EMPHASIS SPREAD IN THE NAJDI ARABIC DIALECT

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LIST OF ABBREVIATIONS

NA	Najdi Arabic
CA	Classical Arabic
SAr	Standard Arabic
MSA	Modern Standard Arabic
SA	Saudi Arabia
V1	The first Vowel
V2	The second vowel
VOT	Voice onset time
JA	Jordanian Arabic
LA	Libyan Arabic
PA	Palestinian Arabic
EA	Egyptian Arabic
CAr	Cairene Arabic
MA	Moroccan Arabic
IA	Iraqi Arabic
SdA	Sudanese Arabic
YE	Yemeni Arabic
TA	Tunisian Arabic
LbA	Lebanese Arabic
SyA	Syrian Arabic
KA	Kuwaiti Arabic
AA	Ammani Arabic
GA	Gulf Arabic
DJ	Djelfa Algerian dialect
BA	Baghdadi Arabic

LIST OF PHONETIC SYMBOLS

The description symbol of the Najdi Arabic dialect consonants

Najdi Arabic dialect consonant	Description	Symbol
أ	Glottal stop	ʔ
ب	Voiced bilabial stop	b
ت	Voiceless alveolar stop	t
ث	Voiceless dental fricative	θ
ج	Voiced post-alveolar affricate	dʒ
ح	Voiceless pharyngeal fricative	ħ
خ	Voiceless uvular fricative	χ
د	Voiced alveolar stop	d
ذ	Voiced dental fricative	ð
ر	Voiced alveolar approximant	r
ز	Voiced alveolar fricative	z
س	Voiceless alveolar fricative	s
ش	Voiceless post-alveolar fricative	ʃ
ص	emphatic voiceless alveolar fricative	ṣ
ض	emphatic voiced alveolar stop	ḍ
ط	emphatic voiceless alveolar stop	ṭ
ظ	emphatic voiced dental fricative	ð̣
ع	Voiced pharyngeal fricative	ʕ
غ	Voiced uvular fricative	ʁ
ف	Voiceless labio-dental fricative	f

ق	Voiced velar stop	g
ق	Voiceless uvular stop	q
ك	Voiceless velar stop	k
ل	Voiced alveolar lateral-approximant	l
م	Voiced bilabial nasal	m
ن	Voiced alveolar nasal	n
هـ	Voiceless glottal fricative	h
و	Voiced bilabial glide	w
ي	Voiced palatal approximant	j

The description symbol of the Najdi Arabic dialect vowels

	Front		**Central**		**Back**	
	Short	**Long**	**Short**	**Long**	**Short**	**Long**
Close	i	iː			u	uː
Mid		eː				oː
Open			a	aː		

ABSTRACT

Among the phonemic features of Semitic languages, emphasis (pharyngealization, velarisation or uvularisation), a secondary articulation in the posterior vocal tract, is an indisputably distinctive phenomenon in most modern Arabic dialects. Due to its prevalence, emphasis has become one of the most intriguing and discussed phenomena in numerous Arabic studies. Nonetheless, upon comparing these descriptive studies, it appears that there is no consensus regarding the nature of emphasis and its influence on neighbouring vowels. Therefore, this study aims to examine emphasis in Najdi Arabic (NA) from phonetic and phonological perspectives. To begin with, this study illuminates the acoustic characteristics of the emphatics in NA and the phonemic opposition between emphatic segments and their plain counterparts. Several acoustic parameters were examined, including voice onset time (VOT), the closure duration of voiceless stops, the friction noise durations of fricatives, the duration of adjacent vowels and the frequency of their formants in the onset, midpoint and offset positions (F1–F3).

Overall, the results indicate that emphatic vowels are characterised by a decrease in F2 when compared to plain vowels. The results of this study also indicate that the VOT and closure duration are reliable acoustic correlates of emphasis, particularly for voiceless stops whose emphatic VOTs are shorter than the ones in plain environments, while the closure durations are significantly longer in emphatic environments than those in plain environments. The vowels formant frequencies F1 and F3, noise duration of the fricatives and the vowel duration, however, are not reliable acoustic cues of emphasis.

The present study also elucidates the phonological behaviour of emphasis spread in NA. The observed variations of F2 lowering suggest a three-way system in which emphasis can spread

categorically, gradiently or not at all. Regarding the domain in which the emphasis spread applies, the results show that emphasis extends beyond the domain of the immediate surroundings and affects all other syllables within the phonological word, regardless of the emphatic position in the word (initial, medial or final). The results indicate that emphasis does not involve one direction having absolute predominance over the other, but rather that the emphasis spreads throughout the entire word in both directions (to the right and the left). The findings also imply that the emphasis domain can extend over other syllables across the morpheme boundary, affecting both prefixes and suffixes. Moreover, there is no directional asymmetry involved in the process in which the emphasis spread in NA is bounded in both directions. Specifically, there is a set of segments—/i(ː), u(ː), j, ʃ, dʒ, ɡ, k, q/—that appear to impede the emphasis spread. Interestingly, NA exhibits some differences concerning these opaque segments. For instance, the results demonstrate that the phonemes /i(ː), u(ː), j, ʃ, dʒ/ always block further spreading of emphasis, whereas /ɡ, k, q/ are inconsistent since they act as blockers in some cases and undergoers in others. Moreover, one of the blockers reported in previous studies, the [+ high] phoneme /w/, is emphasised in NA, as it fails to block the emphasis spread in both bisyllabic and trisyllabic words.

DECLARATION

I declare that no portion of this work referred to in this thesis has been submitted in support of an application for another degree or qualification of this or any other university or other institute of learning.

DEDICATION

I wholeheartedly dedicate this thesis to the light of my life, my loving parents,

Muneera Altwijri and Abdullah Almuhaimeed,

to my beloved sisters: Amal, Areej and Ashwag, and

to my dearest brothers: Badur, Muhannad, Abdulaziz and Mohammed

for your endless love and support throughout my life.

I will continue to strive to make you proud of me.

I love you all.

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CHAPTER1: INTRODUCTION

1.1 Overview

Emphasis spread (pharyngealisation) is a unique characteristic of most Semitic languages, such as Arabic, Berber, Aramaic, and Hebrew. This phenomenon has been a topic of great interest for Arab and Western phonologists, especially in terms of the phonetics and phonological nature of the emphatics as well as their behaviours across different Arabic dialects (e.g., Al-Ani, 1970; Davis, 1995; McCarthy, 1997; Watson, 1999; Al-Masri and Jongman, 2004; among others). The phonemic inventory of the Arabic language, including its standard and vernacular forms, contains a number of unique emphasis characteristics, with the exception of a few dialects, such as Jub, Maltese, Nigerian, and Cypriot Arabic, which, according to Hetzron (1998), appear to have lost the emphasis distinction feature over time. Most modern vernaculars of Arabic have minimal pairs of coronal obstruents (emphatic vs. plain), which differ only in terms of the presence or absence of an additional secondary articulation that is generally assumed to retract the dorsum of the tongue toward the walls of the pharynx (Al-Ani, 1970; Ghazeli, 1977; Card, 1983; Laver, 1994; Watson, 2002). However, these Arabic dialects do not necessarily have a similar set of emphatic sounds or the articulatory, acoustic, and perceptual correlates of this emphatic feature.

Many previous studies have examined the phonetic and phonological descriptions of the emphatic versus plain distinction. Cross-dialectal studies have suggested that the difference between these segments involves an emphasis effect on a range of identifiable acoustic parameters (Heath, 1987; Davis, 1995; Watson, 2002; Khattab et al., 2006). Most of these acoustic studies, however, were mainly vocalic acoustic investigations and ignored the consonantal acoustic cues of the trigger segments. Indeed, these studies found that the formant frequencies of the surrounding emphatic vowels (mostly F2) are the most robust and consistent acoustic cues of the plain-emphatic distinction (e.g., Heath, 1987; Wahba, 1993; Davis, 1995; Zawaydeh, 1999; Watson, 2002; Khattab et al., 2006; Al-Masri, 2009; Al-Ammar, 2017). Despite the emergence of extensive studies on emphasis in recent decades, very few experimental studies (e.g., Al-Masri and Jongman, 2004; Kriba, 2009; Abdullah, 2011) have examined other acoustic properties. Moreover, most claim that these acoustic properties show that the plain-emphatic distinction can be observed through a number of consonantal acoustic properties, including the duration of the trigger plain and emphatic consonants, the voice onset time (VOT), the closure duration of stops, and the frication duration of the fricative segments. Many of these earlier dialectal studies have suggested that emphasis can be thoroughly detected with both vocalic and consonantal correlates. Thus, a question that naturally arises at this point and concerns the effect of emphasis on these temporal properties is, ‘Do all emphasis cases in Arabic dialects involve both types of correlates?’ The answer is ‘no’, since there have been several indications that certain dialects do not necessarily involve both types of correlates as reliable acoustic cues of emphasis (Al-Masri and Jongman, 2004; Al-Masri, 2009). A simple way to address this question, as used in this study, is to examine both the vocalic and consonantal acoustic parameters to obtain relevant information about the nature of emphasis and emphatic realisation in contrast to plain segments.

This introductory chapter is organised as follows. The following section, 1.2, presents the dialect under investigation—Najdi Arabic (NA)—and offers a detailed account of its phonemic inventory. The contribution of this thesis to related disciplines is highlighted in Section 1.3. The main goals and questions of the investigation are stated in 1.4, which comprises both broad and specific questions (1.4.1 and 1.4.2, respectively). Finally, the structure of the current investigation is presented in Section 1.5.

1.2 Najdi Arabic

Najdi is a variant of Arabic spoken primarily in the Najd 'highland' province of central Saudi Arabia (SA), shown on the map below (see Figure 1.1). Najdi speakers make up the bulk of the total population of SA: approximately one-third, which is more than 10 million speakers, as estimated in the last population census[1]. NA is unique not only because it is comprised solely of its own features, but also due to its conservative features that are comparative similarity to features of Standard Arabic (SAr) that are not shared across other dialects (Abboud, 1979; Ingham, 1994). There is also social value attached to this dialect, especially because it is most commonly spoken in and around Riyadh, the capital of SA. Many linguists consider NA to be considerably prestigious because it is the dialect of the royal family (Johnstone, 1967; Omar, 1975).

[1] Statistics and Information Department, Saudi Arabia [http://www.citypopulation.de/SaudiArabia.html].

Figure 1.1: Location of the Najd region in Saudi Arabia.

NA is a main dialect[2] with four relatively autonomous sub-dialects: (i) Northern Najdi, which is spoken in Al-Qassim, Al-Zulfi, and Jabal Shammar in the north in Hail; (ii) Central Najdi (known as Urban Najdi), which is the main sub-dialect spoken in Riyadh as well as in the surrounding towns in the centre of SA; (iii) Southern Najdi, which is spoken around Al-Kharj and the surrounding towns and villages in the south-central region of SA; and (iv) Badawi Najdi, which is spoken among nomadic tribes in various cities and towns in the Najd region as well as in certain neighbouring countries, such as Kuwait, Jordan, Syria, and Iraq (Abboud, 1979; Ingham, 1994; Gordon, 2005; Lewis, 2013).

It is also important to note that not all individuals who speak one of these sub-dialects speak it the same manner. There can be different forms of speech that individuals use that all exist under a main umbrella dialect. In other words, a dialect can be subdivided into a number

[2]NA is considered a main dialect because it is spoken across an entire region (i.e., the Najdi region) and because it has several sub-dialects.

of sub-dialects that vary in some way from their parent dialect. Moreover, even within these sub-dialects, it is possible to find individuals who speak differently from each other; this phenomenon is usually only observed in local areas, such as towns and villages, within the same city. For example, the Northern Najdi sub-dialect of NA is spoken in three different areas—Zulfi, Al-Qassim, and Jabal Shammar—each of which has its own distinct dialect that shares a generally similar (but not identical) phonological system with the larger, parent dialect. For this reason, the present study examined Northern Najdi, which is mostly spoken in the Al-Qassim region, which lies almost in the centre of the country and approximately 400 km to the northwest of the capital city, Riyadh. The population of Al-Qassim city is approximately 1,464,800, and it covers an area of 58,046 km². This city borders Riyadh to the south and east, with Hail to the north and Madinah to the west[3]. Al-Qassim city is shaded in red in Figure 1.2. The Qassimi dialect is a colloquial dialect used only in daily verbal communication and not in any official written communication.

Figure 1.2: Location of Al-Qassim city in the Najd region.

[3] Al-Qassim Municipality, Geography of Al-Qassim [https://www.qassim.gov.sa/AR/Qassim/pages/Geography.aspx]

The next section provides a brief overview of the basic phonetic properties and symbols of NA.

1.2.1 Background of NA phonemic inventories

Traditionally, the phonemic inventory of a language (or dialect) is divided into two categories: consonants and vowels. Here, the consonantal phonemes are considered first, since NA has a relatively rich consonant inventory.

The full NA consonantal inventory is presented in Table 1.1 (Al-Sweel, 1981; Al-Feneekh, 1983; Ingham, 1994; Alhoody, 2019). It consists of thirty consonants: eight stops, thirteen fricatives, three affricates, two nasals, two approximants, one lateral approximant, and one glide sound. When two sounds appear within a single cell, the left sound indicates the voiceless form and the right indicates the voiced.

Table 1.1: Consonant inventory in NA.

Manner of Articulation	Bilabial	Labio-dentals	Dental	Alveolar	Post- alveolar	Palatal	Velar	Uvular	Pharyngeal	Glottal
Stop	b			t d ṭ			k g[4]	q		ʔ
Nasal	m			n						
Affricate				(t͡s) (d͡z)[5]	d͡ʒ					
Fricative		f	θ ð ð̣	s z ṣ	ʃ			χ ʁ	ħ ʕ	h
Approximant				r		j				
Lateral Approximant				l						
Glide	w									

In Table 1.1, each column corresponds to the precise place of articulation, while each row corresponds to the manner of articulation. NA consonants can be classified into obstruents and sonorants. Obstruents in NA—like in many other dialects of Arabic—are subdivided into three forms: plosives, such as [t, d, k, g]; fricatives, such as [s, z, θ, ð, χ, ʁ]; and affricates, such as [t͡s, d͡z, d͡ʒ]. All are comprised of both voiced and voiceless segments, with voiced segments on the right and voiceless on the left (Table 1.1). In the NA consonant inventory, there is a contrast between some voiced and voiceless obstruents. These obstruents form a

[4]The phoneme [g] only appears in NA and not in Modern Standard Arabic.
[5]Note that both [t͡s] and [d͡z] are the respective affricate allophones of the velar plosives /g/ and /k/ only in NA.

voiceless–voiced pair in which the only difference between the two sounds is their voicing status. In contrast, all NA sonorants are voiced.

The linguistic basics of Modern Standard Arabic (MSA) and NA are fundamentally the same, and the most common difference between them is primarily phonetic. Ingham (1994) pointed out that NA and MSA vary in terms of their phonemic inventories. As the consonant phonemic inventory contains a thorough comparison of the sounds available to NA and MSA, it can be deduced that there are considerable similarities between MSA and NA in terms of their consonant phonemes; however, differences in their consonantal inventories do occur. MSA and NA do not have the same number of phonemes in their phonemic systems. In other words, NA consists of additional phonemes that are not officially part of the MSA phonemic system and vice versa. In regard to the consonant inventory above, the following notable features should be highlighted:

(i) One difference between NA and MSA is that the realisation of the alveolar emphatic stop /ḍ/; /ḍ/ in MSA typically surfaces as /ð̣/ in NA (e.g., /ḍab/ (lizard) in MSA is realised as [ð̣ab] in NA but is still represented orthographically as /ḍ/) (Johnstone, 1967a; Ingham, 1994; Feghali, 2004). In fact, in other contemporary dialects of Arabic, such as Jordanian Arabic (JA), Tunisian Arabic (TA), and Iraqi Arabic (IA), /ḍ/ is realised as /ð̣/, while in other varieties, such as Iraqi Christian dialects and Levantine Arabic, the emphatic stop [ḍ] is generally maintained (AlAni, 1970; Alghazo, 1987).

(ii) Another consonantal variation between MSA and NA is the velar affrication, as demonstrated in (1) below, in which the voiced velar plosive /g/ and its voiceless counterpart /k/ in MSA surface in NA as the voiced alveolar affricate [d͡z] and the voiceless alveolar affricate [t͡s], respectively. This fronting process is applied optionally and does not result in any change in meaning. Notably, the possibility of alternation between the velar stops and the alveolar affricates is limited since the velar affrication only applies in the context of front vowel regardless of vowel length (Ingham, 1994; Johnstone, 1967a; Prochazka, 1988; Alrashed, 2018).

(1) Velar affrication in NA

a. /**ki**ðb/ → [**ts**iðb] ‘lying’
b. /gibiːlih/ → [**dz**ibiːlih] ‘tribe’
c. /χirgih/ → [χir**dz**ih] ‘a piece of cloth’
d. /**k**eːf/ → [**ts**eːf] ‘how’

(iii) An important distinguishing characteristic of NA is the pronunciation of ⟨ق⟩ as the voiced velar stop /g/ instead of the voiceless uvular /q/ as in Classical Arabic (CA) and MSA. The classical uvular is generally pronounced in NA today as a voiced velar stop /g/ even though the velar stop itself is absent in MSA (Newman, 2002; Abdoh, 2010); however, due to the influence of MSA on NA, the uvular /q/ is still maintained, and it is evident, in lexical terms, that every occurrence of /q/ in NA is borrowed from MSA, a phenomenon that is especially salient in religious contexts. A specific illustration of this case is the word ‘Qur'an’, ‘the Holy Book’, which is pronounced in MSA and NA as /qurʔaːn/ (Holes, 2004; Habash, 2006).

The NA vowels are shown in Figure 1.3, which indicates how the phonology of this dialect is characterised by a relatively simple vocalic inventory. The inventory revolves around eight vowels; six of these eight are pure, while the other two are diphthongs (Abboud, 1979; Al-

Sweel, 1987; Prochazka, 1988; Ingham, 1994). Pure vowels in NA are comprised of three sets of pairs, and each pair includes a short and a long vowel (/i, iː/, /u, uː/, and /a, aː/); hence, vowel length is contrastive in NA. However, the two diphthongs /eː/ and /oː/ in NA have no short counterparts. It is important to note that the diphthongs /aj/ and /aw/ in MSA are realised in NA as /eː/ and /oː/, respectively (Ingham, 1994; Aryan, 2001). NA diphthongs are shown in the following examples.

(2) Examples of diphthongs in NA

a. /bayt/ → [beːt] 'house'
b. /lawn/ → [loːn] 'colour'

All the vowels in NA, like in most varieties of MSA, can be classified in terms of the three basic vowel parameters: tongue height, tongue backness, and lip rounding. Figure 1.3 depicts the vowels and diphthongs in NA (Alqahtani, 2014).

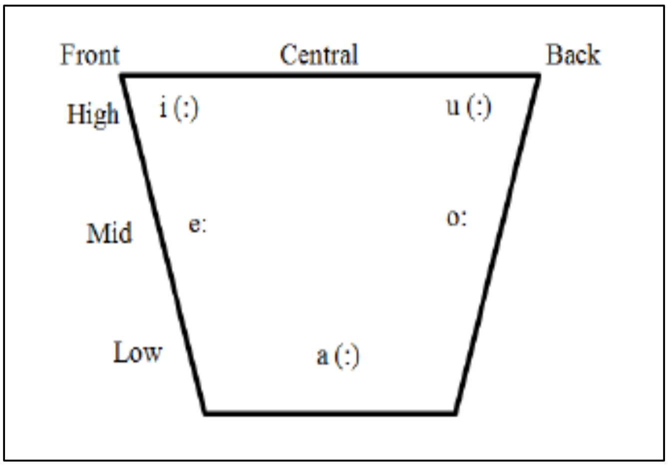

Figure 1.3: Vowel inventory of NA.

In the phonetic description of pure vowels in NA, the short vowels, /a, i, u/, are usually indicated by the diacritics /ʔalħarakaːt/: fatha, kasra, and damma, respectively, as in MSA. Generally, these diacritical marks are written above or below the consonants that precede them in the syllable in order to indicate the presence of the short vowels[6], as illustrated in Table 1.2 (Ibn Jinni, 1952).

Table 1.2: Short vowel presentation in NA.

Short vowels	Symbol	Description
/a/	◌َ	A small diagonal line above the consonant
/i/	◌ِ	A small diagonal line underneath the consonant
/u/	◌ُ	An apostrophe-like mark above the consonant

Thus, diacritics—as extensively reviewed in previous studies—are special in Semitic languages, including Arabic. That is, the use of these diacritics can offer extensive benefits in terms of providing a phonetic guide to help readers articulate text correctly and to eliminate ambiguity among homonyms (Attia, 2008). In other words, any change in a short vowel mark that accompanies a consonant can result in a new meaning[7], as shown below.

(3) Diacritics in Arabic

كَتَب /katab/ 'write'

كُتُب /kutub/ 'books'

[6]The placement of a diacritic above or below a letter means that the vowel comes after that letter.
[7]Farghaly and Shaalan (2009) stated that short vowels in Arabic, both standard and varieties, are typically not written down anymore except in holy texts, works for learners, and sometimes in formal texts, such as poetry.

NA has long vowels as well, which basically involve, as in CA and MSA, the prolongation of the short vowels mentioned above; hence, these vowels are called حركات طويلة /ħaraka:t ṭawi:lah/ 'long vowels' (Ibn Jinni, 1952; Ibn Sina[8] (980 – 1037 AD), cited in Semaan, 1963). However, in written forms, these vowels are not represented with diacritics but with letters. That is, the three long vowels /a:, i:, u:/ are the phonetic representations of the Arabic prolongation letters (ا) /ʔalif/, (ي) /ja:ʔ/, and (و) /wa:w/, respectively. When these three letters are used to represent the long vowels, the diacritics of their short vowel counterparts appear above or below the preceding consonant, such as in مَانع 'preventive'.

The occurrence of vowels in a syllable-initial position in NA—as in CA, MSA, and other dialects of Arabic—is somewhat restricted. In general, it is prohibited for vowels to be in the initial position in the Arabic language; however, for consonants, there is no such restriction (Btoosh, 2006; Fathi, 2013). NA seems to comply with the universal default setting of syllable formatting in which syllables always begin with a consonant (Itô, 1989). Thus, it is important to consider how Arabic and its vernaculars adequately avoid the occurrence of an onsetless syllable. As a straightforward solution to this challenge, a language can apply either epenthesis or re-syllabification processes to produce an onset syllable, as shown below.

(4) Epenthesis and re-syllabification for onsetless syllables

a. aħmad → ʔaħmad 'proper noun'

b. ʃift.ak 'I saw-2nd.Per.MASC.SG.PRO' → ʃif.tak 'I saw you'

In the examples above, the underlying vowel-initial syllables have a consonantal onset via the use of a consonant insertion (i.e., the glottal stop) to initiate the syllable, as in (4a), or through

[8] Ibn Sina is referred to in Western studies by the name Avicenna. Ibn Sina's essay /risa:lat fi ʔsbabħudu:θʔal-ħuru:f/ 'Treatise on the Generation of Speech Sounds' explicitly examined speech sounds and how they occur.

the re-syllabification of the second consonant in the coda of the preceding syllable (CVCC), to become the onset of the succeeding syllable, as in (4b). Given this, it seems clear that vowel occurrence is restricted solely to medial and final positions.

1.3 Contribution and aim of the thesis

Many studies—especially primary phonetic studies regarding emphasis in Arabic literature—have examined a variety of acoustic parameters that provide a thorough account of emphasis. While several of these studies have shown that some of these parameters may be successfully used to clarify the distinction between plain and emphatic segments, only a limited number of the necessary measurements that can provide in-depth and valuable insights into the aspects of emphasis have been examined extensively.

Thus, this thesis aims to improve the understanding of emphasis spread by examining unaddressed related acoustic patterns involved in the production of segments with the [+RTR][9] feature and to develop certain generalisations regarding this assimilatory process in order to contribute to the development and existence of NA research. During this study, a number of other specific goals were also established, including (i) exploring the phonetic distinction between plain/emphatic consonants in NA, paying special attention to the role of durational correlates such as VOT, the closure duration of stops, the friction sound of fricatives, the surrounding vowel durations, and their formant frequencies on this distinction; (ii) utilising other acoustic correlates, such as vowel quality, vowel length, speaker sex, and the attested consonants' manner of articulation and their voicing status to further characterise emphasis distinction; (iii) extending this study to encompass a detailed analysis of the

[9] Emphatic segments were articulatory distinguished from their plain counterparts by the retracted tongue root feature [RTR]. This feature represents the secondary articulation of emphatic consonants. (See Chapter 6 for more details).

phonological behaviour of emphasis in order to obtain a clearer understanding of the phenomenon; and (iv) examining the possible domains of emphasis spreading, such as syllables, stems, and words. This investigation contributes to the determination of whether the distance between the potentially interacting segments also plays a role in the extension of emphasis spread and, thus, aims to (v) explore if there are relevant directionality asymmetries in the behaviour of [+RTR] spread, where one direction of spreading has absolute ascendency over the other. It should, in principle, be possible to distinguish transparent and opaque segments from those that undergo emphasis harmony.

Primarily, this experimental emphasis research must consider aspects that previous studies have generally ignored and for which corresponding data is currently lacking. The predominant research questions of this study, which are stated in detail in Chapters 3, 4, 6, 7, and 8, have emerged from this aim.

1.4 Thesis synopsis

This chapter established the main research aims of the study, following a basic description of the dialect under investigation and a review of certain phonological characteristics of NA, including the phonetic inventories of both consonants and vowels and certain clarifications on related phonological characteristics relevant to the experiments. This dissertation contains eight additional chapters, structured as follows:

The next chapter, Chapter 2, includes a comprehensive review of noteworthy prior studies on emphasis spread in different Arabic vernaculars. This literature review highlights the different opinions that are relevant to this study and identifies certain gaps in prior studies that need to be filled. The review starts with a definition of emphasis, an outline of related descriptions of emphatics in Arabic in general, and a discussion of the nature of emphasis.

The chapter concludes with an exploration of emphatics at the articulatory, acoustic, and phonological levels.

Chapter 3 details the general design of the phonetic investigation process, including samples of the materials used in each chapter, the participants' information, and the approach adopted for data collection. Data analysis methods (e.g., acoustic correlates measurements) are also described in some detail.

Chapter 4 presents the trigger/target acoustic cues, including vowel duration, vowel formant frequencies (F1–F3), stop closure duration, stop VOT duration, and friction noise duration. A detailed description of the data analysis is provided, followed by a presentation of the findings, and finally, where possible, interim conclusions are drawn.

Chapter 5 establishes the criteria for identifying the phonological status of the emphatic feature within and beyond the syllable. In this chapter, the classification system with which the effect of the emphatic triggers can be described is also established. This aids in developing an understanding of the questions concerning the phonological aspect of emphasis spread in NA.

Chapter 6 describes three phonological aspects of emphasis spread in NA. First, this chapter provides an analysis of the domains to which emphasis may spread. Second, the directionality of emphasis and whether emphasis in NA shows any preference for one direction over the other is examined. Third, this chapter investigates the effect of morphology on emphasis spread in particular to assess if morpheme boundaries permit the extension of emphasis spread or block it.

Chapter 7 addresses the so-called blocking and transparent segments relating to emphasis spread. It provides an overview of the behaviour of these segments and reveals whether these segments exhibit asymmetrical behaviour related to the directionality of emphasis spread.

Chapter 8 discusses the uncommon realisation of emphasis spread in sounds, including the velars /g/ and /k/ and the voiceless uvular /q/. This chapter provides a description of segmental behaviour and the patterns that these segments exhibit in those cases.

In Chapter 9, all previous findings and considerations are assessed in order to provide a thorough discussion and make overall conclusions about the nature of emphasis spread in NA. It concludes with potential implications and suggestions for future work.

CHAPTER 2: EMPHASIS AND ARABIC EMPHATICS

2.1 Overview

Arabic has a relatively large consonant inventory—as compared to its vowel inventory—and includes a rare set of consonants conventionally referred to as 'emphatics' /ṣ, ḍ, ṭ, ð̣/[10] < ظ, ط, ض, ص > (Maddieson & Precoda, 1991). The study of emphasis is traceable to the works of Arab grammarians and phoneticians in the early Middle Ages (8th century AD) (Sibawayh and Ibn Sina cited in: Semaan, 1968) who primarily concentrated on the production of emphatics and their vocal tract configurations. Western interest in the study of emphasis, however, began later—in the the twentieth century—with several studies focusing primarily on the phonological features of emphasis (Ferguson, 1956; Davis, 1995; McCarthy, 1997; Watson, 1999). Later, various linguists took the first step towards a more in-depth understanding of the process and, therefore, addressed the gap relating to the acoustic characteristics of the emphasis process in the literature by concentrating mainly on the acoustic cues of emphasis in most Arabic dialects, which has been an active area of research ever since (Kriba, 2004, 2009; Khattab et al., 2006; Bin-Muqbil, 2006; Youssef, 2006; Abudalbuh, 2011; Embarki et al., 2011; Al-Huneety, 2015).

This chapter will equally focus on emphatic sound enquiry and the nature of this phenomenon with some aspects—basic concepts, terminologies and different interpretation issues related to emphasis—through which they are explored. The phonemic opposition between emphatic segments and their non-emphatic 'plain' counterparts and their position in the emphasis spread process is also reviewed. Furthermore, this chapter also discusses the

[10] All reported emphatics in this study were represented with a dot beneath to avoid any confusion since, in prior studies, various symbols were used to represent these segments.

current literature regarding articulatory gestures, the phonetic and phonological characteristics of emphatics in Arabic and most of its dialects.

2.2 Emphasis in Arabic

Emphasis is a term that is more complicated than it first appears. The term ‘emphasis’ has been used synonymously in previous research to refer to ‘pharyngealisation’, which typically refers to a secondary articulation of consonants by which the pharynx is constricted—due to the lowering of the back of the tongue and the retraction of the root towards the pharynx wall—simultaneously with a primary dental/alveolar articulation of these sounds (Laufer & Baer, 1988). It can further be regarded as the addition of a [ʕ] quality to the primary articulation, and the diacritic for emphatic consonants is a raised voiced pharyngeal approximant [ˤ], symbolising the secondary articulation in the pharynx. This is the traditional phonetic description, which broadly distinguishes emphatic from plain sounds by generally considering elevating the back part of the tongue as the most major characterisation of the articulatory and auditory properties of these sounds. Yet, in the literature, several terminologies of emphasis have been used to consider its numerous phonetic and phonological identifications. Alternatively, Arabic grammarians and phoneticians have proposed different terms to stress the same emphasis idea, which indicates the phonetic identity of these sounds. Among these, earlier in the eighth century (796 A.D.), Sibawayh used many terms to refer to the emphatic consonants, including مطبقة /muṭbaqah/[11] ‘covered, high’, مستعلية /mustaʕliyah/ ‘raised/high’ and مفخمة/mufaxxamah/ ‘thickened’ (Cantineau, 1960; Lehn, 1963; AI-Nassir 1993; Khattab et al., 2006; Bin-Muqbil, 2006). Sibawayh stated

[11] Sibawayh used the terms /ʔitˤbaq/ and /ʔinfitaħ/ (corresponding to emphatic and plain consonants, respectively) to distinguish between Arabic consonants.

that /ʔiṭbaq/ ‘covered, high’ described the production of the emphatic sounds in which the tongue is closely covered through contacting the part of the palate it faces, which implies that the tongue is raised towards the palate while producing the emphatics (Cited in: Semaan, 1968: 45). Here, /ʔiṭbaq/ primarily involves a secondary stricture of an approximant nature that simultaneously accompanies another primary stricture, which could be either dental or alveolar. However, the term /mustaʕliyah/ ‘raised/high’ describes the production of both emphatic /ṣ, ḍ, ṭ, ð̣/ and uvular consonants /q, χ, ʁ/ where the tongue is thought to be raised towards the velum. The only difference between the two sound classes, in this case, is that the term /mustaʕliyah/ describes the primary articulation of the uvulars, while it only describes the secondary articulation of the emphatics. Based on these descriptions, the terms /muṭbaqah/ and /mustaʕliyah/ are quite equivalent since all of them describe the secondary articulation of emphatics, but the term /mustaʕliyah/ also describes the primary articulation of uvulars. Sibawayh has also noted that these emphatic sounds [ṭ, ḍ, ṣ, ð̣] share the same primary coronal articulation with their corresponding plain cognates [t, d, s, ð]. Modern Arabic dialect studies have provided extensive support for Sibawayh’s assertion and have illustrated that emphatic sounds differ only from their non-emphatic counterparts in that emphatics have a secondary articulation comprising ‘backing the tongue towards the pharyngeal wall’ (Yeou 2001: 1). This secondary articulation demonstrates that the distinction between these two sound categories is phonemic. Minimal pairs formed by the emphatic and plain consonants indicate the existence of this phonemic contrast within the Arabic phonology, as in the words /tiːn/ ‘fig’ and /ṭiːn/ ‘mud’ (Obrecht 1968; Trubetzkoy 1969).

Ibn Jinni’s (1952, p. 70) definition of emphatics did not appear to validate such terms. He described emphatic sounds as those produced with the tongue raised to cover most of the mouth roof, including the alveolar ridge and hard palate. Perhaps the distinction between these two terms is that emphatics are the only consonants among these categories characterised by a ‘pressed voice’ (Cantineau, 1960). Finally, the third well-known term is /mufaxxamah/ ‘thickened’, which mainly refers to the sounds articulated with tongue depression towards the pharyngeal wall, inducing a reduced pharyngeal space even if the constriction is part of the primary or secondary articulation of these sounds. This involves the emphatics /ṭ, ḍ, ṣ, ð̣/, uvulars /q, χ, ʁ/ and the pharyngeals /ħ, ʕ/ (Jakobson, 1957; Khattab et al., 2006). Ibn Sina (980–1037 AD) also addressed emphatics as sounds articulated by a depression of the tongue dorsum (Cited in: Semaan 1963; Card, 1983). He compared the phonetic descriptions of articulating the emphatic [ṭ] with both the voiceless plain [t] and the voiced plain [d] and emphasised that all the three sounds have the same place of articulation. The distinction between the three sounds, however, is that the level of impedance of air movement through the vocal tract varies between these sounds to some extent. Ibn Sina provided a thorough phonetic and anatomic description of these sounds and the vocal tract parts involved in their production. This description was confirmed later in other studies of Arabic dialects, such as IA, TA and JA (Ali & Daniloff, 1972; Ghazeli, 1977; Al-Tamimi & Heselwood, 2011). Different studies have also endeavoured to provide relevant definitions of the emphasis process. According to Finch (1984), the term emphasis is used in phonetics and phonology for ‘... a group of velarised or pharyngealised interdental and dental consonants’ (p. 32). Meanwhile, Ibn Al-Jazari defined emphasis as ‘thickness that enters into the body of the consonant so that the mouth fills with its echo’, while plainness is the ‘thinness that enters into the body of the consonant so that the mouth does not fill with its echo’ (Cited in: Abu-Sha^{c}ar, 1996, p. 271). However, other studies have confirmed that it is difficult to define this process simply by including a single secondary articulatory feature due to the articulatory complexity of emphasis (AI-Nuzaili, 1993; Lehn, 1963).

Emphasis harmony generally can be described by the phonetic effect of one segment over another within a certain domain. In this matter, the emphasis spreading process requires basic elements to occur: a triggering segment, a target segment, a domain and a direction in which the harmony applies. Emphasis in Arabic is triggered by a set of coronal emphatic segments that cause their emphatic feature to spread and affect surrounding segments. However, in the past 60 years of Arabic emphasis studies, some perspectives and core features have changed. So what does emphasis in this matter no longer involve nowadays that it once did? One area of inconsistency is the number of emphatics that exist in Arabic and its dialects (Al-Ani, 1970). In CA, the conventional term 'emphasis' refers to a set of coronal and guttural sounds, for which their articulations are distinctively characterised by raising the back section of the tongue. Based on this, emphatics are classified into two categories: the first category takes place when the tongue is in complete contact with the velum as a primary articulation, while the second category occurs when the tongue is partially raised in contact with the velum as a secondary articulation. The second articulation occurs simultaneously with another primary articulation, but primary articulation takes place in an anterior area of the oral cavity. The first group includes the uvulars /χ, q, ʁ/, while the other contains the emphatics /ṭ, ḍ, ṣ, ð̣ or ẓ/ with other sounds only in specific contexts such as /r/, /l/, /m/, /b/, the low front vowel /a/ and its long counterpart /aː/ (Broselow 1976; Ghazeli 1977).

Regarding modern dialects of Arabic, various studies lack consensus on the number of emphatics either across or within the same dialects; however, it is relatively simple to establish relationships among these dialects (Table 2.1). That is, the set of emphatic consonants introduced in the literature regarding Arabic dialects can help divide these dialects into three groups: (i) those that include only three emphatic consonants, (ii) those that comprise four primary emphatic consonants and (iii) those that include more than four emphatics. Table 2.1 reports a summary of these groups and the different emphatics (e.g. primary or secondary) included within each dialect.

Table 2.1: Summary of the consonants included in the emphatic set of various Arabic dialects.

Investigated dialect	Primary emphatics	Secondary emphatics
Cairene Arabic (CrA) (Harrell, 1957; Lehn, 1963; Youssef, 2006)	/ṣ, ṭ, ḍ, ẓ, ṛ/	/ḅ, ḷ, ṃ, f̣, x̣, ḳ/
Lebanese Arabic (LbA) (Obrecht, 1968)	/ṣ, ṭ, ḍ, ẓ/	/ ḅ, ḷ, ṃ, ṇ, ṛ/
Tripoli Libyan Arabic (LA) (Laradi, 1972; 1983)	/ṣ, ṭ, ḍ, ẓ, ḷ/	Consonants occur in the vicinity of the primary emphatics and open vowels /a(:)/
IA (Al-Ani, 1970; Ali & Daniloff, 1972b; 1974; Wallace, 2004)	/ṣ, ṭ, ð̣/	/ḅ, f̣, ḷ, ṃ, p̣, ẓ/
TA (Ghazali, 1977)	/ṣ, ṭ, ð̣/	/ḅ, ḷ, ṃ/
Palestinian Arabic (PA) (Card, 1983; Herzallah, 1990; Younes, 1993, 1994)	/ṣ, ṭ, ḍ, ẓ, ṛ[12]/	/ḅ, ḷ, ṃ/
Sudanese Arabic (SdA) (Ahmed, 1984)	/ṣ, ṭ, ḍ, ẓ/	
Benghazi & Zliten dialects of LA (Abumdas, 1985)	/ṣ, ṭ, ð̣/	/ ḅ, ḷ, ṃ, ṇ, ṛ/
Moroccan Arabic (MA) (Heath, 1987; Kenstowicz & Louriz, 2009)	/ṣ, ṭ, ḍ, ẓ, ṛ/	/ḅ, ḷ, ṃ/
Southern rural PA (Davis, 1995)	/ṣ, ṭ, ð̣/	/ẓ/
Damascus Syrian Arabic (SyA) (Daher, 1998;	/ṣ, ṭ, ð̣, ẓ/	/ḷ, ṇ, ṃ, ḅ/

[12] Younes (1994) stated that [ṛ] can be identified as a primary emphatic in PA, as he described that both [ṛ] and [r] appeared to be allophones of the same underlying emphatic. Other studies, however, such as those regarding Hijazi Arabic, described these sounds as allophones of an underlying plain consonant (Al-Mozainy, 1981). For more detail, see (Younes, 1994).

Cowell, 1964 cited in: Bellem, 2007)		
JA (Zawaydeh, 1999)	/ṣ, ṭ, ḍ, ẓ/	
Wadi Mousa dialect of JA (Al-Huneety, 2015)	/ṣ, ṭ, ð̣/	/ḷ, ṛ, ṃ /
Wadi Ramm dialect of JA(Al-Mashaqba, 2015)	/ṣ, ṭ, ð̣/	/ḷ, ṛ, ṃ, ḅ, g[13]/
Meccan Saudi Arabic (Bakalla, 2002)	/ṣ, ṭ, ḍ, ẓ/	

All modern Arabic dialects mentioned above differ regarding the segments included in their primary and secondary set of emphatics due to dialectal variation (Herzallah, 1990). Previous research has also distinguished between these types of emphatics. Specifically, while 'primary emphatics' were only used to refer to the sounds inherently and constantly identified as emphatics, i.e. /ṭ, ḍ, ṣ, ð̣ or ẓ/ in all vocalic environments (Broselow, 1976; Ghazeli, 1977; Younes, 1982; Herzallah, 1999), secondary emphatics occur only in certain environments in which they are in the vicinity of the low vowels /a(:)/ (Davis, 2009: 637; Youssef, 2013: 101). Younes (1994) added that primary emphatics contrast with another set of plain sounds, which are /t/, /d/, /s/ and /ð/, while secondary emphatics generally do not, except for /ṛ/ (216–217). He confirmed that /ṛ/ acts as a primary emphatic since, for instance, it is associated with the back variant of the low front /æ/. Moreover, /ṛ/ propagates the emphatic feature and colours neighbouring segment. Yet, Younes suggested to place /ṛ/ in a different group from that of the primary emphatics since it is not emphasised in the presence of the high front vowel, non-emphatic coronals, emphatic consonants /ṣ, ṭ, ð̣/ and velars. Moreover, Lehn (1963) mentioned a main difference between these sounds, stating that the primary emphatic

[13] The voiced velar stop /g/ phoneme has two allophones: the plain [g] as in /giblih/ 'Qibla' and the emphatic [g] as exemplified in /gabir/ 'grave'. The emphatic allophone usually occurs before the low vowel /a/.

sounds have their own symbols in the Arabic language orthography, whereas the secondary emphatics do not. A more detailed discussion of these differences is provided in the following section.

2.3 Primary and Secondary Articulation in Emphatics

Consensus regarding the articulation of the emphatic segments implies general articulatory agreement, although such agreement was not necessary with all the details. Phonetically, despite the extreme view that plain and emphatic consonants share the same primary articulation, Norlin (1987), Laufer and Baer (1988), Kriba (2004), Al-Tamimi and Heselwood (2011), Hermes (2014), among others, seem to disagree with the main essence of emphatic articulation. They draw attention to the point that the primary place of articulation is more posterior for emphatics than for their plain counterparts. Specifically, Hermes believed that there is a difference in primary articulation between the plain-emphatic pairs in LbA. His study examined the differences between the voiceless alveolar fricatives /s/ and /ṣ/, and his results suggested that the blade of the tongue is lowered more during the articulation of the emphatic /ṣ/ than the plain /s/. Along similar lines, and as far as phonetic variation is concerned, Al-Ani (1970) stated that, in Baghdadi Arabic (BA), the plain consonants /t, s, d/ are dentals, whereas their emphatic counterparts /ṭ, ṣ, ḍ/ are post-dentals; however, he indicated that the plain /ð/ and the emphatic /ð̣/ are both inter-dental. Hussain (1985) conceded that the emphatic fricative /ṣ/ is a post-alveolar, while the plain /s/ is an alveolar in Gulf Arabic (GA). The findings of Ghazali (1977), Laradi (1983) and Bukshaisha (1985) support the claim that the primary articulation of emphatics differs from plain consonants. They argued that the tongue tip is retracted for emphatics, such as the voiceless fricative /ṣ/ versus the plain /s/. However, Kriba (2004) revealed that plain and emphatic consonants in

LA are both dental. His findings revealed that, in producing both sound sets, the tip or blade of the tongue is pressed against the back side of the upper teeth and can extend and cover the front of the alveolar ridge area.

While there is a slight distinction between the two views regarding the primary articulation of emphatics, analyses of the realisations of the secondary articulation vary from one dialect to another. The variation among modern phoneticians has largely been about the essence of emphatic articulation. The field has yet to come across an integrated conclusion regarding the physiological details of the secondary articulation of emphatics in Arabic dialects. Despite the availability of innovative techniques, such as ultrasound images, videofluoroscopic images and laryngoscopic findings to analyse speech production, the exact mechanism by which the vocal organs function together to produce emphatics remains varied and, thus, this remains a controversial topic. Therefore, the different articulatory correlates of emphatics and the mechanism of their secondary articulation will be discussed in more detail below.

2.3.1 Velarisation, uvularisation or pharyngealisation?

A review of the existing literature illustrates that consensus seems to be lacking regarding the exact term that defines emphatic sounds in Arabic. Due to the complex nature of emphatic articulation and the different perspectives brought to its study, it is unsurprising that attempts to define this concept have proven difficult. Furthermore, the posterior nature of the pharyngeal constriction included in emphatic articulation is perhaps one factor that has impeded the deduction of the precise articulatory configuration of the vocal tract. Also, emphatics production showed some variations, particularly in the configurations of the vocal tract, among which are pharyngealisation, uvularisation, velarisation, glottalisation, pharyngealisation and labialisation, pharyngealisation and dorsalisation, strong articulation, u-resonance, heaviness, and retraction (Lehn, 1963; Ladefoged, 1971; Norlin, 1978; Herzallah, 1990; Watson, 1999). Some of these terms regarding emphasis seem to be inaccurate, as they do not reflect the precise articulation involved in this process—or at least controversial; therefore, to maintain coherence, several scholars have endeavoured to eliminate indefinite and sometimes confusing terms and replace them with more accurate descriptions to cover the full extent of articulating these sounds. There are some terms standing for the exact articulatory nature of emphatic sounds. Pharyngealisation, velarisation and uvularisation, for instance, have been the most frequently identified articulatory configurations of emphasis throughout the literature (Norlin, 1978; Laufer and Baer, 1988; Wahba, 1993; Davis, 1995; Hetzron, 1998; Zawaydeh, 1999; Hassan, 2005; Al-Tamimi et al., 2009). The main difference between these three articulatory exponents is whether the precise place of the pharyngeal constriction occurs at the upper pharynx 'velarisation or uvularisation' or at a point of the lower pharynx 'pharyngealisation' (Zawaydeh, 1999; Bellem, 2007). Since different Arabic dialects show different realisations of emphasis production, a review of the experimental findings regarding the articulatory assumptions of emphasis in some Arabic dialects is described in detail below.

2.3.1.1 As velarised

One view of traditional grammarians and Western phoneticians on this matter has been the assumption that emphasis can be realised as velarisation (Trubetzkoy, 1969; Al-Nassir, 1993). Velarisation—as a secondary articulation—closely corresponds to /ʔitˤbaq/ 'covered, high' in CA phonetics. Emphatic sounds in Arabic are produced with the tongue dorsum (an active articulator) drawn far up and back towards /ʔal-ħanak ʔal-ʔaʕla/ 'the upper palate' (a passive location) (Sibawayh, 1982: 436; Ibn Jinni, 1954: 70). This point of articulation lies somewhere between the places of articulation of the velar plosive /k/ and the fricative pharyngeal /ħ/ (Giannini & Pettorino, 1982), and therein lies the problem that, based on their descriptions, it is difficult to determine whether the upper palate is a velar or uvular point. Yet, these definitions and their corresponding examples and inferences have suggested that /ʔiṭbaq/ includes a secondary stricture that simultaneously accompanies a primary stricture, which is coronal (i.e. either dental or alveolar).

Other accounts of this tendency, however, have explicitly described emphasis as velarisation—in Arabic and even in other languages, such as English—in which the so-called velarised 'dark' [l] is distinguished from the plain [l] by an integral raising of the tongue back to the velum (Nasr, 1959a; Obrecht, 1968; Ladefoged, 1982, 1997; Kenstowicz, 1994). Interestingly, Nasr (1959), in LbA, confirmed that velarisation is actually applied to both velarised consonants and uvulars; however, a velarised consonant can have a greater degree of emphasis than the uvulars. He declared that since the language exhibits this process in continuum, it is perhaps best to view this tendency as a continuum in which the consonants can be arranged on a scale as follows:

(1)

voiceless alveolar stop /ṭ/ most emphatic	↓	Most emphatic
voiced alveolar stop /ḍ/	↓	
voiceless alveolar fricative /ṣ/	↓	
voiced dental fricative /ð̣/	↓	
voiceless uvular stop /q/	↓	
voiced uvular fricative /ʁ/[14]	↓	
voiceless uvular fricative /χ/ least emphatic	↓	Least emphatic

2.3.1.2 As uvularised

There is another insight that has arisen and opened new avenues for studies on emphatic articulation. Specifically, Kahn (1975), McCarthy (1994), Shahin (1997), Zawaydeh (1999), among others, have suggested that emphasis appears in Arabic with ‘uvularisation’ as a secondary feature of emphatic sounds. Yet, the articulatory description of these sounds—in particular, the secondary articulation—in some of these studies ended up being mostly indistinct. Kahn (1975), for example, used uvularisation alongside other terms to refer to emphatic articulation. Nevertheless, her study mainly focused on differences beyond the physiological, such as, in particular, the interaction between emphasis and gender-related differences. Her findings for native speakers of CrA show that the acoustic distinction, i.e. F2 differences, between emphatic and non-emphatic segments was substantially reduced for female speakers compared to male speakers. However, non-native, in particular, American speakers, who were taught Arabic by male speakers, showed slight F2 differences between

[14] The uvular here referred to ‘غ’.

emphatic and non-emphatic segments. Accordingly, her study attempted to mirror the acoustic correlates of emphasis in CrA rather than their articulatory counterparts.

Dologopolsky (1977) identified emphatics as uvularised sounds articulated by drawing the back part of the tongue towards the uvula and the back wall of the pharynx. McCarthy (1994) and Czaykowska-Higgins (1987) suggested that any consonant pronounced in this way is called a uvularised consonant, arguing that the constriction of the upper pharynx appearing in articulating the uvulars is similar to that of the emphatics. Their articulatory account of the emphatics was based on the analysis of the lateral X-ray images from Ghazeli's (1977) study of TA. Ghazeli' s results demonstrated that a velopharyngeal constriction is associated with the primary articulation of the uvulars; however, a constriction in the middle of the pharynx, which is the location between the points of articulation of uvulars and pharyngeals, is estimated to correlate with the secondary articulation of the emphatics.

Other articulatory reports assuming uvularisation as the secondary correlate of emphatics were also proposed by Shahin (1997), Zawaydeh (1999), Bin-Muqbil (2006), Zawaydeh and de Jong (2011) and Shar (2012), among others, who described how these sounds were produced. Their ultimate conclusion was that the constriction included in producing these emphatics occurred in the uppermost portion of the oropharynx, which is quite close to the uvula. Hence, it is perhaps more accurate to name these sounds 'uvularised' rather than 'pharyngealised'. This posterior articulation of the emphatics was directly related to the extrinsic tongue muscles (i.e. styloglossus and hyoglossus muscles), which are mainly responsible for drawing the tongue backward towards the pharynx (Bin-Muqbil, 2006)[15].

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[15] Bin-Muqbil assessed and summarised the x-ray images in some prior studies, such as Al-Ani (1970) and Ghazeli (1977), and it appeared that, during emphatic production, there are differences in tongue height because

Hassan and Esling's (2011: 229) laryngoscopic observations suggested that the rearward movement of the tongue 'has all the characteristics' of the upward movement of the tongue towards the uvula.

Zeroual (1999) compared the articulation of the uvulars, pharyngeals and emphatics in MA. His fiberscopic observations revealed an articulatory similarity between the uvular and the emphatics. That is, while producing the uvular /q/, the base of the tongue and epiglottis simultaneously moved backward and raised themselves. He observed that the backward movement of the epiglottis is a sequence of the tongue movement and also found that, in the emphatics /ṣ/ and /ṭ/, just as in the uvular, there was a horizontal backward movement at the base of the tongue that pushes the epiglottis with it. Thus, he identified uvularisation as the secondary articulation of emphatic consonants in MA.

2.3.1.3 As pharyngealised

There is another different perspective in prior studies regarding the exact articulatory configurations of emphatic consonants in the Arabic dialects. A series of physiological and acoustic studies of emphatics have indicated that the secondary articulation of pharyngealised consonants involves the pharynx, not the velum (Al-Ani, 1970; Ghazeli, 1977; Card, 1983; Ahmed, 1984; Watson, 1999; Hasan and Esling, 2007; among others). Bin Muqbil (2006) argued that 'pharyngealised' was apparently the most suggested term for referring to these sounds. This term traditionally corresponds to the secondary pharyngeal constriction that occurs while producing emphatic sounds. Among these experimental phonetic analyses,

the styloglossus muscle acts as an antagonist to the hyoglossus muscle (the former raises the back of the tongue, whereas the later lowers it).

Wallin (1855) and Brucke (1860) were among the first to suggest that ‘pharyngealisation’ might appear to be the most appropriate description of this secondary stricture (cited in: Laufer and Baer, 1988). Wallin (1855) reported that the point of articulation of emphatic consonants is situated deep in the pharynx and larynx. Nonetheless, he did not explicitly state the precise physiological instrument on which he rested his judgment, nor did he mention which part of the pharynx was involved or the role the laryngeal articulator plays in producing these sounds. Willian reported that the epiglottis shuts down over the glottis and partially closes off the larynx. Although Brucke (1860) did concede on the role of the epiglottis in producing emphatic sounds, he also highlighted that the epiglottis completely obstructed the airway when producing /ṭ/ and /q/. The role of the epiglottis in producing the emphatics was also confirmed in Libyan, Palestinian, Iraqi, Lebanese and Jordanian dialects of Arabic (Laradi, 1983; Laufer & Baer, 1988; Heselwood et al., 2006). Emphatics in these dialects show a retraction of both the tongue root and the epiglottis into the posterior pharyngeal wall.

Laufer and Baer (1988) observed in Arabic and Hebrew that ‘emphaticness’[16] entailed a secondary articulation much lower in the pharynx. The constriction was located between the epiglottis and the pharyngeal wall. Their results also revealed a consistent retraction of the tongue root when producing the emphatics. This supports the conclusions made by Ali and Daniloff (1972), in which emphasis is primarily realised as pharyngealisation and not as velarisation. Following this claim, Al-Tamimi et al. (2009) stated that emphatics in JA are described with a retraction of the tongue root towards the oropharynx, elevation of the hyoid bone and lifting the larynx.

[16] to mean pharyngealisation

Research exploring observations about emphatic consonants has produced valuable findings regarding the exact location of constriction in the pharynx; however, to date, there has been no agreement on this in the current literature. Ghazeli (1977) emphasised that emphatics typically have different primary articulations (e.g. dental or alveolar) but tend to have the same secondary gesture: retracting the back of the tongue to the back pharyngeal wall at the level of the second cervical vertebra. An xeroradiographic study of JA postulated that pharyngeal constriction occurs at the height of the second and third cervical vertebrae (AI-Halees, 2003). In their study of Baghdadi Arabic, Giannini and Pettorino (1982) revealed that the emphatics /ṭ, ḍ, ṣ/ are produced with a constriction at the lower section of the cervical spine, in particular, the third and fourth cervical vertebrae. Articulatory experiments using advanced methods, such as direct visual laryngoscopic recordings and real-time magnetic resonance imaging, conducted by Hassan and Esling (2011) and Israel et al. (2012), respectively, demonstrated that emphatics are characterised by a lowered, retracted tongue and upper-pharyngeal constriction. Khattab et al. (2006) illustrated that the constriction of the emphatic consonant /ṭ/, compared to its plain cognate /t/, occurs in the upper two-thirds of the pharynx.

2.3.1.4 As multi articulators

Evidently, most emphatic research has investigated a single articulatory configuration, with little, if any, concern for other articulators that might be included in producing these sounds. Hussain (1990: p. 90) proposed that the mechanism behind emphatic sound production includes ‘more than pharyngealisation’. Wahba (1993) also demonstrated that the diversity of terms used to indicate emphasis production can be directly related to the complex activity of multiple sets of articulatory gestures. This view regarding the complexity of emphasis articulation was successfully established by Meinhof (1921) (Cited in: Laufer & Baer, 1988). In Meinhof's view, the articulation of emphatic consonants distinctively involves the movement coordination of three articulators: (i) the back of the tongue raised to the velum, (ii) the hyoid bone depressed and (iii) the epiglottis dropped down over the larynx. While Meinhof justified Sibawayh's argument that emphasis is overall velarisation, as it was too obvious to note the tongue positions over other articulators located in the deep pharynx, Laradi (1983) disagreed when her videofluorographic findings revealed that the retraction of the tongue root is associated with either raising or lowering gestures at the back of the tongue being contingent upon the adjacent vowel. Panconcelli-Calzia (1924) also added that the production of emphatics often involves contracted pharyngeal walls and a raised larynx (Cited in Laufer& Baer, 1988). Ghazeli (1977) suggested that the muscular walls of the pharynx are compressed, which consequently induces the larynx being raised. This implies that this physiological activity does not appear to be an essential gesture regarding emphatic articulation, as it is solely an involuntary physiological outcome of constriction in the pharyngeal cavity.

Much research has recognised the tendency of emphasis articulation and has argued that the articulatory behaviour of these sounds may involve more than one articulator. ^{c}Umar (1991), for instance, reported that emphasis can be simultaneously regarded as velarisation and pharyngealisation by some vertical and horizontal movements of the tongue. ^{c}Umar's main point is that emphasis is recognised as velarisation based on the vertical movement of the back part of the tongue, while it is recognised as pharyngealisation based on the horizontal movement of the tongue towards the pharyngeal wall. Yet, he did not state which articulator was more dominant regarding the articulation of the emphatics. Al-Nassir (1985) also compared the differences in tongue position during the articulation of the minimal pair /tiːn/

‘fig’ and /ṭiːn/ ‘clay’. His x-ray results indicated raising the tongue dorsum into the velum edge simultaneously by retracting the tongue root towards the posterior wall of the upper pharynx. This view does not appear to validate the radiographic findings of Marçais (1948), which indicated the existence of a similar articulatory mechanism for producing these sounds. Regarding this, Jakobson (1957) firmly concluded that emphasis can be regarded as velarisation, which is considerably associated with a specific degree of pharyngealisation.

Lehn (1963) provided a more detailed definition of emphasis that indicated its articulatory complexity. He confirmed that emphasis in Cairene Egyptian Arabic involves the following articulatory gestures: (i) ‘slight retraction, lateral spreading, concavity of the tongue and raising of its back’ (p. 30), which is known as velarisation. He also stated that emphasis can be associated with (ii) ‘faucal and pharyngeal constriction’, referred to as pharyngealisation, (iii) ‘slight lip protrusion or rounding’ (labialisation), (iv) ‘increased tension of the entire oral and pharyngeal musculature’ (p. 31), which thus shows that emphatic segments are more fortis than their plain counterparts. Moreover, El-Halees’s (1985) and Watson’s (1999) descriptions of emphatic articulation further involved the addition of another secondary articulation: the rounding of the lips. Harrell (1957) provided more details in this respect, as he specified that emphasis is not always accompanied by labialisation. His results proved that not all the emphatic consonants are characterised by labialisation, as he demonstrated that the lips are neutral in producing /ṭ/, /ṣ/ and /ḍ/ and rounded for /ð̣/. However, Delattre (1971) and Ghazeli (1977) further elaborated that the size of the anterior oral cavity increases when the tongue is retracted and the dorsum depressed. According to their arguments, labialisation occurs to accommodate these actions, especially for the uvulars, which incorporate a more posterior position of the tongue. Here, it can be argued that lip rounding may play a major role in characterising emphatic production.

Results from previous instrumental studies have so far primarily described the articulatory correlates of emphasis as involving either velarisation, uvularisation, pharyngealisation or a combination of more than one of these or some other part of the vocal tract (Al-Ani, 1970; Ghazeli, 1977; Al-Nassir, 1993; Zawaydeh, 1999; Bin-Muqbil, 2006). Variance in the exact articulatory exponents of the secondary articulation, as has been noted, raises the questions if there is a consistent single articulatory exponent of emphasis in various Arabic dialects. The difficulty in producing a unanimous description of emphasis could be related to either methodological differences, dialectal variation, or speaker variables—gender, social background, age, and education level—all of which and more may have a knock-on effect on the articulatory strategies used to produce emphatics (Khattab et al., 2006). This concept is a potentially major avenue for future research since it has received extremely little empirical attention in the literature so far.

2.3.2 Pharyngealised or pharyngeal?

Sometimes, there are sounds in some languages that sound deceptively similar yet prove to have minute differences. Arabic, for instance, is predominantly rich in sounds, with its place of articulation primarily located in the pharynx. In general, the consonantal phonetic inventory of the Arabic language includes the pharyngeal sounds /ħ, ʕ/ < ح, ع> and the emphatic or 'pharyngealised' sounds /ṣ, ḍ, ṭ, ð̣/ <ظ, ط, ض, ص >. The fundamental differentiation between the two classes is that 'pharyngeal' signifies sounds whose primary articulation is in the pharynx, while 'pharyngealised' denotes sounds whose secondary articulation lies in the pharynx (Card, 1983; Laufer & Baer, 1988). To illustrate, the pharyngeals are produced solely at one place of articulation: the pharynx. Pharyngealised consonants, however, are produced at two simultaneous places of articulation, one of which is narrow and involves the more extreme constriction between the tongue (tip or blade) and the teeth and alveolar ridge to form the primary articulation. The other stricture, called pharyngealisation, is wider than the former (i.e. the dental/alveolar stricture) and is formed in the pharynx (Lehn, 1963; Al-Ani 1970; Ghazeli, 1977; Card 1983; Esling, 1999; Ashby, 2011). The production of these segments involves the constriction between the epiglottis, the pharyngeal walls and the tongue root in the pharynx. Laufer and Baer (ibid) concluded that both sound categories exhibit similar constrictions in the pharynx; however, they may manifest different constriction degrees. In this case, the constriction is wider in the secondary articulation of the emphatics than the primary articulation of the pharyngeal since consonantal segments are produced with constriction somewhere in the vocal tract. Three major categories of strictures can be distinguished (Figure 2.1):

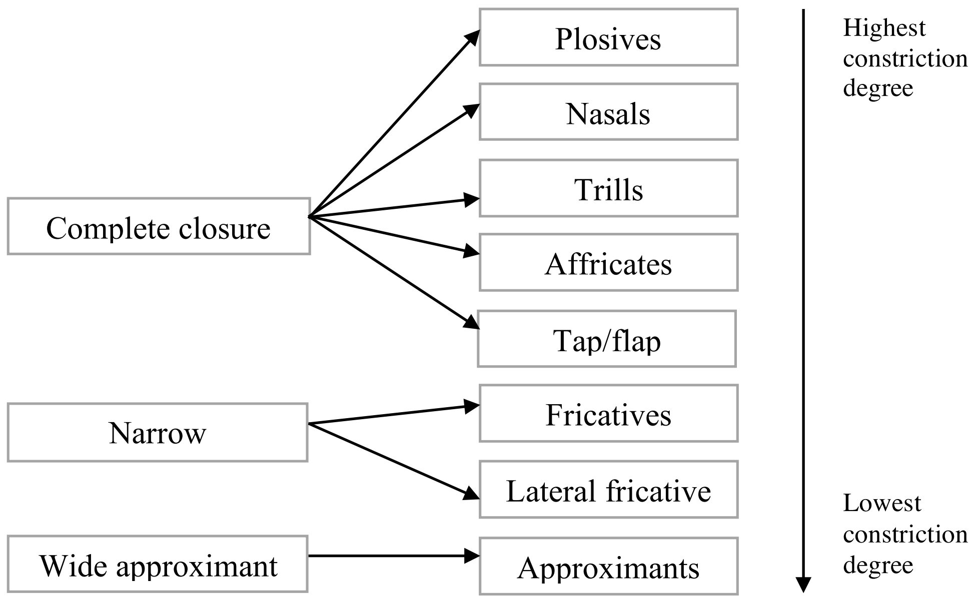


Figure 2.1: The rank scale of articulation strictures.

Another difference between these two classes is that the location of the secondary constriction of emphatics exceeds that of the pharyngeals (Ladefoged & Maddieson, 1996; Zeroual, 1999). Esling (1996) also reported that the secondary articulation of emphatics comprises a lingual constriction in the upper wall of the pharynx, while the pharyngeals exhibit constriction in the lower part of the pharynx. Delattre (1971) used X-ray motion images to compare the articulation mechanisms of pharyngeals and uvulars and found that, during the production of pharyngeals, the articulation is characterised by a constriction in the lower pharynx, whereas the uvulars are associated with constriction in the upper pharynx (Figure 2.2). He stated that ‘a pharyngeal articulation is one in which the tongue root assumes the shape of a bulge and is drawn back towards the vertical back wall in the pharynx to form a stricture. This radical bulge generally divides the vocal tract into two cavities: one below, extending from the stricture to the glottis, and the other above, extending from the stricture to the lips’ (p. 129). These findings indicate that constriction for the pharyngeal sounds /ħ, ʕ/ occurs at and below the epiglottis.

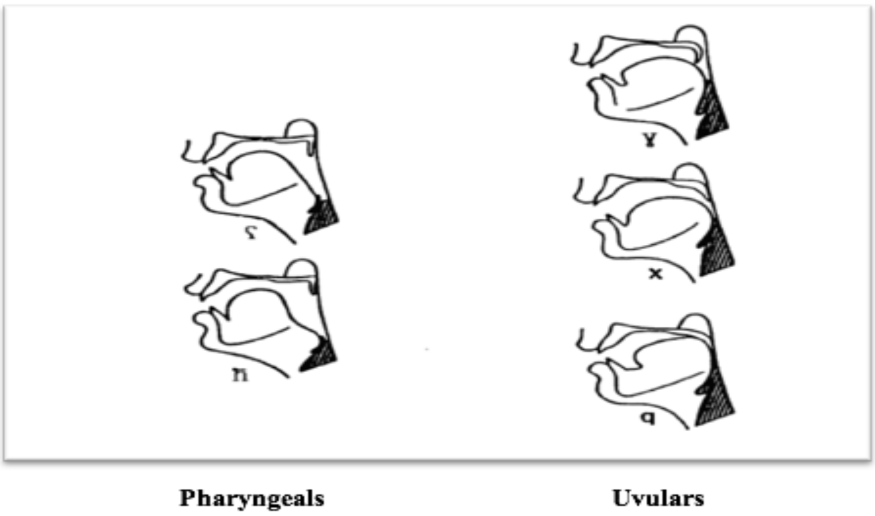


Figure 2.2: The constriction position for pharyngeals and uvulars, adopted from Delattre (1971)[17].

[17] Delattre’s (1971) study only included schematic diagrams, and there were no images of actual speech.

Ghazali's (1977) cinefluorographic results agree with this view, as he emphasised the fact that constriction of the pharyngeals occurs below the epiglottis—particularly at the level of the fourth and the fifth vertebrae—while constriction for emphatics is formed at the level of the second vertebrae (i.e. the upper pharynx). He also illuminated the crucial role of both the tongue root and the epiglottis in articulating the pharyngeals. Conversely, Laradi (1983) mentioned that the tongue root is not involved in producing pharyngeals, while epiglottis retraction is. Heselwood and AI-Tamimi (2006) investigated the pharyngeal sounds set in Jordanian Arabic, reporting that the epiglottis is more retracted for pharyngeals than for emphatics, which indicates that pulling the tongue root back into the pharyngeal wall does not participate in articulating the pharyngeals.

These consonants have stimulated various interest in the literature, some of which have suggested that pharyngeals and emphatics can be considered part of the same phonological class (i.e. [guttural]) (Jakobson, 1957; Zawaydeh, 1999; Watson, 2002). This class comprises sounds articulated at the posterior portion of the vocal tract or with a constriction in the pharynx. This suggests that these sounds may also share many acoustic characteristics that distinguish them as a single class separate from other classes of consonants. Various studies have addressed the acoustic correlates of the pharyngeals and the pharyngealised sounds, demonstrating that both classes are generally characterised by an upsurge in F1 and a decline in F2 (Al-Ani, 1970; Ghazeli, 1977; Laufer & Baer, 1988; Zawaydeh 1998; Al-Tamimi & Heselwood 2011; Hassan & Esling 2011). These correlates fully conform with the observed constriction in the larynx (higher F1) and the pharynx (lower F2). This effect extends to the surrounding vowels by backing and, sometimes, lowering them (Al-Masri & Jongman, 2004; Hassan, 2005; Zawaydeh & de Jong, 2011). However, other studies have postulated that these sounds are in two different classes and that the acoustic correlate contrast between these classes appears to be based on their associated formant transitions (Delattre, 1971; McCarthy, 1994; Bin-Muqbil, 2006). Bin-Muqbil examined the co-articulatory effect of these consonants on the formant frequencies of the surrounding vowels. His results showed that pharyngeals and emphatics are accompanied by high F1; nonetheless, the F1 transitions for emphatics were not as high or consistent as the transitions associated with the pharyngeals. Faircloth (2017), in her production experiment on IA, found that F1 was higher for both pharyngeal and emphatic consonants, whereas F2 was lower for emphatics than for pharyngeals. Furthermore, she suggested that the vowels adjacent to the pharyngeals were not as associated with F2 lowering as the emphatics. This coincided with Watson's suggestion (2002:46) that the effect of emphatics spreads over longer distances, affecting surrounding vowels than that of pharyngeals. Moreover, Broselow (1976:41) indicated that pharyngeal segments do not provoke co-articulation in the adjacent vowels, as emphatic segments do. He also stated that pharyngeal segments /ħ/ and /ʕ/ can be 'pharyngealised' in emphatic environments since this allows them to display significantly lower F2. Also, the increasing F1 and lowering F2 in vowels adjacent to emphatics was primarily related to the combined strictures in producing these sounds. That is, unlike pharyngeals, emphatics are produced with a fronted tongue body, which is essential to accomplishing their primary stricture. Unlike their primary stricture, the simultaneous secondary stricture of emphatics requires a backward drift of the tongue towards the posterior wall of the oropharynx (Ali and Daniloff, 1972). Therefore, there are two major opposed muscle manoeuvres inducing the palatine dorsum depression. As these antagonistic manoeuvres occur, the larynx as a whole is mainly drawn upwards (Odisho, 1988; Esling, 1999). These combined strictures eventually induce an increase in F1 and a lower F2 in the surrounding vowels. Table 2.2 summarises the acoustic consequences of the gestures involved in the articulation of both pharyngeals and emphatics.

Table 2.2: Articulatory gestures and acoustic correlates for pharyngeals and emphatics.

Sound	Primary Articulatory gestures	Secondary Articulatory gestures	Acoustic correlates
Pharyngeals	The tongue root against the back of the pharynx		- High F1 (considerably higher than emphatics) - Low F2
Emphatics	The tip/blade of the tongue against the top teeth/alveolar ridge	A constriction in the pharynx	- High F1 - Low F2 (lower than pharyngeals)

2.4 Trigger Segments: Acoustic Exponents of Emphasis

The core effect of emphasis was signalled by several acoustic parameters. Such parameters comprise the closure duration, VOT, and trigger consonant durations, which are considered additional acoustic dimensions that majorly identify the basic discrimination between plain and emphatic consonants. Multiple findings have revealed a correlation between emphasis and these temporal parameters. Table 2.3 summarizes the consonantal correlate findings (e.g. closure duration, VOT, and trigger consonant: plain/emphatic durations) that have been linked to emphasis in these dialects of Arabic.

Table 2.3: Summary of the consonantal correlate findings related to emphasis in different Arabic dialects (The '+' sign indicates that the correlate considerably differs when comparing them in plain vs emphatic contexts; 'n.s.' indicates that the correlate is not effective; and the grey cell indicates that the correlate was not examined).

Investigated Arabic dialect	**VOT duration**	**Closure duration**	**Spectral mean of consonants**	**Trigger consonant duration contrast**
Northern dialect of JA (Al-Masri & Jongman,2004)				n.s.
JA (Khattab et al., 2006; Jongman et al., 2007; 2011; Abudalbuh, 2011)	+ shorter for emphatic stops		+ lower for emphatic stops n.s. for fricatives	+ shorter for emphatic consonants
LA (Kriba, 2004; 2009)	+ shorter for emphatic stops	+ longer for emphatic stops		n.s.
Egyptian Arabic (EA) (Shaheen, 1979; EI-Dalee 1984; Norlin, 1987; Rifaat, 2003)	n.s.		+lower centre of gravity for fricative	n.s.
SdA (Ahmed, 1984)	+ longer for emphatic stops	+ longer for emphatic stops		
IA (Ali and Daniloff, 1972b; Hassan, 1981; Heselwood, 1996)	+ shorter for emphatic stops			n.s.
Yemeni Arabic (YA) (AI-Nuzaili, 1993)	+ shorter for emphatic stops	+ longer for emphatic stops		

From Table 2.3, VOT stop durations are dialectal features and among the principal temporal acoustic properties of the emphasis process for most Arabic dialects. This is because VOT exhibits reliable behavior—except in the Egyptian dialect—since it effectively accounts for the distinction between emphatic and plain consonants. Most of the observed Arabic dialects in Table 2.4 exhibited shorter VOT for the trigger emphatic consonants than plain consonants. This is illustrated in LA (Kriba, 2004; 2009), in which the VOTs are (mean = 18 ms) for the emphatic stop /ṭ/ and (mean = 35 ms) for the plain /t/.

Previous studies have shown that the closure duration of stops has not been studied as extensively as the other durational correlates. For all dialects in which the closure durations were examined, the observations generally revealed that the closure duration exhibits consistent behavior and always plays a substantial role in distinguishing trigger emphatic consonants from their plain counterparts. The results for all these dialects also showed that the closure duration for the emphatic plosive /ṭ/ was considerably longer than its plain cognate /t/ (Ahmed, 1984; AI-Nuzaili, 1993; Kriba, 2004; 2009).

The spectral mean of trigger emphatics has also been reported as an acoustic cue of emphasis. Jongman et al. (2011) reported that, in JA, trigger emphatics showed a spectral mean lower than their plain counterparts. However, this tendency was noticeable only in stop emphatic contexts when the trigger emphatic was in word-initial and word-final positions. The spectral mean of emphatic fricatives exhibited no significant differences compared to plain fricatives.

Another acoustic cue that has received further attention is the durational distinction between plain and emphatic consonants. Most studies agree that the durational contrast between these consonants had no cue value in the dialects reported above; therefore, this property has not been typically used for plain–emphatic distinction. Only one exception should be noted: the results for JA indicated that emphatic consonants were notably shorter than plain consonants (Abudalbuh, 2011).

Emphasis harmony includes four basic elements, one of them is the trigger segments have been discussed in this section. In the following section, I will discuss the acoustic influence of emphasis on the target segments in this process, as reported in previous studies.

2.5 Target Segments: Acoustic Exponents of Emphasis

Emphasis spread was reported as an assimilatory process in which trigger emphatics propagate their emphatic features and extend them to affect the next segment or segments. However, studies examining the acoustic cues of emphatics have been limited (Al-Masri and Jongman, 2004). Many studies concerning varieties of Arabic have attempted to examine emphasis spread; however, only a few have analysed the principal acoustic correlates of this process. Most of these studies have also been rather limited to vocalic acoustic cues over consonantal cues' analyses. This section presents a literature review of the effects of emphasis on various vocalic and consonantal parameters of target segments and their impacts on this harmonic process.

2.5.1 *Vocalic Parameters*

Prior findings in various Arabic dialects, in which the central cues of emphasis spread were examined, asserted that F2 frequencies for vowels in emphatic contexts were lower than those in plain contexts despite the location of the emphatic consonant in the attested word (Card, 1983; Zawaydeh, 1999; Al-Masri and Jongman, 2004; Khattab et al., 2006; Jongman et al., 2007; Al-Masri, 2009; Kriba, 2004, 2009; Abudalbuh, 2011; Jongman et al., 2011). Card (1983) and Al-Masri and Jongman (2004) reported that F2 lowering was more apparent in the vowels with the same syllable as the trigger emphatic rather than the vowels in a neighboring syllable, whether the emphatic consonant was in any position: word-initially, word-medially, or word-finally.

El-Dalee (1984) stated that emphasis propagates and acoustically influences many vowels in EA. The question that then arose was: Does emphasis spread in a similar manner in distinctly different vowel contexts? El-Dalee tried to classify the vowels in EA based on the distinction between the F2 frequencies in plain and emphatic contrast contexts. He ranked the vowels as illustrated in the table below:

Table 2.4: Effect of the emphasis feature on different vowel contexts in EA.

Vowel	Distinction degree of F2
/a(:)/	great
/i(:)/	fair
/u(:)/	least (if any)

Wahba (1993), Al-Masri (2009) and Jongman et al. (2011) also confirmed that the high back vowels were least affected by emphasis compared with the front vowels. Jongman et al. (2007) added that F2 lowering was more apparent in short vowel contexts than in long vowel contexts.

Different dialects that have presented an acoustic analysis of emphasis also revealed diverse findings regarding the vowels' F1 and F3. For instance, in some dialects of Arabic, there is no consistent impact of F1 and F3 on the emphasis process, which suggests that F1 and F3 are not reliable cues of emphasis in this dialect (Card, 1983; EI-Dalee,1984 [For F3 only]; Wahba, 1993 [For F1 only]; Khattab et al., 2006 [For F3 only]; Watson, 2007 [For F1 only]). Other dialects found that emphasis is also acoustically signalled by a significant rise of F1 and F3 in emphatic consonant contexts compared to those in plain contexts (Zawaydeh, 1999 [For F1 only]; Khattab et al., 2006 [For F1 only]; Jongman et al., 2007; Al-Masri, 2009;

Kriba, 2004, 2009; Abudalbuh, 2011; Jongman et al., 2011). El-Dalee (1984) reported a rise in F3 values in emphatic over plain environments; however, the overall effect of emphasis is still inconsistent and varies according to vowel quality. F3 was higher in back vowel contexts but lower in high front vowel contexts, with no effect of emphasis on F3 being reported in low front vowel contexts (Kriba, 2004; Al-Tamimi & Heselwood, 2011; Jongman et al., 2011; Zeroual et al., 2011).

Some studies also observed different results regarding another acoustic cue of emphasis: vowel duration. The researchers found that vowels in emphatic contexts were not different from the vowels in plain contexts in terms of duration (El-Dalee, 1984; Al-Masri and Jongman, 2004). The results of other studies indicate that the emphatic vowel duration is longer than that of their cognate plain counterparts (Abudalbuh, 2011). The data in LA showed that vowel durations yielded inconsistent results: in the emphatic context, the vowel following /ṭ/ was significantly longer than the vowel in the plain context /t/. The vowel durations between the plain and emphatic contexts of /d/-/ḍ/ and /s/-/ṣ/ revealed no such significant differences (Kriba, 2004, 2009).

Overall, the available evidence from previous studies seems to verify that F2 lowering is the most discernible acoustic proponent related to emphatic segments (Al-Ani, 1970; Bukshaisha, 1985; Herzalla, 1990; Sakarnah, 1999; Al-Masri & Jongman, 2004; Heselwood, 2007). Delattre (1951) and Sakarnah (1999a) declared that such lowering of F2 is correlated with tongue retraction, regardless of the retracted tongue position. However, the acoustic results for F1 and F3 revealed numerous acoustic variations regarding the emphatic–plain contrast. Some studies have emphasized that F1 and F3 lack substantial influence on the identification of the emphatics, whereas others have claimed a significant rise in both F1 and

F3 in emphatic environments. These various findings, according to Giannini and Pettorino (1982), may be related to the diverse realisations of secondary emphatic consonant articulations in these dialects of Arabic. Kent and Read (1992) reported a relationship between the behavior of F3 and the location of constriction in the pharynx, stating that lower pharyngeal constriction is characterized by raised F3 values and that mid-pharyngeal constriction is associated with a drop in F3, while upper-pharyngeal constriction may have either no effect or minimally raised the values of F3.

2.5.2 Consonantal Parameters

Numerous cross-dialectal studies have proposed that emphasis could be distinguished through more than just emphatic vowel F2 lowering (Zawaydeh, 1999; Kriba, 2004; Khattab et al., 2006; Heselwood, 2007; Embarki et al., 2011; Al-Tamimi, F. & Heselwood, 2011; Jongman et al., 2011). However, the consonantal cues of emphasis in target segments have not been systematically examined in the literature. To the best of my knowledge, only a few studies have discussed such emphasis cues. First, Jongman et al. (2011) presented an acoustic study of emphasis in Urban Jordanian Arabic. They examined both vocalic and consonantal cues of emphasis in monosyllabic CVC pairs, including emphatic and plain consonants word-initially and word-finally. Their results showed a significant effect of emphasis on the spectral mean of emphatic stops but not fricatives in both word-initial and word-final positions. Kulikov et al. (2020) examined whether the leftward emphasis spread in Qatari Arabic affects the syllable initial coronal stop /t/ and how this affects the coronal VOT. What is important here is whether /t/ shows a shorter VOT value within the vicinity of an emphatic consonant and, therefore, becomes more comparable to the VOT value of emphatic /ṭ/. Their data was collected from CVC nonsense words wherein the emphatic and plain contrast were located word-initially and word-finally. The acoustic analysis of the spectral mean of coronal stop showed a significant influence of emphasis, revealing a lowered spectral mean of burst in the stop in emphatic environments. This result supports Jongman et al.'s results in Urban Jordanian Arabic. However, Kulikov et al.'s results also showed there was no evidence of any impact of emphatic environments on the coronal's VOT. The coronal /t/ in emphatic contexts still exhibited a long-lag VOT, which is the acoustic characteristic of plain /t/. Alwabari (2020), however, has proven the emphatic feature effect on target consonants; yet her results were based on articulatory analysis, not acoustic analysis. Alwabari provided ultrasound and audio recordings of Eastern Peninsular Arabic and traced the tongue contours of both trigger and target consonants. Her articulatory findings asserted that the trigger emphatics /ṭ, ṣ/ are pharyngealised since the tongue root is retracted and, consequently, the tongue body and dorsum are depressed. Her study also confirmed that the contrastive plain consonants /t/ and /s/ undergo emphasis harmony, in which the target /s/ is produced with a similar lingual configuration (i.e., a retracted tongue root) to that of its emphatic counterpart /ṣ/.

2.6 Emphasis and Gender Differences

The role of gender has also been an area of study in the emphasis spread literature. Many studies have suggested a link between gender and acoustic variation in producing emphasis (Ahmad, 1979; Wahba, 1993; Al-Masri and Jongman, 2004; Khattab et al., 2006; among others). This effect was noticed in CrA as early as 1957 (Harrell, 1957). Harrell reported a mismatch between male and female speakers in which females realized the emphatic coronal /ḍ/ in /ḍala:l/ 'backsliding' as a plain /dala:l/. He also stated that some words in CrA can be realized with either an emphatic or a plain pronunciation, such as /ra:gil/ - /ṛa:gil/ 'man'. Harrell inferred that women in these words showed much stronger preferences for the plain realization than men. Several arguments provide further support for such a claim. Lehn (1963) and Ahmed (1979), for instance, claimed that emphasis production in CrA was less prominent for female speakers compared to males. Royal (1985) added that there is a notable fronting tendency of emphatics in the speech of females. Palatalising the emphatics /ḍ/ and /ṭ/ was most favoured for the high front vowel [i] for females than males. Haeri (1996) also reported a similar trend, especially for women below 50 years of age.

Khan (1975) conducted two acoustic investigations of emphasis to compare differences in men's and women's speech. As in the first study, native CrA speakers were recruited, and the vowels' F2 differences among emphatic and plain environments were smaller for women than men. Despite the size difference of F2, men's and women's F1 frequencies were more similar. In the second study, however, Khan recruited American learners of Arabic. She found slightly lower F2 frequencies of vowels in emphatic contexts compared to those in plain contexts for both genders.

Wahba (1993) examined the impact of gender differences on acoustic variation in emphasis production in Alexandrian Egyptian Arabic. He also concluded that gender has been shown to account for variations among emphatic and plain contexts in which women show a lower emphasis than men.

Al-Masri and Jongman (2004) proposed that emphasis varies depending on gender differences, as it clearly seems that emphasis was a dominant attribute of female speech. Al-Masri and Jongman found that the F2 frequencies of adjacent vowels in emphatic contexts were dramatically greater for females by 704 Hz compared to F2 within plain contexts. Males, however, showed that emphasis lowers F2 values by 565 Hz.

Khattab et al. (2006) conducted a study on acoustic and auditory differences between female and male speech in JA. Unlike what has been proposed by Al-Masri and Jongman's study, Khattab et al. confirmed that the phonemic contrast between the emphatic coronal /ṭ/ and its plain cognate /t/ is influenced by gender-related differences. Their results showed more overlap between plain and emphatic vowels for female speakers, whereas plain and emphatic vowels were more distinct for males.

Another study on gender-related differences conducted by Almbark (2008) on Syrian Arabic yielded diverse results. Emphasis regarding F2 lowering was more noticeable for females within emphatic plosive contexts. However, the decrease in F2 was more evident for males within emphatic fricative contexts. These acoustic conclusions in Syrian Arabic partially harmonize with some prior studies (Kahn, 1975; Wahba, 1993; Al-Masri and Jongman, 2004), while contrary to other claims (Khattab et al., 2006). Almbark attributed these different results to the dialectal variation regarding gender's impact on emphasis production.

Alzoubi (2017) examined the effect of different social aspects, including gender, on emphasis production in the Ammani Arabic dialect (AA). He found that when examining vowel formant frequencies, female speakers exhibited a lower emphasis than males. Another acoustic parameter (i.e., stop VOT) has also shown similar results.

Almomany (2018) conducted a socio-phonetic study in Ajlouni JA. He pinpointed that the effect of gender on emphasis was significant only for the VOT of stops. His results showed that VOT values for males were significantly longer than for females. The closure durations of stops and the first three formants of the attested vowels, however, were not different among the speakers.

Omari and Jaber's (2019) study considered how gender influences the acoustic correlates of emphasis in JA. They concluded that F1 and F2 at vowel onset and midpoint showed significant gender variances in emphasis production. Their results showed that male speakers exhibited further F1 rising and F2 lowering effects in emphatic contexts, revealing stronger acoustic correlates of emphasis in males' speech than females.

Overall, previous research on gender differences shows that gender, as a social factor, appears to predict contrast between plain and emphatic coronals in various Arabic dialects. These differences among both genders were predominantly noticeable in the F2 of adjacent vowels.

2.7 Domain of emphasis spread

In Semitic languages, the emphatic coronals and their effect on neighboring segments, comprising minimally the syllable and maximally the phonological word, is historically one of the most attested features of Arabic phonology. Because the extent to which the phonetic realization of the emphatic feature prevails over the word, many Arabic studies conclude that it is plausible for emphasis to prevail over many syllables. These observations have been noted in several studies. For example, Ali and Daniloff (1972) argue that the domain of emphasis in some dialects of Arabic stretches essentially over the entire word, which, in this account, may encompass more than one syllable. Hassan (1981) states in his study that the distinctive phonetic features of emphatics do not appear to be segmentally conditioned; that is, emphasis can target both consonantal and vocalic segments. In this respect, Watson (1999) suggests that the domain of emphasis spread varies widely across Arabic dialects. In CrA, for instance, emphasis extends throughout the phonological word, whereas in Abha Arabic, the emphatic feature effect hardly extends beyond the neighboring vowel (Younes, 1993). Such variations in the emphasis domain have also been reported in many other Arabic dialects (Zawaydeh, 1999; Bin-Muqbil, 2006; Al- Khatib, 2008; Jongman et al., 2011). In northern PA, however, the emphasis domain appears to vary regarding emphasis directionality. Emphasis extends the emphatic feature leftward, starting from the emphatic trigger until it reaches the beginning of the word. Rightward emphasis spread is generally restricted to the tautosyllabic vowel (Herzallah, 1990). There are cases, however, in other dialects, such as Qatari Arabic, in which emphasis appears to spread bidirectionally over the word (Bukshashia, 1985).

The domain of emphasis can also extend and affect syllables across morpheme boundaries, affecting both prefixes and suffixes (Algryani, 2014). Schulte (1985) stated that emphasis can even spread and affect more than one prefix within the word. Davis (1991) also suggested that emphasis extends and covers the attached suffixes depending on the position of the emphatic trigger and the suffix. Emphasis spread into suffixes can be obligatory if, and only if, the word ends with the emphatic segment and is followed by a vowel-initial suffix, such as in /MAXṬuṬ-AAT/ ‘manuscripts’; otherwise, emphasis spread is optional as in /ṬAALIB-AAT/ /ṬAALIB-aat/ ‘students (f)’. Emphasis in the Djelfa Algerian dialect (DJ) spread rightward into suffixes, however, with some restrictions. In vowel-initial suffix contexts, emphasis spreads into the suffix only if the suffix is preceded by a tautosyllabic emphatic trigger as in /ħatˤtˤ-ik/ ‘he put you’. Consonant-initial suffixes block the emphasis spread, such as in /tˤoħ-na/ ‘we fell down’ (Slimani, 2018). Woidich (2006a) stated that emphasis in CrA can extend and color all types of attached suffixes, such as nominal and verbal suffixes, regardless of the emphatic trigger position. Jaber et al. (2019), however, found that emphasis spread in JA is always blocked by morpheme boundaries.

Emphasis, as has been reported in previous studies, can spread bidirectionally. However, emphasis shows asymmetries between leftward and rightward spread in which the leftward spread of emphasis was absolute, whereas the rightward spread was restricted by some opaque segments. Card (1983) examined emphasis in PA and noticed that the emphatic feature spreads in both rightward and leftward directions, lowering F2 for all surrounding vowels in an entire phonological word. However, she also observed that the emphatic feature spread is blocked by the intervention of the [+high] vowels /i/ and /u/. In southern and northern PA, Davis (1995) found there is some restriction to the bidirectional spread of emphasis. Although the leftward emphasis spread is absolute, the rightward spread of emphasis, however, is blocked by a set of blocking segments. In southern PA, for instance, the rightward emphasis spread is blocked by /i/, /j/, /ʃ/ and /dʒ/, while in northern PA, it is blocked by the high segments /i/, /u/ and /w/. In CrA, Watson (2002) illustrated that leftward emphasis spread is not restricted, while rightward emphasis spread is bounded and blocked by the non-tautosyllabic high vowel /i/ and the palatal /j/. Watson emphasized that the tautosyllabic high front vowel does not block the propagation of rightward or leftward emphasis, such as in /sˤaːħib/ 'my friend' and /ʔamisˤ/ 'shirt', respectively. Al-Masri and Jongman (2004), in JA, described that the high vowels /i/ and /u/ in the target syllables blocks the emphatic feature propagation to other vowels in any right-adjacent syllables, in which there was no substantial decrease in F2 of vowels within emphatic contexts compared to those within plain contexts. Huneety (2015) examined emphasis spread directionality in Wadi–Mousa JA. He found that emphasis spread bidirectionally and, as in many other Arabic dialects, exhibits asymmetrical behavior, in which leftward emphasis is uninterrupted, whereas rightward emphasis spread is subject to be blocked by the high front vowel /i(ː)/, the palatal /j/ and the palato-alveolar /ʃ/. Slimani (2018) also reported similar behavior of emphasis spread in the presence of opaque segments. The emphasis in DJ is unbounded in leftward spreading, whereas rightward spreading is blocked by the high front /i/ and the palatals /j/, /ʒ/ and /ʃ/.

Conversely, other Arabic dialects show that the spread of emphatic features can be absolute and never restricted by any segment or blocked in both directions (Youssef, 2013). Zawaydeh (1999), for instance, found that the emphasis spread in Ammani–Jordanian Arabic is bidirectional and pinpointed that emphasis in this dialect exhibits no directional asymmetry; that is, high segments do not block either rightward or leftward emphasis spread. In Abu Shusha PA, however, Shahin (2002) demonstrated that the obstruents such as /ʃ/, /tʃ/ and /dʒ/ blocks emphasis spread in rightward and leftward directions. The high back vowel, as in /<u>m</u>u<u>h</u>u<u>rˤaːtˤ</u>/ ‘fillies’, was found to be transparent to the emphatic feature spread.

2.8 Conclusion and Summary

Overall, according to the available literature, there are changes in the acoustic properties of the vowels preceding or following emphatics in most Arabic dialects, especially regarding the values of F1 and F2. Generally, the invariably decreased frequencies of F2 indicate that the emphasis effect is discernible in the formant frequencies of the surrounding vowels. However, in numerous Arabic dialects, lowering the F2 values was the most constant acoustic proponent of emphatic segments (Al-Ani, 1970; Bukshaisha, 1985; Herzalla, 1990; Sakarnah, 1999; Al-Masri & Jongman, 2004; Heselwood, 2007). Lowering the F2 frequency values supports the idea that the tongue is placed in a back position (i.e., retraction) while producing emphatics (Sakarnah, 1999). This would validate Watson’s claim that ‘F2 lowering is more significant than F1 raising in identifying emphasis' (2002:270). However, the acoustic findings for F1 and F3 differ across different Arabic dialects, which may highlight the realizations of the secondary articulation of emphatics. These conflicting findings have led some to claim that the articulatory exponent of emphasis is velarisation (Gairdner, 1925: cited in Laufer & Baer, 1988:183), uvularisation (Zawaydeh, 1998) or pharyngealisation (Al-Ani, 1970; Giannini & Pettorino, 1982). Consonantal cues of emphasis, either for trigger or target consonants, have been discussed. Different cues have proven to signal the difference between emphatic and plain environments, such as closure duration and VOT of stops, spectral mean of both stops and fricatives, and consonant durations. Gender effects on these parameters in various Arabic dialects were also reported.

From a phonological viewpoint, emphasis spread in Arabic dialects shows many differences regarding emphasis domain and its directionality in which the domain of emphasis extension can minimally affect the adjacent syllable (Younes, 1991) and/or maximally cover the entire word (Youssef, 2013). Emphasis was also reported to spread its influence and cover attached affixes in some dialects. Regarding the directionality of emphasis spread, emphasis can be absolute in both directions or show leftward/rightward asymmetry. In the latter case, emphasis is blocked by [+high] segments that differ from one dialect to another. The domain of emphasis extension can minimally affect the adjacent syllable (Younes, 1991) and/or maximally cover the entire word (Youssef, 2013).

CHAPTER 3: METHODOLOGY

3.1 Overview

Following the detailed review of the cross-dialectal acoustic results of emphasis in the previous chapter, this chapter outlines the general methodology used in conducting both phonetic and phonological experiments, which involves an investigation of the occurrence of emphatic and non-emphatic contrasts in NA, an examination of a diverse set of acoustic correlates characterising emphasis spread in NA and a comparison of the findings with those of previous studies.

Apart from investigating the results of prior acoustic studies on Arabic dialects, the current experiment is aimed at contributing to the state of knowledge of NA by thoroughly examining previously unexplored areas of the subject, describing the prevailing emphasis spread in Arabic dialects in general and deliberating on aspects shared with NA. For instance, the opposition between emphatic and plain consonants is usually defined in terms of the acoustic properties of neighbouring vowels. However, for a variety of Arabic vernaculars, researchers studying emphatic versus plain contrasts have proposed that the emphatic contrast is not signalled solely by correlates to emphasis coming from the surrounding vocalic segments (e.g., vowel duration and vowel formant frequencies); rather, the phonetic implementation of emphasis may include additional language-specific acoustic cues not typically considered, such as the temporal characteristics of the attested consonants. Another aspect of the present examination is the phonological behaviour of emphasis spread within the word, which provides evidence of the extension of the emphasis spread domain, the directionality of feature spread and the restrictions imposed on the iterative spread.

This chapter presents a general description of the experimental design, the participants and other methodological issues. The lists of stimuli are discussed in subsequent chapters. Section 3.2 introduces the general research questions and the rationale for exploring these issues. Section 3.3 reports the materials used in this study and how they were prepared. Section 3.4 presents comprehensive information about the participants who took part in this study, including a description of the method used to recruit them. Section 3.5 presents the methods used to collect the data necessary to answer the research questions. Section 3.6 offers a description of the measurements and segmentation criteria. Finally, Section 3.7 summarises the chapter.

3.2 General research questions

Many modern Arabic dialects are characterised by emphatic versus plain contrasts. A great deal of research has focused on the phonological properties of emphasis. The acoustics of emphasis, however, have not been sufficiently explored. To fill this gap, the present study focuses mainly on the acoustic correlates of emphasis in NA.

In the literature on Arabic dialects, several studies have reported on the common role of the F2 in defining plain versus emphatic contrasts. That is, emphasis is reliably manifested by lowering the F2 values of surrounding vowels. Based on data from Watson (2002), Al-Katib (2008), AlMasri (2009) and Algryani (2014), among others, the following research questions were raised regarding the major acoustic features of emphasis spread in NA:

1- What effect does emphasis have on surrounding vowels, and do the formant frequencies of these vowels undergo any changes?

2- What are the acoustic parameters that distinguish emphatic segments from their plain counterparts? Can it be confirmed that the phonetic behaviours of emphasis concerning these NA parameters differ from those of other Arabic dialects?

Additionally, most studies in this field focus on vocalic acoustic parameters. Therefore, it is crucial to know whether emphasis simultaneously comprises both consonantal and vocalic cues. Given the dearth of comprehensive phonetic evidence on this topic, it is productive to also include a multi-parametric analysis of the consonant correlates. The present study, therefore, offers a comprehensive account that considers different components in the analysis of emphasis. Hence, the following questions, which explore question 2 above in more detail, were raised:

a. Is the presence of consonantal acoustic properties of a relative value a cue for a plain/emphatic distinction?

b. Is there a correlation between emphasis and a trigger consonant's manner of articulation or the voicing status of the contrast consonants?

In addition to phonetic differences concerning the realisation of emphasis in Arabic dialects, phonological differences between dialects have been noted. These differences relate to the domain of emphasis spread especially with the variations that involve the iterative spread of emphasis reported in prior dialectal studies in Arabic. Hence, the main question here is,

3- To what extent does emphasis spread? Is it restricted to the syllable or can emphasis spread beyond the target syllable?

The direction of emphasis spread within the word (rightward or leftward) has also been of great interest (Davis, 1995; Watson, 2002; Al-Masri and Jongman, 2004). Emphasis spread displays different behaviours with regards to its direction: leftward spread is generally unbounded for the entire word, while rightward emphasis spread is blocked by [+high, –back] segments. With respect to this tendency, the key questions are as follows:

4- Does NA exhibit any asymmetrical patterns of emphasis spread?

5- Can emphasis spread be blocked in NA? If so,

    a. Does this blockage occur in leftward spread, rightward spread or both?

    b. What are the opaque segments that block emphasis spread? What do these segments have in common?

More intriguing is the behaviour of emphasis spread across morpheme boundaries. Emphasis spread does not appear to be limited to stems; under certain conditions, it can also spread into affixes (Algryani, 2014). However, the data from previous studies are inconsistent with regard to what type of spreading can affect morpheme boundaries: obligatory spreading into prefixes and suffixes or optional spreading at other times, in particular when the stem words do not end with an emphatic segment (Davis, 1995; Watson, 1999). In contrast, emphasis can also be highly unlikely to occur across morpheme boundaries, confirming the broadly accepted conclusion that the maximum domain of emphasis is the word (Card, 1983; Herzallah, 1990; Al-Khatib, 2008). This gives rise to the following question:

6- Does emphasis spread apply across morpheme boundaries in NA? Are there any restrictions to such spread?

Each of these broader questions is further discussed in the following chapters. Furthermore, more specific questions concerning emphatic versus non-emphatic contrast, as characterised above and exemplified in NA, are fully explored.

3.3 Materials

This experiment involved a comprehensive set of acoustic cues relevant to the difference between emphatic and non-emphatic segments. The experimental stimuli were divided into eight lists, each representing an emphatic/plain opposition. As this experiment was designed to investigate consonants' temporal characteristics, such as stop VOTs, closure duration and the duration of fricatives' friction noises, all three pairs of coronal emphatics /ṭ, ṣ, ð̣/ and their plain cognates /t, s, ð/ were included in the target word pairs. The emphatic voiced stop /ḍ/ and it its plain cognate /d/ were not included in this study since in NA the voiced fricative /ð̣/ is the result of the merger of both the emphatic stop /ḍ/ and the emphatic fricative /ð̣/. Moreover, the plain /d/ was not included as a plain counterpart of /ð̣/ as in this study the main focus is to distinguish between sounds in which the only difference between them is the presence and the absence of the emphatic feature.

Many authors have suggested that the effects of emphasis are mainly demonstrated by surrounding vowels and their properties (Card, 1983; Zawaydeh, 1999; Khattab et al., 2006). In light of these findings, surrounding vowels were included in the analysis of the current experiment; hence, NA short and long vowels /a, aː, u, uː, i, iː/ in emphatic and plain contexts were selected. Since short vowels are not represented in full letters in the Arabic writing system (as in all Semitic languages), diacritical marks were added to illustrate the occurrence of these vowels. The acoustic correlates of emphasis spread were also assessed in the preceding and following vowels, that is, the durations of the target vowels and their formant frequencies (F1, F2 and F3) were measured at vowel onset, midpoint and offset points to detect their effects on emphasis spread.

In addition, stimuli were selected within various consonantal feature class environments (plosives, fricatives, affricates, nasals, approximants and liquids) to present the widest range of possible stimuli. The effects of the adjacent phonetic environment were also considered in the selection of stimulus materials, that is, the consonantal contexts surrounding the trigger coronal segments within the lexical pairs were controlled so that the distinction effect of [+RTR, -RTR] on the production of harmonic and non-harmonic vowels was not confounded by variances in the adjacent segments. Here, I kept the consonants surrounding the target vowels in the selected pairs as similar as possible. Both preceding and following consonants and vowels in each target stimulus were identical, as in /ṣad/ versus /sad/. Although I endeavoured to structure word lists with identical lexical pairs to control the possible effects of surrounding segments on the opposition between emphatic and plain consonants, this proved impossible since, as the number of syllables per word increased, the incidence of minimal pair formation decreased. Thus, the pairs were carefully structured to be as closely matched as possible, and some of the pairs included phonotactically acceptable non-words (Appendix 1).

It was crucial to examine whether emphasis does indeed spread beyond the syllable, including the trigger coronal consonants. Minimal pairs were examined to confirm the extent to which the emphasis effect prevailed over multisyllabic words. Minimal pair tokens vary only in terms of the feature [±emphatic] elicited, including disyllabic words in various prosodic structures. The trigger segments (plain and emphatic) in these examples appeared in word-initial, word-medial and word-final positions, with a range of intervening consonants. In these word lists, the quality of the vowels surrounding the trigger consonants was controlled to avoid any intervening segments that may affect the domain and directionality preferences of the emphasis spread. Moreover, to explain how certain phonemes are capable of blocking emphasis spread, word lists of tokens, including potential blockers of emphasis identified in other Arabic vernaculars (e.g., high-front vowels and consonants), were formed.

Furthermore, as emphasis spreads not only within the phonological word but also across morpheme boundaries (targeting prefixes and suffixes), tokens across morpheme boundaries were also tested to determine the extent to which the emphatic feature spread. The trigger emphatics in these examples were located in different word positions (initial, medial and final).

All the tokens were embedded in a carrier sentence, as shown in (1):

(1) Carrier sentence:

‘قل X مرة ثانية’ /gil X marrah θaːnjah/

‘Say X once again.’

The main reason behind choosing to have target words read in carrier sentences instead of in isolation was to control for any possible contextual (acoustic and linguistic) effects. Moreover, such sentences can be used to obtain more natural speech materials, since they are embedded in a relatively normal linguistic context. The full lists of all the examples used are presented in Appendix 1. Each attested list is thoroughly explained in subsequent chapters.

3.4 Speakers

Five native NA speakers participated in the study: three female participants (AA, AM and AT) and two male participants (MA and MM), with ages ranging from 20 to 30 years (Table

3.1). The number of participants was limited to five due to the large amount of data that was expected to be generated through the analysis. A total of 594 tokens were recorded per speaker (2970 tokens for all speakers). Various acoustic measurements were taken from these tokens, and they will be explained in detail in the following chapters. None of the participants reported a history of any speech deficiency. All the participants recruited as subjects in this investigation were university educated, and some were postgraduate students at the time of the experiment.

Table 3.1: Participants' profiles.

No.	Participant	Age	Gender	Other spoken languages
1	AA	30	Female	English
2	AM	25	Female	English
3	AT	24	Female	English
4	MA	28	Male	English
5	MM	21	Male	English

The sample subjects were born in the Najd region and primarily used NA in their daily communications. The five speakers were recruited through personal contacts. Some of the participants were living in Manchester and studying at the University of Manchester or other universities. Others were students at universities in Saudi Arabia. Participation in the study was entirely voluntary, and the participants were not paid.

3.5 Data collection procedure

In this section, the procedures followed in conducting this study are described. The researcher explained the procedures and the instructions to the NA participants individually to ensure that they could complete their tasks correctly. All participants completed an initial practice session to familiarise themselves with the experiment.

3.5.1 Participants' consent

Before starting the recordings, all participants were given an information sheet that clarified the key objectives of the investigation. Then, the participants were given the opportunity to ask questions about the research. Subsequently, the potential subjects were fully informed about their right to withdraw at any time. Finally, the participants gave formal verbal consent to take part in the study. This consent was audio recorded at the beginning of the recording session, and assurances of confidentiality and identity anonymity were provided during the recording process. Research ethics approval was granted by the University of Manchester Research Ethics Committee UREC5576.

3.5.2 Procedure

The recordings took place in a quiet room. Each session lasted between one and two hours. The data were displayed on a computer monitor using a PowerPoint presentation that showed each example on a separate slide in MSA script, since NA (unlike MSA) is an oral dialect and thus lacks standard orthographic conventions. The presented lists were written using the Arabic alphabet, and its orthographic conventions were employed. All selected tokens were presented in random order.

Each participant was individually recorded under the researcher's supervision and asked to repeat each sentence three times. The participants were asked to produce the sentences aloud and in an informal style. Prior to the recording process, the participants were given time to review the lists and take part in training sessions to familiarise themselves with the overall production experiment and prepare to produce the target sentences fluently. After the experimental trial, the speakers were asked to read all the tokens in each list casually as they normally would, as any change in the speech rate could influence the durations of the target segments. After each list, the participants were allowed to take a short break. Furthermore, participants were monitored throughout the session to ensure adequate recording and performance levels. Some of the participants unintentionally produced some words with a standard Arabic pronunciation; in such cases, the recording was stopped and repeated. Similarly, any mispronunciations or reading errors in utterances were discarded from the analysis.

All the sessions were digitally recorded using the Audacity recording software and an Audix OM2 dynamic microphone, and the recordings were digitised in WAV format at 44100 Hz.

3.6 Measurements and segmentation

The token recordings collected during this study were acoustically analysed to measure the durations of the target segments. The resulting files were analysed using Praat 5.3.56 speech analysis software (Boersma and Weenink, 2010). The sound files were manually transcribed and segmented using the criteria discussed below.

(a) *VOT of voiceless stops /t, ṭ/*. It has been demonstrated that the VOT of stops may differ by one factor or a combination of various factors, including emphasis. Most studies have demonstrated that the VOT of stops may serve as a cue for the phonemic differences between emphatic and plain consonants (Ghazali, 1977; Zeroual, 1999; Kriba, 2004, 2009; AlDahri, 2012b, 2013). In fact, some studies (e.g., Mitleb, 2001; Khattab et al., 2006; AlDahri, 2013) revealed that VOT values of emphatic stops were consistently shorter than those of plain stops. Additionally, AlDahri (2013) reported that the VOTs of both voiceless and voiced plain stops /t, d/ tend to be twice as long as their emphatic counterparts /ṭ, ḍ/. In contrast, Ahmed (1984) found that the voiceless plain stop /t/ has shorter VOT values than that of the emphatic /ṭ/. No significant effect of emphasis on VOT was reported for Egyptian Arabic (Rifaat, 2003). These diverging findings motivate an investigation into how VOT patterns depend on emphasis in NA. VOT duration is the interval time between the point at which the transient marking of the release burst appears (i.e., the end of the stop closure) and the point in the waveform where the wave becomes more periodic, which denotes the onset point of the following vowel (Figure 3.1).

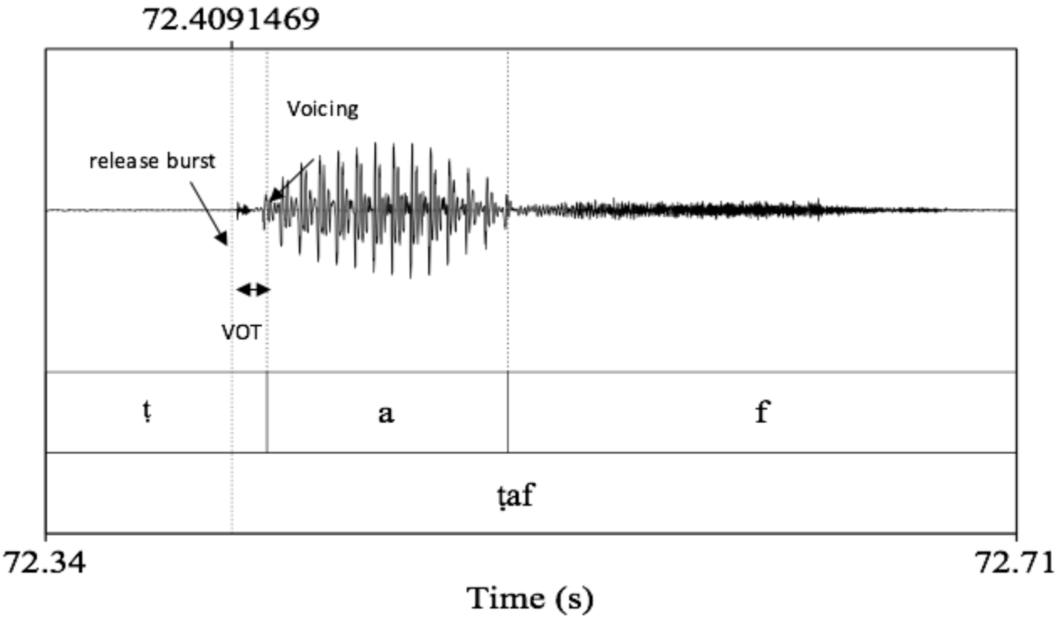


Figure 3.1: Boundaries of VOT in voiceless stops.

(b) *Closure duration of the voiceless stops*. Even though VOT of stops has been identified as one of the most relevant cues for the plain/emphatic distinction cross-dialectally, I have included closure duration as a temporal measurement in this study because it has been shown to play a role in some Arabic dialects, such as the Sudanese, Yemeni and Libyan dialects (Ahmed, 1984; AI-Nuzaili, 1993; Kriba, 2004; 2009, respectively). These studies suggest that the emphatic stop /ṭ/ is always produced with a significantly longer closure duration than that of the plain /t/. The closure duration of the voiceless stop was measured by detecting the beginning of the gap in the waveform at the point where both a decrease in amplitude levels and the absence of the high frequency of the preceding sound were noticed. The end point of the closure, in contrast, was determined on the basis of the appearance of the release spike, as illustrated below.

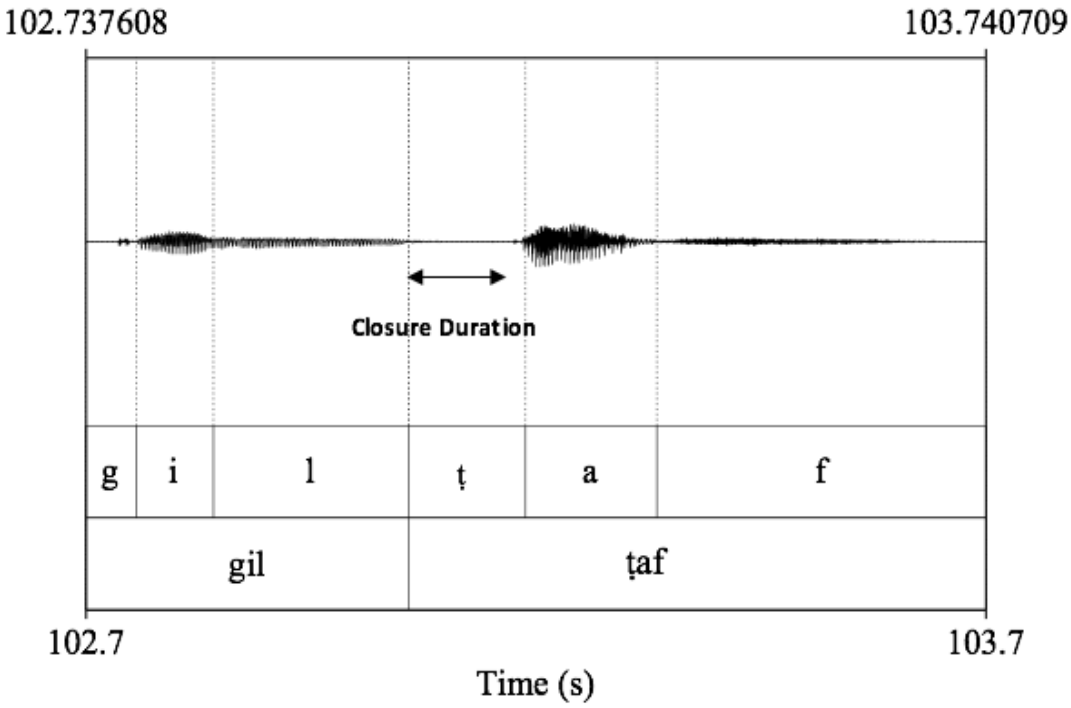


Figure 3.2: Closure duration in voiceless stops.

(c) *Friction noise duration.* This acoustic measure was obtained to evaluate the impact of emphasis on friction noise duration in NA. A study of JA by Abudalbuh (2011) suggested that gender is a primary determinant of friction duration, showing that females produced longer friction noise durations compared to males. Friction noise duration was obtained by measuring the time between the starting point of a fricative, which was determined by the lowest intensity energy, and visual detection of the friction noise onset, while the ending point was determined at (but not including) the onset of glottal pulsing for the following vowel (Figure 3.3).

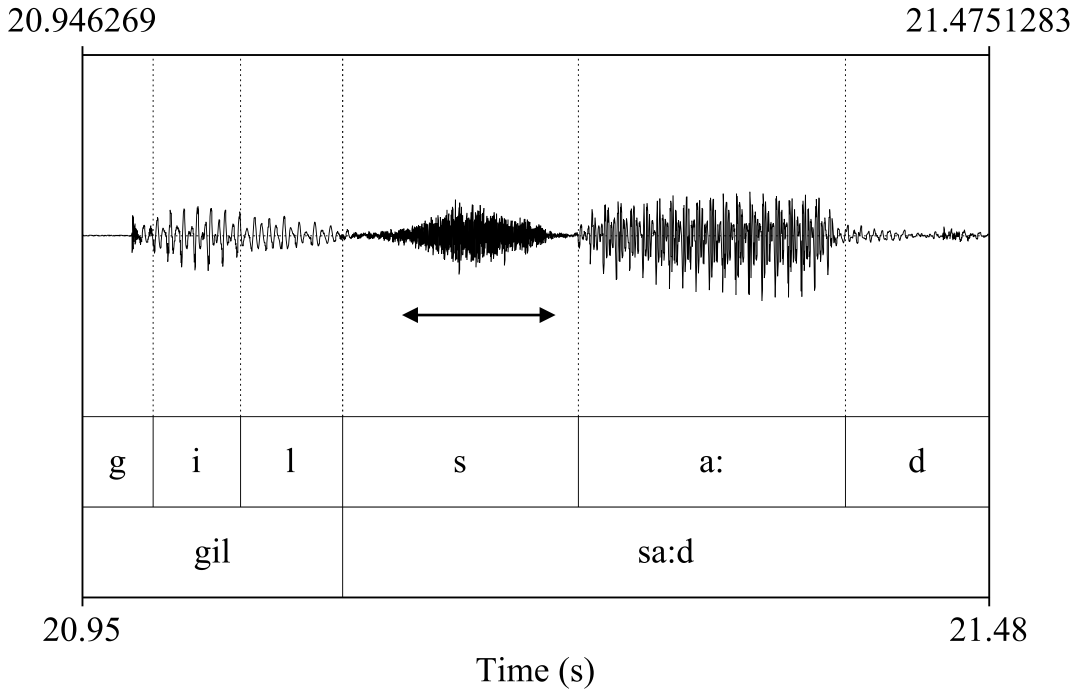


Figure 3.3: Friction noise duration in a fricative.

(d) *Vowel duration.* Based on previous literature, the durational differences between the emphatic and plain vowels could possibly contribute to the contrast among plain and emphatic contexts. More explicitly, emphatic vowels tend to have longer durations than plain vowels (El-Dalee, 1984; Hussain, 1985; Al-Bannai, 2000; Kriba, 2009). Thus, this study was also designed to evaluate vowel duration as a cue for the plain/emphatic distinction. The durations of vowels in plain and emphatic environments were measured. Vowel onset was pinpointed as the time at which the second formant energy appeared in the spectrogram. The vowel offset was defined as the beginning of the abrupt decrease in the amplitude of the waveform (i.e., the beginning of the following consonant; Figure 3.4).

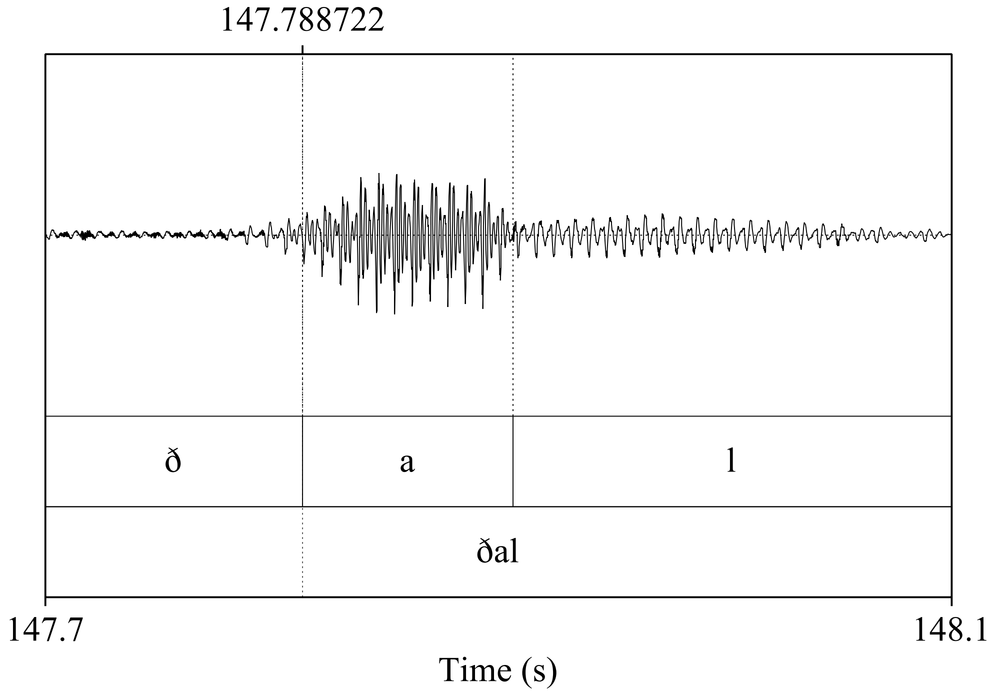


Figure 3.4: Boundaries of measuring vowel duration.

Various estimates of the vowels' formant frequencies (F1, F2 and F3) were obtained from three different time points: vowel onset, vowel midpoint and vowel offset of the six attested vowels following or preceding the emphatic consonants and their plain counterparts. This is motivated by previous reports that formant frequencies are among the most robust and consistent cues for emphasis (Bin-Muqbil, 2006; Khattab et al., 2006; Jongman et al., 2007).

Vowel formants (F1–F3) were measured automatically using a Praat script. The three measurement time points, onset, midpoint and offset, were defined by the script at 10%, 50% and 90% of the vowel duration, respectively. The onset and offset points were chosen at these points to reduce the immediate influences of preceding and following consonants on vowel transitions. The script also defined vowels' midpoints as the temporal midpoint, and taking formant measurements at this point of the vowel was also essential given the fact that it is the point in the vowel that is least affected by the influence of the coarticulation of neighbouring segments (Lehiste and Peterson, 1961; Lindblom, 1963b). At these three points, all formant frequencies (F1, F2 and F3) were measured for the vowels surrounding the plain and emphatic consonants. Choosing these three temporal points affords enough information about the variation in vowel formants due to the effects of emphasis. Praat analysis parameters were individually adjusted as they are conditioned by speaker sex. This was achieved using the default settings of Praat; the standard formant value was adjusted to 5000 Hz for male speech and 5500 Hz for female speech, the number of formants was 5 and the window length was 0.025.

The choice of acoustic variables in this study was based on earlier research findings on emphasis spread in Arabic (e.g., Card, 1983; AI-Nuzaili, 1993; Heselwood, 1996; Al-Masri and Jongman, 2004; Khattab et al., 2006; Kriba, 2009; Abudalbuh, 2011). All the measurements included in this study— vowel duration, vowel formant frequencies, consonant closure duration, VOT and friction noise— have been previously reported to correlate with the emphasis/plain contrast in Arabic. These measurements of the trigger consonants and the following vowels were chosen to discuss the role of each of such measurements as cues in emphasis spread. However, the effect of emphasis on the acoustics of the following (target) consonant was not covered in this study. The materials included in prior studies that examined the target consonants were specifically formed with plain obstruents /t, s, ð/ (Kulikov et al., 2020; Alwabari, 2020). Applying a such word formation in NA is very rare and thus would lead to the formation of either phonotactically acceptable non-words or sound sequencings that are not acceptable in NA, such as /sað̣/ and /ðað̣/. The former formation was avoided as much as possible in the selection of stimulus materials in this study so that the speaker would pronounce real words in a more natural manner. With the later formation, which includes non-acceptable sound sequencings, forming a balanced word list with minimal pairs was impossible. Thus, the acoustic correlates of the target consonants were not examined, and, consequently, I chose to structure the stimuli word list with various consonantal environments.

3.7 Conclusion and summary

The various methods and approaches used in this experiment to analyse the collected data and observe the plain/emphatic contrast in NA were described in this chapter. Based on this production experiment, this study aims, in the following chapters, to investigate whether the vocalic and the consonantal acoustic parameters have been consistently and reliably distinguishing between emphatic and plain contexts. Moreover, this study also aims to assess whether emphasis has a restricted domain (i.e., the syllable boundary) or it extends beyond either within the stem or even across the morpheme boundaries. In addition, it provides evidence about the direction of emphasis spread and the existence of certain consonants and vowels that block emphasis extension in either direction.

CHAPTER 4: ACOUSTIC FEATURES OF EMPHASIS SPREAD IN NAJDI ARABIC

4.1 Overview

The contrast between plain and emphatic segments in several Arabic dialects has been widely investigated (Al-Masri, 2009). These studies have focused on the vocalic cues of emphasis to identify phonetic distinction. The consonantal cues of emphasis, however, have not been as widely studied. Thus, this chapter investigates which of the following acoustic cues are systematically affected by the presence or absence of emphasis in NA: vowel duration, vowel formant frequencies (F1–F3), stop closure duration, stop VOT duration, or friction noise duration. In this chapter, the phonetic analysis only examines monosyllabic stimuli because monosyllabic words are the clearest and most controlled case, allowing us to examine how emphasis in NA is realised in the simplest case.

Several hypotheses were made regarding the acoustic cues of emphasis in NA. The first addresses the effect of emphasis on vowel duration [a(ː), i(ː), u(ː)]. Most Arabic dialects show no significant differences in vowel duration between emphatic and plain contexts (Ali and Daniloff, 1972b; El-Dalee,1984; Norlin 1987; Hussain 1985, Kriba, 2009). Therefore, it is expected that there will be no difference between emphatic and plain vowel durations.

The second hypothesis assumes that emphatics in NA will be associated with F2 lowering in adjoining vowels when compared to plain ones. The articulatory mechanism involved in emphatic production is tongue root retraction, which corresponds with the co-articulatory effects of lowering F2 in adjacent vowels (Al-Ani, 1970; Bin-Muqbil, 2006; Shar, 2012). Accordingly, it seems reasonable to suggest that F2 is an important acoustic cue that signals the emphatic/plain contrast.

With regard to F1 and F3 of the surrounding vowels, the effects of emphasis seem to vary across different Arabic dialects. A few studies have reported F1 and F3 as reliable cues for the plain/emphatic opposition (Jongman et al., 2007; Kriba, 2004, 2009; Al-Masri, 2009; Jongman et al., 2011; Al-Tamimi and Heselwood, 2011; Aldamen, 2013). However, other Arabic studies have suggested that these formants, especially F3, are inconsistent and unreliable acoustic correlates of emphasis (Giannini and Pettorino, 1982; Card, 1983; Norlin, 1987; Wahba, 1993; AI-Nuzaili, 1993; Khattab et al., 2006). The third hypothesis posits that if there is an effect of emphasis on F1 and F3 in NA, it will be in the following direction: F1 and F3 will considerably increase in emphatic contexts compared to plain contexts.

Several studies on Arabic VOT have revealed a difference between voiceless emphatic stops and their plain counterparts. In general, the vocal folds start vibrating earlier when the vowel is within the vicinity of an emphatic segment (Kriba, 2004; Khattab et., 2006). Several previous studies have found that the VOT of the aspirated plain stop /t/ is significantly longer than that of the unaspirated emphatic /ṭ/ (Ghazali, 1977; Bukshaisha, 1985; Al-Nuzaili, 1993; Kriba, 2004; Khattab et al., 2006). However, a few studies on EA (Shaheen, 1979; Heselwood, 1996; Rifaat, 2003) have shown that VOT is not a systematic acoustic cue of the emphatic/plain contrast. In this respect, SdA has been found to exhibit completely different findings, in which the emphatic stop /ṭ/ had a significantly longer VOT than its plain counterpart /t/ (Ahmed, 1984). Considering these different results, no strong predictions can be made about the effect of emphasis on VOT in NA, but VOT is nevertheless investigated as a cue in this study.

Stop closure duration has been reported to be longer in emphatic contexts than in plain contexts (Ahmed, 1984; Bukshaisha, 1985; AI-Nuzaili, 1993; Kriba, 2004, 2009). Previous researchers have asserted that the retraction of the tongue into the upper pharynx is not the only articulatory movement involved in the secondary articulation of emphatics. Rather, it co-exists with other gestures, such as the sulcalisation of the tongue dorsum, jaw lowering, and slight lip protrusion or rounding (labialisation) (Bellem, 2007; Watson and Bellem, 2011). Together, these articulatory gestures result in minimising the size of the pharyngeal cavity and comparatively enlarging the volume of the oral cavity (Bellem, 2014), which accounts for longer closure durations, as these sounds require more time to achieve complete closure. Based on this articulatory model, stop closure duration has been described as a potential acoustic correlate of emphasis in many Arabic dialects (Ahmed, 1984; Bukshaisha, 1985; AI-Nuzaili, 1993; Kriba, 2009). This cue, therefore, is also investigated in the present study of NA.

Finally, the effect of emphasis on friction noise duration seems to have only been explored in one study. Abudalbuh (2010) reported a significant distinction in friction noise duration among emphatic and plain contexts in JA. That is, emphatic fricatives were shorter, on average, than plain fricatives. Based on this result, friction noise duration is also studied as a cue to the emphatic/plain contrast in NA in the present study.

4.2 Analysis

4.2.1 Materials

The stimuli discussed in this chapter are listed in Table 4.1. The table includes 36 monosyllabic words, contrasting word-initial plain consonants (/t, s, ð/) with their emphatic counterparts (/ṭ, ṣ, ð̣/) in NA. These voiced and voiceless obstruents were embedded in CVC and CVCC syllables, where the initial C was the trigger consonant. Each pair of these trigger consonants was used along with the six vowels of NA (i.e. /a, aː, u, uː, i, iː/). All the plain-emphatic stimuli pairs formed minimal pairs.

Table 4.1: List of stimuli with the trigger obstruents.

Emphatic Segments	Gloss	Plain Segments	Gloss
/ṣad/	to avoid	/sad/	to close
/ṣa:d/	to hunt	/sa:d/	to obstruct sth
/ṣid/	to prevent	/sid/	to block
/ṣi:ħ/	to cry	/si:ħ/	to melt
/ṣuf/	pictures	/suf/	to eat
/ṣu:f/	wool	/su:f/	to sponge
/ṭaf/	being used to	/taf/	to spit
/ṭa:b/	to heal	/ta:b/	to repent
/ṭib/	medicine	/tib/	to forsake
/ṭi:n/	mud	/ti:n/	figs
/ṭuf /	to get used to	/tuf/	to spit
/ṭu:b/	red chalk	/tu:b/	to forsake
/ð̣al/	to get lost	/ðal/	to be frightened
/ð̣a:l/	aberrant	/ða:l/	afraid
/ð̣il/	shadow	/ðil/	fear
/ð̣i:ʕ/	get lost	/ði:ʕ/	to announce
/ð̣um/	to hug	/ðum/	nonsense word
/ð̣u:g/	encompassed	/ðu:g/	to taste

This chapter focuses on a variety of acoustic measurements (see Section 4.1). The number of the attested tokens was (36 * 5 * 3 = 540). A total of 6120 acoustic measurements were taken from these monosyllabic tokens. To examine the cues mentioned above, the segmentation criteria presented in Section 3.6.1 were applied.

4.2.2 Data normalisation

One of the independent variables explored in this study was speaker gender, i.e., gender-specific ways of marking emphasis. Since speaker anatomy is known to systematically affect the spectral differences between male and female speech, the formant measurements were normalised. The formant measurements were z-scored within speakers, which is a modification of the Lobanov (1971) method. Normalisation methods produce vowel data that are not represented by Hertz or Bark values. Thus, to interpret the resulting values as Hertz-like values, the scale-normalised Hertz results are provided.

The Lobanov method is appropriate for use in this study for several reasons. First, it is a vowel extrinsic/formant intrinsic normalisation method that requires information about a speaker’s various vowels since it does not operate on information from a single vowel. It works perfectly when a speaker’s vowel system is included entirely, as is the case in the data presented in the present study.

Moreover, the Lobanov method is effective in fulfilling the ultimate purpose of normalisation, i.e., phonemic and sociolinguistic preservation and minimisation of anatomical/physiological variation among speakers. The Lobanov method performs better in this than other normalisation procedures (Nearey, 1978; Detering, 1990; Adank et al., 2004; Volín and Studenovský, 2007; Volín, 2009). The data were normalised using R Software Version 3.6.2 (2019).

4.2.3 Speech rate

This study examines several durational measurements, such as vowel duration, stop closure duration, stop VOT duration, and friction noise duration, which are expected to be systematically influenced by speech rate. Because of this, speech rate was included in the modelling as a co-variate. Speech rate was calculated as the duration of the carrier phrase, ‘قل X مرة ثانية’ /gil X marrah θaːnjah/ measured in ms. Test items were excluded, represented as ‘X’ in the carrier phrase, so that the measure of speech rate was independent of the duration of the test items. The phrase itself was segmented manually. Then, a script in Praat was used to measure the duration of each repetition of the carrier phrase.

4.2.4 Statistical analysis

The data were analysed using mixed-effects linear regression. The dependent variables were the acoustic measurements, duration measurements, and formant values, as described in Section 3.6.1. These measurements included vowel duration, vowel formant frequencies (F1–F3), stop closure duration, stop VOT duration, and friction noise duration.

The following fixed predictors were considered in the modelling: environment (plain, emphatic), vowel quality (a, i, u), vowel length (short, long), vowel measurement time point (onset, midpoint, offset), consonant voice (voiced, voiceless), consonant manner (stop, fricative), participant sex (female, male), and speech rate. Some of the predictors were not relevant or applicable to modelling some of the dependent variables (e.g., VOT was only measured for voiceless stops). Table 4.2. lists the predictors considered in modelling each of the dependent variables. In addition to the fixed predictors, random intercepts for participants and items were included in each of the models in order to account for autocorrelation introduced by the repeated-measures design.

Table 4.2: Predictors considered for each of the dependent variables.

Dependent Variables	Independent Variables
Vowel formants: F1, F2, F3[18]	Environment: plain, emphatic. Vowel measurement time point: onset, midpoint, offset. Vowel length: short, long. Consonant manner: stop, fricative. Consonant voicing: voiced, voiceless. Sex: female, male. The presence of a pharyngeal consonant: pharyngeal, non-pharyngeal (if applicable).
Vowel duration	Vowel quality: a, i, u. Vowel length: short, long.

[18] Vowel quality was not added as an independent variable when conducting the models for the vowels formants. The reason behind this is to avoid the assumption that the effect of plain versus emphatic is the same for all vowels. Therefore, I conducted separate models for each of the attested vowels /a, i, u/ and presented the results separately.

	Consonant manner: stop, fricative. Consonant voicing: voiced, voiceless. Sex: female, male. Speech rate.
VOT duration	Vowel quality: a, i, u. Vowel length: short, long. Sex: female, male. Speech rate.
Closure duration	Vowel quality: a, i, u. Vowel length: short, long. Sex: female, male. Speech rate.
Friction noise duration	Environment: plain, emphatic. Vowel quality: a, i, u. Vowel length: short, long. Consonant voicing: voiced, voiceless. Sex: female, male. Speech rate.

4.2.4.1 Model selection

The overall goal of the statistical analysis was to determine the effect of emphasis on each acoustic dimension while controlling for other variables that might contribute to the overall variance. Thus, emphasis was included in all the models as the main predictor as well as part of an interaction with other independent variables. Interactions were included to investigate the possibility that the effect of emphasis may vary according to the different levels of some predictors (e.g., it may be different for males and females).

The interactions were tested using a maximum likelihood comparison of fit for the nested models (Cousineau and Allan, 2015). Interactions were tested by removing the interaction terms one by one and comparing the log-likelihood ratio of the nested models. Non-significant interactions were not retained. Based on this procedure, the final model in each case includes all the possible main effects and all the significant interactions.

Mixed-effects regression was implemented in R (3.62 version) using the lme4 package (Bates et al., 2015). Significance values and confidence intervals were estimated using the effects package (Fox and Weisberg, 2019). The optimx optimiser was used in all models to improve model convergence (Nash and Varadhan, 2011).

4.3 Results

4.3.1 Vocalic cues

4.3.1.1 Vowel duration

Vowel duration was analysed using mixed-effects linear regression, as introduced in Sections 3.6.3 and 3.6.4. The following predictors were considered in the model as fixed effects: environment (emphatic, plain), sex (male, female), consonant voicing (voiced, voiceless), consonant manner of articulation (stop, fricative), vowel quality (/a, i, u/), vowel length (short, long), and speech rate. No significant interaction was found between the environment and any of the other predictors. The regression summary in Table 4.3 below displays the results. The intercept in this model corresponds to the short vowel /a/ preceded by a voiced fricative emphatic.

Table 4.3: Regression model summary of the dependent variable (vowel duration) in monosyllables.

Predictors	Estimate	Std. Error	CI	*t*-statistic	*p*-value
(Intercept)	148.82	12.72	123.89–173.76	11.70	**< 0.001**
Environment [Plain]	-9.89	6.42	-22.46–2.69	-1.54	0.123
Speech rate	-0.02	0.01	-0.04–0.00	-1.81	0.070
Vowel quality [i]	-20.57	7.86	-35.97–-5.17	-2.62	**0.009**
Vowel quality [u]	-19.52	7.86	-34.93–-4.10	-2.48	**0.013**
Sex [M]	-0.67	2.71	-5.98–4.63	-0.25	0.804
Consonant voice [Voiceless]	-10.66	7.87	-26.08–4.77	-1.35	0.176
Consonant manner [Stop]	3.15	7.86	-12.25–18.55	0.40	0.688
Vowel length [Long]	58.96	6.42	46.39–71.54	9.19	**< 0.001**

Random Effects	
σ^2	102.18
τ_{00} Example	363.50
τ_{00} Participant no.	7.69

ICC	0.78
N Example	36
N Participant no.	5
Observations	540
Marginal R^2/Conditional	0.681/0.931

The results from the model comparison show that, across the board, the difference between the mean vowel durations in the plain and emphatic environments was not significant ($p = 0.093$). In the same fashion, vowel duration was not significantly affected by any of the following predictors: sex ($p = 0.769$), consonant voicing ($p = 0.138$), manner of articulation of the preceding trigger consonants ($p = 0.656$), or speech rate ($p = 0.068$).

In contrast, the influence of vowel quality on vowel duration was significant. The vowel /a/ was significantly longer than /i/ or /u/ ($p = 0.009$ and $p = 0.013$, respectively). Unsurprisingly, the main effect of vowel length was significant ($p < 0.001$). Overall, long vowels were about 58.96 ms longer than short vowels.

In the following analysis of the vowel formants, examining the effect of emphatic versus plain environments on the vowels' formants should not combine all vowels together; conflating all vowels together assumes that the effect of plain versus emphatic is the same for all vowels. Therefore, I conducted separate models for each of the attested vowels and presented their results separately.

4.3.1.2 First formant frequency (F1)

The model of F1 presented here for the vowel /a/ included the following predictors as fixed effects: environment (emphatic, plain), vowel measurement time point (onset, midpoint, offset), sex (male, female), consonant voicing (voiced, voiceless), consonant manner of articulation (stop, fricative), and vowel length (short, long). No significant interaction between the environment and any of the other predictors was observed.

Table 4.4 below presents a summary of the F1 regression model for the vowel /a/. The intercept is the estimated value of the normalised F1 for a long /a/, measured at the vocalic midpoint, preceded by an emphatic voiceless fricative.

Table 4.4: Regression model summary of the dependent variable (F1) for the vowel /a/ in monosyllables.

Predictors	Estimate	Std. Error	CI	t-statistic	p-value
(Intercept)	0.42	0.15	0.13–0.71	2.85	**0.004**
Environment [Plain]	-0.05	0.13	-0.31–0.21	-0.37	0.710
Vowel measurement time point [Onset]	-0.26	0.03	-0.32– 0.21	-9.01	**< 0.001**
Vowel measurement time point [Offset]	0.04	0.03	-0.02– 0.10	1.40	0.161
Sex [M]	-0.01	0.02	-0.06–0.03	-0.53	0.598
Consonant voice [Voiced]	-0.47	0.16	-0.78– -0.15	-2.91	**0.004**
Consonant manner [Stop]	-0.17	0.16	-0.48– 0.15	-1.04	0.300
Vowel length [Short]	-0.30	0.13	-0.55– -0.04	-2.25	**0.025**

Random Effects	
σ^2	0.08
τ_{00} Example	0.05
τ_{00} Participant no.	0.00
^{N} Example	12
^{N} Participant no.	5
Observations	540
Marginal R^2/Conditional R^2	0.507/NA

The model comparison reveals that the difference between F1.z for/a/ in the plain and emphatic environments is not statistically significant (p = 0.628). Similarly, none of the following predictors had a significant effect on F1.z in /a/ contexts: sex (p = 0.597), and manner of articulation of the preceding trigger consonants (p = 0.191).

By contrast, F1.z values were significantly higher in voiceless contexts than in voiced contexts (p = 0.004). Moreover, the main effect of vowel length was significant (p= 0.025) in which F1.z values were significantly lower in short-vowel contexts than in long-vowel contexts. As demonstrated in the regression table above, the influence of the vowel measurement time point was significant only in the comparison between F1.z values at the vowel onset and those at the vowel midpoint. F1.z values at the vowel offset, however, were not significant when compared with those at the vowel midpoint.

A model of F1 for the high front vowel /i/ was selected with the following predictors structure: main effects of the environment (emphatic, plain), the speaker's sex (male, female), vowel length (short, long), consonant manner of articulation (stop, fricative), consonant voicing (voiced, voiceless), and the presence of a pharyngeal after the vowel (pharyngeal, non-pharyngeal).

The following table summarises the regression model. The intercept in this model is the estimated value of the normalised F1 for a long /i/, measured at the vocalic midpoint, preceded by an emphatic voiceless fricative and followed by a non-pharyngeal consonant.

Table 4.5: Regression model summary of the dependent variable (F1) for the vowel /i/ in monosyllables.

Predictors	Estimate	Std. Error	CI	t-statistic	p-value
(Intercept)	-1.49	0.51	-2.48–-0.49	-2.93	**0.003**
Environment [Plain]	-0.05	0.02	-0.09– -0.00	-1.97	**0.049**
Vowel measurement time point [Onset]	-0.07	0.03	-0.13– -0.02	-2.54	**0.011**
Vowel measurement time point [Offset]	-0.00	0.03	-0.06– 0.05	-0.07	0.942
Sex [M]	-0.39	0.80	-1.96–1.17	-0.49	0.623
Consonant voice [Voiced]	0.02	0.03	-0.04– 0.08	0.70	0.482
Consonant manner [Stop]	-0.00	0.04	-0.07– 0.07	0.02	0.987
Vowel length [Short]	0.51	0.04	0.43– 0.59	12.64	**< 0.001**

IncPharyngeal [Pharyngeal]	0.02	0.05	-0.07 – 0.12	0.49	0.626

Random Effects	
σ^2	0.07
τ_{00} Example	0.00
τ_{00} Participant no.	0.76
^{N} Example	12
^{N} Participant no.	5
Observations	540
Marginal R^2/Conditional R^2	0.577/NA

The results in the high front vowel contexts reveal that F1.z in emphatic environments was significantly higher than that in plain environments ($p = 0.049$). Additionally, the main effect of vowel length was significant ($p < 0.001$), with F1.z values being significantly higher in contexts with short vowels than those in contexts with long vowels. The influence of vowel measurement time point, as illustrated in the table above, was significant only in the comparison between F1.z values at the vowel onset and those at the vowel midpoint. F1.z values at the vowel offset, on the other hand, did not differ significantly from those at the vowel midpoint.

According to the model comparison, the main effect of gender on F1 was not significant. (p = 0.534). In a similar vein, consonant voicing had no significant effect on the F1.z values of the high front vowel (p = 0.479). Neither the manner of articulation of consonants nor the presence of a pharyngeal consonant following the vowel had a significant effect on F1 (p = 0.987, and p = 0.624, respectively).

The last model of F1 presented here was for the high back vowel /u/. The model was designed with the following predictors structure: the main effects of the environment (emphatic, plain), vowel measurement time point (onset, midpoint, offset), sex (male, female), consonant voicing (voiced, voiceless), consonant manner of articulation (stop, fricative), and vowel length (short, long). As with earlier models, no significant interaction was observed between the environment and the other variables. The intercept in this model was the estimated value of the normalised F1 for a long /u/, measured at the vocalic midpoint, preceded by an emphatic voiceless fricative.

Table 4.6: Regression model summary of the dependent variable (F1) for the vowel /u/ in monosyllables.

Predictors	Estimate	Std. Error	CI	t-statistic	p-value
(Intercept)	-1.00	0.47	-1.93– -0.08	-2.13	**0.033**
Environment [Plain]	-0.05	0.09	-0.23– 0.13	-1.97	0.592
Vowel measurement Timepoint [Onset]	-0.07	0.03	-0.12– -0.02	-2.55	**0.011**
Vowel measurement Timepoint [Offset]	-0.17	0.03	-0.22– -0.12	-6.73	**< 0.001**
Sex [M]	-0.37	0.73	-1.79–1.06	-0.50	0.614
Consonant voice [Voiced]	-0.44	0.11	-0.66– -0.22	-3.86	**< 0.001**
Consonant manner [Stop]	-0.07	0.11	-0.29– 0.16	-0.59	0.558
Vowel length [Short]	0.25	0.09	0.07– 0.43	2.69	**0.007**

Random Effects	
σ^2	0.06
τ_{00} Example	0.02
τ_{00} Participant no.	0.63
ICC	0.92
^{N} Example	12
^{N} Participant no.	5
Observations	540
Marginal R^2/Conditional R^2	0.113/0.927

The model comparison results indicate no significant difference in F1.z values between the plain and emphatic environments (p = 0.506). Moreover, the speaker's sex and manner of articulation of the preceding trigger consonants had no significant effect on the F1.z values of the high back vowel (p = 0.524, and p = 0.467, respectively).

By contrast, vowel measurement time point had a significant influence only in the comparison between F1.z values at the high vowel onset and offset and those at the vowel midpoint ($p = 0.011$ and $p < 0.001$, respectively). The main effect of vowel length was also significant ($p = 0.007$). Overall, F1.z values for short vowels were higher than those for long vowels. The results indicate that the main effect of voicing was highly significant ($p < 0.001$). In the presence of voicelessness, F1.z values tended to be considerably higher than F1.z values in voiced contexts.

4.3.1.3 Second formant frequency (F2)

A model of F2 for the vowel /a/ was selected with the following predictors structure: interactions between the environment (emphatic, plain), vowel measurement time point (onset, midpoint, offset), vowel length (short, long), and consonant voicing (voiced, voiceless). In addition, the model included the main effects of the following explanatory variables: the speaker's sex (male, female) and consonant manner (stop, fricative). The model summary is shown in Table 4.7 below. Here, the intercept is the estimated value of the normalised F2 for a long /a/, measured at the vowel midpoint, preceded by an emphatic voiceless fricative.

Table 4.7: Regression model summary of the dependent variable (F2) for the vowel /a/ in monosyllables.

Predictors	Estimate	Std. Error	CI	*t*-statistic	*p*-value
(Intercept)	-1.21	0.05	-1.30–-1.11	-25.61	**< 0.001**
Environment [Plain]	1.77	0.06	1.65–1.88	30.08	**< 0.001**
Vowel measurement Time point [Onset]	-0.10	0.03	-0.16–-0.05	-3.48	**0.001**
Vowel measurement Time point [Offset]	0.03	0.03	-0.02–0.08	1.19	0.233
Sex [M]	0.09	0.02	0.05–0.12	5.40	**< 0.001**
Consonant voice [Voiced]	-0.10	0.06	-0.21–0.01	-1.78	0.075

Consonant manner [Stop]	0.01	0.04	-0.07–0.10	0.33	0.741
Vowel length [Short]	-0.28	0.05	-0.38–-0.19	-5.80	**< 0.001**
Environment [Plain] * Vowel measurement Time point [Onset]	0.32	0.04	0.25–0.40	8.44	**< 0.001**
Environment [Plain] * Vowel measurement Time point [Offset]	-0.01	0.04	-0.08–0.07	-0.20	0.838
Environment [Plain] * Vowel length [Short]	0.34	0.07	0.20-0.48	4.93	**< 0.001**
Environment [Plain] * Consonant voice [Voiced]	0.18	0.07	0.03–0.32	2.43	**0.015**

Random Effects	
σ^2	0.03
τ_{00} Example	0.00
τ_{00} Participant No.	0.00
^{N} Example	12
^{N} Participant No.	5
Observations	540
Marginal R^2/Conditional R^2	0.972/NA

As stated earlier, the model shows three interactions. The first interaction was between environment and measurement time point, as illustrated in Figure 4.1.

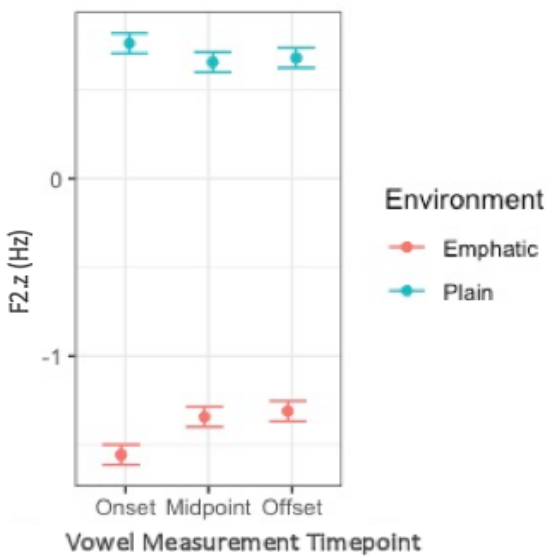


Figure 4.1: The interaction between environment and vowel measurement time point in a model predicting normalised F2 for the vowel /a/ in monosyllables.

The difference in F2.z between the emphatic and plain contexts was significant at the onset of the vowel compared with that at the vowel midpoint ($p < 0.001$). However, the difference in F2.z between the emphatic and plain contexts was not significant at the vowel offset compared with that at the vowel midpoint ($p = 0.838$). As a result, the intercept was reset and the model was re-run to compare the difference in F2.z in the emphatic and plain contexts at vowel onset versus vowel offset. F2.z was determined to be significantly different ($p < 0.001$). Despite the presence of interactions, a robust difference in F2 between emphatics and plains was observed, and the confidence intervals did not overlap.

The second interaction reported in this model was between environment and vowel length. This interaction, illustrated in Figure 4.2 below, was highly significant ($p < 0.001$). The difference between the emphatic and plain contexts was greater in the short vowel contexts than in the long vowel contexts.

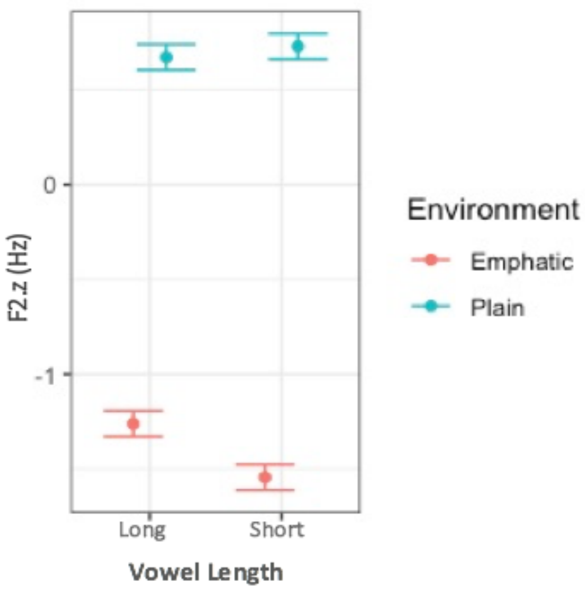


Figure 4.2: The interaction of environment and vowel length in a model predicting normalised F2 for the vowel /a/ in monosyllables.

The third interaction was between environment and consonant voicing. The difference between the emphatic and plain contexts was consistently higher in voiced than in voiceless contexts (see Figure 4.3).

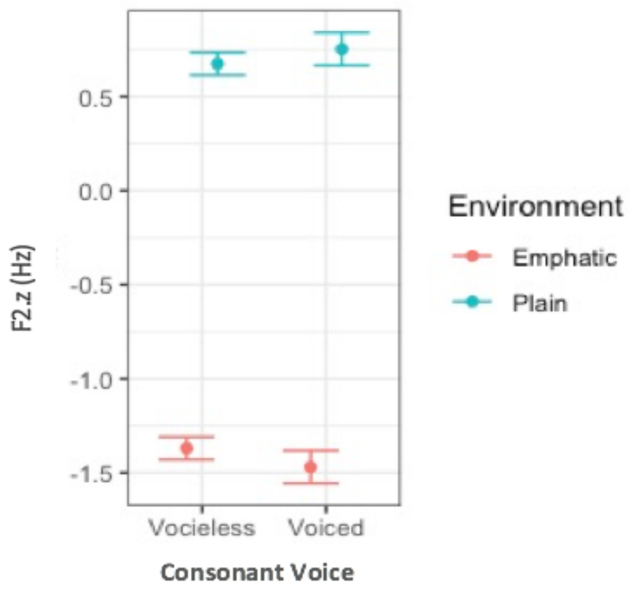


Figure 4.3: The interaction of environment and consonant voicing in a model predicting normalised F2 for the vowel /a/ in monosyllables.

According to the model comparison, there was no significant main effect of consonant manner (p = 0.611). By contrast, the model comparison shows that the effect of speaker sex was significant ($p < 0.001$).

Another model of F2 was designated for the high front vowel /i/ with the following predictors structure: significant interactions between the environment (emphatic, plain) and vowel measurement time point (onset, midpoint, offset), vowel length (short, long), the presence of a pharyngeal after the vowel (pharyngeal, non-pharyngeal) and consonant manner (stop, fricative). Along with these interactions, the model also included the main effects of speaker sex (male, female) and consonant voicing (voiced, voiceless). Table 4.8 below summarises the regression model. The intercept here represents the estimated value of the normalised F2 for a long /i/, measured at the vowel midpoint, preceded by an emphatic voiceless fricative and followed by a non-pharyngeal consonant.

Table 4.8: Regression model summary of the dependent variable (F2) for the vowel /i/ in monosyllables.

Predictors	Estimate	Std. Error	CI	*t*-statistic	*p*-value
(Intercept)	-0.69	0.06	-0.81–-0.57	-11.16	**< 0.001**
Environment [Plain]	1.53	0.09	1.36–1.70	17.91	**< 0.001**
Vowel measurement Time point [Onset]	-0.16	0.02	-0.21–-0.12	-7.56	**< 0.001**
Vowel measurement Time point [Offset]	-0.01	0.02	-0.05–0.03	-0.46	0.647
Sex [M]	0.06	0.01	0.04–0.09	4.99	**< 0.001**
Consonant voice [Voiced]	0.01	0.03	-0.04–0.06	0.44	0.657
Consonant manner [Stop]	-0.07	0.05	-0.17–0.02	-1.55	0.121
Vowel length [Short]	-0.42	0.05	-0.52–-0.31	-7.89	**< 0.001**
IncPharyngeal [Pharyngeal]	-0.29	0.06	-0.42–-0.17	-4.53	**< 0.001**
Environment [Plain] * Vowel measurement Time point [Onset]	0.15	0.03	0.09–0.21	5.03	**< 0.001**
Environment [Plain] * Vowel measurement Time point [Offset]	0.03	0.03	-0.03–0.09	0.97	0.331
Environment [Plain] * Vowel length [Short]	0.28	0.07	0.14 – 0.43	3.78	**< 0.001**
Environment [Plain] * IncPharyngeal [Pharyngeal]	0.45	0.09	0.27– 0.63	4.94	**< 0.001**
Environment [Plain] * Consonant manner [Stop]	0.25	0.06	0.12–0.38	3.87	**< 0.001**

Random Effects	
σ^2	0.02
τ_{00} Example	0.00
τ_{00} Participant No.	0.00
^{N} Example	12
^{N} Participant No.	5
Observations	540
Marginal R^2/Conditional R^2	0.979/NA

Four significant interactions were identified in this model. To begin, an interaction between environment and vowel measurement time point was observed, as illustrated in Figure 4.4 below. The model shows that the difference in F2.z between the emphatic and plain contexts was significant at the vowel onset compared with that at the vowel midpoint ($p < 0.001$). Nonetheless, this difference between emphatic and plain contexts was not significant at the vowel offset compared with that at the vowel midpoint ($p = 0.331$). Consequently, the intercept was reset and the model was re-run to evaluate the difference in F2.z at vowel onset versus vowel offset for the emphatic and plain contexts. The difference in F2.z was considered to be statistically significant ($p < 0.001$).

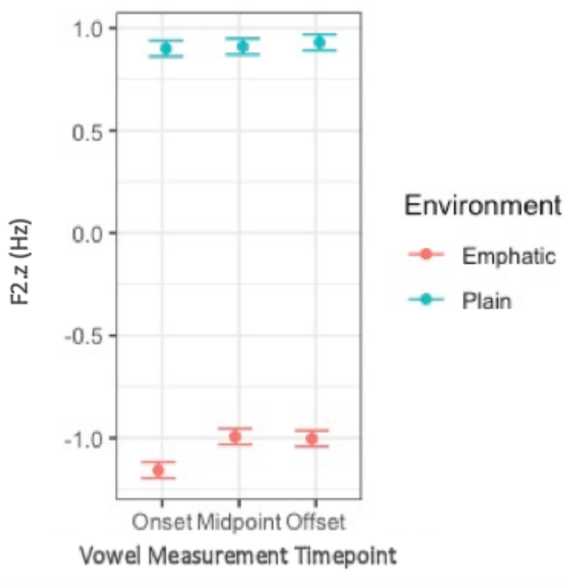


Figure 4.4: The interaction of environment and vowel measurement time point in a model predicting normalised F2 for the vowel /i/ in monosyllables.

The second interaction was between environment and vowel length (see Figure 4.5). The differences in F2.z values between the plains and emphatics in the short vowel contexts were greater than the differences in the long vowel contexts ($p < 0.001$).

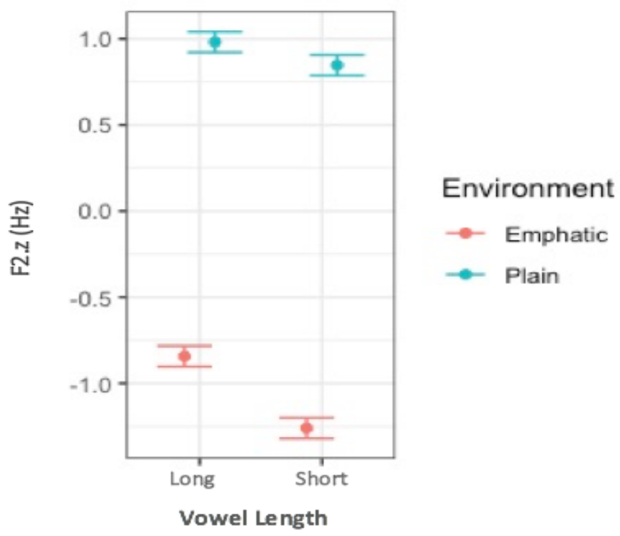


Figure 4.5: The interaction of environment and vowel length in a model predicting normalised F2 for the vowel /i/ in monosyllables.

The third interaction was between environment and the presence of a pharyngeal consonant after the vowel ($p < 0.001$). The results revealed that the examples that included a pharyngeal consonant after the vowel had greater differences in their F2.z values between the plains and emphatics than those examples that did not (see Figure 4.6).[19]

[19] Although the results show that the presence of a pharyngeal consonant exhibited a significant effect on F2, they cannot be considered conclusive because the pharyngeal consonants were only attested in the high front vowel /i/ context.

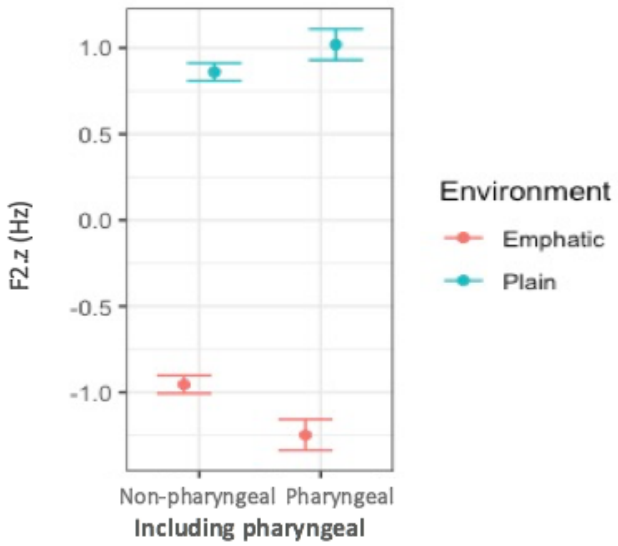


Figure 4.6: The interaction of environment and including a pharyngeal consonant in a model predicting normalised F2 for the vowel /i/ in monosyllables.

The last interaction between environment and consonant manner was significant ($p < 0.001$). Overall, the mean F2 in the high front vowel /i/ context was significantly higher in the stop contexts than in the fricative contexts. Figure 4.7 illustrates this interaction.

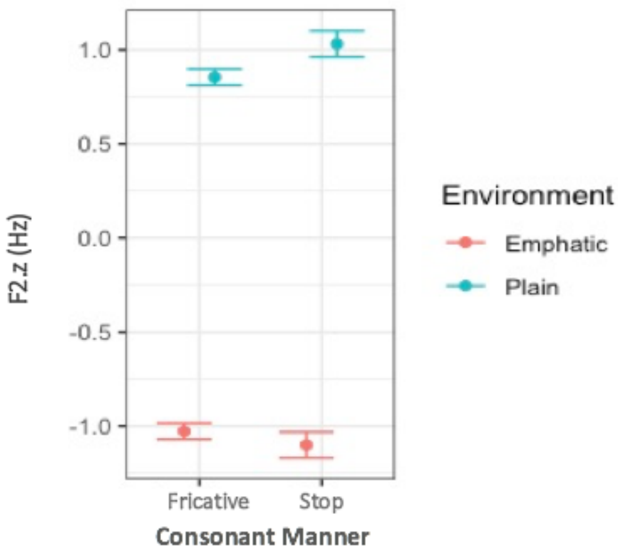


Figure 4.7: The interaction of environment and consonant manner in a model predicting normalised F2 for the vowel /i/ in monosyllables.

According to the model comparison, there was no significant main effect of consonant voicing ($p = 0.441$). On the contrary, the model comparison reveals a considerable effect of speaker sex ($p < 0.001$). The F2.z values were considerably lower for female speakers than for male speakers.

The last model of F2 was selected for the high back vowel /u/ with the following predictors structure: significant interactions between the environment (emphatic, plain) and vowel measurement time point (onset, midpoint, offset), speaker sex (male, female), consonant voicing (voiced, voiceless), and consonant manner (stop, fricative). In addition to these interactions, the model comprises the main effect of vowel length (short, long). The regression model is summarised in Table 4.9 below. The intercept here represents the estimated value of the normalised F2 for a long /u/, measured at the vowel midpoint, preceded by an emphatic voiceless fricative.

Table 4.9: Regression model summary of the dependent variable (F2) for the vowel /u/ in monosyllables.

Predictors	Estimate	Std. Error	CI	*t*-statistic	*p*-value
(Intercept)	-1.50	0.10	-1.69–-1.30	-14.87	**< 0.001**
Environment [Plain]	1.36	0.13	1.10–1.62	10.31	**< 0.001**
Vowel measurement Time point [Onset]	-0.10	0.03	-0.16–-0.05	-3.48	**0.001**
Vowel measurement Time point [Offset]	-0.20	0.03	-0.26 – -0.15	-6.82	**< 0.001**
Consonant manner [Stop]	-0.11	0.13	-0.36– 0.14	-0.85	0.395
Sex [M]	- 0.08	0.03	-0.13– -0.03	-3.28	**0.001**
Consonant voice [Voiced]	-0.10	0.13	-0.35–0.15	-0.77	0.443
Vowel length [Short]	-0.00	0.07	-0.15–-0.14	-0.02	0.981
Environment [Plain] * Vowel measurement Time point [Onset]	0.32	0.04	0.24–0.40	7.58	**< 0.001**
Environment [Plain] * Vowel measurement Time point [Offset]	0.14	0.04	0.05–0.22	3.23	**0.001**

Environment [Plain] * Consonant manner [Stop]	0.34	0.18	-0.02 – 0.70	1.87	0.062
Environment [Plain] * Sex [M]	0.52	0.04	0.45–0.58	14.57	**< 0.001**
Environment [Plain] * Consonant voice [Voiced]	0.25	0.18	-0.11– 0.61	1.35	0.176

Random Effects	
σ^2	0.04
τ_{00} Example	0.02
τ_{00} Participant No.	0.00
^{N} Example	12
^{N} Participant No.	5
Observations	540
Marginal R^2/Conditional R^2	0.960/NA

As previously noted, this model had four interactions. The first interaction was between the environment and the vowel measurement time point, as shown in Figure 4.8 below.

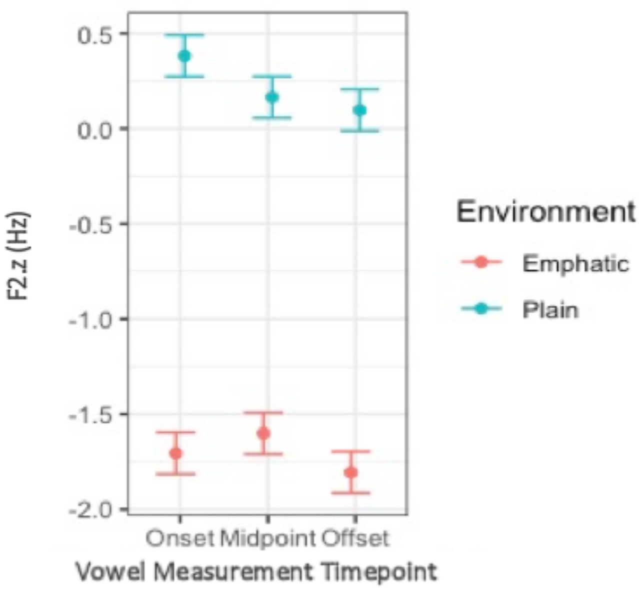


Figure 4.8: The interaction of environment and vowel measurement time point in a model predicting normalised F2 for the vowel /u/ in monosyllables.

The difference in F2.z between the emphatic and plain contexts was significant at the onset of the vowel compared with that at the vowel midpoint ($p < 0.001$). The difference in F2.z between the emphatic and plain contexts was also significant at the vowel offset compared with that at the vowel midpoint ($p = 0.001$).

The second interaction reported here was between environment and the speaker's sex ($p < 0.001$). As shown in Figure 4.9 below, male speakers demonstrated higher differences in F2.z values between the emphatic and plain contexts than female speakers did.

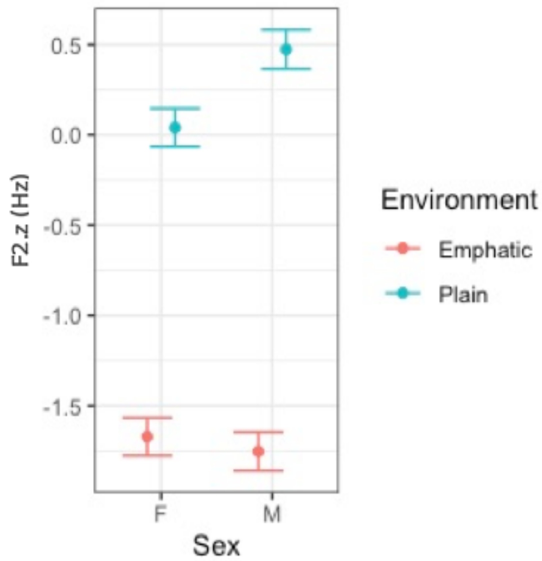


Figure 4.9: The interaction of environment and speaker sex in a model predicting normalised F2 for the vowel /u/ in monosyllables.

The last two interactions were between environment and consonant voicing and consonant manner. Although these interactions were not significant, including them improved model fit significantly ($p = 0.05$, and $p = 0.01$, respectively). According to the model comparison, the result shows that the effect of vowel length was not significant ($p = 0.646$).

4.3.1.4 Third formant frequency (F3)

A model of F3 for the vowel /a/ was selected with the following predictors structure: main effects of the environment (emphatic, plain), vowel measurement time point (onset, midpoint, offset), sex (male, female), consonant voicing (voiced, voiceless), consonant manner of articulation (stop, fricative), and vowel length (short, long). Table 4.10 below summarises the results of this model. The intercept is the estimated value of the normalised F3 for a long /a/, measured at the vocalic midpoint, preceded by an emphatic voiceless fricative.

Table 4.10: Regression model summary of the dependent variable (F3) for the vowel /a/ in monosyllables.

Predictors	Estimate	Std. Error	CI	*t*-statistic	*p*-value
(Intercept)	0.27	0.36	-0.44–0.97	0.74	0.459
Environment [Plain]	-0.02	0.30	-0.60–0.55	-0.08	0.933
Sex [M]	-0.17	0.23	-0.61–0.28	-0.73	0.462
Vowel length [Short]	0.49	0.30	-0.08–1.07	1.68	0.094
Vowel measurement Time point [Onset]	0.33	0.06	0.21–0.46	5.41	**<0.001**
Vowel measurement Time point [Offset]	0.04	0.06	-0.08–0.16	0.70	0.485
Consonant voice [Voiced]	-0.95	0.36	-1.65–0.24	-2.62	**0.009**
Consonant manner [Stop]	-0.46	0.36	-1.17–0.25	-1.28	0.201

Random Effects	
σ^2	0.34
τ_{00} Example	0.25
τ_{00} Participant no.	0.06
ICC	0.48
^{N} Example	12
^{N} Participant no.	5
Observations	540
Marginal R^2/Conditional R^2	0.268/0.616

The model comparison reveals that the difference between F3.z for/a/ in the plain and emphatic environments is not statistically significant (*p* = 0.9141). Similarly, none of the following predictors had a significant effect on F3.z in /a/ contexts: sex (p = 0. 0.3924), and manner of articulation of the preceding trigger consonants (p = 0.1176). However, a significant effect of vowel length on F3.z values was observed (p = 0.047).

On the other hand, F3.z values were considerably higher in contexts with voiceless consonants than in contexts with voiced ones (p = 0.009). The regression table above shows that the effect of vowel measurement time point was significant only in the comparison between F3.z values at the vowel onset and those at the vowel midpoint ($p < 0.001$). However, F3.z values at the vowel offset were not significantly different from those at the vowel midpoint (p = 0.485).

The second model of F3 here was designed for the high front vowel /i/ with the following predictors structure: main effects of the environment (emphatic, plain), speaker sex (male, female), vowel length (short, long), consonant manner of articulation (stop, fricative), consonant voicing (voiced, voiceless), and the presence of a pharyngeal after the vowel (pharyngeal, non-pharyngeal).

Table 4.11 below summarises the regression model. The intercept here is the estimated value of of the normalised F3 for a long /i/, measured at the vocalic midpoint, preceded by an emphatic voiceless fricative and followed by a non-pharyngeal consonant.

Table 4.11: Regression model summary of the dependent variable (F3) for the vowel /i/ in monosyllables.

Predictors	Estimate	Std. Error	CI	*t*-statistic	*p*-value
(Intercept)	-0.30	0.34	-0.97–0.38	-0.86	0.388
Environment [Plain]	-0.03	0.14	-0.31–-0.24	-0.25	0.803
Sex [M]	-0.25	0.29	-0.81– 0.31	-0.89	0.374
Vowel length [Short]	0.54	0.24	0.07–1.01	2.23	**0.026**
IncPharyngeal [Pharyngeal]	0.53	0.30	-0.05– 1.11	1.80	0.072
Vowel measurement Time point [Onset]	0.10	0.04	0.02–0.17	2.47	**0.013**
Vowel measurement Time point [Offset]	-0.07	0.04	-0.15–0.00	-1.85	0.064
Consonant voice [Voiced]	-0.21	0.17	-0.55–0.12	-1.24	0.214
Consonant manner [Stop]	0.40	0.23	-0.04–0.85	1.79	0.073

Random Effects	
σ^2	0.14
τ_{00} Example	0.05
τ_{00} Participant no.	0.10
ICC	0.52
^{N} Example	12
^{N} Participant no.	5
Observations	540
Marginal R^2/Conditional R^2	0.184/0.609

The result of the model comparison shows that the difference between F3.z for /i/ in the plain and emphatic environments is not statistically significant (p = 0.734). Furthermore, there was no significant main effect of consonant voicing (p = 0.109) or speaker sex (p = 0.2871). By contrast, significant effects of both consonant manner and the presence of a pharyngeal consonant after the vowel were observed (p = 0.028, and p = 0.028, respectively).

On the other hand, the regression table above shows that F3.z values were significantly higher in the short vowel contexts than in the long vowel ones (p = 0.026). Moreover, the effect of vowel measurement time point was significant only in the comparison between F3.z values at the vowel onset and those at the vowel midpoint (p = 0.013). F3.z values at the vowel offset, however, were not significant compared with those at the vowel midpoint (p = 0.064).

Another model of F3 was selected for the high back vowel /u/. Here, the model included the following predictors structure: the main effects of the environment (emphatic, plain), vowel measurement time point (onset, midpoint, offset), sex (male, female), consonant voicing (voiced, voiceless), consonant manner of articulation (stop, fricative), and vowel length (short, long). As with earlier models, there was no significant interaction between the environment and the other variables. The intercept in this model was the estimated value of of the normalised F3 for a long /u/, measured at the vocalic midpoint, preceded by an emphatic voiceless fricative.

Table 4.12: Regression model summary of the dependent variable (F3) for the vowel /u/ in monosyllables.

Predictors	Estimate	Std. Error	CI	*t*-statistic	*p*-value
(Intercept)	0.50	0.11	0.28–0.72	4.45	**< 0.001**
Environment [Plain]	-0.04	0.10	-0.23–0.15	-0.45	0.653
Sex [M]	-0.64	0.04	-0.72– -0.56	-16.34	**<0.001**
Vowel length [Short]	-0.01	0.10	-0.20–0.18	-0.14	0.888
Vowel measurement Time point [Onset]	0.02	0.05	-0.07–0.11	0.43	0.669
Vowel measurement Time point [Offset]	-0.42	0.05	-0.51–0.33	-8.92	**<0.001**
Consonant voice [Voiced]	-0.66	0.12	-0.90– -0.43	-5.58	**<0.001**
Consonant manner [Stop]	-0.35	0.12	-0.58–0.18	-2.92	**0.004**

Random Effects	
σ^2	0.20
τ_{00} Example	0.02
τ_{00} Participant no.	0.00
^{N} Example	12
^{N} Participant no.	5
Observations	540
Marginal R^2/Conditional R^2	0.517/NA

The model comparison reveals that there is no statistically significant difference between the plain and emphatic environments in terms of F3.z values ($p = 0.506$). Similarly, vowel length showed no significant effect on the high back vowel's F3.z values ($p = 0.524$).

By contrast, the regression table above shows that vowel measurement time point had a significant influence only in the comparison between F3.z values at the high back vowel offset and those at the vowel midpoint ($p < 0.001$). The F3.z values at the vowel onset, on the other hand, did not differ significantly from those at the vowel midpoint ($p = 0.669$). The main effect of speaker sex was also significant ($p < 0.001$). Compared with male speakers, female speakers generally had higher F3.z values. Moreover, consonant voicing had a highly significant main effect ($p < 0.001$). F3.z values in voiceless contexts tended to be considerably higher than those in voiced contexts. Consonant manner of articulation likewise showed a significant effect, with F3.z values in fricative contexts being significantly higher than those in stop contexts ($p = 0.004$).

4.3.2 Consonantal cues

4.3.2.1 Stop closure duration

A model of closure duration was selected with the following predictor structure: an interaction between the environment (emphatic, plain) and speech rate, as well as main effects of vowel quality (a, i, u), vowel length (short, long), and speaker sex (male, female). Table 4.13 below shows a summary of the closure duration regression model. The intercept is the estimated value of the emphatic closure duration in a short /a/ context.

Table 4.13: Regression model summary of the dependent variable (closure duration) in monosyllables.

Predictors	Estimate	Std. Error	CI	*t*-statistic	*p*-value
(Intercept)	53.29	9.54	34.60–71.99	5.59	**< 0.001**
Environment [Plain]	3.23	11.67	-19.65–26.11	0.28	0.782
Speech rate	0.03	0.01	0.00–0.05	2.32	**0.020**
Vowel quality [i]	-7.20	3.14	-13.35–-1.06	-2.30	**0.022**
Vowel quality [u]	-5.67	3.13	-11.80–0.46	-1.81	0.070
Sex [M]	4.89	2.18	0.61–9.16	2.24	**0.025**
Vowel length [Long]	-3.01	2.55	-8.01–2.00	-1.18	0.239
Environment [Plain] * Speech rate	-0.03	0.01	-0.06–-0.01	-2.46	**0.014**

Random Effects	
σ^2	18.60
τ_{00} Example	18.30
τ_{00} Participant no.	5.11
ICC	0.56
^{N} Example	12
^{N} Participant no.	5
Observations	180
Marginal R^2/Conditional	0.802/0.912

The interaction between environment and speech rate was significant ($p = 0.014$). As can be seen Figure 4.10 below, the distinction between emphatics and plains was greatest in relatively slower speech. Irrespective of that, closure duration seemed to be consistently greater in emphatics than plain stops.

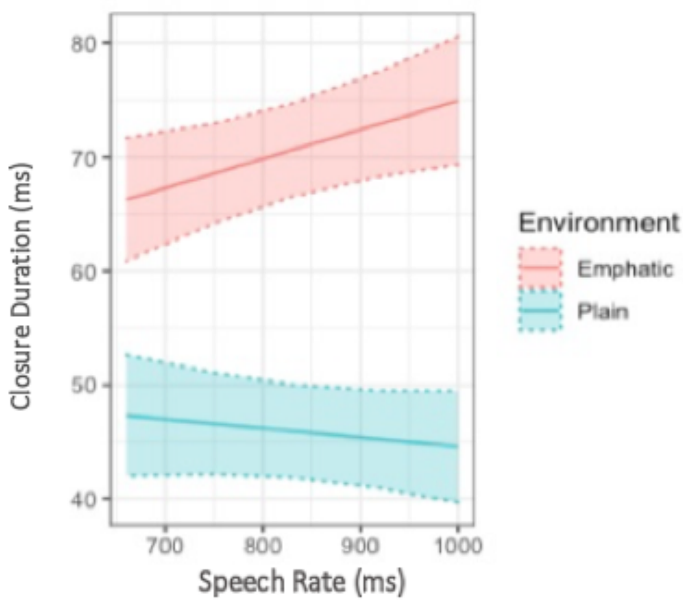


Figure 4.10: The interaction between environment and speech rate in a model predicting closure duration in monosyllables.

With regard to the main effect of vowel length, the model comparison results showed that vowel length did not affect closure duration (p = 0.146). In contrast, a significant effect of gender on closure duration was observed (p = 0.034): the mean closure duration was 4.89 ms longer for males compared to females. Furthermore, the main effect of vowel quality was also noted. Closure duration was significantly longer when preceding /a/ than /i/ or /u/ (p = 0.028).

4.3.2.2 VOT of stops

The VOT model included significant interactions between environment (emphatic, plain) and vowel length (short, long), vowel quality (a, i, u), speaker sex (male, female), and speech rate. Table 4.14 provides a regression model summary. The intercept is the estimated value of the emphatic VOT in a short /a/ context.

Table 4.14: Regression model summary of the dependent variable (VOT) in monosyllables.

Predictors	Estimate	Std. Error	CI	*t*-statistic	*p*-value
(Intercept)	0.28	10.96	-21.21–21.77	0.03	0.980
Environment [Plain]	-6.89	14.56	-35.43–21.64	-0.47	0.639
Vowel quality [i]	2.03	1.93	-1.76–5.82	1.05	0.294
Vowel quality [u]	0.88	1.90	-2.84–4.61	0.46	0.643
Vowel length [Long]	2.41	1.54	-0.60–5.42	1.57	0.116
Sex [M]	-1.75	1.19	-4.08–0.58	-1.47	0.141
Speech rate	0.02	0.01	-0.01–0.05	1.50	0.134
Environment [Plain] * Vowel quality [i]	3.75	2.72	-1.59–9.09	1.38	0.169
Environment [Plain] * Vowel quality [u]	-1.84	2.68	-7.08–3.41	-0.69	0.493
Environment [Plain] * Vowel length [Long]	13.65	2.19	9.36– 17.94	6.24	**< 0.001**
Environment [Plain] * Sex [M]	3.88	1.71	0.54–7.23	2.27	**0.023**
Environment [Plain] * Speech rate	0.04	0.02	0.01–0.07	2.28	**0.023**

Random Effects	
σ^2	27.02
τ_{00} Example	1.74
τ_{00} Participant no.	0.00
^{N} Example	12
^{N} Participant no.	5
Observations	180
Marginal R^2/Conditional	0.931/NA

This model showed four significant interactions. First, there was an interaction between environment and vowel length ($p < 0.001$). The differences in the VOT values between the plains and emphatics in long-vowel contexts were greater than the differences in short-vowel contexts (see Figure 4.11).

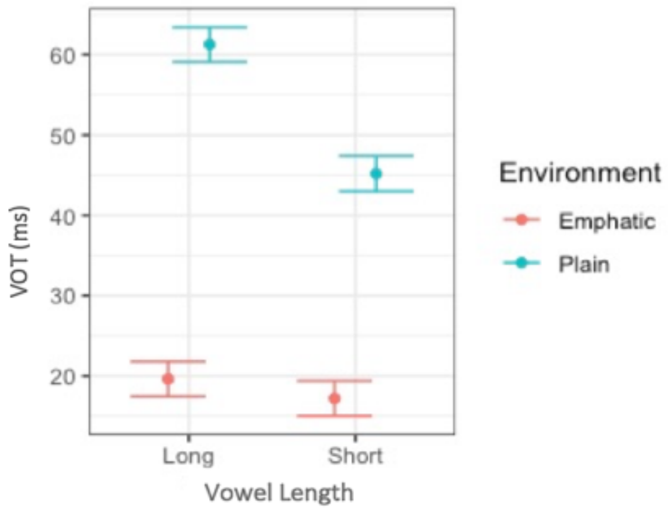


Figure 4.11: The interaction between environment and vowel length in a model that predicts VOT in monosyllables.

The second interaction was between environment and vowel quality (see Figure 4.12). In this case, including the interaction significantly improved the model fit ($p = 0.02001$). Pairwise comparisons showed that the difference between the emphatics and non-emphatics in the /u/ context was significantly smaller than the difference between the emphatics and non-emphatics in the /i/ context ($p = 0.039$). There was no significant difference when comparing /a/ and /i/.

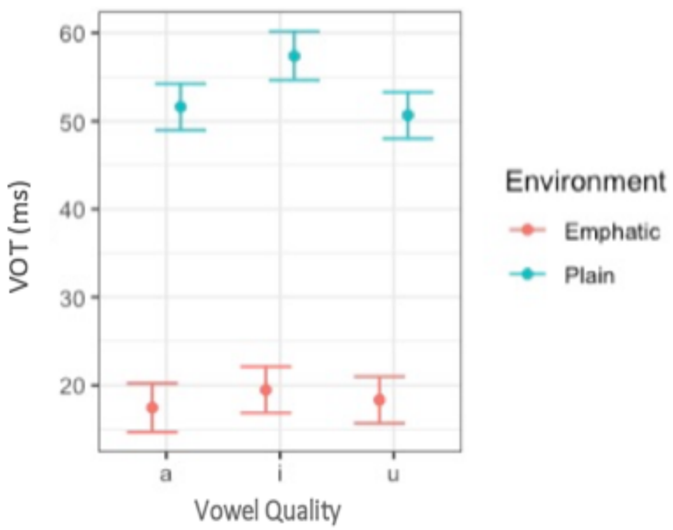


Figure 4.12: The interaction between environment and vowel quality in a model that predicts VOT in monosyllables.

The third interaction was between environment and speaker sex (p = 0.023). The results revealed that male speakers had greater differences in their VOT values between the plains and emphatics than their female counterparts (see Figure 4.13).

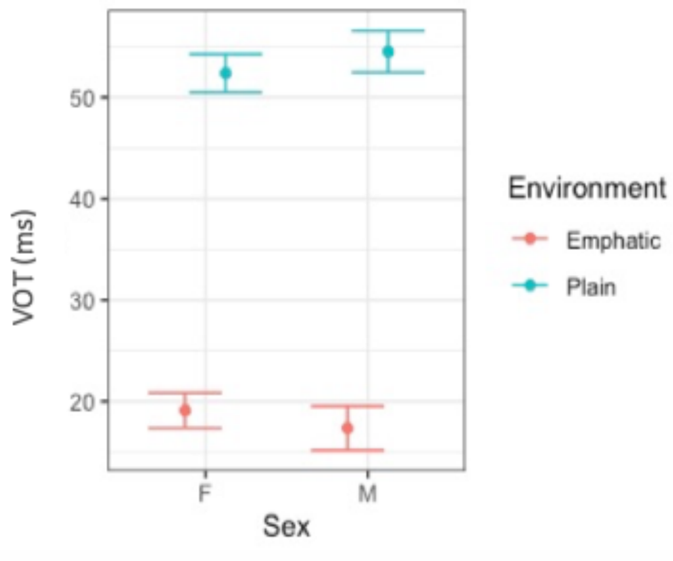


Figure 4.13: The interaction between environment and sex in a model that predicts VOT in monosyllables.

The interaction between environment and speech rate was significant (p = 0.023). Overall, the difference between emphatics and plains was greater in relatively slower speech. Nevertheless, the VOT durations were consistently greater in plain stops compared to emphatic stops. This interaction is displayed in Figure 4.14.

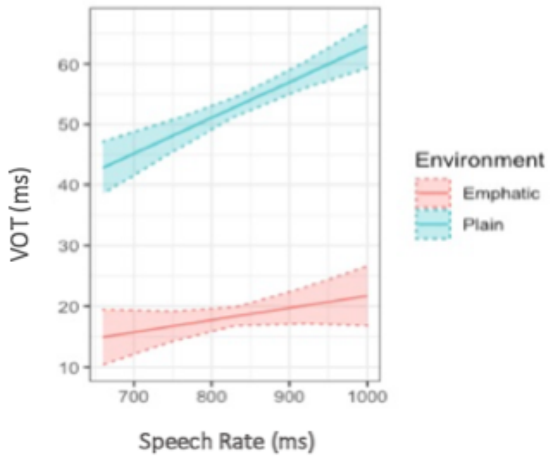


Figure 4.14: The interaction between environment and speech rate in a model that predicts VOT in monosyllables.

4.3.2.3 Friction noise duration of fricatives

The model of friction noise duration was designated based on the conditions presented in Sections 4.2.3 and 4.2.4. This model only included an interaction between environment (emphatic, plain) and speaker sex (male, female), as well as the main effects of speech rate, vowel quality (a, i, u), vowel length (short, long), and consonant voicing (voiced, voiceless). The intercept in this model was the estimated value of the emphatic voiced friction noise duration in a short /a/ context.

Table 4.15: Regression model summary of the dependent variable (friction noise duration) in monosyllables.

Predictors	Estimate	Std. Error	CI	*t*-statistic	*p*-value
(Intercept)	22.69	9.69	3.70–41.68	2.34	**0.019**
Environment [Plain]	7.99	3.83	0.48–15.50	2.09	**0.037**
Sex [M]	14.95	1.91	11.20–18.71	7.81	**< 0.001**
Speech Rate	0.01	0.01	-0.01–0.03	0.75	0.453
Vowel quality [i]	7.28	4.64	-1.80–16.37	1.57	0.116
Vowel quality [u]	4.80	4.66	-4.34–13.93	1.03	0.303
Vowel length [Long]	4.54	3.79	-2.88–11.96	1.20	0.230
Consonant voice [Voiceless]	55.71	3.81	48.24–63.17	14.62	**< 0.001**

Environment [Plain] * Sex [M]	5.46	1.52	2.48–8.45	3.59	**< 0.001**

Random Effects	
σ^2	49.16
τ_{00} Example	82.67
τ_{00} Participant no.	2.83
ICC	0.63
^{N} Example	24
^{N} Participant no.	5
Observations	360
Marginal R^2/Conditional	0.868/0.952

The data showed that the interaction between environment and speaker sex was significant ($p < 0.001$). The difference between emphatic and plain contexts was consistently higher for male speakers compared to female speakers (see Figure 4.15).

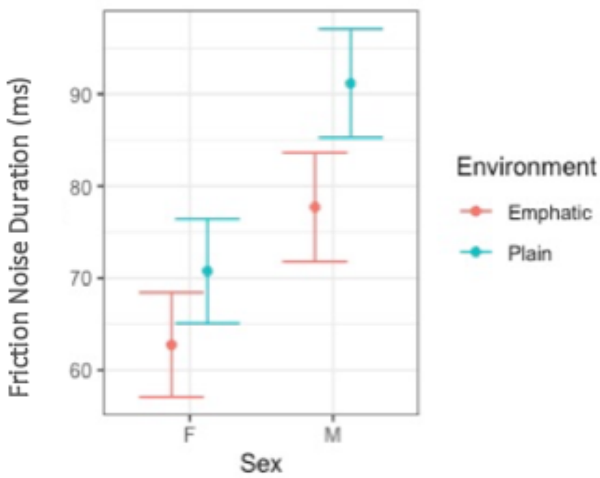


Figure 4.15: The interaction between environment and sex in a model that predicts friction noise duration in monosyllables.

Vowel quality had no influence on friction noise duration when comparing the high vowels /i/ and /u/ to the low vowel /a/ ($p = 0.116$ and $p = 0.303$, respectively). The results of the model comparisons suggested that neither vowel length ($p = 0.175$) nor speech rate had a significant effect on friction noise durations ($p = 0.413$). In contrast, the results demonstrated a highly significant main effect of voicing ($p < 0.001$). The friction noise duration tended to be significantly longer in the presence of voicelessness fricatives compared to the friction noise duration of voiced fricatives.

4.4 Summary

This chapter established and explored the phonetic correlates of emphasis in NA. The characteristics of emphasis in the NA dialect were described, and a comprehensive set of potential acoustic correlates provided, among which F2 stands out as the most robust indicator of emphasis spread.

The present results regarding emphasis in NA underscore the importance of various acoustic parameters, such as the duration of vowels, the first three formant frequencies of the attested vowels, closure duration, VOT, friction noise duration, and whether any could be major signals exhibiting the greatest distinction between emphatic and plain contexts. Table 4.16 summarises the findings related to vocalic and consonantal cues.

Table 4.16: A summary of the emphatic/plain distinction effects on different variables in monosyllabic words.

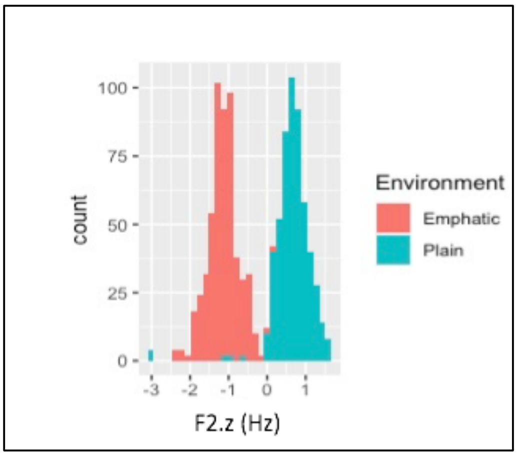
Dependent Variable	Main Effect
Vowel duration	n.s.
F1	↑ for /a, u/ and ↑* for /i/
F2	↓*
F3	↑
Stop closure duration	↑*
VOT of voiceless stops	↓*
Friction noise duration	n.s.

↑* indicates a significant rise in values in emphatic contexts.
↓* indicates a significant lowering effect in emphatic contexts.
n.s. = not significantly effective.

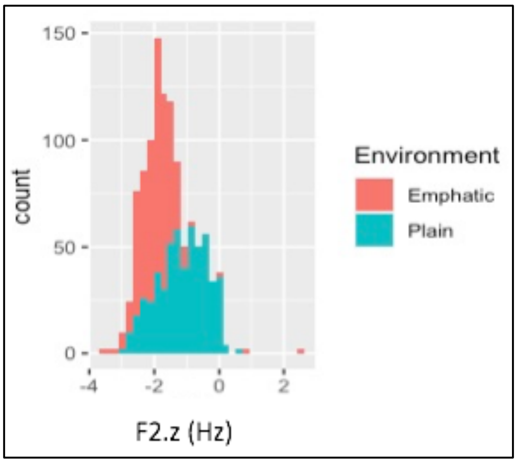
The general impression is that any change in the magnitude of the effect of emphasis on these acoustic parameters may depend on the vocalic context (vowel quality or length), consonant manner, consonant voicing, speaker sex, and speech rate—if applicable.

In conclusion, the results described in this chapter suggest that the effect of emphasis is most obvious in the vowel F2. That is, the vowel adjacent to an emphatic consonant is always associated with a considerable lowering of F2. This suggests that the F2 of the adjacent vowel is a clear and reliable acoustic cue of emphasis. It is important to note that even though there was an interaction between emphasis and the vowel measurement time points (onset, midpoint, and offset), which indicated the differences in F2 lowering degree among these time points, the F2 lowering effect was still robust and categorical throughout the whole duration of the vowel.

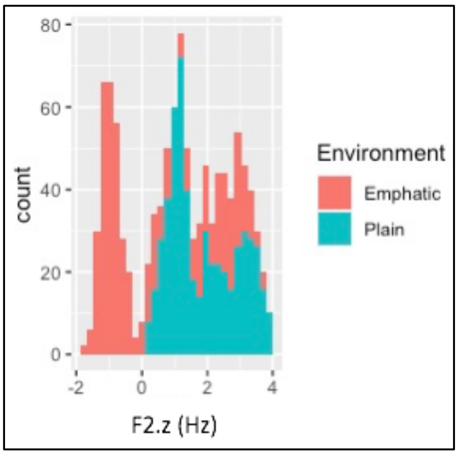
The distinction between the emphatic consonant features and vowel features, which are the features of spread, will require an analysis of vocalic cues since subsequent chapters deal specifically with emphasis spread. Of these, F2 is the most robust because F1 shows a small time-limited effect, and F3 varies depending on gender. However, based on the F2 results, there is clearly a vowel interaction, as the histograms shown in Figure 4.13 show a substantial overlap in F2 values for emphatics and plains when the vowel is /i/ or /u/. In comparison, there is only a categorical effect on F2 for /a/, which is acceptable because the following chapters focus mainly on /a/.



(a)



(b)



(c)

Figure 4.16: The distribution of the F2 of the (a) low vowel /a/, (b) high back vowel /u/, and (c) high front vowel /i/ in emphatic and plain environments.

CHAPTER 5: IDENTIFYING EMPHASIS SPREAD

5.1 Overview

Thus far, I have considered questions related to phonetics, namely, the phonetic correlates of emphasis in a controlled case of monosyllables (see Chapter 4). In this chapter and those that follow, the focus is on questions concerning the phonological aspects of emphasis spread in NA. The broad aims of this chapter and those that follow are as follows: (i) to establish criteria for identifying whether emphasis spread takes place, (ii) to investigate the directionality of emphasis spread within monomorphemic words and its interaction with opaque segments, and (iii) to investigate emphasis spread and its maximal domain across morpheme boundaries.

This chapter's core focus is to establish the criteria for identifying the emphatic feature's phonological status within and beyond the syllable. Based on many of the Arabic emphasis systems discussed so far (see Chapter 2), precisely determining the nature of emphasis spread in NA is necessary, as variation exists in the way emphasis spread occurs in different Arabic dialects. In fact, the contextual effect of emphasis can be either a coarticulatory or phonological effect. In the same vein, some Arabic dialects show that emphasis is gradient in nature, as F2 values are not equally low when comparing the vowel adjacent to the emphatic segment to those occurring further away (Al-Masri and Jongman, 2004; Al-Masri, 2009; Embarki et al., 2011; Jongman et al., 2011). Conversely, other dialects display categorical emphasis spread in which F2 values are equally decreased, whether the vowel is tautosyllabic with the emphatic trigger or distant from the emphatic segment (Herzallah, 1990; Younes, 1994; Shahin, 1997; Zawaydeh, 1999; Maiteq, 2013). A preliminary evaluation of my study results shows that emphasis in NA involves a mixture of categorical and gradient emphasis spreads. Therefore, classifying all potential instances of emphasis spread is crucial if generalisations are to be made about what emphasis spread types occur and under which conditions.

Because of the presence of surrounding segments, continuous speech displays a high degree of articulatory and acoustic sound variability. Such segmental variability, also known as coarticulation or assimilation, as well as the effects of phonological and physiological constraints on these segments, has been of long-standing concern in coarticulation models (Clements, 1987; Cohn, 1990; Keating, 1990). These effects are defined as either phonetic or phonological by comparing the effect's degree and temporal extent on the target segment to the trigger's effect. Some studies have assumed that there is a binary distinction between the two assimilatory systems (Clements, 1985; Keating, 1990). The first is the gradient coarticulatory effect, which appears to indicate the phonetic nature of the assimilatory process (Embarki et al., 2011; Jongman et al., 2011). In the second, the categorical effect represents the abstract phonological nature of the process, which is fulfilled by feature spreading (Herzallah, 1990; Younes, 1994; Davis, 1995).

Many researchers consider emphasis to be a type of feature spreading, which is why it has been referred to as emphasis spreading (Herzallah, 1990; McCarthy, 1991, 1994; Younes, 1993; Davis, 1995; Watson, 1999; Zawaydeh, 1999; Al-Katib, 2008; Zawaydeh and de Jong, 2011; Algryani, 2014). Despite this view reflecting the phonological nature of emphasis, an articulatory examination of emphasis spread was also conducted by Alwabari (2020) to determine whether emphasis was induced by featural spread or gestural coarticulation. She examined whether phonological variables, such as phoneme contrast, bound the contextual influence exerted by emphatic consonants. That is, comparing plain consonants (i.e. non-emphatics such as /t/ and /s/ and other consonants such as /l/ and /n/) reveals similar assimilatory effects in an emphatic's vicinity. Therefore, Alwabari obtained ultrasound and audio data from eastern peninsular Arabic speakers and manually traced the tongue contours of both the target and trigger segments at different times. This study found that the emphasis effect's realisation as either phonetic or phonological varies according to the presence of phonological or physiological constraints. Emphasis can be defined as a categorical process in two cases: first, when there is a phonemic contrast, such as in the plain consonants /t/ and /s/ that shift to become articulatorily indistinct from their emphatic counterparts /ṭ/ and /ṣ/; and second, when gestural antagonism exists between the emphatic triggers and target consonants, such as /ʃ, j/, which are associated with a gestural conflict resulting from tongue root advancement during their articulation. In contrast, emphasis can be realised as a gradient when both previous constraints are absent (i.e. in unconstrained contexts such as /b, f, l/; Alwabari, 2020).

Considering this distinction among these processes, the following question remains: Should the contextual influence provoked by emphatics in this study be described as coarticulation from the coproduction of gestures or assimilatory feature spreading? Such a classification could also justify differences in the minimal and maximal domains of emphasis spread in NA and other Arabic dialects.

To distinguish between categorical and gradient emphasis, I follow a model in which the phonological component deals with categorical and abstract features and the phonological processes are feature-changing, from which categorical phonetic effects follow (Keating, 1988; 1990b; Cohn, 1993; Zsiga, 1997; Myers, 2000; Ramsammy, 2015). In contrast, phonetic processes are not category-changing but result in gradient changes commonly attributed to coarticulatory effects. This type of phonology–phonetics distinction is also consistent with modular theories of speech production (Levelt, 1989; Norris, 1994).

In my emphasis data on NA, major differences in magnitude can be observed when comparing the normalised F2 values of vowels in emphatic and non-emphatic contexts. Acoustically, emphasis was constantly manifested by lowering the F2 of vowels within emphatic contexts when compared to those in plain contexts. Therefore, lowering F2 is thought to be the most important acoustic cue to the emphatic/plain contrast (Zawaydeh, 1999; Al-Masri and Jongman, 2004; Khattab et al., 2006; Jongman et al., 2011; Zeroual et al., 2011). My results show that while some target vowels display considerable and stable F2 lowering, others show only limited and time-varied F2 lowering. Furthermore, some vowels show no change in F2 at all. This variation suggests a three-way system in which emphasis spread is categorical, gradient or not at all. This chapter presents the criteria for identifying which type of emphasis spread occurred, mainly informed by the distribution of F2 values in the target vowel. The target vowel is defined as one not directly adjacent to an emphatic consonant. The examples presented in this chapter are from disyllabic monomorphemic words. Minimal pairs were constructed, differing only in the presence or absence of trigger consonant emphasis. Since minimal pairs were used, all potential factors affecting F2 values were strictly controlled, allowing generalisations to be made about emphasis through pairwise comparisons of F2 values.

5.2 Classification of Emphasis Spread in NA

Vowels in the vicinity of emphatic consonants had lower F2 values than those in plain contexts. However, the amount and extent of F2 lowering in those vowels may vary. Based on this variation, NA shows different classifications of emphasis spread. Prior descriptions of emphasis spread in Arabic literature indicate that the surrounding vowels can be categorically influenced by the trigger emphatic consonant (e.g., Herzallah, 1990; Zawaydeh, 1999; Maiteq, 2013). This type of spread can also be observed in the present study. Emphasis spread can be identified via consistently lower F2 frequency values throughout the vowel. This constant reduction in F2 frequency in vowels in emphatic environments, compared to higher frequencies for corresponding vowels in plain environments is evidence of a categorical spread of emphasis in the attested example. This type of emphasis spread differs to gradient emphasis spread, in which emphasis spread change over time, that is, the emphatic feature spreads in a cline-like manner.

Figures 5.1a and 5.1b illustrate a case of categorical emphasis spread in the disyllabic pair /ṭamas/ versus /tamas/. To classify an example as a categorical emphasis spread, I examined the boxplot, which shows all speakers' repetitions for each minimal pair. The boxplot shown in Figure 5.1b represents the overall F2 distribution in the vowels, V1 and V2, at their onset, midpoint and offset. These three time points were defined at 10%, 50% and 90% of the vowel duration, respectively. This type of emphasis realisation is stable across speakers and repetitions, such that the normalised F2 values have non-overlapping distributions throughout vowels when comparing emphatic and non-emphatic contexts. The F2 differences in these two categories of cases are large, and the vowels' F2 values included in the attested words do not change throughout the vowels. This type of emphasis spread presents with a steady state of lowered F2 frequencies throughout the vowel's duration in emphatic contexts, as compared to plain contexts. These formant differences in the vowels are clearly visible in the spectrogram presented in Figure 5.1a.

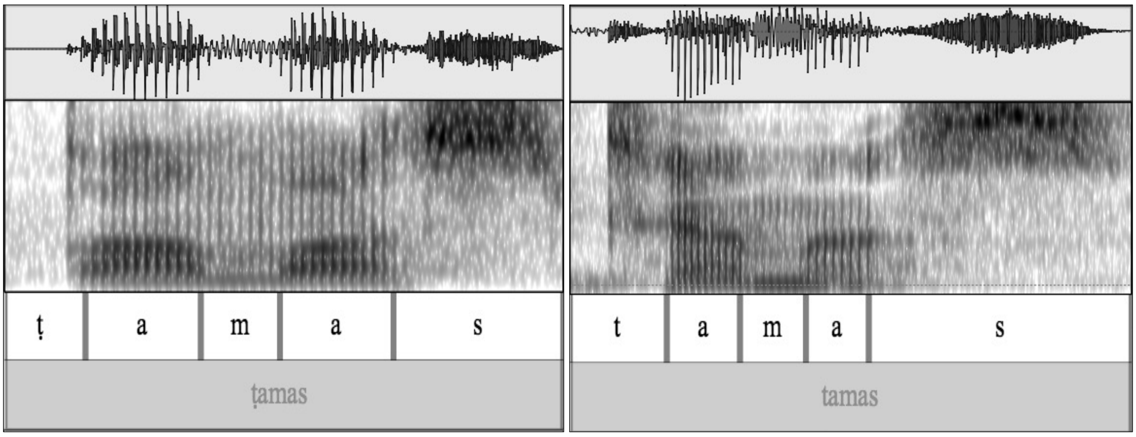


Figure 5.1a: A waveform and a spectrogram of an example realisation for the pair /ṭamas/ vs. /tamas/ by speaker [5], showing categorical emphasis spread in V1 and V2 in /ṭamas/.

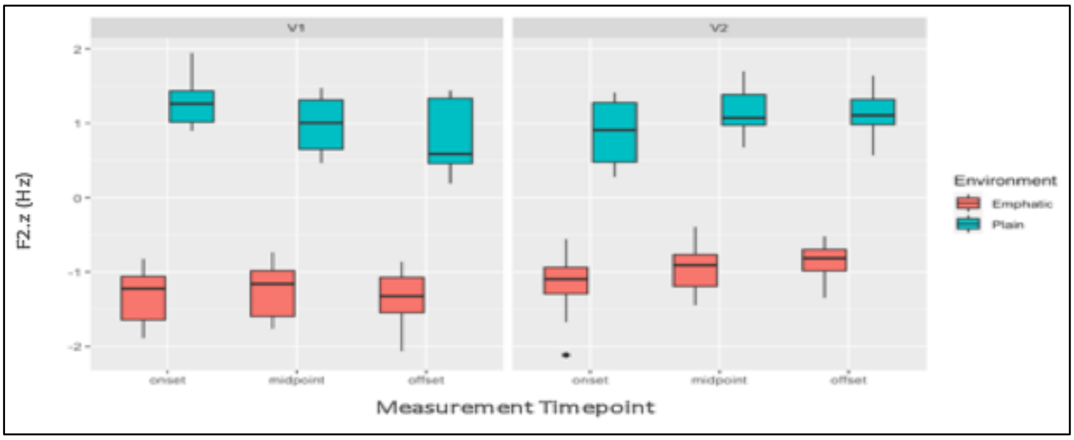


Figure 5. 1b: Boxplot of the distribution of the F2 values in /ṭamas/ and /tamas/, depending on the presence of emphasis, vowel adjacency and vowel measurement time point.

The example above shows categorical emphasis spread in NA. All the data, which consisted of minimal pairs, were analysed using the same procedure. The emphasis in 80 of the examples could be clearly classified as one of the three aforementioned types.

In some cases, emphasis spread was blocked. When a blocker was present, the vowels were not significantly influenced by emphasis. That is, the F2 values of vowels in emphatic environments were not very different to those of vowels in plain environments. In such cases, emphasis does not extend beyond the blocker and consequently does not lower the F2 values of these vowels. This type of case is shown in Figures 5.2a and 5.2b, which present the data for the pair /naʃaːṭ/ and /naʃaːt/. In the spectrogram shown in Figure 5.2a, F2 lowering is clearly visible in the second vowel, which is directly adjacent to the emphatic consonant. However, there are no immediately visible differences in the F2 values of the vowel in the first syllable in emphatic and plain contexts. This finding is confirmed by a more systematic comparison of the overall F2 distribution for V1 and V2 in this stimuli pair comparing in emphatic and plain contexts, which is shown in Figure 5.2b. For V2, the F2 values have non-overlapping distributions; however, they overlap substantially for V1. This suggests that the local vowel (i.e. vowel within the same syllable as the emphatic trigger) is emphasised but the vowel in the neighbouring syllable is not.

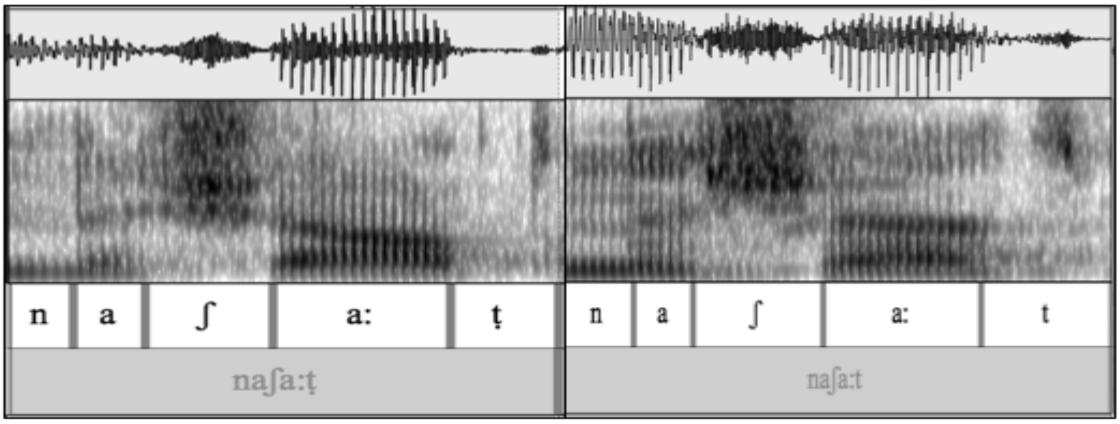


Figure 5.2a: A waveform and a spectrogram of an example realisation for the pair /naʃaːṭ/ vs. /naʃaːt/ by speaker [5], showing the absence of emphasis spread in V1 in /naʃaːṭ/.

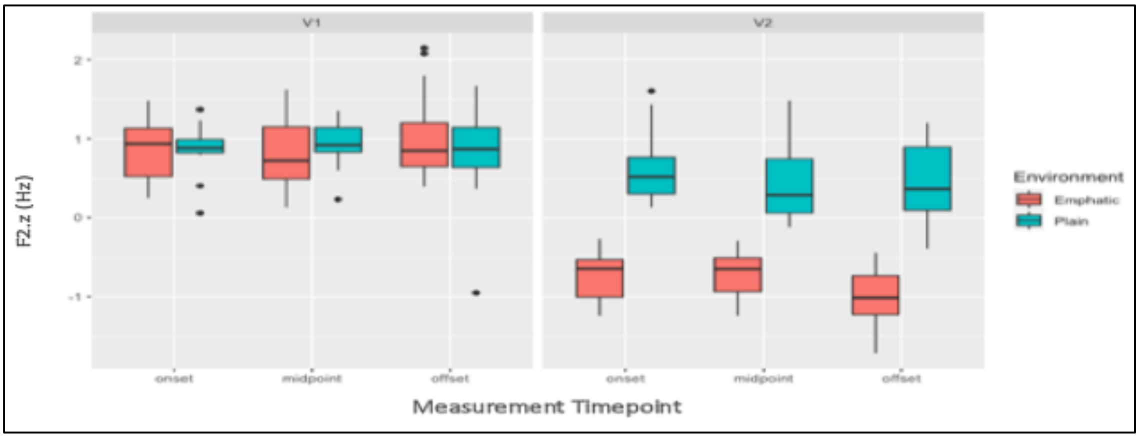


Figure 5. 2b: Boxplot of the distribution of the F2 values in /naʃaːṭ/ and /naʃaːt/, depending on the presence of emphasis, vowel adjacency and vowel measurement time point.

Finally, a third type of emphasis spread was identified in NA: some emphasis spread, in the form of lowered F2 values, was observed to move from the trigger consonant to the vowel in neighbouring syllable. However, the magnitude of lowering gradually decreases as the vowel's distance from the trigger increased. In other words, in this type of emphasis spread, the degree of emphasis is not consistent across for all the vowels in a given word; the closer the vowel is to the emphatic segment, the more pronounced the drop in F2. In this type of emphasis spread, the vowel that is non-adjacent to the emphatic does not appear to be fully emphasised. In other words, the emphatic feature spreads gradually and covers one edge of the vowel to the vowel midpoint. For these vowel segments, F2 values differ significantly in emphatic and plain contexts. At the other edge of the vowel, however, the difference in F2 is not significant, indicating that the vowel is not emphasised at this point. This can be categorised as a spread of gradient emphasis, which is qualitatively different from the previously discussed types of categorical spread.

An illustration of such a gradient emphasis spread is the pair /jabṭir/ versus /jabtir/, which are shown in Figures 5.3a and 5.3b. The onset of the vowel following the palatal /j/ (V1) has an overlapping distribution of F2 values. However, the other edge—that is, the offset—has a non-overlapping distribution. In this case, the gradient spread of emphasis is indicated by the low F2 frequencies in the portions of the vowel that are farther from the palatal /j/, the midpoint and the offset. F2 frequencies increase in the onset of the vowel, which is adjacent to the palatal. In this scenario, emphasis is gradient in the non-adjacent vowel and exerts significant coarticulatory influence, which appears phonetically but not in phonological grammar.

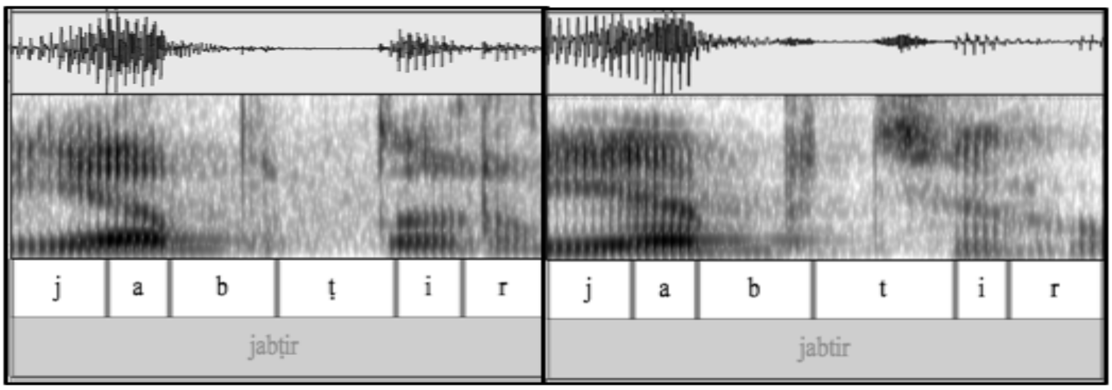


Figure 5.3a: A waveform and a spectrogram of an example realisation for the pair /jabṭir/ vs. /jabtir/ by speaker [5], showing gradient emphasis spread in V1 in /jabṭir/.

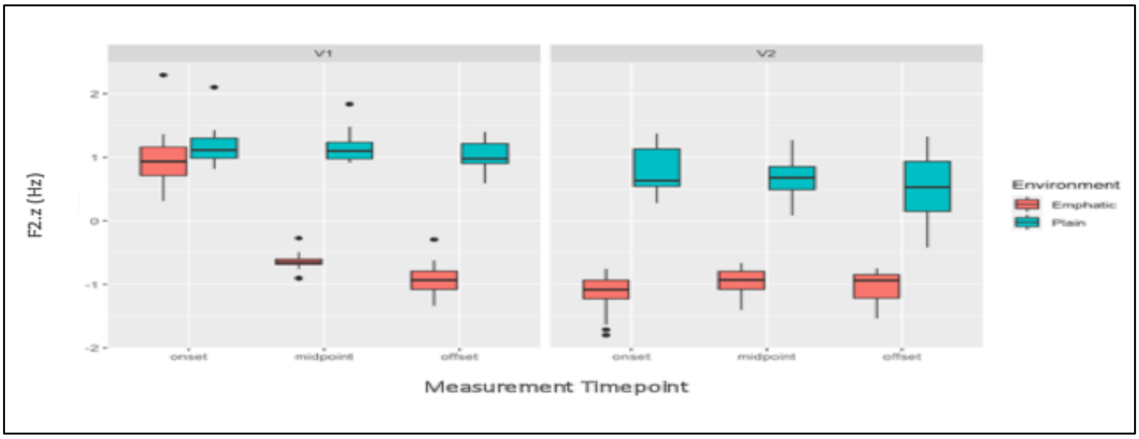


Figure 5. 3b: Boxplot of the distribution of the F2 values in /jabṭir/and /jabtir/, depending on the presence of emphasis, vowel adjacency and vowel measurement time point.

Emphasis spread sometimes differs to the types of spread discussed previously. The NA emphasis spread system presents with varied realisations, as does the categorical classification, in which some cases differ only in the degree of emphasis between onset and offset, as shown in the degrees of F2 lowering (see Figures 5.4a and 5.4b). That is, the difference in the magnitude of the F2 values is considerably larger at one edge of the vowel than at the other. In the example below, the F2 frequencies increase slightly over the course of the emphatic vowel adjacent to the voiceless pharyngeal /ħ/. Yet even though the degree of F2 lowering differs in the vowel adjacent to the emphatic consonant and in the one adjacent to the pharyngeal, it is clear that there is still a non-overlapping distribution; the degree of F2 lowering in emphatic contexts is significantly larger than that in plain contexts. Therefore, this pattern can still be considered categorical.

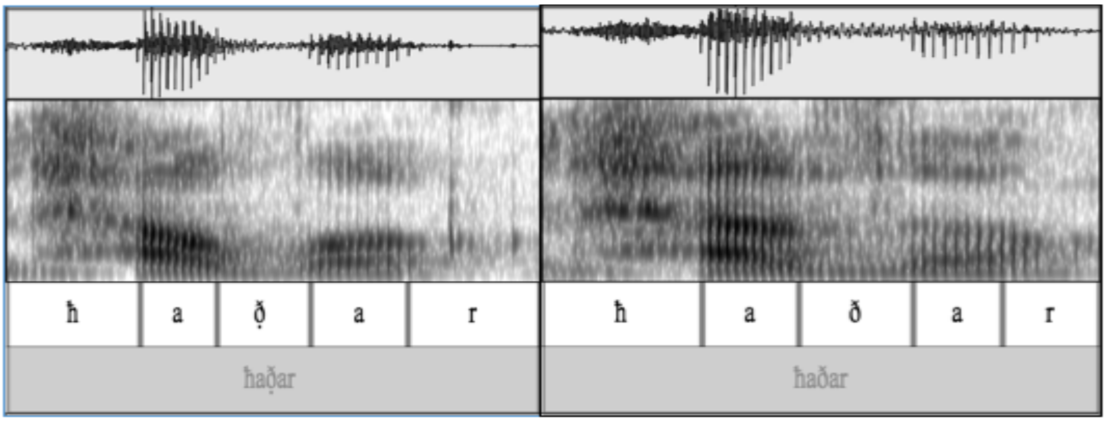


Figure 5. 4a: A waveform and a spectrogram of an example realisation for the pair /ħað̣ar/ vs. /ħaðar/ by speaker [5], showing a different degree of categorical emphasis spread in V1 in /ħað̣ar/.

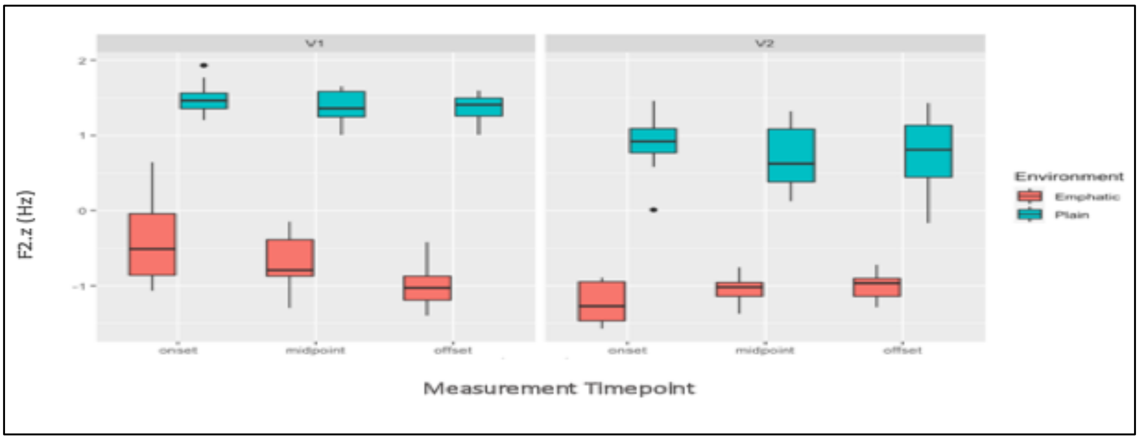


Figure 5. 4b: Boxplot of the distribution of the F2 values in /ħað̣ar/ and /ħaðar/, depending on the presence of emphasis, vowel adjacency and vowel measurement time point.

Another variant case is illustrated in Figures 5.5a and 5.5b, where F2 moves in both plain and emphatic contexts. In this example, the F2 frequencies in both emphatic and plain environments gradually rise as the vowel approaches the velar consonant. Therefore, there is no F2 overlap on one single vowel edge where the difference in of F2 magnitude between emphatic and plain contexts is significant; the F2 values marginally overlaps on the other edge. This pattern, shown in Figures 5.5a and 5.5b below, is restricted to specific cases; one of these is a velar/uvular stop segment (see Chapter 8).

This pattern is unlike the gradient pattern in Figures 5.3a and 5.3b above, where the rise in F2 frequencies can be detected in the emphatic vowels but not in the plain vowels. Moreover, the differences in F2 frequencies in emphatic and plain environments are greater in the gradient example above (in /jabṭir/and /jabtir/) than in the one below (/ʔalgaḍ̞a:/ vs. /ʔalgaða:/).

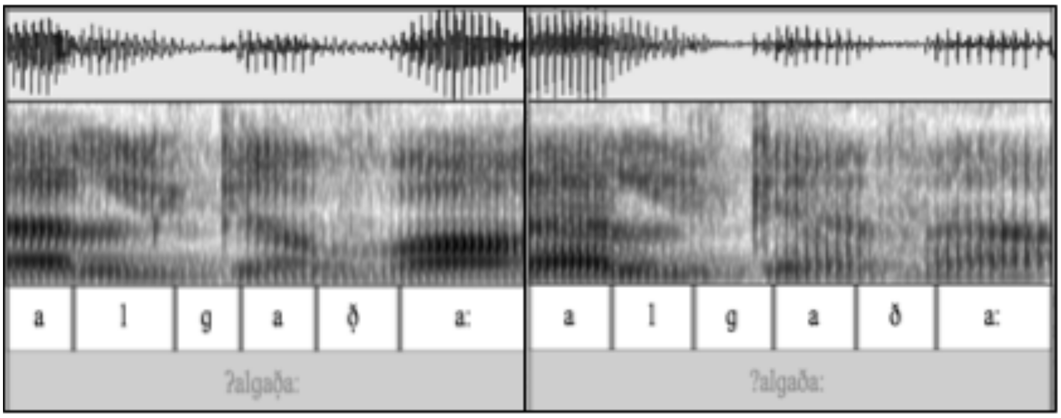


Figure 5.5a: A waveform and a spectrograph of an example realisation for the pair /ʔalgað̞a:/ vs. /ʔalgaða:/by speaker [5], showing a different degree of gradient emphasis spread in V2 in /ʔalgað̞a:/.

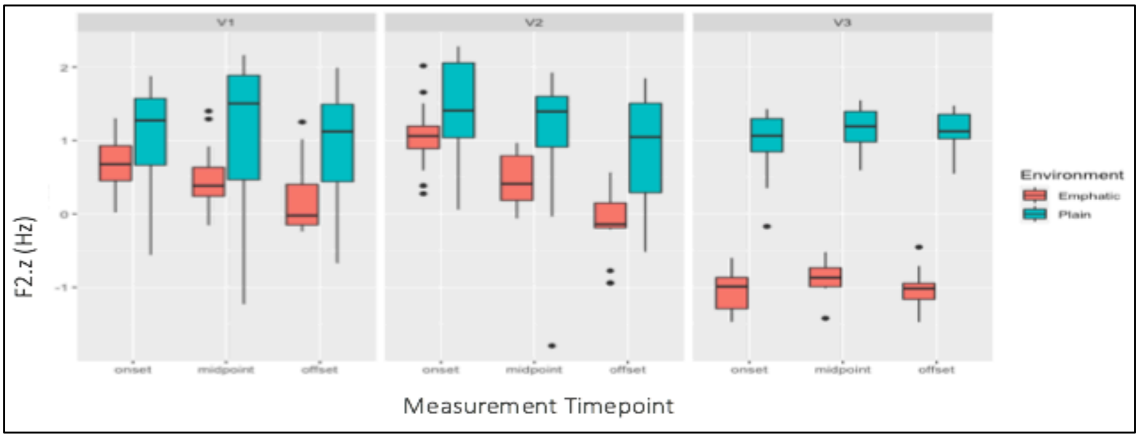


Figure 5. 5b: Boxplot of the distribution of the F2 values in /ʔalgað̞a:/ and /ʔalgaða:/, depending on the presence of emphasis, vowel adjacency and vowel measurement time point.

5.3 Summary

Table 5.1 provides a summary of the classification system and criteria used to diagnose the type of emphatic feature spread. Based on these categories, one could argue that the full picture of the emphasis spread system in NA is more complex than previously thought.

Table 5.1: Summary of the criteria used for identifying emphasis spread in NA.

Emphasis spread type	**Classification criteria**
Categorical spread of emphasis	Non-overlapping F2 values comparing vowels in emphatic and non-emphatic contexts were found across all measurement points. The lowering of vowels' F2 in emphatic contexts was clearly visible in the spectrogram when compared to those in plain contexts.
No spread of emphasis	Substantial overlap in F2 values was found in all vowel measurement timepoints. No visible difference was found in the vowels' F2 values in the spectrogram when the emphatic and non-emphatic contexts were compared.
Gradient spread of emphasis	Overlapping distribution of F2 values was found on one vowel edge, whereas the other edge had a non-overlapping distribution. In the spectrogram, F2 lowering was observed in the emphatic context, but the degree of lowering decreased as the distance from the trigger increased.

CHAPTER 6: DOMAIN AND DIRECTIONALITY OF EMPHASIS SPREAD

6.1 Overview

This chapter uses the classification system that was introduced in Chapter 5 to describe the conditions in which emphasis spread occurs and when it is blocked. The three aspects of emphasis spread that are investigated here include emphasis domain, its directionality and the interaction of the emphasis spread with the morphological structure. Thus, three wordlists were constructed: one to examine the emphasis domain and explore the directionality preferences of emphasis spread and the other two were designed to gain a comprehensive account of emphasis spread across morpheme boundaries. To this end, the two lists consist of minimal pairs of multisyllabic words that were segmentally restricted. That is, the examples used here to investigate the domain include no segmental interference as this is how the specific contribution of both direction and morpheme boundaries was found. Therefore, to prevent any effect of intervening segments, such as the coarticulatory resistance effect and to isolate the effect of directionality from the effect of blockers, the quality of the vowel was limited to the low vowel /a/ to avoid the high vowels /i/ and /u/, which are considered blocking segments to emphasise spread in many Arabic dialects. Moreover, any consonant that was reported in the prior literature as being capable of blocking emphasis spread was also avoided in these lists. Based on this, any example in the prefixes and suffixes list, including any intervening segment, will be discussed after examining the blockers' behaviour in Chapter 7. In chapter four, the main focus was to investigate emphasis spread and its effect on various acoustic correlates of the trigger consonants or the following vowels depending on various variables such as speaker's sex, vowel quality, vowel length and consonant voicing.

Therefore, the chapter's analysis includes the results of the mixed-effects linear regression. However, this chapter and the ones that follow focus on the presence/absence of emphasis to define the emphasis domain and its directionality. This phonological analysis relied on the categorisation of each word token based on the F2 patterns to differentiate between emphatic and plain contexts. The mixed-effects linear regression was not included in these chapters because I examined each example independently and used the quantitative data to establish a basis for categorisation. I then categorised each token according to the patterns. Finally, I provided a phonological description relying on what this analysis shows about the surface phonological representations of my examples.

In what follows, I investigate emphasis, analyse the extent to which the emphatic feature prevails over the syllables of the word in NA and examine whether the segments to the left or right of the emphatic segment are more vulnerable to emphasis spread. The rationale behind this examination is that the extension of the emphasis domain differs widely across Arabic dialects. That is, emphasis can be confined to the syllable, including just the underlying emphatic segment (Broselow, 1976; Jaber, 2001; Jongman et al., 2011), or it can occur over many syllables within the phonological word (Ali and Daniloff, 1972; Davis, 1995; Watson, 1999; Zawaydeh, 1999; Watson, 2002; Al-Khatib, 2008; Youssef, 2013; Al-Huneety, 2015). Watson (2002) argues that emphasis operates bidirectionally within the phonological word. Therefore, predicting the exact extent to which the emphasis in NA may spread and affect neighbouring segments based on the diverse results in the literature is difficult. However, in most Arabic dialects, the domain of emphasis can extend over several syllables and influence the phonological word, so I expect the emphasis in NA to spread over the word as well.

Another asymmetry I address is manifested at the morphological level; there appears to be a universal preference for vowel harmony spreading into suffixes over prefixes (Hyman, 2005). Thus, it is interesting to examine whether the emphasis harmony spreading would show a similar preference. Here, the concern lies mainly with the identification of whether the morpheme boundary allows or blocks emphasis spread in NA. The current study presents some generalisations about the effect of morpheme boundaries on emphasis spread and identifies potential asymmetries. Several studies have also shown that emphasis in Arabic dialects spreads differently over words into attached affixes (Davis, 1991; Watson, 2002; Algryani, 2014; Youssef, 2014; Al-Huneety, 2015). Youssef (2014) points out that morpheme boundaries do not block emphasis spread; thus, the emphasis affects both prefixes and suffixes. In contrast, Watson (2002) demonstrates that in San‘ani Arabic, emphasis fails to spread into affixes, even if these affixes are tautosyllabic with an emphatic trigger. Al-Huneety (2015), however, reports that emphasis only spreads into suffixes that are within the syllable, including the emphatic segment. Davis (1991) notes more restrictions on emphasis spread into suffixes, arguing that emphasis obligatorily spreads into vowel-initial suffixes attached to words ending with an emphatic segment; otherwise, emphasis spread into suffixes is optional. In light of the dialectal variation among these studies, my data analysis also includes the domain of emphasis spread across morpheme boundaries, but no certain predictions can be made about the effect of morpheme boundaries on emphasis extension.

6.2 Phonological Analysis of Emphasis Spread in NA

Before reporting the results of emphasis spread extension and its directionality in multisyllabic words, it is important to provide a brief overview of the representation of emphatic consonants and an autosegmental phonological description of the iterative spread of the emphatic feature over a word in NA. Here, I am demonstrating the autosegmental representations to illustrate the pattern of emphasis spread. However, in this study, I do not use this autosegmental theory as a formal theoretical analysis of the phonology.

Like other Arabic dialects, NA has a group of coronal consonants known as emphatics (Abboud 1979; Ingham, 1994; Alqahtani, 2014). NA includes three pairs of emphatics, /ṣ, ṭ, ð̣/, and non-emphatic counterparts, /s, t, ð/. Along with their primary articulation, emphatics have a secondary articulation (Davis, 1993). The autosegmental representation of emphasis spread in Arabic and its varieties suggests that the emphatic consonant spreads its emphatic feature to neighbouring segments (McCarthy, 1994). This means that neighbouring segments are not inherently associated with the emphatic feature until they are within the vicinity of an emphatic consonant. To represent emphatic consonants in Arabic, phonologists have proposed a variety of features that distinguish emphatics from their plain counterparts. For instance, Elgadi (1986) suggested that emphatic consonants are associated with the feature [+emphatic] and that this feature spreads into adjacent segments. Chomsky and Halle (1968) referred to the emphatic feature as [-high, +low, +back], since they considered emphatic consonants as pharyngealised. McCarthy (1994) associated emphatic consonants with the feature [Pharyngeal]. On the other hand, Brame (1970) classified emphatics as velarised segments associated with the feature [-high, -low, +back], and Broselow (1979) distinguished emphatic sounds from plain ones by using the feature [+constricted pharynx]. Similar to other dialects of Arabic, NA shows that these emphatic dental and alveolars, /ṭ, ṣ, ð̣/ are produced with a primary [coronal], which is accompanied by a pharyngeal constriction. Phonologically, these consonants are distinguished from their plain counterparts /t, s, ð/ by a non-primary constricted pharynx feature [+CP] (Alhoody, 2019). Table 6.1 below lists the representation of these consonants in NA.

Table 6. 1: Representation of the emphatic consonants and their plain counterparts in NA.

NA Consonant	IPA symbol	Sonorant	Labial	Coronal	Anterior	Strident	Continuant	Constricted Pharynx	Voiced
ت	t	-	-	+	+	-	-	-	-
ط	ṭ	-	-	+	+	-	-	+	-
س	s	-	-	+	+	+	+	-	-
ص	ṣ	-	-	+	+	+	+	+	-
ذ	ð	-	-	+	+	-	+	-	+
ظ	ð̣	-	-	+	+	-	+	+	+

All prior features were used to represent the secondary articulation of emphasis. To emphasise the secondary articulation of sounds alongside their primary articulation, McCarthy (1994) split the root node into two parts when presenting consonants with secondary articulation. That is, the root node includes one part representing the primary place of articulation and a second representing the secondary articulation. McCarthy suggested that the production of guttural sounds, including emphatics, involves a [dorsal] articulator with a [pharyngeal] constriction. Rose (1996) proposed a representation similar to McCarthy's for guttural sounds, wherein the the [RTR] feature was added to differentiate laryngeal sounds from non-laryngeals. Rose used the [RTR] feature to identify all non-laryngeal sounds produced by a retraction of the tongue root or a constriction of the pharynx, including uvulars, pharyngeals and emphatics. Figure 6.1 and Figure 6.2 illustrate McCarthy's and Rose's representations of gutturals, respectively.

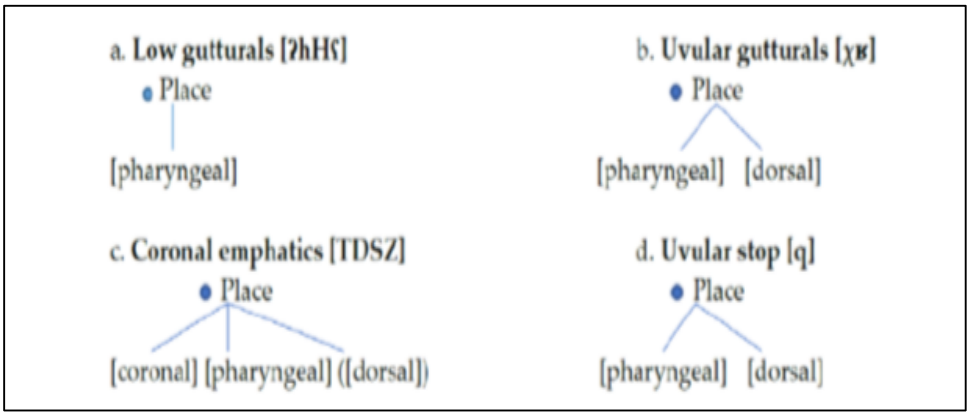


Figure 6. 1: McCarthy's representation of guttural sounds.

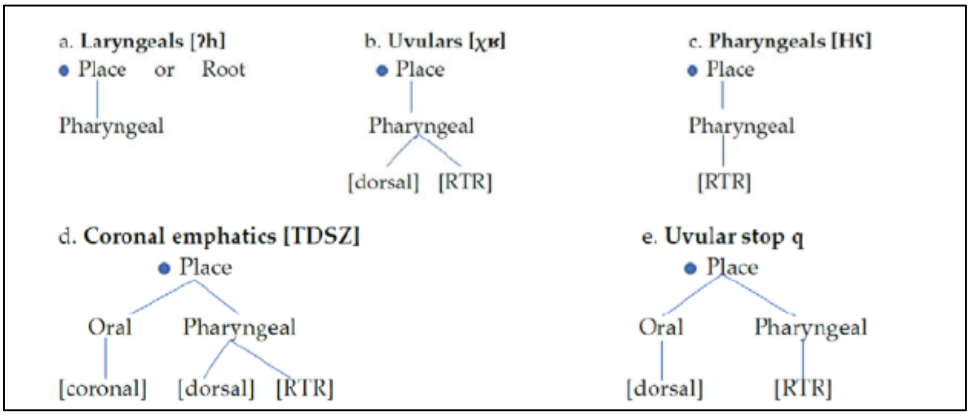


Figure 6. 2: Rose's representation of guttural sounds.

Davis (1995) and Watson (2002) also used the feature [RTR] to represent emphatics. Using the autosegmental framework proposed by Rose (1996), Davis (1995) and Watson (2002) in which emphatic consonants are associated with the feature [RTR], this study presents an analysis of two examples of the NA data to represent the presence and absence of the emphatic feature spread.

In Figure 6.3 below, the feature [+RTR] propagates rightwards from the emphatic consonant /ṭ/ into the following segments /a/ and /f/, converting them into emphatics.

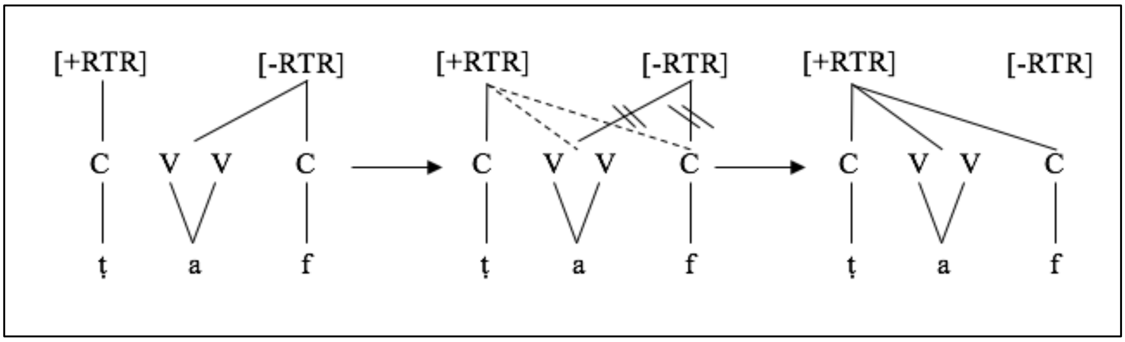


Figure 6. 3: Feature RTR propagation from an emphatic consonant to following segments /ṭaf/ → [taf] 'being used to'.

Figure 6.4 below illustrates that emphasis spreads from the emphatic /ṭ/ leftwards to the preceding segments but does not spread rightwards to the following segments. The reason behind this is that the presence of the voiceless post-alveolar fricative /ʃ/ acts as a blocker to the propagation of the emphatic feature.

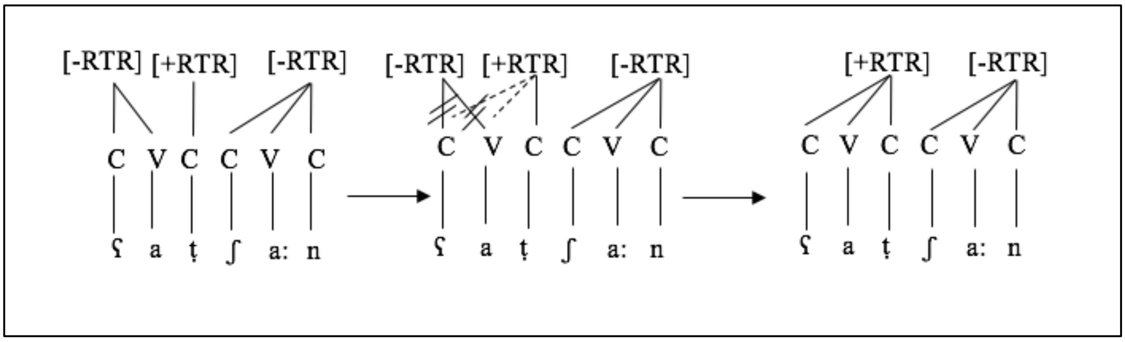


Figure 6. 4: Emphasis spread from the emphatic consonant in the presence of a voiceless post-alveolar fricative /ʕaṭʃaːn/ → [ʕaṭʃaːn] 'thirsty'.

6.3 Directionality of emphasis spread

All word-pair stimuli in this section consist of two syllables: CV.CVC or CVC.CVC (i.e., disyllabic words). The wordlist consists of all three emphatic consonants and their plain counterparts occurring in all possible positions: word initial, word medial and word final (as illustrated in set B in Appendix 1). In total, 630 acoustic measurements of the vowels' F2 for the disyllabic tokens (14 * 5 * 3 = 210) were taken. Then, the emphasis classification procedure explained in Chapter 5 was used to identify how emphasis operates within and beyond the syllable.

There is no single system of transcription to mark emphasis spread that has been applied in other Arabic dialects. Rather, researchers in prior examinations of emphasis have adopted different approaches. Davis (1995) and Watson (2002), for instance, transcribe the underlying emphatic trigger with a dot underneath it, targeting emphatic segments with uppercase letters, whereas lowercase segments represent non-emphatic surface segments. They also represent the voiced palate-alveolar affricate, /dʒ/ with /j/, and the palatal glide, /j/ with /y/. Watson transcribes the voiceless pharyngeal fricative with a dot under the symbol, the interdentals are transcribed with a line under the symbol and the emphatic interdental fricative is transcribed with a dot and a line underneath it. Other researchers represent the span of emphasis spread with underlined segments (Huneety and Mashaqba, 2016; Al-Bataineh, 2019). Slimani (2018) also uses a similar transcription method, representing the emphatic trigger segments in boldface. In the current study, I follow Huneety and Mashaqba's (2016) and Al-Bataineh's (2019) transcription systems for marking emphasised syllables by representing the emphasis domain with underlined segments. The reason behind this is that some segments in NA are represented by symbols and not letters,[20] so capitalising those segments will be an issue. In addition, it will be easier for readers to follow if I transcribe segments as they appear in the NA inventory.

It is also important to note that even though only the acoustic correlates of the vowels and the trigger emphatics are examined in the current study, all segments, including target consonants, are underlined and considered to be emphasised at the surface output. This choice is based on previous acoustic and articulatory studies that have confirmed that consonants within the domain of emphasis spreading are also undergoers; that is, emphasis spread starts from the trigger emphatic and affects both the vowels and consonants in the CVC string (Hassan, 1981; Jongman et al., 2011; Kulikov et al., 2020; Alwabari, 2020). The change in segments is only represented by a line underneath them. Furthermore, I have also added a new transcription style for the gradient spread of emphasis within a syllable. Any segment showing such behaviour will be represented as an italic underlined segment, and this formatting will be used throughout the current thesis.

The findings are reported according to the location of the trigger consonants; they assess whether the effect of emphasis remains constant and comparable in magnitude across these positions.

6.3.1 Word-initial trigger consonant

The progressive spread of emphasis in disyllabic words is shown in the examples presented in (1).

[20] Some segments in NA are represented by symbols, such as the voiceless dental fricative /θ/ and the voiced dental fricative /ð/, among others.

(1) Progressive emphasis spread

	Input	**Output**	**Gloss**
(a)	/ṭamas/	[ṭamas]	‘to be erased’
(b)	/ṣaraf/	[ṣaraf]	‘to spend’
(c)	/ð̣alam/	[ð̣alam]	‘to persecute’

An examining of the data in this set shows that when the emphasis comes at the beginning of disyllabic words, it spreads categorically to the neighbouring syllable. That is, F2 is lowered to a comparable degree in both vowels V1 and V2. The progressive spread of the emphatic feature colouring all adjacent vowels can be illustrated in Figure 6.5, which shows the distribution of the F2 values in all the examples stated above, depending on the presence/absence of the emphatic feature in the attested words.

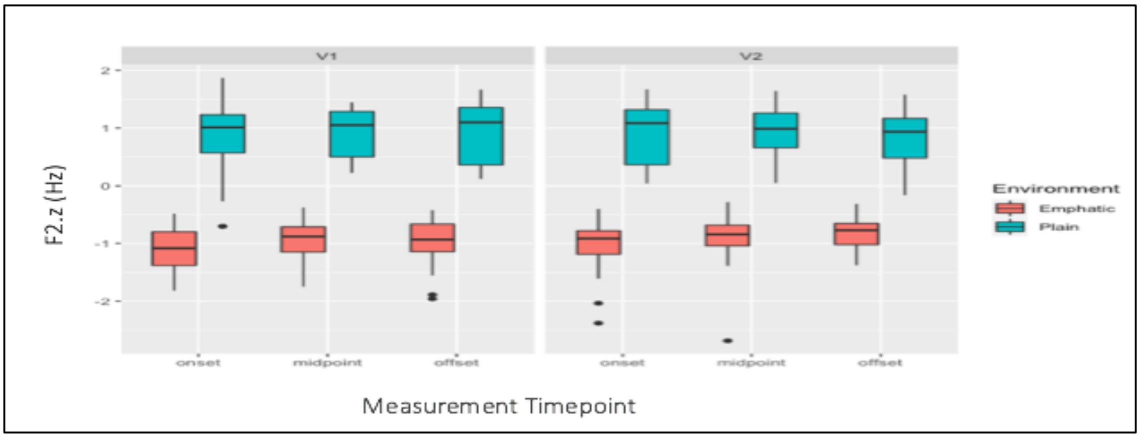


Figure 6. 5: Boxplot of the distribution of the F2 values in progressive spread of emphasis in disyllabic words, depending on the presence of emphasis, vowel adjacency and vowel measurement time point.

6.3.2 Word-medial trigger consonant

When the emphasis is word medial, the bidirectional spread of emphasis does not show any variability regarding its spread into vowels following and preceding the emphatic segments, as shown in the examples below.

(2) Bidirectional emphasis spread

	Input	**Output**	**Gloss**
(a)	/baṭar/	[baṭar]	'to show excessive arrogance'
(b)	/ħaẓ̌ar/	[ħaðar]	'to forbid'

In these examples, the emphasis spread is similar to progressive emphasis spread, wherein the vowels preceding (V1) and following (V2) the emphatic segments are both categorically emphasised. The F2 values of the vowels in these examples were lower in emphatic contexts than in plain contexts. The F2 distributions in Figure 6.6 below clearly show that emphasis in these examples spread in both directions (rightwards and leftwards) affecting all surrounded vowels.

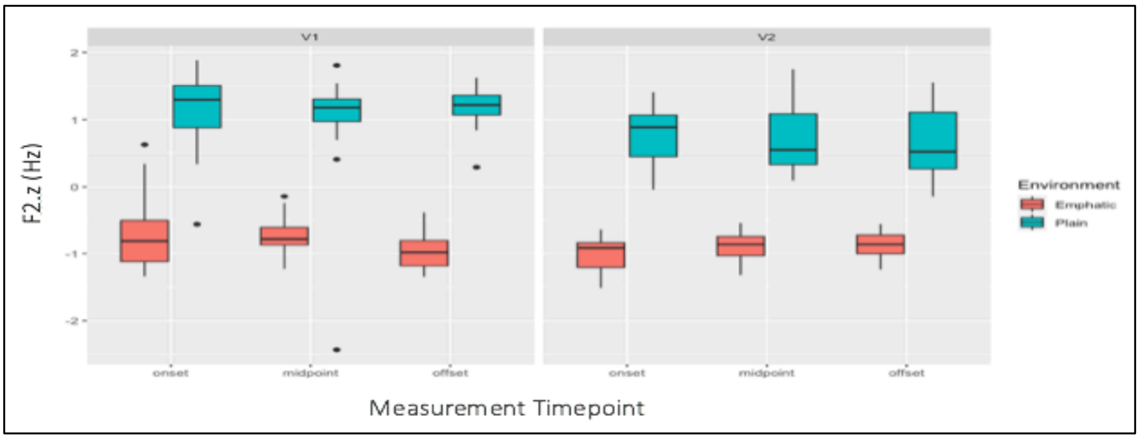


Figure 6. 6: Boxplot of the distribution of the F2 values in bidirectional spread of emphasis in disyllabic words, depending on the presence of emphasis, vowel adjacency and vowel measurement time point.

It should be clarified that this bidirectional set originally included three examples, but one example is not discussed here because it involves the velar /g/, which shows a different behaviour of emphasis spread; this will be discussed in Chapter 8.

6.3.3 Word-final trigger consonant

When the trigger consonant is located at the end of the word, the results are relatively similar to the previous results on the progressive and bidirectional spread of emphasis, as exemplified below.

(3) Regressive emphasis spread

Input	**Output**	**Gloss**
(a) /χallaṣ/	[<u>χallaṣ</u>]	‘to finish’
(b) /ħafað̣/	[<u>ħafað̣</u>]	‘to memorise’

The examples above show that the emphasis spreads regressively, with all preceding syllables bearing the emphatic feature that originates from the triggering segments /ṣ/ and /ð̣/. The emphasis displays a categorical spread in both V1 and V2. As shown in Figure 6.7, the F2 values in emphatic contexts were lower throughout these vowels when compared to those in plain contexts.

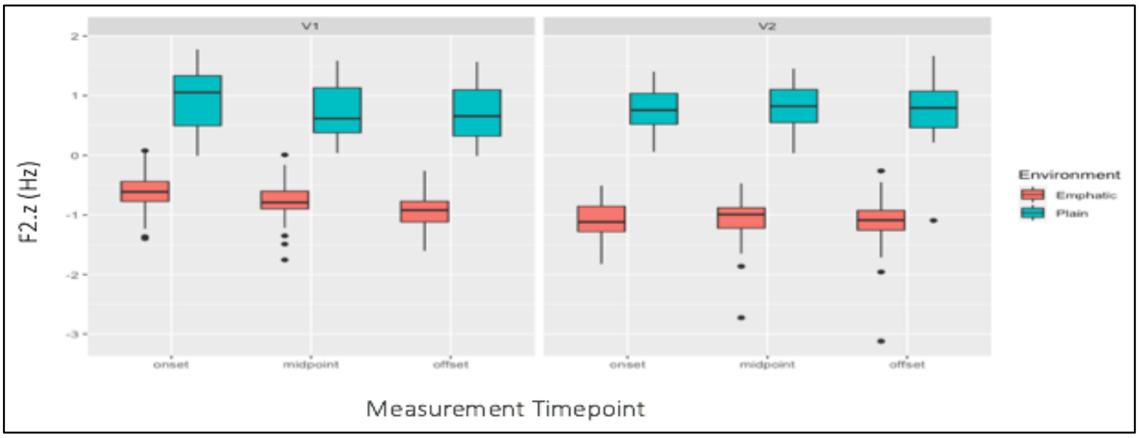


Figure 6. 7: Boxplot of the distribution of the F2 values in regressive spread of emphasis in disyllabic words, depending on the presence of emphasis, vowel adjacency and vowel measurement time point.

Similar to the bidirectional set, the examples in the regressive set included three examples, although only one of them included the velar /g/; thus, it will be explained later in Chapter 8.

6.4 Effect of morphology on emphasis spread

Before reporting the results of emphasis spread across the morpheme boundary, it is important to provide a brief overview of the Arabic root and pattern system. Arabic morphology, as well as those of similar Semitic languages, differ from that of English, as they are based on discontinuous morphemes (Ryding, 2005). Hence, word formation in Arabic primarily includes a consonantal root system placed into patterns to form a range of correlated words. For example, when one looks at the discontinuous[21] subsequence root ktb, one may deduce that it refers to the semantic concept ‘writing’. A vast array of words with different meanings can be formed by inserting different vowels between these root consonants and by adding affixes, as seen in Table 6.2 below.

Table 6. 2: Examples demonstrating the root-pattern system in Arabic.

IPA transcription	Arabic transcription	Gloss
/kataba/	كَتَبَ	he wrote (v.)
/ja-ktubu/	يَكْتُب	he writes (v.)
/ka:tib/	كاتِب	writer (n.)
/kutta:b/	كُتّاب	writers (n.)
/kita:b/	كِتاب	book (n.)
/kutub/	كُتُب	books (n.)
/ma-ktab/	مكتب	office (n.)
/ma-ktab-ah/	مَكْتَبَة	library (n.)
/kita:b-ah/	كِتابَة	writing (n.)

These consonantal roots must always be included and must be displayed in the same sequence. Adding vowels and affixes to the root corresponds to the ‘pattern’ concept, which is considered a template onto which the root consonants are mapped (McCarthy and Prince, 1990). Roots and patterns are integrated components that both express a distinct form of meaning. In other words, the root signifies the base meaning of the word, while the pattern conveys the grammatical information that characterises the word types. Nevertheless,

[21] Consonantal roots in Arabic are discontinuous because they can be separated by vowels.

because they are abstract mental representations that yield real words, neither can exist without the other. Moreover, many studies have focused on two aspects of Arabic morphology: derivational and inflectional (Ryding, 2005; Farida, 2013). Derivational morphology comprises word formation, while inflectional morphology establishes the grammatical forms of one lexeme to display, for example, gender, number or tense. Based on this, the morphological operation in Arabic begins with derivation to generate lexical items, which is followed by inflection, which modifies the root (Watson, 2002; Ryding, 2005). This root-pattern system enables us to understand the basic morphological norms in Arabic to which affixes are attached.

It is widely established that there is a strong association between morphology and phonological processes, as morpheme combinations that form words often yield new phonological environments that differ in their adherence to universal and language-specific phonological constraints. For example, when progressive vowel harmony in Turkish takes place, the vowels of the suffixes are altered to harmonise the final stem vowels in certain features. The value of [back] for suffixal vowels surface in the front following the final front stem vowels as in [anne-ler] ‘mother-pl’; however, they surface as back vowels if the final stem vowel is a back one (e.g., [elma-lar] ‘apple-PL’) (Inkelas, 2011). Such integration between phonology and morphology is essential to understand how phonological processes operate across the word and to identify whether the harmonic processes are confined to the stem domain or are active beyond the morpheme boundary. Therefore, the examples in sets C and D in Appendix 1 focus mainly on the fact that emphasis is subject to harmony spreading across the morpheme boundary; that is, prefixes and suffixes are labelled as part of the domain in which emphasis spreading applies. In these examples, I examine different kinds of verbal and nominal affixes to observe how emphasis spreading acts across the morpheme boundary, which, in turn, may motivate mapping from morphological constituents to phonological domains. When it comes to the vowels' F2 for prefix and suffix tokens (50 * 5 * 3 = 750), 2,250 acoustic measurements were taken.

6.4.1 Emphasis spread into prefixes

The same clear differences between emphatic and plain contexts previously observed can be found throughout the stem and attached prefixes, suggesting that emphasis spread is present regardless of whether the vowel is in the stem or prefix. The emphasis in these examples propagates from the stem to all the attached prefixes. The examples below illustrates the regressive spread of emphasis in stem stimuli with attached prefixes.[22]

(4) Categorical emphasis spread into prefixes

	Input	**Output**	**Gloss**
(a)	/ʔa-ṣfar/	[ʔa-ṣfar]	'yellow'
(b)	/ʔa-rʕaṣ/	[ʔa-rʕaṣ]	'I press'
(c)	/ta-ṣlaχ/	[ta-ṣlaχ]	'she peeled off'
(d)	/ta-ħḍar/	[ta-ħḍar]	'she attended'
(e)	/na-ṭbaʕ/	[na-ṭbaʕ]	'we print'
(f)	/na-rḍaχ/	[na-rḍaχ]	'we obey'
(g)	/ʔal-raṣṣ/	[ʔal-raṣṣ]	'compact' (n)

[22] As stated before, because some prefixes include the high front vowel /i/, which is considered a blocker, I have chosen to discuss the behaviour of these examples after discussing the blockers, which may help in understanding their behaviour regarding emphasis spreading.

However, pointing out that emphasis spread is categorical and comparable for both stem and prefix vowels is essential. It is also worth mentioning here that the emphatic segments used in these examples are placed in different positions (i.e., at the beginning of the stem, where they are syllabified as a coda for the prefix, such as in /ta-ṣ.laχ/, or at the middle or end of the stem word, such as in /na-rð̣aχ/ and /ʔal-raṣṣ/, respectively). In all these cases, emphasis spreads leftward across the morpheme boundary.

Evidently, the prefix data indicate that all phonemes within the span of the emphatic trigger surface are emphasised segments. As shown in Figure 6.8 below, emphasis can spread iteratively and affects prefixes that do not block the spread of the emphatic feature. The F2 distributions of both prefix and stem vowels show that the F2 values were always lower within the vicinity of the emphatic feature.

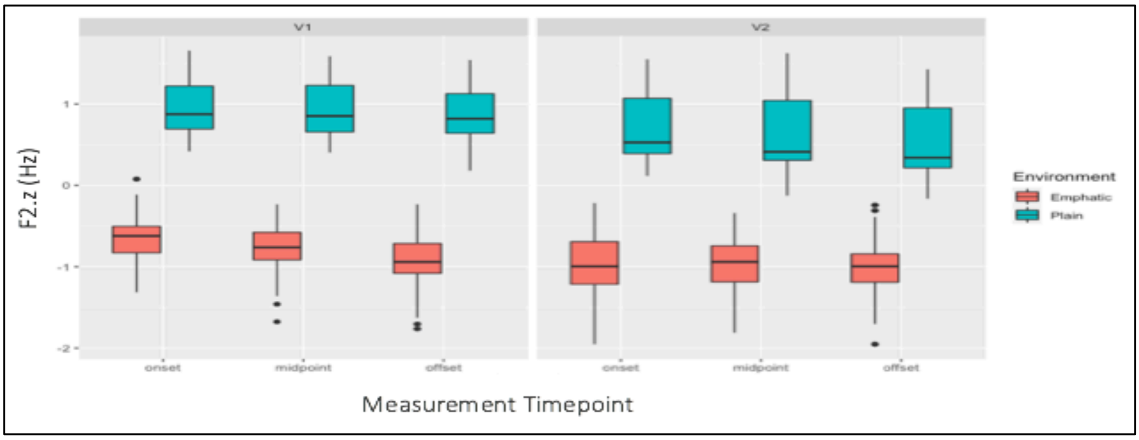


Figure 6. 8: Boxplot of the distribution of the F2 values of spread of emphasis into prefixes, depending on the presence of emphasis, vowel adjacency and vowel measurement time point.

6.4.2 Emphasis spread into suffixes

The progressive spread of emphasis generally starts from the emphatic trigger at the beginning of the stem word and extends to the end of the word, affecting all the segments that follow. However, emphasis can also extend and propagate over the morpheme boundary, affecting the suffix vowel.

In all the examples in this section, the stem vowel(s) are categorically emphasised. As a result, these vowels surface further back because of the presence of the underlying emphatic segment at the beginning, middle and end of the stem words. In fact, all stimuli in (5) suggest that emphasis spread not only extends over the stem but also affects the suffixes attached to the stem.

(5) Categorical emphasis spread into suffixes

	Input	Output	Gloss
(a)	/ṣaχχan-at/	[ṣaχχan-at]	‘she had a fever’
(b)	/ballaṭ-naː/	[ballaṭ-naː]	‘we paved’
(c)	/ṣaffar-naː/	[ṣaffar-naː]	‘we whistled’
(d)	/ṣabb-aːt/	[ṣabb-aːt]	‘concrete cast’
(e)	/maṭaːr-aːt/	[maṭaːr-aːt]	‘airports’

In (5a), for instance, when the singular feminine marker /-at/ is attached to the verb /ṣaχχan/, emphasis categorically spreads beyond the morpheme boundary, affecting the suffix. Therefore, it can be said that the morpheme boundary in these examples does not appear to block emphasis spread, as shown in Figure 6.9 below.

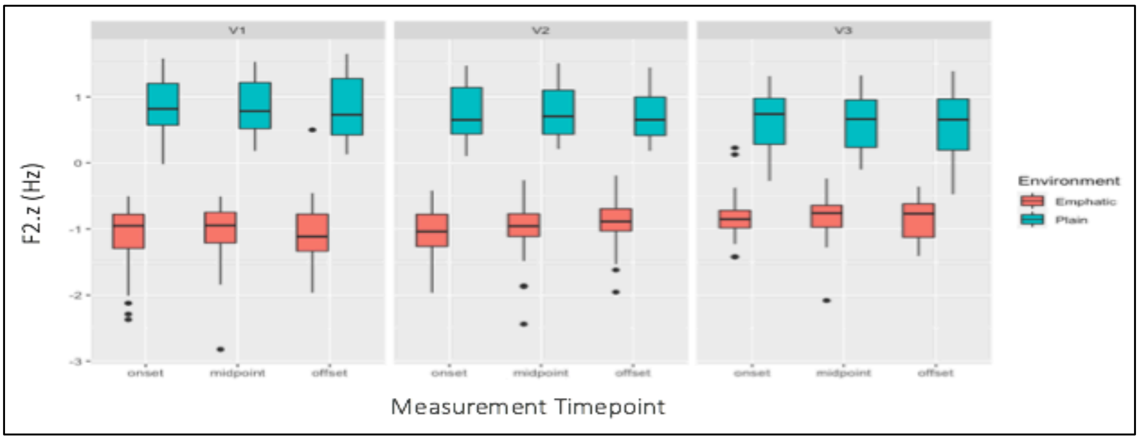


Figure 6. 9: Boxplot of the distribution of the F2 values of spread of emphasis into suffixes, depending on the presence of emphasis, vowel adjacency and vowel measurement time point.

It is also noticeable that the suffix examples include not only disyllabic words but also trisyllabic words. Thus, in this case, word length can be accounted for as a factor that may affect the propagation of emphasis. However, it is clear that all the examples in (5) show that this factor does not affect emphasis spread and that long-distance spread is also applicable here.

6.5 Summary

The primary aim of this chapter was to offer a detailed account of the domain of emphasis spread in NA. The typology of emphasis harmony in NA outlined here finds that the behaviour of segments in emphasis harmony fall into one basic category: the target segments within the vicinity of the emphatic triggers become categorically emphasised. This type of emphasis spread was found in disyllabic stem words, regardless of the position of the emphatic triggers. Moreover, it is clear that emphasis spread was not blocked by morpheme boundaries; rather, emphasis appears to spread beyond morpheme boundaries, targeting both prefixes and suffixes.

CHAPTER 7: OPACITY AND TRANSPARENCY IN EMPHASIS SPREAD IN NA

7.1 Overview

It is generally assumed that opacity arises due to the fact that some segments do not extend the feature that the trigger segment spreads. Under this view, these “blocking/opaque” segments can be characterised by the value opposite to the harmonising feature (Rose, 2011). Existing Arabic studies have already shown the extent to which emphasis spread can be blocked by a set of opaque segments.

This study elucidates the observed regularities in the direction of emphasis spread and presents an account of the asymmetry in the directionality of this process. This investigation is concerned with whether there are directionality effects (left-right asymmetry) on emphasis propagation. In this matter, the main interest is to observe whether there is a phonological preference of unbounded emphasis spread in one direction over the other. Therefore, I examine a set of phonemes reported as opaque and phonemes reported as transparent to emphasis spread. I explain which segments in NA act as opaque segments, preventing the spread of the emphatic feature, and which segments will be transparent to the emphatic feature effect (for more details see Chapter 2, section 2.7). This examination is to assess the effect of opacity and transparency on emphasis spread in NA.

The domain of emphasis in many Arabic varieties shows that emphasis appears to spread bidirectionally over the word, affecting segments in both directions (e.g., Bukshaisha, 1985; Davis, 1995; McCarthy, 1997; Al-Masri and Jongman, 2004; Algryani, 2014). Nevertheless, the literature pertaining to emphasis directionality strongly suggests an asymmetry in the direction of emphasis spread (i.e., rightward/leftward). Interestingly, these studies generally vary on the preferred direction of emphasis. In the relatively more common point of view (e.g., Herzallah, 1990; Davis, 1991, 1995; Watson, 1999, 2002; Al-Masri, 2009; Algryani, 2014), leftward spreading of emphasis is apparently more predominant than rightward spreading, which is subject to further restriction, that is, some phonemes associated with features [+high, -back] tend to interact differently with the emphatic feature spread depending on its directionality, revealing a rightward/leftward asymmetry in which these blocking segments may block emphasis spread in one direction but not in the other (Herzallah, 1990; Sakarnah, 1999; Al-Huneety, 2015; Mashaqba, 2015). However, in this matter, an unbounded spread of emphasis in both directions has also been reported in some dialects of Arabic, in which no segment impedes emphasis propagation over the word (Bukshaisha, 1985; Hoberman, 1995; Watson, 1999). Accordingly, I will examine emphasis directionality and determine whether NA exhibits a rightward/leftward asymmetry when reported blocking segments are included.

Unlike blocking segments, transparent segments do not participate in the harmonic process and do not block the harmonic feature, allowing it to pass through to the following segments. These intervening non-participant segments have not been reported in previous Arabic studies of emphasis spread, except in Shahin's (2002) work, the results of which showed that in Abu Shusha, a dialect of PA, high vowels, such as [u], were transparent to emphasis spread, as in /muhṛ-aːt/ → /m̠uh̠uṛa̠ːṯ/ 'fillies'. Thus, I attempted, from the beginning of this study, to include any segment that was reported as a transparent in the example set in order to assess its behaviour in terms of its transparency to emphasis spread. In this respect, I expect that no segment will behave as transparent because such segmental behaviour has only been reported in the PA dialect.

7.2 Emphasis spread: blocker/transparent segments

Intervening segments that apparently block the spread of a harmonising feature are thoroughly discussed in harmony literature in general. Prior studies suggest that blocking segments of a particular process can be shared, to some extent, among different harmony systems, such as nasal harmony, which is blocked by intervening obstruents, obstruents and liquids or by obstruents, liquids and glides in Kayan, Warao and Sundanese languages, respectively. In contrast, other harmonic systems can exhibit a different set of blocking segments. For instance, rounding harmony can be blocked by non-high vowels such as in Turkish or by high vowels as in Ulcha (Smith, 2016). Emphasis spread in the Arabic literature displays a similar tendency as the one in the nasal harmony system, in which Arabic dialects have a similar set of blocking segments that block emphasis spread, as shown in Table 7.1 below.

Table 7.1: Summary of the blocking segments of emphasis spread in various Arabic dialects.

Investigated dialect	Blocking segments
PA (Card, 1983)	/i/ and /u/
Northern PA (Herzallah, 1990)	/i/, /j/ and /ʃ/
Southern PA (Davis, 1995)	/i/, /j/, /d͡ʒ/ and /ʃ/
Northern PA (Davis, 1995)	/i/, /u/, /j/, /ʃ/, /d͡ʒ/ and /w/
CA (Watson, 2002)	Non-tautosyllabic /i/ and /j/
JA (Al-Masri and Jongman, 2004)	/i/ and /u/
LA (Algryani, 2014)	/i(ː)/, /j/ and /ʃ/
Wadi Mousa JA (Huneety, 2015)	/i/, /j/ and /ʃ/
Juffīn JA (Al-Huneety and Al-Mashaqba, 2016)	/i/, /j/ and /ʃ/
DJ (Slimani, 2018)	/i/, /j/, /ʃ/ and /ʒ/

Based on the predicted blockers reported earlier, the wordlist here was created to examine the behaviour of blocking and transparent segments in NA. The stimuli for the experiment are listed in set E in Appendix 1, which was formed by including a range of possible blocking/transparent patterns to the emphatic feature reported in the Arabic literature. For the purposes of this study, the words included were formed as minimal pairs. I compared the examples including the blocking/transparent segments in emphatic contexts with their counterpart examples in plain contexts. In addition, as has been reported in some prior studies of emphasis harmony, blocking impact may vary according to the spread direction of the harmonic feature. Thus, the selected words have the trigger segment in the word-initial, word-final and sometimes word-medial positions to track the effect of emphasis directionality on those segments. These words are either disyllabic or polysyllabic, and the blocking/transparent segment is located either within the trigger syllable or in an adjacent syllable. The target words in this set are divided into six categories based on the attested blocking/transparent segments. These categories include high front vowel /i(ː)/, high back vowel /u(ː)/, post-alveolar fricative /ʃ/, post-alveolar affricate /d͡ʒ/, palatal approximant /j/ and the glide /w/.

Emphasis spread in NA can operate in regressive or progressive directions or bidirectionally. However, the data in this study indicate that certain phonemes can block the propagation of the emphatic feature within the phonological word. Findings have shown various patterns for the behaviour of all potential blockers under investigation that somehow do not behave as expected.

Fristly, the high vowels /i(ː)/ and /u(ː)/ are capable of blocking emphasis spread in both progressive and regressive directions. Hence, in general, the vowels following /i(ː)/ and /u(ː)/ are not associated with the [+RTR] feature, as shown in (1) and (2) below.

(1) Blocking segment: high front vowel /i(ː)/

	Input	**Output**	**Gloss**
(a)	/ṣifah/	[ṣifah]	‘a feature’
(b)	/ʕaːṣifah/	[ʕaːṣifah]	‘a storm’
(c)	/naːfið̣/	[naːfið̣]	‘to dust off’
(d)	/χaraːbiːṭ/	[χaraːbiːṭ]	‘nonsense, crap’
(e)	/faraːʔið̣/	[faraːʔið̣]	‘duties’

(2) Blocking segment: high back vowel /u/

	Input	**Output**	**Gloss**
(a)	/ṭubbah/	[ṭubbah]	‘jump it’
(b)	/ð̣urrah/	[ð̣urrah]	‘fellow wife’

With regard to blocking vowel behaviour, the position of the high blocking vowel can affect the way it behaves. On the one hand, when the high vowels /i(ː)/ and /u/ are locally adjacent to the emphatic segment within the same syllable, the vowels are categorically emphasised. However, some instances exhibited different behaviour. Example /ʕaːṣifah/ (1b) contains some variations amongst speakers; speakers 1, 2 and 5 categorically emphasised /i/, whereas speakers 3 and 4 did not emphasise the vowel[23]. In addition, in example (1d) /χaraːbiːṭ/, the emphatic segment is syllabified with the long high vowel /iː/, indicating that only the vowel

[23]Speaker 3 is a female participant, whereas speaker 4 is a male participant.

offset was categorically emphasised, whereas the vowel's onset and midpoint were not emphasised. The long high vowel /uː/ exhibits that emphasis also spread but in a gradient manner, as shown below.

(3) Blocking segment: high back vowel /u(ː)/

	Input	**Output**	**Gloss**
(a)	/masṭuːrah/	[mas*ṭuː*rah]	'being hit'
(b)	/maːṣuːrah/	[maː*ṣuː*rah]	'a pipe'
(c)	/marbuːṭ/	[mar*buːṭ*]	'tied up'

On the other hand, when the high vowels occurred in a syllable adjacent to the emphatic triggers, /i(ː)/ was not emphasised, such as in examples (4a–4c), while /uː/ is gradiently emphasised, as shown in (4d).

(4) Blocking segment: non-adjacent high vowels /i(ː)/ and (uː)

	Input	**Output**	**Gloss**
(a)	/ṭabiːbah/	[ṭabiːbah]	'a doctor'
(b)	/ð̣aliːlah/	[ð̣aliːlah]	'shady'
(c)	/ʔalribaːṭ/	[ʔalribaːṭ]	'knee ligament'
(d)	/ṣabuːrah/	[ṣa*buː*rah]	'patient'

To illustrate the behaviour of the high front vowel /i/ as blockers, the distributions of F2 for the example /ṭabiːbah/ is presented in Figures 7.1 below. In the example of the high front vowel /i/, F2 distributions showed that the vowel's F2 values in the syllable, including the emphatic consonant, were lowered when compared to F2 values in the syllable including the plain counterpart. On the other hand, the vowels in the following syllables, including the high front vowel /i/ and the vowel beyond, showed no difference in the F2 values between the emphatic and plain contexts.

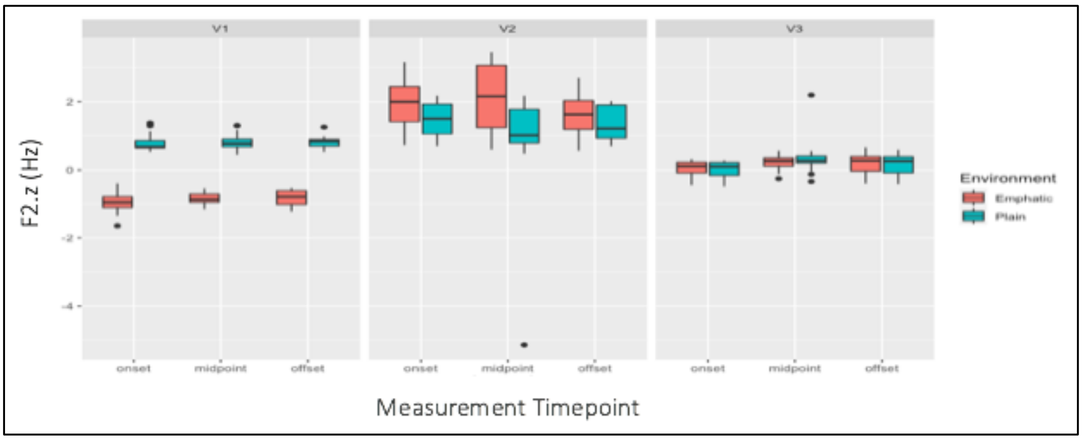


Figure 7. 1: Boxplot of the distribution of the F2 values in /ṭabiːbah/ and /tabiːbah/, depending on the presence of emphasis, vowel adjacency and vowel measurement time point.

The behaviour of the high back vowel /u/ as a blocker is also illustrated below in Figures 7.2 and 7.3. The examples represented here are /ṭubbah/ and /masṭu:rah/. The high vowel /u/ acts as a blocker in both examples, however, the spread of emphasis was categorical in /ṭubbah/ as the F2 distribution show greater F2 lowering in the emphatic context when compared to the plain one. By contrast, emphasis in /masṭu:rah/ spread in gradient manner in the syllable including /uː/.

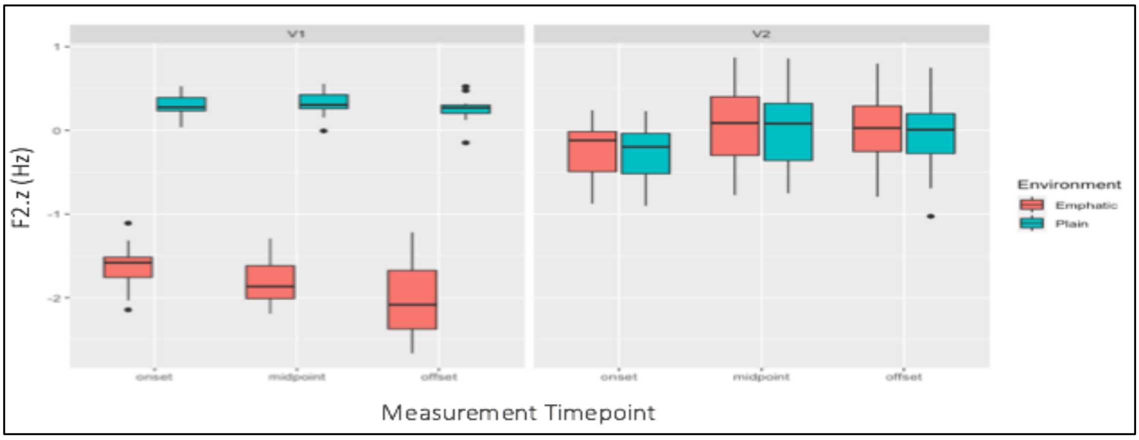


Figure 7. 2: Boxplot of the distribution of the F2 values in /ṭubbah/ and /tubbah/, depending on the presence of emphasis, vowel adjacency and vowel measurement time point.

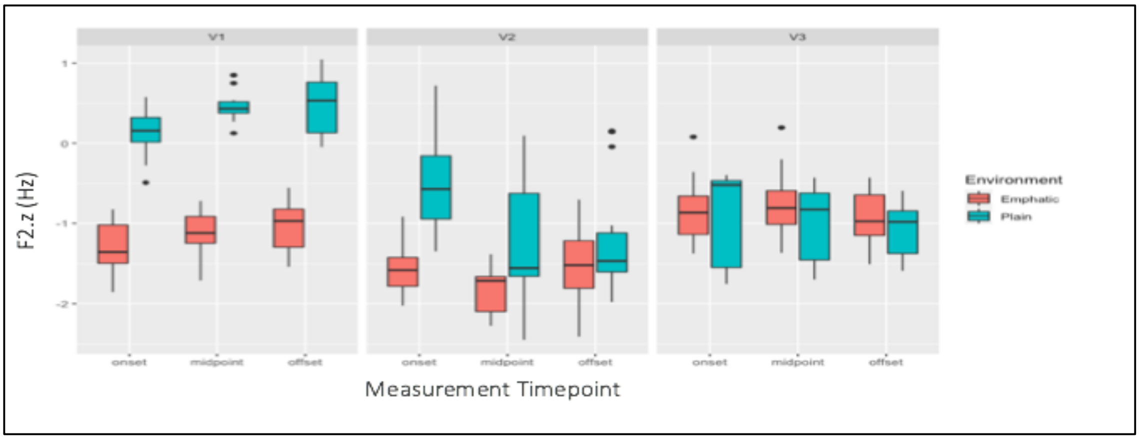


Figure 7. 3: Boxplot of the distribution of the F2 values in /masṭuːrah/ and /mastuːrah/, depending on the presence of emphasis, vowel adjacency and vowel measurement time point.

The data in (5, 6 and 7) below indicate that the voiced and voiceless post-alveolars /ʤ/ and /ʃ/ and the palatal /j/ restrict emphasis in forward spreading.

(5) Blocking segment: voiced post-alveolar affricate /ʤ/

	Input	Output	Gloss
(a)	/ṭandʒah/	[tandʒah]	'a city in Morocco'
(b)	/ṣaːdʒatnaː/	[saːdʒatnaː]	'our baking tin'

	Input	Output	Gloss
(c)	/ʔadʒhað̣at/	[ʔadʒhaðat]	‘she miscarried’

(6) Blocking segment: voiceless post-alveolar fricative /ʃ/

	Input	Output	Gloss
(a)	/ṭannaʃat/	[ṭannaʃat]	‘she ignored’
(b)	/ʕaṭʃaːn/	[ʕaṭʃaːn]	‘thirsty’
(c)	/naʃṭaħ/	[naʃṭaħ]	‘we exceed’
(d)	/naʃaːṭ/	[naʃaːṭ]	‘exercise’

(7) Blocking segment: voiced palatal /j/

	Input	Output	Gloss
(a)	/ð̣ajaːʕ/	[ð̣ajaːʕ]	‘loss’
(b)	/ṭajbah/	[ṭajbah]	‘a name of a city: Medinah’
(c)	/haːjaṭ/	[haːjaṭ]	‘haughty’

In all the examples above, these phonemes intervened and prevented the emphatic feature of the emphatic triggers from spreading further and affecting any syllable beyond these phonemes, yielding non-emphasised segments. Again, comparing all examples in these sets, one can see that emphasis categorically spread and affected any syllable occurring before these blockers. Figure 7.4 below illustrates such behaviour of these blocker, in particular in the voiceless post-alveolar fricative /ʃ/ in the example /ʕaṭʃaːn/. The F2 values of the vowel before the blocker were lowered in the emphatic context in comparison to those in the plain context. After the blocker, however, there was no difference between the vowels in emphatic and plain contexts.

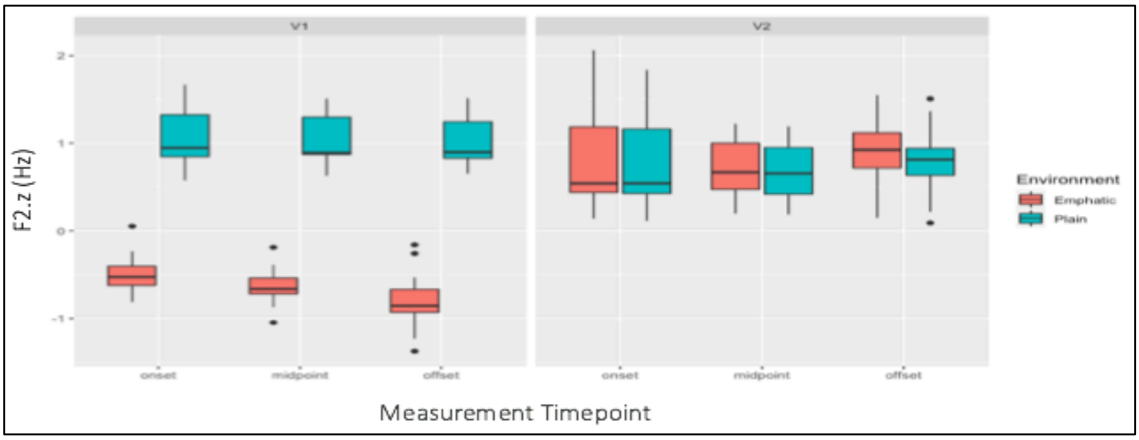


Figure 7. 4: Boxplot of the distribution of the F2 values in /ʕaʈʃaːn/ and /ʕatʃaːn/, depending on the presence of emphasis, vowel adjacency and vowel measurement time point.

In the previous examples in (6d, 7b and 7c), even though the fricative /ʃ/ and the palatal /j/ occurred within the same syllable as the emphatic /ṭ/, they do not block emphasis spread of the local vowels within the same syllable, but they did block emphasis from spreading further.

Emphasis also applies when there is the voiced glide /w/. In general, the syllables that included emphatic triggers were all categorically emphasised. The intervening glide in the examples below was neither a transparent nor a blocker of emphasis harmony; it was, however, an undergoer that participated in emphasis harmony, as illustrated in Figure 7.5.

(8) Emphasis spread: voiced glide /w/

Input	**Output**	**Gloss**
(a) /ṭawa:f/	[ṭawa:f]	'circumambulation'
(b) /ʔalwasaṭ/	[ʔalwasaṭ]	'the centre'

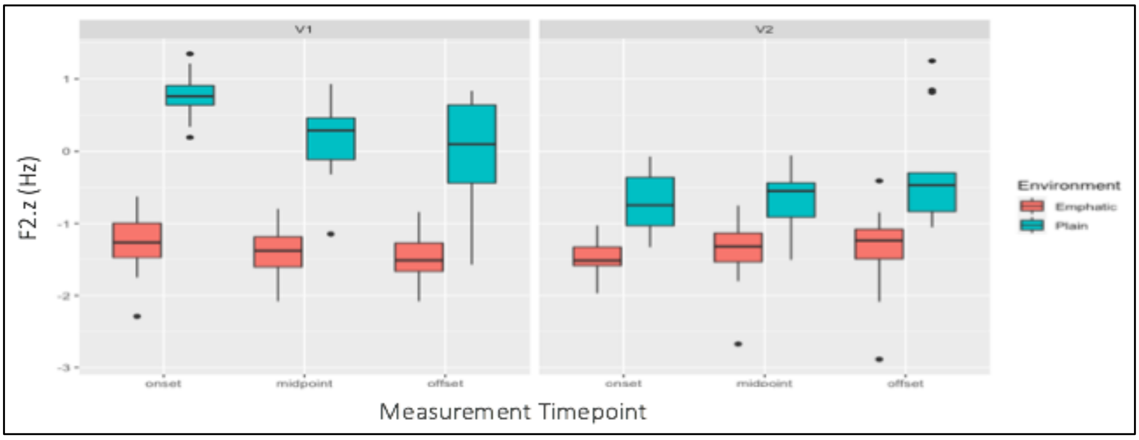


Figure 7. 5: Boxplot of the distribution of the F2 values in /ṭawaːf/ and /tawaːf/, depending on the presence of emphasis, vowel adjacency and vowel measurement time point.

having examined the blockers, it is now appropriate to discuss the examples of prefixes and suffixes including both high vowels and the palatal, to determine their behaviour. Firstly, the prefix examples that included the high front vowel /i/ in (9) below demonstrated that the emphatic feature affected the vowels within the stem and also propagated over the morpheme boundary and emphasised the prefixal vowel /i/, regardless of its articulatory antagonism with the emphatic trigger feature, as shown in Figure 7.6 below.

(9) Categorical emphasis spread into prefixes: high front vowel /i/

	Input	**Output**	**Gloss**
(a)	/ʔin-ṣalaχ/	[ʔin-ṣalaχ]	‘being flayed’
(b)	/ʔin-ʕaṭaː/	[ʔin-ʕaṭaː]	‘he was given (sth)’

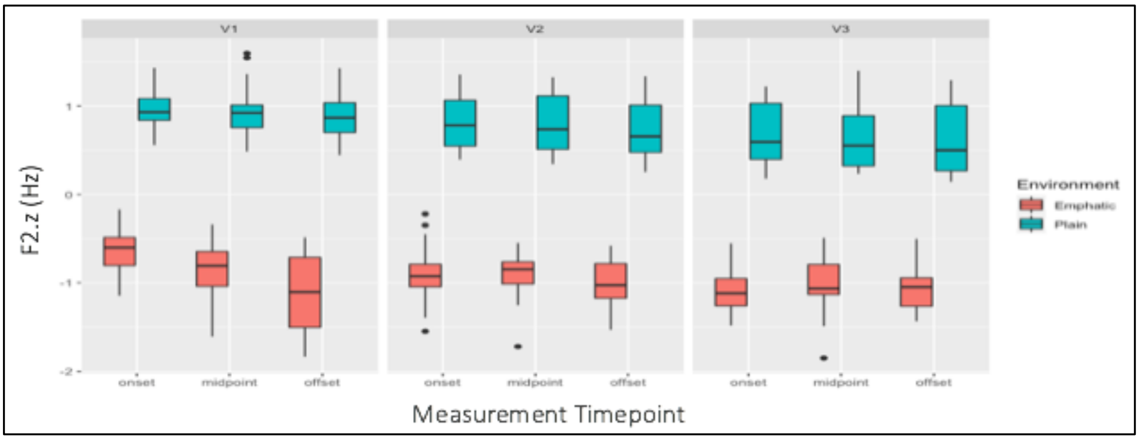


Figure 7. 6: Boxplot of the distribution of the F2 values in categorical emphasis spread into prefixes for the high front vowel /i/, depending on the presence of emphasis, vowel adjacency and vowel measurement time point.

The suffixal front vowel /i/ in any type of suffix, however, displayed two different behaviours of emphasis spread: one occurred when emphasis spread in a gradient manner, as seen in the examples in (10) below.

(10) Gradient emphasis spread into suffixes: emphasised high front vowel /i/

	Input	**Output**	**Gloss**
(a)	/ṣanaʕ-hin/	[ṣanaʕ-*hin*]	'he made them'
(b)	/ṭaraf-hin/	[ṭaraf-*hin*]	'their sides'
(c)	/baṣm-ih/	[baṣ*m*-*ih*]	'fingerprint'

However, the suffixal /i/ in (11) below failed to harmonise with the stem vowel. In these examples, the high front vowel remained in front and was not affected by the back feature of the emphatic stem vowel. This behaviour of the suffixal /i/ is illustrated in Figure 7.7. below.

(11) No emphasis spread into suffixes: high front vowel /i/

	Input	Output	Gloss
(a)	/ħaṣa:n-ih/	[ħaṣa:n-ih]	‘immunity’
(b)	/ṣabb-ik/	[ṣabb-ik]	‘your pouring’ (the way you pour sth)
(c)	/baṭn-ik/	[baṭn-ik]	‘your stomach’

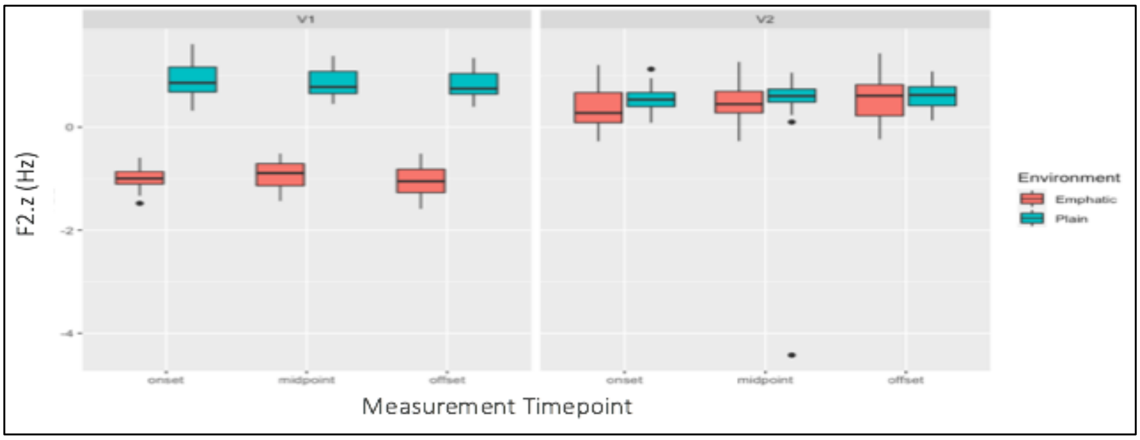


Figure 7. 7: Boxplot of the distribution of the F2 values in the absence of emphasis spread into suffixes for the high front vowel /i/, depending on the presence of emphasis, vowel adjacency and vowel measurement time point.

Such disharmonic behaviour can be related not only to the presence of the high front vowel, which included two antagonistic feature specifications [+high] and [+front], but also to the presence of the long vowel (as in 11a) or the voiceless velar /k/ (as in 11b and 11c). Jongman et al. (2011) suggested that vowel length can impact emphasis spread primarily because the temporal interval between the emphatic trigger and the vowel midpoint is smaller in short vowel contexts than in long vowel contexts. Meanwhile, including a velar /k/ with a feature specification [+high] that is articulatorily antagonistic with the feature associated with emphatic segments can also hinder emphasis spreading. In both cases, the combination of such segments with the high front vowel /i/ can prevent harmony from applying across the morpheme boundary.

The suffixal high back vowel /u/ also exhibited similar behaviour to that of the suffixal high front vowel. That is, in (12) below, the suffix vowel (i.e., /u/) in the consonant-initial suffix /-hum/ was not emphasised, and so the rightward morpheme boundary in these examples blocked emphasis spread (see Figure 7.8).

(12) No emphasis spread into suffixes: high back vowel /u/

	Input	**Output**	**Gloss**
(a)	/ħaṣar-hum/	[ħaṣar-hum]	‘he counted them’
(b)	/ð̣alam-hum/	[ð̣alam-hum]	‘he persecuted them’

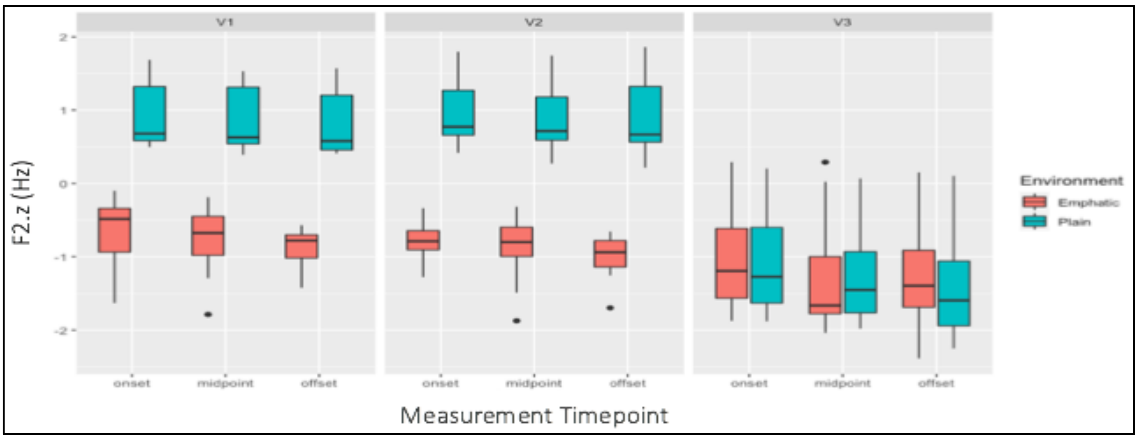


Figure 7. 8: Boxplot of the distribution of the F2 values in the absence of emphasis spread into suffixes for the high front vowel /u/, depending on the presence of emphasis, vowel adjacency and vowel measurement time point.

In this case, emphasis spread was blocked even though the stem vowels were all categorically emphasised, and the emphatic segments occurred stem initially and stem medially. This blocking behaviour can be attributed to the morpheme boundary and not the blocking segment /u/ behaviour because, in the example including the initial-vowel suffix /-uh/ below, the suffix vowel was emphasised, whereas in the examples above it was not, as shown in Figure 7.9 below. It should be noted that, in the example below, the trigger emphatic was word initially.

(13) Emphasis spread into suffixes: high back vowel /u/

Input	**Output**	**Gloss**
(a) /ṣabb-uh/	[ṣabb-uh]	'he poured it'

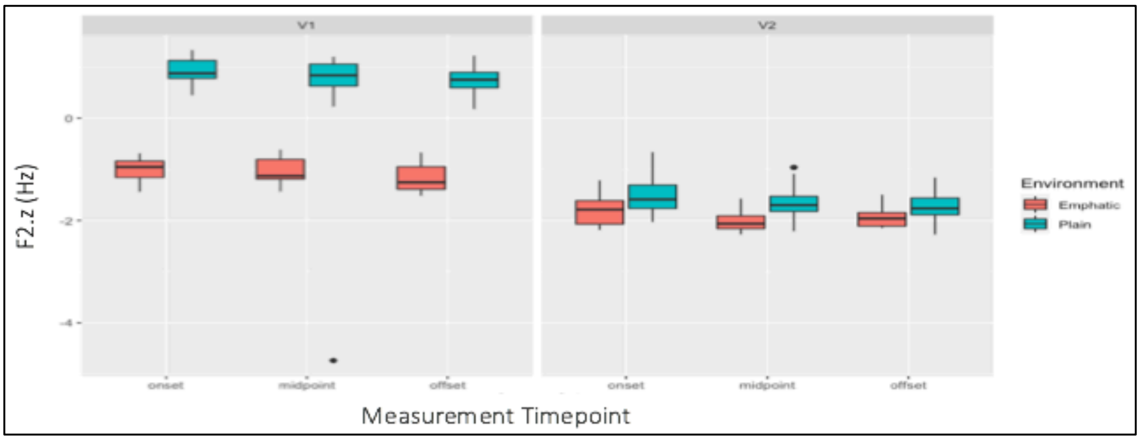


Figure 7. 9: Boxplot of the distribution of the F2 values of emphasis spread into suffixes for the high front vowel /u/, depending on the presence of emphasis, vowel adjacency and vowel measurement time point.

The results also revealed that vowels within the prefixes starting with the palatal /j/[24] showed a gradient emphasis spread, such as the vowels in (14) below. This gradient spread of emphasis was observed only in the prefix vowels, whereas the stem vowels (V2) showed a categorical spread of the emphatic feature throughout the vowel, as shown in Figure 7.10 below.

[24]The prefixes that start with the palatal /j/ can all be classified as personal pronoun prefixes for verbs in the present tense.

(14) Gradient emphasis spread into prefixes: palatal /j/

	Input	Output	Gloss
(a)	/ja-bṭir/	[*ja*-bṭir]	‘he shows off’
(b)	/ja-rʕaṣ/	[*ja*-rʕaṣ]	‘he squeezes’

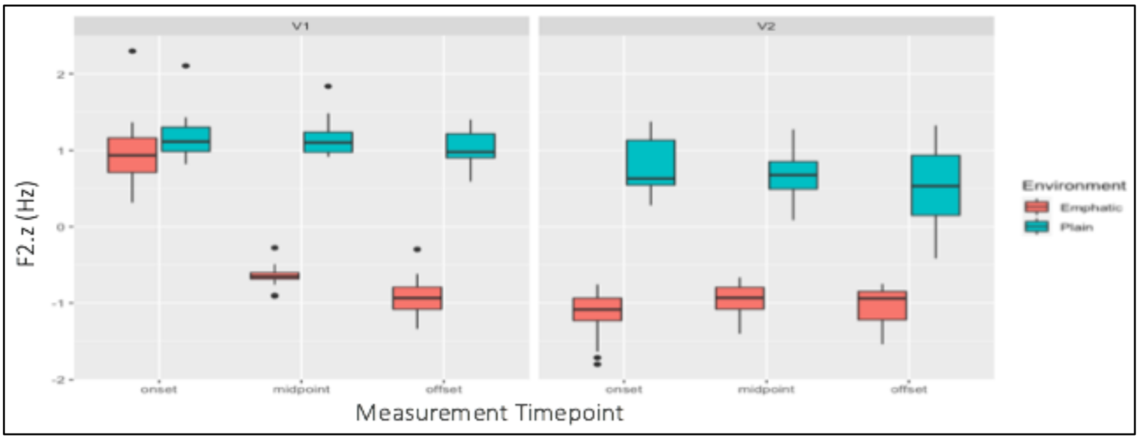


Figure 7. 10: Boxplot of the distribution of the F2 values of gradient emphasis spread into prefixes for the palatal /j/, depending on the presence of emphasis, vowel adjacency and vowel measurement time point.

This behaviour of emphasis spread over these affixes now indicates that the emphasis domain was bidirectional across morpheme boundaries. That is, emphasis harmony may spread freely to prefixes and to suffixes, with some limitations. These limitations only related to the examples including the consonant-initial suffix /-hum/, the vowel-initial suffixes /-ik/ and some examples of /-ih/ wherein the high vowels were not emphasised.

7.3 Summary

To sum up, segmental opacity and transparency effects are common cross-linguistically in different harmony systems. Such effects arise as an essential result for the occurrence of incompatible segments of the spreading feature (van der Hulst and Smith, 1982a). The typology of emphasis harmony in NA outlined here finds that the behaviour of segments in emphasis harmony falls into two basic categories: (i) target segments, which are the majority, become emphasised; and (ii) blocking segments that may either remain unaffected or harmonised and in both cases always block the further spread of the emphatic feature and initiate a new harmony span.

Though not common cross-dialectally, opaque segments in NA appear to occur comparably in either plausible direction of emphasis spread (i.e., leftward or rightward). Moreover, a distinct feature of NA is that there is some positional restriction on the segments that blocks emphasis: if the blocking consonant is immediately next to the emphatic, the vowel in-between will be emphasised. Otherwise, emphasis will not take place, except for the high back vowel wherein the vowel is emphasised even though it is not syllabified with the emphatic trigger. Yet, all vocalic and consonantal blockers block any further spread of the emphatic property. However, the voiced glide /w/ was not a blocker and emphasis spreads and affects all segments beyond the glide.

CHAPTER 8: VELARS AND UVULAR /q/ CASES IN EMPHASIS SPREAD IN NA

8.1 Overview

Blocking segments, discussed in chapter 7, completely block emphasis from spreading further over the word. However, there is a set of segments that exhibits a different behaviour from that of blocking segments explained earlier. The velars /g/, /k/ and the uvular /q/ cannot be consistently classified as blocking segments, that is, they occasionally act as blockers and in other cases, allow emphasis to spread over the entire word. For this reason, these segments have not been discussed so far.

In this chapter, I will examine the phonological status of emphasis in such cases and present the intricacies that trigger such irregular behaviour of emphasis spread. Then, I will focus on whether these differences in emphasis realisation are subject to specific types of segmental environments. If so, a crucial question is whether it is plausible to establish a link between those environments. Since this behaviour of both the velars and the uvular with regard to emphasis spread has not been previously reported in other Arabic dialects, it is difficult to predict precisely how these segments would behave in different contexts with regard to emphasis spread in NA.

The knowledge that the velars /g/ and /k/ and the uvular /q/ behave differently was data driven, as explained earlier in Chapter 6, when the voiced velar /g/ was included as a transparent segment in the examples in the word list of disyllables examining the domain of emphasis. Thus, I have constructed three wordlists for the voiced and voiceless velars and the uvular /q/. I included examples of the uvular /q/ because of the diachronic change of this phoneme. The uvular /q/, as discussed in Chapter 1, is still used in some contexts in NA, along with its variant /g/. Thus, the uvular /q/ was included to examine whether it showed a behaviour similar to its variant. The word list here was designed in a similar way to that of the blockers. The list includes multisyllabic minimal pairs in which the trigger emphatic consonants are placed in initial, medial and final word positions to assess whether the effect of these segments differ with different spread directions.

8.2 Characterisation of uncommon triggering in NA

In the examples below, all but one syllable containing the voiced velar /g/ were emphasised. Accordingly, it appears that the vowel tautosyllabic with the voiced velar participates in emphasis harmony; yet, the velar /g/ blocks the effect of the emphatic trigger from further spreading to other syllables regardless of the emphatic consonant position. Hence, it is a blocker.

(1) Emphasis spread: voiced velar /g/

	Input	**Output**	**Gloss**
(a)	/ʔalga:fṭah/	[ʔal*ga:f*ṭah]	‘someone alert to notice’
(b)	/ṣargaʕah/	[ṣar*ga*ʕah]	‘noise’
(c)	/ʔalgarṣa:t/	[ʔal*gar*ṣa:t]	‘pinches’
(d)	/ʔalganna:ṣ/	[ʔal*gan*na:ṣ]	‘sniper’
(e)	/ʔalgabð̣a:t/	[ʔal*gab*ð̣a:t]	‘the grips’
(f)	/ʔalgabð̣ah/	[ʔalgabð̣ah]	‘the grip’

Despite the fact that the tautosyllabic vowel with /g/ in (1f) still blocks the propagation of the emphatic feature, it remains in front and disharmonic to the emphatic trigger.

In contrast, /g/ is an undergoer in the examples listed in (2a–e) below.

(2) Emphasis spread: beyond the voiced velar /g/

	Input	**Output**	**Gloss**
(d)	/ʔalmgallaṭ/	[*ʔalmgal*laṭ]	‘dining room’
(e)	/laṣgatnaː/	[laṣ*gatnaː*]	‘our plaster’
(c)	/ʔalgað̣aː/	[*ʔalga*ð̣aː]	‘judgement’
(d)	/gaṣab/	[*ga*ṣab]	‘cane’
(e)	/laggaṭ/	[*laggaṭ*]	‘to collect’

Such differences in voiced velar behaviour, a blocker in some cases and an undergoer in others, could be related to a specific segmental context. However, it is not possible to definitely identify the reason behind such behavioural variation since there is no consistent segmental pattern that can explain such behaviour. Illustrative examples for each segment that can provide an additional description of what occurs acoustically with these segments are provided below. The figures below represent the behaviour of the voiced velar /g/ when it acts as a blocker (8.1a–b) and an undergoer (8.2a–b).

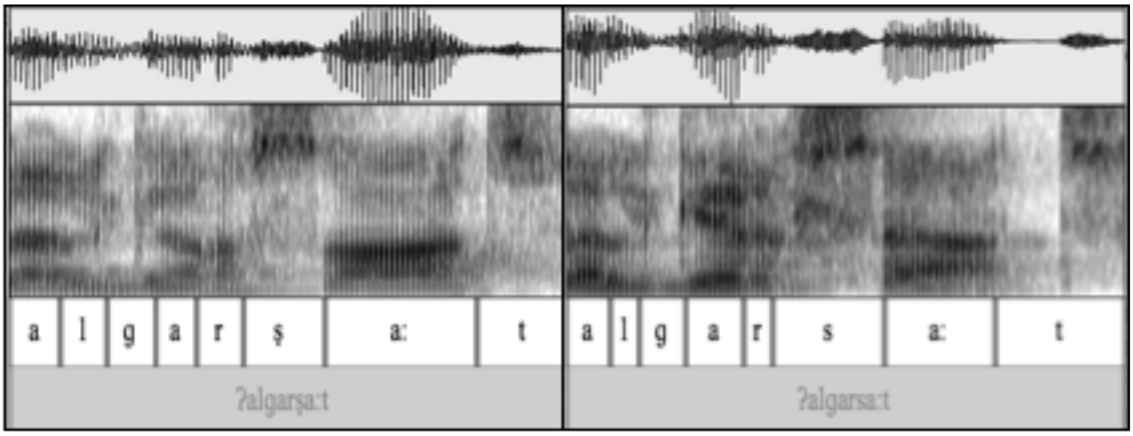


Figure 8.1a: A waveform and a spectrogram of an example realisation for the pair /ʔalgarṣaːt/ vs. /ʔalgarsaːt/ by speaker [5].

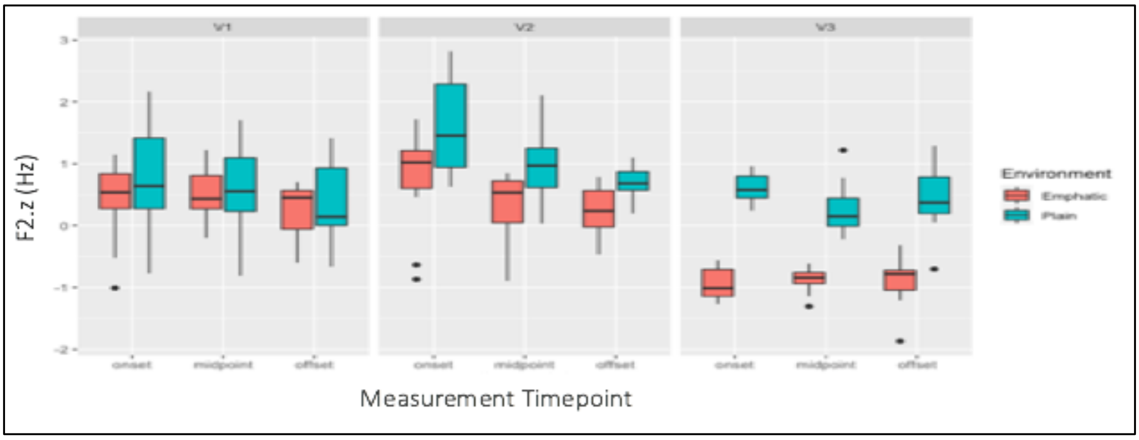


Figure 8. 1b: Boxplot of the distribution of the F2 values in /ʔalgarṣaːt/ and /ʔalgarsaːt/, depending on the presence of emphasis, vowel adjacency and vowel measurement time point.

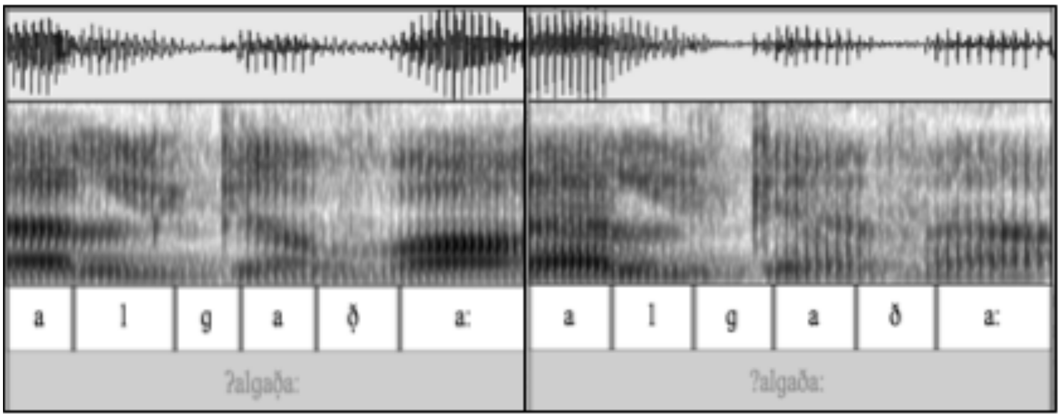


Figure 8.2a: A waveform and a spectrogram of an example realisation for the pair /ʔalgaḍaː/ and /ʔalgaðaː/ by speaker [5].

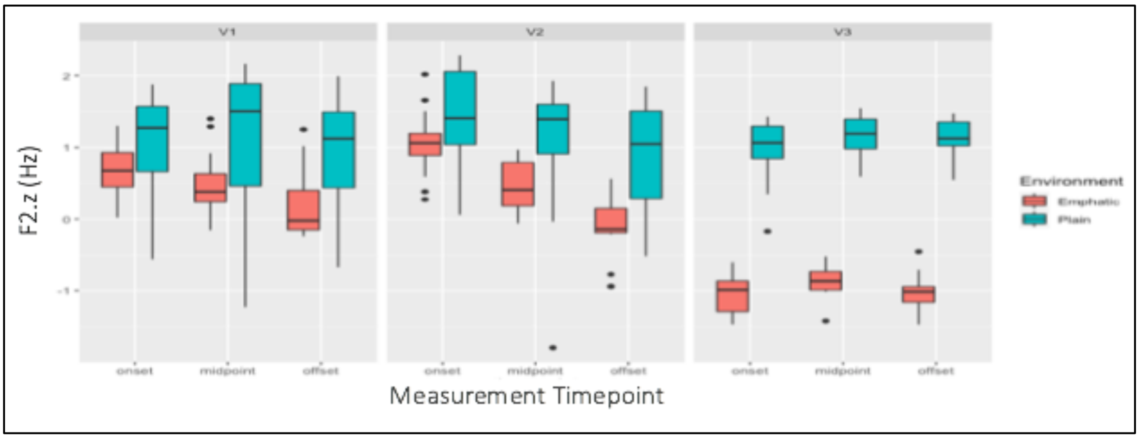


Figure 8. 2b: Boxplot of the distribution of the F2 values in /ʔalgaḍaː/ and /ʔalgaðaː/, depending on the presence of emphasis, vowel adjacency and vowel measurement time point.

The voiceless velar /k/ displays a similar behaviour to the voiced velar /g/ in that emphasis colours the vowel if preceded or followed by the tautosyllabic voiceless velar regardless of the emphatic trigger position. This behaviour was exemplified in all but one case: in (3a), the vowel following the velar /k/ in the second syllable fails to undergo emphasis harmony. It should be noted, however, that the voiceless velar in this example is a geminate in which one /k/ is syllabified with the first syllable, whereas the other /k/ is syllabified with the second. Thus, the disharmonic behaviour of the second vowel could be related to the antagonistic effect of the voiceless velar when compared to that of the trigger emphatic in the first syllable.

(3) Emphasis spread: voiceless velar /k/

	Input	Output	Gloss
(a)	/ṣakkathaː/	[ṣak*kat*haː]	‘she hit her’
(b)	/raːkað̣at/	[raː*ka*ð̣at]	‘to run’
(c)	/ʔalkaːð̣im/	[ʔal*kaː*ð̣im]	‘restraint’
(d)	/ʔalmakð̣uːm/	[ʔal*makð̣uːm*]	‘distressed’
(e)	/taraːkað̣aww/	[taraː*ka*ð̣aww]	‘they ran’

The vowels in syllables beyond the voiceless velar in all the examples above are resistant to emphasis harmony and surface as non-emphatics, so the voiceless velar is a blocker. However, an exception was found in the behaviour of emphasis spread that was not induced in the syllable containing the voiceless velar but in the proceeding syllable. See the example below.

(4) Emphasis spread: beyond the voiceless velar /k/

	Input	Output	Gloss
(a)	/ʔalmraːkað̣/	[ʔal*mraːk*að̣]	‘running’

In this case, emphasis spreads to the first syllable adjacent to the voiceless velar but not to the one beyond. The acoustically gradient behaviour of the voiceless velar /k/ when acting as a blocker is illustrated below.

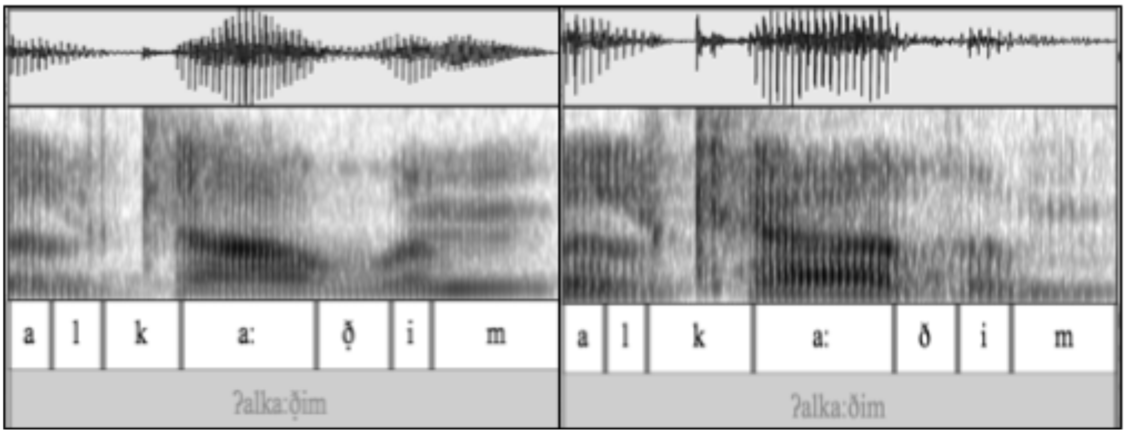


Figure 8.3a: A waveform and a spectrogram of an example realisation for the pair /ʔalkaːð̣im/ and /ʔalkaːðim/ by speaker [5].

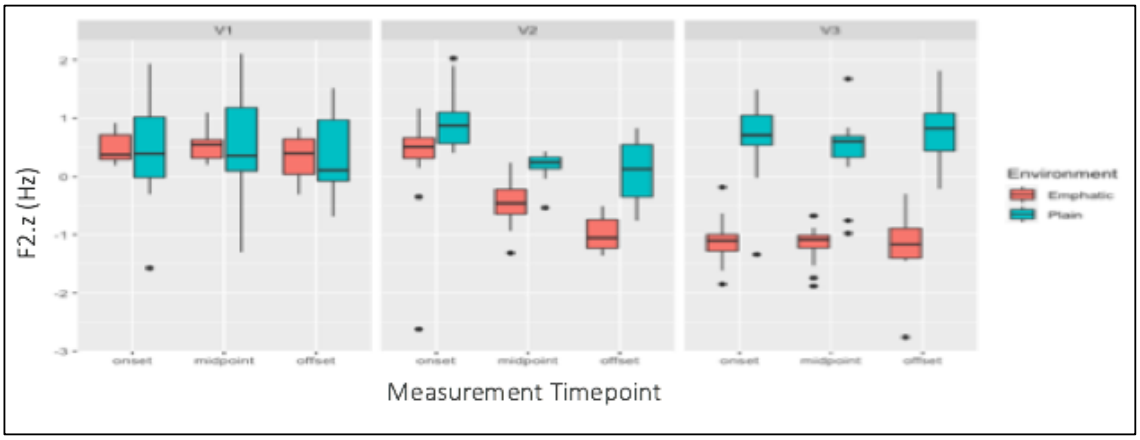


Figure 8. 3b: Boxplot of the distribution of the F2 values in /ʔalkaːð̣im/ and /ʔalkaːðim/, depending on the presence of emphasis, vowel adjacency and vowel measurement time point.

Finally, all the examples involving the voiceless uvular /q/ appear to have a different behaviour: the tautosyllabic vowel with the uvular and the vowels beyond it can be either emphasised (as in 5c and d) or not emphasised as in 5a and b.

(5) Emphasis spread: voiceless uvular /q/

	Input	**Output**	**Gloss**
(a)	/taqaːð̣aː/	[taqaːð̣aː]	‘to prosecute’
(b)	/ʔalʔaqbaːṭ/	[ʔalʔaqbaːṭ]	‘Catholic Copts’
(c)	/ʔalqað̣aː/	[*ʔalqa*ð̣aː]	‘judgement’
(d)	/naːqað̣at/	[*naːqa*ð̣at]	‘to conflict with’

Looking at these examples, it appears that the uvular /q/ shows two different patterns regarding emphasis blocking. First, in (5a and b), the uvular acts as a blocker since it blocks emphasis from spreading to the syllable beyond, as illustrated below.

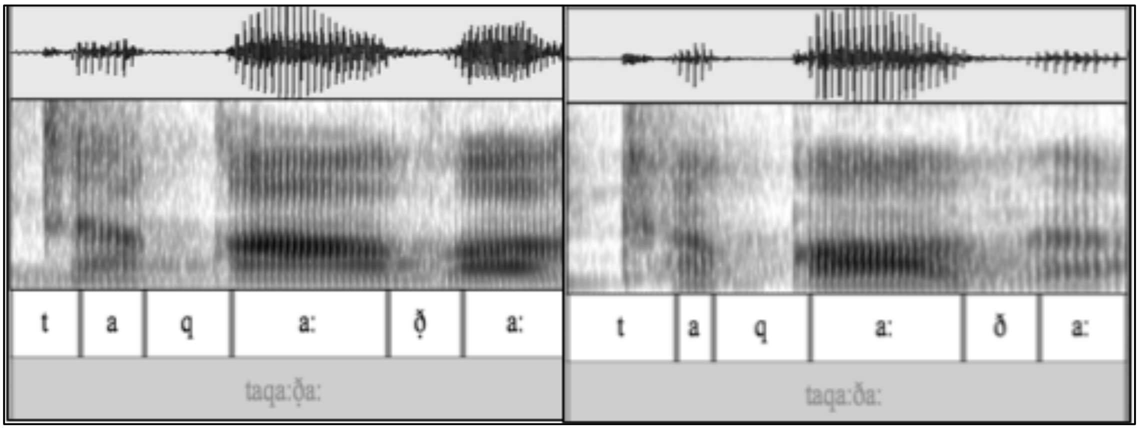


Figure 8.4a: A waveform and a spectrogram of an example realisation for the pair /taqaːð̣aː/ and /taqaːðaː/ by speaker [5].

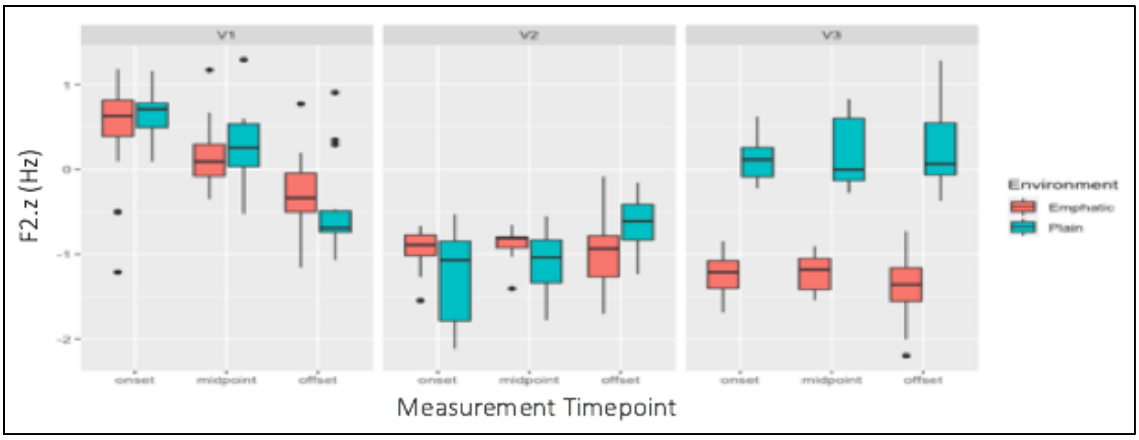


Figure 8. 4b: Boxplot of the distribution of the F2 values in /taqaːð̣aː/ and /taqaːðaː/, depending on the presence of emphasis, vowel adjacency and vowel measurement time point.

Second, in (5c and d), the uvular emerges as an undergoer to the harmonic feature, and thus, emphasis spreads further. This behaviour of the uvular /q/ is shown below.

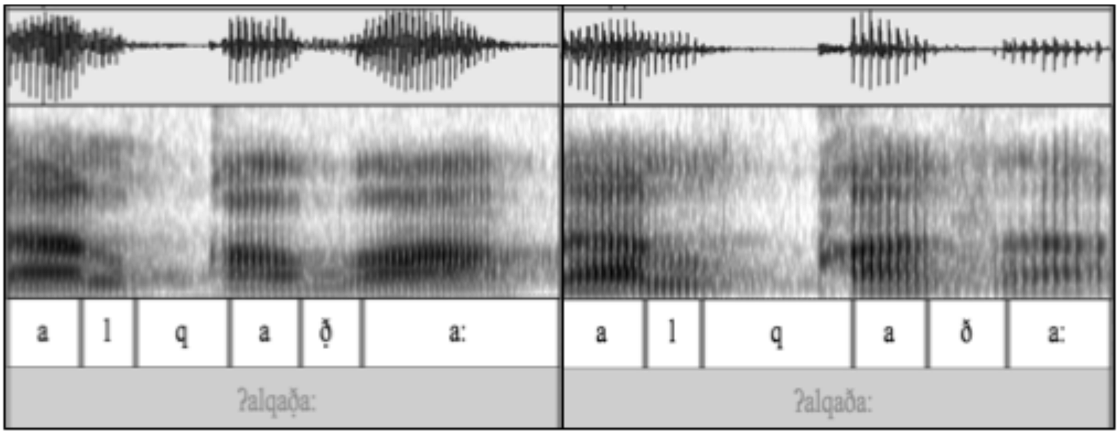


Figure 8.5a: A waveform and a spectrogram of an example realisation for the pair /ʔalqað̣aː/ and /ʔalqaðaː/ by speaker [5].

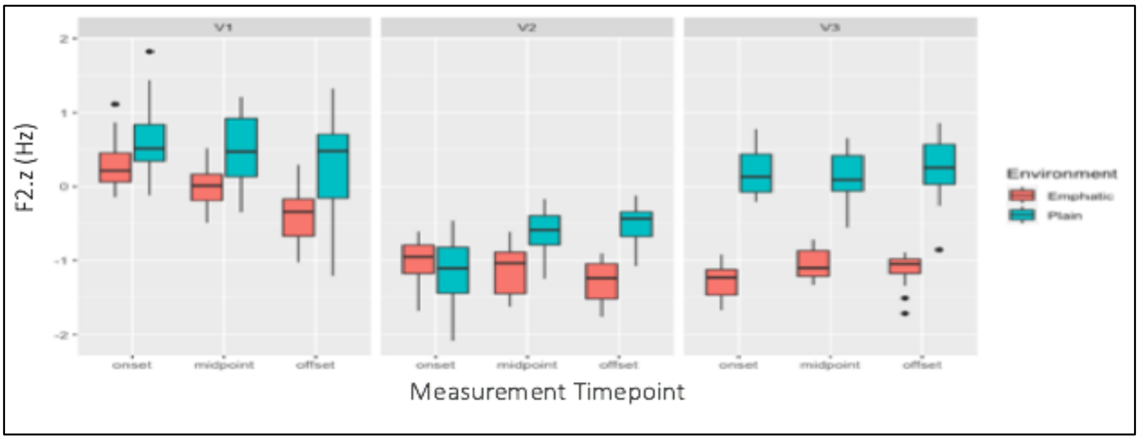


Figure 8. 5b: Boxplot of the distribution of the F2 values in /ʔalqaðˤa:/ and /ʔalqaða:/, depending on the presence of emphasis, vowel adjacency and vowel measurement time point.

After observing all the examples above, one can say that there is no segmental, morphological or directional pattern that could be related to the behaviour of these segments.

8.3 Summary

The velars /g/ and /k/ and the uvular /q/ show different opacity and transparency behaviour from the segments examined in Chapter 7. That is, the velars and the uvular can act as either blockers or undergoers. The effect of the emphatic trigger on the syllables containing these segments and the ones beyond them can be classified into two trends. First, the tautosyllabic vowels with these segments are emphasised except for some examples in the voiced velar /g/ and the uvular /q/ sets such as [ʔalgabðˤah] 'the grip' and [taqa:ðˤa:] 'to prosecute'. Second, the syllables beyond the velars and the uvular vary: these segments either allow emphasis to propagate and affect all neighbouring syllables or they block emphasis from spreading further. This irregularity in the spread behaviour in the presence of these segments did not give rise to a uniform pattern that could explain why these segments behave differently in comparison to other blocking segments.

CHAPTER 9: DISCUSSION, CONCLUSION AND FUTURE WORK

9.1 Overview

As one goal of this study was to comprehend how different acoustic correlates of the trigger emphatics and the surrounding vowels are affected by the presence or absence of emphasis, I investigated both vocalic and consonantal cues. Briefly, the findings in this study show that emphasis in NA can be signalled by different acoustic cues, both consonantal and vocalic. Vowels in emphatic contexts exhibited a significant lowering of F2 compared with vowels in plain contexts. The contrast between plain and emphatic segments was also signalled in the trigger emphatics VOT and the closure durations of stops.

A phonological analysis of the criteria at which the spread of emphasis beyond the syllable is established was conducted to identify the emphasis harmony system in NA and related phonological aspects, such as directionality and domain. My results show that emphasis in NA can spread and colour adjacent segments regardless of the trigger emphatic position within the word. The domain of emphasis was not blocked by morpheme boundaries in which it can extend and affect both prefixes and suffixes except for some cases. In addition, the spread of emphasis in NA was subject to some restrictions in which the iterative spread of emphasis was blocked in the presence of a set of segments, such as /i, u, ʃ, ʤ/. Velars /g/ and /k/ and the uvular /q/ acted differently with regard to emphasis spread; in some cases, they acted as blockers, whereas in others, they were undergoers.

This chapter discusses the findings of this study in detail, as reported in Chapters Four, Six, Seven and Eight, each in a separate section. In each section, I point out how the behaviour of emphatic segments distinguishes the realisation of emphasis in NA from that in other dialects in relevant Arabic literature.

9.2 Discussion

9.2.1 Phonetic discussion

One of the primary purposes of the current investigation was to offer an account of the acoustic correlates of emphasis in NA. To begin with, Chapter Four's findings on the vocalic correlates in NA revealed that emphasis had no effect on vowel duration. This result agrees with our assumptions and previous studies, in which the difference in vowel duration between emphatic and plain contexts was not significant, as in IA (Ali and Daniloff, 1972b), EA (El-Dalee, 1984; Norlin, 1987), GA (Hussain, 1985), various Arabic dialects (Al-Bannai, 2000) and LA (Kriba, 2009).

Supporting the assumption I made earlier in Chapter Four, the results showed that emphasis in NA was consistently represented by a significant lowering of F2 for vowels within emphatic contexts compared with those in plain contexts. This lowering effect on F2 confirmed the findings reported by previous studies, which provide compelling confirmation that F2 is indeed a highly dependable acoustic correlate of emphasis spread in Arabic and its dialects, including LbA (Obrecht, 1968), CrA (Kahn, 1975), TA (Ghazeli, 1977), PA (Card, 1983), EA (Norlin, 1987; Wahba, 1993), MA (Alioua, 1995; Yeou, 1997), Ammani JA (Zawaydeh, 1998, 1999), JA (Al-Masri and Jongman, 2004; Khattab et al., 2006; Al-Tamini and Heselwood, 2011), MSA and four Arabic dialects (YA, Kuwaiti Arabic [KA], JA and MA) (Embarki et al., 2007; Embarki et al., 2011), Urban JA (Al-Masri, 2009; Jongman et al.,

2011) and IA (Hassan and Esling 2011). This acoustic result is primarily related to the combined strictures in emphatic production (for more details, see Section 2.3).

By contrast, the influence of emphasis on F1 and F3 frequencies was not significant eventhough F1 and F3 were higher following emphatics compared with plain consonants. However, there was an exception in the front vowel /i/ contexts. F1 values of the high front vowel were significantly higher in emphatic contexts than in plain contexts. These F1 and F3 results are consistent with some previous findings (Card, 1983; Norlin, 1987; Wahba, 1993; Khattab et al., 2006 [for F1 results only]). My results also showed a pattern contradictory to those reported in other studies, in which significant effects of F1 and F3 were reported (Khattab et al., 2006 [for F3 results only]; Jongman et al., 2007; Kriba, 2004, 2009; Al-Masri, 2009; Jongman et al., 2011; Al-Tamimi and Heselwood, 2011; Aldamen, 2013; Faircloth, 2017).

Besides providing a more plausible account of the effect of emphasis on vowel formants, the analysis also yielded several interesting implications. The first is the effect of the speaker's sex on the production of emphasis in NA. The results showed that the F2 lowering degree was more considerable amongst the female speakers than the male ones. This difference could be related to the relatively low F2 values in emphatic contexts for females compared with those for males. This result agrees with findings from previous studies, which revealed that the lowering degree of F2 in the speech of female speakers is more evident than that in the speech of male speakers (Jordanian Arabic: Al-Masri and Jongman, 2004; Syrian Arabic: Al-Mbark, 2008). However, several researchers have found contradictory results, in which emphasis is more acoustically shown amongst males than females, indicating that male speakers emphasise more than their female counterparts (Lehn, 1968; Kahn, 1975; Ahmad, 1979; Royal, 1985; Wahba, 1993; Haeri, 1996; Khattab et al., 2006). It is thus plausible to say that the effect of sociolinguistic implications, such as sex-related variations in emphasis production, differs from one dialect to another.

Research focusing on emphasis has also shown that VOT plays a reliable role in signalling the plain/emphatic distinction in voiced and voiceless stops (TA: Ghazali, 1977; MA: Zeroual, 1999; YA: AlNuzaili, 1993; LA: Kriba, 2004, 2009; MSA and CA: AlDahri, 2012b; 2013). Such studies have found that the VOT values for /ṭ/ were lower than those for /t/. This is in line with the findings of this study, as I found that the VOT of voiceless emphatic stops was shorter than the VOT in plain contexts. However, this result contradicts the proposal in Ahmed’s (1984) study of SdA, in which the emphatic /ṭ/ had longer VOT values than those in plain /t/ contexts. Moreover, Rifaat (2003) found no significant effect of emphasis on the VOT of stops.

In general, my results seem to reflect the assumptions indicated in Chapter Four, in which VOT confirms the acoustic aspect of emphatic/plain differences in stops. In line with this, various Arabic studies have also provided ample evidence that the VOT of the voiceless emphatic /ṭ/ falls within the short lag category, whereas its plain /t/ has a long-lag VOT (Heselwood, 1996, p. 31; Khattab et al., 2006, p. 135; Abudalbuh, 2011, p. 28). This is in closer agreement with the findings reported in our investigation; that is, we found that the unaspirated voiceless emphatic stop /ṭ/ was associated with shorter VOT values than the mean value of VOT in the context of the aspirated plain /t/. The VOT values of the emphatic stops seemed to be short lags, whereas those of the plain stops were long lags in NA. This difference in VOT is essentially relative to the common physiological configuration of the production of emphatics as characterised by pharyngeal constriction. This leads the voicing to start at the stop release, hence a short VOT lag, whereas for the aspirated plain stop, the voicing starts after the release of the stop, leading to a long-lag VOT.

In fact, I also observed the closure duration for the pair /ṭ/ and /t/ to determine whether the closure duration can function as a key correlate for the emphatic/plain distinction amongst voiceless stops. As my findings showed a decrease in the VOT values for the emphatic /ṭ/, the closure duration was increased in this context. Related to these findings, an inverse temporal correlation was found between VOT and closure duration; that is, in emphatic contexts, longer closure durations coincided with shorter VOTs. In general, this pattern has been found to be consistent with other Arabic dialects, such as YA (AI-Nuzaili, 1993) and LA (Kriba, 2004, 2009). The longer closure duration for the emphatic /ṭ/ seems to be related to the tense secondary articulation of emphasis, in which the pharyngeal constriction causes the occlusion of the stop to last longer than in plain contexts (Bukshaisha, 1985).

The results also showed a trend in which the friction noise duration of plain fricatives was longer than that of emphatic fricatives. Nevertheless, a closer look at the results clearly showed a more irregular pattern, in which male and female speakers revealed differential outcomes. To put it differently, male speakers always produced plain fricatives with longer durations than their emphatic equivalents. The results for female speakers, however, were more complex. The results showed irregular behaviour in which the friction noise duration in the emphatic fricatives in some examples was longer than that in the plain ones. With this irregularity in the results noted, there is good reason to believe that the friction noise duration of fricatives is not a consistent acoustic cue of emphasis in NA.

Moreover, the noise duration in NA can robustly signal the voicing contrast in fricatives. Our results suggested that the differences between the emphatic and plain voiceless fricatives were greater than those of the voiced ones. This observation holds true in previous studies of fricatives, which have suggested that noise durations in voiceless fricative contexts are generally longer than those in voiced contexts (Baum and Blumstein, 1987; Behrens and Blumstein, 1988a; Crystal and House, 1988). The shorter friction noise durations of voiced fricatives could be mainly related to the quantity of air flowing through the oral cavity constriction.

9.2.2 Phonological discussion

This study also examined the phonological aspects of emphasis spread in NA because the vowels' F2 distribution, as shown in Chapter Four, is a strong indicator of phonological emphasis.

The findings in all sets of data reported in my study lead to the proposal that emphasis spread in NA can be categorical, which is the most dominant attested category of emphasis spread. It can be gradient, especially in cases of the palatal /j/ in the prefix /ja-/ and the velar when tautosyllabic with the emphatic trigger. It can also be absent, especially in cases of segments beyond the blockers. This, to some extent, differs from the findings of Zawaydeh (1999) for Ammani Jordanian Arabic. She reported that the emphasis spread category is dependent on the directionality of emphasis spread. To put it simply, progressive emphasis spread is gradient, as the F2 of the vowels adjacent to the trigger emphatic segment appears to be considerably lower than that of the vowels in other neighbouring syllables. By contrast, regressive emphasis spread is categorical, with the F2 of the vowels being equally low regardless of vowel adjacency to the emphatic segment. The gradient nature of emphasis spread has also been reported in previous studies (Al-Masri and Jongman, 2004; Jongman et al., 2011). These studies indicate that the spread of the emphatic feature is gradient, as the emphasis effect persists throughout the entire word, but it weakens when adjacent segments occur farther away from the emphatic consonant.

The main aim of the second part of my study was to offer a thorough account of emphasis and give a better idea of the directionality and domain of emphasis spread in NA. In disyllabic examples, emphasis is shown to spread beyond the syllable. Emphasis in NA spreads and affects both syllables in disyllabic root words, indicating that emphasis extends and colours the entire word. Arabic dialects, however, display differences regarding the domain of emphasis spread. That is why Ali and Daniloff (1972) stated that emphasis spread in IA affects the entire word but could be signalled in a certain number of open syllables (one, two or three). Watson (1999) indicated that the emphasis domain is dependent on the examined dialect; that is, emphasis can either prevail over the entire word, such as in CA, or only affect the vowel adjacent to the trigger emphatic segments, as in Abha Arabic (a dialect spoken in the southern region of SA). Thus, emphasis could be exhibited as a local assimilation process affecting its minimum domain, that is, the syllable, or it could iteratively spread, colouring the phonological word as its maximum domain (Rose and Walker, 2011).

In light of the assessed disyllabic data, we have already seen that emphasis spread does not differ with respect to directionality. Emphasis spread is shown to affect the segments to the right of the trigger (i.e. rightward spreading) and those to its left (i.e. leftward spreading). Emphasis is also shown to apply bidirectionally, targeting all segments in both directions (rightward and leftward). These results agree with Card (1983) in the general pattern displayed for emphasis spread, in which the feature spreads across the entire word, regardless of the spread's directionality.

A central observation that emerges from these cross-dialectal studies is that this segmental opacity effect is only effective in rightward emphasis spread by a set of opaque segments (i.e. [+high, -back]), differing somewhat from one dialect to another, whereas leftward emphasis is absolute, and no segment impedes the spread of the emphatic feature (Card, 1983; Herzallah, 1990; Davis, 1995; McCarthy, 1997; Sakarnah, 1999; Watson, 2002; Al-Masri and Jongman, 2004; Al-Huneety, 2015; Al-Mashaqba, 2015; Slimani, 2018). Nevertheless, some dialects, such as CrA, show emphasis spread unblocked or interrupted by any segments (Youssef, 2013). However, NA exhibits quite a different tendency regarding the behaviour of these blocking segments compared with those in prior studies. To begin with, not all previously mentioned segments function opaquely in the NA harmony system. That is, the opaque interveners in this dialect are the high front vowel /i(:)/, the high back vowel /u(:)/, the palatal /j/, the post-alveolars /d͡ʒ/ and /ʃ/, the voiceless velar /k/ and some examples of both the voiced velar/g/ and one example of the voiceless uvular /q/. The voiced glide /w/, which was reported to block emphasis in the PA dialect, was not a blocker in NA. Emphasis spread in NA starts from the trigger emphatic and propagates the colouring of adjacent segments until it reaches these blockers, which, in turn, blocks emphasis from spreading into segments beyond them.

However, it is important to say that in NA, these blockers, whether vowels or consonants, act differently when they are either syllabified with the trigger emphatics or located in a neighbouring syllable. The vowel blockers themselves, the high front vowel /i(:)/ and the high back vowel /u(:)/, when they are locally adjacent to the emphatic segment within the same syllable, are categorically emphasised. However, when these vowels occur in another adjacent syllable, the front /i(:)/ is not emphasised, whereas the back /u(:)/ is emphasised.

When consonant blockers are present, variances seem to occur depending on the consonant blocker itself. That is, when the consonant blockers were either the voiced and voiceless post-alveolars /d͡ʒ/ and /ʃ/ or the palatal /j/, the local vowel is not emphasised except for the example in which the emphatic trigger is syllabified with the blocker within the same syllable. On the other hand, when the consonant blockers were the velars /g/ and /k/, the uvular /q/ and the glide /w/, the local vowels were all emphasised regardless of the trigger emphatic position to these segments, except for two examples in the uvular's set. In these examples, the local vowels were not emphasised.

Vowels in neighbouring syllables were not emphasised for all these blocking segments except for /g/, /q/ and /w/. The glide /w/ was an undergoer, that is, it was affected by the emphatic feature, and it does not block further emphasis spread. Examples of both the voiced velar /g/ and the voiceless uvular /q/, however, do not show a clearly opaque manner in emphatic spread and interrupting emphasis harmony. Some examples of the velar /g/ and the uvular /q/ show that the vowels in adjacent syllables were all emphasised, whereas in other examples, they were not affected by emphasis. All blocking segments and their behaviour in NA are summarised in Table 9.1 below.

Table 9.1: Summary of all so-called blocking segment behaviours in NA.

Blocking segment	**Behaviour of the blocking vowel/vowel adjacent to the blocking consonant**	**Behaviour of vowels beyond blockers**
/i(:)/	• Emphasised when tautosyllabic with the trigger emphatic, in the prefix /-ʔin/, in the suffixes /-hin/ and some examples of /-ih/ • Not emphasised in other contexts	Never emphasised
/u(:)/	• Not emphasised in consonant-initial suffix /-hum/ • Emphasised elsewhere	Never emphasised
/j, ʃ, dʒ/	• Emphasised when tautosyllabic with the emphatic segment • Not emphasised in other contexts	Never emphasised
/w/	Always emphasised	Always emphasised (i.e. not a blocker)
/g/	Always emphasised[25]	Vary (emphasised in some cases and not in others)
/k/	Always emphasised	Never emphasised
/q/	Vary (emphasised in some cases and not in others)	Vary (emphasised in some cases and not in others)

The blocking of emphasis spread beyond the segments mentioned above arises from the gestural conflict provoked by physiological antagonism with tongue root position that is associated with emphatic articulation (Davis, 1995; Watson, 1999; Algryani, 2014; Jaradat, 2020). The articulation of these blocking segments includes tongue root advancement, which

[25] Except for the example: [ʔalgabð̠ah]

directly opposes tongue root retraction in the production of emphatics, creating same-articulator contradiction. This conflict imposes more limitations on emphasis spread, leading to complete resistance to the iterative spread of emphasis in segments beyond these blockers. Thus, Alwabari (2020) stated that the absence of such physiological antagonism in segments such as labials will permit further emphasis spread. Because these segments do not include any gestural conflict—advanced tongue root or raised dorsal—they are affected by emphatic features spreading from the emphatic trigger, so they exhibit tongue root retraction similar to that of the emphatic trigger. Moreover, NA results show that the back vowel /u(ː)/ acts as a blocker regardless of its low F2 frequencies. This could be related to the low F2 frequencies of the vowel in all contexts, resulting in small differences between plain and emphatic contexts. This compatibility between the articulatory configurations of the back vowels and the emphatics could minimise the effect of emphasis on these vowels and ultimately upsurge coarticulation.

Alwabari also stated that as root retraction identifies emphasis, gestural conflict may result from dorsal raising, advancing the tongue root or a combination of the two. Based on this, the restrictions on segments surrounding the emphatic trigger can be divided into three categories. First, the most restricted segments are those produced by both dorsal raising and advanced tongue root, as in [ʃ, ʒ, j, i]. As a result, this set of segments is not influenced by emphasis spread. The second category includes segments that are produced with dorsal raising only, such as the high back vowel [u], the velars [k, g, x] and the uvulars [q, χ]. As these segments involve only one antagonistic gesture, they are marked as less constrained segments. Therefore, these segments are less affected by emphasis. The third category is correlated with those segments produced without primary dorsal raising, such as [b, θ, n, l]. These segments are therefore not constrained and are likelier to undergo emphasis spread (ibid).

Different researchers have also proposed that feature spread can be confined to a specific direction (Davis, 1995; Watson, 2002; Huneety, 2015). This suggests that languages may exhibit some directional restrictions on harmony application. Arabic dialects, in this matter, exhibit rightward/leftward asymmetry in which emphasis spread may differ regarding its vulnerability to blocking effects. That is, different blocking segments that have been reported previously reveal asymmetric behaviour in which the feature spread is unbounded in one direction and restricted by these blockers in the other, irrespective of the bidirectionality of the process. However, NA shows that these blockers are active in both directions. This tendency agrees with Watson's (1999) hypothesis, which predicts all logical possibilities of emphasis directionality, with NA reflecting the third possibility, which indicates that emphasis spread is bounded in both directions (p. 294).

In NA, the emphatic feature also appears to propagate outward from the root—the innermost morphological constituent of a word. In all cases, the affix vowels basically alternate in agreement with the emphatic feature in the root by lowering their F2 compared with the vowels within plain settings. In light of my data, one observation is that the root-outward harmonic process in NA operates bidirectionally, from right to left (root to prefix) and left to right (root to suffix). However, some affix vowels, particularly the vowel in the prefix /ja-/, alternate harmonically, and the emphatic feature in the root systematically succeeds in affecting the prefix vowel, albeit in a gradient manner. As one can see, the vowel F2 rising is, in fact, observable, and our experiment confirms that the vowel immediately following a palatal glide is indeed more fully fronted than those in other contexts. The articulatory explanation for such a fronting effect is that /j/ is palatal, meaning that the tongue has to be drawn upward, whereas the emphatic entails pulling the tongue back. Consequently, a combination of these tongue positions at the same time is impossible, so the vowel onset particularly seems to acquire a palatal quality.

An extension of the effect of emphasis into the attached affixes is also apparent in other Arabic dialects, such as LA and CrA (Algryani, 2014; Youssef, 2014). In both dialects, morpheme boundaries do not block the propagation of emphasis in either direction—left to right or right to left. These dialects predict no effect of morpheme boundaries on the extension of the emphatic feature, but the data from other dialects show that this absolute spreading pattern may differ. Juffīn JA and Fallaahi JA, for instance, show that emphasis spreads rightward over suffixes only if the emphatic consonant is tautosyllabic with the suffix. Prefix vowels, on the other hand, are not subject to emphasis, even in cases in which the emphatic consonant is syllabified with the target prefix (Al-Huneety, 2015; Jaradat, 2020). However, Al-Mashaqba (2015) reported that morpheme boundaries block the spread of progressive emphasis into suffixes in Wadi Ramm Arabic. Hezallah (1990) and Younes (1993) stated that emphasis on inflectional prefixes is optional, such as in ma/MA-XAṬAb-iʃ/ 'he did not get engaged'. In NA, emphasis iteratively spreads and affects prefixes even when they include high vowels, such as in [ʔin-ṣalaχ] 'got heat rash'. Suffixes, on the other hand, show behaviour similar to that of prefixes in which emphasis spread over the words, except where the consonant-initial suffix includes the high back vowel /-hum/ (third person possessive masc. pl.). Thus, the rightward morpheme boundary in these cases blocks emphasis spread. It is plausible to say that emphasis in NA can freely spread over the leftward and rightward morpheme boundaries, except for the consonant-initial suffix /-hum/.

It should be noted that the examples, including both prefixes and suffixes in NA, comprise both disyllabic and trisyllabic words. However, the word length factor did not show any effect on the iterative spreading of emphasis. That is, emphasis spread in such cases was neither weakened nor blocked as the number of syllables increased. Therefore, one can say that the long-distance spread of emphasis in NA is possible even across morpheme boundaries.

9.3 Conclusion and future work

The findings of the present study showed that emphasis in NA can be signalled by several acoustic features. These features comprise the vowel's F2 which decreases in emphatic contexts compared with that in plain contexts. Moreover, the closure duration and VOT of stops play an important role in differentiating between emphatic and plain consonants. That is, there is an inverse correlation between the closure duration and the VOT of an emphatic voiceless stop, in which a longer closure duration in an emphatic context is associated with shorter VOT values. On the other hand, other cues showed no effect on emphatic/plain distinction, such as the vowel duration, the vowel's formant frequencies F1 and F3 and friction noise of fricatives.

This study also examined emphasis spread in NA from a phonological point of view. Emphasis in NA was found to spread over the phonological word, showing no asymmetrical behaviour regarding the feature spread direction. Even though blocking segments were deducted in the NA emphasis system, these segments appear to apply similarly in rightward and leftward emphasis spread. The blocking behaviour of these segments can be related to the featural specification (i.e. [+high, -back]), which is opposite to the emphatic feature that interrupts and blocks the path of the spreading feature. The domain of emphasis in NA also extends and spreads across morpheme boundaries, colouring both prefixes and suffixes. The extension of emphasis over the morpheme boundary was found regardless of differences in word length.

Regardless of the diversity of the results obtained in the present study, several areas of research are worthy of consideration and deserve further examination. Over the last 60 years or so, various previous studies of emphasis have largely focused on its articulatory configurations (e.g. Al-Ani, 1970; Ghazeli, 1977; Zawaydeh, 1999; Alwabari, 2020). A wide variety of instrumental techniques has been used, and more recently, imaging techniques, including magnetic resonance imaging, have been applied to the studies, but all these techniques often cover a much broader range of comparative goals. As mentioned in Chapter Two, despite the use of these advanced techniques, most of the literature available shows a lack of consensus and wide variations in the exact nature of the production of emphatics, particularly of secondary articulation. Al-Nassir (1993) concluded that the secondary articulation of emphatics was velar, and McCarthy (1994) believed that uvularisation best displayed the physiological features of the secondary constriction of emphatics. Most recent research has suggested that the constriction included in the production of emphatics is more posterior; therefore, it has been found to be consistent with pharyngealisation (Al-Masri and Jongman, 2004; Al-Tamimi et al., 2009). These variations in the articulatory exponent of emphasis could be related to differences in the degree of constriction and larynx height (Hassan and Esling, 2007). More recent studies have shown that the common belief that plain and emphatic consonants share the same primary articulation is not very accurate (Al-Tamimi and Heselwood, 2011; Hermes, 2014). That is, the primary place of articulation of emphatics is more posterior than that of plains. Such phonetic variations attested to in the literature can help shed further light on the articulatory variability of consonants in many Arabic dialects and may prove that emphasis is a dialect-specific feature. Furthermore, one should always remember that the differences amongst Arabic dialects regarding the identification of emphatics and the behaviour of the segments in their vicinity prove that every dialect has its own system. These intriguing variances and inconsistencies, which are fundamental to achieving a full and deep understanding of the nature of emphatic segments, must await further examination. To provide a dependable understanding of the nature of emphasis and its spread, future research is needed on the articulation of emphatics in NA.

Furthermore, based on the results of the present study, in NA, emphasis can colour all vowels in the vicinity of the emphatic consonant within multisyllabic words and even across morpheme boundaries. These results have been noted in previous works on emphasis harmony. As a consensus on the domain of emphatic spread is still lacking (see Al-Ani, 1970; Laufer and Baer, 1988; Davis, 1995; Zawaydeh, 1999; Shahin, 2002; Al-Katib, 2008; AL-Masri, 2009, etc.), some cross-dialectal studies have proposed that the domain of emphasis could extend beyond the phonological word. That is, even though the probability of emphasis spread is more common within a phonological word, the emphatic feature can also spread across word boundaries (Bukshaisha, 1985; Adra, 1999). In Cairene Arabic, for instance, emphasis is claimed to extend to adjacent words when a word-initial emphatic is adjacent to a homorganic plain coronal at the right edge of a preceding word, as exemplified in Table 9.2 below.

Table 9.2: Examples of emphasis spread across word boundaries in Cairene Arabic

Example	**Gloss**
ɣatit # tˤaħn	very unpleasant
balad # dˤaiʕa	a lost country

With such cases being rarely observed in the Arabic literature, whether this pattern is also applicable in NA should be explored. Under the same condition, examining what might be called the *mirror pattern*, in which emphasis might spread rightward across word boundaries, is also possible. Even beyond this condition, the maximal span of the emphatic feature should be explored. This would help define more precisely the domain of the process by examining the domain of emphasis across the word boundary in which the emphatic consonants are located in different positions: initial, medial and final. In this examination, one should avoid all possible so-called opaque segments, which show resistance to the further propagation of emphasis, to avoid any possible effect compatible with emphatics and so that no segment in any way impedes the process of emphasis spread. Alongside the data in this thesis, some pilot data about emphasis spread across word boundaries have been collected, and it seemed that there is something interesting regarding the maximal extension of the emphasis domain.

Also needed is an analysis that derives the acoustic and articulatory properties of the velars /g, k/ and the uvular /q/. Taking steps in this direction may yield some developments in the interpretation of the diverse behaviour of these segments in emphatic contexts, as making accurate predictions regarding the outcomes of the present study without more detailed studies of the behaviour of these segments is difficult. Therefore, acoustic and articulatory studies of these segments seem warranted. In future work, lists should be designed to determine the nature and the possibly affected domain of these back segments in NA. In the same vein, the outcomes of these studies may shed new light on the reasons for the variances reported in the present study. Furthermore, analysis of the behaviour of these segments in environments that do not include emphatics could show the precise mechanism of these segments without the influence of the harmonic feature. In this case, understanding the phonetic realisation of these segments and affording a more comprehensive view of whether their effect on adjacent vowels would extend beyond and potentially prevail over one or more syllables, regardless of whether the segments are word-initial, word-medial or word-final, would be possible.

Despite the considerable progress made over the last several years in the research of emphasis spread, covering such a vast topic in a single study remains difficult. Still, this work has sought to elucidate the key contributions of the present comprehensive investigation to the literature on emphasis harmony.

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APPENDIX 1

(a) Emphasis spread: Monosyllabic wordlist

Emphatic segments	Gloss	Plain segments	Gloss
/ṣad/	to avoid	/sad/	to close
/ṣaːd/	to hunt	/saːd/	to obstruct sth
/ṣid/	to prevent	/sid/	to block
/ṣiːħ/	to cry	/siːħ/	to melt
/ṣuf/	pictures	/suf/	to eat
/ṣuːf/	wool	/suːf/	to sponge
/ṭaf/	being used to	/taf/	to spit
/ṭaːb/	to heal	/taːb/	to repent
/ṭib/	medicine	/tib/	to forsake
/ṭiːn/	mud	/tiːn/	figs
/ṭuf /	to get used to	/tuf/	to spit
/ṭuːb/	red chalk	/tuːb/	to forsake
/ð̣al/	to get lost	/ðal/	to be frightened
/ð̣aːl/	aberrant	/ðaːl/	afraid
/ð̣il/	shadow	/ðil/	fear
/ð̣iːʕ/	get lost	/ðiːʕ/	to announce
/ð̣um/	to hug	/ðum/	nonsense word
/ð̣uːg/	encompassed	/ðuːg/	to taste

(b) Emphasis spread: Disyllabic wordlist

Example no.	Trigger consonant position	Emphatic example	Gloss	Plain example	Gloss
1	initially	/ṭamas/	to be erased	/tamas/	nonsense word
2	initially	/ṣaraf/	to spend	/saraf/	nonsense word
3	initially	/ð̣alam/	to persecute	/ðalam/	nonsense word
4	medially	/baṭar/	to show excessive arrogance	/batar/	to cut off
5	medially	/gaṣab/	cane	/gasab/	nonsense word
6	medially	/ħað̣ar/	to forbid	/ħaðar/	caution
7	finally	/laggaṭ/	to collect	/laggat/	to give
8	finally	/χallaṣ/	to finish	/χallas/	nonsense word
9	finally	/ħafað̣/	to memorise	/ħafað/	nonsense word

(c) Emphasis spread into prefixes: Wordlist

Prefix type	Emphatic example	Gloss	Plain example	Gloss
3rd-person masculine singular present-tense verb form I	/ja-bṭir/	he shows off	/ja-btir/	he cuts off
3rd-person masculine singular present-tense verb form I	/ja-rʕaṣ/	he squeezes	/ja-rʕas/	nonsense word
masculine singular colour adjective	/ʔa-ṣfar/	yellow	/ʔa-sfar/	brighten up
1st-person singular present-tense verb form I	/ʔa-rʕaṣ/	I press	/ʔa-rʕas/	nonsense word
passive verb form VII	/ʔin-ṣalaχ/	got heat rash	/ʔin-salaχ/	being flayed
passive verb form VII	/ʔin-ʕaṭaː/	he was given (sth)	/ʔin-ʕataː/	nonsense word
2nd-person feminine singular present-tense verb form I	/ta-ṣlaχ/	she peeled off	/ta-slaχ/	she has exuviated
2nd-person feminine singular present-tense verb form I	/ta-ħð̣ar/	she attended	/ta-ħðar/	she was cautious
1st-person plural present-tense verb form I	/na-ṭbaʕ/	we print	/na-tbaʕ/	we follow
1st-person plural present-tense verb form I	/na-rð̣aχ/	we obey	/na-rðaχ/	nonsense word
definite article of a noun	/ʔal-raṣṣ/	compact (n)	/ʔal-rass/	a city in Al-Qassim Province

(d) Emphasis spread into suffixes: Wordlist

Suffix type	Emphatic example	Gloss	Plain example	Gloss
3rd-person feminine plural pronoun	/ṣanaʕ-hin/	he made them	/sanaʕ-hin/	their skilfulness
3rd-person feminine plural pronoun	/ṭaraf-hin/	their sides	/taraf-hin/	their wealth
3rd-person masculine plural pronoun	/ħaṣar-hum/	he counted them	/ħasar-hum/	nonsense word
3rd-person masculine plural pronoun	/ð̣alam-hum/	he persecuted them	/ðalam-hum/	nonsense word
singular feminine marker	/ṣaχχan-at/	she had a fever	/saχχan-at/	she heated up
2nd-person masculine singular pronoun	/ṣabb-ik/	your pouring (i.e. the way you pour sth)	/sabb-ik/	he insulted you
2nd-person masculine singular pronoun	/baṭn-ik/	your stomach	/batn-ik/	nonsense word
1st-person plural pronoun	/ballaṭ-na:/	we paved	/ballat-na:/	she dampened us
1st-person plural pronoun	/ṣaffar-na:/	we whistled	/saffar-na:/	he sent us away
sound feminine plural form	/ṣabb-a:t/	concrete cast	/sabb-a:t/	insults
sound feminine plural form	/maṭa:r-a:t/	airports	/mata:r-a:t/	nonsense word
3rd-person masculine singular	/ṣabb-uh/	he poured it	/sabb-uh/	he insulted him
singulative feminine marker	/baṣm-ih/	fingerprint	/basm-ih/	a smile
singulative feminine marker	/ħaṣa:n-ih/	immunity	/ħasa:n-ih/	nonsense word

(e) Blocking segments of emphasis spread in NA: Wordlist

Opaque segment	Emphasis spread direction	Emphatic example	Gloss	Plain example	Gloss
/i(:)/	rightward	/ṣifah/	a feature	/sifah/	to ignore
	rightward	/ṭabi:bah/	a doctor	/tabi:bah/	nonsense word
	rightward	/ð̣ali:lah	Shady	/ðali:lah	submissive
	bidirectional	/ʕa:ṣifah/	a storm	/ʕa:sifah/	nonsense word
	leftward	/na:fið̣/	to dust off	/na:fið/	infiltrative
	leftward	/χara:bi:ṭ/	nonsense/crap	/χara:bi:t/	nonsense word
	leftward	/fara:ʔið̣/	duties	/fara:ʔið/	nonsense word
	leftward	/ʔalriba:ṭ/	knee ligament	/ʔalriba:t/	nonsense word
/u(:)/	rightward	/ṭubbah/	jump it	/tubbah/	nonsense word
	rightward	/ð̣urrah/	fellow wife	/ðurrah/	nonsense word
	rightward	/ṣabu:rah/	patient	/sabu:rah/	nonsense word
	bidirectional	/masṭu:rah/	being hit	/mastu:rah/	being screened
	bidirectional	/ma:ṣu:rah/	a pipe	/ma:su:rah/	nonsense word
	leftward	/marbu:ṭ/	tied up	/marbu:t/	nonsense word
/ʃ/	rightward	/ṭannaʃat/	she ignored	/tannaʃat/	nonsense word
	bidirectional	/ʕaṭʃa:n/	thirsty	/ʕatʃa:n/	nonsense word
	bidirectional	/naʃṭaħ/	we exceed	/naʃtaħ/	nonsense word
	leftward	/naʃa:ṭ/	exercise	/naʃa:t/	nonsense word
	rightward	/ð̣aja:ʕ/	loss	/ðaja:ʕ/	nonsense word

/j/	rightward	/ṭajbah/	a name of a city: Medinah	/tajbah/	nonsense word
	leftward	/ha:jaṭ/	haughty	/ha:jat/	nonsense word
/dʒ/	rightward	/ṭandʒah/	a city in Morocco	/tandʒah/	nonsense word
	rightward	/ṣa:dʒatna:/	our baking tin	/sa:dʒatna:/	nonsense word
	bidirectional	/ʔadʒhað̣at/	she miscarried	/ʔadʒhaðat/	nonsense word
/w/	rightward	/ṭawa:f/	circumambu-lation	/tawa:f/	nonsense word
	leftward	/ʔalwasaṭ/	the centre	/ʔalwasat/	nonsense word

(f) Blocking segments of emphasis spread in NA: Voiced velar /g/ wordlist

Emphatic example	Gloss	Plain example	Gloss
/ṭangarah/	to be angry	/tangarah/	nonsense word
/ʔalga:fṭah/	someone alerts to notice	/ʔalga:ftah/	nonsense word
/ʔalmgallaṭ/	dining room	/ʔalmgallat/	nonsense word
/ṣargaʕah/	noise	/sargaʕah/	nonsense word
/laṣgatna:/	our plaster	/lasgatna:/	nonsense word
/ʔalgarṣa:t/	pinches	/ʔalgarsa:t/	nonsense word
/ʔalganna:ṣ/	sniper	/ʔalganna:s/	nonsense word
/ʔalgað̣a:/	judgement	/ʔalgaða:/	nonsense word
/ʔalgabð̣a:t/	the grips	/ʔalgabða:t/	nonsense word
/ʔalgabð̣ah/	the grip	/ʔalgabðah/	nonsense word

(g) Blocking segments of emphasis spread in NA: Voiceless velar /k/ wordlist

Emphatic example	**Gloss**	**Plain example**	**Gloss**
/ṣakkatha:/	she hit her	/sakkatha:/	he shut her up
/ra:kað̣at/	to run	/ra:kaðat/	nonsense word
/ð̣aħħakatha:/	she made her laugh	/ðaħħakatha:/	nonsense word
/ʔalka:ð̣im/	restraint	/ʔalka:ðim/	nonsense word
/ʔalmakð̣u:m/	distressed	/ʔalmakðu:m/	nonsense word
/tara:kað̣aww/	they ran	/tara:kaðaww/	nonsense word
/ʔalmra:kað̣/	running	/ʔalmra:kað/	nonsense word

(h) Blocking segments of emphasis spread in NA: Uvular /q/ wordlist

Emphatic example	**Gloss**	**Plain example**	**Gloss**
/taqa:ð̣a:/	to prosecute	/taqa:ða:/	nonsense word
/ʔalqað̣a:/	judgement	/ʔalqaða:/	nonsense word
/na:qað̣at/	to conflict with	/na:qaðat/	nonsense word
/ʔalʔaqba:ṭ/	Catholic Copts	/ʔalʔaqba:t/	nonsense word