of less than 10 dB was considered as indicative of the vowel being nasal (see Chapter 4). The second measure of nasalisation is that of $B1$, whereby an increase to the range 200-300Hz was considered as indicative of the presence of nasalisation. This measure was interpreted with caution and together with the $*H1$-$A1$ results, as $B1$ is also used to examine phonation types and the amount of glottal opening (glottal chink). An increase in $B1$ would lead to an increase of the $*H1$-$A1$ value, suggesting breathiness. Therefore, the increase of $B1$ could indicate either effect but in view of a number of cues and findings we were able to decide whether the effect is triggered by nasalisation, breathiness or both. The fourth nasalisation measure was that of the $F1$/$F2$ frequency change, or more accurately changes in $F1$ mainly as is preferred in most of the literature, an to a lesser extent in *F*2. The changes depend on type of vowel with a drop in *F*1 expected in low vowels and a rise in high vowels; while *F*2 is expected to rise in low vowels and drop in high ones. The last acoustic measure of nasalisation is that of *overall vowel intensity,* where a drop in the value is suggested to be indicative of nasalisation.

11.4.2.1 ***Auditory results of nasalisation***

Results of the auditory impression of nasalisation showed a distinction between nasal and non-nasal contexts; nasal pharyngeal contexts had similar perceived nasalisation to other nasal contexts; non-nasal pharyngeal contexts had more perceived nasalisation than oral and isolation contexts; nasal-oral context had more perceived nasalisation than oral-nasal, suggesting a progressive effect of nasalisation; nasalisation increased when there are two nasals, when a nasal is combined with a pharyngeal (irrespective of position or type of pharyngeal), when a nasal is initial and combined with a final oral, when a pharyngeal is initial and combined with a final oral. These results group pharyngeal contexts with nasal contexts (regardless of degree of nasalisation) because they all show more nasalisation than oral and isolation contexts. This coincides with impressionistic views of Arabic pharyngeal consonants as being produced with accompanying nasalisation (Hetzron, 1969). Nasalisation was found to be segment-specific and not a general feature of IA. However, there were cross-dialectal differences in perceived nasalisation, with Baghdad being perceived as the most nasalised and more interestingly, with nasalisation in this dialect extending to other contexts. This finding may explain why speakers of other IA dialects often describe the Baghdad dialect as involving an over-use of nasalisation. It may also explain why speakers of other Arabic dialects find IA to be nasalised since most speakers investigated were from Baghdad.

It was a presupposition by the present researcher that the nasalisation accompanying the production of pharyngeal consonants is due to the stop or stop-like realisations of IA pharyngeals, which differentiates them from those of many other Arabic dialects. An explanation would be that a full closure somewhere in the pharynx would lead to force together the two articulators responsible for the closure. According to findings in the literature, the epiglottis is the place of articulation of IA pharyngeal consonants; therefore the epiglottis and the wall of the pharynx come together to form a closure. This closure would pull other parts of the vocal apparatus attached to the upper part of the pharynx, particularly the back of the tongue and velum. The tighter the constriction the lower the velum is pulled. This pulling of the velum results in opening the velopharyngeal passage enabling nasal airflow to pass and in effect results in nasalisation. This explanation could be true of the Baghdad speakers since their productions were accompanied by the highest degree of perceived nasalisation as well as the highest number of stop realisations. However, results of pharyngeal consonants by Mosul speakers showed stop realisations similarly prevailing over other realisations but speakers showed lower levels of nasalisation than for Baghdad but more than those of Basra. Furthermore, other results showed no significant differences connecting certain realisations of pharyngeal /ʕ/ and the auditory impressions of nasalisation, suggesting other factors are at play.

Laver (1980: 46-47) offers a further explanation as to how pharyngeal consonants could be accompanied by nasalisation: other than the two constrictions of the middle of the pharynx (pharyngalised voice) and of the lower pharynx and upper larynx (laryngo-pharyngalised voice), other physiological and acoustical occurrences tend to accompany any constriction in the pharynx such as a lowering of the larynx leading to a breathy-like phonatory setting; and because the velum is attached to the tongue by the palatoglossus muscle, the velum tends to be pulled downwards resulting in some nasalisation.

11.4.2.2 *Acoustic results of nasalisation*

Overall investigations of acoustic measures of nasalisation showed a number of results which will be presented below in relation to each individual measure.

1- ***The A1-*P1 measure***

The *A*1-**P*1 measure of nasalisation distinguished between nasal and non-nasal contexts and showed the following: pharyngeal consonants, whether occurring with nasal or oral consonants, have a lowering effect on the value of *A*1-**P*1, showing even lower values than for contexts containing two nasals or a nasal and an oral; this is irrespective of vowel type. This indicates that nasal pharyngeal contexts exhibit nasalisation the most regardless of the position of the nasal and pharyngeal consonants. One reason for this might be that both nasal and pharyngeal production is accompanied by velum lowering. Therefore when the two consonants are combined in one context, the velum is lowered further than it usually does in the environment of either consonant.

When measuring *A*1-**P*1, there was a difference between vowel types with regards to which ones showed distinctions between nasal and non-nasal contexts and which ones did not. This result coincides with findings of Chen (1997, 2000) and Chen et al. (2000, 2007) who showed that vowel type has an impact on the appearance of the extra peak above *F*1, hence the use of the *A*1-**P*1 measure. Accordingly, there are vowels (/iː, ɪ, ɛː, ʊ, uː/) with overall high *A*1-**P*1 values and others (/ aː, ʌ, ɔː/) with overall low values. This would be explained in light of the distance between the first formant frequencies. This distance is very big in the first set of vowels, so when a prominent peak appears one can be confident that is it due to the effect of nasalisation; but in the case of vowels /a:, ʌ, ɔ:/ and, with less effect, vowel /u:/, the distance is small(er), sometimes down to one or two harmonics in between formants. This small distance leads to any extra peak appearing between the two formants being due to formant influence even if a normalisation procedure is applied to decrease the effect of formants. This could be explained in light of Amino and Osanai (2012)'s findings that low *A*1-**P*1 values in vowels like / a:, ʌ, ɔ:/ and to some extent /u:/ were caused by the two formants becoming close to each other and enhancing the amplitude of the extra peak *P*1, leading to a lowering of the value of *A*1-**P*1 (ibid: 99). The *A*1-**P*1 measure was applied to all vowels in the present study due to the fact that this is the first attempt to carry out such an investigation on IA in addition to the variety of consonants used in this study. However, findings have shown that a distinction should be made in future research.

Other *A*1-**P*1 results show both nasals and pharyngeals as having a progressive effect on nasalisation: when there are two nasal consonants more than when there is one in final position; when the nasal is in initial position combined with a final oral; when pharyngeal consonants are in initial position more than when they were in final position. The first result in the case of nasals also coincides with that of the auditory impression of nasalisation. This result is surprising, given that it is more common to have a regressive effect of nasalisation in other languages. In fact researchers like Delattre (1962: 1142) believe that "nondistinctive nasalisation of vowels, whenever it occurs, in any language, is often due to the following consonant, never to the preceding one". Ferguson (1975: 181) states that the universal tendency is for the spread of nasality from one segment to the other, particularly in vowels preceding a nasal consonant. However, despite what would seem as a universal tendency, Clumeck (1975) believes there are significant variations of details between languages which contain patterns that are phonologically specific to them.

When looking at more detailed results of the *A*1-**P*1 measure, we find that vowels neighbouring pharyngeal /ħ/ showed more nasalisation than those neighbouring /ʕ/. This result coincides with findings of Butcher and Ahmad (1987), who found nasal airflow in the production of /ħ/ by one of their three Iraqi speakers. This could be explained in light of findings by Laradi (1983: 126), who found /ħ/ to be produced with a less constricted velum than /ʕ/ during the speech of her Libyan and Yemani speakers (ibid: 126). In a detailed comparison of the two pharyngeals in Libyan Arabic, Laradi (ibid: 123) found the tongue for /ħ/ was slightly lowered, the root of the tongue retracted towards the back of the pharynx, causing a narrowing at the oropharyngeal cavity and creating a constriction between the epiglottis and the pharyngeal wall. /ħ/ was also accompanied with larynx raising, jaw lowering, and velum raising. However, only a small part of the velum was partially in contact with the nasopharynx while the rest of it seemed to be away from it. In /ʕ/, there was not much difference in the shape of the tongue; the jaw was also lowered; the root of the tongue was horizontally displaced; the constriction between the root of the tongue and the back wall of the pharynx was greater at the level of the epiglottis, but not as great as that for /ħ/ (ibid: 126). The larynx was raised higher in /ʕ/ than in /ħ/, creating a narrower laryngo-pharyngeal cavity for /ʕ/ than for /ħ/. This greater constriction in /ʕ/ in Laradi's (ibid) findings could explain why it is realised as a stop as well as having more laryngealisation than /ħ/.

The present study showed that only contexts containing nasal and pharyngeal consonants have accompanying nasalisation, not the overall IA dialect, because nasalisation increased in these contexts, especially pharyngeal ones, but not in oral and isolation ones. However, results of particular sub-dialects of IA showed otherwise, as will later be discussed.

2- *The B1 measure*

*B*1 results showed a tendency to distinguish between nasal and non-nasal contexts, whereby the former have higher *B*1 values. This result is similar to that of *A*1-**P*1 with regards to nasal contexts containing pharyngeals showing nasalisation the most. However, pharyngeal oral contexts showed low *B*1 values that were similar to non-nasal contexts, whether the pharyngeal was initial or final. Generally, the *B*1 measure results were able to significantly differentiate between nasal and non-nasal contexts in three vowels /a:, u:, ɔ:/. Vowels /i:, ɪ, ɛ:, ɛ, ʌ, ʊ/ only showed high average *B*1 values within nasal contexts and tendencies for the nasal/non-nasal distinction but the significant differences in these vowels were between pharyngeal and non-pharyngeal contexts. In fact, pharyngeal contexts sometimes showed the lowest overall *B*1 values except for /a:/, which showed the same pattern for *B*1 and *A*1-**P*1, whereby both pharyngeal-oral and pharyngeal-nasal contexts show nasalisation and pattern with nasal contexts. The discrepancy in the pharyngeal-oral results for *B*1 between /a:/ and the other vowels may be due to the degree of tongue root retraction that takes place in this vowel, leading to more velum lowering compared with the other vowels and similar results for pharyngeal-nasal. In the pharyngeal-nasal contexts, this downward movement would lead to a further pulling down of the velum which is already lowered when producing nasal consonants. The additional velum-lowering increases the amount of nasal airflow which in effect increases the area of damping already created by the additional channel when producing nasal consonants. This extra damping leads to widening the bandwidths (Kakata, 1956: 662; Fujimura, 1962: 1874; Dickson, 1962: 104) especially that of *F*1. The same explanation could apply to back vowels /u:, ɔ:/ because they are produced by the back part of the tongue which could also lower the velum leading to a wider *B*1. These three vowels have also been noted to have similar results of *A*1-**P*0 whereby values in high and mid vowels showed a distinction between pharyngeal and non-pharyngeal contexts rather than nasal and non-nasal ones. For that measure, only vowels /a:/ showed a distinction of both nasalised/non-nasalised and pharyngeal/non-pharyngeal contexts. They were interpreted in relation to the position of the two first formants and how vowels with low *F*1 and a wide distance between *F*1 and *F*2 would show a rise in *F*1 in effect to pharyngealisation.

As for the other vowels, different patterns are evident in these two contexts due to the different degrees of velum lowering involved. High *B*1 values are due to pharyngeal consonants being produced with a lowered velum, which further lowers when a nasal consonant is present, showing an increase in nasal airflow and therefore an increase in nasalisation. Pharyngeals are produced with a slight lowering of the velum but not to the extent that causes changes to *B*1; velum lowering in this case may lead to extra prominent peaks, resulting in lower *A*1-**P*1 values. But when a pharyngeal is combined with a nasal, the velum has two forces affecting it and causing it to lower further, showing changes to *B*1 and the extra peak *P*1. Other results of applying the *B*1 measure showed nasal and pharyngeal consonants as having a progressive effect on nasalisation similar to the *A*1-**P*1 results.

3- *The A1-*P0 measure*

The *A*1-**P*0 measure proved to be sensitive to the position of *F*1 and should be used with caution as a nasalisation measure, especially for pharyngeal contexts. There was a distinction between nasal and non-nasal contexts providing they did not contain pharyngeal consonants; and when a pharyngeal was present, the measure distinguished between pharyngealised and non-pharyngealised contexts due to the overall high values these contexts had. Therefore, with the pharyngeal consonants in mind, this measure was more suitable for measuring pharyngealisation rather than nasalisation. However, pharyngeal consonants aside, the measure did distinguish between nasal and non-nasal contexts but not in all vowels. This takes us back to the discussion above about the *A*1-**P*1 measure being useful for some vowels but not others. The vowels which did not show good discrimination for the *A*1-**P*1 measure are the ones that should be investigated for *A*1-**P*0. This is again due to the position of *F*1, as no extra peak would be expected to appear in vowels with a low *F*1. Therefore vowels /i:, ɪ, ɛ:, u:, ʊ, ɔ:/ are not expected to show extra peaks below *F*1 while vowels /a:, ɛ, ʌ/ are not expected to show extra peaks between *F*1 and *F*2 due to the close distance between the two formants. Nevertheless, results indicated that only vowel /a:/ showed significant differences between nasal and non-nasal contexts for the *A*1-**P*0, although vowels /ɛ:, ɛ, ɔ:/ also showed tendencies for a distinction. This is because low, low-mid and mid vowels had high(er) $F1$ and a closer distance between $F1$ and $F2$. Other measures have also shown vowel /u:/ to pattern with the low and low-mid vowels instead of the high and high-mid ones. Results of vowel /u:/ often showed different trends to what was expected or noted in similar high and back vowels. This is due to the fact that this vowel showed variation of production by speakers, ranging between having a low $F1$ and wide distance between $F1$ and $F2$ similar to other high vowels, to a high $F1$ with little distance between $F1$ and $F2$ resembling low vowels; the latter was more common, indicating that /u:/ patterned with low vowels more often than with high ones and highlighting the need for a future investigation of variation in the realisation of this vowel across Iraqi dialects and speakers.

In nasal contexts containing pharyngeals and initial nasals, $A1$-$*P0$ values decreased as a result of nasalisation whereas in contexts containing initial pharyngeals values tended to increase as a result of pharyngealisation, even though these same pharyngeal consonants showed nasalisation with low values of $A1$-$*P1$ and high values of $B1$. This again indicates that the position of $P1$ and $P0$ was affected by the position of the first two formants. Pharyngeal consonants lead to a rise in $F1$ in all vowels, leading to the appearance of an extra peak $P0$; but due to the parallel rise in $A1$, the $A1$-$*P0$ value remained very high. Furthermore, contexts containing pharyngeal /ʕ/ show higher $A1$-$*P0$ values, suggesting more pharyngealisation than those containing /ħ/.

Oral and isolation contexts, on the other hand, showed two different trends. Oral contexts exhibited some of the lowest $A1$-$*P0$ values for all vowels. These results group them with nasal contexts although in other nasalisation measures the oral contexts showed no nasalisation. Isolation contexts, however, showed two different trends, with low $A1$-$*P0$ values similar to oral and nasal contexts in two of the five long vowels [19] /i:, u:/; but with high $A1$-$*P0$ values similar to pharyngeal contexts in three long vowels /ɛ:, a:, ɔ:/. These results indicate that all vowels showing high $A1$-$*P0$ values for isolation contexts are those which showed the most tendencies for distinguishing between nasal and non-nasal contexts as well as high values for pharyngeal contexts. This suggests that high values in these vowels were related to non-nasalisation. Having non-nasalisation could explain the high values in isolation contexts because it was earlier established that this context does not show any nasalisation. Accordingly, the $A1$-$*P0$ measure further confirms that IA speakers in general show no nasalisation.

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[19] Only long vowels have isolation contexts.

4- *The F1/F2 frequency measure*

In comparing changes in frequencies of the first two formants of vowels across all contexts (Chapters 7 and 9), results showed that both pharyngeals led to a general rise in *F*1 and a drop in *F*2 in front vowels /iː, ɪ, ɛː, ɛ/ and a rise in *F*2 in back vowels /uː, ʊ, ɔː/; central vowel /aː/ showed only a rise in *F*1 indicating a more open quality but no significant changes in *F*2. These results coincide with those suggested by Al-Ani (1970) and Butcher and Ahmad (1987). They also match those found when measuring *A*1-**P*0, whereby pharyngeal contexts showed the overall highest values indicating pharyngealisation. Vowels in the context of /ʕ/ showed significantly higher rises in *F*1 and lower drops in *F*2 (at onset of front vowels /ɛː, ɛ/) than those containing /ħ/, indicating more pharyngealisation for /ʕ/. Results of higher degrees of pharyngealisation in initial position coincide with progressive effects of nasalisation and laryngealisation, with initial pharyngeals also leading to more pharyngealisation in this position.

This pharyngealisation effect explains why using the *F*1/*F*2 frequency change as a cue for nasalisation did not show expected results in an environment with nasalisation. This was particularly true in pharyngeal contexts. Therefore, only vowels with nasal consonants neighbouring the portion that is measured showed effect of nasalisation even if a pharyngeal consonant was present in the other position of the word. In fact, the nasal-pharyngeal contexts showed the most *F*1/*F*2 frequency changes, suggesting more effect of nasalisation than other nasal contexts. This indicates that when a measure is taken near an initial nasal consonant its nasalisation effect would cancel the pharyngealisation effect of a final pharyngeal consonant. Instead, the nasalisation effect of the final pharyngeal tends to enhance that of the initial nasal leading to a further increase of nasalisation. This explains the extreme formant changes these contexts showed in comparison to other nasal contexts, indicating what would be expected in vowels affected by nasalisation. This also shows us that the effect of pharyngealisation is restricted to the portion nearing the pharyngeal. These results were very clearly observed in Chapter 7, whereby *F*1/*F*2 changes taken at midpoint of vowels neighbouring pharyngeal consonants showed less effect of pharyngealisation than those taken at onset and offset. This reduced effect was noted by the closeness in the vowel space noted in charts at midpoint; this is in comparison to the wider space at the other two portions. A difference of effect on formant changes between onset and offset was also noted whereby the distance between contexts at onset were even wider than those taken at offset. Even the number of significant differences between contexts (as opposed to mere tendencies) was more pronounced at onset. This indicates that pharyngealisation has a progressive effect on neighbouring vowels as with the effects of nasalisation and laryngealisation.

Nasalisation, on the other hand, has a completely different effect on formant frequency changes. Most studies have considered the shift in *F*1 frequency as one of the main cues of nasalisation (House and Stevens, 1956; House, 1957; Fry, 1979; Hawkins and Stevens, 1985; Chen et al., 2007) while few others also considered that of *F*2 (Fry, 1979; Ladefoged, 2003). Therefore following the majority of studies, the present study relied mostly upon the change in *F*1 but also included those of *F*2 as additional evidence. In order to characterise these changes in each type of vowel, this study adopted findings of Beddor (1983) of *F*1 frequency changes: **1-** for high front unrounded vowels there was a consistency of a rise; **2-** for high back rounded vowels, there was little consistency but with more instances of a drop; **3-** for mid front unrounded vowels there was no consistency of results; **4-** for mid back rounded vowels, there was a drop; **5-** for low central unrounded vowels, there was consistency of a drop; **6-** for low front unrounded vowels there were variations of results but the majority showed a drop. For front mid vowels of this study, the same inconsistency was found; but when looking at other measures these same vowels tend to mostly behave in a way similar to the low central vowel /a:/ especially for *A*1-**P*0. Vowels /u:, ʊ, ɔ:/ were also similar in their behaviour to that of /a:/, but that was also noted in Beddor (1983) above.

*F*1/*F*2 vowel findings from the present study showed: a distinction between nasal and pharyngeal contexts; context nasal-pharyngeal showed the most nasalisation in vowels /a:, u:, ɔ:/ due to it reflecting the largest drop in *F*1 and rise in *F*2 (see Chapter 4); all nasal contexts except in a few instances showed the effect of nasalisation by the change of frequency of both or one formant particularly *F*1. Generally, formant frequency changes showed pharyngeals as being articulated in a manner that changes the quality of neighbouring vowels towards that of low central vowel /a:/. This lowering effect of pharyngeals was also noted by Bellem (2007: 142) in connection to the Iraqi dialect of Muslim Baghdadi. It can also be summed up from results of Beddor (1983), apart from those for front mid and back high vowels Other nasalisation measures also showed the same effect, with these vowels behaving similar to vowel /a:/, particularly for the *A*1-**P*1 and *A*1-**P*0 measures.

5- *The overall vowel intensity measure*

The third measure of nasalisation, also related to results of pharyngealisation, is that of the *overall vowel intensity*. Nasal contexts were expected to show the lowest values, and non-nasal contexts the highest. Pharyngeal contexts were also expected to show high values due to the effect of pharyngealisation. The measure distinguished between contexts with nasalisation and those with no nasalisation; pharyngeal contexts showed the highest values as was expected due to pharyngealisation effects. Isolation contexts showed the lowest overall values, although they were expected to show high values since they showed amongst the least nasalised contexts according to the *A*1-**P*1 measure. One reason for the low *intensity* values could be due to the increased laryngealisation in this context, which was the prominent effect in the absence of any consonantal neighbours. Laryngealisation is associated with a low f0 and with male voices (Klatt and Klatt, 1990) which are characterised as being creaky. This low f0 resulting from laryngealisation could in effect lead to a lower *intensity* in isolation and accordingly a feature of speakers of the present study.

Further investigations of *overall intensity* showed that pharyngeal /ʕ/ had progressive and /ħ/ had regressive effects of lowering *overall vowel intensity*. This is the only measure that showed differences between the two pharyngeal consonants in terms of the direction of their effect. This may be due to the fact that pharyngeal /ʕ/ showed more laryngealisation effect than /ħ/ at onset, therefore lowering intensity; whereas at offset it is not clear why pharyngeal /ħ/ would lower intensity since pharyngeal /ʕ/ exhibited higher laryngealisation levels in both word positions.

11.4.3 Auditory and acoustic results of phonation types

The study also aimed at investigating phonation types associated with the production of pharyngeal consonants by IA speakers. Creaky voice (laryngealisation) has been associated with pharyngeals, /ʕ/ in particular, in a number of studies on Arabic dialects like Ghazeli (1977), Butcher and Ahmad (1987), Zeroual et al. (2008), Bellem (2007) and Heselwood (2007), and mostly with stop realisations occurring in final position in IA (Butcher and Ahmad, 1987). Laryngealisation was also reported in other languages like Hebrew (Laufer and Condax, 1979) where either stop realisations of /ʕ/ or creaky voice were noted. Ladefoged (2001: 146) does not believe everyone is capable of producing a pharyngeal stop; He adds that pharyngeal /ʕ/ is produced with a great amount of laryngealisation and therefore believes that a constriction in the pharynx leads to a constriction in the larynx. Heselwood (2007: 6), on the other hand, attributes creaky voice to the constricted larynx, which leads to a less modal-like phonation; and therefore believes that it is the laryngeal constriction that leads to a pharyngeal constriction.

The following sections tackle results of the present study in as far as phonation types are concerned.

11.4.3.1 *Auditory results of phonation types*

Results of the auditory impression of phonation types showed a distinction between three types: creaky, breathy, modal. Nasal contexts had the least perceived laryngealisation and pharyngeal ones the highest. Results also distinguished between pharyngeal and non-pharyngeal contexts, whereby those with pharyngeals showed the highest levels of laryngealisation. These results coincide with creaky voice accompanying all realisations of pharyngeal /ʕ/ and stop realisations in particular (Chapter 7). This connection with realisations of /ʕ/ is also confirmed by findings that contexts containing pharyngeal /ʕ/ showed more perceived laryngealisation than those containing /ħ/. Oral contexts, on the other hand, consisted of a variety of consonants which could have an impact on increasing the perception of laryngealisation. Isolation contexts also had some of the highest perceived laryngealisation levels whereas oral contexts showed the least. The reason isolation contexts have high levels of laryngealisation, which was also noted in the acoustic investigation of phonation types, is that vowels produced in isolation reflect the speakers' normal phonation without any impact of neighbouring consonants. Therefore, not only pharyngeal contexts but also the speech of all speakers of the present study is produced with laryngealisation.

11.4.3.2 *Acoustic results of phonation types*

Overall investigations of acoustic measures of phonation types showed a number of interesting results which will be presented below in relation to each individual measure.

1- **The *H1-*H2 measure**

When applying the *H1-*H2 acoustic measure to investigate phonation types, results showed that pharyngeal contexts had low *H1-*H2 values, denoting laryngealisation. These same contexts showed high levels of pharyngealisation as noted by the A1-*P0 results, indicating that pharyngealisation is accompanied by laryngealisation. Laryngealisation was noted in all realisations of pharyngeal /ʕ/, but the auditory investigation showed it was more pronounced for stop realisations (Chapter 8). These findings are supported by those in the literature which confirm the occurrence of laryngealisation with the production of pharyngeal consonants, in particular those produced with a full or semi constriction. Furthermore, these same contexts showed low A1-*P1 and high B1 values, denoting nasalisation and providing evidence that what we have in these contexts is not breathiness masked as nasalisation but laryngealisation that is accompanied by nasalisation. In fact, even the auditory impression of phonation types showed breathy phonation to be the least present of all three types. Non-pharyngeal nasal contexts on the other hand showed the highest *H1-*H2 values, indicating the least laryngealisation. These nasal contexts also showed high levels of nasalisation. This indicates that nasal (non-pharyngeal) contexts have high levels of nasalisation and low levels of laryngealisation. This result is also supported by the B1 values, whereby nasal contexts showed some of the highest values indicating nasalisation.

Oral contexts were similar to nasal contexts in showing high values of *$H1$-*$H2$; whereas isolation contexts showed some of the lowest values in vowels /ɛː, aː, uː, ɔː/, similar to pharyngeal contexts and indicating high levels of laryngealisation. These results support the auditory analysis of phonation types. They also show that the effect of supraglottal consonants within oral contexts masks laryngealisation. Isolation contexts, on the other hand, do the opposite by showing more laryngealisation effects. This would indicate that the normal speakers' laryngeal settings without the impact of producing consonants is characterised as having laryngealisation. Moreover, all speakers are males and creaky voice is typical of male voices, which could explain the dominance of this feature especially in the auditory investigation. In fact, some researchers such as Klatt and Klatt (1990), Hanson and Chuang (1999) and Simpson (2012) consider and use the *$H1$-*$H2$ measure for sex-differences of phonation types with creaky voice profiling those of male speakers and in many languages.

Other results of the *$H1$-*$H2$ acoustic measure showed pharyngeal /ʕ/ as having more pronounced laryngealisation on neighbouring vowels than /ħ/. /ʕ/ also showed more pharyngealisation, as was noted by the $A1$-*$P0$ values. Similar to the progressive effect of nasalisation and pharyngealisation, pharyngeal consonants also had a progressive effect of laryngealisation. This progressive effect was confirmed by the less significant differences among contexts in final position as well as the high overall values of *$H1$-*$H2$, showing less laryngealisation. It should also be noted that contexts containing vowel /uː/ showed the overall highest *$H1$-*$H2$ values, indicating the least laryngealisation. This result coincides with results of the auditory impression of laryngealisation, whereby contexts of the same vowel showed the lowest overall levels. The result was also consistent across dialects. For the *$H1$-*$H2$ measure, this vowel showed one of the highest values, even for pharyngeal contexts.

2- The *$H1$-$A1$ measure results

All pharyngeal contexts showed low $H1$*-$A1$ values similar to the low *$H1$-*$H2$ values, suggesting high levels of laryngealisation in these contexts. Nasal contexts, on the other hand, showed the highest *$H1$-$A1$ values, indicating the least or no laryngealisation. The high $B1$ values within nasal contexts support the low laryngealisation claim. These results suggest a connection between nasalisation and low pharyngealisation, which could either indicate breathy or modal types of phonation (see Chapter 4).

More detailed results showed the overall highest *$H1$-$A1$ values in contexts containing vowel /uː/, indicating the least laryngealisation. This result coincides with results of the *$H1$-*$H2$ measure and auditory impression of laryngealisation whereby contexts of /uː/ showed the lowest overall levels. Isolation contexts showed low *$H1$-$A1$ values in vowels /ɛː, aː/ similar to pharyngeal contexts; whereas oral contexts showed high *$H1$-$A1$ values in all vowels similar to nasal contexts. The type of consonant near the position of the vowel portion being investigated influences the amount of laryngealisation no matter what type of consonant falls on the other side of the vowel. Accordingly a measure at vowel onset within a nasal-pharyngeal context would show high *$H1$-$A1$ values suggesting little or no laryngealisation, but low *$H1$-$A1$ values at vowel onset within a pharyngeal-nasal context, suggesting laryngealisation. These results confirm those of other measures whereby pharyngeal contexts have shown the highest degrees of laryngealisation irrespective of realisation.

All pharyngeal contexts with an initial pharyngeal near onset showed low *$H1$-$A1$ values, indicating laryngealisation. In all nasal and non-nasal pharyngeal contexts, pharyngeal /ʕ/ had lower *$H1$-$A1$ values in contexts ʕ-n and ʕ-o than /ħ/ in contexts ħ-n and ħ-o, indicating more laryngealisation. More importantly /ʕ/ showed lower *$H1$-$A1$ values. In contexts n-ħ and n-ʕ, it is nasalisation and not laryngealisation that is affecting *$H1$-$A1$ values. These results again confirm accompanying laryngealisation for both pharyngeal consonants but with more effects shown by /ʕ/, even in final position.

Results of the $B1$ measure could also be interpreted in relation to the *$H1$-$A1$ results because $B1$ is also used by researchers as a measure of breathy phonation in addition to a measure of nasalisation. A posterior glottal opening leads to the increase of $B1$, which on its part increases the *$H1$-$A1$ value. Acoustic results of phonation types (Chapter 10) showed that in pharyngeal contexts whether a nasal consonant was present or not, the *$H1$-*$H2$ and *$H1$-$A1$ values were very low, indicating laryngealisation. Accordingly, $B1$ values are expected to be low as well. However, many of the $B1$ values within pharyngeal contexts were very high, which could not be explained in relation to the effect of a glottal opening and must instead be related to nasalisation. Nasal (non-pharyngeal) contexts, on the other hand, showed the least laryngealisation as is noted by results of the two phonation measures *$H1$-*$H2$ and *$H1$-$A1$ in addition to their tendency to having high $B1$ values. This indicates that nasal contexts have little or no laryngealisation as well as nasalisation because if no other contexts showed nasalisation these in particular are guaranteed to have nasalisation. Furthermore, results at onset showed higher values of laryngealisation in pharyngeal contexts than at offset suggesting a progressive effect.

Overall results of the *$H1$-*$H2$ and *$H1$-$A1$ acoustic investigations of phonation types have shown that laryngealisation is a general feature of both pharyngeal consonants that accompanies all realisations and in all word positions. Other studies only found laryngealisation (or creaky voice) accompanying particular pharyngeal realisations of /ʕ/ and in particular word positions. Overall results thus far suggest that pharyngeal contexts containing both pharyngeal consonants have low *H*1*-*A*1 and **H*1-**H*2 values, denoting laryngealisation, and low *A*1-**P*1 and high *B*1 values, denoting nasalisation. However, more effect of laryngealisation was noted in relation to pharyngeal /ʕ/ and more nasalisation in relation to pharyngeal /ħ/. These results show that nasalisation in these contexts is actual nasalisation and not a breathy phonation masked as nasalisation.

11.5 Cross-dialectal comparisons

Cross-dialectal results showed that speakers of Baghdad, a *gelet* dialect, and Mosul, a *qeltu* dialect, had the most stop-like productions. The Baghdadi results agree with conclusions of a survey conducted by Bellem (2007: 270) on the *gelet*-dialectal group whereby the Bedouin and many rural Levantine dialects of the group were found to have a 'stronger' (creakier and more stop-like, rather than approximant-like) pharyngeal /ʕ/. However, Basra speakers, another *gelet* dialect, had the most approximant realisation with very few instances of stops. When investigating the association between pharyngeal realisation and perceived nasalisation on the one hand and perceived types of phonation on the other, results showed no significant differences but tendencies for Baghdad approximant realisations to show more nasalisation than those of Basra and Mosul; for Basra approximants and Baghdad stops to show the highest levels of perceived laryngealisation; for Mosul approximants and stops to show the least perceived laryngealisation. No significant differences or tendencies were noted between dialects associating perceived laryngealisation and the realisations of /ʕ/ as a fricative. However, overall results showed all realisations had varying levels of laryngealisation.

Results of *A*1-**P*1 showed Baghdad speakers as having the lowest values, indicating the most nasalisation, and Basra the highest values, indicating the least nasalisation. Interestingly, this does not only apply to contexts containing nasal and pharyngeal contexts but also to oral and isolation ones at offset portion in particular indicating that nasalisation may be a general feature of Baghdad speakers. The *B*1 measure results also showed Baghdad the most nasalised but also showed that Mosul, and not Basra, was the least nasalised. Accordingly, Baghdad results are shown to be consistent in the way they demonstrate more nasalisation in both *A*1-**P*1 and *B*1 measures, while Basra and Mosul results vary across these two measures. Nevertheless, these results would not explain why speakers of IA are perceived by other Arabic speakers as having nasalisation but the following interpretations may provide that explanation. There may be other speech sounds that have not yet been investigated that are also being produced with a lowered velum or with a *cul de sac* somewhere in the speech apparatus therefore generating perceived nasalisation. A more practical explanation is that what people perceive as IA speech is in fact the speech of Baghdadi speakers who seem to be the ones mostly investigated in most studies even by Blanc (1964). While Baghdadi speakers did turn out to have nasalisation, those of Basra, a dialect also belonging to the same *gelet* dialectal group showed the least nasalisation. This study is therefore the first quantitative investigation showing potential within dialect differences in the prevalence of nasalisation as well as in the production of pharyngeal consonants.

Results of the *A*1**P*0 measure did not distinguish between nasalised and non-nasalised dialects, as was noted earlier; instead it was able to distinguish between those with pharyngealisation and ones without. Accordingly, Baghdad was shown to have more pharyngealisation in more contexts and vowels than the other two dialects and Basra the least. The reason for this conclusion is due to the fact that the other nasalisation measures, particularly *A*1-**P*1 and *B*1, showed Baghdad the most nasalised, so high *A*1**P*0 values would contradict these results as it did for pharyngeal contexts and therefore can only be explained in relation to the effect of the two formants. Therefore, high *A*1**P*0 values for dialects would be an indication of high levels of pharyngealisation rather than low levels of nasalisation. This is even noted in oral and isolation contexts. These results match descriptions of the Muslim Baghdad *gelet* dialectal group, which sounded more emphatic or more guttural than other dialects. The results could also explain why some people, particularly of speakers other Arabic dialects, would characterise IA speakers as having an over-usage of the pharyngeal cavity ('speak in throat'). A related measure is that of *overall vowel intensity*, which showed Baghdad speakers having the highest levels of *intensity* while Basra speakers had the lowest. The same high *intensity* results were noted near pharyngeal consonants, which also showed the highest *A*1**P*0 values, indicating pharyngealisation. These two results of pharyngeal consonants showed that pharyngealisation is accompanied by high *intensity*. The same was noted for Baghdad speakers; they had high levels of pharyngealisation as well as high levels of *intensity*, indicating them as having the most pharyngealised voice quality.

Measures of phonation types showed Baghdad as having the lowest **H*1-**H*2 and **H*1-*A*1 values, indicating the highest degree of laryngealisation, while Basra speakers exhibited the lowest degree of laryngealisation. The Baghdad result agrees with guttural and emphatic quality. This view also agrees with results of the auditory impressions of laryngealisation produced by Baghdad speakers but not with those of Basra speakers. All cross-dialectal comparisons thus far show that Baghdad speakers not only exhibited the highest levels of pharyngealisation but also the most stop realisations. The dialect therefore showed: **a)** the highest levels of nasalisation; **b)** the highest levels of laryngealisation; and **d)** the highest level of pharyngealisation. Basra speakers on the other hand showed the lowest degrees of nasalisation, laryngealisation, intensity and pharyngealisation. Mosul results did not show much consistency except in the case of *B*1 values whereby it proved to be the least nasalised.

These differences between Baghdad and Basra revealed major differences between dialects of the same group, each representing a region, Central and Southern of Iraq, respectively. It may be that when generalisations were made on the *gelet* group, investigations including those of Blanc (1960), Al-Ani (1970), Butcher and Ahmad (1987) and Bellem (2007) were either carried out on Baghdad speakers or relied on studies using Baghdad speakers to make conclusions about the entire IA dialect. One explanation for the differences between Baghdad and Basra speakers would be that Basra is a city situated in the very South of Iraq and has borders with two countries, Kuwait and Iran (Khūzistān in particular). This, in addition to the continuous immigration of populations from other cities to Basra, may have led to many changes in the dialectal features that used to relate it to other *gelet* dialects. This contrast with changes happening to Baghdad, which is situated in the middle of Iraq and is only surrounded by Iraqi cities; due to it being the capital city, another wave of fast immigration is taking place from speakers of rural areas of Lower Iraq whose dialects have been mainly influenced by Bedouinization. The different new influences of immigration may have led the Basra dialect to show less Bedouin features and Baghdad to become more Bedouinized. This may partly explain the higher proportion of stop-like realisations of pharyngeals and the more guttural quality of speech in Baghdad than in Basra, and certainly deserves future investigation. It also coincides with Heselwood's (2007: 4) comparison between two Arabic dialects, Egyptian and IA, saying that they respectively represent the least and most likely to have stop realisations of /ʕ/. His explanation is related to the nature of the dialects considering IA to be a more conservative dialect and Egypt an innovative one.

It is also noted that nasalisation in Baghdadi Arabic was not only restricted to pharyngeal contexts but also to oral and isolation ones, particularly at offset. This result suggests that the process of nasalisation in the speech of Baghdadi speakers may extend beyond the production of pharyngeal consonants and could start to spread into the production of other consonants or even colour the speech of the entire dialect irrespective of context. Therefore, research is further needed to investigate the production of other consonants, the speech of a larger population from Baghdad and female speakers as well as speakers from different age groups.

11.6 Speaker variability

Nine speakers participated in the present study, each three belonging to one of the three IA dialects: Baghdad, Basra and Mosul. Despite similarities of results between speakers of the same dialect, there was variability across those speakers; this was not described in great detail in the results chapters as it was not the main focus of this study, but is given consideration here due to its implications for future research.

The variability that was found was mainly in the results of the Baghdad dialect, which is not surprising given that this is the dialect where nasalisation and pharyngealisation were witnessed the most and spread beyond nasal and pharyngeal contexts, suggesting a potential change in progress. For instance, one of the speakers from Baghdad produced all realisations of pharyngeal /ʕ/ as a stop irrespective of word position. This result both contributed to the overall pattern that was found for Baghdadi speakers and suggested a potential trend for an increase in stop realisations of pharyngeal /ʕ/ in Baghdad beyond final word position. In relation to the auditory impression of phonation types, the same Baghdadi speaker mentioned above showed the highest overall impression of laryngealisation, with another Baghdadi speaker showing the lowest impression of laryngealisation. However, this speaker's productions had some of the lowest auditory impressions of nasalisation, suggesting that the link between pharyngeal realisation and degree of nasalisation is still far from understood.

Another speaker variability was found in the results of the Mosul speakers who also had a high number of stop realisations similar to the Baghdadi speakers. One of the Mosul speakers produced more stop realisations irrespective of word position than the other two speakers. However, unlike the Baghdadi speaker, this Mosul speaker did not show any other distinctive differences from the other two speakers in as far as the auditory impression of nasalisation and phonation types.

As for Basra speakers, the only speaker variability noted was for one of the speakers who showed the least laryngealisation across all contexts and instead produced the most modal-like phonation type; other results showed all three speakers having similar realisations of pharyngeal /ʕ/ and comparable impressions of nasalisation.

While the relatively small number of speakers does not allow one to look at variability in more detail in this study, this issue should be taken into consideration in future research when investigating pharyngeal consonants in as far as their realisations, dialectal differences and overall language change.

11.7 Suggestions for Further Research

Results obtained from the present study could be used by future researchers investigating the study of language change, dialectal variation, the study of voice quality, and realisations of pharyngeal consonants and features accompanying their production like nasalisation and laryngealisation. Teachers and learners of Arabic could make use of results on the sound-system of IA, in general, and the description of pharyngeal consonants, in particular. Speech therapists and forensic investigators could make use of the phonation types and profiles of IA speakers. The present study has a number of recommendations and suggestions for future research in as far as topics and approaches:

1- *Realisations of pharyngeal consonants*: A wider study is needed into the realisation of pharyngeal consonants produced by speakers of IA and its dialects.

2- *Nasalisation*: Due to the interesting results of nasalisation in as far as direction of effect and dialect-specific prevalence, more research is recommended into investigating nasal consonants alone.

3- *Phonation Types*: A profile of phonation types produced by speakers based upon dialect, sex, gender and age is required for IA or any of the other Arabic dialects.

4- *Instrumental approach*: It is recommended for future research to apply a combination of articulatory and acoustic investigations if articulatory equipment is available, such as nasendoscopy (for investigating nasal airflow), electroglottography and laryngoscopy (for investigating laryngeal activity), in addition to MRI, EMA and Ultra-sound (for investigating pharyngeal and vocal tract movements).

5- *Number of speakers*: The productions of a larger number of speakers are required with fewer measures, taking into account weaknesses of some of those measures outlined in the present study. The present study recorded 32 speakers but due to time-limitations and a wide range of measures, only recordings of 9 of the speakers were analysed.

6- *Gender and sex comparisons of phonation types*: in light of the results obtained in the present study regarding the high levels of laryngealisation in isolated vowels and the fact that all speakers were males, there is a need to conduct comparisons between males and females to find out if this is a sex-specific features or a general IA feature.

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Appendixes

Appendix A: The target words forming the final analysed list

del	daas	nuun	3eeb	7es
noo3	maat	meez	7aash	saam
ruu7	qu7	3uudj	dhiib	been
qiis	Xed	faa7	3aadj	shaam
7ub	3iS	doom	3ed	7ey
djuu3	7en	3oon	3aam	Xaam
dem	raa7	noom	7aad	7aD
nuu7	diin	muun	sin	7aq
mel	lib	Sa7	gheeb	2iid
sheb	2in	taab	sheeb	zeen
3oo3	zaa7	sed	3aar	baab
seb	maas	nuub	7eel	siim
loo7	ka3	3aT	3een	baa3
dub	Saa7	muus	7aal	loon
bii3	naas	mooz	3iish	7edj
muX	qes	3et	7eef	beet
Sii7	naa7	7ook	Xaan	gheem
min	miil	3em	3iid	7ar
dhii3	duun	7oom	haan	boosh
3en	naam	Xaab	7aT	buum
be7	miim	7aar	7ak	thuum
daaX	laa7	3aaf	baan	buut
zii7	niil	3ish	7el	buuz
qaas	3uuf	3aash	zaad	
la7	duud	7ed	bes	

Appendix B: Results of the second auditory analysis tested for reliability on realisations of pharyngeal /ʕ/

Speaker	realisation of pharyngeal /ʕ/ (reliability)						Discrepancy
	approximant		fricative		stop		
	time 1	time 2	time 1	time 2	time 1	time 2	
Bg1	3	3					0
			1	1			0
					2	2	0
Bg3					6	6	0
Bs1	6	6					0
Bs3	4	4					0
			2	2			0
Mo2	1	1					0
		1	1				1
					4	4	0
Grand Total	14	15	4	3	12	12	1/30

Appendix C: Results of the second auditory analysis tested for reliability on nasalisation

Speaker	context	nasalisation (reliability)						Discrepancy
		very		little		none		
		Time1	Time2	Time1	Time2	Time1	Time2	
Bg1	ħ-n	1			1			1
	ħ-o					1	1	0
		1			1			1
	n-ʕ	1	1					0
	o-ħ					3	3	0
	o-ʕ			1			1	1
		1			1			1
	ʕ-n	1	1					0
	ʕ-o	2			2			2
Bg2	n-n	3	2		1			1
	n-o	4	4					0
	o-n	2			2			2
	o-o			2	2			0
						1	1	0
Bg3	ħ-o			3	2		1	1
	o-ħ			1			1	1
					1	2	1	1
	o-ʕ				2	3	1	2
	ʕ-n	1	1					0
	ʕ-o			1			1	1
						1	1	0
Bs1	ħ-o				2	2		2
		1	1					0
	n-ħ	1	1					0
	n-ʕ	1			1			1
	o-ħ			2	1		1	1
	o-ʕ			1			1	1
						1	1	0
	ʕ-n	1			1			1
	ʕ-o			1			1	1
						1	1	0
Bs2	n-n	3	2		1			1

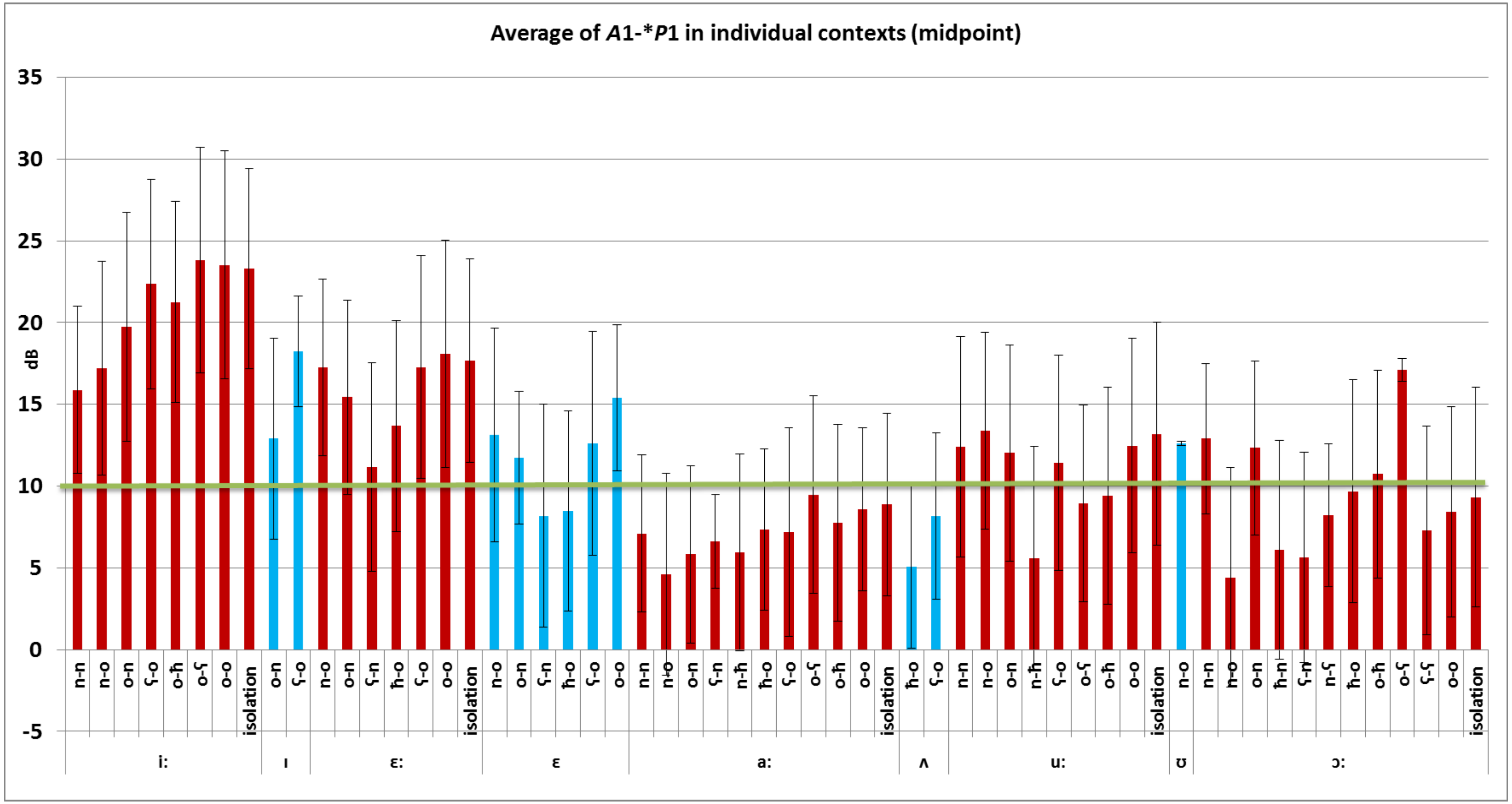
	n-o			1	1			0
		2	2					0
	o-n				1	1		1
		2	2					0
	o-o				2	3	1	2
Bs3	ħ-o			1			1	1
						1	1	0
		1	1					0
	n-ħ	1	1					0
	o-ħ			1	1			0
					1	1		1
	o-ʕ			1			1	1
						1	1	0
		1			1			1
	ʕ-n	1	1					0
	ʕ-o			1	1			0
						1	1	0
Mo1	n-n	3	2		1			1
	n-o	3	1		2			2
	o-n		1	2			1	2
		1	1					0
	o-o				1	3	2	1
Mo2	ħ-o			3	1		2	2
	n-ħ	1			1			1
	n-ʕ	1	1					0
	o-ħ			2			2	2
	o-ʕ			1	1			0
					1	1		1
	ʕ-n	1			1			1
	ʕ-o			1			1	1
		1			1			1
Mo3	n-n		1	1				1
		2	1		1			1
	n-o	3	3					0
	o-n	3	3					0
	o-o				1	2	1	1
		1	1					0
Grand Total		52	37	27	41	29	30	48/108 (44.45%)

Appendix D: Results of the second auditory analysis tested for reliability on phonation types

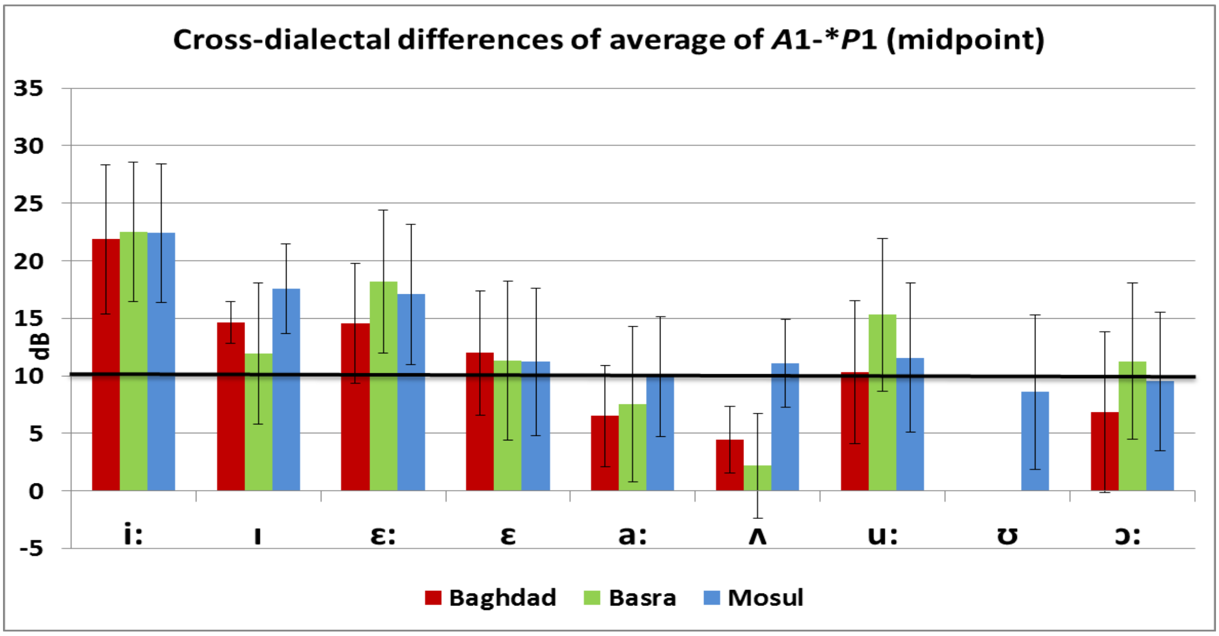
Speaker	context	phonation types (reliability)						Discrepancy
		creaky		breathy		modal		
		Time1	Time2	Time1	Time2	Time1	Time2	
Bg1	ħ-n					1	1	0
	ħ-o		1			2	1	0
	n-ʕ					1	1	0
	o-ħ	1	1					0
			1			2	1	1
	o-ʕ					2	2	0
	ʕ-n		1			1		1
	ʕ-o					2	2	0
Bg2	n-n	2	1				1	1
						1	1	0
	n-o	2	2					0
			1			2	1	1
	o-n	2	1				1	1
	o-o	3	2				1	1
Bg3	ħ-o	3	2				1	1
	o-ħ	3	2				1	1
	o-ʕ	3	3					0
	ʕ-n	1	1					0
	ʕ-o	2	1				1	1
Bs1	ħ-o	2	1				1	1
						1	1	0
	n-ħ	1	1					0
	n-ʕ	1	1					0
	o-ħ	1					1	1
						1	1	0
	o-ʕ		1			2	1	1
	ʕ-n	1					1	1
	ʕ-o	2	1				1	1
Bs2	n-n			1			1	1
		2					2	2
	n-o	3					3	3
	o-n	1					1	1
			1			2	1	1

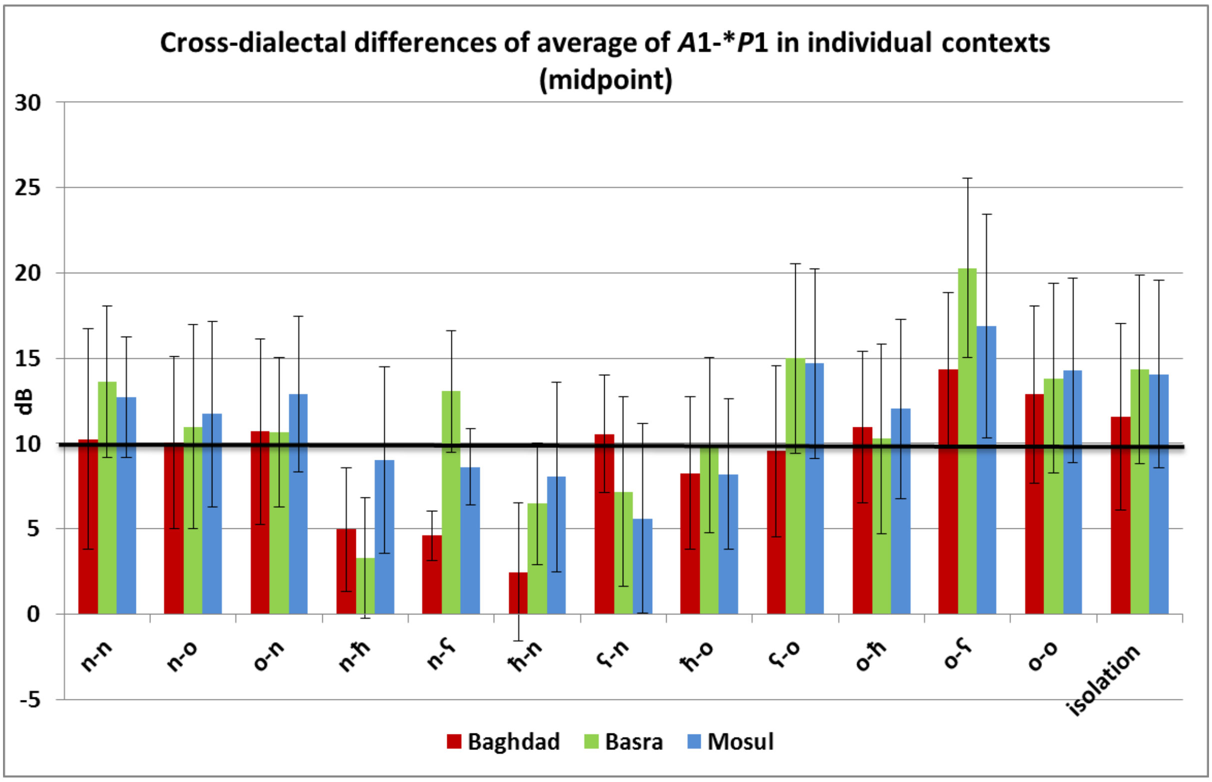
	o-o	1					1	1
					1	2	1	1
Bs3	ħ-o					3	3	0
	n-ħ	1					1	1
	o-ħ			1			1	1
						1	1	0
	o-ʕ	1					1	1
						2	2	0
	ʕ-n	1					1	1
	ʕ-o					2	2	0
Mo1	n-n		2			3	1	2
	n-o	1	1					0
						2	2	0
	o-n	2	1				1	1
						1	1	0
	o-o	2	1				1	1
						1	1	0
Mo2	ħ-o	3	1				2	2
	n-ħ					1	1	0
	n-ʕ					1	1	0
	o-ħ	1					1	1
						1	1	0
	o-ʕ	1			1			1
			1			1		1
	ʕ-n					1	1	0
	ʕ-o	1					1	1
						1	1	0
Mo3	n-n					3	3	0
	n-o	1	1					0
						2	2	0
	o-n	1	1					0
						2	2	0
	o-o			1			1	1
		1					1	1
						1	1	0
Grand Total		54	35	3	2	51	71	40/108 (37.04%)

Appendix E: Results of applying *A*1-**P*1 measure of nasalisation within individual contexts at midpoint

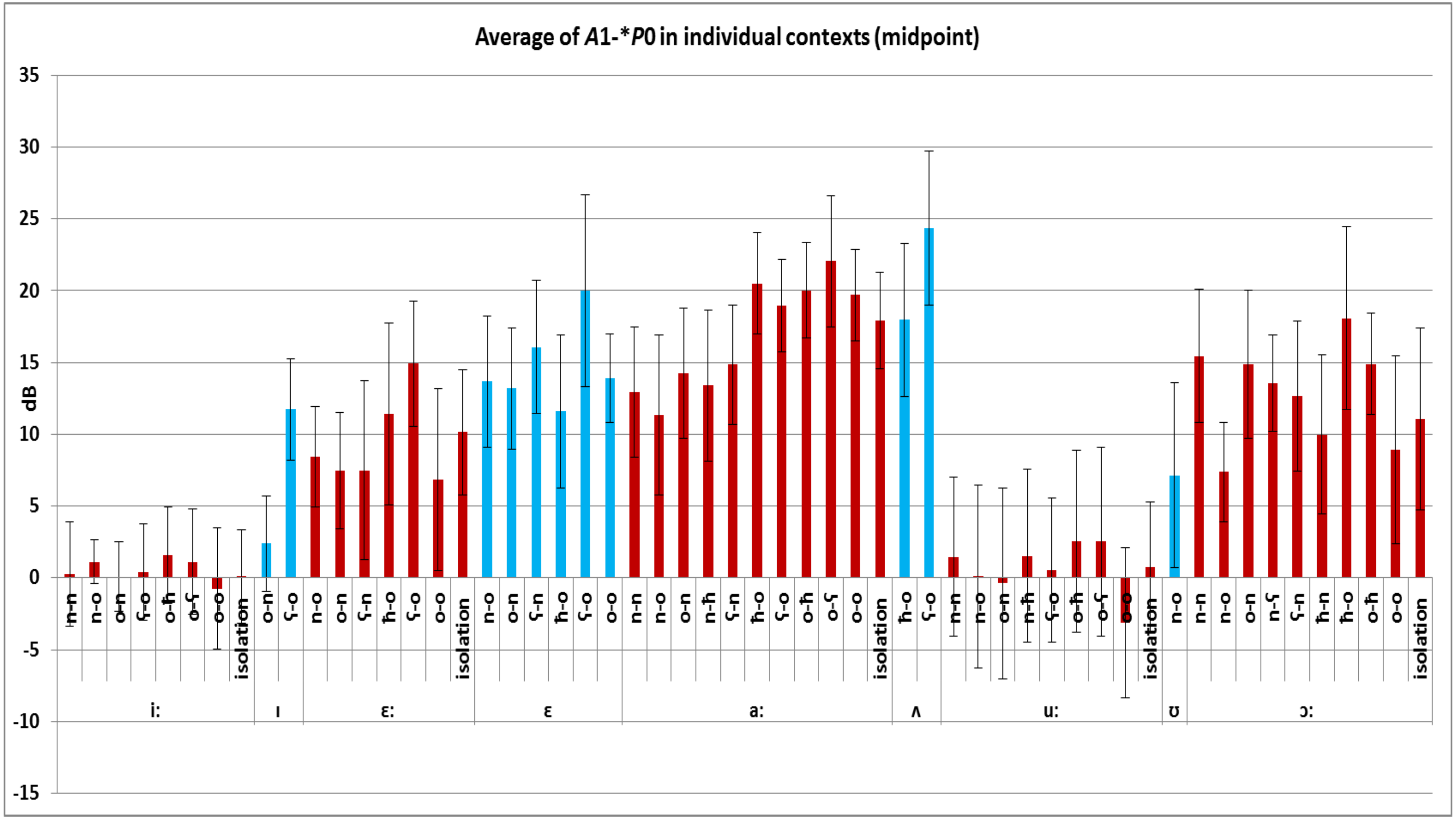


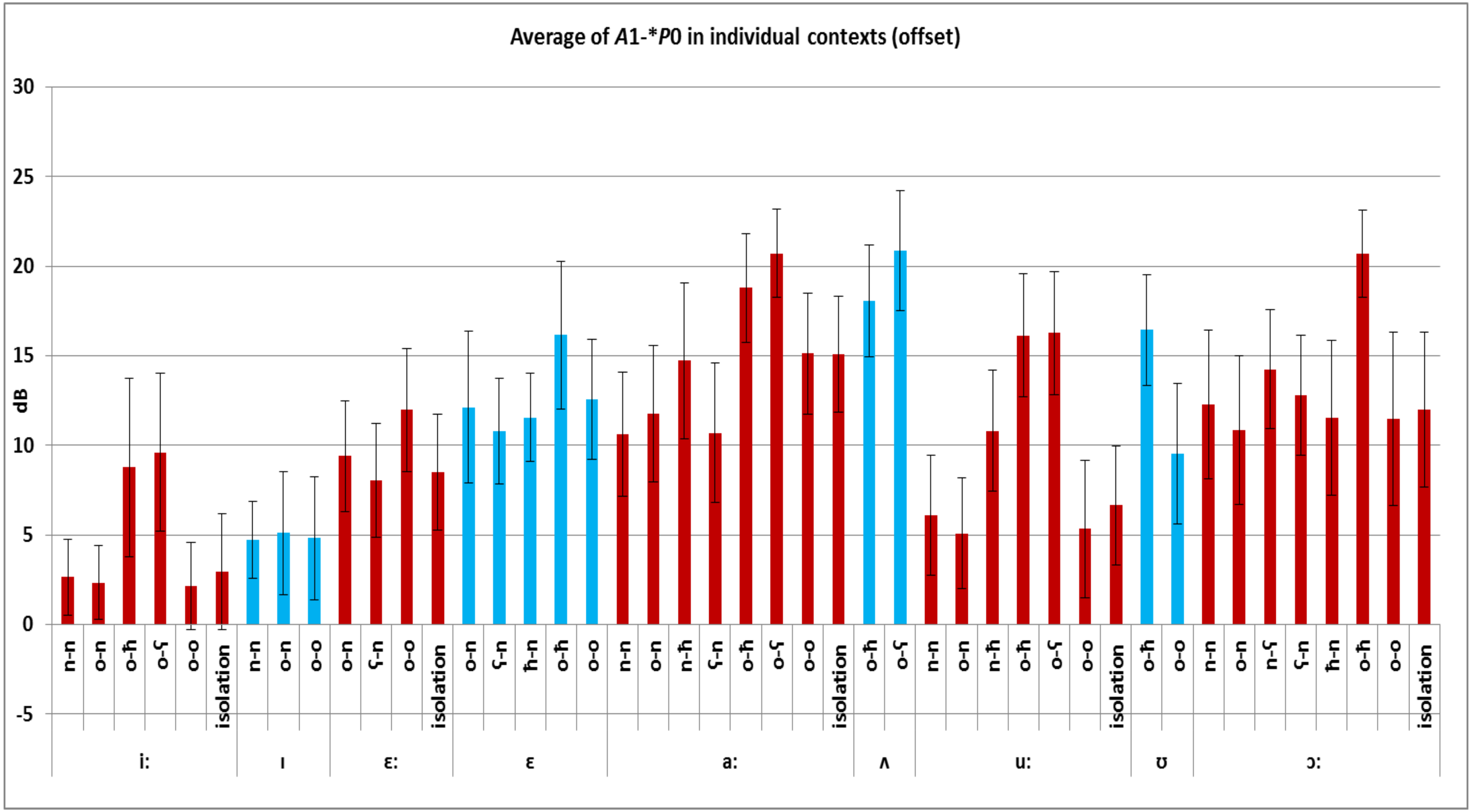
Appendix F: Results of applying cross-dialectal comparisons of *A*1-P*1 measure of nasalisation within vowels and individual contexts at midpoint**





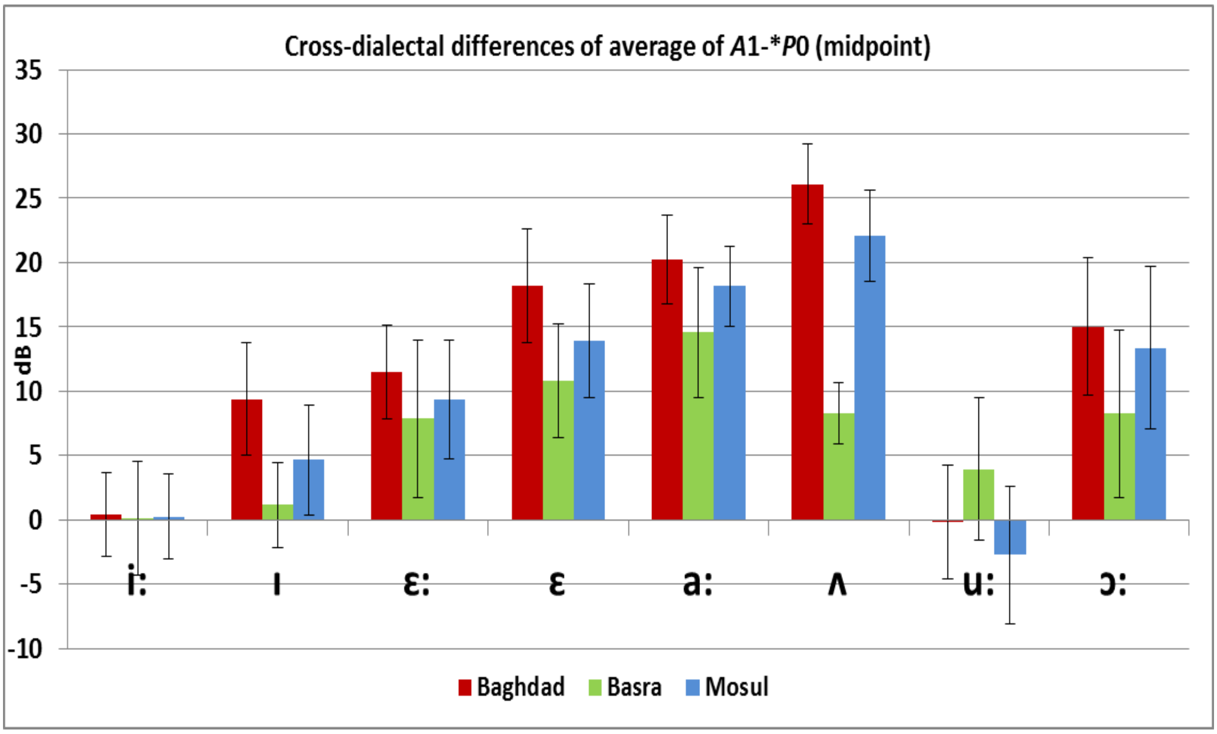
Appendix G: Results of applying *A*1-**P*0 measure of nasalisation within individual contexts at midpoint and offset

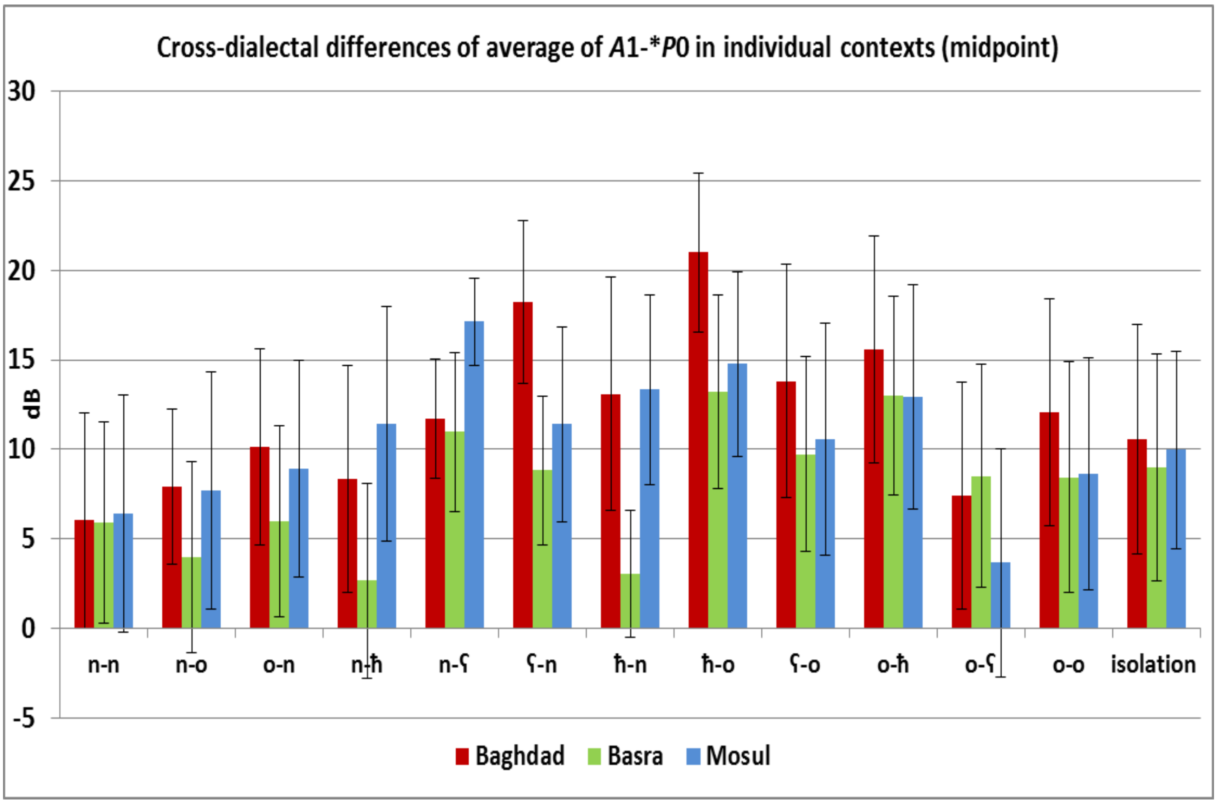


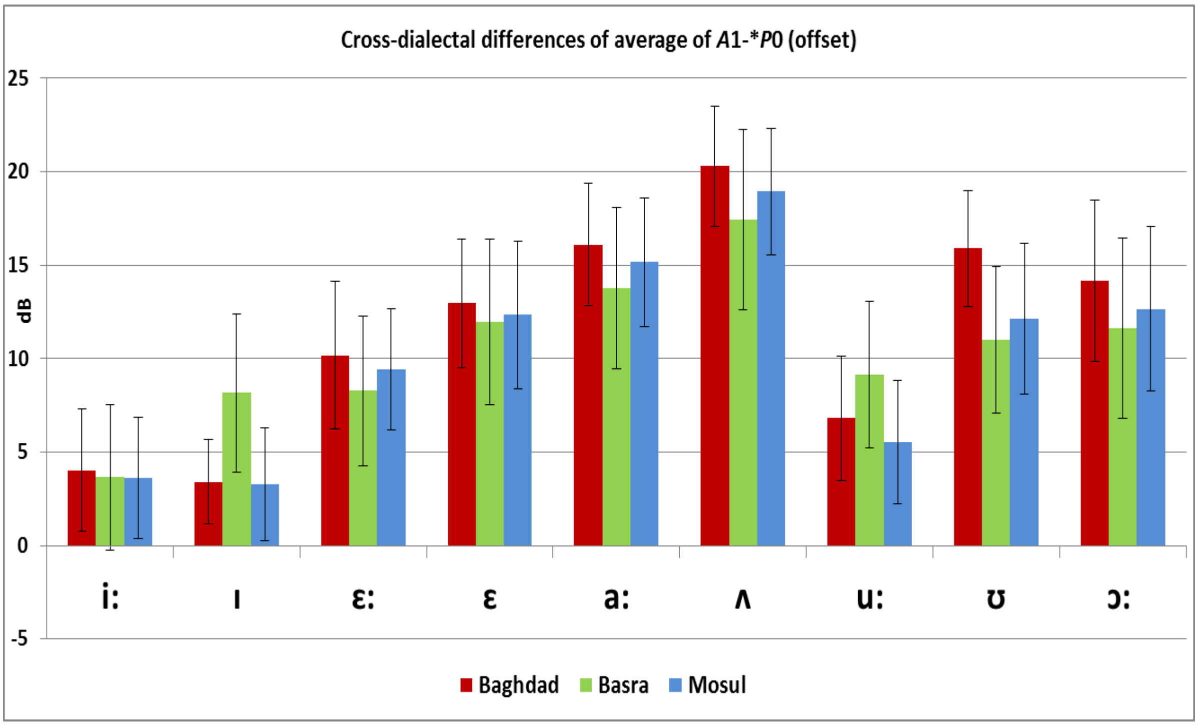


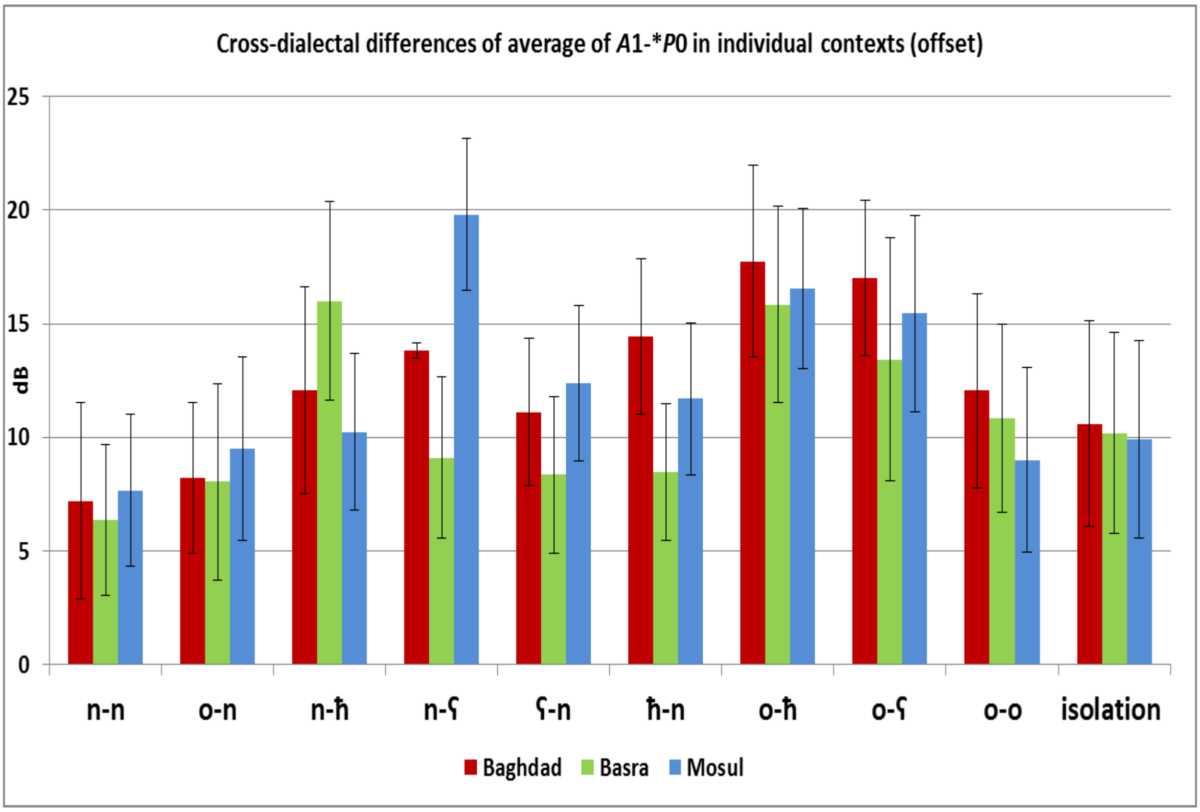
Average of A1-*P0 in individual contexts (offset)
dB
30
25
20
15
10
5
0
-5
n-n
o-n
o-ħ
o-ʕ
o-o
isolation
iː
ɪ
ɛː
ɛ
aː
ʌ
uː
ʊ
ɔː

Appendix H: Results of applying cross-dialectal comparisons of *A*1-P*0 measure of nasalisation within vowels and individual contexts at midpoint and offset**

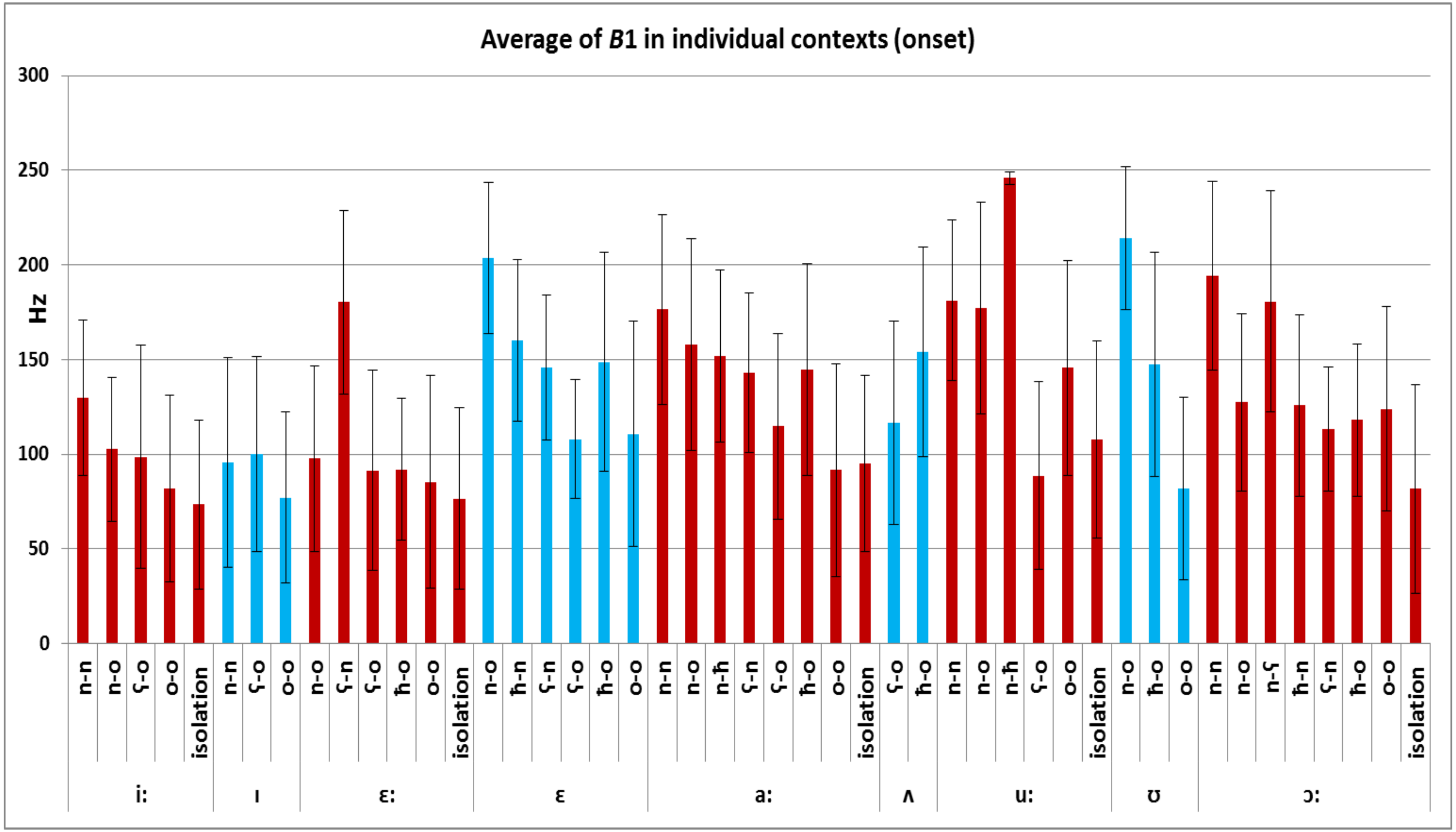


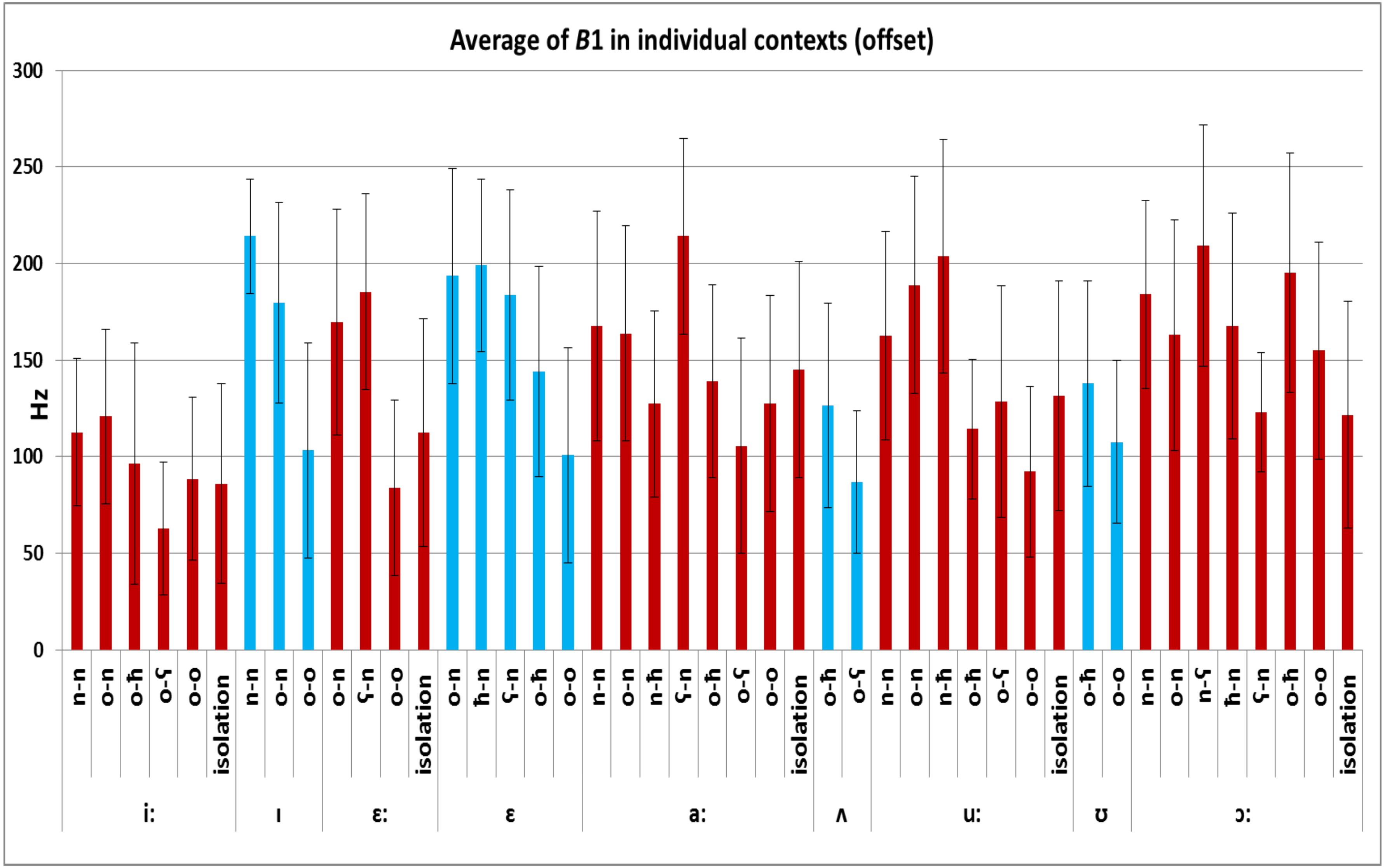



Cross-dialectal differences of average of A1-*P0 (offset)
25
20
15
10
5
0
-5
dB
iː
ɪ
ɛː
ɛ
aː
ʌ
uː
ʊ
ɔː
Baghdad
Basra
Mosul

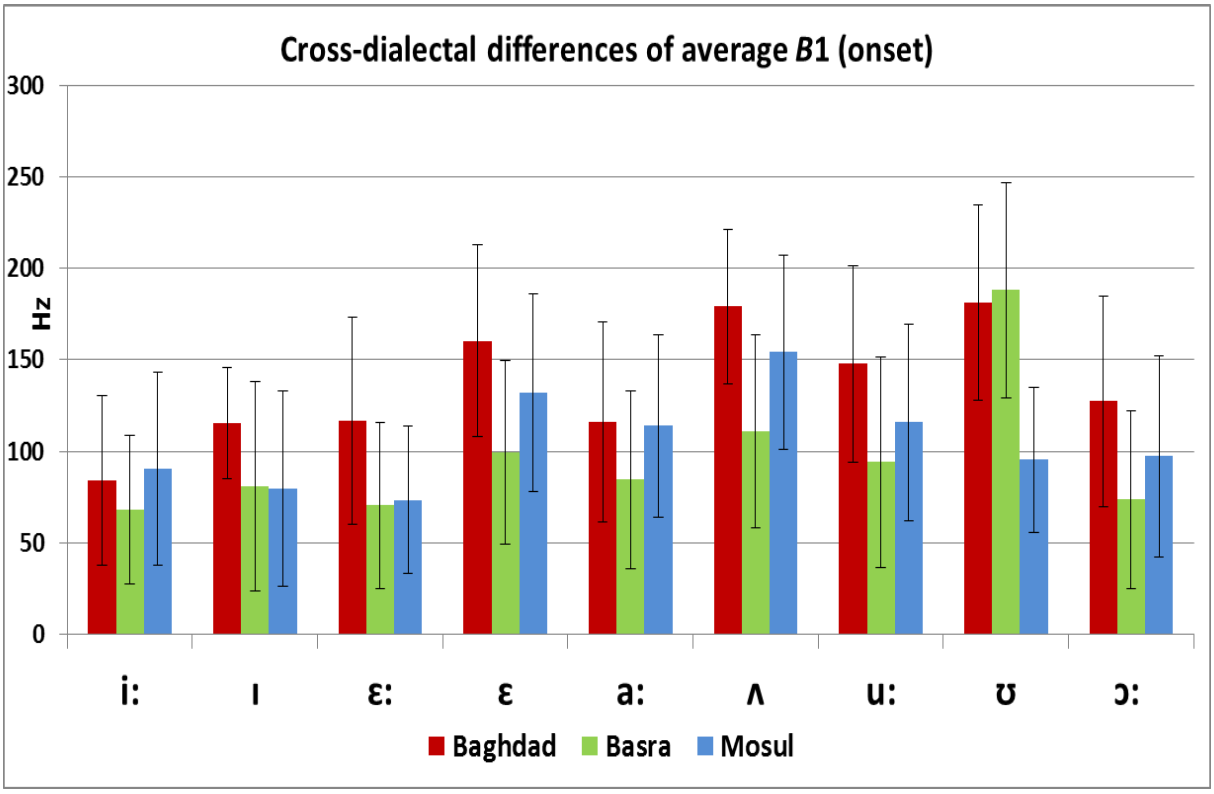

Cross-dialectal differences of average of A1-*P0 in individual contexts (offset)
25
20
15
10
5
0
dB
n-n
o-n
n-ħ
n-ʕ
ʕ-n
ħ-n
o-ħ
o-ʕ
o-o
isolation
Baghdad
Basra
Mosul

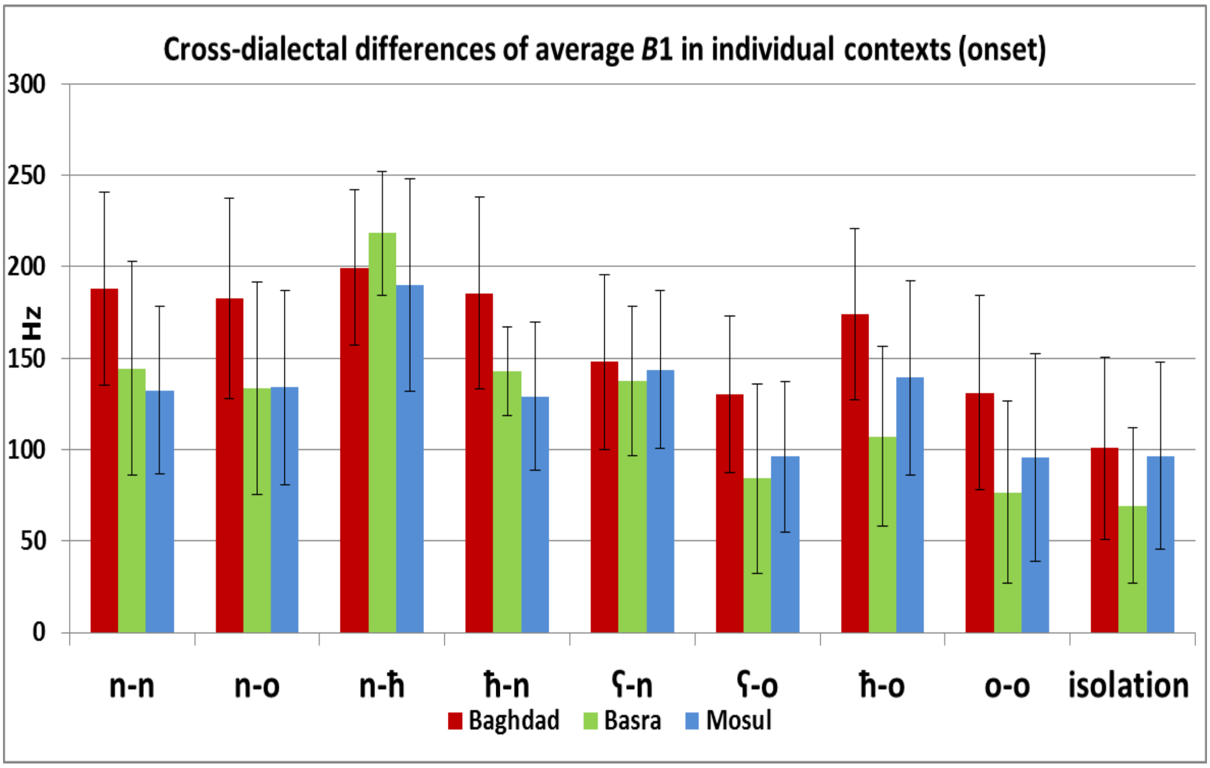
Appendix I: Results of applying *B*1 measure of nasalisation within individual contexts at onset and offset

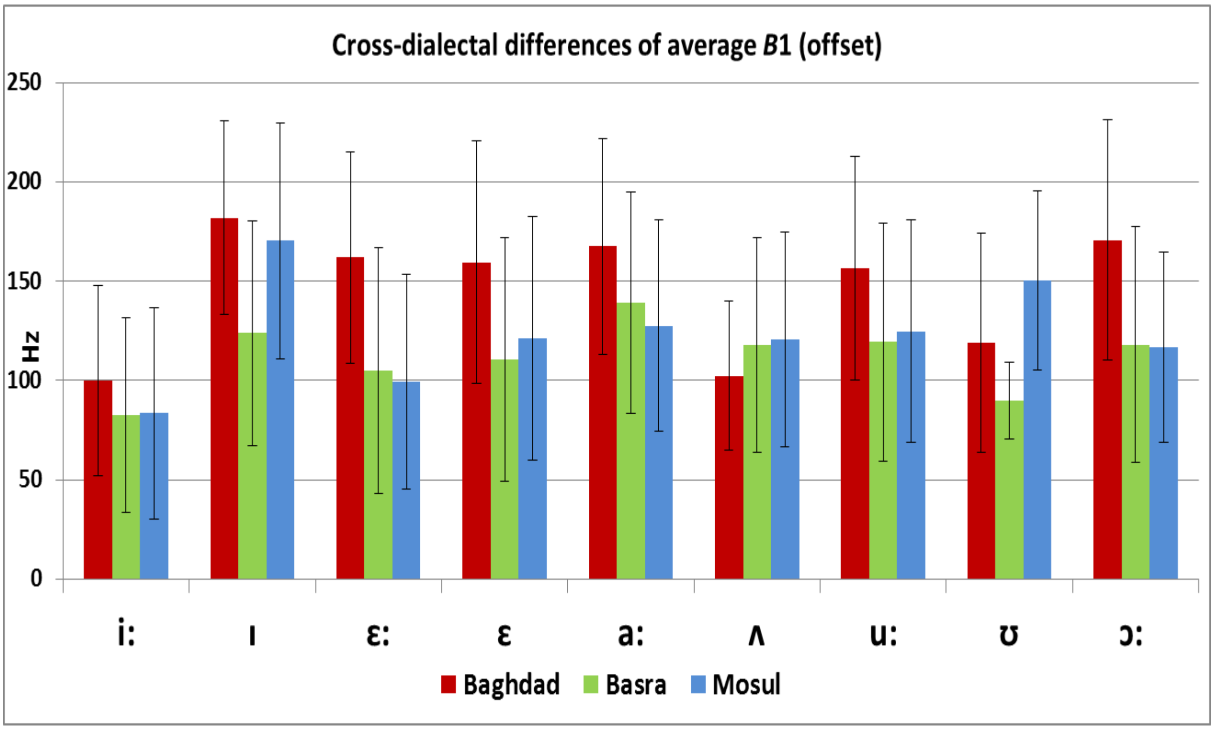



Average of B1 in individual contexts (offset)
Hz
300
250
200
150
100
50
0
n-n
o-n
o-ħ
o-ʕ
o-o
isolation
n-n
o-n
o-o
o-n
ʕ-n
o-o
isolation
o-n
ħ-n
ʕ-n
o-ħ
o-o
n-n
o-n
n-ħ
ʕ-n
o-ħ
o-ʕ
o-o
isolation
o-ħ
o-ʕ
n-n
o-n
n-ħ
o-ħ
o-ʕ
o-o
isolation
o-ħ
o-o
n-n
o-n
n-ʕ
ħ-n
ʕ-n
o-ħ
o-o
isolation
iː
ɪ
ɛː
ɛ
aː
ʌ
uː
ʊ
ɔː

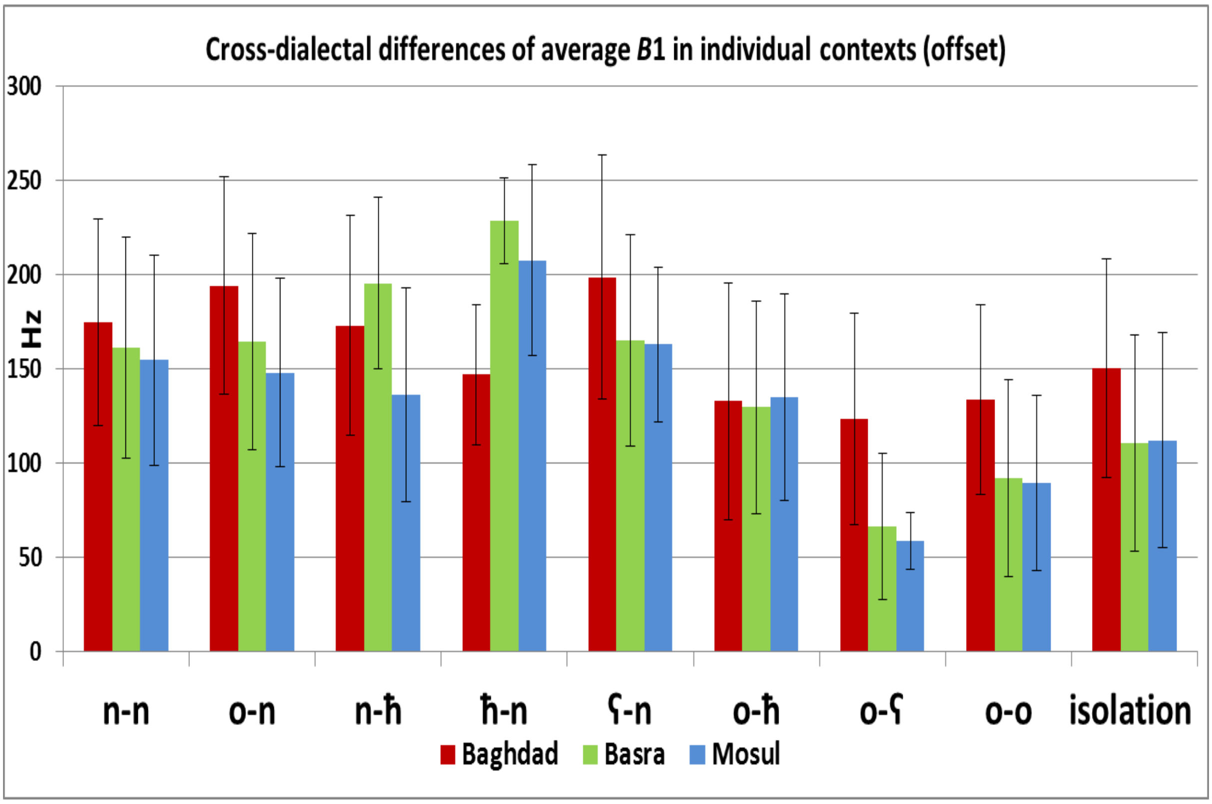
Appendix J: Results of applying cross-dialectal comparisons of *B*1 measure of nasalisation within vowels and individual contexts at onset and offset







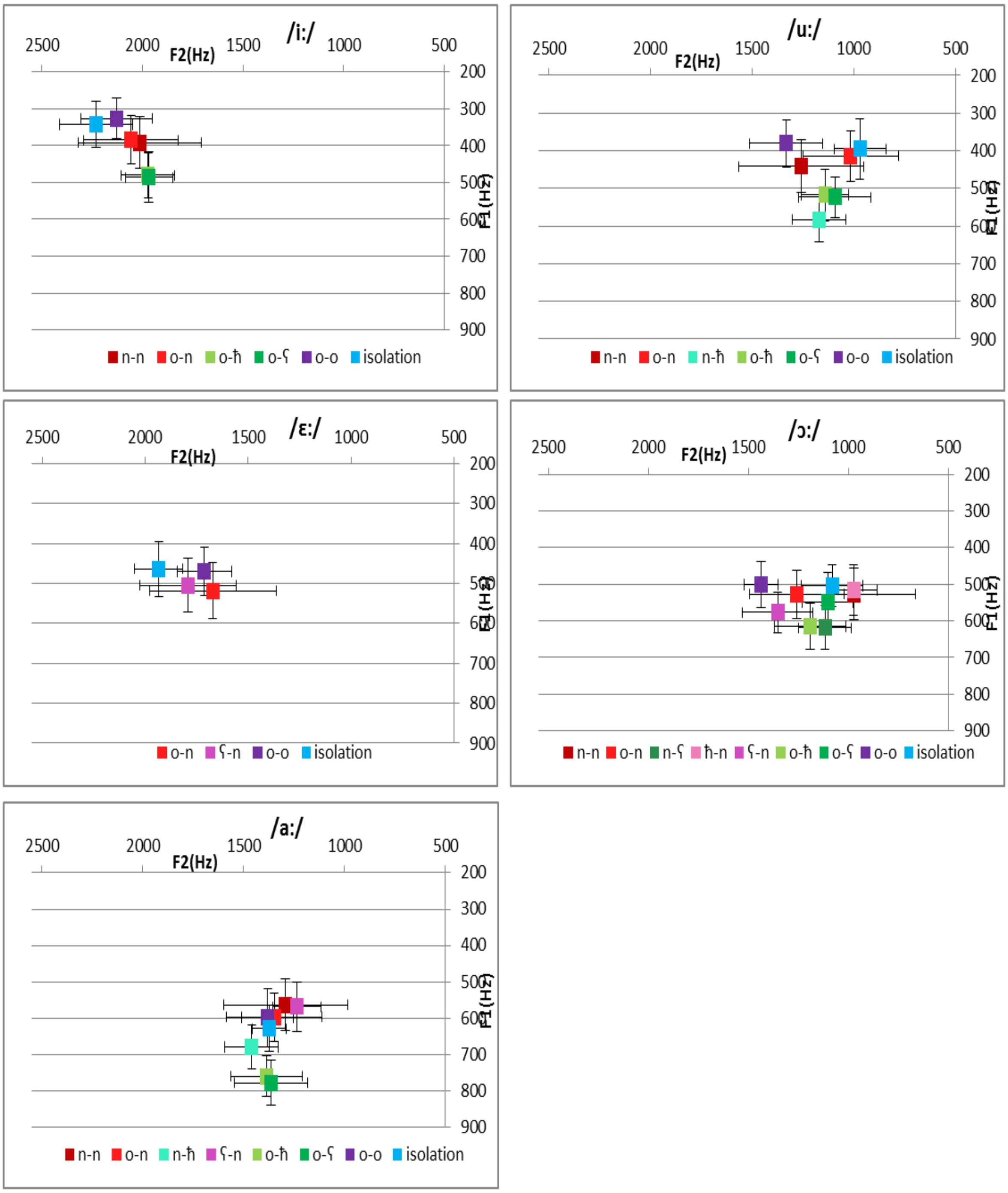
Cross-dialectal differences of average B1 (offset)
Hz
250
200
150
100
50
0
i:
ɪ
ɛ:
ɛ
a:
ʌ
u:
ʊ
ɔ:
Baghdad
Basra
Mosul



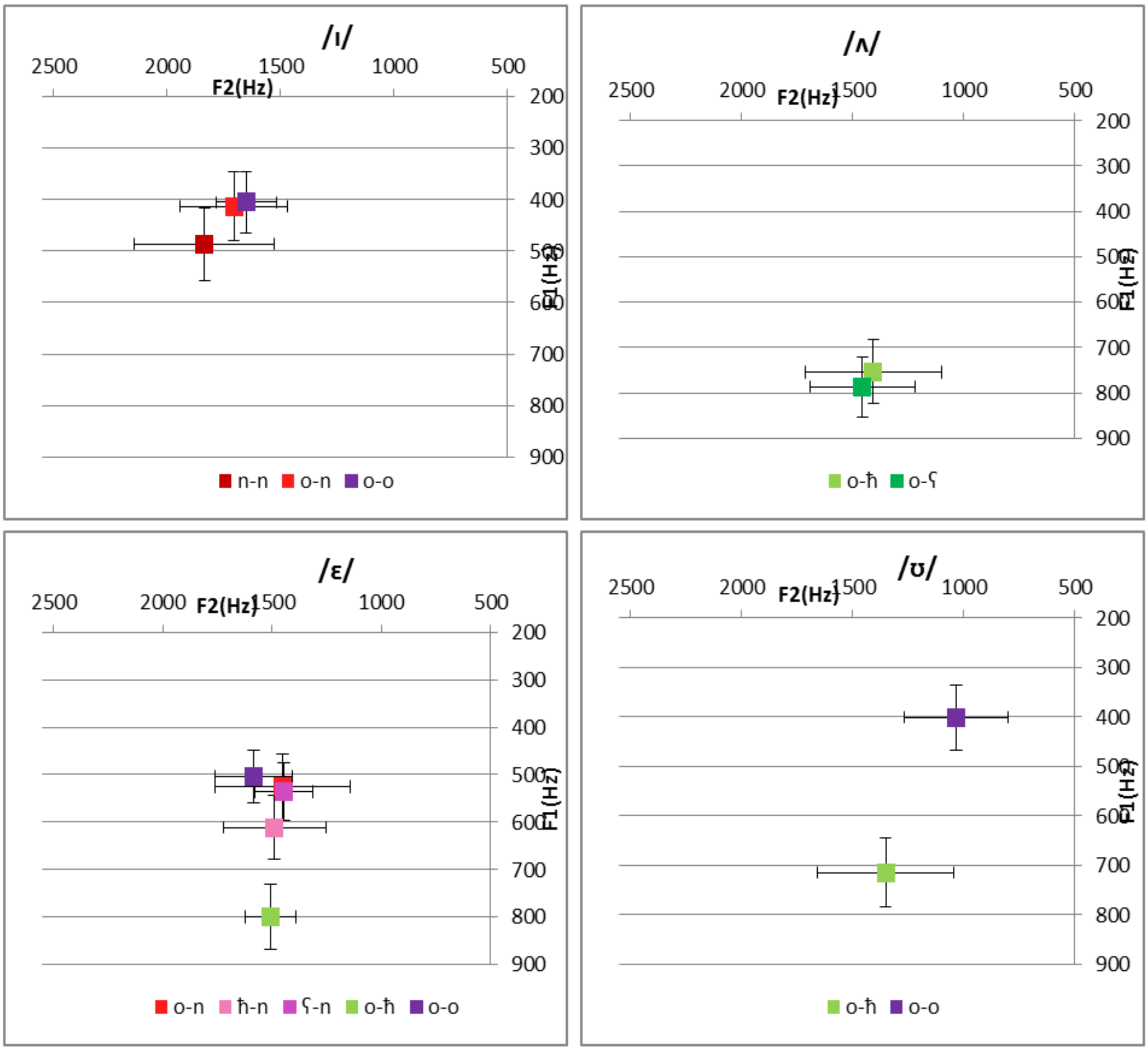
Cross-dialectal differences of average B1 in individual contexts (offset)
Hz
300
250
200
150
100
50
0
n-n
o-n
n-ħ
ħ-n
ʕ-n
o-ħ
o-ʕ
o-o
isolation
Baghdad
Basra
Mosul

Appendix K: Results of applying *F*1/F2 frequency changes at offset of long and short vowels within individual contexts

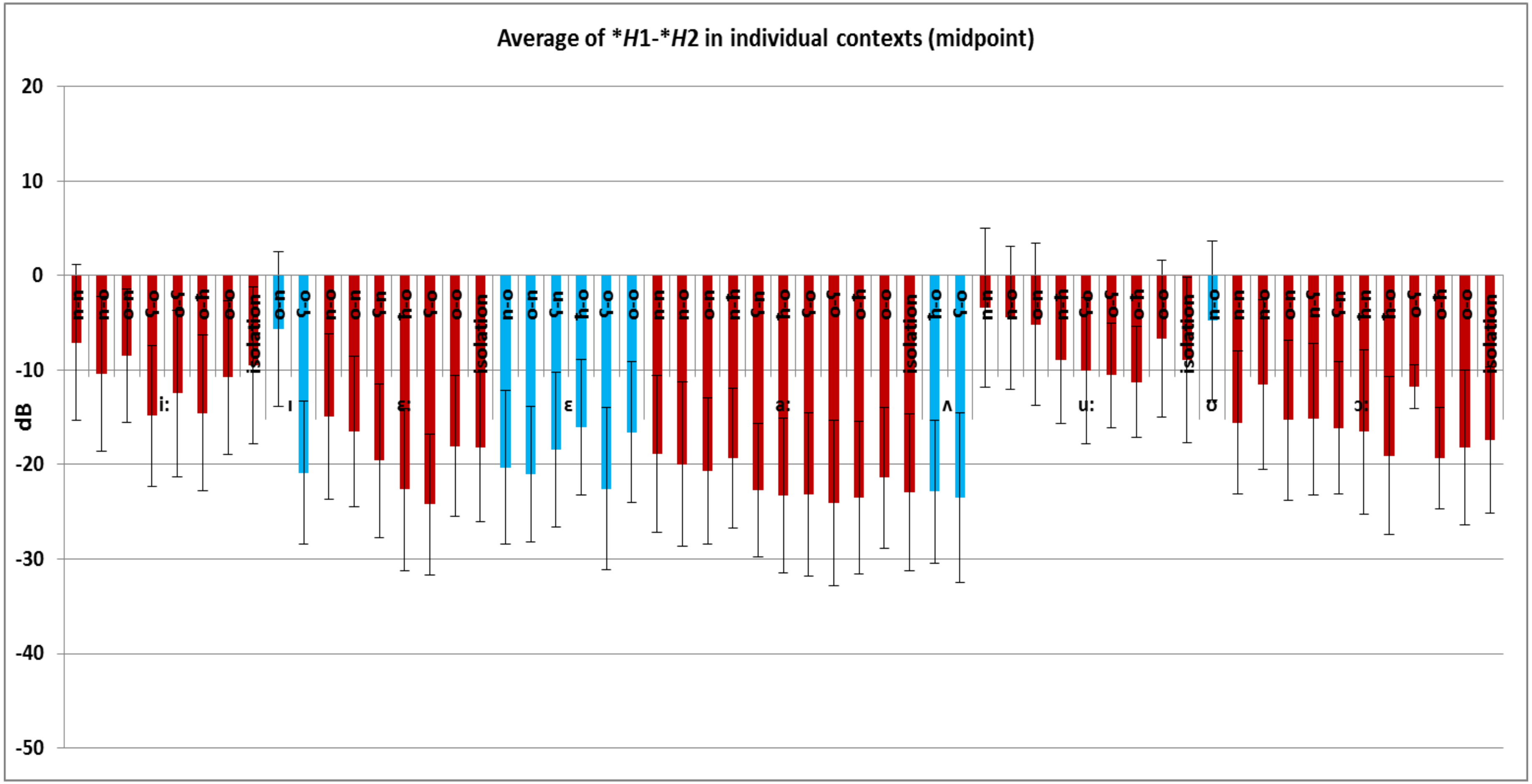
***F*1/F2 frequency changes of long vowels within individual contexts (offset)**



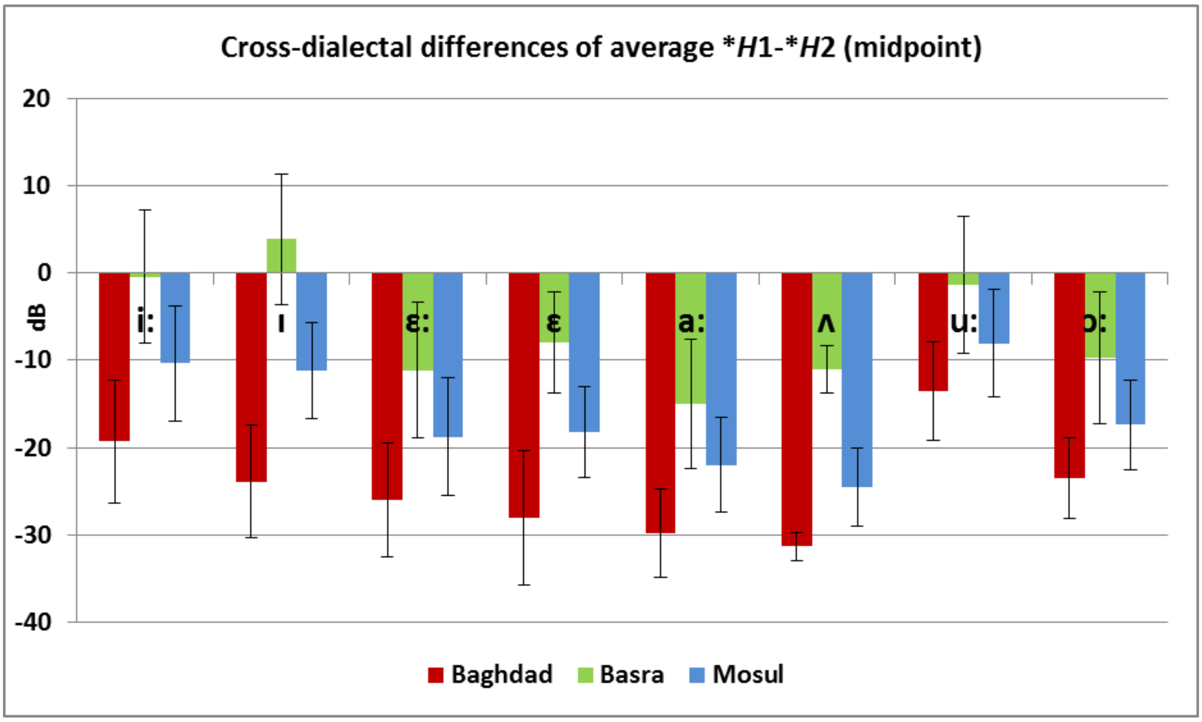
*F*1/F2 frequency changes of short vowels within individual contexts

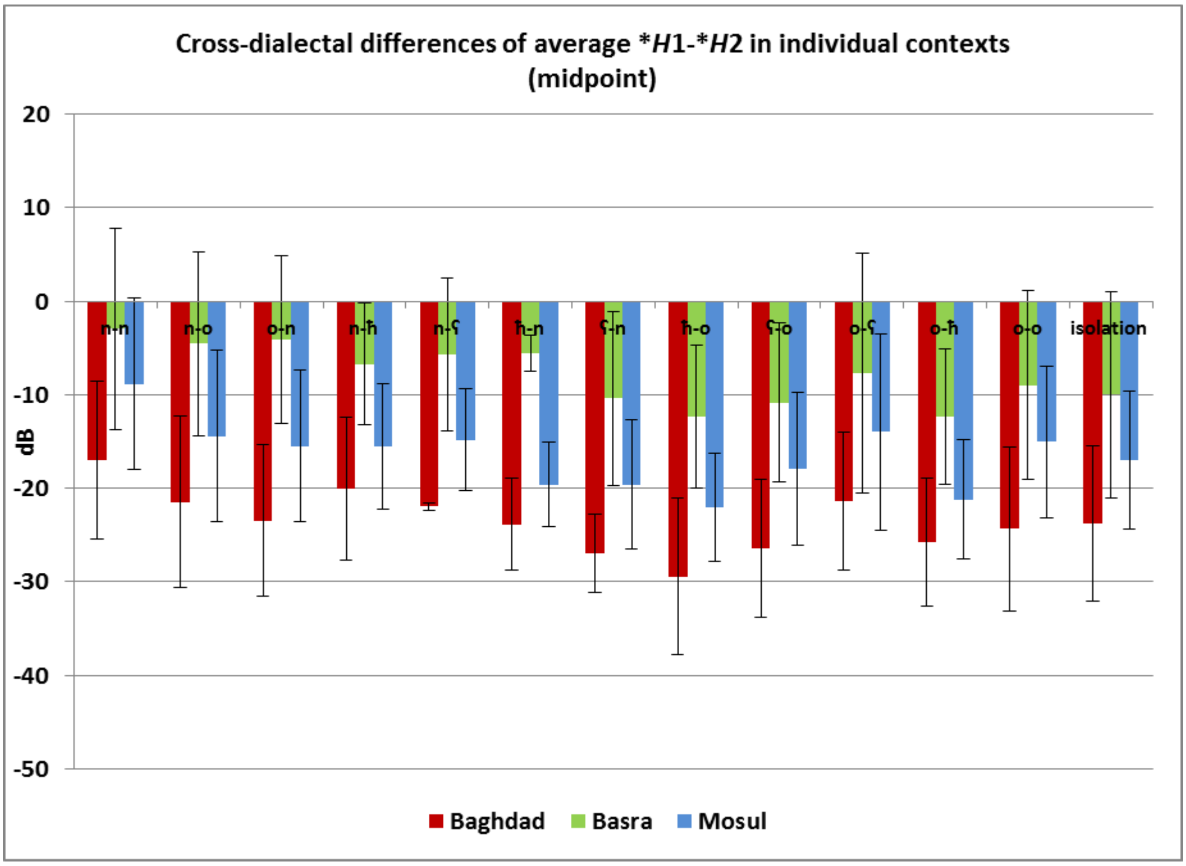


Appendix L: Results of applying *H1-*H2 measure of phonation types within individual contexts at midpoint

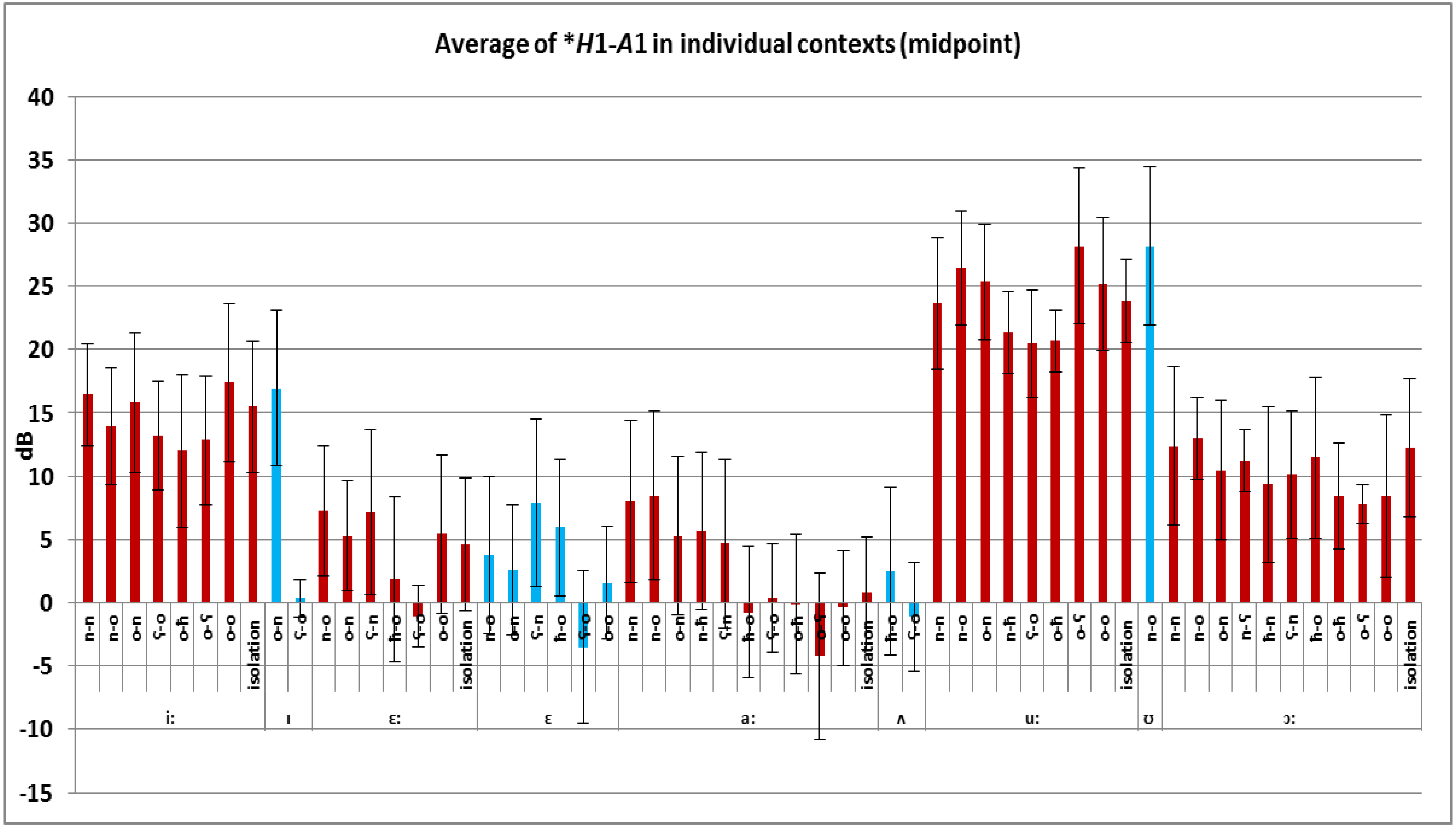


Appendix M: Results of applying cross-dialectal comparisons of **H*1-H*2 measure of phonation types within vowels and individual contexts at midpoint**





Appendix N: Results of applying **H*1-*A*1 measure of phonation types within individual contexts at midpoint



Appendix O: Results of applying cross-dialectal comparisons of *$H1$-$A1$ measure of phonation types within vowels and individual contexts at midpoint