The phonetics and phonology of assimilation and gemination in Rural Jordanian Arabic

by

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Abstract

This dissertation explores the phonetics and phonology of voicing and emphatic assimilation across morpheme boundaries and investigates gemination word-medially and word-finally in Rural Jordanian Arabic (RJA).

The results reveal that assimilation across morpheme boundaries behaves differently from assimilation across word boundaries in RJA. Vowel duration and vowel F1 were found robust parameters to indicate voicing assimilation. Similarly, F1, F2, and F3 were also adequate correlates to indicate emphatic assimilation. Phonologically, assimilation is best accounted for through the Sonority Hierarchy, Notion of Dominance, and Obligatory Contour Principle. For gemination, consonant as well as vowel durations were found robust acoustic correlates to discriminate geminates from singletons. Phonologically short vowels in the geminate context are significantly shorter than those in singleton context, while phonologically long vowels in geminate context are significantly longer than those in singleton context. The results indicate that the proportional differences between geminates and singletons based on word position and syllable structure are significantly different. Geminates word-medially are one and a half times longer than geminates word-finally. It has also been found that there is a temporal compensation between geminate consonants and the preceding vowels. Phonologically, geminates are best accounted for through prosodic weight rather than prosodic length.

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Dedication

This dissertation is dedicated to the soul of my mother, who always waited impatiently for my graduation, and to my father for his endless encouragement and love.

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Abbreviations

BJA	Bedouin Jordanian Arabic
Con	Consonant
Cons.	Consonants
F1	First Formant Frequency
F2	Second Formant Frequency
F3	Third Formant Frequency
Hz	Hertz
JA	Jordanian Arabic
Ms	Millisecond
MSA	Modern Standard Arabic
OCP	Obligatory Contour Principle
RJA	Rural Jordanian Arabic
SPE	Sound Pattern of English
UJA	Urban Jordanian Arabic

Chapter One

1. Introduction

This dissertation investigates the phonetics and phonology of Rural Jordanian Arabic (henceforth RJA), focusing on patterns of assimilation and gemination. This study investigates the full extent of assimilation across morpheme boundaries in terms of voicing and emphasis, and the full extent of gemination word-medially and word-finally in an understudied variety of Arabic, RJA, a Levantine dialect spoken by village dwellers in the north part of Jordan. This work will contribute to the literature of the phonology and typology of Arabic dialects in general and Jordanian Arabic dialects in particular. More particularly, it will bridge a gap in the literature concerning voicing assimilation, emphatic assimilation as well as gemination.

Assimilation and gemination have received a good amount of attention in the literature on Spoken Arabic in general. However, for assimilation across morpheme boundaries (between bound morphemes and stems), this attention is nearly completely limited to the study of the assimilation of the definite article (Elramli, 2012; Heselwood and Watson, 2013; Benyoucef and Mahadin, 2013; Youssef, 2013). Similarly, little is known about the phonetic realization of geminate-singleton contrast in Jordanian Arabic, to the best of my knowledge. Most studies have investigated gemination word-finally (Al-Tamimi, Abu-Abbas, and Tarawneh, 2010; Abu-Abbas, Zuraiq and Abdel-Ghafer, 2011).

In this dissertation, I adopt the view that phonetics and phonology operate in tandem, and that they should be integrated and combined as they complement each other. The rationale behind this view in this work is to deal with assimilation and gemination in a comprehensive manner: investigating them phonetically as well as phonologically, which gives the present study more value. Ohala (1990) metaphorically describes the inseparability of phonetics and phonology as studying chemistry and biology in molecular biology. He also refers to phonology as the 'software' which drives the act of speech, since it includes the 'mental representations' of words and the knowledge speakers have of the relationships between words, and describes phonetics as the 'hardware' which 'implements the control signals from the phonological component' (cf. Zawaydeh, 1999). He lists the following two merits of combining phonetics and phonology when studying a language phenomenon. First, a sense of simplicity can be achieved when employing both phonetics and phonology in language study. This sense of simplicity can be achieved through investigating and accounting for phonological processes phonetically. One example he provides is accounting for stop devoicing and the affrication of stops before high vowels and diphthongs using aerodynamic factors. The second advantage is that phonological hypotheses can be tested empirically provided that phonetics and phonology are integrated and employed. Therefore, it is good to further investigate assumptions in phonology phonetically (Zawaydeh, 1999). Kingston (2007) also asserts that phonetics interfaces with phonology in three domains. First, distinctive features are defined using phonetic terms. Second, many phonological patterns have phonetic grounding. Third, phonological representations are needed for phonetic research. Therefore, the results of the study are treated and processed first phonetically and acoustically and then are explained in light of the non-linear phonology approaches.

Based on the discussion above on the importance of couching language study phonetically and phonologically, in this study I investigate voicing and emphatic assimilation as well as gemination phonetically to see what phonetic properties they may exhibit, and then these properties are discussed phonologically using current and widely used phonological frameworks, i.e., autosegmental theory and moraic theory.

The importance of the current study is fourfold. First, RJA is an understudied variety of Arabic, which appears to display different phonetic properties from other Arabic varieties, including Urban Jordanian Arabic and Bedouin Jordanian Arabic. Second, this is the first study to acoustically analyze Arabic assimilation across morpheme boundaries in a comprehensive manner, investigating several different morphemes and not just the definite article and using different acoustic correlates. Third, it acoustically analyzes gemination word-medially and word-finally, using different durational acoustic correlates and using all the consonants of RJA. Finally, the acoustic and phonetic findings are explained within the current nonlinear phonological approaches.

One of the goals of this study is to compare the similarities/differences between RJA (based on the findings of the current study) and other Arabic dialects, especially in the Levantine region (based on the findings of the published studies in the literature) in terms of assimilation and gemination. This helps us to draw a better picture of the dialect phonetic differences and to check whether these phonetic differences are more prominent within or outside the same geographical areas. The anticipated similarities and differences will be based on acoustic analysis. Thus, the current study seeks answers to the following questions:

1. Do voicing assimilation and emphatic assimilation across morpheme boundaries behave like assimilation across word boundaries?
2. Does RJA have unique phonetic properties that are not shared with other spoken Arabic dialects in terms of voicing and emphatic assimilation?
3. In what positions does RJA contrast geminates with singletons? And is there a temporal compensation between consonant duration and the preceding vowel duration?

The motivation for the study comes from my observation that some Rural Jordanian Arabic speakers tend to spell out assimilation between consonants across morpheme boundaries in computer-mediated communications on the social media in Romanized Arabic. For example, they would assimilate the definite article '*ʔil*' to a following fricative phoneme like 's' in a word like *salam* 'peace' and write it as *is-salam* 'the peace', or even when they code-switch between the Arabic definite article *ʔil* and English lexical words on computer-mediated communications in a word like 'el-security' and write it as 'essecurity', meaning 'the security' (see Al-Deaibes, 2016). They also tend to double/duplicate a consonant when it is geminated to tell the reader that it is a geminated version of a singleton consonant to avoid confusion of meaning. For example, the word *badal* 'exchange.N' is contrasted with the word *baddal* 'exchange.V' by doubling the letter /d/ to show that it is a verb not a noun.

The dissertation is comprised of seven chapters and is organized as follows. In the current chapter, I show the importance of investigating assimilation and gemination from the point of view of the relationship between phonetics and phonology. Then, I introduce the phonological frameworks that I am following to explain the phonetic results of assimilation and gemination. Finally, I shed some light on the Jordanian Arabic dialects with special emphasis on the dialect under investigation.

Chapter two is dedicated to the vowel and consonant inventory in RJA. It also compares/contrasts the RJA vowels and consonants with those in Modern Standard Arabic (MSA) and shows how vowels shifted overtime. In this chapter, I also examine whether the diphthongs in MSA have undergone monophthongization in RJA, and I investigate whether this phenomenon is allophonic or phonemic. Then, I briefly introduce some phonological processes in RJA, e.g., epenthesis, metathesis, syncope, and word stress. Finally, I provide and a brief overview of the morphology of RJA.

Chapter three is dedicated to the methods used in collecting and analyzing the data. It describes the speech material used in the study for both assimilation and gemination, gives some information about the participants from whom I collected the data, and describes the research ethics followed for the data collection. It, then, shows how the data is collected and how it is analyzed acoustically. Finally, I give an explanation of the statistical analysis used in the dissertation.

Chapter four discusses voicing assimilation. In this chapter, I provide some background on assimilation in Arabic as well as the most relevant literature pertaining to voicing assimilation. Later, I present the acoustic correlates that will be used in the experiment. I present the voicing assimilation results. I show how voicing assimilation across morpheme boundaries as contrasts with assimilation across word boundaries, and I also use acoustic measurements to support my results and to avoid making the study impressionistic. After presenting the results of the experiment, I explain the results phonologically and compare and contrast my results with other published work on voicing assimilation.

In chapter five, I give a brief background on emphatic assimilation followed by an overview of the acoustic correlates adopted in the experiment. Then, I present emphatic assimilation results. I also show that emphasis should be taken into consideration when investigating assimilation in Arabic. I acoustically show that emphasis does take place in RJA assimilation across morpheme boundaries and discuss the most salient acoustic correlates to examine emphatic assimilation in RJA. I also show that my results are different from those conducted on emphatic assimilation across word boundaries.

Chapter six deals with gemination word-medially and word finally. In this chapter, I give an introduction of gemination followed by relevant work on consonant gemination. Later, I present the acoustic correlates that will be used in the experiment. Then, I examine the durational acoustic correlates on gemination and conclude with which is the most salient acoustic correlate to be adopted when investigating gemination in RJA. Finally, I show that gemination does exist and that it is phonemic in RJA, and I investigate the controversy in the literature whether there is gemination word-finally in RJA.

Chapter seven is dedicated to the discussion of the results of assimilation and gemination findings in comparison with the results drawn from other studies on other dialects. This chapter also summarizes and discusses the overall results of the experiments.

1.1 Theoretical frameworks

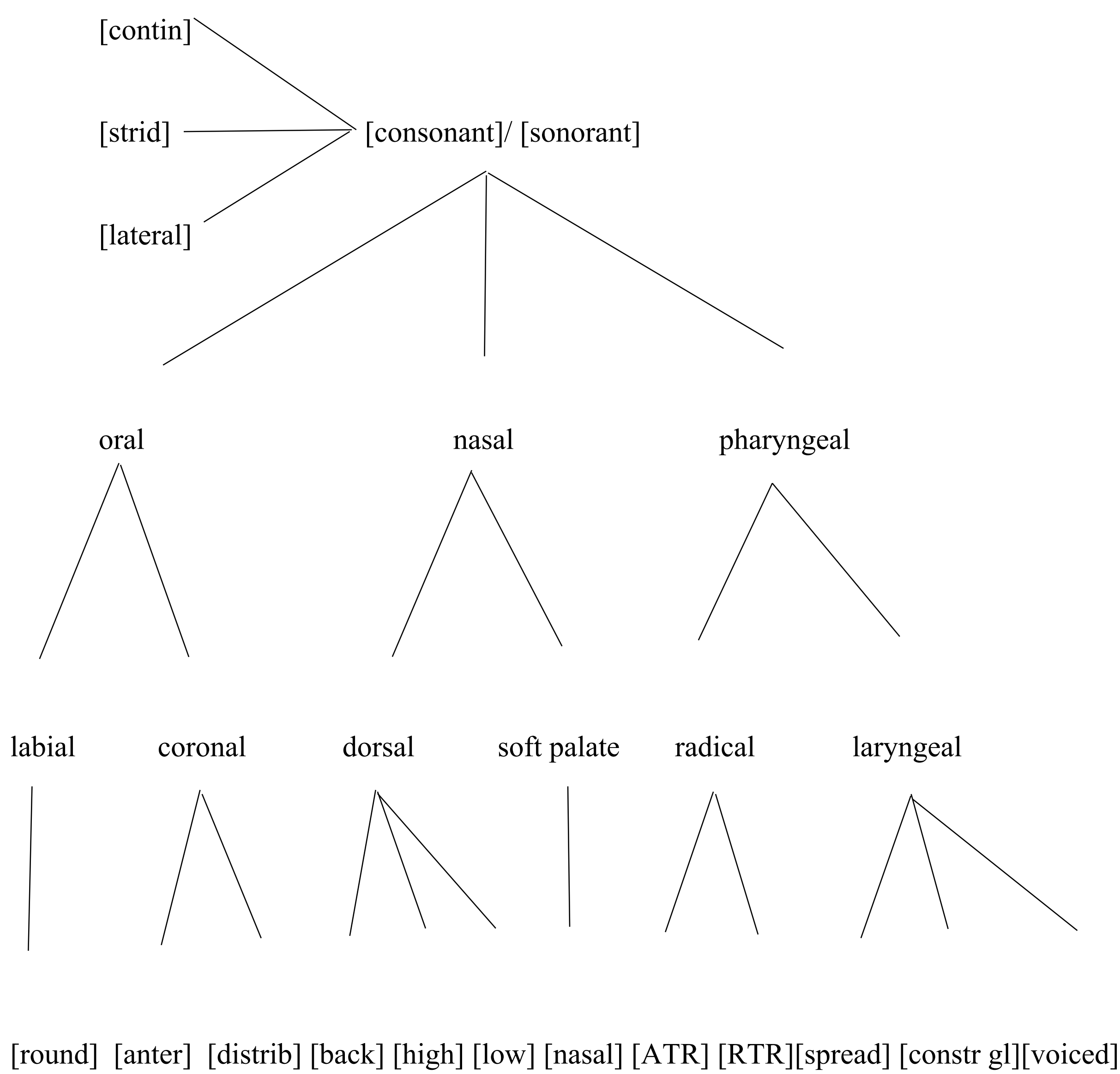
In this section, I briefly present the primary frameworks of non-linear phonology, i.e., autosegmental phonology (Goldsmith, 1976), Feature Geometry (Clements, 1985; McCarthy, 1988), and Moraic theory (Hyman, 1985; McCarthy and Prince, 1986; Hayes, 1989) for the representation of assimilation and gemination and provide the relevant assumptions that will be adopted in this dissertation.

1.1.1 Autosegmental theory and feature geometry

Autosegmental theory was proposed by Goldsmith (1976) in his dissertation and has been adopted and argued for by other linguists (Clements, 1976; 1985a; Kiparsky, 1981; McCarthy, 1986; Odden, 1988; Goldsmith, 1990; Odden, 1994; Myers, 1997) as a result of the Sound Pattern of English (SPE) Chomsky and Halle, 1968) model's failure and inappropriateness to account for the suprasegmental phenomena. Autosegmental theory is primarily a nonlinear model that treats features independently, not as if they were grouped together in segments, and it allows features to overlap, and thus, features are organized as autosegments associated with nodes to consonants (Cs) and vowels (Vs). This model focuses on stress, tone, nasal harmony, vowels, etc., and goes beyond manner and place of articulations. According to this model, each autosegmental tier contains a sequence of autosegments that are organized linearly, and different features are placed on separate tiers that are organized by association lines. These features are organized under subordinate nodes called 'class nodes' that are dominated by another upper class node called 'root node'. The class node entails the laryngeal nodes, supralaryngeal nodes, place nodes, and manner nodes. The root node is linked to the CV-tier (Clements, 1985). According to Mahadin and

Bader (1996), this kind of organization triggers association and dissociation of lines and features to take place at different tiers, and that the spreading of the root node results in a total assimilation, and the spreading of place nodes results in homo-organic clusters (p. 90). The following Figure (1) illustrates one possible alternative for the organization of the tiers in this model.

Figure (1): Distribution of features (Kenstowicz, 1994: 146)



According to Figure (1) above, any node that is an independent object is called 'autosegment' and is represented on its own tier and includes a set features. Goldsmith, (1990) describes it as 'each tier itself consists of a string of segments but the segments on each tier differ with regards to what features are specified in them (p. 8).' The distribution of features in Figure (1) above can be explained through Feature Geometry (Clements, 1985; Halle, 1992), which grew out of the autosegmental theory. In Feature Geometry, features act as units and some features are dependent on other features. For instance, the features [distributed] and [anterior] are compatible with coronals but not velars or labials, and in assimilation processes, certain spreading features are contingent on the presence of features shared between the trigger and the undergoer (Cole, 1987, cited in Watson, 2002: 24). For example, in the words [green beans] the [n] becomes [m] when followed by the labial [b] because the trigger [b] and the undergoer [n] are both [+anterior], which is a shared feature. The distinctive features within this model are organized in a hierarchical manner and forming a natural class. The top root node includes the major class features [consonants] and [sonorants] which classify sounds into vowels vs. consonants and obstruents vs. sonorants. Right below the root node lies the cavity specification which includes oral, nasal, and pharyngeal, where the constriction is formed. The major articulators, labial, coronal, dorsal, soft palate, radical, glottal, are grouped under the cavity specification and different terminal features are dependent on these major articulators.

Watson (2002:25) proposes that the features and the feature values should meet the following criteria, and she also proposes a feature geometry tree for Arabic as shown in Figure (2) below.

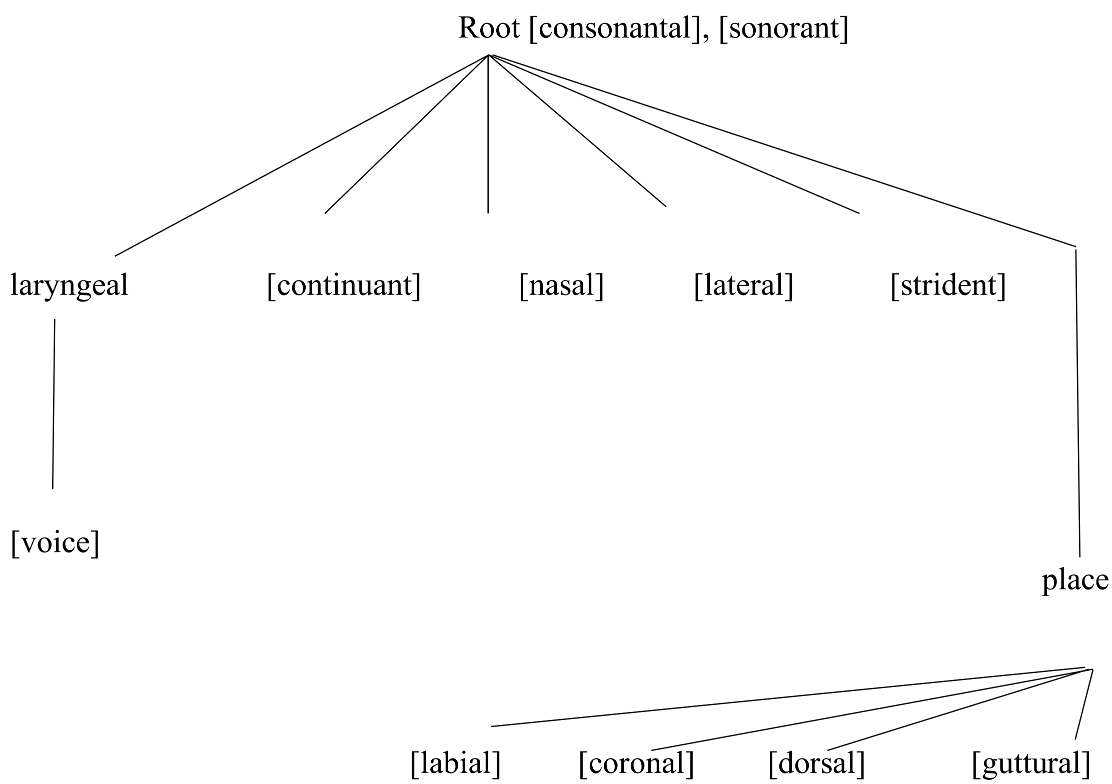
(1). Phonological features are articulatorily appropriate.

(2). Phonological features and the relationships between phonological features are sufficient to distinguish all the phonemes in the language.

(3). Phonological features are sufficient and necessary to account for phonological processes in the language.

(4). The inventory of phonological features in a language is minimally redundant.

Figure (2): Feature geometry tree for Arabic (Watson, 2002: 25)



Watson (2002) describes this organization of features as follows. The laryngeal node and the place node are not enclosed in square brackets because they are structural organizational nodes, and they cannot be terminal nodes because they do not have any phonetic content. The structural organizational nodes, according to McCarthy (1988), play no role in the feature geometry because they do not have any phonetic content. Any node that does not have dependent nodes is considered a terminal node that must have phonetic content. Nodes which are dominated are referred to as daughter nodes while the dominant nodes are referred to as mother nodes.

In this dissertation, I adopt the *Notion of Dominance* model (the property that makes linguistic units survive) proposed by Mohanan (1993) to account for the emphatic as well as the voicing assimilation. The essence of this models is that the dominant unit resists the forces to alter its properties. According to Mohanan (1993), an assimilatory situation is one in which two units have 'conflicting specification' and the specification of one unit dominates, and therefore overrides that of the other. He also provides this example for clarification. In /mk/ →/ŋk/, the specification [+back, -ant] dominates and overrides the specification [-back, +ant]. When the specification of X overrides the specification of Y, X is the trigger and Y is the undergoer (p. 89). Dominance is manifest in a number of areas: certain phonological features are more dominant than others: [sonorant] is a weak feature, for example, and the target of assimilation is usually the more sonorous consonant. Conversely, the trigger is the less sonorant consonant, and sonorants rarely trigger assimilation (Watson, 2002: 214). According to Mohanan, the features [-coronal], [-anterior], and [+back] are dominant because they are marked values while [+coronal], [+anterior], and [-back] are not because the latter are unmarked values, and, accordingly, he provides the following dominance scale (1).

(1). Dominance scale (Mohanan, 1993)

Least dominant				Most dominant
Alveolar	<	palatal	<	velar
		labial		

Mohanan’s (1993) Dominance Model can be summarized as follows:

(1). [-son] is dominant while [+son] is not.

(2). [dorsal] is dominant with respect to [labial], and [labial] is dominant with respect to [coronal].

(3). The onset is dominant in relation to the coda.

(4). The following element is dominant in relation to the preceding element.

In light of what has been presented so far, my argument is that the voicing assimilation process as well as the emphatic assimilation process both undergo a right-to-left[1] spreading across morpheme boundaries (between a bound morpheme and a stem word). For example, when the coronal [l] of the bound morpheme of the definite article ‘*ʔil*’ is followed by a stem word that begins with an emphatic coronal, the consonant [l] undergoes emphatic assimilation since it is in the coda position (undergoer) of the preceding syllable, and the coronal of the stem is in the onset position of the following syllable (trigger) as

[1] It is worth pointing out that right-to-left in linguistic terms usually means end-to-beginning, even in the context of languages that are written the other way.

suggested by Mohanan (1993). This kind of assimilation is triggered by the Obligatory Contour Principle (OCP), which prohibits two adjacent identical elements at the melodic level (Leben, 1973; McCarthy, 1986), and this violation is resolved by delinking the leftmost place feature. The spreading of the feature [emphasis] from right to left is shown below in (2a) – (2c) (The dotted line denotes the spreading of a certain feature whereas the line crossed with the equals sign represents the deletion or delinking).

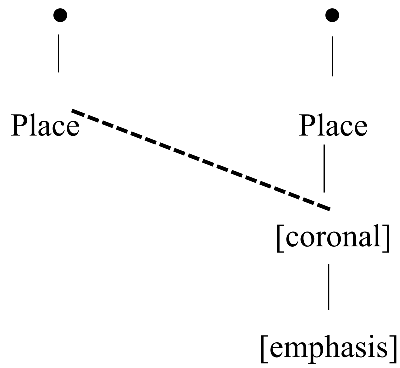
(2a).

●	●	
Place	Place	
[coronal]	[coronal]	OCP violation!
	[emphasis]	

(2b). Delinking of leftmost matrix from place node

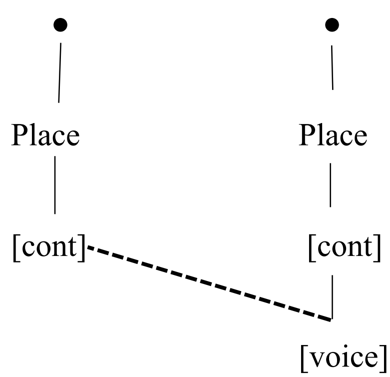
●	●	
Place	Place	
[coronal]	[coronal]	OCP violation!
	[emphasis]	

(2c). Right-to-left spread of rightmost matrix



Similarly, with regards to voicing assimilation, it spreads from right to left, but the OCP does not motivate this spread because no two identical sounds are required in order for the [voice] feature to take place. For example, in RJA when the consonant [t] in the bound morpheme 'mit' is followed by a stem word that begins with a voiced non coronal obstruent, [t], at the coda position, undergoes voicing assimilation (it vacuums the [voice] feature from the onset as it is more dominant) as shown below in (3), which is adapted from Watson (2002), but generalized for any [F].

(3). right- to-left spread of voice



1.1.2 Moraic theory

Moraic Theory has been first introduced by Hyman (1984) and been argued for by other linguists like Hayes, 1989; Davis, 1994; Davis, 1999; Topintzi, 2008, to mention a few. Geminates-singleton contrast has been investigated cross-linguistically in different models and has been viewed differently. For example, in SPE, Chomsky and Halle (1968) describe geminates based on their binary distinctive feature [± long] in which one representation is a single consonant [+long] whereas in the second there are two consonants where each of which is specified for the [-long] feature as shown in the following example (4) (Ham, 2001).

(4). Geminate representation in SPE

a. One [+long] consonant

$$\begin{pmatrix} +\text{long} \\ +\text{cons} \end{pmatrix}$$

b. Two [-long] consonants

$$\begin{pmatrix} -\text{long} \\ +\text{cons} \end{pmatrix} \quad \begin{pmatrix} -\text{long} \\ +\text{cons} \end{pmatrix}$$

This representation, according to Ham, (2001) creates an ambiguity problem because in some languages geminates are bi-segmental sequences whereas in other languages they are single long consonants. This is essentially the difference between Delattre (1971) and Ladefoged's (1971) view of geminates (see section 6.1).

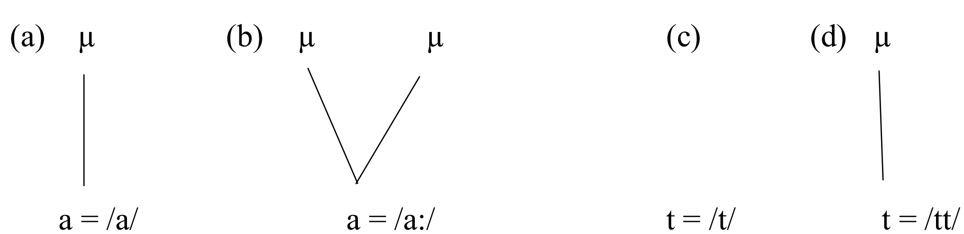
With regards to the prosodic length representation, a geminate is linked to two C-slots as in (5a), which shows that a geminate is a long consonant that has two timing units, whereas a singleton is linked to a single C-slot and has one timing unit as in (5b) (McCarthy, 1979; Leben, 1980) as shown in (5) below.

(5). Geminate-singleton representation in prosodic length

a. Geminate consonant b. Singleton consonant

Geminates and singletons are distinguished within Moraic Theory based on their inherent weight. While geminates are underlyingly moraic, singletons are not. Long vowels are bimoraic, short vowels are monomoraic (Hayes, 1989), and any CVC syllable is considered a heavy syllable if the coda consonants is part of an underlying geminate. The following representation in (6) shows the length contrast based on inherent weight.

(6). Geminate consonants represented as prosodic weight (Hayes, 1989)

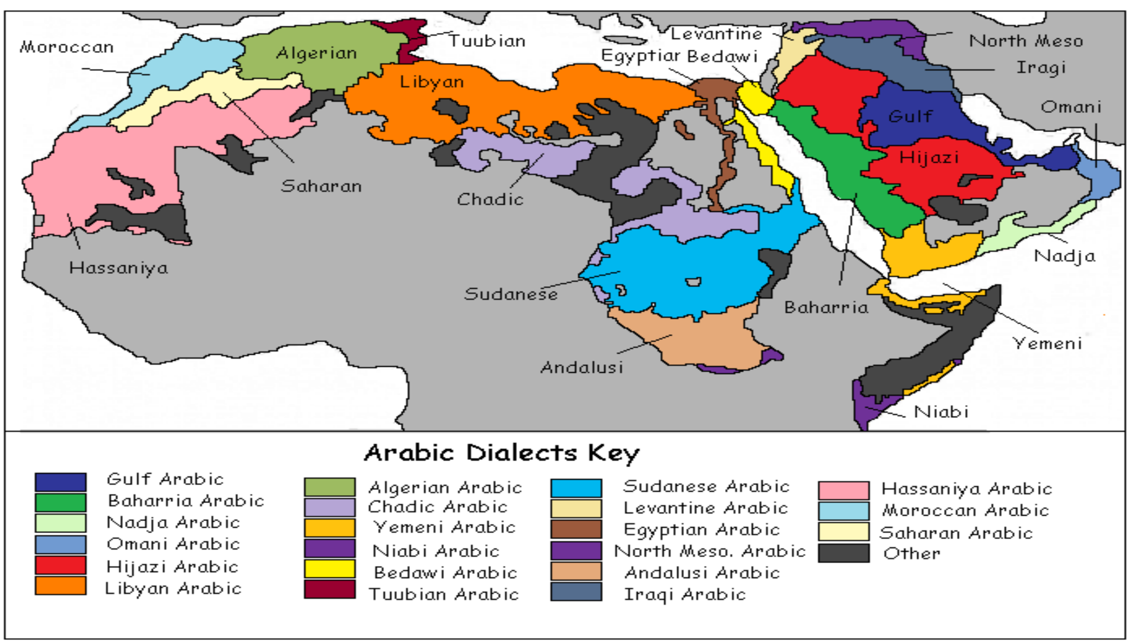


As shown in the above representation (6), a short vowel (a) and a geminate (long) consonant (d) are linked to one mora whereas a long vowel (b) is linked to two morae, and a singleton consonant is moraless/weightless.

1.2 An overview of Arabic dialects

The Arabic language, spoken in the Middle East and North Africa and one of the official six languages of the United Nations (United Nations, 2011), encompasses many dialects distributed according to the geographical areas in the Arab World as shown in Figure (3) below.

Figure (3): Regional dialects of Arabic[2]



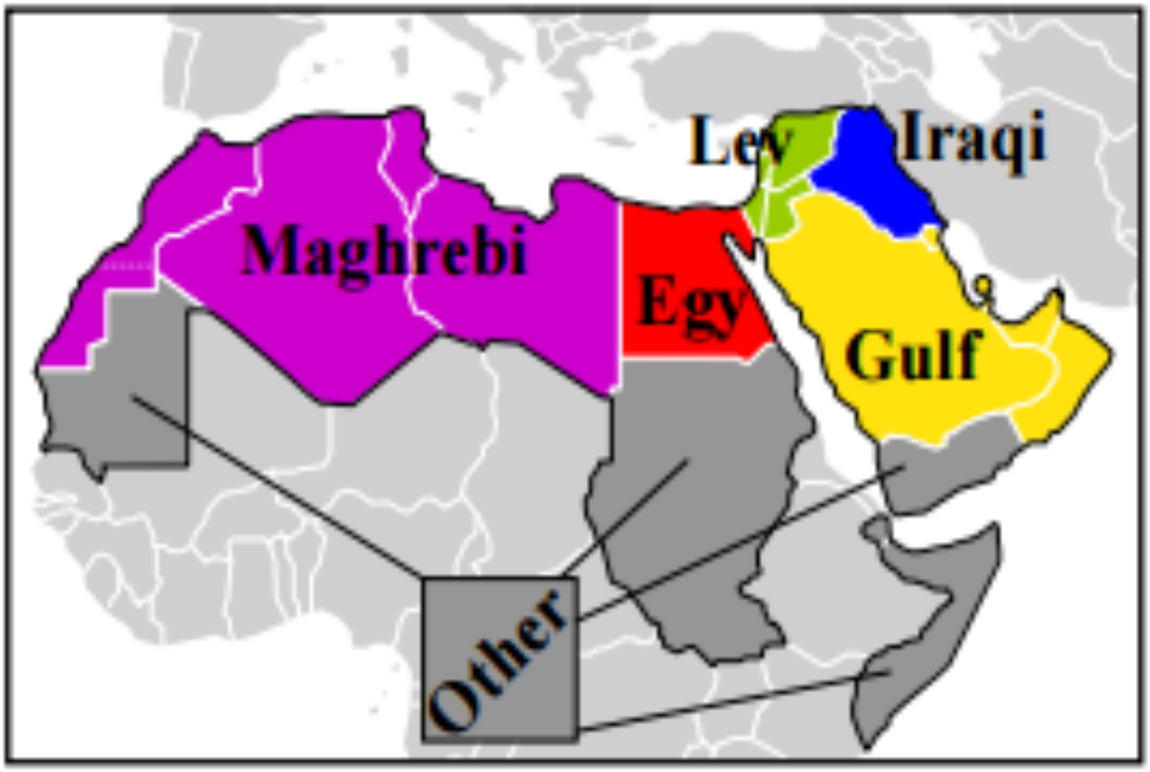
[2] This map is taken with permission from: https://asianabsolute.co.uk/arabic-language-dialects/

The lack of cross-dialectal studies makes it hard to predict what is linguistically common and what is not in spoken Arabic dialects. Although Arabic dialects are frequently named using political labels, such as Jordanian Arabic, Egyptian Arabic, Syrian Arabic, etc., spoken Arabic dialects, especially the ones spoken in neighboring countries, are best viewed and classified geographically rather than politically. The political boundaries were drawn by the British and French colonial powers in the early twentieth century.

Although there are political boundaries that separate countries from each other, the dialects are not affected by these fuzzy geographical boundaries, and thus we find shared dialects between two or more countries. For example, Levantine Arabic is spoken by the people of Jordan, Syria, Lebanon, West Bank, and Israel. Gulf Arabic is spoken by the people of the Gulf States that include Saudi Arabia, Kuwait, United Arab Emirates, Oman, Qatar, and Bahrain. Maghrebi Arabic is the dialect spoken by the people of Algeria, Morocco, Tunisia, and Libya. Egyptian Arabic is spoken by the people of Egypt and many others in Sudan (see Figure 4 below).

Geographically-close dialects (e.g., Levantine dialects, Gulf dialects, etc.) may show some linguistic similarities though there are also many striking differences between them as well. And on many syntactic, phonological and morphological levels, the political boundaries between the countries, where these dialects are spoken, 'have no bearing on the placing of isoglosses', but crucial differences still do exist (Horesh, 2014: 13).

Figure (4): Breakdown of Arabic dialects (Zaidan and Callison-Burch, 2013)



However, in each country of those mentioned above, there are sub-dialects that are somewhat phonetically, lexically, or syntactically different from each other because they are spoken by different tribes that descend from different countries and regions and because of the language contact between the people who live in the areas that are close to the borders of other countries, where there are no sharp geographical boundaries. Therefore, we can find dialects that are shared by speakers of two or more cities in two different countries to be more homogenous than others in cities within one country. For example, the people who live in the southern parts of Syria and the people who live in the northern parts of Jordan speak the same dialect due to the geographical proximity of those two areas, which are referred to as ‘Houran Plains’, including a city from Jordan ‘Irbid’ and a city from Syria ‘Dira’a’. Similarly, the tribes that live in the southern-eastern parts of Jordan and the Saudi tribes in the northern-western borders of Saudi Arabia speak the same dialect because of the geographical proximity between the areas where these tribes reside.

Theoretically speaking and based on the information given above on the spoken Arabic dialects, it is obvious that the political borders do not coincide with the dialectal boundaries. Also, the geographical distributions of the Arabic dialects do not stop at the political boundaries, and thus, these dialects should be labelled geo-linguistically, rather than politically especially if the geographical boundaries between two dialects are not sharp and not creating isoglosses. That being said, the political boundaries do not line-up with the geographical dialects and do not serve as a major contributor to the linguistic variation. Rather, it is the social factors as well as the language contact that play a role in shaping the regional dialects. For example, there are isoglosses that separate JA from Moroccan Arabic because they are geographically distant; whereas JA, Syrian Arabic (especially south of Syria) and Palestinian Arabic share a lot of similarities because they are geographically proximate, though they have different political labels. Therefore, isoglosses are important indicators of different regional dialects that may not be real, “convenient fiction existing in an abstract moment in time” (Carver, 1987: 13). On the other hand, there appears to be a linguistic divergence among the rural, urban, and Bedouin dialects even within the same country as is the case in Jordanian Arabic, where there are three distinct dialects.

1.2.1 Jordanian Arabic sub-dialects

This section is intended to give the reader a general idea of the different dialects in Jordan and the complexity of classifying these dialects. Jordanian Arabic (JA) is one of the dialects spoken in the Levantine region which comprises Jordan, Syria, West Bank, Israel and Lebanon (See Figure 5). The term Jordanian Arabic, like the term 'The Arabic Language' is vague as it entails at least three different dialects that are syntactically, morphologically, and phonologically different to some extent. Al-Wer (2007) asserts that in order to understand the dialect geography in Jordan, we should learn how the political borders were drawn in 1920. The north borders extend to the Houran Plains and Badiyat Ash-sham in Syria. This northern area in Jordan includes hundreds of towns and villages. The south borders extend to the Hijaz area in Saudi Arabia and includes the cities of Aqaba and Ma'an. The eastern borders stretch to the Al Bidiya Ash-Sharqiyya (the eastern desert) that is shared between Jordan and Iraq while the western borders stretch to the Jordan Valley that is shared between Jordan, West Bank and Israel (see map in Figure 5).

There are three basic sub-dialects of spoken JA distributed according to the geographical areas (Al-Sughayer, 1990; Sakarna, 1999, Al-Deaibes, 2015a). These sub-dialects are classified into Urban Jordanian Arabic (UJA), Bedouin Jordanian Arabic (BJA), and Rural Jordanian Arabic (RJA) (Suleiman, 1985). UJA functions as a lingua franca or a dominant dialect, so to speak, alongside with MSA in Jordan as it is considered more prestigious than other dialects since it is spoken by the educated and the elite people. The following map in Figure (5) shows where the JA dialect are mainly spoken. For example, (R) stands for rural which consists of the villages of Irbid, Jerash, and Ajlun in northern

Jordan, (U) stands for urban which covers the urban areas of the city of Irbid, Zarqa, and Amman in northern and center of Jordan, (B) stands for Bedouin which covers the desert areas in Mafraq, Ma'an, Kerak and Tafila in southern Jordan.

Figure (5): The Levantine Region[3]

UJA is mainly spoken in the big cities (Amman, Zarqa, and Irbid) and by city dwellers who are originally Palestinians or Syrians, who migrated to Jordan in the past two centuries

[3] This map is adapted with permission from: http://www.lonelyplanet.com/maps/middle-east/jordan/

due to wars, expulsion, and political unrest whether due to the British colonization, the Ottoman ruling, or the Israel-Palestinian conflict. Therefore, it is worth mentioning in this respect that UJA is not the whole picture of Jordanian Arabic. Because its speakers descended from other countries, UJA shares many similarities with other dialects, i.e., Syrian, Palestinian, and Lebanese (Ibrahim, 1984).

Bedouin Jordanian Arabic, on the other hand, is spoken by the desert dwellers (nomadic tribes) in the northern, eastern and southern parts of Jordan in the districts of Mafraq, Kerak, Ma’an, and Al-Badiya Al-Shamaliya. According to Sakarna (1999), there are five main Bedouin dialects in Jordan spoken by five different Bedouin tribes: Bani Hasan tribe dialect, Bani Sakher tribe dialect, Al-Huwaitat tribe dialect, Al-Ajarma tribe dialect, and Al-Abady tribe dialect.

Lastly, RJA is mainly spoken by villagers (farmers) who live in the suburbs and the countryside of north Jordan like the districts of Al-Ramtha, Bani Kanana, Bani Ebeid, and Al-Koura and the city of Der’aa and its villages in Syria. This variety is also spoken by city dwellers who are originally from the suburbs but moved to the city. According to Jarbou and al-Share (2012), the variants of many vowels and consonants in RJA and BJA are mostly the same while the same sounds used in UJA are ‘distinguishably different’. The distinction between the three dialects lies in the pronunciation of different variants of several consonants and vowels ‘rather than being restricted to only one consonant or one vowel’ (pp. 6-7).

According to the information given above, I believe that the dialects in Jordan have a special yet complicated status due to the divergence between them due the differences in the background of their speakers. For example, RJA is spoken only in the northern parts of Jordan and is also shared with the Syrian city of Dera'a in the south of Syria. So, the geographical status plays a role here. Similarly, BJA is spoken in the eastern, northern, as well as the southern parts of Jordan, i.e., not bound to a certain geographical area in Jordan as it is scattered throughout Jordan. So, this dialect is a good manifestation of the dialects of the Bedouin people in Jordan, Syria, and Iraq as well as in Saudi Arabic. Finally, UJA is spoken in the main cities (centers) especially in Irbid, Zarqa and Amman, which have the biggest number of immigrants from the West Bank due to the Palestinian-Israeli dispute and from Syria during the Ottoman rule. So this dialect is closer to the dialects spoken in Damascus or Jerusalem, for example, than to RJA or BJA. Therefore, investigating dialects should not be based on the political entity because the geographical nature and the language contact also play an important role in shaping the dialects. In other words, rural dialects should be viewed as geographical continuum that mirrors historical contracts between the people who live in the villages across the political boundaries in Jordan and Syria, like in Jordan and Syria, instead of viewing the dialects as political entities, like Jordanian Arabic, Syrian Arabic, etc., as the geographical dialects give a better linguistic picture than the political classification of dialects.

The distinction between these three varieties is primarily phonetic though it can also be lexical as well (see Zuraiq and Zhang, 2006; Jarbou and Al-Share, 2012; Al-Deaibes, 2015a). For example, phonetically, the word '*coffee'* is pronounced as [gahwa] in RJA, and pronounced as [ghawa] with a two consonant cluster in the onset of the syllable, in BJA, whereas it is pronounced as [ʔahwe] by the UJA speakers. Similarly, the word '*how*' is realized as [t͡ʃe:f] in RJA, while it is realized as [kif] in UJA. Lexically, for example, the word ‘*tired*’ in RJA is referred to as [hat͡ʃban] whereas it is referred in all other dialects including MSA as [taʕban]. Likewise, the word ‘*centipede*’ is referred to as [laddan] in RJA, while in UJA it is realized as [om arbaʕa o arbʕin].

As shown in table (1) below, the MSA phoneme /k/ in (a) is realized as [t͡ʃ] in Rural and Bedouin varieties while it is pronounced as [k] in the UJA. The MSA voiceless uvular plosive phoneme /q/ in (b) is realized as [g] in the Rural and Bedouin varieties whereas it is pronounced as [ʔ] in the urban variety. As well, /θ/ in (c) is realized as [t] is UJA while it remains [θ] in RJA and BJA. Similarly, /dˁ/ in (d), /ð/ in (e) and /d͡ʒ/ in (f) are realized as [ðˁ], [ð], and [d͡ʒ] respectively, in RJA and BJA whereas in UJA they are realized as [dˁ], [z], and [ʒ] respectively.

Table (1): Examples of phonetic differences between the JA varieties

	Word in MSA	RJA	BJA	UJA	Gloss
a.	/**k**/ kalb	[t͡ʃ] /t͡ʃalib/	[t͡ʃ] /t͡ʃalb/	[k] /kalb/	dog
b.	/**q**/ qalb	[g] /gałub/	[g] /gałb/	[ʔ] /ʔalb/	heart
c.	/**θ**/ θuluθ	[θ] /θiliθ/	[θ] /θilθ/	[t] /tult/	third
d.	/**dˁ**/ dˁarab	[ðˁ] /ðˁarab/	[ðˁ] /ðˁarab/	[dˁ] /dˁarab/	He hit.Past
e.	/**ð**/ iða	[ð] /iða/	[ð] /iða/	[z] /iza/	if
f.	/**d͡ʒ**/ d͡ʒar	[d͡ʒ] /d͡ʒar/	[d͡ʒ] /d͡ʒar/	[ʒ] /ʒar/	neighbor

According to Suleiman (1985), the three JA varieties mainly differ in the consonantal inventory. However, as clearly shown in the table above (1), vowels and syllable structure also show a major distinction between the three varieties especially the epenthetic vowels. For example, in (a) and (b) RJA speakers tend to break up the consonant cluster in the coda by inserting the vowel /i/ and /u/, respectively. Similarly, in (c) RJA speakers tend to maintain the epenthetic vowel (though a different vowel /i/) to break up the consonant cluster, whereas UJA and BJA speakers tend to maintain the consonant cluster in the coda as is. As such, vowels and consonants side by side make each dialect more distinct from the other dialects and yield a better picture of the phonetic/phonological differences among the Jordanian Arabic dialects. Another difference that distinguishes RJA from other varieties and MSA has to do with the phonotactics of RJA. For example, RJA does not allow a two-consonant cluster word-initially, whereas in UJA and BJA a two-consonant cluster is permissible in the two positions. Also, consonant clusters are avoided word-finally and an epenthetic vowel is always used to break up this sequence of segments like in the word [bard] 'cold' where it is realized as [barıd] word-finally (see section 2.2.1).

Although Classical Arabic or MSA is the official language by constitution in Jordan, and used in newspapers, radios, government issues, official speeches, regulations, Friday sermons, etc., people speak their own dialects in their everyday life conversations according to their region or place of origin. So, Jordan (like all Arabic speaking countries) is in a diglossic[4] situation where MSA is used only in formal settings (Ferguson, 1959 and El-Hassan, 1977) and other vernaculars are spoken in everyday-life communications.

[4] Ferguson (1959: 336) defines diglossia as a relatively stable language situation in which, in addition to the primary dialects of the language (which may include a standard or regional standard), there is a very divergent highly codified (often grammatically more complex) superposed variety, the vehicle of a large and respected body of written literature, either of an earlier period or of another speech community, which is learned largely by formal education and is used for most written and formal spoken purposes.

To sum up, the spoken dialects (RJA, UJA, BJA) are the true native language forms that people first acquire before they learn MSA as these dialects are used more often in everyday-life communications verbally, and recently these dialects started to take the form of written communication especially electronically, though the roman letters are used to represent the Arabic phonemes (See Al-Deaibes, 2016).

1.3 Summary

In this chapter, I outlined the theoretical frameworks namely, Autosegmental Theory, Feature Geometry, and Moraic Theory and discussed the importance of integrating phonetics and phonology to examine assimilation and gemination. I also gave an overview of the Arabic dialects and shed some light on the Jordanian Arabic dialects with special emphasis on the dialect under investigation, RJA and showed that the primary distinction between these dialects is phonetic. More phonological and morphological description about RJA will be covered in the next chapter.

Chapter Two

2. An overview of the phonology and morphology of RJA

This section presents the vowel and consonant inventory in RJA. It lays out the acoustic properties of the vowels in RJA. It also compares/contrasts the RJA vowels and consonants with those in Modern Standard Arabic (MSA) and shows how vowels and diphthongs shifted overtime. It also examines whether the diphthongs in MSA have undergone monophthongization in RJA, and it investigates whether this phenomenon is allophonic or phonemic using minimal pairs. Finally, I briefly introduce some phonological processes in RJA, e.g., vowel epenthesis, syncope and metathesis, which will help the reader get a better view of the assimilation and gemination processes in chapters four, five and six.

2.1 Vowel and consonant inventories in RJA

2.1.1 Monophthongs

There are a total of six vowels in MSA and most spoken dialects; three underlying short vowels /a/, /i/, /u/ and three corresponding long vowels /a:/, /i:/, /u:/ (Saadah, 2011). These vowels are shown below in Figure (6). In Arabic orthography, the long vowels are represented by letters (e.g., ا /a:/, و /u:/, and ي /i:/), while the short vowels are represented as small diacritics. For example, /a/ ‘◌َ’ and /u/ ‘◌ُ’ are placed on top of the consonants that are supposed to precede these short vowels, and /i/ ‘◌ِ’ is placed underneath the consonant that is supposed to precede this short vowel.

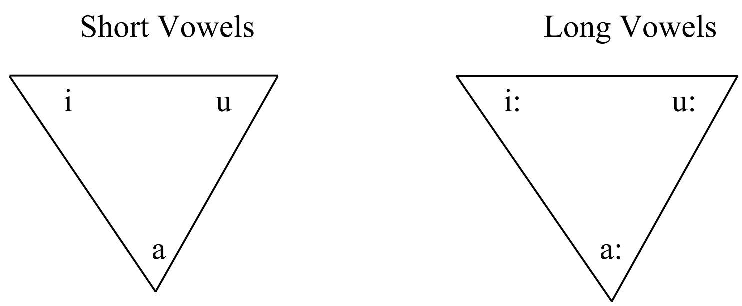


Figure (6): Traditional schematic representation of MSA vowels

On the other hand, RJA has a total of nine vowels, four short vowels /i/, /u/, /e/, /a/ and five long vowels /i:/, /u:/, /e:/, /a:/, /o:/. The three vowels that are not shared with MSA are the mid front long vowel /e:/, the mid front short vowel /e/, and the mid back long vowel /o:/. The mid front long vowel /e:/ is common in RJA in words like [s**e:**r] 'traffic', and [w**e:**n] 'where', which are realized as [s**ay**r] and [ʔ**ay**n], respectively, in MSA. The mid back long vowel /o:/ is common in words like [l**o:**z] 'almonds' and [l**o:**ħ] 'board', which are realized as [l**aw**z] and [l**aw**ħ] , respectively, in MSA. The mid front short vowel [e][5] functions as a feminine marker at the end of nouns and adjectives like in *t*$^{\text{ʕ}}$*awle* 'table', *kabi:re* 'big' (f), which are realized as *t*$^{\text{ʕ}}$*awila* and *kabi:ra*, respectively, in MSA. It is worth mentioning here that in Arabic (whether MSA or all other spoken dialects) all nouns have a grammatical gender that can be either a feminine or masculine, and the post-nominal adjectives agree with the nouns they modify in number and gender. For example, the words *table*, *wardrobe*, *university, school* and so on are considered feminine whereas the words *chair*, *book*, *flag*, and so on are considered masculine. Another example of gender

[5] The mid front short vowel [e] is used in phonetic brackets and not in phonemic slashes because later on I will show that it is not a phoneme; rather, it is an allophonic variant of the vowel /a/, given its limited distribution.

agreement that triggers adjectives to end with the feminine marker vowel [e], to agree with the nouns they modify, is the noun *riħle* ‘trip’ and the adjective *gas*ˤ*i:re* ‘short’, making up the phrase *riħle gas*ˤ*i:re* ‘short trip’. The previous example can be contrasted with the word *tho:b* ‘dress’, which is masculine, when followed by the adjective *gas*ˤ*i:r,* making up the phrase *tho:b gas*ˤ*i:r,* where the feminine marker does not appear.

With regards to the vowel inventory in RJA, I argue, based on minimal pairs that were checked by RJA native speakers for grammaticality judgement, that it has three more vowels in addition to the six vowels that are used in Standard Arabic namely, /a:/, /i:/, /u:/, /a/, /i/, /u/. These three vowels are the mid front long /e:/, the mid front short [e], and the mid back long /o:/[6]. This can be validated through the use of contrastive minimal pairs that show the use of these vowels in RJA, especially for /e:/ and /o:/. Consider the following Tables (2) and (3) for clarification.

Table (2): Minimal Pairs for the vowel /e:/ in RJA

Vowel	Minimal Pairs	
e:	sˤe:d (hunting)	sˤi:d (hunt.V)
e:	tˤe:r (bird)	tˤi:r (fly.V)
e:	d͡ʒe:b (pocket)	d͡ʒi:b (bring.V)
e:	ze:ħ (moving)	zi:ħ (move.V)

[6] Youssef (2013) argues against the existence of short mid vowels and explains the occurrence of long mid vowels as the result of total assimilation of two adjacent vocalic root nodes of an underlying diphthong.

Table (3): Minimal Pairs for the vowel /o:/ in RJA

Vowel	Minimal Pairs	
o:	ro:ħ (life)	ru:ħ (go.V)
o:	mo:t (death)	mu:t (die.V)
o:	d͡ʒo:r (oppression)	d͡ʒu:r (oppress.V)
o:	go:l (saying)	gu:l (say.V)

As shown in the tables above, the mid back long and mid front long vowels do exist in RJA especially word-medially. As for other environments, they do not occur word-finally. However, the mid front long vowel /e:/ may occur word initially, though not frequently, in words like /e:ʃ/ 'what' or the word /e:ma/ 'ice cream'. It is very rare, if not impossible, to find minimal pairs or other words where the mid front long vowel occurs word-initially. These vowels often have a grammatical function. That said, if we compare the high front vowel /i:/ with the mid front vowel /e:/ on the one hand, and we compare the high back vowel /u:/ with mid back vowel /o:/ on the other, we can notice that /i:/ and /u:/ are used (but not exclusively) with verbs, as they also appear with nouns (e.g., broken plurals), while /e:/ and /o:/ are used (also not exclusively) with nouns in RJA. Based on the minimal pairs in tables (2) and (3) as well as the vowel chart (Figure 7), it is obvious that there is an emergence of two new vowels in RJA. I think this emergence is not totally new; but rather, it is a vowel shift and that these two vowels were realized as diphthongs over a certain period of time and shifted (monophthongized) to long vowels at a certain point and became part of the vowel inventory in RJA. This can be validated if we use the words in the minimal pairs in Tables (2) and (3) in MSA, which leads us to conclude that these vowels were originally diphthongs. For example, the mid front long vowel in the words /sˤe:d/ 'hunting' and /tˤe:r/ 'bird' is a diphthong and realized as /sˤayd/ and /tˤayr/, respectively, in MSA. Similarly, the mid back long vowel /o:/ in the words /mo:t/ 'death' and /d͡ʒo:r/ 'oppression' is a diphthong and realized as /mawt/ and /d͡ʒawr/, respectively, in MSA. As for the mid front short [e], it is used exclusively word-finally as a feminine marker with nouns and adjectives. This vowel is, however, realized as /a/ in MSA, but it underwent raising over time and became [e] as shown in the following Table (4). Since the vowel [e] occurs in the final position as a feminine marker and cannot be contrasted with other vowels in the same position in minimal pairs, i.e., very limited, then it is not a phoneme; rather, it is an allophonic variant of the vowel /a/ that undergoes vowel raising due to dialect differences. Youssef (2013) makes a persuasive case that the surface long mid vowels in Arabic dialects are derived from /ay/ and /aw/. This is relevant for RJA since the patterning of the long mid vowels and [ay] and [aw] is similar to what Youssef discusses for Cairene Arabic. The basic insight of Youssef's analysis is that /ay/ and /aw/ monophthongize to [e:] and [o:] in nonderived environments (excepting some monosyllables) but remain as diphthongs in derived environments.

Table (4): Feminine markers [e] and [a] in RJA and MSA

RJA feminine marker vowel	MSA feminine marker vowel
kabi:re (big.F)	kabi:ra (big.F)
kilme (word.F)	kilma (word.f)
kamle (complete.F)	kamla (complete.F)
sane (year.F)	sana (year.F)

It is worth mentioning here that unlike BJA (which is considered a non-raising dialect) or even MSA, the feminine marker vowel in RJA is rule-governed. In MSA and BJA, all feminine words end with the vowel /a/ whereas in RJA the vowel /a/ is mostly used when the words to which it is affixed end with emphatic consonants, gutturals, other back consonants like /x/, /ɣ/, /q/, and the semi-vowel /w/, just like MSA and BJA, (Owens, 2006). The pharyngeal consonants, /ʕ/ and /ħ/, are also argued for to be inhibitors of the raising of the feminine ending (Al-Wer, 2007). Therefore, these consonants are considered inhibitors of the vowel raising in RJA. On the other hand, the rest of the consonants are followed by the vowel /e/.

In order to obtain a better picture of the properties of the vowel system in RJA, I elicited tokens containing all the vowels in RJA to draw some conclusions and provide a description of the vowel space in RJA. In this experiment, I extracted the duration and the formant frequencies (F1, F2, and F3) of the short and long vowels since, to the best of my knowledge, no previous acoustic studies have been conducted on RJA vowels. The experiment consisted of a word-list, where each vowel is used in a common word that contains no pharyngealized vowels as pharyngealization/emphasis affects the formant frequencies of adjacent vowels (see section 1.3.1.4). All formant frequencies were extracted from the middle of the vowel at 50% as the formants are steadier at this point of measurement. The word-list was comprised of nine words read by four RJA native speakers, two males and two females (age mean = 32.7) in the carrier phrase [ʔiħki___kama:n mar:a] ("Say____ again"). Praat (version 5.4.09) (Boersma and Weenink, 2009) was used to perform the acoustic measurements of the study. The four participants were graduate students at the University of Manitoba at the time of recordings had no previous history of speech or hearing impairment. The average time for them of being in Canada and outside Jordan is 4.75 years.

Table (5): Wordlist used for eliciting vowels acoustic properties

Vowel	Word	Gloss
/i:/	di:r	Turn around
/i/	diz	Push
/u:/	tu:t	Berry
/u/	bukra	Tomorrow
[e:]	se:f	Sword
[e]	azme	Crowd
[o:]	mo:z	Bananas
/a:/	ba:t	Slept over
/a/	mad	Extended something

The participants were not informed of the specific purpose of the study to make the production of phrases more natural and unbiased. The recordings were performed with a Marantz PMD-660 solid state recorder and an Audix OM 2 microphone in the anechoic chamber in the linguistics lab at the University of Manitoba. The word-list that the participants read is in Table (5) above. The following Tables (6) and (7) show mean duration, F1, F2, and F3 for short and long vowels as produced by the RJA female and male participants.

Table (6): Means of the acoustic measurements of vowels based on 2 female speakers

Vowel/diphthong	F1(Hz)	F2 (Hz)	F3 (Hz)	Duration (Ms.)
/i:/	372	2606	2932	250
/i/	543	1990	2464	184
/u:/	379	1452	2475	200
/u/	421	1006	2503	57
[e:]	536	1959	2727	218
[e]	505	1773	2746	116
[o:]	590	1634	3215	271
/a:/	652	1555	2355	250
/a/	696	1734	3120	136

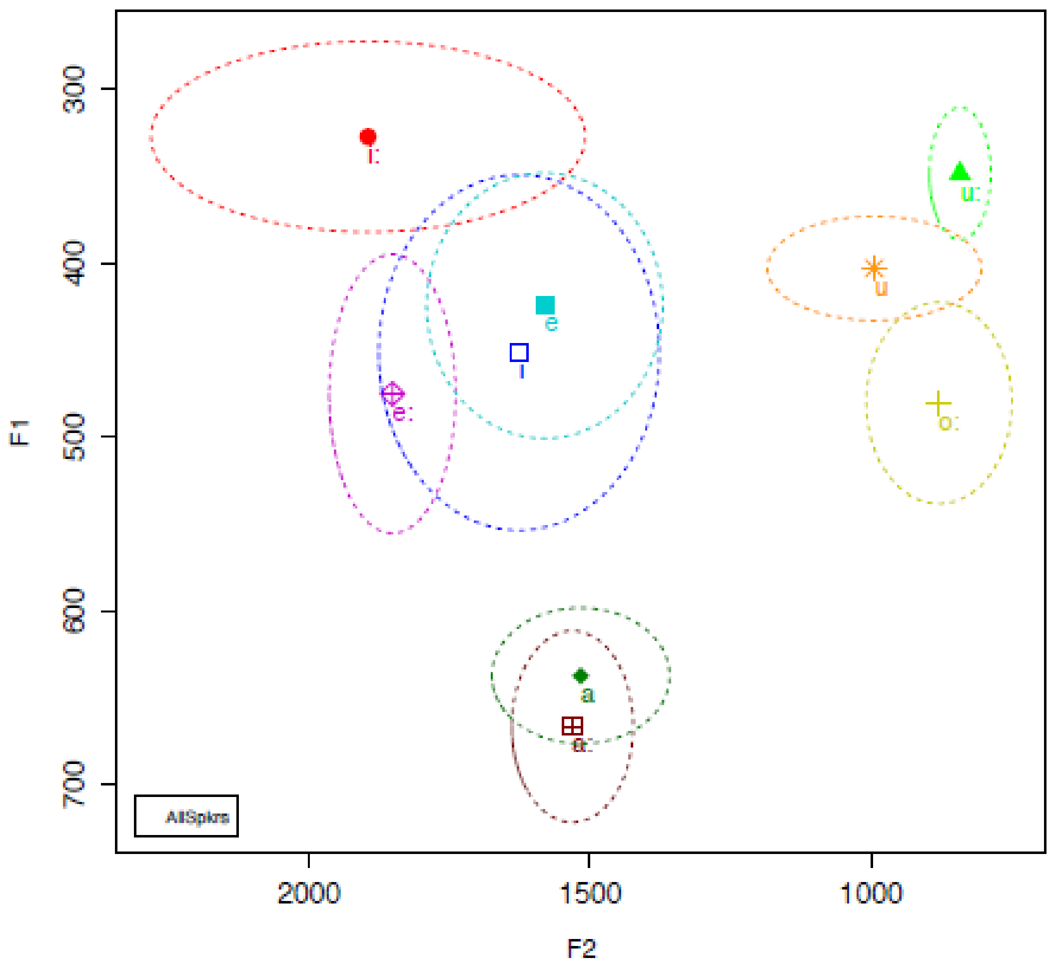
Table (7): Means of the acoustic measurements of vowels based on 2 male speakers

Vowel/diphthong	F1(Hz)	F2 (Hz)	F3 (Hz)	Duration (Ms.)
/i:/	284	2340	2624	229
/i/	368	1950	2616	137
/u:/	317	2173	2945	223
/u/	408	1106	2492	63
[e:]	444	2035	2605	226
[e]	394	1945	2665	82
[o:]	536	1346	2642	293
/a:/	683	1535	2463	264
/a/	586	1758	2588	105

In order to visualize the vowel space in RJA, I plotted F1 and F2 for all speakers as shown in Figure (7) below. The Figure shows that there is an overlap between the high front vowels /i:/ and /i/ on the one hand and the mid front vowels [e:] and [e] on the other, which suggests that there is a remarkable difference in the tongue body height (F1) when producing these vowels. According to the Figure below, the vowels /i/, [e], and /e:/ appear to be centralized due to the lowering of the vowel /i/ and the raising of the vowels [e] and [e:].

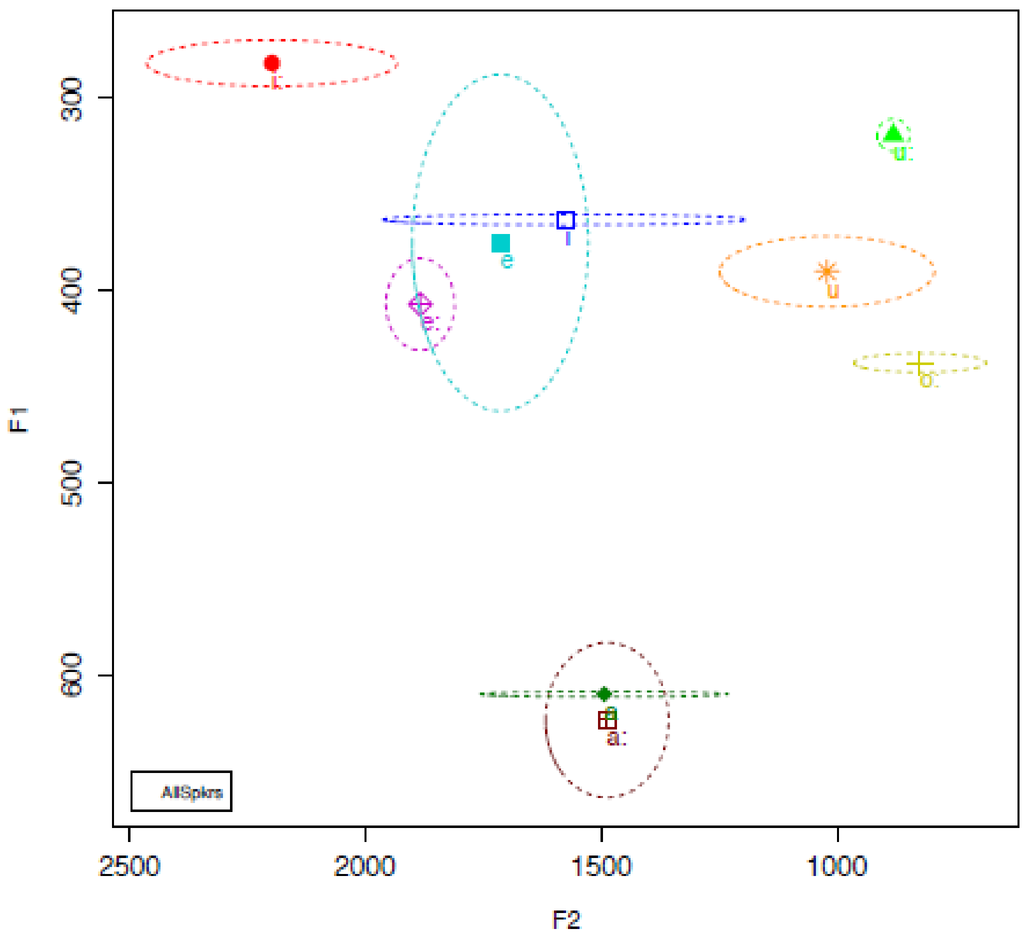
Further, the vowel /u/ appears to be more fronted than the vowels /u:/ and [o:], which suggests a closeness of the low F2.

Figure (7): Vowel space in RJA based on four speakers



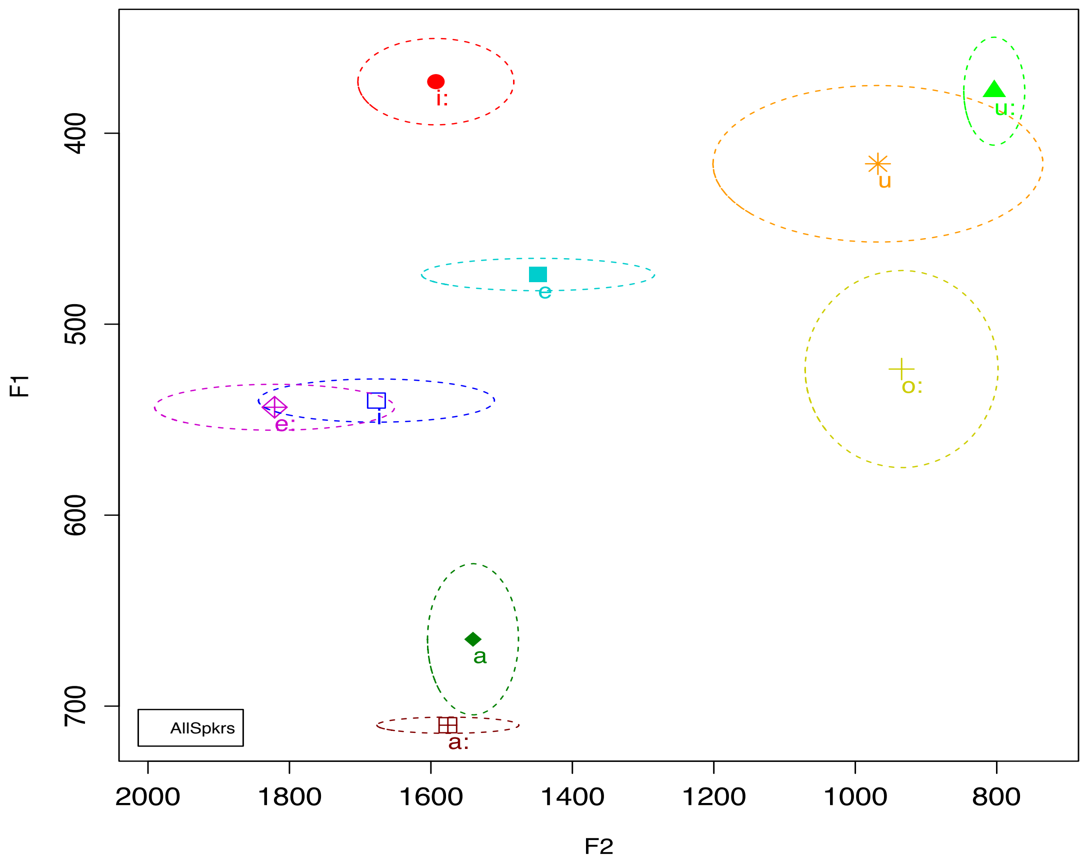
Further, in order to visualize the gender differences when producing vowels in RJA, I plotted F1 and F2 of the male and female speakers separately. Figure (8) and Figure (9) below show the differences between male and female speakers' vowel spaces. Based on Figure (8) below, there seems to be an overlap between the vowels /i/, [e], and [e:]. These vowels are also centralized due to the lowering of the vowel /i/ and the raising of the vowels [e] and [e:], as previously noted in Figure (7) above.

Figure (8): Vowel space in RJA based on 2 male speakers



Similarly, the vowel /u:/ is lower than the vowel /i:/, and the vowel /u/ is more fronted than the vowel /u:/ and [o:] as shown in Figure (8). In contrast, the female speakers in Figure (9) below tend to have the vowel /i/ more lowered (overlapping with the vowel [e:]) and the vowel [e] is more raised and centralized. Also, unlike the male speakers, female speakers tend to have the long vowel /i:/ a bit backer and the vowel /u:/ a bit more fronted.

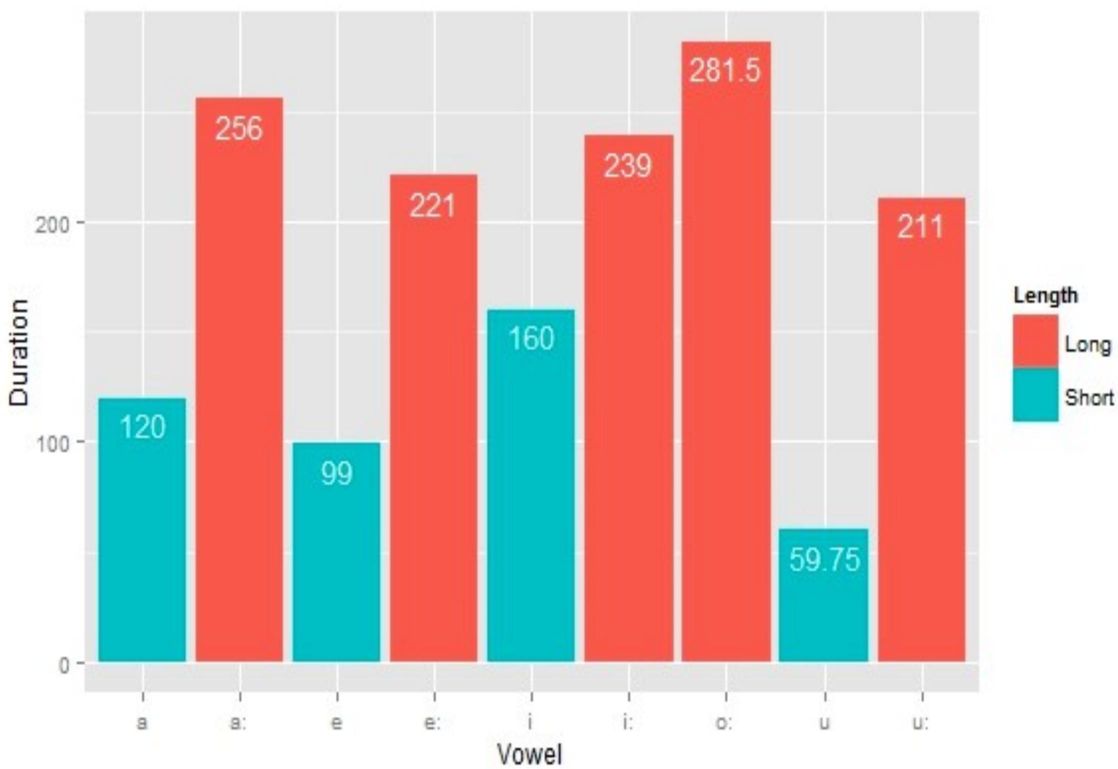
Figure (9): Vowel space in RJA based on 2 female speakers



In both male and female speakers, long vowels are more peripheral than short vowels, which are more centralized. Although the vowel space differences between RJA males and females is beyond the scope of the current study, it is worth further investigating these differences by having more speakers to draw better conclusions.

With regards to the duration of the short and long vowels, the following Figure (10) shows the average duration of long vowels as compared to short vowels based on the four speakers. According to the Figure below, the duration of the long vowels /a:/, [e:], /u:/ are more than twice the length of their short counterparts /a/, [e], /u/, respectively.

Figure (10): Long vs. short vowel durations (in Ms.).



The vowel /i:/ is longer than its short vowel counterpart /i/, but not twice the length as is the case with the other vowels. While the vowel [o:] is the longest among the long vowels, the vowel /u:/ is the shortest. Similarly, the vowel /i/ is the longest among the short vowels while the vowel /u/ is the shortest. Gender differences are also noted when it comes to vowel durations. For example, the vowel /a/'s duration as produced by female speakers is longer than that by male speakers by 31 ms. The vowel /a:/'s duration as produced by female speakers is shorter than that by male speakers by 14 ms. The vowel [e]'s duration as produced by female speakers is longer than that by male speakers by 34 ms. The vowel [e:]'s duration as produced by female speakers is shorter than that by male speakers by 8 ms. The vowel /i/'s duration as produced by female speakers is longer than that by male speakers by 47 ms. The vowel /i:/'s duration as produced by female speakers is longer than that by male speakers by 21 ms. The vowel [o:]'s duration as produced by female speakers is shorter than that by male speakers by 22 ms. The vowel /u/'s duration as produced by female speakers is shorter than that by male speakers by 6 ms. The vowel /u:/'s duration as produced by female speakers is shorter than that by male speakers by 23 ms. Accordingly, despite the small number of participants, it is clear that female speakers tend to have longer front vowels and shorter back vowels than male speakers do. Thus, according to the four speakers of the study, vowels in RJA can be contrasted in terms of duration (see Figure 10), position as well as gender differences.

2.1.2 Diphthongs

Although the monophthongs in MSA and RJA are somewhat similar except for the three new vowels in RJA, vowel inventorial differences lie in the diphthongs as well. For example, in MSA, there are only two diphthongs, i.e., /aw/ and /ay/. These two diphthongs exist in RJA but are replaced by the mid back long vowel [o:] and the long mid front vowel [e:], respectively, in certain environments, not all. For example, in MSA the dual form in the accusative case uses the diphthong /ay/ like in the word *kitab**ayn*** 'two books' whereas in RJA the dual form is represented using the long mid front vowel [e:]. As such, RJA cognates of SA words with /ay/ replace the diphthong with /e:/ and so on as in ***sayf*** 'sword' in MSA and *se:f* 'sword' in RJA. According to Dyson and Amayreh (2007), there are only two diphthongs in JA, which are [e:] and [o:]. Dyson and Amayreh (2007) did not specify what Jordanian dialect they have investigated; thus it is hard to generalize that JA has these two diphthongs. As such, I would argue here, following Youssef (2013), that [e:] and [o:] are two long vowels in RJA that are originally diphthongs as shown in the minimal pairs in Tables (2) - (3). Like the case in MSA, RJA has two diphthongs which are /aw/ and /ay/. They are very common in words like /d͡ʒ**aw**/ 'weather' and /**ay**bas/ 'drier'. However, they appear in certain environments, some of which are shared with MSA and some are not. For example, the diphthongs /aw/ and /ay/ appear in certain environments that are shared between RJA and MSA like comparative adjectives as in ***aw**saʕ* 'wider', ***aw**nas* 'more entertaining', ***aw**ʕa* 'more aware' ***ay**man* 'safer', ***ay**sar* 'simpler'. They are also shared in the passive participle as in *m**aw**ʕu:d* 'promised', *m**aw**su:l* 'connected', *m**ay**soor* 'simplified/rich', or in broken plurals as in ***aw**ha:m* 'illusions', ***aw**a:ʔil* 'diligent students/pioneers', ***ay**ya:m* 'days', ***aw**z:an* 'weights'.

2.1.3 Consonants in RJA

The consonantal inventory in RJA is somewhat different from that of MSA in the sense that MSA has 28 consonants, whereas RJA has 29 consonants. The following Tables (8) and (9) illustrate the RJA and MSA consonantal inventories, where voiceless consonants are aligned to the left of each cell and the voiced consonants are aligned to the right. The vowel differences between RJA and MSA are bolded for clarification.

Table (8): RJA consonantal inventory

	Labial	Labio-dental	Inter-dental	Alveolar	Palatao-Alveolar	Palatal	Velar	Pharyngeal	Glottal
Plosive	b			t d tˤ			k **g**		ʔ
Nasal	m			n					
Trill				r					
Fricative		f	θ ð ðˤ	s z sˤ **zˤ**	ʃ		x ɣ	ħ ʕ	h
Affricate					**t͡ʃ** d͡ʒ				
Lateral				l					
Glide	w					j			

Table (9): MSA consonantal inventory

	Labial	Labio-dental	Inter-dental	Alveolar	Palatao-Alveolar	Palatal	Velar	Pharyngeal	Uvular	Glottal
Plosive	b			t d tˤ **dˤ**			k		**q**	ʔ
Nasal	m			n						
Trill				r						
Fricative		f	θ ð ðˤ	s z sˤ	ʃ		x ɣ	ħ ʕ		h
Affricate					d͡ʒ					
Lateral				l						
Glide	w					j				

Based on Tables (8) and (9), there are three consonants that exist in RJA but not in MSA. These consonants are the emphatic voiced alveolar fricative /zˤ/, the voiceless palato-alveolar affricate /t͡ʃ/, and the voiced velar plosive /g/, whereas the rest of the consonants are shared between both RJA and MSA. And, there are two consonants that exist in MSA but not in RJA. These consonants are the uvular plosive /q/ and the emphatic alveolar plosive /dˤ/.

It is worth pointing out here that the voiceless uvular plosive /q/ and the emphatic voiced alveolar plosive /dˤ/ in MSA do not exist in RJA whereas /zˤ/ exists in RJA and UJA, but not MSA. With regards to / t͡ʃ/ and /g/, they are usually (though there are some exceptions) in free variation with the MSA voiceless velar stop /k/ and the voiceless uvular plosive /q/, respectively. While / t͡ʃ/ and /g/ are used in informal speech or in vernacular, /k/ and /q/ are used in formal or standard Arabic speech. For example, the word 'said' is realized as [qa:l] in MSA while realized as [ga:l] in RJA. Likewise, the word 'palm' is realized as [kaf:] in MSA while realized as [t͡ʃaf:] in RJA. With regards to /zˤ/, it is used either with words that are solely vernacular and don't exist in MSA like the word *ba:zˤ* 'broke down' or as an allophonic variant for the phoneme /z/ that becomes emphatic due to the existence of a (neighboring or long-distance) emphatic consonant like in *mazˤatˤ* 'passed easily', in which the emphatic consonant /tˤ/ spreads its emphasis feature to a long-distance phoneme, i.e., /zˤ/ in the same syllable. It is worth pointing out here that /z/ does not become emphatic in MSA, and the phoneme /zˤ/ is used in UJA to replace the emphatic interdental voiced fricative phoneme /ðˤ/ in MSA.

Now, that the consonant and vowel inventories of RJA have been outlined, I will provide a brief description of some subsidiary phonological processes in RJA namely, vowel epenthesis, syncope, and metathesis.

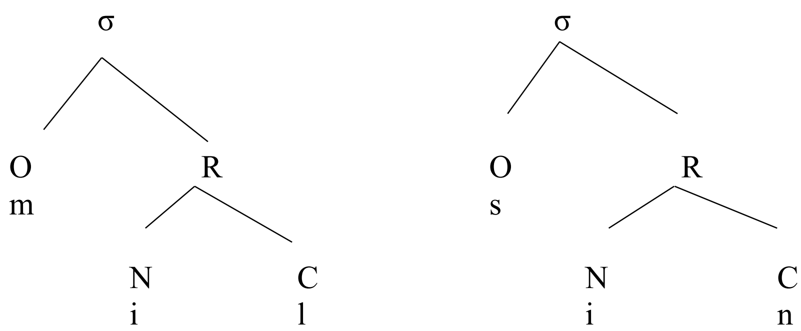
2.2 A brief description of some phonological processes in RJA

In this section, I briefly introduce some phonological processes, namely vowel epenthesis, syncope, and metathesis to give an idea how these processes function in RJA, leading to a better understanding of the whole picture of assimilation and gemination, which are the core processes of this dissertation.

2.2.1 Vowel epenthesis

As we mentioned earlier in section 2.1.1 RJA has four short vowels and five long vowels. Only short vowels are involved in epenthesis, and particularly the vowels /i/ and /u/. The behavior of vowel epenthesis in RJA is different from that in MSA or even the other two JA dialects namely, UJA and BJA. In RJA, the syllable structure does not allow a sequence of two or more consonants in the onset or in the coda as RJA speakers always tend to break up any sequence of two or more consonants by inserting the vowels /i/ or /u/ as having a consonant cluster in the onset or the coda is undesirable. These restrictions take place at the syllable level. However, when it comes to the word level, a consonant cluster is permissible given that one consonant belongs to the coda of one syllable and the other belongs to the onset of the following syllable. As such, it is possible to have a two-consonant cluster word-medially as shown in the example below where the cluster of /l+s/ in the word *milsin* 'talkative' is allowed word-medially, but they are assigned to different syllables.

a) *milsin* ‘talkative’



According to Hall (2011), ‘[i]n most cases, the function of vowel epenthesis is to repair an input that does not meet a language’s structural requirements. In particular, vowel epenthesis allows the surfacing of consonants that underlyingly appear in phonotactically illegal contexts’ (p. 1576). Consider the following examples that illustrate the behavior of vowel epenthesis in RJA in Table (10) below.

Table (10): Illustration of vowel epenthesis and consonant clusters word finally

Epenthetic Vowel	RJA	MSA	Gloss
u	rub**u**ʕ	rubʕ	Quarter
u	baħ**u**r	baħr	Sea
u	$s^{ʕ}$aʕ**u**b	$s^{ʕ}$aʕb	Difficult
i	laħ**i**m	laħm	Meat
i	waz**i**n	wazn	Weight
i	bar**i**d	bard	Cold

Any consonant cluster that occurs word initially is preceded by an epenthetic vowel. So, RJA speakers tend to insert vowels between any two consonant clusters for the sake of ease of articulation. As well, the phonotactics of RJA impose restrictions that any consonant cluster has to be broken up by a vowel whether at the onset or the coda positions. In support of this, when RJA speakers pronounce English words that begin with a two or three consonant cluster, they may insert a vowel at the beginning of these English words due to the influence of their L1 phonotactics. For example, they would pronounce the word ‘square’ as ‘isquare’ or ‘siquare’, the word ‘stamp’ as ‘istamp’. Even word final consonant clusters like the words ‘six’ or ‘box’, some would pronounce them as ‘sikis’ and ‘bukis’, respectively.

Another interesting example in support of this is the definite article, which assimilates to a following coronal. However, when it is followed by a two-consonant cluster, RJA speakers would metathesize the vowel /i/ of the definite article before consonant ‘l’ to avoid a potential three-consonant cluster. For example, the word *il-ktab* would be realized as ‘liktab’ or in the word *il-blad* it would be realized as *‘liblad’* to avoid having a consonant cluster in the onset of the syllable of the stem. As such, there are two processes involved to break the consonant sequence [l+ two-consonant cluster]; epenthesis and metathesis, which are also used to avoid assimilation.

With regards to the selection of the vowels [i] and [u] over other vowels, say, [a] as epenthetic vowels, this appears to be exclusive to RJA, as in UJA as well as BJA speakers use [a], [i], and [u] when breaking up a consonant cluster word-finally. For example, they would use the vowel [a] to break up the sequence of the consonants [ħ] and **[**r] in the word [baħ**a**r] ‘sea’ while RJA speakers would use the vowel [u] as in [baħ**u**r]. Vowel epenthesis in RJA is rule-governed, and the selection of a certain vowel over another has to do with phonotactics of RJA, as where one vowel occurs another does not. In support of this, Al-Sughayer (1990) provides the following rules that predict and summarize the environments where the epenthetic vowels [u] and [i] occur.

Rule one: Ø→ V / C____ C C

[+high]

[-back]

Rule two: Ø→ V / V C____ CC

[+high] [+high]

[+back] [+back]

Rule three: Ø→ V / C ____ C C

[+high] [-coronal] [+back]

[+back]

Rule four: Ø→ V / C ____ C C

[+high] [+back]

[+back] [+coronal]

Rule five: Ø→ V / C ____ C C

[+high] [+back] [-coronal]

[+back]

In addition to these rules, whenever there is a consonant cluster in which one consonant is an emphatic consonant (whether before or after the vowel), the vowel will be [u] not [i]. This is contrary to UJA where the vowel [i] is used, and the vowel [u] is avoided, which is one of the phonetic properties that distinguishes RJA from the other dialects in Jordan.

2.2.2 Syncope

In RJA, like other dialects e.g., Iraqi (cf. Erwin, 1963:56) a syncope rule deletes short stressless vowels from stem-final open syllables when vowel-initial suffixes are added. For example, the second vowel [u] in the word [ʃuɣ**u**l] 'work' is deleted when the genitive masculine suffix '-ak' or the genitive feminine suffix '-ik' are added because they begin with a vowel and become [ʃuɣlak] 'your(2M) work' and [ʃuɣlik] 'your (2F) work', respectively, but not [*ʃuɣulak] or [*ʃuɣulik]. Thus, only the short vowels (which are stressless) /a/, /u/, and /i/ are subject to deletion when followed by a suffix that begins with a vowel as represented in the following rule:

$$\underset{[a,\ u,\ i]}{V} \rightarrow \text{Ø} \ / \ C\_\_\_\_ \ CV\ (C)$$

The following examples (7a)- (7k) illustrate how the syncope works in RJA using the word [ʕirif] that shows when the vowel [i] is syncopated and when it is not.

(7).

a) ʕirif 'he knew'
b) ʕi**rf**at 'she knew' [i] between [r] and [f] is syncopated
c) ʕi**rf**u 'they(m) knew' [i] between [r] and [f] is syncopated
d) ʕi**rf**in 'they(f) knew' [i] between [r] and [f] is syncopated
e) iʕrifit 'you(2MS) knew'

f) iʕrifti ‘you(2FS) knew’

g) iʕriftu ‘you(2MP) knew’

h) iʕriftin ‘you(2FP) knew’

i) iʕrifti ‘you(2FS) knew’

j) iʕrifit ‘I knew’

k) iʕrifna ‘we knew’

Based on the examples above, it is obvious that the examples in (7 b-d) represent the sequence of CVCC because they are followed a by a suffix-initial vowel, which motivates the vowel to be syncopated, whereas the examples in (7 a, e-k) represent the sequence of CVCVC because the suffix that follows them does not begin with a vowel, which blocks the vowel deletion; otherwise, we will end up having a three consonant cluster, which is not permissible in RJA. Therefore, syncope as in (7 b-d) is obligatory.

2.2.3 Metathesis

Unlike other phonological processes that appear to be systematic, linear, and rule-based, metathesis does not follow a pattern and is unpredictable. Webb (1974) posits that metathesis does not exist as a regular phonological process in synchronic grammar.

In RJA, like in other dialects, metathesis involves an alternation between two segments whether these segments are adjacent or long-distance. As long as metathesis is observed in child speech, speech errors as well as adults’ speech in RJA, it is worth showing some common examples of adjacent and long-distance metathesis as in Table (11) that are considered free variants.

Table (11): Metathesis examples from RJA

Word	alternating consonants	results	gloss
yibga	b+g → g+b	yigba	Stay(m)
zand͡ʒabi:l	z+d͡ʒ → d͡ʒ+z	d͡ʒanzabi:l	Ginger
fanila	n+l → l+n	falina	Undershirt
ʕarabo:n	ʕ+r → r+ ʕ	raʕabo:n	Down payment
zo:d͡ʒ	z+d͡ʒ → d͡ʒ+z	d͡ʒo:z	Husband
yilʕan	n+l → l+n	yinʕal	Curse
makate	k+t → t+k	matake	Ashtray
baraʃ	r+ʃ → ʃ+r	baʃar	He shredded

It is worth pointing out here that metathesis in RJA is not systematic but sporadic as it applies only to the lexical items in Table (11) above. For example, if we take the word /yibga/, it is realized as [yigba] 'stay (m.)', but this metathesis rule does not affect all forms of the verb. For example, the past tense of the word /yibga/ is [bageet] 'I stayed' but not [gabeet].

2.2.4 Word stress

Word stress assignment in RJA, like in most spoken Arabic dialects, is based on syllable position as well as syllable weight. Arabic recognizes three kinds of syllables based on weight: light, heavy, and super-heavy. Light syllables are always open, heavy syllables are open or closed, and super- heavy syllables are closed or doubly closed (Watson, 2011c). The syllable that attracts the stress is said to be prominent as opposed to the syllable that does not attract stress. According to Al-Ani (1992), stressed syllables are longer in duration, higher in pitch level, and louder than the unstressed syllables. Stress assignment in RJA is predictable and rule-governed. The following examples provide different possible stress assignment in RJA based on the syllable structure and syllable weight.

(1) Monosyllabic words:

a) mur — ‘bitter’

b) ħas — ‘he felt’

c) tˤax — ‘shooting’

d) d͡ʒaw — ‘weather’

e) tˤa:r — ‘flew away’

f) mo:t — ‘death’

(2) Disyllabic words:

a) ˈli.bis — ‘apparel’

b) ˈsa.mak — ‘fish. PL’

c) ˈba.rad — ‘got cold’

d) ma.ˈkab: — ‘dumping site’

e) ʔa.ˈgal: — ‘less than’

f) ma.ˈtˤab: — ‘bump’

(3) Trisyllabic words

a) ma.tˤa:.ˈra:t — ‘airports’

b) mu.di:.ˈri:n — ‘managers’

c) ˈmad. ra.se — ‘schools’

d) ˈma.li.ka — ‘queen’

e) ˈla.ba.tˤa — ‘trouble’

f) ˈsa.ma.ka — ‘fish.SGF’

(4) Quadrisyllabic words

a) mo. xa:.ba.ˈra:t ‘intelligence’

b) mo. na:.sa.ˈba:t ‘occasions’

c) in.ˈta.ba.hu ‘they became aware’

d) im.ˈħa:.ta.fe ‘stinginess’

e) mu.ˈka:. la.me ‘a phone call.SGF’

f) ka.ˈtab.na:.ha ‘we wrote it’

As shown in the examples above, stress assignment in RJA is rule-governed. CVC syllables in monosyllabic words do not receive stress because they are considered light as in examples (1a) – (1f). In disyllabic words, stress is assigned on the first syllable as in examples (2a) – (2c) unless the second syllable is heavy (e.g., ending with a geminate), as in examples (2d) – (2f), in which case stress shifts to the final syllable. In words of more than two syllables, stress is assigned on final heavy syllables as in examples (3a-b), (4a-b). If there is no final heavy syllable, stress falls on the antepenultimate syllable, as in (3c-f), (4c-f) (Abu-Abbas 2008: 15). Therefore, stress is assigned to the rightmost heavy syllable if the syllable is not separated from the right edge of the word by more than two syllables. In short, stress assignment in RJA is systematic and can be summarized as follows. When the final syllable is (super)heavy, it always attracts stress regardless of the number of the syllables. In trisyllabic and quadrisyllabic words, stress is assigned on the antepenultimate syllable in the absence of a final heavy syllable. If two heavy syllables occur in the same word, the rightmost heavy syllable gets stressed as in (4a) and (4b).

2.3 The morphology of the affixes used in the study

The consonants of the bound morphemes examined in the present study are the non-coronal obstruent consonant /h/, which appears at the beginning of the genitive/accusative suffix in the pronouns /*-hum/*, /*-hin*/, and /*-ha*/, the coronal obstruent consonant /t/, which appears at the end of the active participle prefix /*mit-*/, the coronal sonorant consonant /l/, which appears at the end of the definite article /*ʔil-*/, and coronal sonorant consonant /n/, which appears in the end of the passive voice prefix /*ʔin-*/. With regards to consonants /t/, /l/, and /n/, they appear in prefixes, which means that they are used in the coda position of the first syllable, whereas the consonant /h/ appears in the suffixes, which means that it is used in the onset position of the final syllable. The phonological assimilation of these consonants in these morphemes to other adjacent consonants in the free morphemes is investigated thoroughly in terms of voicing and emphatic assimilation.

It is worth mentioning here that the morphological system in all Arabic varieties is called the root-and-pattern system, in which roots provide the general meaning of the word and patterns contribute the derived meaning (Elgadi, 1986:85). This can be illustrated in the following table (12) which is exclusive to the RJA morphology. Based on table (12) below, the first pattern is the simplest and the commonest in RJA, and it functions as a base for the verb. In other words, the verb that carries this pattern should be CVCVC. The consonants in this verb are the triconsonantal (triliteral) root, i.e., (t͡ʃ-ð-b) and the vowels will be only the high front short vowel /i/. Similarly, the second type *faʕʕa:l* is the template for any verb that is CVCCV:C, which means that the consonants in this verb are (t͡ʃ-ð-b) in which the middle consonant is geminated, and the vowels are the low front short vowel /a/ and the low front long vowel /a:/. This applies to the other types of patterns.

Table (12): Examples of root and pattern in RJA

Type	Pattern	Example	Root	Gloss
I.	fiʕil	t͡ʃiðib	t͡ʃ-ð-b	‘lying’
II.	faʕʕa:l	t͡ʃaððа:b	t͡ʃ-ð-b	‘liar’
III.	tafʕi:l	tat͡ʃði:b	t͡ʃ-ð-b	‘to belie’
IV.	faʕʕal	t͡ʃaððab	t͡ʃ-ð-b	‘he lied’
V.	mitfaʕʕil	mitt͡ʃaððib	t͡ʃ-ð-b	‘to be belied’

In the following subsection, I provide morphological description for each affix and I classify them based on place articulation and affixation (suffix and prefixes). While /h/is a non-coronal consonant that is used at the beginning of the suffixes, /t/, /l/, /n/ are coronal consonants that appear at the end of the prefixes.

2.3.1 Suffixal /h/

With regards to the genitive/accusative suffixes /*-hum*/ (3PM), /*-hin*/ (3PF) and /*-ha*/ (3SF) in RJA, they are third person bound suffixes that cannot stand alone without being attached to the terminal of a verb or a noun. These pronouns agree in number and gender with the entity to which they refer except for the singular masculine, which is vowel-initial (-u) and thus does not participate in the assimilation of interest here. The following examples below show how these suffixes are used in RJA.

a) *Ali katab-ha*
Ali wrote- 3SF
‘Ali wrote it.’

b) *Ali katab-hin*
Ali wrote-3PF
'Ali wrote them.'

c) *Ali katab-hum*
Ali wrote-3PM
'Ali wrote them.'

d) *Ali katab-u*
Ali wrote-3SM
'Ali wrote it.'

According to the examples above, the third person masculine pronoun is excluded in this paper because it has a different realization, which is the suffix -*uh*, thus there will be no assimilation between the phoneme /h/ in *uh* and the preceding consonants because of the vowel /u/.

2.3.2 Prefixal /t/

The second morpheme investigated in the study is final consonant of the active participle prefix /mit-/. This prefix is a dependent (bound) morpheme that cannot stand by itself, i.e., it has to be connected to a verb to function. When the active participle prefix /mit-/ in RJA is affixed to a verb, it acts as an adjective, and in this case it agrees with its subject in number and gender. It is mainly used to describe the state of being, to describe an event that is happening at the moment, and to indicate that an action is in the state to have been done. The following examples show how the active participle in RJA is used.

e) *Ali mit-d͡ʒawiz*
Ali AP-marry
'Ali is married.'

f) *Maha mit-d͡ʒawz-e*
Maha AP-marry-FS
'Maha is married.'

g) *Ali w Maha mit-tˤalg-een*
Ali and Maha AP-divorce-MPL
'Ali and Maha are divorced.'

h) *Maha w Laila mit-tˤalg-at*
Maha and Laila AP-divorce-FPL
'Maha and Laila are divorced.'

As shown in the examples above (e-h), the prefix (mit-) is attached to the verbs, resulting in active participles that act as adjectives in RJA. It is also clear for the examples in (e-h) that the active participles agree in gender and number with their subjects.

2.3.3 Prefixal /l/

The third morpheme scrutinized in this study is the Arabic definite article *ʔil-,* which has to be attached to either a noun or a postnominal adjective that is preceded by a noun that is prefixed with *ʔil*. In Arabic grammar, the sounds are categorized into two groups: lunar[7] (non-coronals) and solar (coronals). Only solar (coronals) sounds can fully assimilate to /*ʔil-*/,

[7] In Arabic traditional grammar, the definite article is either solar (ʃamsiya) as it appears in the word *aʃ-ʃams* 'the sun' and it undergoes total assimilation to the following coronal, or lunar (qamariya) as it appears in the word *al-qamar* 'the moon' and does not undergo total assimilation to the following coronal. I think this classification based on solar vs. lunar was a way to teach how the definite article is used in Arabic so people would realize that any ʃamsiya /l/ would be pronounced as the word *aʃ-ʃams* and any qamariya /l/ would be pronounced as the word *al-qamar*.

meaning that coronal sounds cause/trigger assimilation of the preceding /l/ in /*ʔil*/ whereas non-coronal sounds do not. Consider the following examples for illustration.

i) *ʔil-bint* *ʔil-d͡ʒami:le*
the-girl the-beautiful
'The beautiful girl.'

j) *ʔis-salam* *niʕme*
the-peace blessing
'Peace is a blessing.'

As shown in examples above, if the first consonant of the stem to which the definite article *ʔil* is attached is lunar (non-coronal), there is not total assimilation as in (i), whereas in (j) *ʔil* totally assimilates to the coronal /s/ because it is a solar sound.

2.3.4 Prefixal /n/

The final morpheme to be examined in this paper is the passive voice prefix /ʔin-/. It is a bound morpheme that is always attached to a past tense tri-consonantal verb, resulting in a passive voice past tense verb. The following example illustrates the use of this morpheme.

k) *id-dars* *ʔin-katab*
the-lesson Pass-wrote.Past
'The lesson was written.'

As shown in the example above, *ʔin-* is prefixed to a past tense verb. It is worth pointing out in this respect that *ʔin-* is the only passive form in RJA and that it does not show any kind of agreement with the subject; it can be used with all subjects irrespective of the number, gender, and person.

Finally, the affixes under investigation are an exhaustive list of productive prefixes and suffixes that I will base my analysis on.

2.4 Summary

In this chapter, I discussed the vowel and consonant inventories in RJA. I also compared/contrasted the RJA vowels and consonants with those in Modern Standard Arabic (MSA) and other JA dialects and showed how vowels shifted overtime. Furthermore, I showed how diphthongs in MSA have undergone monophthongization in RJA. Then, I briefly introduced some phonological processes in RJA, e.g., epenthesis, metathesis, syncope, and word stress. Finally, I provided and a brief overview of the morphology of RJA, focusing on the morphemes that will be discussed in the voicing and emphatic assimilation in chapters four and five, respectively.

Chapter Three

3. Methods

In this chapter, I describe the speech material used in the study for both assimilation and gemination, give some information about the participants from whom I collected the data, and describe the research procedure and the research ethics followed for the data collection. I, finally, show how the data is collected, and how it is analyzed acoustically.

3.1 Participants

Participants of the study are four male and two female native speakers of RJA with no known history of either speech or hearing impairment whose L1 is RJA and L2 is English as shown Table (13) below.

Table (13): Participants profiles

Participant code name	Sex	Age	# of years in Canada	Languages spoken
MS	Female	33	6	Arabic and English
HS	Female	31	3	Arabic and English
AO	Male	32	4.5	Arabic and English
MO	Male	34	6	Arabic and English
HD	Male	38	6	Arabic and English
MD	Male	34	3	Arabic and English

The participants were all born and raised in Jordan and were all graduate students at the University of Manitoba and residing in Winnipeg (Manitoba, Canada) at the time of recordings. They are all primarily speakers of Arabic despite being in Canada. They are all within the same age range (age mean = 33.6), and they were all acquaintances of the researcher.

To protect the participants' confidentiality and to meet research ethics, a consent form (see Appendix A) was given to the participants before collecting the data to explain the purpose of the study and to seek their permission to record the speech material of the study.

3.2 Recordings

The recordings took place on two different sessions for each speaker, where one session was dedicated to the assimilation experiment, which was conducted before the other experiment. The second session was also dedicated to the gemination experiment.

For the assimilation experiment, the participants were provided with a written list of common words, where each word contained a word followed or preceded by an affix. The words were written in the Arabic orthography, supplemented with diacritic markings where needed. The participants were asked to read the words at a normal speaking rate and to read them the way they would use them in everyday-life communications in the carrier phrase [ʔiħki___kama:n mar:a] ("Say____ again").

For the gemination experiments, following (Khattab and Al-Tamimi, 2009; Khattab and Al-Tamimi, 2014) the participants were provided with a written list of minimal pairs. Because creating minimal pairs that represent the entire consonantal inventory in RJA is very challenging, only five words were used in near minimal pairs due to the low frequency of these words, but for the rest of the words, I was successful to put them in minimal pairs.

The participants were asked to read the randomized (near) minimal pairs at a normal speaking rate. Each stimulus was read once. The words were presented to participants in the Arabic language orthography supplemented with diacritic markings where needed. The target word pairs were recorded in the carrier phrase [ʔiħki___kama:n mar:a] ("Say____ again").

The participants were not informed of the specific purpose of the study to make the production of phrases more natural and unbiased. The recordings were performed with a Marantz PMD-660 solid state recorder and an Audix OM 2 microphone in the anechoic chamber in the linguistics lab at the University of Manitoba. The recordings were made at 44.100 Hz and then down-sampled to 22, 050 Hz for acoustic analysis.

3.3 Speech material

The assimilation experiments consisted of 113 words for a total of 678 words. Twenty-nine words were recorded for the prefix-final consonant /t/ in /mit-/, whereas 27 words for the prefix-final consonant /ʔin-/ because it does not occur with the palatal glide /j/ nor with the glottal stop /ʔ/ across morpheme boundaries in RJA, 29 words for the prefix-final consonant /ʔil-/ whereas 28 words for the suffix-initial consonant /h/ in /-hum/, /-hin/ and /-ha/ because the glottal stop in RJA does not occur word-finally. The prefix-final consonants as well as the suffix-initial consonant were affixed to 29 and 28, respectively, different free morphemes, each of which begins with a different consonant.

For the gemination experiments, the speech material consisted of 204 words used in minimal pairs for a total of 1224 words. Some consonants were excluded such as the glottal stop /ʔ/ as it does not occur word medially or finally in RJA. The minimal pairs contrasted words that have singleton consonants with words that have geminate consonants as follows:

- The first group contrasts the disyllabic CVCVC words with the disyllabic CVC:VC words that contain a geminate word-medially, in which the target consonants are preceded and followed by a short vowel. This group comprised 54 (near)minimal pairs.
- The second group contrasts the disyllabic CVCV:C words with the disyllabic CVC:V:C words that contain a geminate consonant word-medially, in which the target consonants are preceded by a short vowel and followed by a long vowel. This group comprised 54 (near)minimal pairs.
- The third group contrasts the monosyllabic CVC words with the monosyllabic CVC: words that constrain a geminate consonant word-finally, in which the target consonants are preceded by a short vowel. This group comprised 48 (near)minimal pairs.
- The fourth group contrasts the monosyllabic CV:C words with the monosyllable CV:C: words that contain geminate consonants word-finally, in which the target consonants are preceded by a long vowel. This group comprised 48 (near)minimal pairs.

3.4 Acoustic measurements

In this section, I show how vowel durations, vowel formant frequencies, consonant duration (geminates and singletons) were determined and measured through simultaneous evaluation of waveforms, spectrograms, and an amplitude envelope.

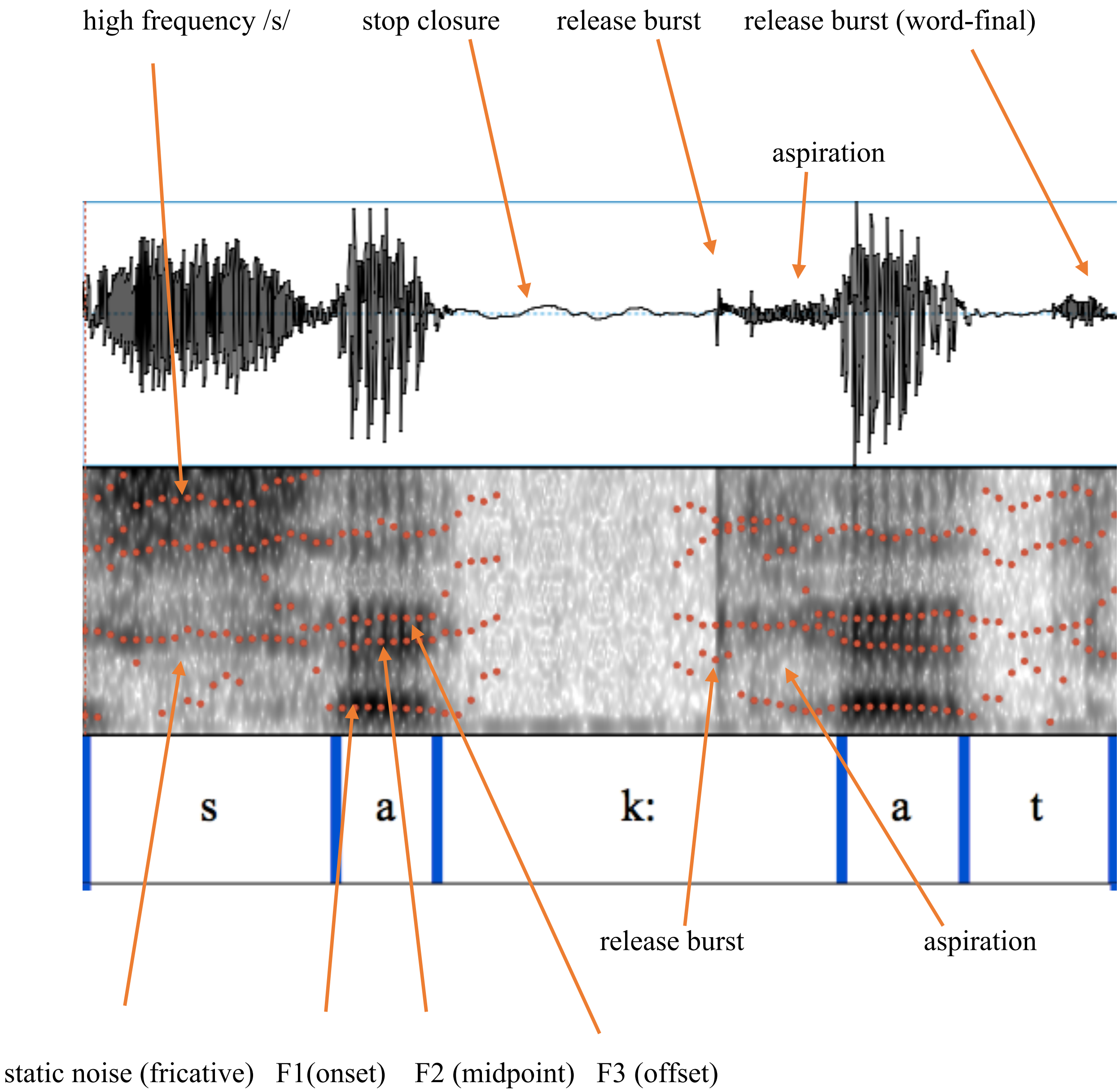
3.4.1 Voicing and emphatic assimilation measurements and segmentations

For the assimilation experiments, Praat (version 5.4.09) (Boersma and Weenink, 2009) was used to perform the acoustic measurements of the study. These acoustic measurements consisted of the duration of the vowel and the first formant frequency at 20%, 50% and 80% (onset, midpoint, and offset) before voiced and voiceless consonants to check the effect of consonant voicing on the duration of the vowel (cf. Kulikov, 2012). The segments were manually marked for boundaries using Praat. I also used a Praat script to extract vowel duration and vowel F1, F2, and F3 at the three positions. All measurements and segmentation were done through simultaneous evaluation of the waveform, a spectrogram, and an amplitude envelope. Following Kulikov (2012), F1, F2, and F3 frequencies were taken 10 ms after the release of initial and intervocalic stops, as well as 10 ms before a closure onset for intervocalic stops as the vowel formant is steadier and not affected by preceding or following consonants. For vowel duration, the beginning of the vowel boundary was determined based on the rise in amplitude from the preceding consonant and appearance of formant structure, and the end of the vowel boundary based on the drop in amplitude and disappearance of abrupt change in formants as in Turk, Nakai, and Sugahara, (2006); Khattab and Al-Tamimi, (2014). The presence/absence of low frequency periodicity was checked and shown visually on a spectrogram to show the presence/absence of voicing assimilation. As for emphatic assimilation, the acoustic measurements involved the first three formant frequencies as well as the duration of the vowel preceding the emphatic consonants for the emphatic assimilation. Praat was also used to show total assimilation, or lack of assimilation by examining the spectrogram of the consonants through visual and auditory inspection of spectrograms and waveforms.

3.4.2 Gemination measurements and segmentations

In the gemination experiments, Praat (version 5.4.09) was used to perform the acoustic measurements of the experiments (see Figure 11 on how boundaries were determined). The acoustic measurements consisted of the duration of the vowels /a/ and /a:/ preceding and following word-medial singletons and word-medial geminated consonants in the disyllabic words used in minimal pairs, and the duration of the vowels /a/ and /a:/ preceding the word-final singleton and geminated consonants in the monosyllabic words used in the minimal pairs. The measurements included the duration of the singleton and geminated consonants used in the minimal pairs as well. The segments were manually marked for boundaries using Praat. I also used a Praat script to extract vowel duration and consonant duration in both contexts, i.e., geminates and singletons. Following and adapting work by Ham, (2001); Turk, Nakai, and Sugahara, (2006); Kulikov, (2012); Khattab and Al-Tamimi, (2014), the boundaries of vowels and consonants in both contexts (geminates and singletons) were determined through simultaneous evaluation of the waveform, a spectrogram, and an amplitude envelope. The beginning of the vowel boundary was determined based on the rise in amplitude from the preceding consonant and appearance of formant structure, and the end of the vowel boundary based on the drop in amplitude and disappearance of abrupt change in formants. So, it is basically from the onset of the F2 to the offset of F2. The beginning of the stop closure was marked at the end of the second formant structure of the preceding vowel, which typically coincides with a significant drop in amplitude of vocal fold vibration (Jessen, 1998). The end of the closure was marked at the left-edge of the release burst (Kulikov, 2012) for final stops. It is worth mentioning here that geminate and singleton stops word-finally have clear release bursts. Because of the final release, word-final geminate stops can be perceptually and acoustically distinct from word-final singleton stops. For medial stops, the end of closure was marked before the beginning of the formant structure and voicing of the following vowel. For nasal stops, closure duration was determined based on the beginning of the offset of F2 to the ‘reappearance’ of F2 for medial consonants or the offset of nasal murmur for medial consonants (Ham, 2001: 33). The beginning of the fricative boundaries was determined based on the onset and offset of visible and/or audible friction, including any period of silence which sometimes precedes the start of the following vowel for medial fricatives (Khattab and Al-Tamimi, 2014: 246). The boundaries for nasals, laterals, and approximants were determined based on the drop in amplitude and beginning and/or end of transitions in the surrounding vowels (depending on the consonant position) as well as the absence of higher formants for approximants. Trill boundaries were determined based on the beginning of the drop in amplitude and/or cessation of formants in the preceding vowel to the rise in amplitude indicating the release of tongue contact and start of formants in the following vowel.

Figure (11): Screenshot of a Praat textgrid showing boundaries for the word 'sakkat' (Speaker MS)



3.5 A description of the statistical analysis used in this work[8]

As for the gemination experiment, three separate Linear Regression statistical tests were carried out in R-studio (Version 0.99.473). with the *lm* function (Chambers, 1992), one for geminates word-medially, one for geminates word-finally, and one for all geminates (medial and final position). As for geminates word-medially, geminate duration, singleton duration, preceding short vowel duration, and following short as well as long vowel duration were used as dependent variables (they were placed in the same order mentioned in this section), while consonant type (geminate and singleton), place of articulation (alveolar, interdental, labial, labio-dental, palatal, palate-alveolar, pharyngeal, velar, glottal), manner of articulation (affricate, fricative, glide, lateral, nasal, plosive, trill), emphasis (emphatic and plain), voice (voiced and voiceless), and gender (male and female) were used as independent variables (they were placed in the same order mentioned in this section). It is worth-mentioning here that when an independent variable turned out to be non-significant, it would be removed and the same test would be run again without it in order to get the best fitted model (cf. Cotton, 2013).

As for geminates word-finally, geminate duration, singleton duration, preceding short vowel duration, and following long vowel duration were used as dependent variables (they were placed in the same order mentioned in this section), while consonant type (geminate and singleton), place of articulation (alveolar, interdental, labial, labio-dental, palatal, palate-alveolar, pharyngeal, velar, glottal), manner of articulation (affricate, fricative, glide, lateral, nasal, plosive, trill), emphasis (emphatic and plain), voice (voiced

[8] Special thanks go to Dr. Kevin Russell for his time discussing statistical analysis with me and answering all my questions as well as for having me in his Research Methods class.

and voiceless), and gender (male and female) were used as independent variables(they were placed in the same order mentioned in this section). The third Linear Regression model was carried out to compare the duration of geminates word-medially and word-finally. Again, when an independent variable turned out to be non-significant, it would be removed and the same test would be run again without it in order to get the best fitted model.

With regards to voicing and emphatic assimilation, two Linear Regression tests were carried in R-studio (Version 0.99.473) with the *lm* function (Chambers, 1992), one for voicing and one for emphasis. Preceding vowel F1 (onset, midpoint, offset), and vowel duration were used as dependent variables (they were placed in the same order mentioned in this section), whereas voice (voiced and voiceless), position (affix and root), place of articulation (alveolar, interdental, labial, labio-dental, palatal, palate-alveolar, pharyngeal, velar, glottal), manner of articulation (affricate, fricative, glide, lateral, nasal, plosive, trill), and gender (male and female) were used as independent variables (they were placed in the same order mentioned in this section). As was done with other experiment, when an independent variable turned out to be non-significant, it would be removed and the same test would be run again without it in order to get the best fitted model.

Another Linear Regression test was carried for emphasis using vowel duration, vowel F1 (onset, midpoint, offset), vowel F2 (onset, midpoint, offset), vowel F3 (onset, midpoint, offset) as dependent variables (they were placed in the same order mentioned in this section), while vowel type (a, u, i), position (affix and root), place of articulation (alveolar, interdental, labial, labio-dental, palatal, palate-alveolar, pharyngeal, velar, glottal), manner of articulation (affricate, fricative, glide, lateral, nasal, plosive, trill), and gender (male and female) were used as independent variables (they were placed in the same order mentioned in this section). Similarly to what has been done with the gemination experiment, when an independent variable turned out to be non-significant, it would be removed and the same test would be run again without it.

In this chapter, I gave an overview of the participants of the study and presented the speech material and acoustic measurements that have been used to collect and analyze the data. Further, I included a detailed description of the statistical analysis tests that have been used in analyzing the results. I now move on to the next chapter to present and discuss the results of voicing assimilation.

Chapter Four: Voicing assimilation

4. Introduction

Assimilation is a phonological process in which one segment takes on the feature of another within its environment (cf. McCarthy and Smith, 2003). The segment that changes its phonological properties to pattern with another segment is called the target or the undergoer, whereas the segment that gives the phonological properties to the target is referred to as the trigger. Assimilation can occur within a word, across word boundaries, and across morpheme boundaries. It may also occur between vowels and consonants, between vowels, and between consonants. According to Zuraiq and Abu-Joudeh (2013), different features can be involved when investigating assimilation such as 'place, manner, voicing, vowel height, vowel rounding, and nasalization' (p.1). There are three types of assimilation based on directionality, namely progressive, regressive, and reciprocal. Progressive assimilation occurs when a sound becomes more like a preceding sound, left-to-right direction, so in progressive assimilation the preceding sound affects the following sound (x→y) like in the following example (8).

(8). 'bags'→[bæ**gz**]

In example (8), [s] is assimilated in voicing to [z] due to the influence of the preceding sound [g]. So, in this case, [g] is the trigger and [s] is the target. In contrast, regressive assimilation occurs when a sound becomes more like a following sound, right-to-left direction, so in regressive assimilation, the following sound affects the preceding sound (x←y) like in the following example (9).

(9). ‘bad boy’→ [bæ**b** **b**ɔi]

In example (9), the alveolar stop [d] becomes [b] when followed by a bilabial consonant. So, in this case, [b] is the trigger and [d] is the target. As for reciprocal assimilation, two sounds influence each other, thus the directionality may be left-to-right or right-to-left, so in reciprocal assimilation both neighboring sounds merge into a different sound (x↔y). An example on reciprocal assimilation in English is when the alveolar [z] becomes [ʒ] when followed by [j], resulting in a new sound as shown in the following example (10).

(10). ‘buzz you’ → [bʌ**ʒ** **ʒ**u].

Moreover, assimilation can be either complete, in which two sounds become alike as in example (11) below where the [n] and the [m] become identical; or partial, where one sound takes on one or more features of another sound, but not all, as in example (12).

(11). ‘in March’ → [i**m** **m**ɑrʧ]

(12). ‘sunbath’→ [sʌ**m** **b**æθ]

As shown in example (12), [n] assimilates to [b] partially because it does not share all the features with [b].

4.1 Previous studies on assimilation

Phonological assimilation has been studied cross-linguistically (Mohanan, 1993; Jun, 1995; Lombardi, 1995; Lombardi, 1999; Hansson, 2001; Rose and Walker, 2004, among others) especially across word boundaries.

Table (14): Summary of studies on assimilation in Arabic

Dialect	Boundary Affected	Study Reference	Basic Findings
Cairene & Baghdadi Arabic	Morpheme Boundary /ʔil-/, /-h/, /t-/	Youssef (2013)	• /l/ totally assimilates to a following coronal. • /-h/ devoices preceding /ɣ/ and /ʕ/. • /t-/ undergoes total assimilation to a following coronal stop.
Algerian Arabic	Morpheme boundary (/t-/ and / ʔil-/)	Benyoucef & Mahadin, (2013)	• /t/ →[+voice]/[+voice, +obst] • /l/ totally assimilates to a following coronal.
Cairene Arabic	Morpheme boundary (/ʔil-/)	Heselwood & Watson, (2013)	• /l/, the following coronal undergoes gemination.
Misrata Libyan Arabic	Morpheme boundary (/ʔil-/ and /t-/)	Elramli, (2012)	• /t/ →[+voice]/[+voice, +cons] • /l/ totally assimilates to a following coronal.
Cairene Arabic	Word Boundary	Kabrah, (2011)	• [+voice, +obst]→[-voice]/ [-voice, +obst]___
Urban Jordanian Arabic	Word Boundary Morpheme Boundary /ʔil-/	Zuraiq & Zhang, (2006)	• Coronal obstruents assimilate to following coronal obstruents. • /l/ totally assimilates to a following coronal.

However, in spoken Arabic, few studies have dealt with investigating assimilation across morpheme boundaries. Also, except for Heselwood and Watson (2013)'s study, most studies investigate this phenomenon based on auditory impression. In RJA, particularly, no single study, to the best of my knowledge, has investigated assimilation across morpheme boundaries to date. The above Table (14) lays out and summarizes some of the studies that dealt with both types of assimilation; across word boundaries as well as across morpheme boundaries in spoken Arabic. All previous studies that dealt with Jordanian Arabic dialects (mainly the Urban dialect) have focused on consonantal assimilation across word boundaries using auditory impression (See Zuraiq and Zhang, 2006; Abu-Abbas, Zuraiq, and Al-Tamimi, 2010; Zuraiq and Abu-Joudeh, 2013; Abu-Abbas, Zuraiq, and Abdel-Ghafer, 2014). As shown in Table (14), assimilation has been studied by many scholars in different Arabic dialects whether across word boundaries or across morpheme boundaries. In these studies, it has been argued that the definite article undergoes total assimilation when followed by a coronal consonant. For example, when the definite article /l/ is followed by the coronal /n/, /l/ undergoes total assimilation as in this example: 'a**l**-**n**ar' [a**n**-**n**ar]. It has been also shown that voicing assimilation is always regressive, and that nasality and sonority always resist assimilation (Elramli, 2012). Also, it is worth pointing out that emphasis has been always part of the assimilation investigation (mostly auditory impression, not instrumental) in Arabic as the emphasis features spread to the neighboring (local and long distance) sounds.

As far as the prefix-final /t-/ is concerned, it always undergoes regressive voicing assimilation when followed by a voiced obstruent but not a sonorant. Elramli, (2012) gives the following example show to how sonorants block assimilation '(**t**-+ **l**aagi) → [**tl**aagi] ‘you meet’. As far as Jordanian Arabic is concerned, Zuraiq and Zhang (2006) investigated consonantal assimilation in UJA and found out that place assimilation is always regressive. They also reported that alveolars and postalveolars undergo assimilation if the sonority of the consonants already matches, and that coronal obstruents assimilate to following coronal obstruents but not velar obstruents. Further, they asserted that voicing as well as emphasis occur if the places of the adjacent non-coronal consonants are identical, so, according to them, the similarity in place of articulation plays an important role in accounting for the behavior of voicing as well as emphasis assimilations as in the following example they provided /ba**s**-**z**alame/ → [ba**z**-**z**alame].

Other studies in the literature of JA assimilation, however, have focused on investigating assimilation across word boundaries. For example, Zuraiq and Abu-Joudeh, (2013) found that the coronal sonorants /n/ and /l/ undergo total assimilation to a following /r/ but not to any other continuant. This poses a question on the special way the definite article in Arabic behaves when it comes to assimilation. For example, when /l/ is a terminal consonant in a word and followed by a word that begins with a coronal, no assimilation takes place as in the word /mal/ ‘what’s wrong’ when followed by the word /zeyad/ ‘proper name’ the result is [mal-zeyad]; no assimilation. By contrast, when the definite article /ʔil/ is followed by a word that begins with the /z/ like in the word /zalame/ ‘man’, /l/ undergoes total assimilation as in this example /ʔil-zalame/ → [ʔiz-zalame]. This brings up a question on the different patterns the coronal /l/ displays in Arabic and how different it is when it is in the definite article that when it occurs elsewhere.

To my knowledge, no studies have dealt with the assimilation of other bound morphemes, other than the definite article /ʔil/, to a free morpheme in JA in general or in RJA in particular. In this study, I phonetically (through acoustic analysis) and phonologically investigate, in addition to the definite article /ʔil/, the assimilatory behavior of new morphemes that have not been tackled in other studies (see section 2.3 for more details on these morphemes) in order to check if assimilation across morpheme boundaries behaves differently from assimilation across word boundaries in RJA.

4.2 Acoustic correlates for voicing assimilation

Drawing on the previous experimental phonetic studies that dealt with assimilation, in this section, I introduce the acoustic correlates that I use in the current study, which include the vowel duration before voiced and voiceless consonants, vowel first formant frequency (F1) before voiced and voiceless, and visually show the presence/absence of low frequency periodicity.

4.2.1 Vowel duration

Voicing assimilation acoustic correlates cross-linguistically usually focus on the temporal as well as the spectral differences between voiced and voiceless consonants. One of the important temporal correlates to distinguish voicing assimilation between intervocalic consonants is the duration of the vowel preceding the first consonant (Zimmerman and Sapon, 1958; Peterson and Lehiste, 1960; Fintoft, 1961; Chen, 1970; Laeufer, 1992; Jongman, Sereno, Raaijmakers, and Lahiri, 1992; Kulikov, 2012, among others). It has been reported that vowels preceding voiced consonants are longer at about 10-30% (Zimmerman and Sapon, 1958; Fintoft, 1961) and 60% (Peterson and Lehiste, 1960) than vowels preceding voiceless consonants. Laeufer, (1992) (cited in Kulikov, 2012) argues that regardless what difference of values and ratios of the duration of vowels before voiced and voiceless consonants, there is still a difference, and this is a universal one. Myers (2010) posits that vowels before voiced consonants are significantly longer in duration than those before voiceless fricatives. However, he states that this duration is not the same across the board because he found that the consonant that follows the postvocalic consonants affect the duration as well. Similarly, Hagiwara (2015) found that monophthongs that are produced with the voiceless coda were 91% the duration of their counterparts before /d/ in a Canadian (Winnipeg) English sample.

4.2.2 Adjacent vowels F1

Furthermore, another important acoustic correlate for voicing assimilation is the frequency of the first format (F1) of the vowel adjacent to the target consonant. According to Benkí (2005), F1 is a universal cue to distinguish voiced from voiceless consonants. He also adds that the difference between aspiration and a true voice is affected by in the relationship between VOT and F1. Ladefoged, 1967; Ohala, 1972; Hombert et al, 1979; Westbury, 1983, Al-Deaibes, 2015b claim that F1 tends to be lower when the vowel is adjacent to a voiced consonant, which is caused by the larynx lowering gesture due to the extension of the vocal tract, and that it tends to be shorter when the vowel is adjacent to a voiceless consonant because the vocal tract is shorter when voiceless consonants are produced. This gesture expands the supralaryngeal cavity and facilitates voicing (see Ladefoged, 1967, Ohala, 1972, Hombert et al 1979, cited in Kulikov, 2012). Fagan (1988) posits that F1 is the most important acoustic correlate for voicing contrast. Thurgood (2004) also asserts that F1 is lower and F2 is higher when preceding a voiced consonant in Javanese. Accordingly, vowel F1 of neighboring voiced and voiceless consonants is an important acoustic correlate/cue to distinguish voicing contrast for both perception and production.

4.3 Results and discussion

In this section, I present the results of the voicing assimilation experiment (see Chapter 3 for more information on data collection, measurements, etc.). First, I visually show the presence/absence of low frequency periodicity to show the presence /absence of voicing on spectrograms and waveforms. Second, I report the results of the acoustic correlates of voicing, which include the vowel duration before voiced and voiceless consonants, adjacent vowel first formant frequency (F1). Then, I explain the phonological patterning of the directionality of voicing.

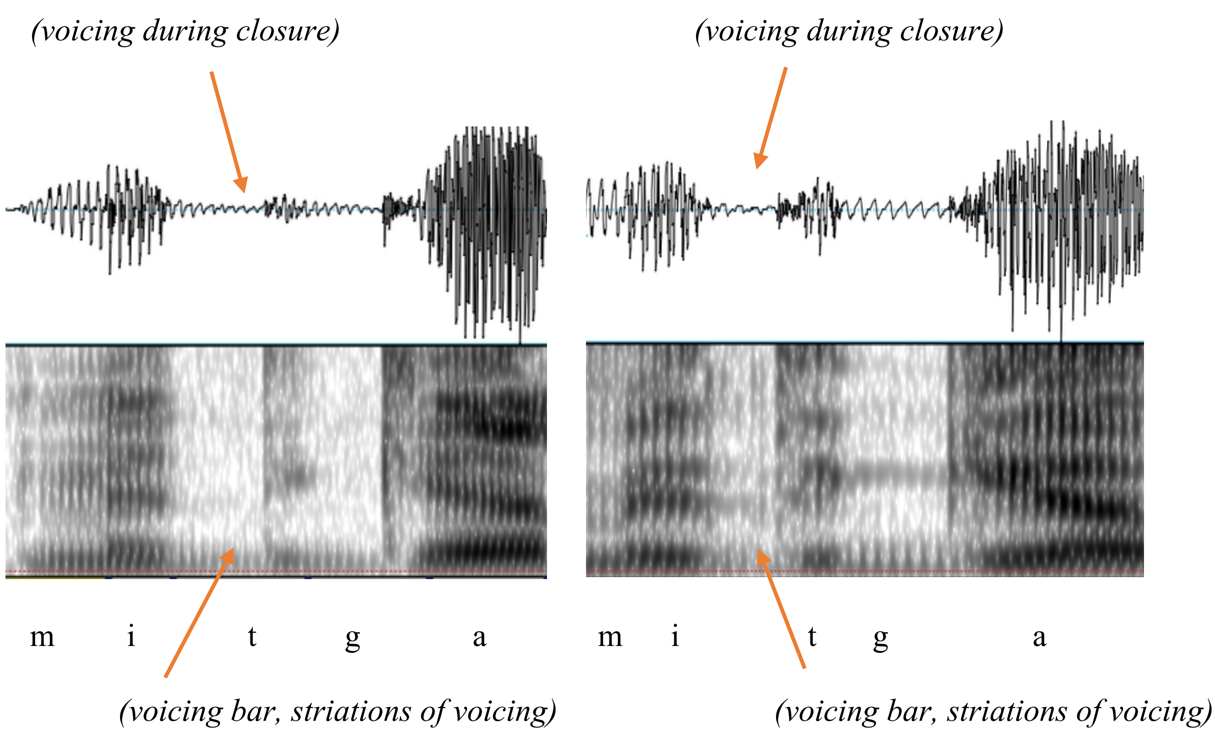
4.3.1 Visualization of low frequency periodicity through assimilation examples

In this section, I show how voicing assimilation takes place through using spectrograms and waveforms. The results show that when the phoneme /t/ in the affix *mit* is followed by a voiced non-coronal obstruent, /t/ undergoes voicing assimilation, i.e., becomes a voiced plosive [d]. Voicing assimilation can be clearly seen in Figure (12) below, which shows how the coronal voiceless plosive /t/ becomes a voiced plosive [d] when followed by a voiced non-coronal obstruent, like the voiced velar plosive /g/, which results in /t/ undergoing voicing assimilation.

In Figure (12), there is a voicing bar that extends between the vowel /i/ and the consonant /g/ that can be seen as a faint band along the bottom of the spectrograms at the frequency of F0, which indicates that voicing is activated. Also, the spike of closure of [t] can be scarcely observed due to the vibration of the vocal cords and voicing of the following voiced consonants, which indicates that the voicelessness of /t/ is affected by the voicing of the following voiced consonant /g/. If we compare the potentially voiced [t] with /g/ that follows it as shown in the spectrogram, we can notice that they both have striations and both have voicing during closure.

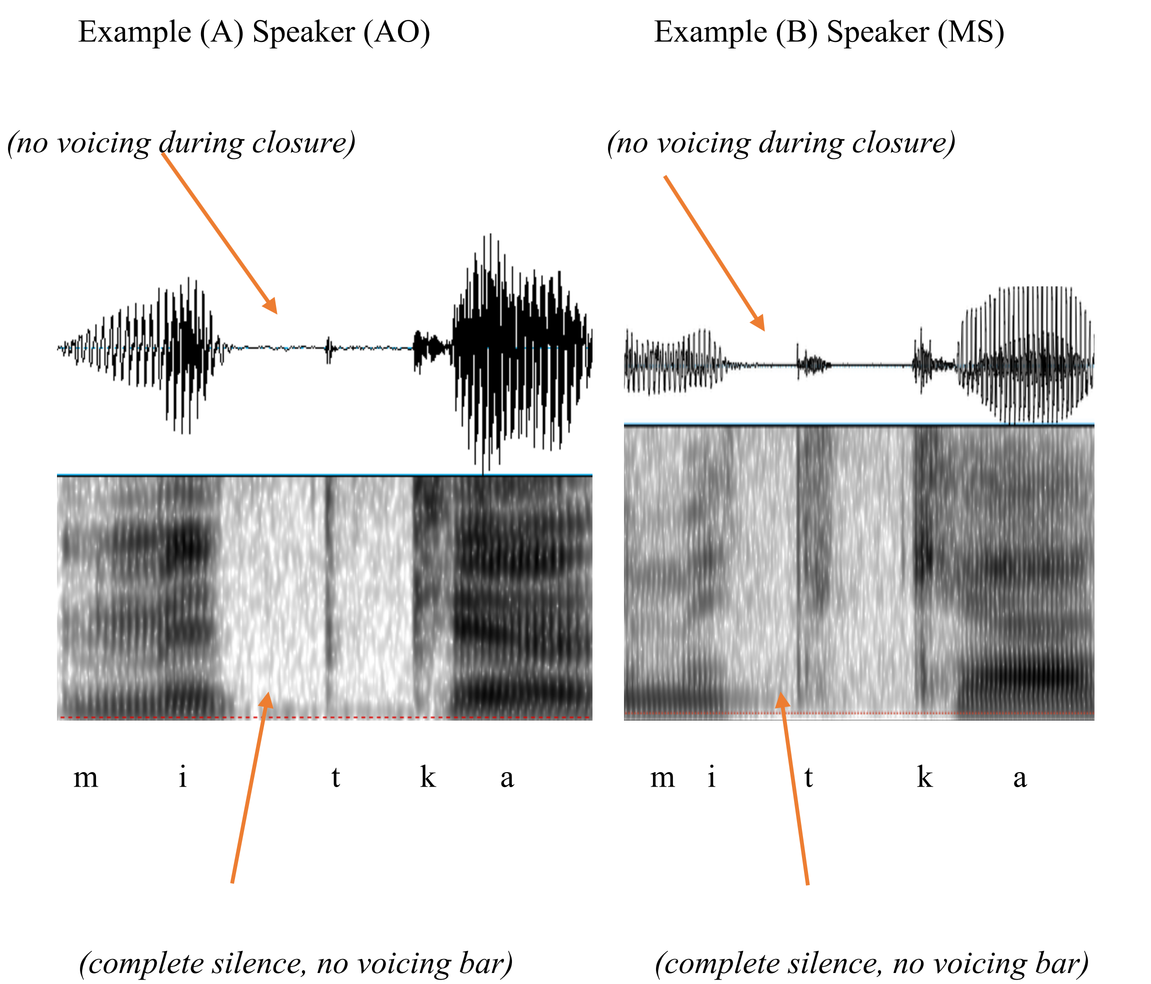
Figure (12): Illustration of voicing assimilation for the word /mit-galisˤ/, [**mid-galisˤ**]

Example (A)-Speaker (AO) Example (B)-Speaker (MO)



This also can be contrasted with /t/ when followed by the voiceless velar /k/ as shown in Figure (13), where /t/ does not undergo any voicing assimilation since it is followed by the voiceless consonants /k/. This can be observed through the spike of the closure of /t/ that can be clearly seen because it is not preceded or followed by a vocal cord vibration. Also, this can be shown by visualizing the lack of the voicing bar due to the complete silence can be observed in the spectrogram.

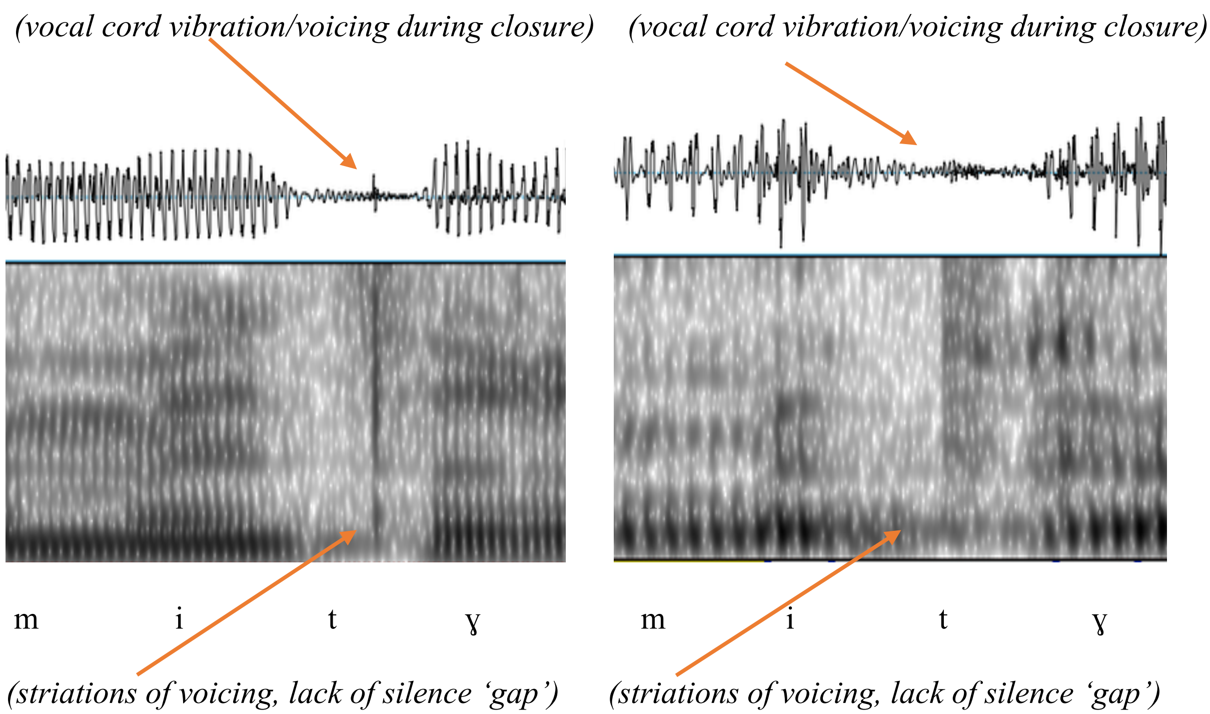
Figure (13): Illustration showing lack of voicing assimilation for the word ‘mit-kasil’



If we, also, compare /t/ with /k/ on the spectrogram in Figure (13), we can notice that they are similar when it comes to lack of vibration, lack of striation, and the period of silence.

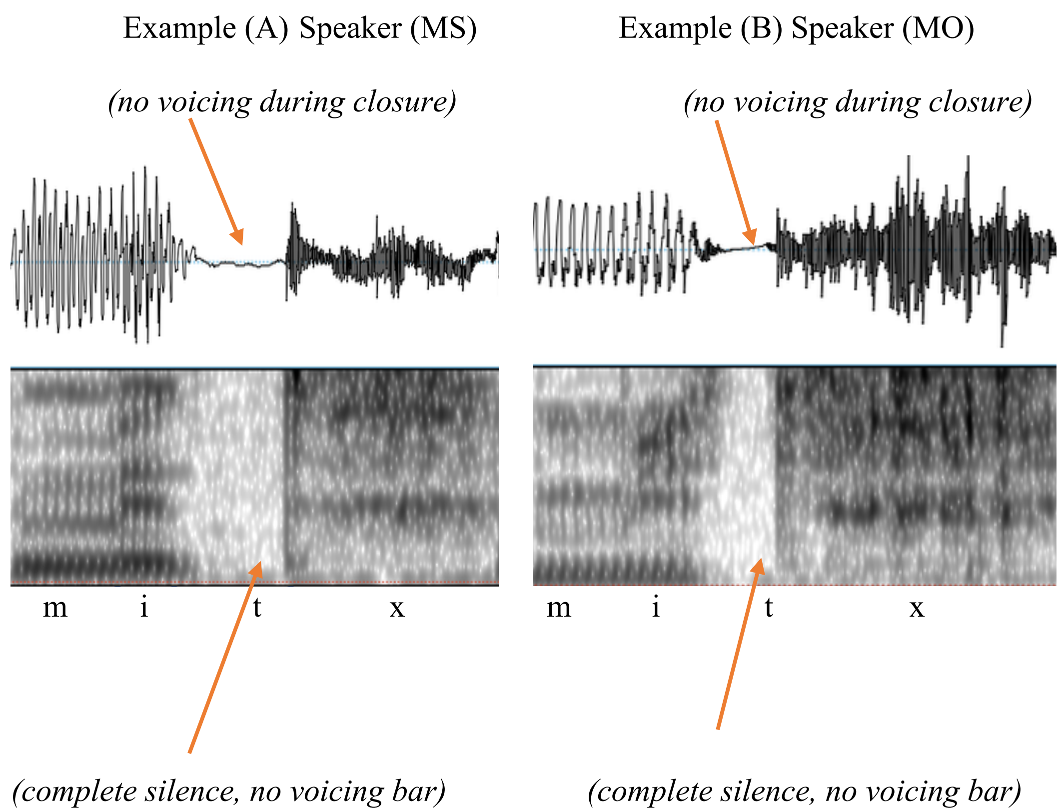
Figure (14): Illustration of voicing assimilation for the word /mit-ɣarib/, [**mid-ɣarib**]

Example (A) Speaker (HS) Example (B) Speaker (HD)



Similarly, the coronal voiceless plosive /t/ becomes a voiced plosive [d] when followed by a voiced non-coronal obstruent, like the voiced velar fricative /ɣ/, which results in /t/ undergoing voicing assimilation as illustrated in Figure (14). Based on Figure (14), we can notice that there is a voicing bar between the vowel /i/ and the consonant /ɣ/ that can be seen as a faint band along the bottom of the spectrograms at the frequency of F0, and there is also no complete silence as it should be with voiceless stops. Likewise, when looking at the waveform, we can notice the vocal cord vibration that accompanies the closure of the plosive /t/ → [d].

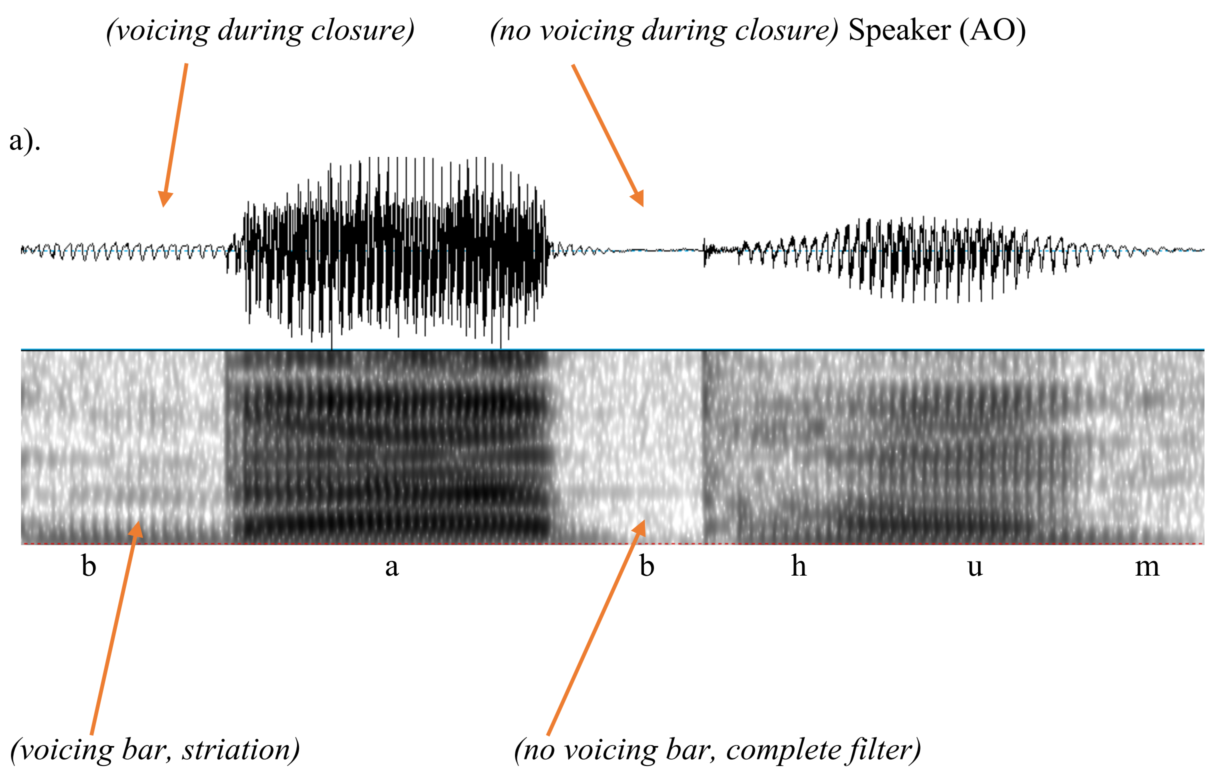
Figure (15): Illustration showing lack of voicing assimilation for the word ‘mit-xayil’



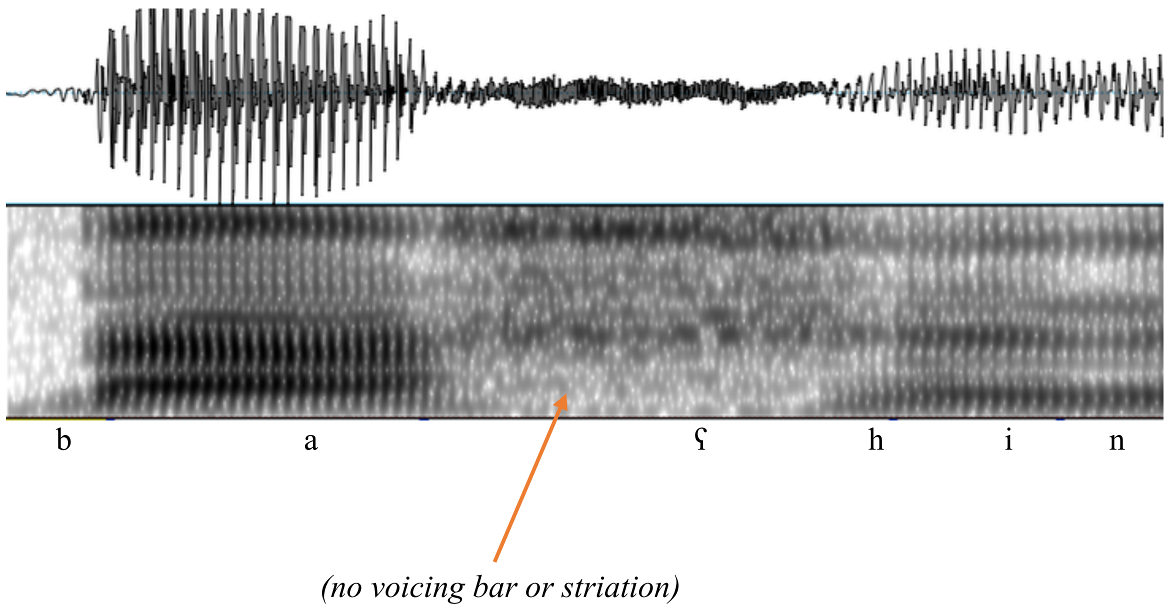
The phoneme /ɣ/ can be contrasted with its voiceless counterpart /x/ when preceded by /t/ to show how no assimilation takes place because both phonemes are voiceless as shown in Figure (15) above. As can be noticed in Figure (15), /t/ does not undergo any voicing assimilation when followed by the voiceless /x/. This can be clearly seen through the spike of its release burst that is not preceded or followed by vocal cord vibration, and through the lack of the voicing bar (complete silence) due to a complete silence that can be observed in the spectrogram near the F0.

As for the phoneme /h/, the results also show that when /h/ is preceded by a plain voiced obstruent, /h/ devoices the preceding voiced obstruent. This devoicing can be noticed in the spectrogram in Figure (16 a-c) below, where the phoneme /b/ in the word ‘bab-hum’ becomes [p], /ʕ/ in the word baʕ-hin becomes [ħ], and /ð/ in the word raðað-hin becomes [θ] when followed by the phoneme /h/, resulting in devoicing /b/.

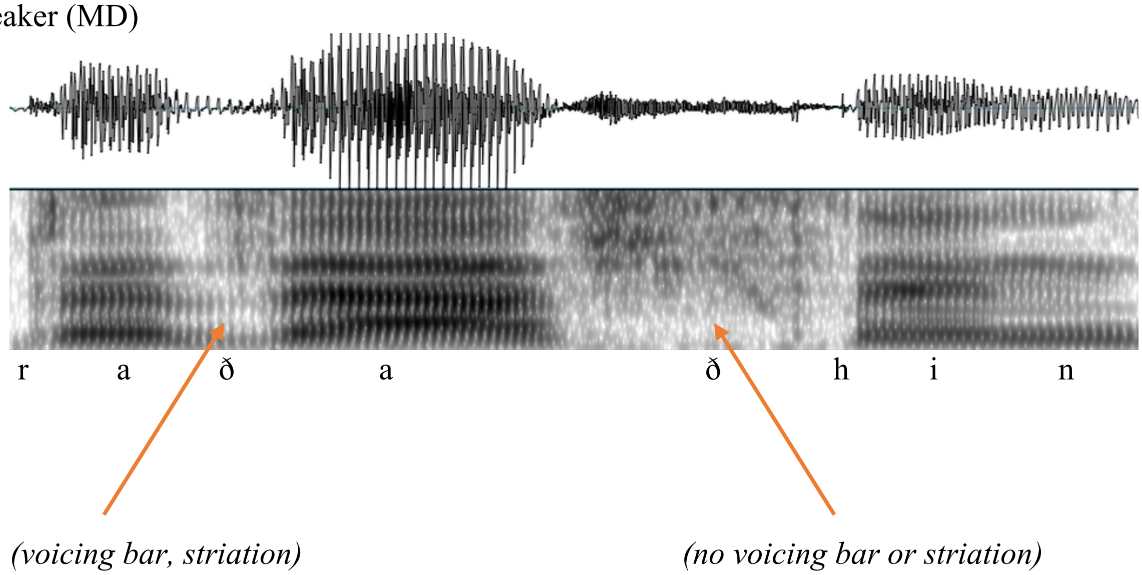
Figure (16): Illustration of the devoicing of /b/, /ʕ/, and /ð/ before /h/



b). Speaker (MS)

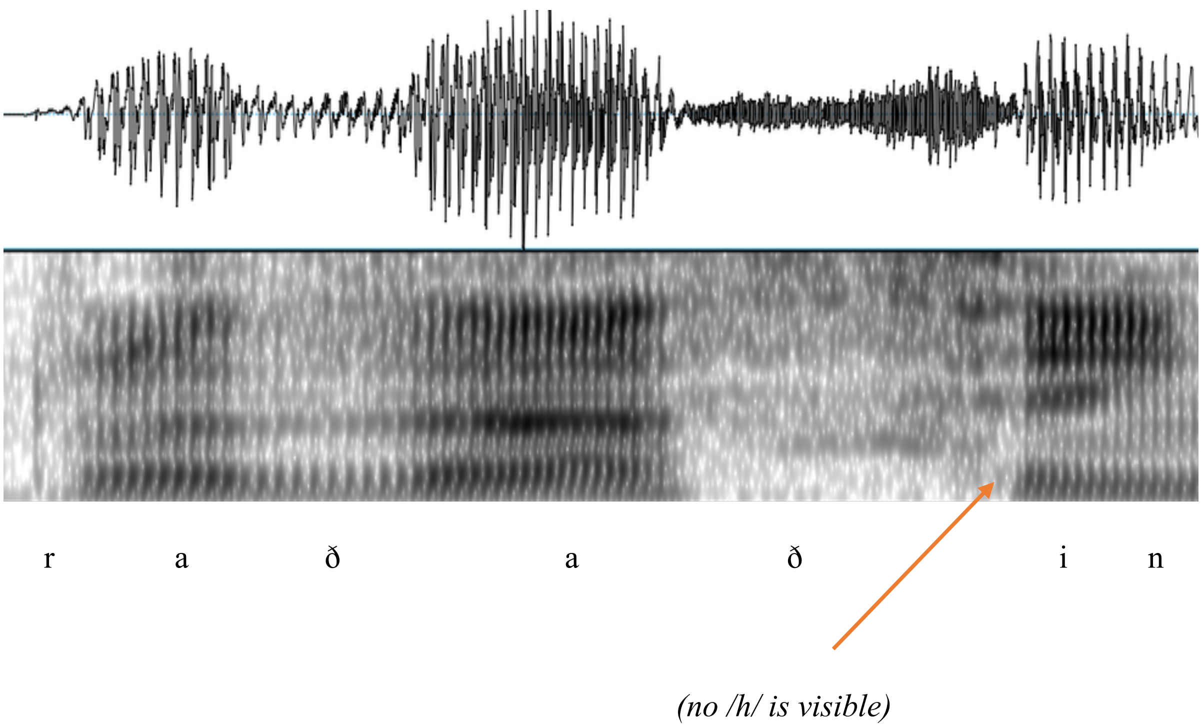


c). Speaker (MD)



Likewise, in Figure (16-b), /ʕ/ gets devoiced and become [ħ] given it is followed by /h/, which is clearly shown in the spectrogram in the form of complete silence and lack of the voicing bar. Finally, in (16-c), the phoneme /ð/ gets devoiced and becomes [θ] when followed by /h/. This can be shown in the spectrogram where the lack of voicing bar indicates devoicing, whereas the other /ð/ in the same word and spectrogram, which is intervocalic, the voicing bar/striations are clearly visible and indicate the voicing of /ð/.

Figure (17): Total assimilation of /h/ after /ð/ in the word /raðað-hin/, [**raðaθ-θin]**
(Speaker (MD))



Interestingly, when /h/ occurs after these voiced phonemes /ʕ/, /ɣ/, /g/, /ð/, /d/, and /ðˤ/, /h/, in many examples by different speakers, totally assimilates to the preceding voiced consonant, and the preceding voiced consonants get devoiced. Therefore, there are two phonological processes involved, first, the voiced consonants are devoiced, and then /h/

becomes totally assimilated to the previous consonant. The above Figure (17) shows these two processes.

As for the phonemes /n/ and /l/, there is no voicing assimilation at all between them and the consonants following them, which indicates that coronal sonorants do not trigger or undergo voicing assimilation.

4.3.2 Results of acoustic correlates

4.3.2.1 Vowel duration

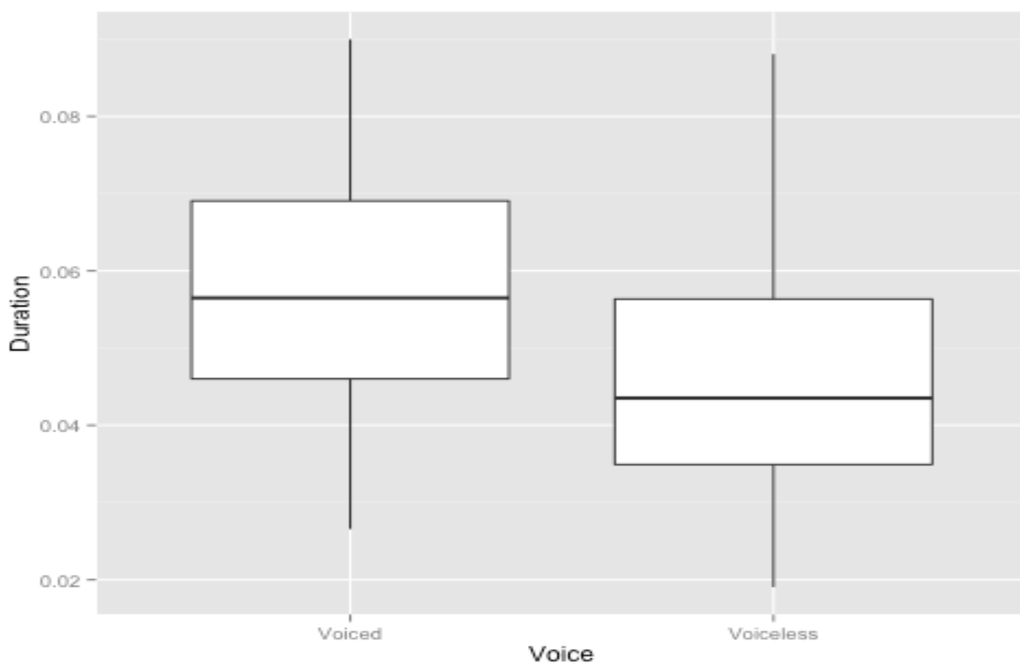
As mentioned in section 4.2.1, vowel duration is an important acoustic correlate when examining voice and voicing assimilation. In this section, I detail the results of the duration of the vowels (/a/, /i/, and /u/) before all voiced and voiceless consonants (see chapter two). The results show that across the board, the duration of the analyzed vowels preceding voiced consonants is longer than that before voiceless consonants. The following Table (15) shows the mean duration of the vowels /a/, /i/ and /u/ before voiced and voiceless consonants. The vowel /a/ mean duration ratio before voiced consonants to /a/ before voiceless consonants is 1:1.2, the vowel /i/ before voiced consonants to /i/ before voiceless ones is 1:1.2, and the vowel /u/ before voiced consonants to /u/ before voiceless ones is 1:1.6.

Table (15): Mean duration of the vowels /a/, /i/, and /u/

Voicing	Vowel /a/	Vowel /i/	Vowel /u/
	Mean (Ms.)	Mean (Ms.)	Mean (Ms.)
Before voiced cons	94	56	69
Before voiceless cons	80	45	43

In order to check if the difference between the duration of the vowels preceding voiced consonants and voiceless ones is statistically significant, I ran a statistical analysis using the Linear Regression model to test the effects of voicing (voiced and voiceless) on the duration of the vowels preceding voiced and voiceless consonants. The results revealed that the duration of the vowels right before voiced consonants (M = 64, SD = 25) is significantly longer than that before voiceless consonants (M = 50, SD = 25) by -14 ms (see Table 15). The following box plot in Figure (18) visualizes mean vowel duration (in Ms.) before voiced and voiceless consonants.

Figure (18): Mean duration (in Ms.) of vowels before voiced and voiceless consonants



This result is in line with Laeufer, 1992; Jongman, Sereno, Raaijmakers, and Lahiri, 1992; Myers, 2010; Kulikov, 2012; Hagiwara, 2015, among others.

Other independent variables namely, gender, place of articulation, manner of articulation, and position were also used in the statistical analysis to check if they contribute any role in the interaction between vowel duration and voicing. Independent variables that turned out to be insignificant were removed one by one and the statistical test was performed again in order to have the best fit. The following Table (16) lays out the statistical results of the Linear Regression test.

Table (16): Statistical results from vowel duration before voiced & voiceless consonants

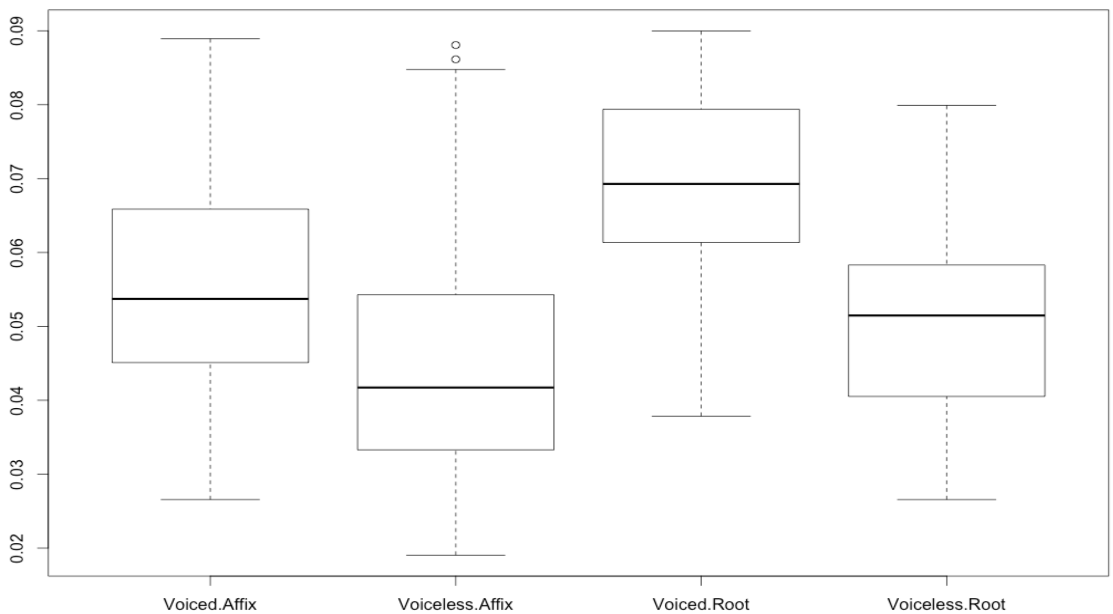
	Estimate	Std. Error	t value	Pr(>|t|)[9]
(Intercept)	0.069170	0.005904	11.717	< 2e-16 ***
VoiceVoiceless	-0.014732	0.002055	-7.169	2.03e-12 ***
PositionRoot	-0.028206	0.001968	14.335	< 2e-16 ***
PlaceGlottal	-0.009925	0.004061	-2.444	0.014785 *
PlaceLabio-dental	-0.012397	0.005020	-2.469	0.013789 *
PlacePalato-alv	-0.015609	0.005020	-3.109	0.001957 **
PlacePharyng	-0.010199	0.003778	-2.699	0.007127 **
PlaceVelar	-0.010316	0.002805	-3.677	0.000255 ***
MannerGlide	-0.021399	0.008323	-2.571	0.010357 *
MannerLateral	-0.015853	0.007409	-2.140	0.032755 *
MannerTrill	-0.017199	0.007409	-2.321	0.020582 *

According to Table (16) above, the statistical analysis results show that vowel mean duration is significantly affected by the places of articulation: glottals, labio-dentals, palato-alveolars, pharyngeals, and velars as opposed to the alveolars, palatals, labials, and

[9] These are the significant codes that will be used as keys for the p-value for all statistical results in this dissertation: **0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1**

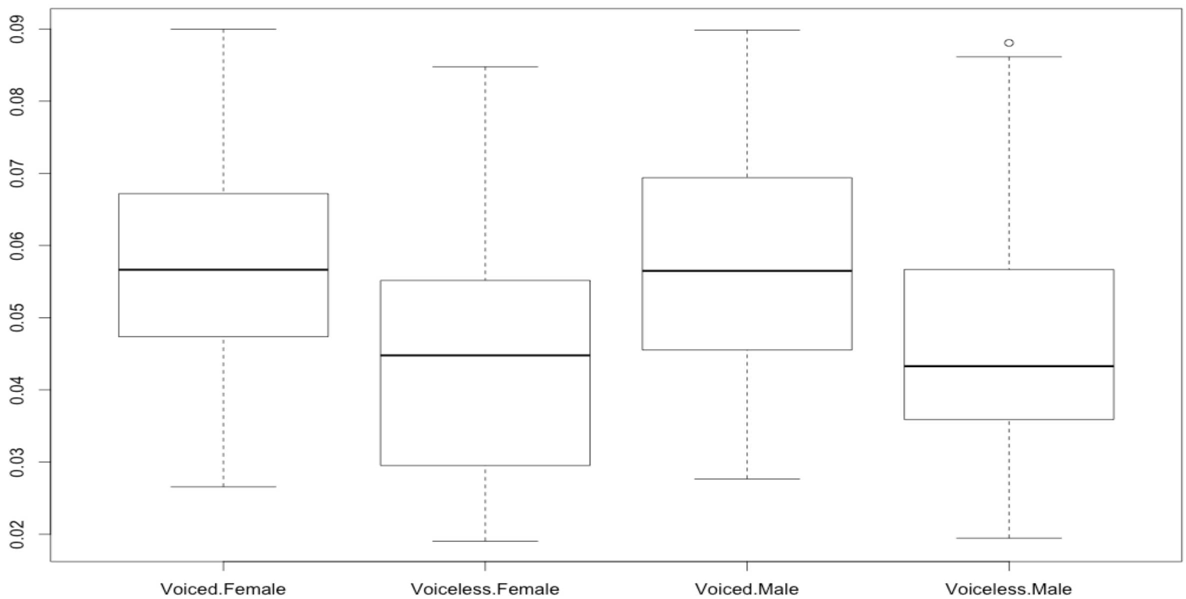
interdentals that do not affect the vowel mean duration. According to the statistical results in Table (16) above, and using alveolars as baseline for all places of articulation since it is alphabetically first in the list, the following results are reported. First, glottal consonants significantly affected vowel mean duration by -9 ms. Second, vowel mean duration was significantly affected by labio-dental consonants by -12 ms. Third, vowel mean duration was significantly affected by palato-alveolar consonants by -15 ms. Fourth, significantly affected vowel mean duration by pharyngeal consonants by -10 ms. Finally, velar consonants significantly affected vowel mean duration by -10 ms. These differences in place of articulation and their role in affecting vowel mean duration can be attributed to the different locations of the articulators in the oral cavity. It can also be attributed to the fact that in these places of articulations, the number of voiceless consonants is eight while voiced consonants are only four, which means that vowels preceding voiceless consonants are shorter in duration while when preceding voiced consonants, they become longer. Similarly, it is clear that the vowel duration is significantly affected by the manners of articulation: trills, laterals, and glides as opposed to affricates, plosives, nasals, and fricatives. So, using the manner affricate as baseline in the statistical analysis, glide consonants significantly affected vowel duration by -21 ms. Also, vowel duration was significantly affected by lateral consonants by -15 ms. Finally, trill consonants significantly affected vowel duration by 17 ms. The vowel duration before consonants that are in the root position appears to be significantly longer than that before consonants in the affix position by -28 ms. The reason behind this is the fact that there is only one affix in the data that triggers devoicing, which is /h/, and, thus, all voiced obstruents in the root position get devoiced by /h/. Therefore, we end up having more voiceless or devoiced consonants in the root position due to this devoicing plus the voiceless consonants that already exist. All these devoiced consonants and voiceless consonants make the vowel that precedes them become shorter. The following boxplot in Figure (19) illustrates the relationship between position (affix and root) and vowel duration and shows that vowel duration before voiced and voiceless consonants in the affix position is shorter than that before voiced and voiceless consonants in the root position.

Figure (19): Vowel duration (in Ms.) in affix and root positions



The statistical analysis results also show that gender plays no role in affecting vowel duration before voiced and voiceless consonants; while males' vowel mean duration before voiced consonants is 63 ms, females' vowel mean duration is 66 ms, with only a 3 ms difference as shown in the boxplot in Figure (20) below, which illustrates that the vowel duration is not different in male and female speakers, whether before voiced or even before voiceless consonants, which again indicates that gender has no influence on the interaction between voicing and vowel duration.

Figure (20): Vowel duration (in Ms.) in male and female speakers



To sum up, vowel mean duration was found to be a salient acoustic correlate when discriminating voiced and voiceless consonants. As shown earlier, vowels tend to be longer before voiced consonants and shorter before voiceless ones, and the ratio of vowel mean duration before voiced to voiceless consonants is 1:1.28.

4.3.2.2 Preceding vowel F1

Similar to the vowel duration, the first formant frequency (F1), as mentioned in section 4.2.2, is another important acoustic correlate that helps discriminate voiced and voiceless consonants and thus helps to detect voicing assimilation. Therefore, the duration of the vowels (/a/, /i/, and /u/) occurring before all voiced and voiceless consonants was measured at onset (20%), midpoint (50%), and offset (80%), and, accordingly, the results show that across the board F1 of the analyzed vowels preceding voiced consonants is lower than that before voiceless consonants. The following Tables (17), (18), and (19) show the mean frequency (in Hz.) of F1 of the vowels /a/, /i/ and /u/, at the three positions of the vowel, as stated earlier, before voiced and voiceless consonants.

Table (17): Mean frequency of F1 of the vowel /a/ at 20%, 50%, 80%

Vowel /a/	Onset (20%)	Midpoint (50%)	Offset (80%)
	Mean (Hz)	Mean (Hz)	Mean (Hz)
Before voiced cons	544	549	521
Before voiceless cons	576	590	575

Table (18): Mean frequency of F1 of the vowel /i/ at 20%, 50%, 80%

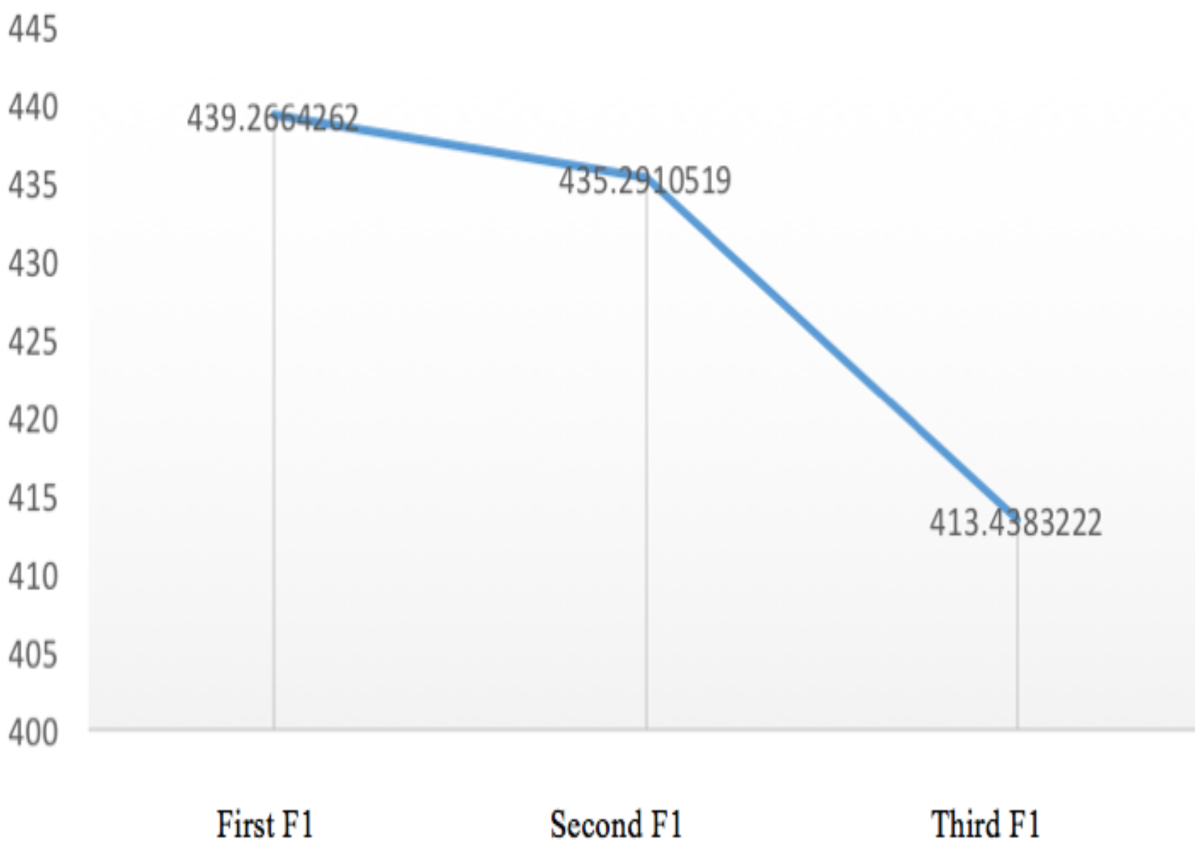
Vowel /i/	Onset (20%)	Midpoint (50%)	Offset (80%)
	Mean (Hz)	Mean (Hz)	Mean (Hz)
Before voiced cons	410	403	382
Before voiceless cons	434	438	420

Table (19): Mean frequency of F1 of the vowel /u/ at 20%, 50%, 80%

Vowel /u/	Onset (20%)	Midpoint (50%)	Offset (80%)
	Mean (Hz)	Mean (Hz)	Mean (Hz)
Before voiced cons	467	481	469
Before voiceless cons	550	557	554

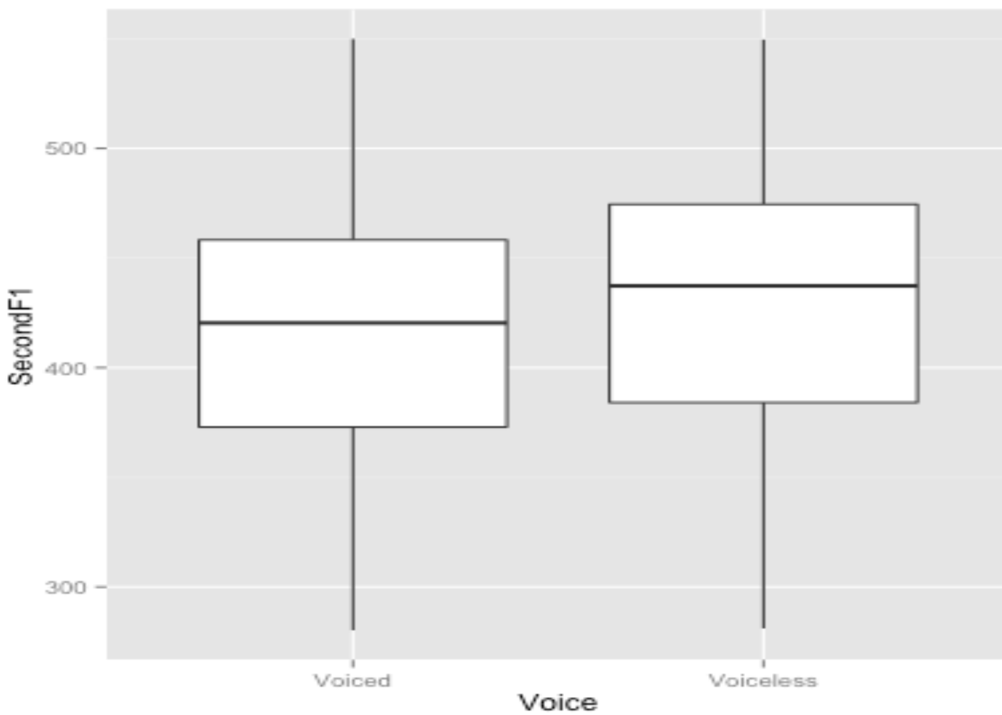
As the Tables (17), (18), and (19) show, F1 is lower in all the vowels /a/, /i/, and /u/ preceding voiced consonants than F1 before voiceless consonants, and the closer the vowel to the voiced consonant, the lower F1 is. For example, F1 at the offset of the vowel is lower than that at the midpoint and at the onset, and the F1 at the midpoint of the vowel is lower than that at the onset of the vowel, which indicates that F1 is affected by the voicing of the following consonant. This can be illustrated in the following Figure (21), which represents the mean frequency of the F1(at onset, midpoint, and offset) for the three vowels /a/, /i/ and /u/.

Figure (21): Mean F1 (in Hz) in the vowels /a/, /i/, and /u/ before voiced consonants



Regarding the ratio of F1 (at midpoint) in vowels preceding voiced consonant to those preceding voiceless consonants, the results indicate that for the vowel /a/ it is 1:1.1, and for the vowel /i/ it is the same, 1:1.1, and for the vowel /u/ it is 1:1.2. In order to check if there is a statistically significant difference between F1 of the vowels proceeding voiced and voiceless consonants, a statistical analysis using the Linear Regression model was used to test the effects of voicing (voiced and voiceless) on F1 at midpoint of the vowels /a/, /i/, and /u/.

Figure (22): F1 (in Hz) before voiced and voiceless consonants



It is worth pointing out here that the onset and the offset of the vowel measurements were excluded from the statistical test in order to maintain the best fit as the vowel format is steadier at the midpoint. The results show that F1 (at 50%) of the vowels preceding voiced consonants (M = 435, SD = 93) is significantly lower than that before voiceless consonants (M = 460, SD = 128) by 25.5 hertz (Hz), which is an indication that the larynx has been lowered due to the extension of the vocal tract (see Table 19). The boxplot in Figure (22) above shows how F1 is more lowered by voiced consonants than before voiceless ones due to the lowering of the larynx in order to make the production of the voiced consonants easier.

Other independent variables namely, gender, place of articulation, manner of articulation, emphasis, and position, were also used in the statistical analysis to check if they bear any significant influence on the frequency of F1 of the vowels preceding voiced and voiceless consonants. Therefore, in order to get the best fit and to be consistent with all statistical tests in the dissertation, the independent variables that turned out to be insignificant were removed one by one, and the statistical test was performed again till we got the best fitted statistical model. The following Table (20) lays out the statistical results of the interaction between the independent variables that were found to play a significant role on the vowel F1 and the dependent variable, i.e., voicing.

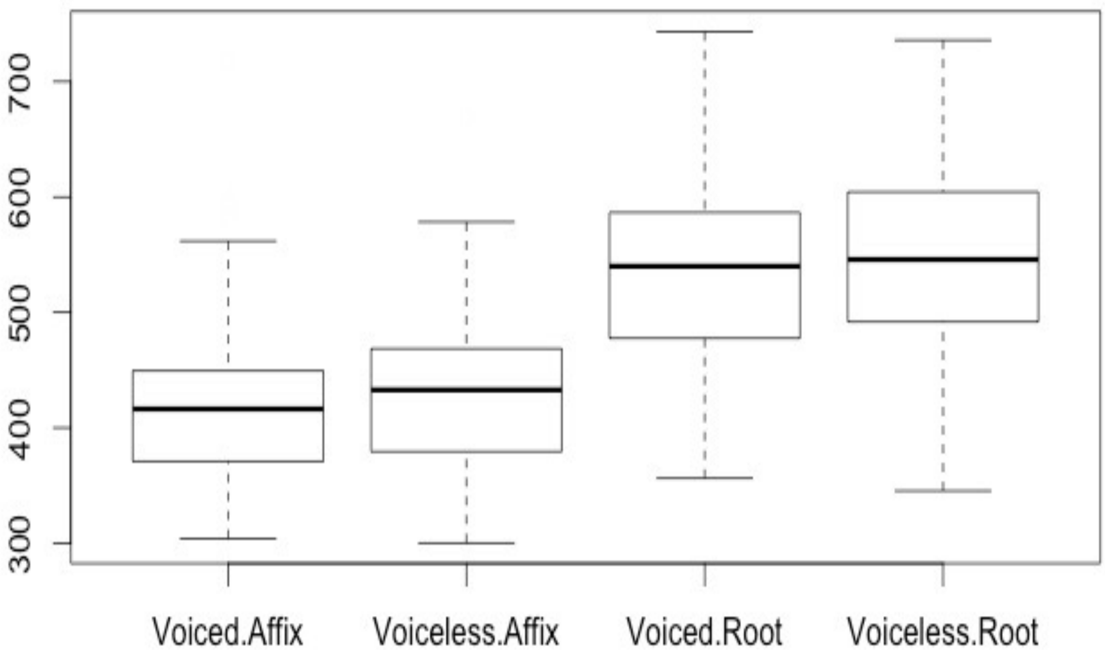
Table (20): Statistical results from vowel F1 before voiced & voiceless consonants

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	437.000	10.286	42.484	< 2e-16 ***
VoiceVoiceless	25.589	7.185	3.561	0.000395 ***
EmphasisPlain	-39.784	10.188	-3.905	0.000104 ***
PositionRoot	134.788	8.211	16.415	< 2e-16 ***

Based on Table (20) above, the statistical analysis results revealed that place of articulation, manner of articulation, and gender bear no influence on F1. By contrast, emphasis and position seem to play a significant role in affecting F1. For example, F1 in vowels preceding plain consonants is lower than those preceding emphatic consonants by -39 Hz. This result is normal because vowels surrounding emphatic consonants tend to have a higher F1 and a lower F2, which will be discussed in the next chapter on emphatic assimilation.

Similarly, F1 in vowels before consonants in the affix position are much lower than those before consonants in the root position by 134 Hz as shown in the boxplot in Figure (23) below.

Figure (23): F1 (in Hz.) in affix and root positions



The low F1 frequency in the affix position whether before voiced or voiceless consonants in comparison with that in the root position can be attributed to the low number of tokens in the root position, as compared to the ones in the affix position, which is represented by the phoneme /h/, which triggers voiced consonants to get devoiced, resulting in higher F1. It may also be ascribed to the fact that /h/ affects the vowel F1 and causes it to be higher in frequency given that /h/ is considered a voiceless copy of the vowel, thus it devoices any voiced obstruent and causes the preceding vowel to have a higher F1.

4.4 Summary of results and discussion

The primary goal of this experiment was twofold. The first was to analyze RJA voicing assimilation across morpheme boundaries in a comprehensive manner, investigating several different morphemes and not just the definite article. The second was to report on the acoustic, temporal as well as spectral, correlates that help in investigating voicing assimilation across morpheme boundaries, which, in turn, helps explain the phonological patterning of the directionality of voicing.

4.4.1 Voicing of the coronal /t/ in the affix/coda position

The results show that when the voiceless coronal consonant /t/ in the coda position which appears in prefix *mit* is followed by a voiced obstruent, /t/ undergoes voicing assimilation, i.e., becomes a voiced plosive [d] as illustrated in the following examples (13-17).

(13).	/mit-ʕarrif/	[mid-ʕarrif]	'He knows them.'
(14).	/mit- ɣarrib/	[mid-ɣarrib]	'He is an expat.'
(15).	/mit-galisˤ/	[mid-galisˤ]	'It is shrinking.'
(16).	/mit-bahi/	[mid-bahi]	'He is bragging.'
(17).	/mit-darrib/	[mid-darrib]	'He is trained.'

As can be seen in the examples above, the phoneme /t/ functions as a target rather than a trigger because it changes its phonological properties, voicing, to pattern with another adjacent segment; thus, the directionality is right-to-left or regressive. The reason why it is regressive can be best accounted for through the Dominance model by Mohanan (1993) as mentioned in section 1.2.1. The Dominance model assumes that there are dominant units that resist the forces to change their properties, and that when the specification of X overrides the specification of Y, X is the trigger and Y is the target ‘undergoer’. According to Mohanan (1993), the features [-coronal], [-anterior], and [+back] are dominant while [+coronal], [+anterior], and [-back] are not because they are underlyingly unspecified for consonants, and, accordingly, he provides the following dominance scale (18).

(18). Dominance Scale (Mohanan, 1993)

Least dominant				Most dominant
Alveolar	<	palatal	<	velar
		labial		

Another criterion that accounts for regressive directionality or the trigger/undergoer relationship is that the onset is more dominant than the coda, and that the following element is more dominant than the preceding one. Accordingly, since the coronal /t/ in the prefix *mit* falls in the coda position of the of the syllable, and the following voiced obstruent is at the onset of the following syllable, then [t] functions as an undergoer and thus receives the voicing feature from its dominant, which is the voiced obstruents. So, /t/ is the phoneme that changes its phonological properties and becomes [d]. Similarly, the phoneme /t/ is an alveolar that has the features [+coronal], [+anterior], and [-back] that is followed by the velar /g/, the velar /ɣ/, the labial /b/, and the pharyngeal /ʕ/, which all have the features [-coronal], [-anterior], and [+back]. Also, given that the consonants that follow /t/ are more dominant than the alveolars, according to Mohanan's scale, then [t] is deemed to undergo voicing assimilation and acquire the voicing feature from the following voiced obstruents since it is the least dominant and thus more vulnerable to change its properties[10]. Another explanation for why [t] is undergoer is through the sonority scale in which /t/ is the lowest/least sonorous since it is a voiceless stop, and that the following consonants are more sonorous since they are voiced fricatives and voiced plosives, thus [t] changes its phonological features to pattern with the following voiced non-coronal obstruents. The more sonorous the consonant is the least it is affected by neighboring consonant. To sum up, we can lump the two explanations together and generalize that consonants in the coda position are targeted by consonants in the following onset of the following syllable given that the consonant in the coda positons are low in terms of sonority as a manner of articulation, or when they have the feature specifications [+coronal], [+anterior], and [-back] as a place of articulation. Also, vowels are always, as mentioned earlier, affected and get lengthened when the consonant at the coda is voiced and get shortened when the consonant at the coda is voiceless.

[10] Stuart Davis (personal communication) suggests that codas are targeted for assimilation because their perceptual cues are less salient than those of an onset, which is worth considering as a different way of motivating codas as targets of assimilation.

4.4.2 Devoicing obstruents in the root/coda position when followed by /h/

The results indicate that when a plain voiced fricative, a plain voiced plosive or a voiced affricate consonant occurs in the coda position of a stem word and is followed by the phoneme /h/, which appears in the suffixes *ha*, *hum*, and *hin*, /h/ devoices these preceding voiced consonants as shown in the following examples (19-27). Thus, the phoneme /h/ functions as a trigger (dominant) rather than a target because it gives its phonological properties to the target adjacent consonants.

(19).	/rud͡ʒ-ha/	[rut͡ʃ-ha]	'You shake it.'
(20).	/baʕ-hin/	[baħ-hin]	'He sold them.'
(21).	/sˤabaɣ-hin/	[sˤabax-hin]	'He painted them.'
(22).	/sarag-hum/	[sarak-hin]	'He robbed them.'
(23).	/bab-hum/	[bap-hum]	'Their door'
(24).	/ruz-ha/	[rus-ha]	'Her rice'
(25).	/blad-hum/	[blat-hum]	'Their country'
(26).	/raðað-hin/	[raðaθ-hin]/ [raðaθ-θin]	'Their spray'
(27).	/aɣraðˤ-hum/	[aɣraθˤ-hum] / [aɣraθˤ-θˤum]	'Their stuff'

Unlike the coronal phoneme /t/ in the coda position in the prefix *mit*-, /h/ functions as a trigger not as an undergoer. This, again, can be explained through the Dominance model. First, the phoneme /h/ occurs at the onset of the syllable and the preceding voiced obstruents that it targets are located at the coda of the previous syllable; thus /h/ is a trigger because it is considered more dominant since an onset is more dominant than a coda. Also, any voiced obstruent that comes before /h/ loses the voicing feature since it is dominated by /h/ given that the voiced obstruent is in the coda of the previous syllable. Likewise, since the /h/ phoneme has the features [-coronal], [-anterior], and [+back] then it is more dominant than the preceding consonants which acquire the voicelessness feature from /h/. Although some of the voiced obstruents have the [+back] feature like the velars /g/ and /ɣ/ and the pharyngeal /ʕ/, /h/ is still more dominant since it is farther back than the velars and the pharyngeals. In other words, /h/'s features override the features of the voiced obstruents that come before it, and thus these obstruent consonants are more vulnerable to change their phonological properties.

As for the phonemes /l/ in the prefix definite article /*ʔil*/ and /n/ in the prefix /*ʔin*/, throughout the study, I found that they do not undergo voicing assimilation at all. So, they do not trigger voicing assimilation whatsoever, which corroborates what Watson (2002) reported that 'sonorants rarely trigger [voicing] assimilation' (p. 214).

The results strongly suggest that voicing assimilation across morpheme boundaries share not only some similarities but also some differences with assimilation across word boundaries as reported by Zuraiq and Zhang, (2006); Zuraiq and Abu-Joudeh, (2013). For example, the results of the current study suggest that voicing assimilation occurs regardless of the similarity in the place of articulation of the two adjacent sounds. More specifically, the coronal phoneme /t/ undergoes voicing assimilation when followed by any voiced non-coronal obstruent though they differ not only in voicing but also in place and manner of articulation. However, this result disagrees with what Zuraiq and Zhang, (2006); Zuraiq and Abu-Joudeh, (2013) reported that for voicing assimilation to take place across word boundaries in UJA, there should be two adjacent non-coronal consonants that differ only in voicing. And that these two consonants have to share all other features; otherwise, voicing assimilation does not take place at all, i.e., voicing is blocked. They provide the following examples for illustration /faraa**ɣ k**ulli/ and /sele**k b**aali/, where, according to them, voicing assimilation is 'blocked' because the /ɣ/ and /k/ have different manner of articulation, and the /k/ and the /b/ have different place of articulation. In contrast, my results are in line with Benyoucef and Mahadin (2013), who found that regressive voicing assimilation takes place when /t/ is followed by any voiced obstruent, regardless of the similarity in the place of articulation. This leads us to the conclusion that the behavior of voicing assimilation across morpheme boundaries is somehow different from assimilation across word boundaries in the sense that in order to for voicing assimilation to take place, two consonants may differ in other features other than voicing. I will elaborate more on this issue in more details and examples in Chapter seven.

All in all, the directionality of voicing assimilation across morpheme boundaries whether it is a prefix-to-a stem or suffix-to-a stem is always regressive in RJA, which is in agreement with the other studies in the literature (see Kabrah, 2011; Abu-Mansour, 1996; Laeufer, 1992; Jongman, Sereno, Raaijmakers, and Lahiri, 1992).

As for the acoustic correlates for voicing, the low frequency periodicity that shows voicing on a spectrogram was visible when discriminating voiced from voiceless consonants. Likewise, F1 and vowel duration of the preceding vowels were also found to be as robust as the low frequency periodicity and equally significant correlates for voicing contrast in my data as they played an important role in distinguishing voiced consonants from voiceless ones. Vowel duration, as mentioned earlier (see Laeufer, 1992; Jongman, Sereno, Raaijmakers, and Lahiri, 1992; Kulikov, 2012; Hagiwara, 2015, among others) is a universal feature when it comes to voicing contrast: a vowel tends to be longer before voiced consonants and shorter before voiceless ones. Similarly, F1 was also a salient acoustic correlate for voicing given the Linear Regression results showed that it is significantly lowered in vowels preceding voiced consonants, which is an indication of the larynx lowering gesture due to lengthening of the vocal tract (Westbury, 1983). These results are in line with (Kulikov, 2012; Benkí, 2005; Westbury, 1983). The vowel /u/ was found to be the most vulnerable to vowel lengthening and F1 lowering among the three vowels /a/, /u/, and /i/. The implications of these results will be discussed in Chapter seven.

In this chapter, I investigated the acoustic correlates that can be used as evidence that voicing assimilation occurred. I also showed how the dominance model can account for the directionality of voicing/devoicing. The difference between voicing assimilation across morpheme boundaries and that across word boundaries will be discussed in Chapter seven. Now that I have presented and discussed the results of voicing assimilation, the next chapter will present and discuss the results of emphatic assimilation.

Chapter Five: Emphatic assimilation

5. Introduction

Semitic languages in general (e.g., Arabic and Aramaic) as well as JA sub-dialects are characterized by pharyngealization features known also as emphasis (Al-Masri and Jongman, 2004). Emphasis refers to consonants that are articulated with a secondary constriction in the posterior vocal tract and a primary constriction usually in the dental/alveolar oral tract (Jongman, Herd, Al-Masri, Sereno, and Combest, 2011). Emphasis is an articulatory feature associated with a constriction near the uvula caused by retraction in tongue root. It is generally defined as a secondary articulation involving the back of the tongue, which accompanies a primary articulation in another point of the vocal tract (Broselow, 1979; Younes, 1994; Davis, 1995; Jongman, Herd, Al-Masri, Sereno, and Combest, 2011, among others). A number of different terms have been employed in the literature to refer to this phenomenon. In addition to emphasis (*'tafxi:m'* in Arabic), the terms pharyngealization, velarization, and backing, have been used. In this study, I use the general term *pharyngealization* and *emphasis* interchangeably. According to Zuraiq and Zhang (2006), the phonetic feature that is most common in MSA as well as other Arabic varieties is the presence of the emphatic sounds which are represented in the IPA as [Cˤ] except for the phoneme /ðˤ/ which does not exist in UJA.

Linguists distinguish between primary emphasis and secondary emphasis. Primary emphasis contrasts the emphatic consonants /tˤ/, /dˤ/, /sˤ/, /ðˤ/, /zˤ/ with the plain consonants

/t/, /d/, /s/, /ð/, /z/ as in (28a) - (28d). Therefore, the contrast between emphatic consonants and plain consonants is phonemic/contrastive as it changes the meaning. Primary emphasis contrasts minimal pairs based on the presence/absence of the emphasis feature as shown in the examples (28a) - (28d) below.

(28).

a. ti:n ‘figs’ vs. $t^{ʕ}$i:n ‘mud’

b. se:f ‘sword’ vs. $s^{ʕ}$e:f ‘summer’

c. dala:l ‘fondness’ vs. $d^{ʕ}$ala:l ‘aberrance’

d. ðal: ‘humiliate’ vs. $ð^{ʕ}$all ‘He stayed’

By contrast, secondary emphasis is a results of assimilation, and in addition to the previously mentioned emphatic consonants namely, /$t^{ʕ}$/, /$d^{ʕ}$/, /$s^{ʕ}$/, /$ð^{ʕ}$/, /$z^{ʕ}$/, the plain consonants /r/ and /l/ can be emphatic as well (allophones); therefore, secondary emphasis is allophonic.

In this chapter, I show that non-emphatic consonants assimilate to emphatic consonants, and the results is an emphatic consonant, as can be demonstrated by the emphasis effect on the preceding vowels. I also investigate whether emphasis is regressive or anticipatory across morpheme boundaries, prefix-stem and stem-suffix. It is worth pointing out that the emphatic assimilation term used in this chapter refers to total assimilation between two coronals, where one coronal is emphatic and the other is not. Thus, the emphasis feature is copied along with the coronal that undergoes assimilation.

5.1 Acoustic correlates of emphasis

Many studies have reported on the effect of the emphatic consonants on the neighboring vowels. So, emphasis is usually scrutinized through investigating its effects on adjacent vowels. It has been claimed (acoustically) that emphasis has no influence on the duration of the target consonants or on the duration of the adjacent vowels (Gordon, Barthmaier, and Sands, 2002). For example, Al-Masri and Jongman (2004) argued that despite the fact that the effects of emphasis were most noticeable in the adjacent vowel(s), the emphatic consonant itself, not the surrounding consonants, showed an effect of emphasis, and thus they are not reliable acoustic correlates to investigate emphasis. It has also been reported that F1, F2 and F3 of vowels adjacent to emphatic consonants are affected and are used to indicate emphasis (see Wahba, 1993; Khattab et al, 2006; Al-Masri, 2009; Jongman, Herd, Al-Masri, Sereno, and Combest, 2011). Card, (1983) found out that the emphasis features spread phonetically to adjacent sounds regardless of the directionality in the whole word.

5.1.1 Emphasis and vowel F2

Acoustically speaking, emphatic sounds have a strong bearing on the F2 of the vowel preceding or following them. It has been noticed that vowels adjacent to emphatic phonemes have a lowered F2 compared to the F2 of the same vowel when not falling in an environment with emphatic sound (Jongman, Herd, Al-Masri, Sereno, and Combest, 2011). This lowering in F2 is consistent with the acoustic correlate of constriction made near the uvula. F2 is significantly lowered because the emphatic consonants drag the adjacent vowels to the low back position due to enlarged mouth cavities as well as a constriction in the back part of the vocal tract. Al-Masri and Jongman (2004) reported that F2 is lowered to a large degree in the vowels adjacent to emphatic consonants compared with the vowels adjacent to the plain consonants. The perturbation theory of vowel formant resonance predicts that F2 will be lowered if there is a narrowing of the vocal tract close to a point of velocity maximum for F2. In a typical male vocal tract, F1 rises and F2 falls if there is a narrowing in the pharynx at least 2.83 cm above the glottis, which is about the level of the laryngeal additus and the aryepiglottic folds (Heselwood, 2007; Al-Tamimi and Heselwood, 2011, cited in Heselwood and Al-Tamimi, 2011).

5.1.2 Emphasis and vowel F1 and F3

Similarly, F1 and F3 frequencies have been found to be raised due to a reduced pharyngeal cavity when they are adjacent to an emphatic consonant compared to the vowels that occur near plain consonants. Jongman, Herd, and Al-Masri, (2007) examined the effects of emphasis (acoustic correlates) in the speech of native speakers of Jordanian Arabic. They found that the acoustic correlates of emphasis involved raised F1, lowered F2, and raised F3 in the vowel(s) adjacent to the emphatic consonant, indicating that emphasis involves a secondary articulation or constriction near the epiglottis. Zawaydeh (1999) reported that emphatic consonants are always characterized with the raising of the F1 in the neighboring vowels. F1 will be raised if there is a narrowing close to a velocity minimum for F1 (Heselwood, 2007). However, F3 has been an issue of controversy whether it is significantly raised or not. For example, Card (1983) claimed that F3 values in vowels neighboring emphatic and plain consonants are significantly different. However, Al-Masri (2009) posited that F3, when adjacent to an emphatic consonant, is significantly raised at the onset, midpoint, and offset of the vowel when compared with that before plain consonants. This difference in F3 in these studies might be ascribed to dialectal differences or experiment design, i.e., minimal pairs or whether the emphatic consonant appears word-initially, word-medially or word-finally, or even the syllable structure of the word list used in these studies.

5.2 Results and discussion

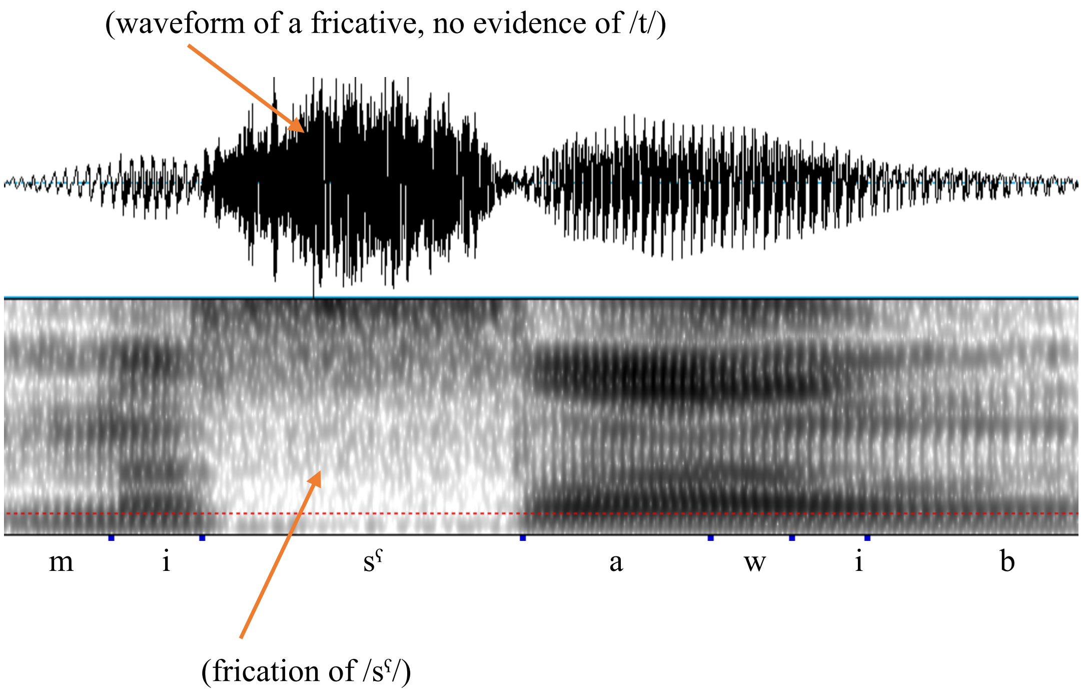
In this section, I present the results of the emphatic assimilation experiment (see Chapter 3 for more information on data collection, measurements, etc.). I first show visually how emphatic assimilation takes place through the use of spectrograms and waveforms. Second, I report the results of the acoustic correlates of emphasis, which include relative frequency of F1, F2, and F3 and duration of the vowels preceding emphatic as well as plain consonants. Then, I explain the phonological patterning of the directionality of voicing.

5.2.1 Visualization of emphatic assimilation

In this section, I show how emphatic assimilation takes place through using spectrograms and waveforms. The results show that when the phoneme /t/ in the affix *mit* is followed by an emphatic coronal obstruent, [t] undergoes total emphatic assimilation.

The emphasis process can also be observed in the spectrogram in Figure (24) below, where /t/ undergoes total emphatic assimilation when followed by the emphatic fricative /sˤ/. As shown in the spectrogram, there is no appearance of the voiceless plosive /t/ after the vowel /i/ as there is no closure and release seen, which would indicate the absence of /t/ due to the total emphatic assimilation. Rather, the vowel /i/ is followed by the frication of the emphatic /sˤ/ that extends between the vowel /i/ and the vowel /a/, since /sˤ/ is intervocalic, indicating that a total emphatic assimilation is taking place.

Figure (24): Illustration of assimilation of emphatic fricative and a plain plosive /mit-sˤawib/, [**misˤ-sˤawib**]



The results also show that when the phoneme /h/ is preceded by an emphatic voiceless fricative consonant or an emphatic voiceless plosive consonant, /h/ undergoes total emphatic assimilation. Emphatic assimilation in this example can also be observed in the spectrogram in Figure (25) below, which shows how the frication of /sˤ/extends from the offset of the vowel /a/ to the onset of the vowel /u/ in the word /basˤ-hum/ →[basˤ-sˤum]. According to Figure (25), when the phoneme/h/ is preceded by the emphatic voiceless fricative /sˤ/, [h] undergoes total emphatic assimilation.

Figure (25): Illustration of emphatic assimilation of /sˤ/ and /h/

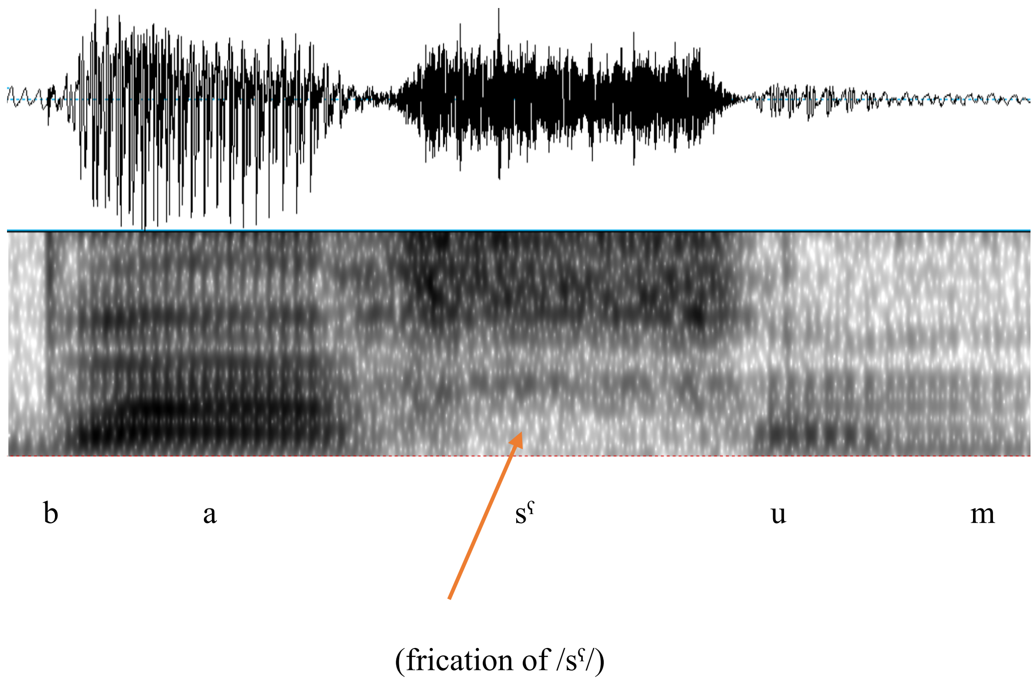
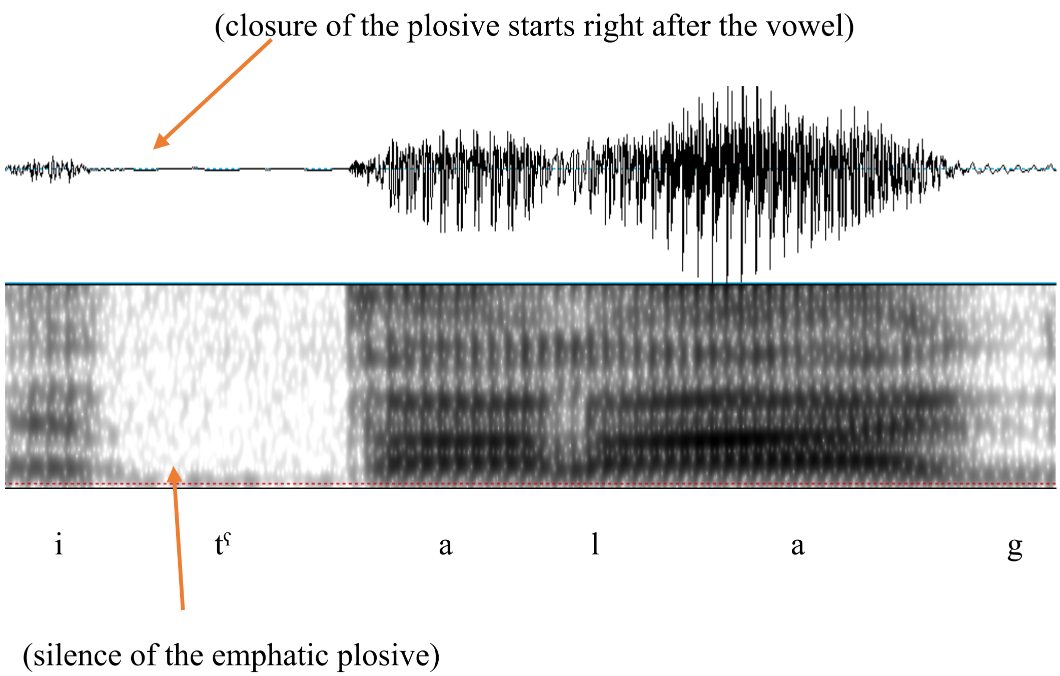


Figure (26): Illustration of assimilation of /l/ and /tˤ/ in the word /ʔil-tˤalag/ [**ʔitˤ-tˤalag**]



With regards to the phoneme /l/, when it is followed by an emphatic coronal, /l/ undergoes total emphatic assimilation. This can be visualized in Figure (26), which shows how /l/ is totally assimilated to a following emphatic coronal. The period of silence of the emphatic plosive /tˤ/ extends between the offset of the vowel /i/ and the onset of the vowel /a/, which indicates that /l/ is totally assimilated to the emphatic plosive as /l/ is not visible as shown in spectrogram in Figure (26) above.

5.2.2 Results of acoustic correlates

5.2.2.1 F1

Emphatic assimilation is investigated acoustically by measuring F1, F2 and F3 at the onset, midpoint, and offset of the vowels preceding the emphatic consonants and comparing them with those before plain consonants. In this section, I detail the results of F1 and show how it is influenced by emphatic assimilation. F1 of the vowels (/a/ and /i/) occurring before all plain and emphatic consonants was measured at onset (20%), midpoint (50%), and offset (80%), and the results show that across the board F1 of the analyzed vowels preceding emphatic consonants is higher in frequency than F1 in vowels preceding plain consonants. The following Tables (21) and (22) show the mean F1 frequency of the vowels /a/ and /i/, at the three positions as stated earlier, i.e., before emphatic and plain consonants. In both vowels /a/ and /i/, the F1 at the onset starts low, gets higher at the midpoint of the vowel, even if slightly, and then drops again at the offset of the vowels. This might have to do with formant of the vowel at 50% being steadier, and this is why I am reporting on the results of formant frequencies of the vowel at the midpoint. It is worth pointing out here that there were no /u/ tokens before emphatic consonants and thus will not be reported in this section and the subsequent sections in this chapter. [11]

Table (21): Mean frequency of F1 of the vowel /a/ at 20%, 50%, 80%

Vowel /a/	Onset (20%)	Midpoint (50%)	Offset (80%)
	Mean (Hz)	Mean (Hz)	Mean (Hz)
Before emphatic cons	580	613	576
Before plain cons	549	551	531

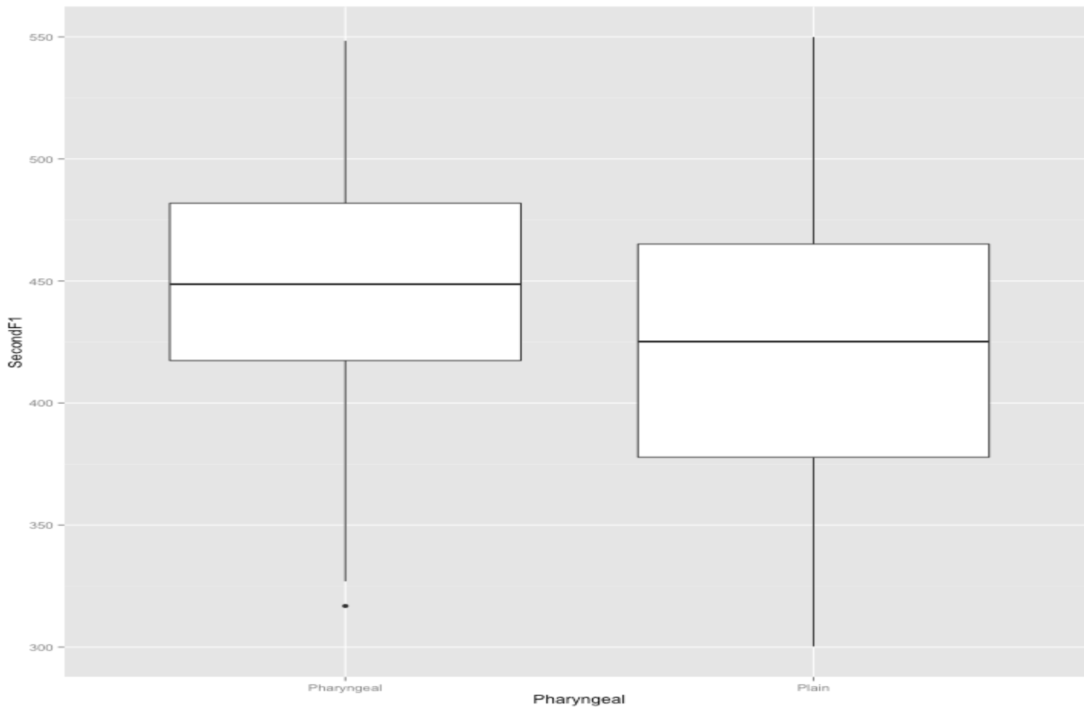
[11] Leaving out tokens that have the vowel /u/ was not purposeful. I realized this after designing the speech material and having the recordings done.

Table (22): Mean frequency F1 of the vowel /i/ at 20%, 50%, 80%

Vowel /i/	Onset (20%)	Midpoint (50%)	Offset (80%)
	Mean (Hz)	Mean (Hz)	Mean (Hz)
Before emphatic cons	438	440	413
Before plain cons	418	415	397

As the Tables (21) and (22) show, F1 is higher when the vowels occur right before the emphatic consonants than when the vowels precede the plain consonants. In order to check if there is a statistically significant difference between F1 of the vowels proceeding emphatic and those before plain consonants, a statistical analysis using the Linear Regression model was used to test the effects of emphasis (emphatic vs. plain) on F1 at midpoint of the vowels. As we mentioned earlier, the other two positions, namely the onset and the offset are excluded because the formants of the vowel at the midpoint are steadier, and to be more consistent with the other results on F2 and F3 at the vowel midpoint in the next sections that will focus on the midpoint of the vowel. The results show that F1 (at 50%) of the vowels preceding emphatic consonants (M = 480, SD =102) is significantly higher than those before plain consonants (M = 441, SD = 110) by -39 (Hz), (see Table 22). This result corroborates the finding of other studies by Khattab, Al-Tamimi, and Heselwood, 2006; Al-Masri, 2009, Abudalbuh, 2010, Jongman, Herd, Al-Masri, Sereno, and Combest, 2011, among others). The ratio of F1 (midpoint) of the vowels preceding emphatic consonants to those preceding plain consonants is 1:1.1 for the vowel /a/ and 1:1.1 for the vowel /i/, which means that both vowels are equally affected by the preceding emphatic consonant. However, I think the vowel /i/ F1 is more affected although it is a high vowel that naturally has a low F1 frequency in the first place. The following boxplot in Figure (27) illustrates how F1 is higher before emphatic consonants and lower before plain ones.

Figure (27): F1 (in Hz.) before emphatic and plain consonants



Other independent variables namely, gender, voice, place of articulation, manner of articulation, and position were also used in the statistical analysis to check if they contribute any significant influence on the frequency of F1 when the vowels preceding emphatic consonants. As is the case with all statistical analyses in this dissertation, if independent variables turned out to be insignificant, they were removed one by one, and the statistical test was performed again in order to get the best fit (cf. Cotton, 2013). The following Table

(23) lays out the independent variables that were found to play a significant role on the vowel F1 when preceding an emphatic and plain consonant.

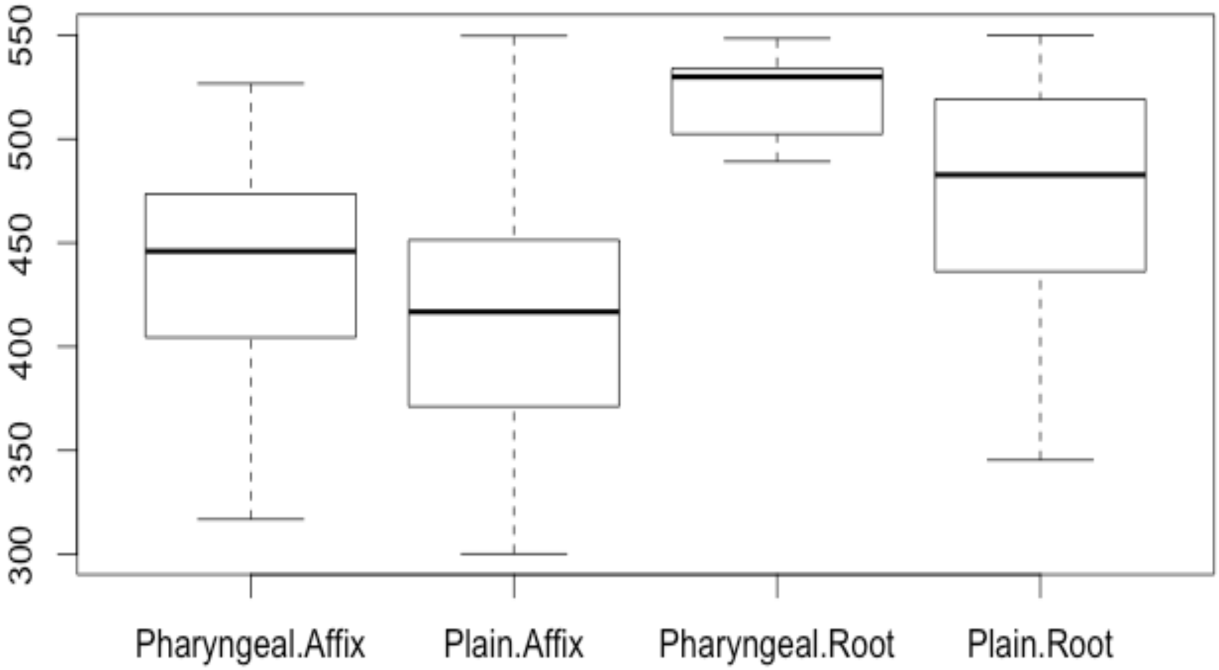
Table (23): Statistical results from vowel F1 before emphatic & plain consonants

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	437.000	10.286	42.484	< 2e-16 ***
EmphasisPlain	-39.784	10.188	-3.905	0.000104 ***
VoiceVoiceless	25.589	7.185	3.561	0.000395 ***
PositionRoot	134.788	8.211	16.415	< 2e-16 ***

According to Table (23) above, the statistical analysis results revealed that place of articulation, manner of articulation, and gender have no influence on F1. By contrast, voice and position play a significant role in affecting F1. For example, voiceless consonants significantly affected F1 by -25.5 Hz. This result can be attributed to the fact that vowels surrounding voiceless consonants tend to have a higher F1 and vowels surrounding voiced consonants tend to have a lower F1 as we have seen in section 4.2.

Similarly, F1 in vowels that occur before consonants in the root position are more affected by emphasis by 135 Hz than those that occur before consonants in the affix position, as shown in Figure (28) below.

Figure (28): F1 (in Hz.) and emphasis in affix and root positions



As Figure (28) shows, though F1 is higher before emphatic consonants in both positions, i.e., affix and root, F1 for both plain as well as emphatic consonants in the affix position is lower than that in the root position, which provides a clue that position significantly affected F1. This results can be attributed to the fact that vowels in the root position are followed by lexical emphatic consonants; in other words, the emphatic consonants are underlyingly emphatic, whereas vowels in the affix positions are followed by emphatic-assimilated consonants. This may indicate that lexical emphatic consonants affect the vowel F1 more than emphatic-assimilated consonants.

5.2.2.2 F2

Another acoustic correlate that helps with detecting emphatic assimilation or emphasis (generally) is F2 at the onset, midpoint, and offset of the vowels preceding the emphatic consonants and compare it with that of vowels preceding plain consonants. F2 has been considered in the literature as the most salient acoustic correlate when dealing with emphasis (see section 5.1). In this section, I detail the results of F2 and show how it is influenced by emphasis. F2 of the vowels (/a/ and /i/) occurring before all plain and emphatic consonants was measured at onset (20%), midpoint (50%), and offset (80%), and the results show that across the board F2 of the analyzed vowels preceding emphatic consonants is lower in frequency than that before plain consonants. The following Tables (24) and (25) show the mean F2 of the vowels /a/ and /i/ at the three positions as stated earlier, before emphatic and plain consonants.

Table (24): Mean frequency of F2 of the vowel /a/ at 20%, 50%, 80%

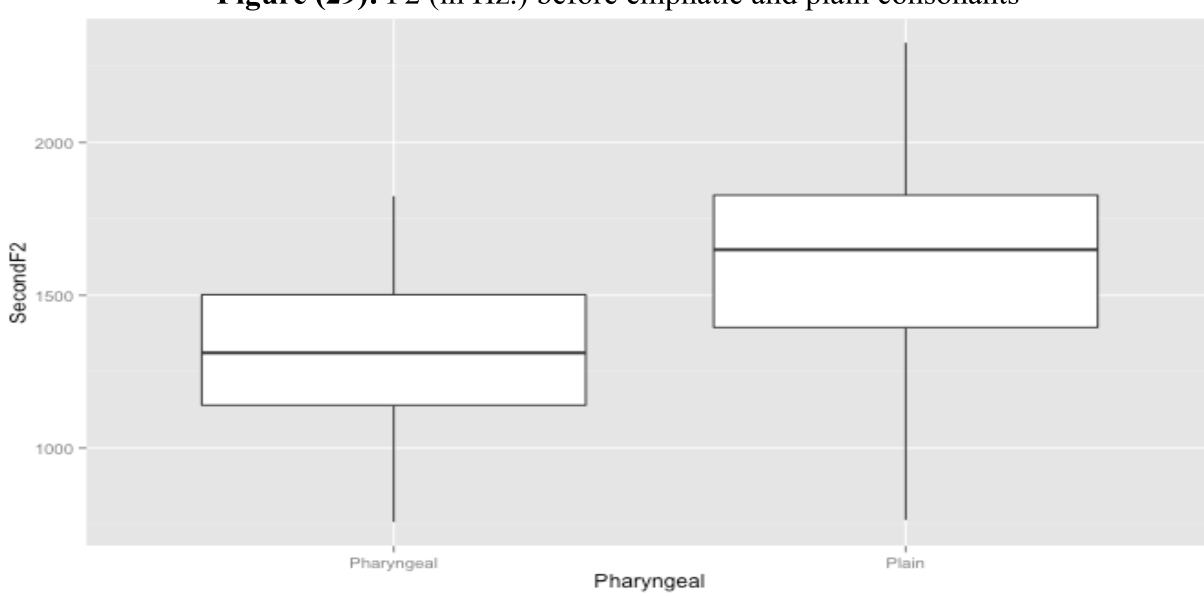
Vowel /a/	Onset (20%)	Midpoint (50%)	Offset (80%)
	Mean (Hz)	Mean (Hz)	Mean (Hz)
Before emphatic cons	1204	1217	1160
Before plain cons	1411	1403	1386

Table (25): Mean frequency of F2 of the vowel /i/ at 20%, 50%, 80%

Vowel /i/	Onset (20%)	Midpoint (50%)	Offset (80%)
	Mean (Hz)	Mean (Hz)	Mean (Hz)
Before emphatic cons	1337	1311	1286
Before plain cons	1581	1563	1600

In order to check if there is a statistically significant difference between F2 of the vowels proceeding emphatic and plain consonants, a statistical analysis using the Linear Regression model was used to test the effects of emphasis on F2 at midpoint of the vowels. The results show that F2 (at 50%) of the vowels preceding emphatic consonants is significantly lower than that before plain consonants by 205 Hz. This result agrees with what has been reported in the literature by Card, 1983; Wahba, 1993; Al-Masri and Jongman, 2004; Khattab et al., 2006; Al-Masri, 2009; Abudalbuh, 2010; Jongman, Herd, Al-Masri, Sereno, and Combest, 2011; Saadah, 2011, among others. Regarding the ratio of F2 (midpoint) of the vowels preceding emphatic consonants to those preceding plain consonants, it is 1:1.2 for the vowel /a/ and 1:1.2 for the vowel /i/, which means that both vowels are equally affected by the preceding emphatic consonant. However, F2 of the vowel /i/ seems to be more affected since it naturally has a higher F2 than the vowel /a/ because it is a front vowel. The following boxplot in Figure (29) visualizes how F2 is lowered before emphatic consonants than before plain ones.

Figure (29): F2 (in Hz.) before emphatic and plain consonants



Other independent variables namely, gender, voice, place of articulation, manner of articulation, and position were also used in the statistical analysis to check if they bear any significant influence on the frequency of F2 of the vowels preceding emphatic consonants, since they were not all used in other studies. Therefore, if any of these independent variables turned out to be insignificant, they were removed one by one, and the statistical test was run again in order to get the best fit. The following Table (26) lays out the independent variables that were found to play a significant role on the vowel F2 when preceding an emphatic and plain consonant.

Table (26): Statistical results from vowel F2 before emphatic & plain consonants

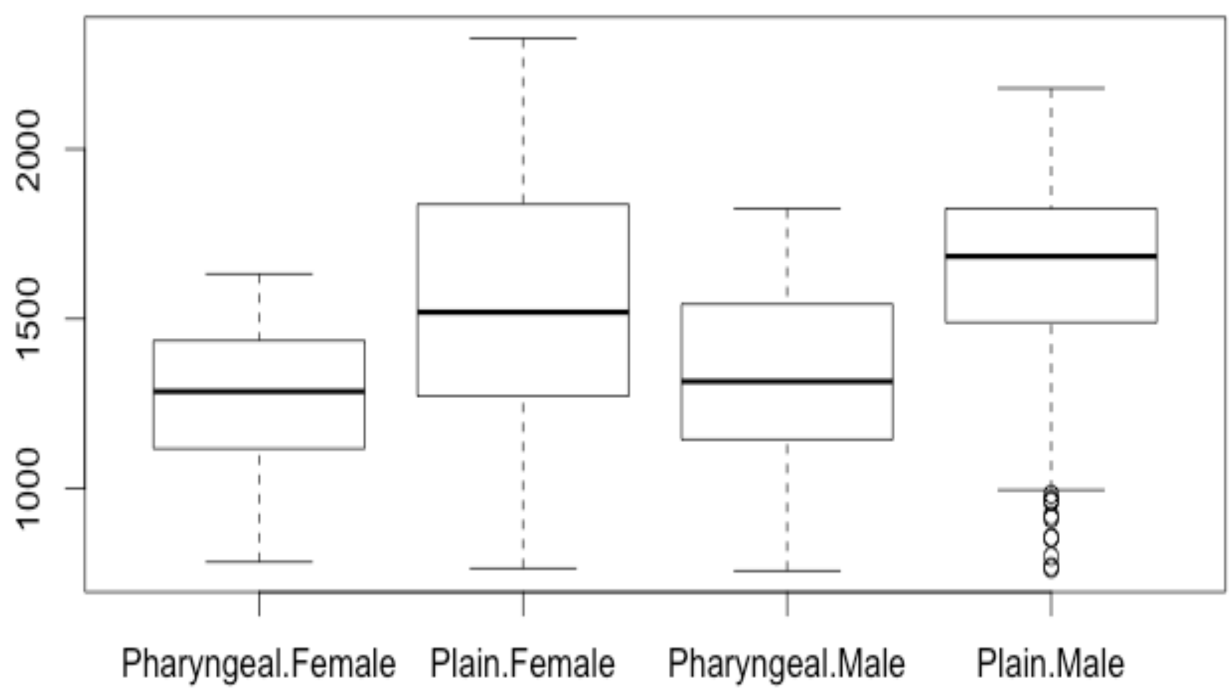
	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	1254.406	49.136	25.529	< 2e-16 ***
EmphasisPlain	205.331	46.579	4.408	1.22e-05 ***
PlaceGlottal	192.263	69.618	2.762	0.005909 **
PlacePalato-alv	186.821	53.530	3.490	0.000515 ***
PositionRoot	-158.287	33.578	-4.714	2.96e-06 ***
GenderMale	93.956	30.703	3.060	0.002301 **

Based on Table (26), the statistical analysis results revealed that manner of articulation and voice have no influence on F2 before emphatic consonants. By contrast, place, position, and gender play a significant role in affecting F2. For example, glottal consonants significantly affected F2 by 192 Hz. It was also found that palato-alveolar consonants significantly affected F2 by 187 Hz. Generally, place of articulation is cued by F2 and F3 while manner is cued by F1; therefore, F2 is affected here by place of articulation while F1 was not affected by place of articulation in section 5.2.2.1.

The other places of articulation such as alveolars, interdentals, labials and velars appeared to have no influence on F2.

As for position, the results indicate that consonants that occur in the root position significantly affected F2 by -158. This can be ascribed to the high number of /i/ tokens in the affix position because the affixes /mit/ and /il/ all have the vowel /i/, and it is well known that the vowel tends to have a higher F2 because it is the frontmost of the front vowels.

Figure (30): F2 (in Hz.) in male and female speakers



Finally, with regards to gender, it is obvious from the Table (26) as well as the boxplot in Figure (30) above that emphasis significantly affected F2 in vowels before consonants that are produced by males by 94 Hz. Females' F2 appears to be lower than that for males'. Although females, generally, tend to have higher formant frequencies than males do due to physiological differences, I found that F2 was lower when produced by female speakers. I think that the reason behind that is that the number of male participants is double the number of female participants, which may have affected this result. Another possible reason is that women are strengthening the cues, with them having more peripheral, i.e., more enunciated, vowels. Relatedly, this might be ascribed to the fact that emphasis generally manifests gender differences: commonality of hyperarticulation in women relative to men. Lower F2 frequency in females has been reported by Abudalbuh (2010), who found that females have lower F2 frequency than males in Jordanian Arabic. However, the gender differences should not be taken as a reliable acoustic correlate because of the anatomically-related formant frequency differences between males and females (Abudalbuh, 2010).

5.2.2.3 F3

The other important acoustic correlate for emphasis or emphatic assimilation is F3 at the three positions (onset, midpoint, and offset) of the vowels preceding emphatic and plain consonants. As mentioned in the literature in section (5.1), F3, just like F1, and contrary to F2, tends to be higher when preceding an emphatic consonant than before a plain one. In this section, I detail the results of F3 and show how it is affected by emphasis. F3 of the vowels (/a/ and /i/) occurring before all plain and emphatic consonants was measured at onset (20%), midpoint (50%), and offset (80%), and the results show that across the board F3 of the analyzed vowels preceding emphatic consonants is higher in frequency than that before plain consonants. The following Tables (27) and (28) show the mean frequency of F3 of the vowels /a/ and /i/ at the three positions before emphatic and plain consonants.

Table (27): Mean F3 of the vowel /a/ at 20%, 50%, 80%

Vowel /i/	Onset (20%)	Midpoint (50%)	Offset (80%)
	Mean (Hz)	Mean (Hz)	Mean (Hz)
Before emphatic cons	2682	2780	2944
Before plain cons	2274	2287	2308

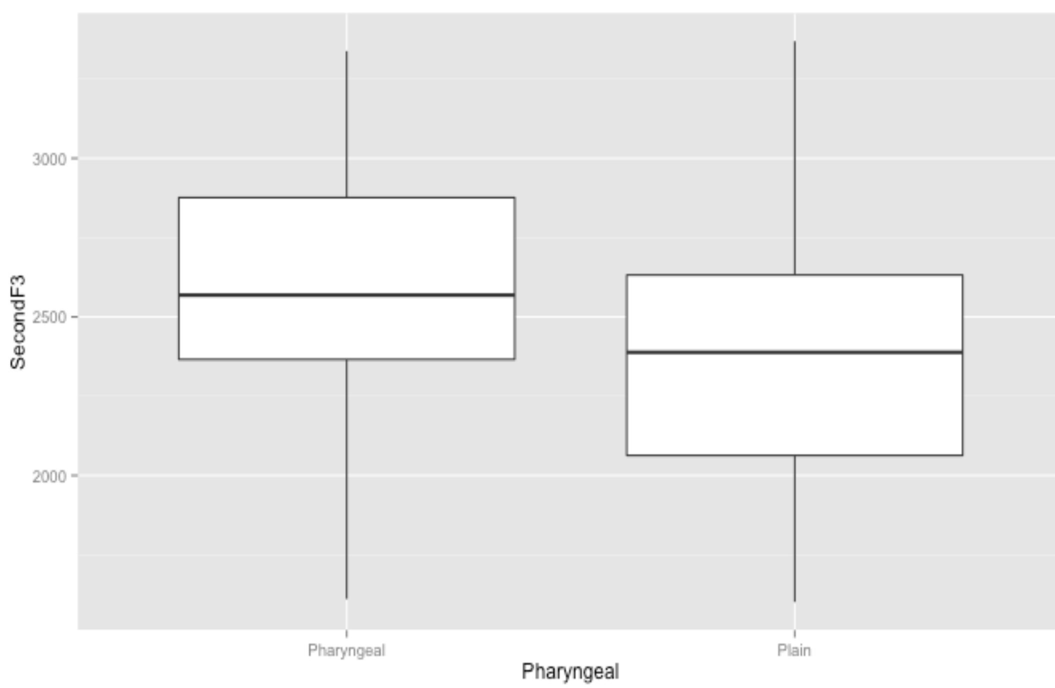
Table (28): Mean F3 of the vowel /i/ at 20%, 50%, 80%

Vowel /i/	Onset (20%)	Midpoint (50%)	Offset (80%)
	Mean (Hz)	Mean (Hz)	Mean (Hz)
Before emphatic cons	2428	2512	2368
Before plain cons	2324	2332	2391

As the Tables (27) and (28) show, F3 is higher when the vowels occur right before the emphatic consonants than when the vowels precede the plain consonants, and the closer the vowel to the emphatic consonant, the higher F3 was. In order to check if there is a statistically significant difference between F3 of the vowels proceeding emphatic and plain consonants, a statistical analysis using the Linear Regression model was used to test the effects of emphasis (emphatic vs. plain) on F3 at midpoint of the vowels, excluding the other two positions namely, the onset and the offset of the vowel. The results show that F3 (at 50%) of the vowels preceding emphatic consonants is significantly higher than that before plain consonants by -256 Hz. Regarding the ratio of F3 (midpoint) of the vowels preceding emphatic consonants to those preceding plain consonants, it is 1:1.2 for the vowel

/a/ and 1:1.1 for the vowel /i/, which means that the vowel /a/ is more affected by the preceding emphatic consonant than the vowel /i/. The following boxplot in Figure (31) visualizes how F3 is higher before emphatic consonants than before plain ones.

Figure (31): F3 (in Hz.) before emphatic and plain consonants



Other independent variables namely, gender, voice, place of articulation, manner of articulation, and position were also used in the statistical analysis to check if they have any significant influence on the frequency of F3 of the vowels preceding emphatic consonants.

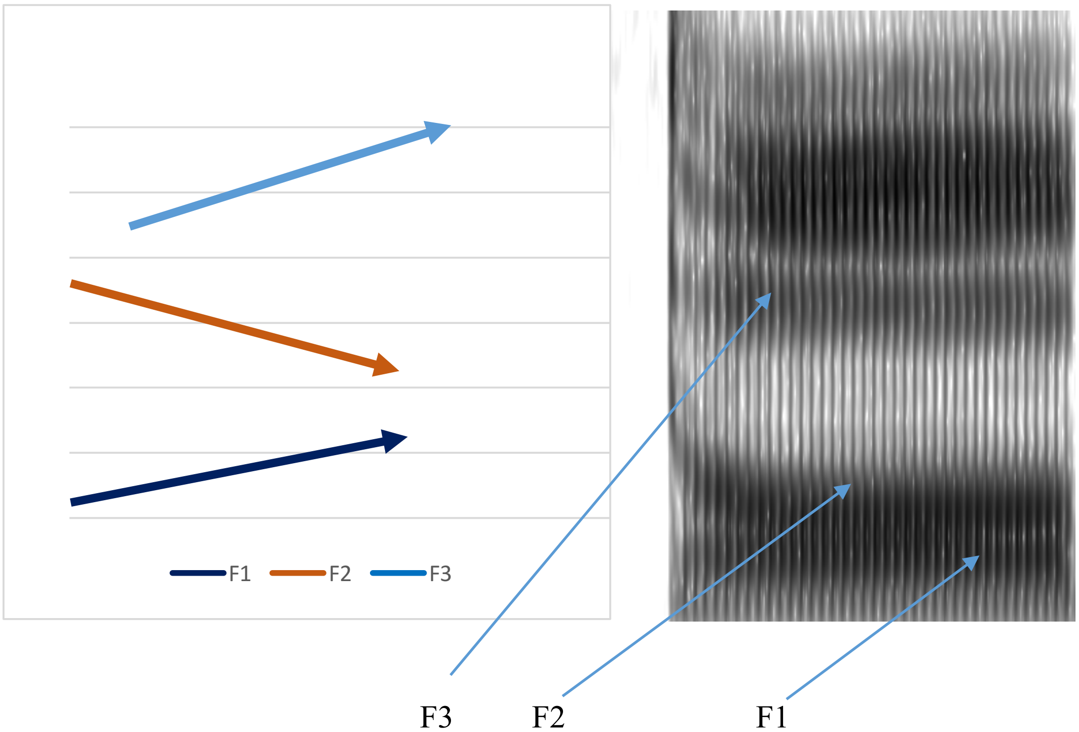
Table (29): Statistical results from vowel F3 before emphatic & plain consonants

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	2535.32	46.43	54.605	< 2e-16 ***
EmphatsisPlain	-256.35	44.24	-5.794	1.05e-08 ***
GenderMale	66.31	32.72	2.027	0.0431 *

The above Table (29) lays out the independent variables that were found to play a significant role on the vowel F3 when preceding an emphatic consonant. Accordingly, the statistical analysis results revealed that manner of articulation, place of articulation, position, and voice have no influence on F3 before emphatic consonants; therefore, their results will not be reported. By contrast, gender appeared to play a significant role in raising F3 before emphatic consonants. For example, consonants produced by male speakers significantly affected F3 by 66 Hz. Thus, gender is the only significant independent variable to be reported for F3.

In conclusion, all the results extracted from the vowels adjacent to emphatic consonants show that F1, F2 and F3 are succinctly affected when a plain consonant assimilates to an emphatic consonant. Therefore, the effect of emphatic consonants on their adjacent vowels should be taken as evidence of emphatic assimilation. While F1 and F3 tend to be higher before emphatic consonants than before plain ones, F2 appears to be lowered before emphatic consonants when compared with that before plain consonants.

Figure (32): Representation of F1, F2 and F3



The above Figure (32) summarizes what is going on in formant frequencies before emphatic consonants by showing how the formant frequencies in vowels preceding emphatic consonants start high in F1, then they drop in F2 and they go back high again in F3.

5.2.2.4 Vowel duration

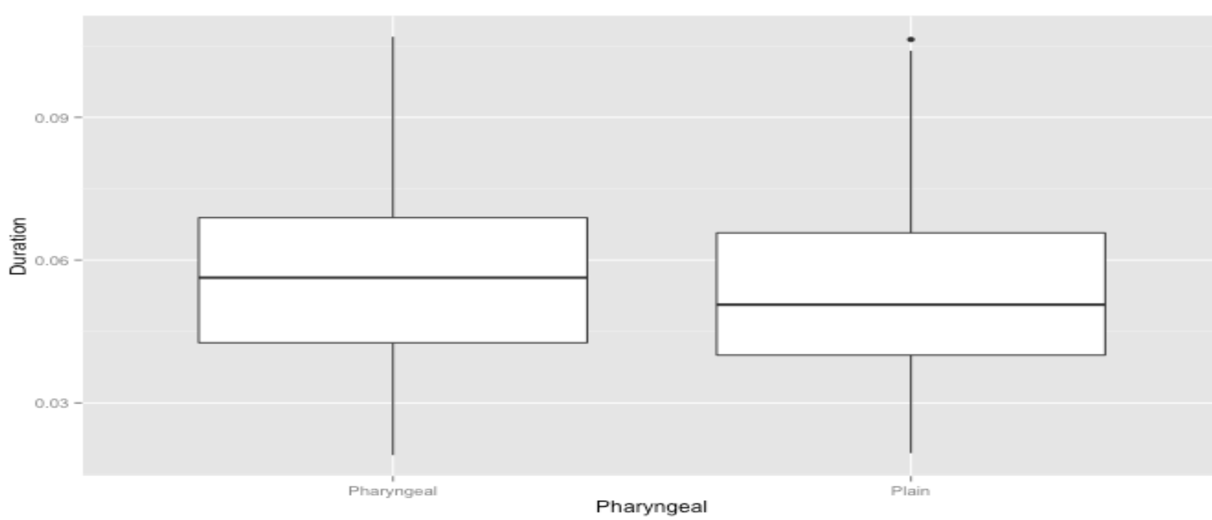
First, vowel mean duration of /a/ and /i/ before all emphatic and plain consonants was measured, and the results show that across the board, the duration of the analyzed vowels preceding emphatic consonants is longer than that before plain consonants. The following Table (30) shows the mean duration of the vowels /a/ and /i/ before emphatic and plain consonants. In order to check if there is a statistically significant difference between the duration of the vowels proceeding emphatic and plain consonants, a statistical analysis using the Linear Regression model was used to test the effects of emphasis on the duration of the vowels that precede emphatic and plain consonants. The results revealed that vowel mean duration before emphatic consonants is insignificantly longer than that before plain consonants by -4 ms, as shown in Table (31) below.

Table (30): Mean duration of the vowels /a/ and /i/

Voicing	Vowel /a/	Vowel /i/
	Mean (Ms.)	Mean (Ms.)
Before emphatic cons	99	54
Before plain cons	86	51

The following boxplot in Figure (31) illustrates the durations of the vowel before emphatic as well as plain consonant.

Figure (33): Vowel duration (in Ms.) before emphatic and plain consonants



Other independent variables namely, gender, place of articulation, manner of articulation, and position, were also used in the statistical analysis to check if they play any role in the vowel duration and voicing as shown in Table (31), below.

Table (31): Statistical results from vowel duration before emphatic & plain consonants

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	0.071219	0.006105	11.667	< 2e-16 ***
EmphasisPlain	-0.003806	0.002909	-1.308	0.19120
VoiceVoiceless	-0.014742	0.002054	-7.178	1.92e-12 ***
PlaceLabio-dental	-0.010636	0.005195	-2.047	0.04103 *
PlacePalato-alv	-0.013848	0.005195	-2.665	0.00788 **
PlacePharyng	-0.008443	0.004008	-2.107	0.03553 *
PlaceVelar	-0.008779	0.003040	-2.888	0.00400 **
MannerGlide	-0.020518	0.008346	-2.458	0.01421 *
MannerTrill	-0.015442	0.007526	-2.052	0.04058 *
PositionRoot	-0.028213	0.001967	14.346	< 2e-16 ***

The statistical analysis results indicate that the places of articulation, labio-dentals, palato-alveolars, pharyngeals, affected the vowel duration significantly as opposed to the alveolars, palatals, labials, and interdentals which did not. Based on the statistical results in Table (31) above, the following results are reported. First, labio-dental consonants significantly affected vowel mean duration by -10 ms. Second, vowel mean duration significantly affected by palato-alveolar consonants by -13 ms. Third, pharyngeal consonants significantly affected vowel mean duration by -8 ms. Finally, vowel mean duration was significantly affected by velar consonants by -8 ms. The reason why these places of articulations negatively affected the vowel mean duration is because they have six voiceless consonants and four voiced consonants, and as we know from previous sections vowels before voiceless consonants have shorter durations than before the voiced ones. Similarly, the manners of articulations, trills and glides cause the vowel mean duration to be significantly longer before them as opposed to affricates, plosives, and fricatives. While glide consonants significantly affected vowel mean duration by -20 ms, trill consonants significantly affected vowel mean duration by -15 ms. As for voicing, the results show that voiceless consonants significantly affected vowel mean duration by -14 ms, which is in line with what has been reported on vowel mean duration before voiced consonants in the voicing assimilation (section 4.2.1) that vowels tend be shorter before voiceless consonants and longer before voiced consonants. Finally, the results show that consonants in the root position significantly affected vowel mean duration by -28 ms. The reason behind this is the fact that there is only one affix in the data, which is /h/, and all voiced obstruents in the root position get devoiced by /h/. Therefore, we end up having less voiced or more devoiced consonants in the root position due to /h/ devoicing as well as the voiceless consonants that already exist.

5.3 Summary of results and discussion

The primary goal of this experiment was twofold. The first was to analyze RJA emphatic assimilation across morpheme boundaries in a comprehensive manner, investigating several different morphemes to provide general observations on how emphatic assimilation behaves across morpheme boundaries in RJA. The second was to report on the acoustic, temporal as well as spectral, correlates that help in investigating emphatic assimilation across morpheme boundaries, which, in turn, helps explain the phonological patterning of the directionality of emphasis.

5.3.1 Emphasis of the coronals /t/ and /l/ in the affix/coda position

When the coronal phoneme /t/ in the coda position, which appears in the prefix *mit*-, is followed by an emphatic coronal obstruent that occurs in the onset position of the stem, /t/ undergoes total emphatic assimilation as shown in the examples below (29-32).

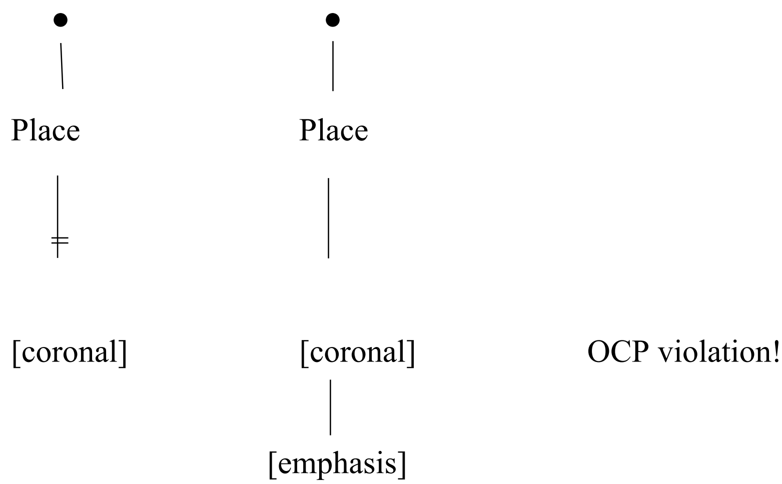
(29).	/mit-sˤawib/	[misˤ-sˤawib]	‘He is injured.’
(30).	/mit-tˤaffil/	[mitˤ-tˤaffil]	‘He is a parasite-like.’
(31).	/mit-ðˤamin/	[miðˤ-ðˤamin]	‘He is renting something.’
(32).	/mit-zˤaɣɣir/	[mizˤ-zˤaɣɣir]	‘He is looking younger.’

Therefore, the phoneme /t/ functions as an undergoer rather than a trigger because it changes its phonological properties, emphasis, to pattern with another adjacent segment. This regressive directionality is due to the fact that /t/ is in the coda position of the first syllable whereas the following coronal obstruents that act as triggers are at the onset of the second syllable, resulting in /t/ having to change its phonological properties. Consequently, the position of the phoneme is more effective and more appropriate to account for the directionality of assimilation than the feature dominance since the undergoer and the triggers are all coronals and share the same place features, which are [+coronal], [+anterior], and [-back]. Another explanation why /t/ is the target is through the sonority scale, manner of articulation, given that /t/ is the lowest on the sonority scale since it is a voiceless stop, then /t/ is more vulnerable to lose its phonological properties than the consonants following it since they are more sonorous. Also emphatic assimilation of this kind is triggered by the Obligatory Contour Principle (OCP), which prohibits two adjacent identical elements at the melodic level (Leben, 1973; McCarthy, 1986), and this violation is resolved by delinking the leftmost place feature. The spreading of the feature [emphasis] from right to left is shown below in (33c) where the dotted line denotes the spreading of a certain feature and the line crossed with the equals sign represents the deletion or delinking.

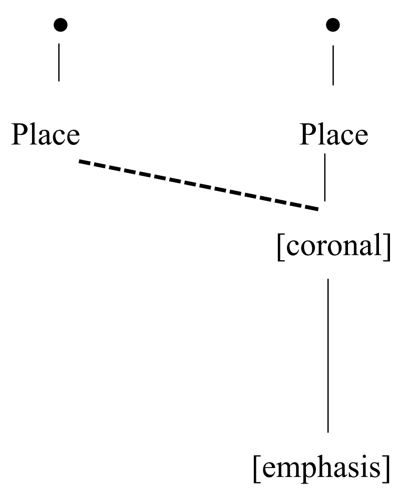
(33a). /t/ /sˤ, tˤ, ðˤ, zˤ/

●	●	
Place	Place	
[coronal]	[coronal]	OCP violation!
	[emphasis]	

(33b). Delinking of leftmost matrix from place node



(33c). Right-to-left spread of rightmost matrix



With regards to the phoneme /l/, when it is followed by an emphatic coronal, it undergoes total emphatic assimilation as presented in the examples (34-37). Therefore, the phoneme /l/ is an undergoer rather than a trigger because it changes its phonological properties to pattern with another adjacent segment.

(34).	/ʔil-sˤadi:g/	[ʔisˤ-sˤadi:g]	‘The friend’
(35).	/ʔil- tˤalag/	[ʔitˤ-tˤalag]	‘The divorce’
(36).	/ʔil-ðˤahir/	[ʔiðˤ-ðˤahir]	‘The appearance’
(37).	/ʔil-zˤaɣi:reh/	[ʔizˤ-zˤaɣi:reh]	‘The little one’

The directionality of emphatic assimilation is regressive, not progressive, as it spreads right-to-left. More specifically, when the coronal /l/ of the bound morpheme of the definite article ‘*ʔil*’ is followed by a stem word that begins with an emphatic coronal, the consonant [l] undergoes total emphatic assimilation since it is in the coda position (undergoer) of the preceding syllable, and the coronal of the stem is in the onset position of the following syllable (trigger) as suggested by Mohanan (1993). As is the case with the phoneme /t/, when applying the dominance of features to account for the total emphatic assimilation of the definite article, we can notice that it is not appropriate for this kind of assimilation because given the definite article is a coronal and the following consonants it totally assimilates to are coronals that share the same features [+coronal], [+anterior], and [-back], then it is the positions of the phoneme in the syllable that accounts for this kind of assimilation. However, this kind of assimilation is triggered by the Obligatory Contour Principle (OCP), which prohibits two adjacent identical elements at the melodic level (Leben, 1973; McCarthy, 1986), and this violation is resolved by delinking the leftmost place feature. The spreading of the feature [emphasis] from right to left is shown below in (38c) where the dotted line denotes the spreading of a certain feature and the line crossed with the equals sign represents the deletion or delinking.

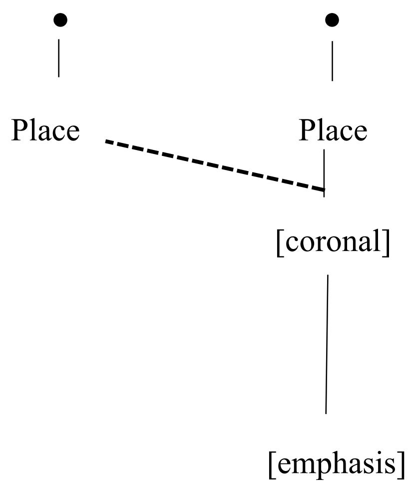
(38a). definite article /l/ following coronals

•	•	
Place	Place	
[coronal]	[coronal]	OCP violation!
	[emphasis]	

(38b). Delinking of leftmost matrix from place node

•	•	
Place	Place	
[coronal]	[coronal]	OCP violation!
	[emphasis]	

(38c). Right-to-left spread of rightmost matrix



5.3.2 Emphasis of /h/ in the affix/onset position

Furthermore, when an emphatic voiceless fricative consonant or an emphatic voiceless plosive consonant(s) are followed by the phoneme /h/, /h/ undergoes total emphatic assimilation as shown in the examples below (39-40).

(39).	/basˤ-hum/	[basˤ- sˤum]	‘Their bus’
(40).	/ballatˤ-hin/	[ballatˤ- tˤin]	‘He tiled them.’

The directionality of emphatic assimilation here is progressive, not regressive as opposed to /t/, as it spreads left-to-right. This might have to do with temporal compensation in that the emphatic consonant is longer than a plain consonant, which may affect the following /h/. This can happen with only voiceless emphatic consonants. By contrast, when the emphatic voiced fricative consonant /ðˤ/ is followed by the phoneme /h/, it undergoes a two-process assimilation: /ðˤ/ gets devoiced as an undergoer by the trigger /h/and then /h/ becomes an undergoer that undergoes total emphatic assimilation as presented in the following example (41).

(41). aɣraðˤ-hum/ [aɣraθˤ- θˤum] ‘their stuff’

According to example (41) above, /ðˤ/ undergoes devoicing and becomes /θˤ/ and retains the emphasis feature. As for assimilation directionality it is bidirectional; it is regressive (leftward) as a result of devoicing and progressive (rightward) as a result of total emphatic assimilation. This supports my assumption in examples (39 and 40) that /h/ undergoes total emphatic assimilation due to temporal compensation.

The results of the study show that emphasis is an important feature in RJA as it spreads to the adjacent sounds, and that the directionality of emphasis across morpheme boundaries is either progressive as is the case with the phoneme /h/ in the onset position or regressive as is the case with the phonemes /t/ and /l/ at the coda position, as opposed to voicing, which is always regressive. The interesting part of this study is that it deals with the spreading of the emphasis feature from one consonant to another, not just investigating the effect of the emphatic consonants on the adjacent vowels. This study also reports that the phoneme /t/ is a target rather than a trigger for emphasis when followed by an emphatic coronal obstruent.

The phoneme /l/ in the coda position undergoes total emphatic assimilation when followed by an emphatic coronal, while the phoneme /h/ in the onset position picks up the emphasis feature when followed by an emphatic voiceless fricative or an emphatic voiceless plosive. Thus, emphatic assimilation occurs as a result of place assimilation, which disagrees with what Zuraiq and Zhang, (2006); Zuraiq and Abu-Joudeh, (2013) reported that in order for emphatic assimilation to take place across word boundaries in UJA, two adjacent consonants have to have the same place of articulation. This means that emphatic assimilation across morpheme boundaries does not require two adjacent sounds to have the same place of articulation. Thus, emphatic assimilation does not behave similarly in both across morpheme boundaries as well as across word boundaries. This might also be due to dialectal differences because Zuraiq and Zhang, (2006) and Zuraiq and Abu-Joudeh, (2013)'s studies were conducted on UJA while the present study is on RJA, which is a matter that needs more investigation to draw typological generalizations.

Further, when investigating the acoustic correlates of the vowels preceding the affected (emphatic) consonants, the results of the present study are in line with the other studies that dealt with emphasis. For example, F1, F2 and F3 have been found as significant acoustic correlates for investigating emphasis, whereas the duration of the vowel was less salient which is in line with other studies like (Wahba, 1993; Khattab et al, 2006; Al-Masri, 2009; Jongman, Herd, Al-Masri, Sereno, and Combest, 2011). Therefore, investigating emphasis through waveforms and spectrograms is the most valid way of discriminating emphatic assimilation. However, the other acoustic correlates, i.e., F1, F2, F3 and vowel duration of neighboring vowels are also important and cannot be denied in emphasis investigation as well, but they are considered as secondary acoustic correlates when compared with visualizing emphatic assimilation in spectrograms and waveforms. This can also be observed through investigating the emphatic assimilation of the phoneme /l/ in the definite article when it undergoes total emphatic assimilation.

An interesting result that came up in the study is the way the phoneme /ðˤ/ behaves when followed by the phoneme /h/. As mentioned earlier, it undergoes a two-way process of assimilation. It, first, loses its voicing feature (gets devoiced) because it is affected by the voicelessness of the phoneme /h/, which results in a regressive (de)voicing assimilation. Second, the phoneme /h/ undergoes total emphatic assimilation, which changes the directionality of assimilation to progressive, resulting in a new emphatic consonant/allophone, /θˤ/, which does not exist in unconnected speech or any consonantal inventory in any Arabic dialect. This result has not been found in previous studies to date, to my knowledge, which might be a dialect-specific feature since it has only been observed in RJA. Thus, voicing and emphasis features act separately, and in different directions, and this is limited to the coronal /ðˤ/ when followed by the placeless /h/.

Finally, after investigating the phoneme /n/ in the prefix *ʔin-*, I found that it does not undergo voicing or emphatic assimilation, which means that /n/ as a sonorant does not undergo or even trigger voicing and emphatic assimilation. Similarly, the phoneme /l/ does not undergo voicing assimilation. This also supports my point in section 7.3 that the pharyngeal /ʕ/ and the velar /ɣ/ should not be classified as sonorants because sonorants can't be devoiced, and that gutturals do devoice and do not behave like sonorants, at least in the RJA dialect (see section 7.3 for more details). As long as /l/ can undergo emphatic assimilation, but does not undergo or trigger voicing assimilation, and the phoneme /n/ does not undergo or trigger voicing assimilation, then it is more accurate to say that sonorants cannot be undergoers or targets when it comes to voicing assimilation, which supports Watson (2002)'s claim that 'sonorants rarely trigger [voicing] assimilation'. The implications of these results will be discussed in Chapter seven.

In this chapter, I investigated the acoustic correlates that can be used as evidence that emphatic assimilation occurred namely, F1, F2, F3. I also showed how emphatic assimilation occurred through spectrograms. Further, I argued how emphatic assimilation across morpheme boundaries is different from that across word boundaries in RJA, and that the OCP and the dominance model can account for the directionality of voicing/devoicing. Now that I have presented and discussed the results of emphatic assimilation, I turn to presenting and discussing gemination in RJA.

Chapter Six: Consonant gemination

6. Introduction

Gemination is an essential feature in Semitic languages in general and Arabic in particular, but it also occurs across a range of languages such as Japanese, Italian, Swiss German, and Swedish, to mention a few. Phonologically, a geminate refers to a long or doubled consonant that contrasts phonemically with a shorter version counterpart that is referred to as singleton (Davis, 2011). In Standard Arabic as well as other spoken varieties, consonants, just like vowels, can undergo lengthening or doubling. All Arabic consonants can undergo gemination word-medially and almost all of them word-finally, though word-medial positions may have a better perceptibility of geminate consonants than word-final positions because any contrast is better realized if it is in the intervocalic position that offers a clear beginning and an end point for the perception of the target consonant, (see Padgett, 2003). Therefore, geminates in word-final position tend to be understudied, when compared with geminates in word-medial position or word-initial position, because of the poor acoustic cues that they may have at the end of the word.

In Arabic writing, gemination is shown by using a special symbol " ّ "called *shadda* that is placed on top of the consonant that is geminated to draw the readers’ attention that this is a geminate and not a singleton, as the contrast between a singleton and a geminate is phonemic and can change the meaning of the word. The following Tables (32) and (33) show how the geminate-singleton contrast is phonemic word-medially and word-finally.

Table (32): Geminate-singleton phonemic contrast word-medially

Target consonant	Word with a singleton/Arabic orthography	gloss	Word with a geminate/Arabic orthography	gloss
/r/	ha**r**ab (هرب)	escaped	ha**rr**ab (هرّب)	smuggled
/w/	sa**w**a (سوى)	together	sa**ww**a (سوّى)	made something
/d/	ba**d**al (بدل)	exchange	ba**dd**al (بدّل)	he traded something off

Table (33): Geminate-singleton phonemic contrast word-finally

Target consonant	Word with a singleton/Arabic orthography	gloss	Word with a geminate/Arabic orthography	gloss
/n/	fa**n** (فن)	art	fa**nn** (فنّ)	tossed the coin
/m/	la:**m** (لم)	blamed	la:**mm** (لمّ)	collecting
/s/	ba**s** (بس)	enough	ba**ss** (بسّ)	he spread something

It is worth mentioning here that in some words the contrast between a singleton and a geminate does not change the meaning radically. Rather, gemination may change the thematic role of the subject, but the meaning remains unchanged especially word-medially as shown in the following examples in Table (34) below. Gemination may also change the syntactic category from a noun to a verb if the contrast is held word-finally as illustrated in Table (35).

Table (34): Geminate-singleton meaning change word-medially

Target consonant	Word with a singleton	gloss	Word with a geminate	gloss
/s/	ra**s**ab	failed	ra**ss**ab	failed some one
/f/	$t^{ʔ}$a**f**a	turned off	$t^{ʔ}$a**ff**a	extinguished
/k/	sa**k**at	stopped talking	sa**kk**at	made someone shut up
/r/	ba**r**ad	Got cold	ba**rr**ad	made something cold

Table (35): Geminate-singleton meaning change word-finally

Target consonant	Word with a singleton	gloss	Word with a geminate	gloss
/m/	sa**m**	poison	sa**mm**	poisoned someone
/z/	ha**z**	shaking	ha**zz**	shook
/d/	ha**d**	demolishing	ha**dd**	demolished
/g/	ʃa**g**	crack	ʃa**gg**	cracked

There are two types of geminates in Arabic: true and fake. True (or underlying, as it is sometimes referred to) geminates are phonemic and cannot be broken up by an epenthetic vowel. Fake geminates, on the other hand, are often vulnerable to vowel epenthesis, which breaks up the consonant and degeminates it. For example, the word *futt* ‘I entered’ has a fake geminate and this geminate can undergo vowel epenthesis and become *futit* ‘I entered’, in which the meaning remains the same. I will leave the phonetic differences between derived geminates and underived geminates to future study.

6.1 Previous studies on gemination

Gemination has been studied extensively cross-linguistically (Esposito and di Benedetto, 1999 (Italian); Cohn et al., 1999 (Pattani Malay); Ridouane, 2003 (Berber); Hirose and Ashby, 2007 (Japanese); Ridouane, 2007 (Tashlhiyt Berber); Kraehenmann, 2008 (Swiss); Hamzah, 2013 (Kelantan Malay); Khattab and Al-Tamimi, 2014 (Lebanese Arabic), among others). Different approaches have been proposed in the literature to investigate gemination. For example, Delattre (1971) posits that gemination is a process of the rearticulation of the consonant, in which one consonant is in the syllable coda, and the other is in the onset of the following syllable. Ladefoged (1971), however, views gemination as a long single consonant and never two separate consonants or as a process of rearticulation. These different views may relate to the nature of geminates, whether true/fake geminates (bi-segmental sequences or single long consonants as a results of assimilation), and possibly even length/duration.

In spoken Arabic, few studies have investigated gemination, and in RJA in particular, no single study, to the best of my knowledge, has acoustically investigated gemination in both word-medial and word-final positions in a comprehensive manner as this study aims to do; investigating all target consonants and neighboring vowels in terms of manner of articulation, place of articulation, voicing, and emphasis. The following Table (36) lays out and summarizes some of the studies that dealt with gemination in general in spoken Arabic.

Table (36): Summary of studies on gemination in Spoken Arabic

Jordanian Arabic	Word-final	Abu-Abbas et al, (2011)	• Geminates in JA are either 'true' and reject vowel epenthesis, or 'fake' and may be split by an epenthetic vowel. • If a true geminate appears in a monosyllabic word with a long vowel, a degemination process is activated.
Lebanese Arabic	Word-medial	Khattab and Al-Tamimi, (2014)	• Sonorants show the highest singleton to geminate ratios. • Fricatives are amongst the longest consonants; their singleton-to-geminate ratios are relatively less distinct.
Moroccan Arabic	Word-medial	Zeroual et al., (2008)	• MA geminates have a longer oral closure and longer period of alveolar contact. • MA geminates don't induce shortening of their preceding vowel.
Iraqi Arabic	Word-medial	Ghalib, (1984)	• No vowel duration compensation observed in vowels preceding geminate consonants. • There is little or no evidence for rearticulation in the production geminate consonants.
Yemeni Arabic (Ta'zi Dialect)	Word-media	Aldubai, (2015)	• Duration of geminates is generally twice as much as that of singletons. • Trills are the longest among all other consonants.
Lebanese Arabic	Word-medial	Khattab and Al-Tamimi, (2009)	• No evidence for the temporal compensation between medial consonants and preceding vowels. • Fricatives were the longest consonants and liquids the shortest.
Jordanian Arabic	Word-final	Al-Tamimi et al, (2010)	• Vowels preceding singletons are longer than those preceding the geminates • Geminates are longer than singletons

As can be seen from Table (36) above, studies on the different Spoken Arabic dialects have investigated gemination word-medially ignoring an important yet controversial position that is the word-final position geminates (except on JA Abu-Abbas, Zuraiq and Abdel-Ghafer, 2011; Al-Tamimi, Abu-Abbas, and Tarawneh, 2010; Al-Tamimi, 2004). Some of these studies have concluded that fricatives are the longest geminate consonants when compared with other geminate consonants (Khattab and Al-Tamimi, 2009; Khattab and Al-Tamimi, 2014), while other studies have reported that trills are the longest (Aldubai, 2015), which poses a question about which consonants are the longest and which consonants are the shortest when they undergo gemination. This also poses a question whether all consonants undergo gemination in the same way and whether the length is affected in the same way as well. It has also been reported that there is no evidence of a temporal compensation between medial geminates and the vowels preceding them (Ghalib, 1984; Zeroual et al., 2008; Khattab and Al-Tamimi, 2009). Similarly, there has been some controversy over the vowel duration before geminated consonants and whether the vowel is originally a long or a short one. For example, Al-Tamimi, Abu-Abbas, and Tarawneh, (2010) posit that vowels preceding singletons are longer than those preceding the geminates whereas Zeroual et al (2008) claim that geminates don't induce shortening of their preceding vowel. However, what all previous studies have agreed on is that geminated consonants, regardless of the manner of articulation, are remarkably longer than their singleton counterparts. In this regard, Al-Tamimi, Abu-Abbas, and Tarawneh, (2010) assert that geminates are longer in comparison to their singletons counterparts. Aldubai (2015) supports Al-Tamimi's that the duration of geminates is generally twice as much as that of singletons.

More importantly and particularly when talking about JA, no acoustic studies have investigated gemination in RJA. The lack of comprehensive studies that deal with gemination phonetically and phonologically in both the medial as well as the final positions in RJA is what gives the current study its value and importance, as it fills a gap in the literature on Spoken Arabic in general as well as on RJA in particular and provides a comprehensive study of gemination. Also, this study is, to my knowledge, the first to tackle gemination using almost the entire consonantal inventory in RJA and the first to investigate the acoustic patterns of vowel and consonant duration in this variety in terms of manner of articulation, place of articulation, voicing, and emphasis. More specifically, this study will yield a better picture of gemination in Arabic through showing the similarities and differences that may arise between the spoken dialects especially in the Levantine region.

6.2 Acoustic correlates of gemination

Drawing on the existing studies that have dealt with gemination word-medially and word-finally (though rare), in this section I introduce the acoustic correlates that will be used in the current study, which include consonant duration, preceding and following vowel duration of both geminated and singleton consonants. For stops, I will measure duration during consonants closure. For fricatives, I will measure duration of frication, and for affricates, I will measure frication and closure duration. As for sonorants, I will measure the formants structure of the consonant (See section 3.4 for more details on acoustic measurements and segmentation).

6.2.1 Consonant duration

It has been stated in the literature that manner of articulation (Blevins, 2004; Aoyama and Reid, 2006), place of articulation (Local and Simpson, 1999), and voicing (Blevins, 2004) play an important role in affecting the geminate/singleton duration ratios. For example, sonorants show clearer distinction in geminate/singleton ratios than other consonants produced with different manner of articulation. Bilabials and alveolars are longer than other consonants that have different place of articulation. Voiced obstruents are harder to geminate than the voiceless ones. Thus, cross-linguistically, the most reliable and robust acoustic parameter that distinguishes a geminate consonant from a singleton consonant is the duration of the target consonants (See Local and Simpson, 1999; Ham, 2001; Hassan, 2002; Blevins, 2004; Payne, 2005; Ridouane, 2007, among others). For example, in Malayalam, the mean target consonant duration is about 52 ms for short consonants and about 175 ms for long consonants (Local and Simpson, 1999).

According to Khattab and Al-Tamimi (2014), the geminate/singleton duration ratio is not consistent cross-linguistically, and it differs from one language to another. They mention that Finnish and Berber have a 3:1 ratio while in Japanese, Italian, and Turkish the ratio is 2:1. Hamzah (2013) also claims that Norwegian and Malayalam have a 1.3:3.4 ratio. However, regardless what the ratio is in geminate/singleton consonants, geminates are viewed and characterized by the length they have when contrasted with singletons.

6.2.2 Vowel duration

In addition to target consonant duration, the vowels preceding and following the target consonants are also important acoustic correlates to distinguish a geminate from a singleton cross-linguistically (See Arvaniti, 2001; Ham, 2001; Hassan, 2002; Blevins, 2004; Payne, 2005; Ridouane, 2007, among others) though little research has been done on the duration of the vowels following a geminate consonant and the influence of the target consonant on following vowel in terms of duration (whether it is short or long). Generally, there seems to be conflicting results as whether vowels in the geminates context are longer, shorter unaffected. For example, some studies reported that vowels tend to be shorter when adjacent to geminate consonants than when adjacent to singleton ones. For example, Hamzah (2013) reviewed sixteen languages and came up with the fact that vowels preceding geminates are shorter in fourteen languages (Hindi, Icelandic, Toba Batak Bengali, Norwegian, Buginese, Italian, Moroccan Arabic, Malayalam, Tashlhiyt Berber, Madurese, and, Swedish). Pajak (2009) found that vowels before geminates are shorter (about 81 ms) and longer before singletons (about 109 ms), making a discrepancy of 28 ms. On the other hand, in some languages, vowels tend to be longer in the geminate context. For example, Turkish, Finnish, Sinhala, and Persian show longer vowel before geminates (Letterman, 1994; Hansen, 2004). More interestingly, some other languages show marginal discrepancies between vowel duration before geminate and singleton consonants like Hungarian and Lebanese Arabic (Ham, 2001).

6.3 Prosodic length vs. prosodic weight of geminates

As discussed in section 1.1.2, geminates are represented and viewed controversially either as prosodic length or as prosodic weight in the current theories of phonology. With regards to the prosodic length representation, a geminate is linked to two C-slots as in (42a), which shows that a geminate is a long consonant that has two timing units, whereas a singleton is linked to a single C-slot and has one timing unit as in (42b) (McCarthy, 1979; Leben, 1980).

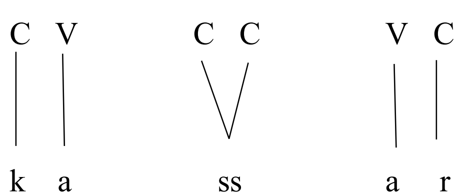
So, this representation is dividing the feature matrices into melodic tiers (containing the features) and skeletal tiers made up of timing slots for consonants (C) and vowels (V) (Ham, 2001:8) as shown in (42) below.

(42).

(a). Geminate consonant (b). Singleton consonant

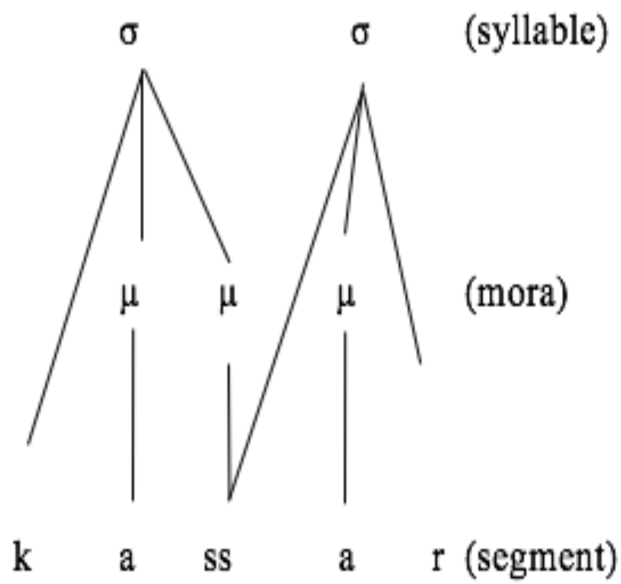
Davis and Ragheb (2014:5) provide the following example for clarification. In the following example (43), they show the CV-tier representation of the Arabic word [kassar] ‘he smashed’ where the consonant [s] is a geminate that is linked to the coda of the first syllable and the onset of the following one.

(43). Geminate consonants represented as prosodic length



However, in prosodic weight representation, within Moraic Theory, (Hyman, 1985; McCarthy and Prince, 1986; Hayes, 1989), the root nodes are linked directly to a higher prosodic level which can be either a syllable or a mora. Geminates within this model are divided into two halves belonging to two different syllables. The first half occupies the coda of the first syllable while the other half occupies the onset of the second syllable. This configuration captures the increased length of a geminate and also expresses the fact that the first syllable can attract stress due to its heaviness (Topintzi, 2008: 148). So the difference between the two views is whether the skeleton is CV/segmental or syllabic and moraic. According to the weight representation, the Arabic word [kassar] in example (43) above in Davis and Ragheb (2014) is represented as follows in (44).

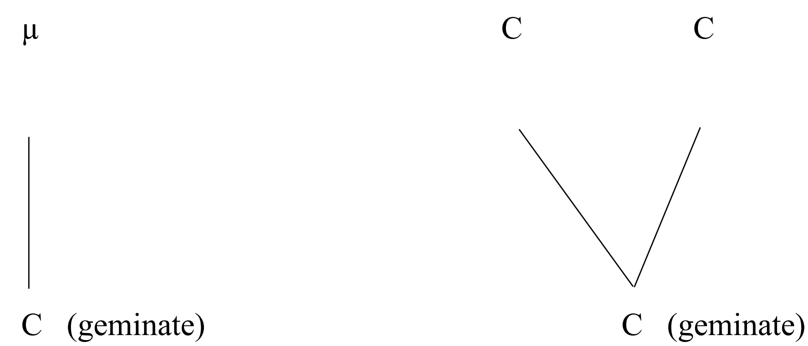
(44). The word [kassar] within Moraic theory



In this chapter, I argue that the geminate-singleton contrast word-medially and word-finally is better to be represented as prosodic weight (Moraic Theory) than to be represented in terms of prosodic length (CV Theory), following the same observation by Davis (2011:880) that in the Hadhrami dialect (spoken in Yemen) consonant clusters (a sequence of two adjacent consonants) are avoided word-finally while geminate consonants are allowed and they attract stress onto the last syllable of the word. Similarly, in RJA, unlike MSA or UJA, consonant clusters are avoided word-finally (see section 2.2 for more information). Accordingly, it would be difficult to explain why word-final geminates are allowed when word-final consonant clusters are avoided under the prosodic length representation of geminates as represented in (45) below, based on Davis (2011) and Topintzi and Davis (2016).

(45). Weight vs. length representation of geminates

(a). Weight representation (b). Length representation



As can be seen in (45) above, the length representation in (45b) predicts that geminates should be viewed and treated similarly to consonants clusters for rules or constraints that reference the CV-tier while the weight representation as in (45a) does not make such a prediction (Davis, 2011) and disambiguates the contrast between a geminate and a consonant cluster.

Ringen and Vago (2011) give an example of Hungarian (which also applies to RJA) showing that since epenthesis is triggered by a word-final consonant cluster (two C-slots), then epenthesis would be predicted to occur in a word that ends in a final geminate since the word would end in two C-slots. However, if a geminate is represented as moraic, epenthesis might not be predicted to occur with a word ending in a geminate, since the consonantal length of a geminate is not segmentally encoded. That is, there would not be two C-slots or two consonantal elements at the end of the word to trigger the epenthesis (Cited in Davis, 2011: 877). Accordingly, if we represent a word ending with a geminate in RJA like in *fann* ‘tossed a coin’ under the C-slots model, then the final geminate *nn* is vulnerable to be broken up by an epenthetic vowel just like a consonant cluster, resulting in *nin*, which is not possible.

Moreover, the attraction of stress onto the final syllable of a word ending in a geminate is consistent with the weight representation; primary stress typically falls on the rightmost bimoraic syllable (Davis, 2011: 880). Similarly, consonant clusters word-finally in RJA are not allowed and usually broken by an epenthetic vowel while geminate consonants are allowed; therefore, it will be more appropriate to account for this phenomenon under Moraic Theory and to view long segments as weight-bearing and not as prosodic length/timing slots, and in this case one model can account for geminates, both word-medially and word-finally.

6.4 Results and discussion

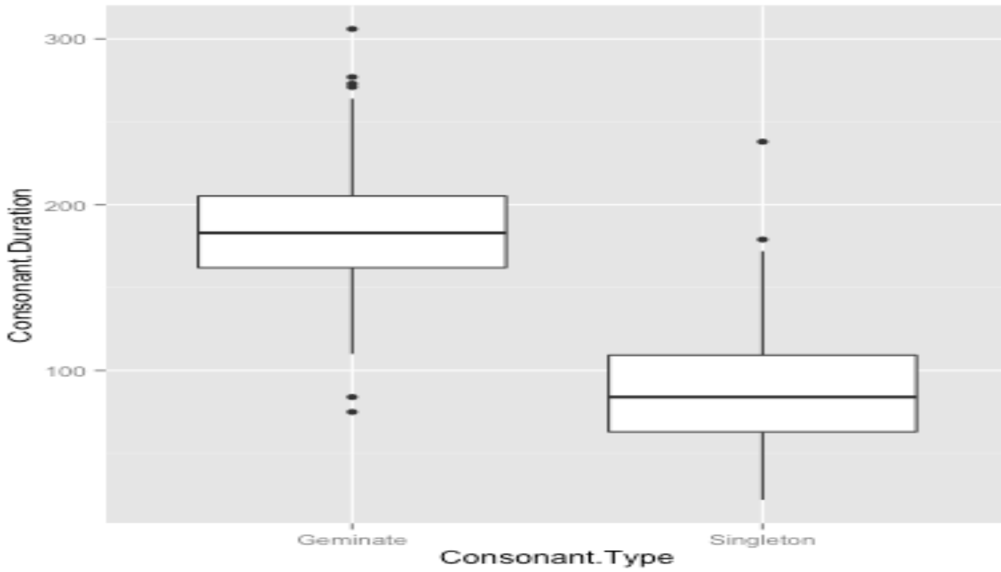
In this section, I present the results of the word-medial and word-final gemination from a phonetic and phonological point of view. I first report the results of the acoustic correlates of gemination, which include the timing properties: the geminate consonant duration and its singleton counterpart duration as well as the preceding and following vowels (short and long) duration for word-medial geminates, and the preceding (short and long) vowels of the word-final geminates. Then, I discuss the results and compare them with those in published works conducted on other Arabic dialects.

6.4.1 Word-medial geminates temporal correlates

6.4.1.1 Consonant duration

Consonant duration is the most important acoustic correlate that enables us to discriminate medial geminates from their singleton counterparts. Thus, this section reports on the results of the duration of geminate consonants and the duration of the singleton consonants in the medial position in hetrosyllabic words CVCVC, CVC:VC, CVCV:C, CVCV:C:, e.g., katab *'he wrote'*, kat:ab *'made someone write'*, zaka: *'charity'*, and zak:a: 'paid charity', respectively. The Linear Regression statistical test results reveal that the mean duration of the consonant in the geminate position (M = 185, SD = 34) is significantly longer than the mean duration of the consonant in the singleton position (M = 87, SD = 33) by 98 ms. This indicates that the geminate duration is almost twice the length of its singleton counterpart, and that the ratio of a medial geminate to a medial singleton is 2.1:1. The following boxplot in Figure (34) visualizes the differences between the two types of consonants.

Figure (34): Mean duration (in Ms.) of geminates and singletons word-medially



Other independent variables namely, gender, place of articulation, manner of articulation, voice, and emphasis were also used in the statistical analysis to check if they play any role in affecting the consonant duration. Independent variables that turned out to be insignificant were removed one by one and the statistical test was performed again in order to guarantee the best fit. The following Table (37) lays out the statistical results of the Linear Regression test.

Table (37): Statistical results from geminate and singleton duration

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	177.41005	7.16620	24.757	< 2e-16 ***
Consonant.TypeSingleton	-97.59568	2.07171	-47.109	< 2e-16 ***
VoiceVoiceless	37.75035	2.58834	14.585	< 2e-16 ***
PlaceGlottal	-23.11238	6.07930	-3.802	0.000158 ***
MannerTrill	-42.98721	8.90237	-4.829	1.73e-06 ***

The statistical analysis results indicate that the glottal consonants affected the consonant mean duration as opposed to the alveolars, palatals, labials, interdentals, labio-dentals, palato-alveolars, and pharyngeals, which did not. Based on the statistical results in Table (37) above, the following results are reported. First, voicelessness significantly affected the consonant mean duration by 38 ms. Second, the glottal consonants, as a place of articulation, affected the consonant mean duration significantly by -23 ms. Finally, the trill consonant /r/ significantly affected the consonant mean duration by -43 ms.

With regards to geminate-singleton contrast in terms of place of articulation, the results (ratios not absolute duration as shown in Table 38) show that labial geminates are longer than their singleton counterparts by 104 ms. The same result applies to alveolars and glottals. Palatal geminates are longer than their singleton counterparts by 90 ms, and so are the palato-alveolars. Pharyngeal geminates are longer than their singleton counterparts by 96 ms. Interdental geminates are longer than their singleton counterparts by 92 ms. Labio-dental geminates are longer than their singleton counterparts by 95 ms. Finally, velar geminates are longer than their singleton counterparts by 87 ms. Based on the ratios of geminates to singletons in Table (38), geminate duration is not the same for all consonants as it varies based on the place of articulation of the target consonants in relation to their singleton counterparts. For example, geminates to singleton ration is the longest when the place of articulation is labial, alveolar, or glottal. Palatal, pharyngeals and interdentals are next in length, whereas labio-dentals, velars, and palato-alveolars are at the bottom of the list, and the shortest is the velars. The reason why geminate alveolars and labials have more distinct duration ratios with their singleton counterparts is that bilabial and alveolar singletons are generally shorter than velars, and that alveolars are the most common type of geminates (Thurgood, 1993; Local and Simpson,1999; Khattab and Al-Tamimi, 2014).

Table (38): word-medial geminate-singleton contrast based on place of articulation

Cons. Type	Place	Cons. Duration (ms)	Difference (ms)	Ratio
geminate	Labial	177	104	1:2.4
singleton	Labial	73		
geminate	Alveolar	183	104	1:2.3
singleton	Alveolar	79		
geminate	Glottal	187	104	1:2.3
singleton	Glottal	83		
geminate	Palatal	173	90	1:2.1
singleton	Palatal	83		
geminate	Pharyngeal	190	96	1:2.0
singleton	Pharyngeal	94		
geminate	Interdental	181	92	1:2.0
singleton	Interdental	89		
geminate	Labio-dental	205	95	1:1.9
singleton	Labio-dental	110		
geminate	Velar	184	87	1:1.9
singleton	Velar	97		
geminate	Palato-Alv	197	90	1:1.8
singleton	Palato-Alv	107		

Geminate-singleton duration contrast is also contingent upon the manner of articulation of the consonant. The following results (ratios not absolute duration) can be reported accordingly: Affricate geminates are longer than their singleton counterparts by 88 ms. Fricative geminates are longer than their singleton counterparts by 94 ms. Glide geminates are longer than their singleton counterparts by 90 ms. Lateral geminates are longer than their singleton counterparts by 114 ms. Nasal geminates are longer than their singleton counterparts by 115 ms. Plosive geminates are longer than their singleton counterparts by 100 ms. Finally, trill geminates are longer than their singleton counterparts by 111 ms. The following Table (39) lays out all the durations of the geminates and singletons based on their manner of articulations. Based on the ratios of geminates to singletons, not the absolute duration, in Table (39), geminates are the longest in duration in trills, laterals, and nasals while the shortest geminate in relation its singleton counterpart is the affricates, glides, and fricatives. The reason why trills, lateral, and nasals are the longest can be attributed to the fact that geminate sonorants can be easily contrasted with singleton sonorants whereas geminate affricates and singleton affricates have less distinct contrast, partly due to singleton sibilant consonants like /s/ and /ʃ/ being intrinsically long (Tserdanelis and Arvaniti, 2001; Blevins, 2004; Aoyama and Reid, 2006; Khattab and Al-Tamimi, 2014). Another reason why the geminate to singleton ratio of sonorants is greater than that of obstruents is that the Arabic singleton sonorants are of quite short duration, thus the geminate to singleton ratio could be naturally larger if there is a target duration for geminates. It is also easier to maintain voicing/duration during a sonorant, making the long sonorants easier to be produced with voicing.

The results also show that emphasis (pharyngealization) plays no role in discriminating the duration of a geminate from that of a singleton. While the difference between an emphatic geminate and an emphatic singleton is 99 ms, the difference between a geminate plain and a singleton plain is 98 ms, so the difference is only 1 ms. On the other hand, while the difference in duration between a geminate voiced consonant and a voiced singleton consonant is 102 ms, the difference between a voiceless geminate and a voiceless singleton is 92 ms, so the difference is 10 ms.

Table (39): Word-medial geminate-singleton contrast based on manner of articulation

Cons. Type	Manner	Cons. Duration (ms)	Difference (ms)	Ratio
Geminate	Trill	141	111	1:4.1
Singleton	Trill	30		
Geminate	Lateral	172	114	1:2.9
Singleton	Lateral	58		
Geminate	Nasal	177	115	1:2.8
Singleton	Nasal	62		
Geminate	Plosive	189	100	1:2.1
Singleton	Plosive	89		
Geminate	Glide	173	90	1:2.1
Singleton	Glide	83		
Geminate	Fricative	189	94	1:2.0
Singleton	Fricative	95		
Geminate	Affricate	192	88	1:1.8
Singleton	Affricate	104		

As we see in the table above, all geminate vs. singleton consonant ratios are significantly different in duration, with trill having the largest ratio while affricates have the smallest (but still significant) ratio.

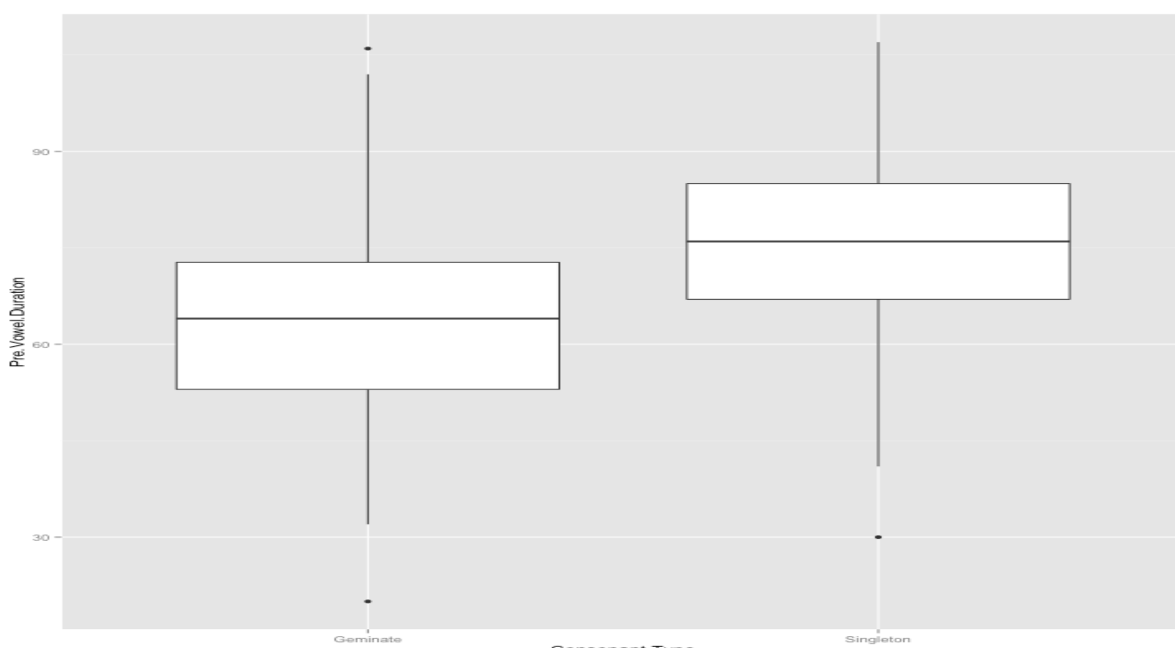
6.4.1.2 Preceding and following vowel duration

The duration of the vowels adjacent to geminates and singletons is one of the important timing properties/ acoustic correlates that enable us to discriminate geminates from their singleton counterparts. Thus, in this section, I detail the results of all vowels in both contexts.

6.4.1.3 Preceding short vowel

First, the duration of the short vowel /a/ before all geminate and singleton consonants in the medial position was measured, and it was found that the mean duration of /a/ before geminates is 64 ms whereas its mean duration before singletons is 77 ms. The Linear Regression statistical results show that when the short vowel /a/ precedes a geminate, it becomes significantly shorter than /a/ in the singleton context by 13 ms. The following Figure (35) visualizes the vowel duration differences in both contexts.

Figure (35): Preceding short vowel duration in (Ms.) in medial geminates and singletons



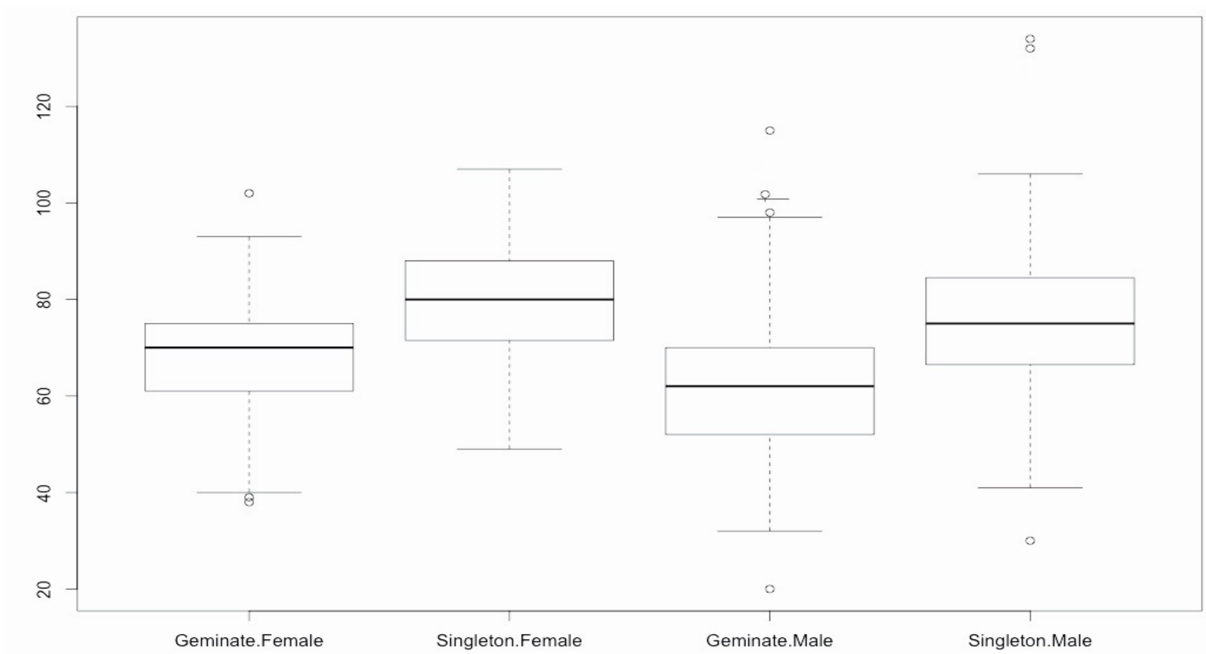
The results also show that the preceding short vowel mean duration is affected by place of articulation, manner of articulation, voicing, and gender as shown in Table (40), where only significant results are reported. More specifically, for place of articulation, first, it was found that labials significantly affected the mean duration of the vowel /a/ by -17 ms.

Table (40): Statistical results of pre short vowel in geminate and singleton contexts

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	80.888	3.809	21.238	< 2e-16 ***
Consonant.TypeSingleton	13.015	1.079	12.065	< 2e-16 ***
PlaceLabial	-17.660	2.524	-6.996	6.73e-12 ***
PlaceLabio-dental	-9.800	3.166	-3.096	0.002051 **
PlacePalato-alv	-11.425	3.166	-3.609	0.000332 ***
PlacePharyngeal	-9.816	2.404	-4.083	5.01e-05 ***
PlaceVelar	-4.051	1.768	-2.291	0.022298 *
MannerLateral	-15.691	4.636	-3.385	0.000757 ***
MannerNasal	-17.298	4.338	-3.988	7.45e-05 ***
VoiceVoiceless	-10.699	1.348	-7.938	9.45e-15 ***
GenderMale	-3.558	1.144	-3.109	0.001959 **

Second, labio-dentals significantly affected the mean duration of /a/ by -9 ms. Third, palato-alveolars significantly affected the mean duration of /a/ by -10 ms. Fourth, the mean duration of /a/ was significantly affected by pharyngeals by -9 ms. For manner of articulation and its effect on the mean duration of the /a/, the results also revealed that while laterals significantly affected the mean duration of /a/ by -15 ms, nasals affected the mean duration by -17 ms. Voicing was also found to play a role in affecting the vowel mean duration. The results indicate that voicelessness significantly affected the mean duration of /a/ by -4 ms. While voiceless consonants tend to be preceded by shorter vowel durations, voiced consonants are preceded by long vowel durations. This also supports the results that were reported on the vowel duration in Chapter Four. Finally, gender significantly affected the mean duration of /a/ by -4 ms. Males tend to have a shorter vowel duration than females do. Consider the following Figure (36) on the effect of gender on vowel duration.

Figure (36): Preceding short vowel duration (in Ms.) in medial geminates and singletons

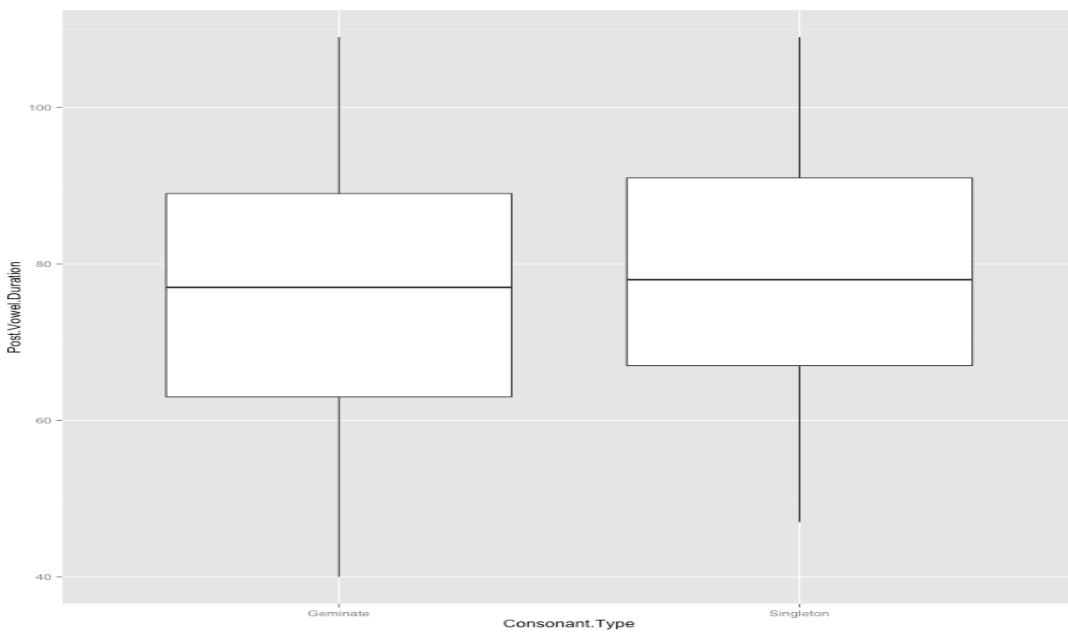


As shown in Figure (34) above, female speakers tend to produce longer vowel durations in both geminate and singleton contexts than male speakers do.

6.4.1.4 Following short vowel

The duration of the short vowel /a/ after all geminate and singleton consonants in the medial position was measured, and the statistical results indicate that the mean duration of /a/ after geminates is 87 ms whereas its mean duration after singletons is 88 ms, with an insignificant difference of 1 ms. The following Figure (37) visualizes the following short vowel duration differences in both contexts.

Figure (37): Following short vowel duration (in Ms.) in medial geminates and singletons



The results also show that the mean duration of the vowel following a geminate is affected by place of articulation, voicing and, gender as shown in Table (41), where only significant results are reported. More specifically, the inter-dentals significantly affected the vowel mean duration by 10 ms, labio-dentals significantly affected the vowel mean duration by 36 ms, and the palato-alveolars significantly affected the vowel mean duration by 10 ms.

Table (41): Statistical results of following short vowel in geminate and singleton contexts

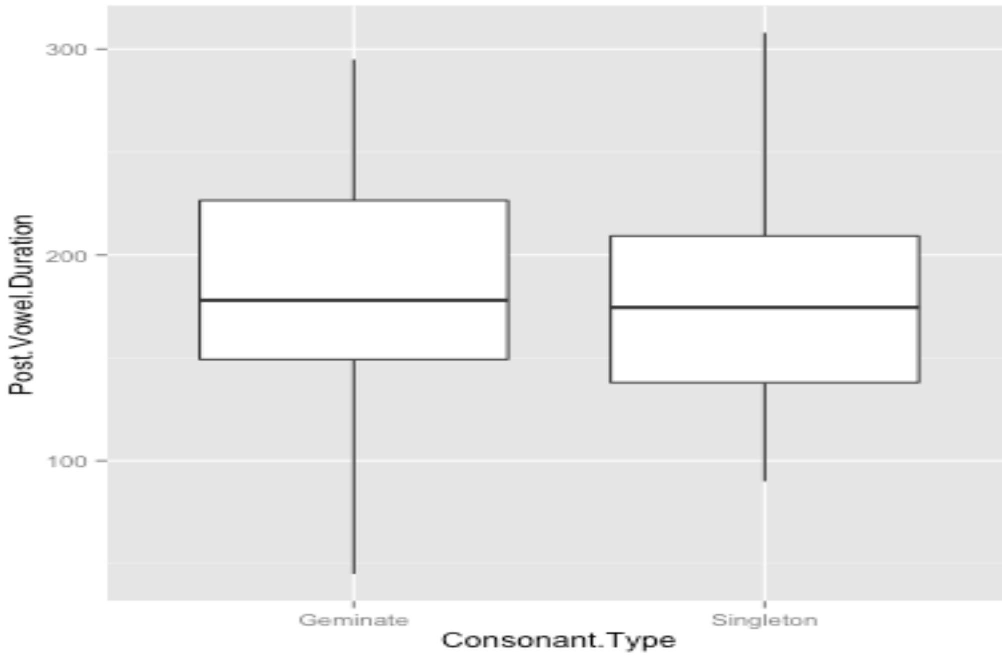
	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	96.8511	3.6297	26.683	< 2e-16 ***
Consonant.TypeSingleton	0.6111	2.8418	0.215	0.82987
PlaceInter-dental	10.4430	4.8649	2.147	0.03259 *
PlaceLabio-dental	36.3461	7.9820	4.554	7.56e-06 ***
PlacePalato-alv	10.2557	4.9358	2.078	0.03854 *
VoiceVoiceless	-8.6879	3.2274	-2.692	0.00749 **
GenderMale	-14.4722	3.0142	-4.801	2.45e-06 ***

With regards to voicing, voicelessness was found to significantly affect the vowel mean duration by -9 ms. Similarly, gender significantly affected the vowel mean duration by -14 ms. This result is consistent with that for short vowel mean duration preceding geminates.

6.4.1.5 Following long vowel

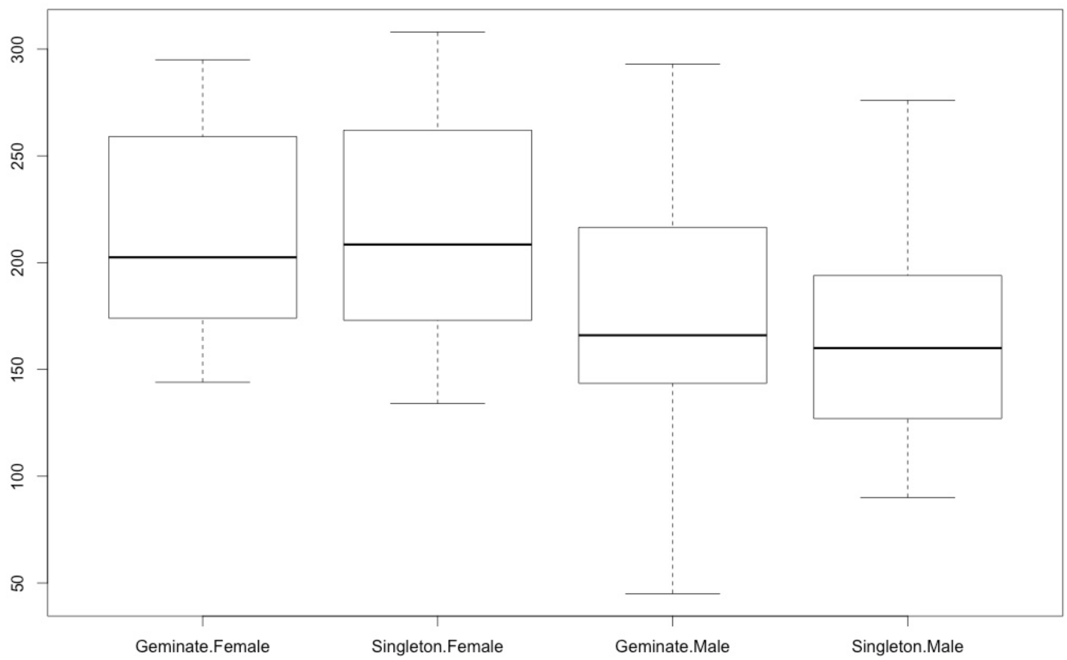
The duration of the long vowel /a:/ after all geminate and singleton consonants in the medial position was measured, and it was found that the mean duration of /a:/ after geminates is 189 ms whereas its mean duration after singletons is 178 ms. The Linear Regression statistical analysis results show that when the long vowel /a:/ follows a geminate, it becomes significantly longer than /a:/ in the singleton context by 11 ms. The following Figure (38) visualizes the long vowel duration differences in both contexts.

Figure (38): Following short vowel duration (in Ms.) in medial geminates and singletons



The statistical results also show that the mean duration of the long vowel following a geminate is not affected by place of articulation, manner of articulation, or voicing, and that only gender significantly affected the duration of the vowel by -42. This result is in line with those for the short vowels before geminates and short vowels after geminates. This shows that across the board for medial geminate/singleton contrast, male speakers had shorter vowel duration than female speakers did as shown in Figure (39). It also shows that in both singletons and geminates, female speakers tend to have longer vowel durations than male speakers do.

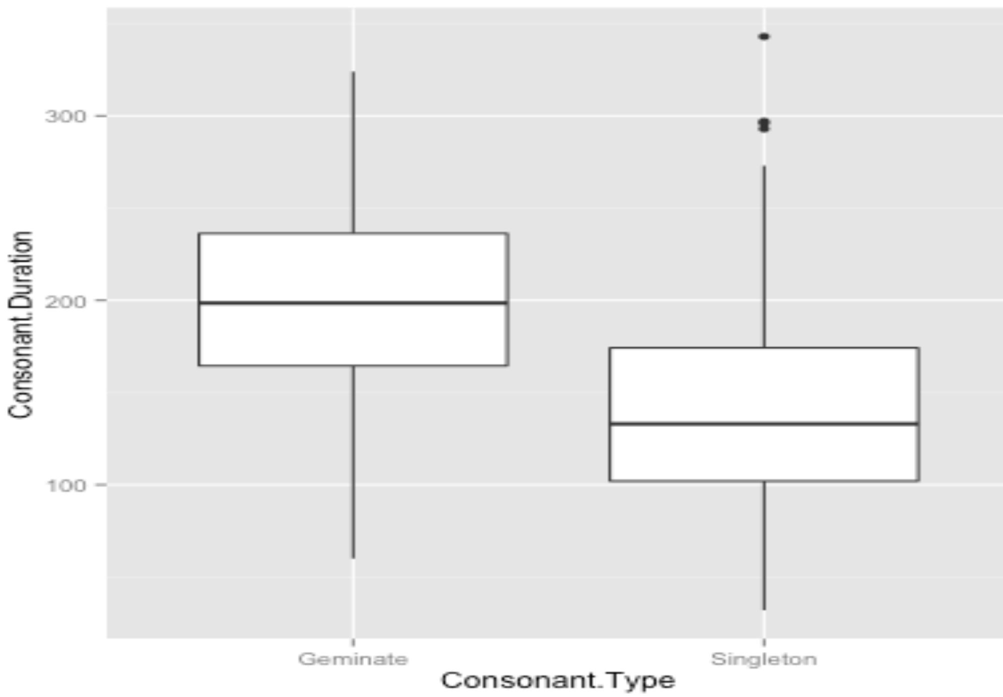
Figure (39): Preceding short vowel duration (in Ms.) in medial geminates and singletons



6.4.2 Word-final geminates temporal correlates
6.4.2.1 Consonant duration

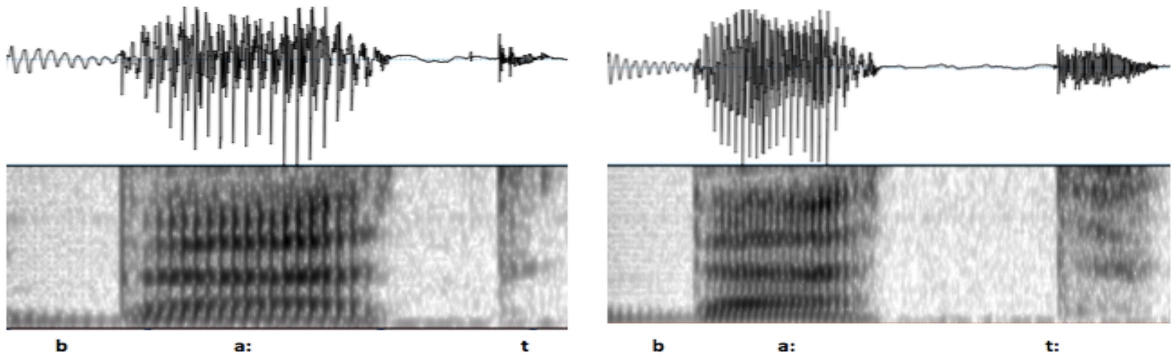
This section reports on the results of the duration of geminate consonants and the duration of the singleton consonants in the final position in tautosyllabic words namely, CVC, CVC:, CV:C and CV:C:, e.g., fan *'art'*, fan: *'tossed a coin'*, ba:t *'slept over'*, and ba:t: *'decisive'*, respectively. The Linear Regression statistical test results indicate that the mean duration of the word-final geminate consonant (M = 198, SD = 55) is significantly longer than the mean duration of the word-final singleton (M = 141, SD = 45) by 57 ms, and that the ratio of the final geminate consonant to its singleton counterpart is 1.4:1. This indicates that the duration of the singleton in the final position is about three quarters of the duration of final geminate duration. The following boxplot in Figure (40) visualizes the differences between the two types of consonants

Figure (40): Mean duration of geminates and singletons (in Ms.) word-finally



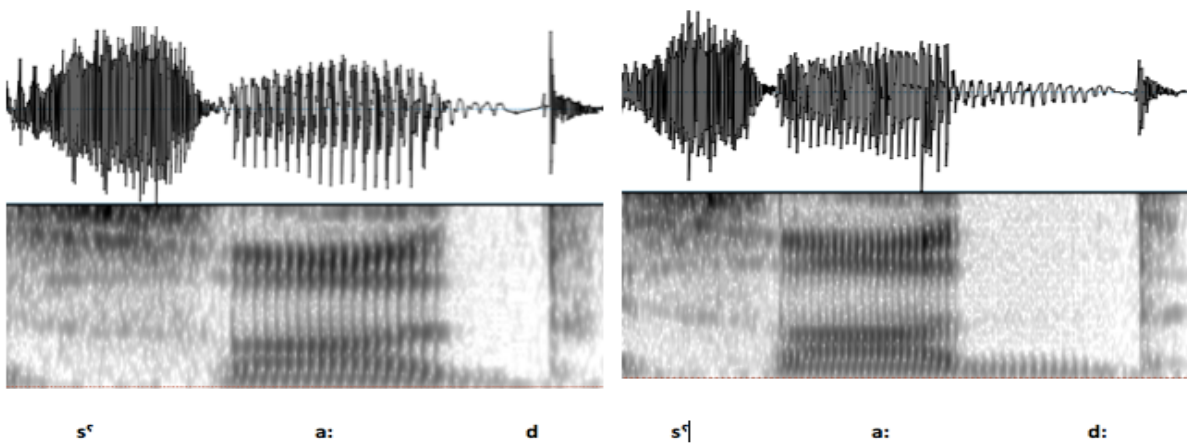
It is worth mentioning here that geminate and singleton stops word-finally have clear release bursts. Because of the final release, word-final geminate stops can be perceptually and acoustically distinct from word-final singleton stops. This can be illustrated in the following spectrograms (41) and (42) that show the final release in voiceless and voiced stops.

Figure (41): Release burst of word-final voiceless geminate and singleton stops



ba:t ‘He slept over.’ **ba:t:** ‘decisive’

Figure (42): Release burst of word-final voiced geminate and singleton stops



sˤa:d ‘He hunted.’ **sˤa:d:** ‘resistant’

Other independent variables namely, gender, place of articulation, manner of articulation, voice, and emphasis were also used in the statistical analysis to check if they play any role in affecting the consonant duration word-finally. Again, independent variables that turned out to be insignificant were removed one by one, and the statistical test was performed again in order to guarantee the best fit. The following Table (42) lays out the statistical results of the

Linear Regression test. The statistical analysis results indicate that place of articulation, gender, and emphasis did not play a significant role in the duration of the consonants word-finally. However, voicing and manner of articulation turned out to be significant variables. More specifically, based on the statistical results in Table (42), voicelessness significantly affected the duration of the consonants by 37 ms.

Table (42): Statistical results from geminate and singleton duration

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	210.125	10.061	20.885	< 2e-16 ***
Consonant.TypeSingleton	-57.083	4.024	-14.184	< 2e-16 ***
VoiceVoiceless	37.163	4.691	7.923	1.24e-14 ***
MannerFricative	-21.835	10.619	-2.056	0.04022 *
MannerGlide	-33.000	13.941	-2.367	0.01826 *
MannerLateral	-42.583	13.941	-3.055	0.00236 **
MannerNasal	-35.250	12.073	-2.920	0.00364 **
MannerPlosive	-26.442	10.903	-2.425	0.01561 *
MannerTrill	-86.708	13.941	-6.220	9.68e-10 ***

With regards to geminate-singleton contrast in terms of manner of articulation, the following results are reported. First, fricatives significantly affected the consonant mean duration by -22 ms. Second, glides significantly affected the consonant mean duration by -33 ms. Third, laterals significantly affected the consonant mean duration by -43 ms. Fourth, nasals significantly affected the consonant mean duration by -35 ms. Fifth, plosives significantly affected the consonant mean duration by -26 ms. Finally, the trill consonant /r/ significantly affected the consonant mean duration by -87 ms.

Table (43): Word-final geminate-singleton contrast based on manner of articulation

Cons. Type	Manner	Cons. Duration (ms)	Difference (ms)	Ratio
Geminate	Trill	120	51	1:1.7
Singleton	Trill	69		
Geminate	Affricate	213	68	1:1.5
Singleton	Affricate	145		
Geminate	Fricative	212	61	1:1.4
Singleton	Fricative	151		
Geminate	Plosive	202	57	1:1.4
Singleton	Plosive	145		
Geminate	Glide	174	51	1:1.4
Singleton	Glide	123		
Geminate	Nasal	171	50	1:1.4
Singleton	Nasal	121		
Geminate	Lateral	152	27	1:1.2
Singleton	Lateral	125		

The results (ratios not absolute duration) also show as shown in Table (43) that trill geminates are longer than their singleton counterparts by 51 ms. Affricate geminates are longer than their singleton counterparts by 68 ms. Fricative geminates are longer than their singleton counterparts by 61 ms. Plosive geminates are longer than their single ton counterparts by 57 ms. Glide geminates are longer than their singleton counterparts by 51 ms. Nasal geminates are longer than their singleton counterparts by 115 ms. Finally, Lateral geminates are longer than their singleton counterparts by 27 ms. Based on the ratios of geminates to singletons in Table (43), geminate-singleton ratios are the greatest when the manner of articulation is trills followed by fricatives while the shortest geminate in relation its singleton counterpart is the laterals.

Geminate-singleton duration contrast is also contingent upon the place of articulation of the consonant. The following results (ratios not absolute duration) are reported as shown in/based on Table (44). The pharyngeal geminates are longer than their singleton counterparts by 121 ms. The interdental geminates are longer than their singleton counter parts by 68 ms.

Table (44): Word-final geminate-singleton contrast based on place of articulation

Cons. Type	Place	Cons. Duration (ms)	Difference (ms)	Ratio
Geminate	Pharyngeal	191	121	1:2.7
Singleton	Pharyngeal	71		
Geminate	Interdental	208	68	1:1.5
Singleton	Interdental	140		
Geminate	Alveolar	195	63	1:1.5
Singleton	Alveolar	132		
Geminate	Palato-Alv	230	71	1:1.4
Singleton	Palato-Alv	159		
Geminate	Labio-dental	219	61	1:1.4
Singleton	Labio-dental	158		
Geminate	Palatal	174	51	1:1.4
Singleton	Palatal	123		
Geminate	Labial	168	46	1:1.4
Singleton	Labial	122		
Geminate	Velar	207	42	1:1.3
Singleton	Velar	165		

The alveolar geminates are longer than their singleton counterparts by 63 ms. The palato-alveolar geminates are longer than their singleton counterparts by 71 ms. The labio-dental geminates are longer than their singleton counterparts by 61 ms. The labial geminates are longer than their singleton counterparts by 46 ms. The palatal geminates are longer than their singleton counterparts by 51 ms. Finally, velar geminates are longer than their singleton counterparts by 42 ms.

Based on the ratios of geminates to singletons in Table (44), geminate duration is not the same for all consonants as it varies based on the place of articulation of the target consonants in relation to their singleton counterparts. For example, geminates are the longest when the place of articulation is pharyngeal, followed by alveolars and interdentals, whereas the shortest is the velar. Labials, labio-dentals, palatals, and palato-alveolars are almost within the same range of difference.

The reason why there are distinctive discrepancies between manner and place of articulation in medial geminates and final geminates and their singleton counterparts can be ascribed to the fact that medial geminates are intervocalic while final geminates are not, and that medial geminates in this study occur only in the disyllables CVCVC, CVC:VC, CVCV:C, CVC:V:C while final geminates occur in monosyllables CVC, CVC:, CV:C, CV:C:, so the word structure plays a role in accounting for these differences.

The results also show that emphasis plays no significant role in discriminating a geminate from a singleton. While the difference between an emphatic geminate and an emphatic singleton is 69 ms, the difference between a geminate plain and a singleton plain is 55 ms, so the difference is 14 ms. Further, while the difference in duration between a voiced geminate consonant and a voiced singleton consonant is 54 ms, the difference between a voiceless geminate and a voiceless singleton is 61 ms, so the difference is 7 ms.

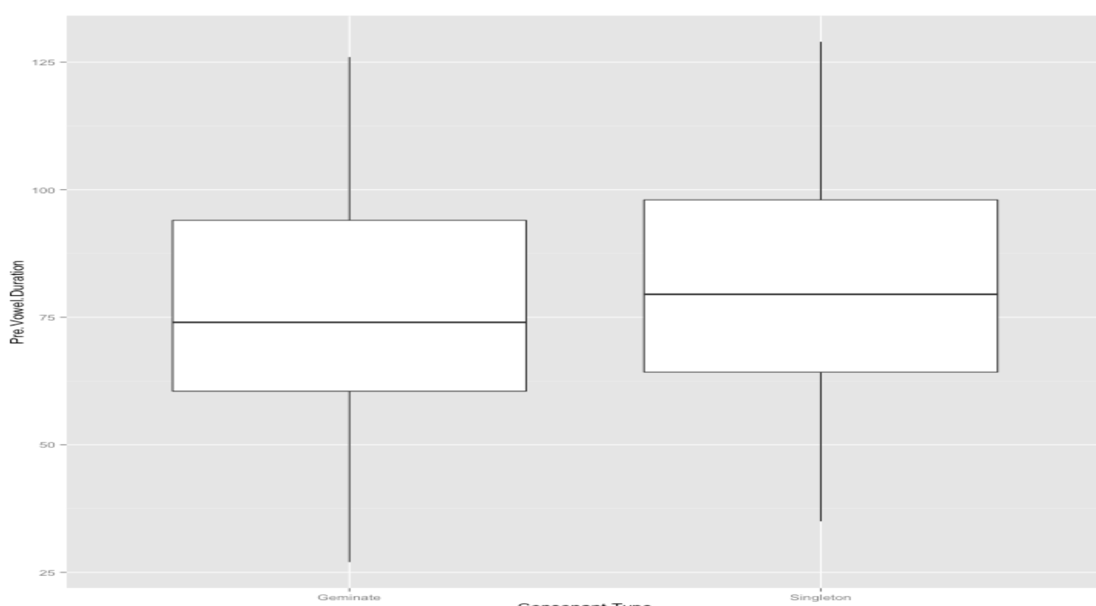
6.4.2.2 Preceding vowel duration

In this section, I detail the acoustic/durational results of the short and long vowels preceding both geminates and singletons.

6.4.2.2.1 Preceding short vowel

First, the duration of the short vowel /a/ before all geminate and singleton consonants in the final position was measured, and it was found that the mean duration of /a/ before geminates is 77 ms whereas its mean duration before singletons is 82 ms. The Linear Regression statistical results show that when the short vowel /a/ precedes a geminate, it becomes significantly shorter than /a/ in the singleton context by 5 ms. The following boxplot in Figure (43) visualizes the vowel duration differences in both contexts.

Figure (43): Preceding short vowel duration (in Ms.) in final geminates and singletons



The results also show that vowel mean duration is affected by place of articulation, manner of articulation, voicing, and gender as shown in Table (45), where only significant results are reported. More specifically, for place of articulation, first, it was found that inter-dentals significantly affected the mean duration of the vowel /a/ by -13 ms. Second, the mean duration of the vowel was significantly affected by labials by -21 ms. Third, labio-dentals significantly affected the mean duration of the vowel by -19 ms. Fourth, the mean duration of the vowel was significantly affected by palatals by -36 ms. Finally, pharyngeals significantly affected the mean duration of the vowel by -30 ms. The results also show that, for manner of articulation, laterals significantly affected the mean duration of the vowel by -36 ms. Second, plosives significantly affected the mean duration of the vowel by -17 ms. Third, trills significantly affected the mean duration of the vowel by -21 ms.

Table (45): Statistical results of pre short vowel in geminate and singleton contexts

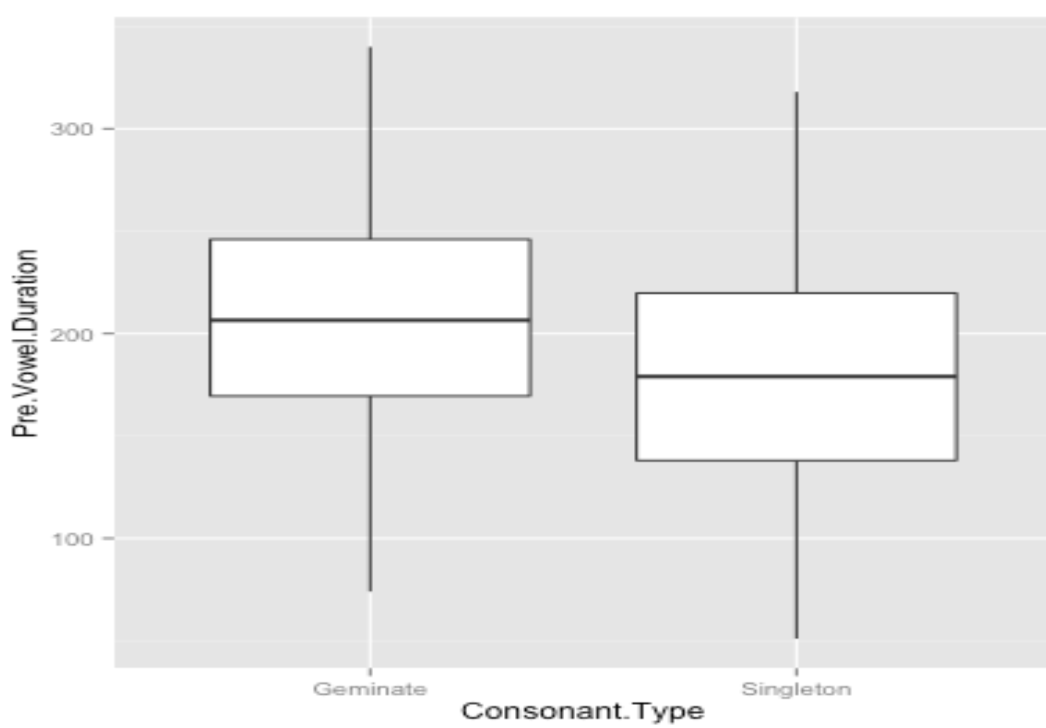
	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	114.309	7.949	14.381	< 2e-16 ***
Consonant.TypeSingleton	5.410	2.085	2.595	0.009967 **
PlaceInter-dental	-13.112	4.042	-3.244	0.001327 **
PlaceLabial	-21.400	4.627	-4.625	5.81e-06 ***
PlaceLabio-dental	-19.306	5.818	-3.318	0.001030 **
PlacePalatal	-36.056	9.273	-3.888	0.000127 ***
PlacePharyngeal	-29.515	4.486	-6.580	2.41e-10 ***
MannerLateral	-35.556	9.273	-3.834	0.000157 ***
MannerPlosive	-16.705	8.297	-2.013	0.045070 *
MannerTrill	-21.056	9.273	-2.271	0.023955 *
VoiceVoiceless	-8.585	2.678	-3.206	0.001506 **
GenderMale	-27.437	2.211	-12.410	< 2e-16 ***

Voicing assimilation also was found to play an important role in vowel durations. Voicelessness significantly affected the mean duration of the vowel by -9 ms. Similarly, gender was found to significantly affect the mean duration of the vowel by -27 ms. Thus, male speakers have shorter vowels as compared with female speakers.

6.4.2.2.2 Preceding long vowel

The duration of the long vowel /a:/ before all geminate and singleton consonants in the final position was measured, and it was found that the mean duration of /a:/ before geminates is 206 ms whereas its mean duration before singletons is 179 ms. The Linear Regression statistical results show that when the long vowel /a:/ precedes a geminate, it becomes significantly longer than /a:/ in the singleton context by 27 ms. The following boxplot in Figure (44) visualizes the vowel duration differences in both contexts.

Figure (44): Preceding long vowel duration (in Ms.) in final geminates and singletons



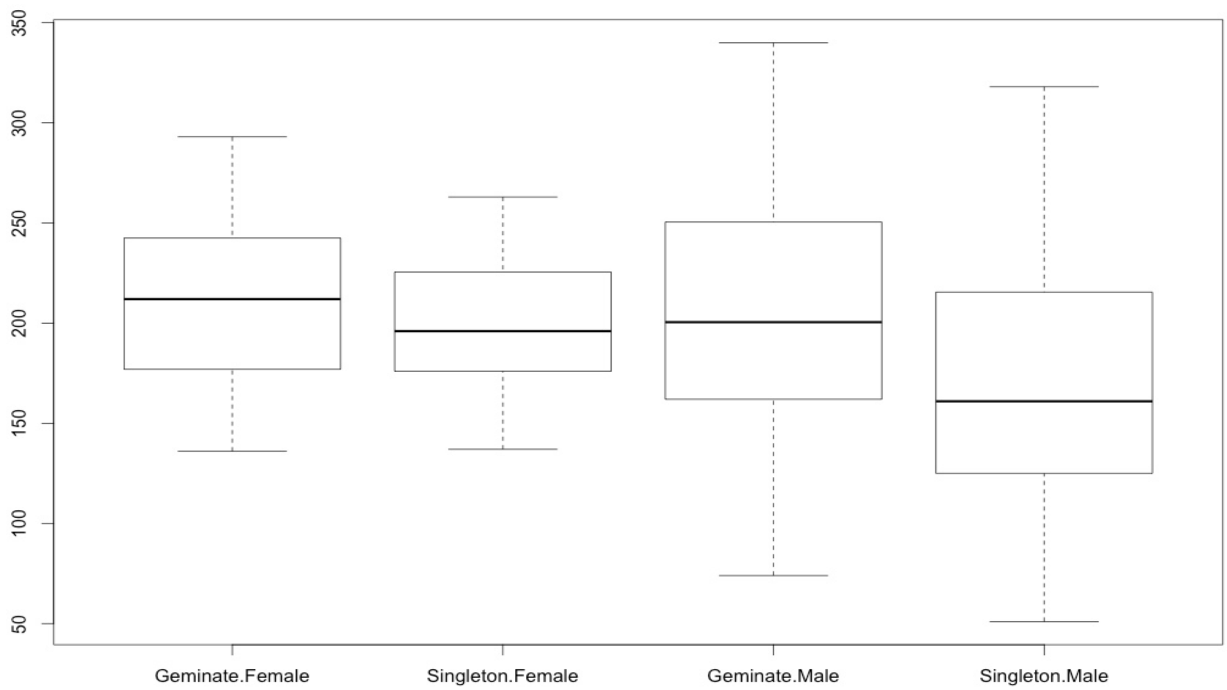
The statistical results also show that the mean duration of the long vowel preceding a geminate in the final position is affected by place of articulation and gender whereas manner of articulation, emphasis, and voicing did not significantly affect the mean duration of the vowel as shown in Table (46) below. For place of articulation, the following results are reported. First, inter-dentals significantly affected the mean duration of the vowel by -20 ms. Second, labials significantly affected the mean duration of the vowel by -38 ms. Third, labio-dentals significantly affected the mean duration of the vowel by -30 ms. Fourth, palatals significantly affected the mean duration of the vowel by -39 ms. Finally, pharyngeals significantly affected the mean duration of the vowel by-39 ms.

Table (46): Statistical results of pre short vowel in geminate and singleton contexts

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	233.691	6.755	34.595	< 2e-16 ***
Consonant.TypeSingleton	-26.778	5.814	-4.606	6.26e-06 ***
PlaceInter-dental	-19.778	9.374	-2.110	0.035773 *
PlaceLabial	-38.458	11.031	-3.486	0.000569 ***
PlaceLabio-dental	-30.333	14.936	-2.031	0.043216 *
PlacePalatal	-38.583	14.936	-2.583	0.010298 *
PlacePharyngeal	-39.375	11.031	-3.570	0.000421 ***
GenderMale	-18.703	6.166	-3.033	0.002650 **

Likewise, gender was found to significantly affect the mean duration of the long vowel by 19 ms, which agrees with all other results pertaining to the vowel being shorter by male speakers and longer by female speakers. The following Figure (45) visualizes the vowel duration differences in both contexts and also shows that female speakers tend to have a longer vowel duration in both geminates and singletons than male speakers do. So, this shows that both short vowels and long vowels across the board are affected by gender, which calls for further investigation by having more speakers, especially female speakers to draw more conclusions on gender differences in this regard.

Figure (45): Preceding long vowel duration (in Ms.) in final geminates and singletons



6.5 Discussion

The primary goal of this chapter was threefold. The first was to analyze RJA gemination using the entire consonantal inventory in word-medial and word-final contexts in a comprehensive manner. The second was to report on the acoustic temporal correlates that help in discriminating geminates from their singleton counterparts, which, in turn, helps explain the phonological patterning of gemination word-medially and word-finally in RJA. The third was to compare the results of word-medial geminates with word-final geminates acoustically/phonetically, and then show how representing geminates in terms the prosodic length best accounts for gemination in RJA. Generally, in this chapter I investigate the durational cues of geminates and their singleton counterparts in Rural Jordanian Arabic (RJA), comparing word-medial and word final positions in terms of surrounding vowels, voicing, emphasis, manner and place of articulation. I build on work investigating geminates by Khattab, 2007; Khattab and Al-Tamimi, 2009; Abu-Abbas, Zuraiq and Abdel-Ghafer, 2011; Khattab and Al-Tamimi, 2014. Unlike these authors, however, who focus on word-medial geminates, the present study investigates acoustic correlates of both word-medial and word-final gemination. I further discuss how my findings support others who found that duration plays an important role in phonetic cues to gemination duration (Lahiri and Hankamer, 1988; Khattab and Al-Tamimi, 2008).

Duration of the targeted geminate and singleton consonants as well as that of the preceding and following vowel was measured. Each consonant was also coded for a number of independent variables including word position, place and manner of articulation, voicing, emphasis, following vowel, preceding vowel, and speaker gender.

The results of this study yield three particularly interesting findings which are the focus of this chapter. First, it was found that the proportional differences between geminates and singletons based on word position are significantly different: in medial position, we see a duration ratio of 2.1:1 of the geminate as compared to the singleton, whereas in final position we see a ratio of 1.4:1, an observation that has not been reported in other studies in Arabic or even cross-linguistically, to my knowledge, due to the dearth of studies on word-final geminates. The difference between the duration of a geminate in word-medial position and a singleton in word-medial position is robust, given that geminates are almost two times the duration of singletons. Similarly, the difference between the duration of a geminate in word-final position and a singleton in word-final position is robust as well, given that geminates are longer that their singleton counterparts by almost a 25%. This shows that the geminate consonant duration in RJA word-medially is in line with other languages such as Turkish, Japanese, Italian, and Lebanese Arabic, that reported that geminates are two times longer than their singleton counterparts, and is different from other languages like Norwegian, Malayalam, Finnish, and Berber in which geminates are three times longer than their singleton counterparts. According to Khattab and Al-Tamimi (2014), the geminate/singleton duration ratio is not consistent cross-linguistically, and that it differs from one language to another. With regards to the duration of the final geminates word-finally as compared to their singleton counterparts, the dearth of studies on this position makes it hard to compare the results of the current study with other languages. Therefore, this study contributes to the literature of gemination in general and to gemination word-finally in particular. It also shows how the duration of geminate consonants in the word-medial position is substantially different (longer) than that in the word-final position.

However, regardless what the ratio is in geminate/singleton consonants, geminates are viewed and characterized by the length they have when contrasted with singletons. The following Table (47) lays out all durations for consonants and vowels in both word-medial and word-final contexts.

Table (47): All word-medial and final durations of consonants and vowels

	Target Consonants/Vowels	Mean duration (ms)	SD	Ratio
MEDIAL	Con. duration in (CC) context	185	34	1:2.1
	Con. duration in (C) context	87	33	
	Pre short vowel in (CC) context	67	15	1:1.2
	Pre short vowel in (C) context	77.5	16	
	Post short vowel in (CC) context	87	29	1:1.0
	Post short vowel in (C) context	88	27	
	Post long vowel in (CC) context	190	50	1:1.1
	Post long vowel in (C) context	179	49	
FINAL	Con. duration in (CC) context	198	55	1:1.4
	Con. duration in (C) context	141	54	
	Pre short vowel in (CC) context	77	26	1:1.1
	Pre short vowel in (C) context	83	26	
	Pre long vowel in (CC) context	207	50	1:1.2
	Pre long vowel in (C) context	180	54	

Accordingly, the ratio of geminates in word medial position to geminates in word-final position is 1.7:1, given the difference between a geminate and singleton in word-medial position is 98 ms and the difference between a geminate and singleton in word-final position is 57 ms. This means that geminates word-medially are more than one and a half times longer than geminates word-finally. This might be attributed to the syllable structure that geminates that are heterosyllabic and intervocalic are longer than those in word-final position, which are tautosyllabic. Second, it was found that all vowels in the geminate context are significantly longer for females than for males, contra Khattab and Al-Tamimi (2008), while gender plays no role when it comes to the consonant duration in the geminate context. Third, it was found that phonologically short vowels in the geminate context are significantly shorter than those in singleton context while phonologically long vowels in geminate context are significantly longer than those in singleton context. These findings for RJA are contrary to Khattab and Al-Tamimi (2008) for Lebanese Arabic, where post-geminate vowels were unaffected by the previous consonant and for Khattab and Al-Tamimi (2014) where only phonologically long vowels were affected. One reason why long vowels are longer in the geminate context might have to do with the perception of the participants that they might have focused on the long vowels more than short vowels when producing geminates that have adjacent long and short vowels. The same result has also been reported on Finnish by Nakai et al., (2009) who found that vowels that occur after the coda (following the geminate consonant) in the geminate context are shorter when the vowels that occur before the coda (preceding geminate consonants) are long. This may suggest that long vowels following a geminate are important acoustic correlates that should be taken into consideration when investigating gemination. It also shows that there may be dialectal differences that also affect the acoustic properties of geminate consonants and vowels. With respect to the phonologically short vowels, they become shorter when preceding geminate context. This is due to the fact that syllables ending a geminate are closed and thus vowels in closed syllables become phonetically shorter (Maddieson, 1997).

Vowel duration, whether long, short, preceding or following, was found to be a robust acoustic correlate (except for the following short vowel) throughout the investigation of both word-medial and word-final positions. Short vowels were found to be shorter when adjacent to geminates whereas long vowels were, surprisingly, longer when adjacent to geminates. This result can very well be related to a sign of temporal compensation, a relationship between a vowel and a consonant within the same word, where the duration of a vowel decreases and the duration of the consonant increases and vice versa. Therefore, when I measured the duration of the geminates in the word-final position when preceded by long and short vowels, I found that the mean duration of the geminates in the long vowel context was 186 ms whereas the duration of the geminate in the short vowel context was 211 ms. This is an indication that there is a temporal compensation between the geminate and its preceding vowel; the longer the geminate the shorter the preceding vowel and vice versa. In support of this, I also measured the geminate duration in the word-medial position whereby the long vowel comes only after the geminates. I found that the geminate duration is longer when followed by a long vowel and shorter when followed by a short vowel. Consequently, this provides evidence that there is temporal compensation between the geminate and the preceding vowels, and that the following vowels do not trigger any temporal compensation. This might be due to the fact that only when the geminate and the vowel are within the rhyme of the same syllable, temporal compensation occurs, and that when the geminate and the vowel are not within the rhyme of the same syllable, no temporal compensation takes place. Thus, VG (where V = vowel, G = geminate) will show temporal compensation but not GV. This is clear in word final positions because all the words in the speech material were tautosyllabic CVC: and CV:C:. When also measuring the short vowel duration before and after word-medial geminates, I found that duration of the short vowels before geminates is 68 ms, and the duration of the short vowels after geminates is 88 ms. This, again, indicates that there is a temporal compensation between the geminate and the preceding vowels, and, therefore, shows that only preceding vowels can trigger/be affected by the temporal compensation. Typologically, the vowel preceding a geminate can be viewed in different ways. For example, in some languages the preceding vowel becomes shorter before a geminate as in (Italian) Esposito and Benedetto, 1999; (Tashlhiyt Berber) Ridouane, 2007; (Lebanese Arabic) Khattab, 2007; Khattab and Al-Tamimi, 2009; Khattab and Al-Tamimi, 2014, while in some other languages, the vowel preceding a geminate becomes longer as in (Turkish) Lahiri and Hankamer, 1988. Therefore, there seems to be conflicting results regarding the duration of the vowels before geminates, which means that vowel duration as a cue to consonant gemination is not the same cross-linguistically; but rather, language-specific. In RJA, the preceding vowel duration matches Italian, Tashlhiyt Berber, and Lebanese Arabic.

As far as the duration of the vowel following the geminate is concerned, very few studies reported on that. For example, Han (1994) and Hussain (2015) reported that the vowel following a geminate is shorter than that following a singleton. Unlike those studies, the present study reports that the duration of the vowel following a geminate is only affected if it is long, but when it is a short vowel, then no difference is observed. Moreover, when comparing the difference of duration for the vowels preceding geminates in the medial position and the final position, I found that the preceding short vowel /a/ in the final geminates context is more affected and is shorter than the vowel /a/ that precedes medial geminates. While the short vowel /a/ preceding geminates is shorter than that preceding singletons in the medial position by 10 ms, the same vowel preceding medial geminates is longer than that preceding singletons in the final position by 6 ms. This can be ascribed to the position of the consonant, and that a geminate that is intervocalic or in the medial position is more vulnerable to being more affected by gemination and so is the preceding vowel.

Phonologically, as has been presented in section 6.3, there are two basic approaches to represent geminates, namely, the prosodic length representation and the prosodic weight representation. After scrutinizing the two approaches regarding the phonological representation of geminates in RJA, I can conclude the geminate-singleton contrast word-medially and word-finally is better investigated as prosodic weight, within Moraic theory, based on moraic weight, than to be represented in terms of prosodic length as timing units. This observation is based on two pieces of evidence from RJA. The first is that consonant clusters word-finally in RJA are not permissible and usually broken by an epenthetic vowel, while geminate consonants are permissible; therefore, it will be more appropriate to account for this phenomenon under Moraic Theory and to view long segments as weight-bearing, and not as prosodic length/timing units, and in this case one model can account for geminates both word-medially and word-finally. If we represent geminates of RJA as prosodic length or C slots, then we will not be able to explain why geminates are allowed word-finally while consonant clusters are not since they have the same representation (CC). Second, the attraction of stress onto the syllable that has a geminate consonant, whether word-medially or word-finally, is consistent with the weight representation; primary stress typically falls on the rightmost bimoraic syllable (Davis, 2011: 880). The following examples (46a) - (46f) illustrate the distinction between representing word-final consonant clusters and word final underlying geminates in RJA.

(46).

a) /bard/ ‘cold’ [bar**i**d] (the epenthetic vowel /i/ breaks up the cluster)

b) /galb/ ‘heart’ [gal**u**b] (the epenthetic vowel /u/ breaks up the cluster)

c) /sagf/ ‘ceiling’ [sag**u**f] (the epenthetic vowel /u/ breaks up the cluster)

d) /ˈfann/ ‘he tossed a coin’ (geminate is immune to a vowel epenthesis)

e) /ˈlamm/ ‘he collected’ (geminate is immune to a vowel epenthesis)

f) /ˈfazz/ ‘he jumped’ (geminate is immune to a vowel epenthesis)

As shown above, in examples (46a) - (46c) a two-consonant cluster is not permissible word-finally and is always broken up by the epenthetic vowels /i/ and /u/. In order to make sure that these vowels are epenthetic and not lexical, we can add the possessive suffix /u/ ‘his’ to the end of the words in (46a) - (46c). Therefore, after adding the possessive suffix, the words will be [bardu], [galbu], [sagfu], respectively, meaning that the vowel fails to be epenthesized when the suffix is used. This indicates that the vowel that breaks up the consonant cluster is an epenthetic vowel, not a lexical one. This is also observed in the Hadhrami dialect as reported by Davis (2011), which prohibits consonant clusters word-finally. To the contrary, the length representation predicts that geminates should be viewed and treated similarly to consonants clusters for rules or constraints that reference the CV-tier while the weight representation does not make such a prediction and disambiguates the contrast between a geminate and a consonant cluster. In support of this, Ringen and Vago (2011) give an example of Hungarian that since epenthesis is triggered by a word-final consonant cluster (two C-slots), then epenthesis would be predicted to occur in a word that ends in a final geminate since the word would end in two C-slots, and that if a geminate is represented as moraic, epenthesis might not be predicted to occur with a word ending in a geminate, since the consonantal length of a geminate is not segmentally encoded. That is, there would not be two C-slots or two consonantal elements at the end of the word to trigger the epenthesis (Cited in Davis, 2011: 877). Accordingly, if we represent a geminate in terms of length (two C-slots), we end up having the following representation as in (47b), where the geminate is not immune to vowel epenthesis, whereas within moraic theory, the weight cannot be penetrated by an epenthetic vowel.

(47). Weight vs. length representation of geminates

(a) Weight representation

μ

C: (geminate)

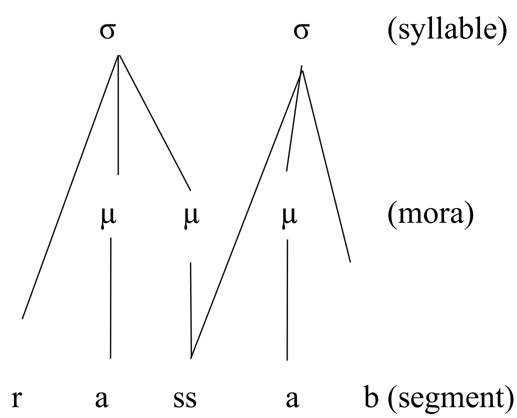
(b) Length representation

* C **(V)** C

C: (geminate)

The second piece of evidence that geminates are best viewed as weight-bearing units is the attraction of stress onto the syllable that has a geminate consonant given that syllables ending with a geminate are heavy and that heavy syllables attract stress in RJA, a quantitysensitive stress dialect. Word-medial geminates within Moraic Theory are divided into two halves belonging to two different syllables. The first half occupies the coda of the first syllable and then as a moraic coda it contributes weight while the other half occupies the onset of the second syllable. This configuration, according to Topintzi (2008), captures the increased length of a geminate and also expresses the fact that the first syllable can attract stress due to its heaviness (p. 148). Therefore, the word-medial geminate as in the word [ˈrassab] ‘made someone fail’ is represented in (48) below. According to (48), the geminate /s:/ is ambisyllabic and contributes a mora just like the vowel. Therefore, the first syllable is bi-moraic and thus attracts the stress due to its heaviness whereas the second syllable is mono-moraic and receives no stress since it is lighter than the previous one.

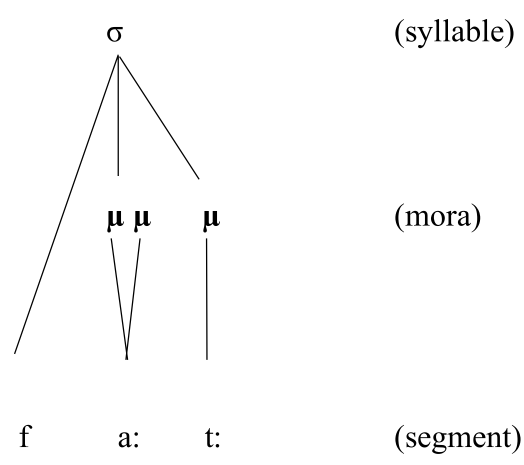
(48). Moraic representation of the word [ˈrassab]



Similarly, word-final geminates attract stress on the final syllable as opposed to word-final singletons which do not attract stress on the final syllable. For example, the word /ˈʔamal/

‘hope’, where it ends with a singleton, the stress is placed on the first syllable whereas in the word /ʔaˈmal:/ ‘more boring’, where the final consonant is a geminate, the stress is placed on the second syllable due to the heaviness of the syllable, which is triggered by the weight of the geminate and the preceding vowel. Therefore, a CVC syllable is usually unstressed while a CVC: syllable is stressed since the latter ends with a geminate. In support of this, Davis and Ragheb (2014) posit that when a stress is attracted to the final syllable in a word-final context, it supports the assumption that geminates are best treated and viewed as weight-bearing consonants and not as a prosodic length since consonant clusters are not permissible word-finally, and, thus that supports the assumption that geminates contribute weight to the final syllable. Also, if we want to represent a geminate that is preceded by a long vowel, we end up having a trimoraic syllable as shown in the following example (49).

(49). Moraic representation of the word-final geminate [ˈfa:t:]



As shown in (49), a syllable with a long vowel will always be at least bimoraic because of the vowel length. Given that the diagram in (49) has a word-final geminate, which contributes one mora, then a final syllable with a long vowel and a geminate coda in RJA will be trimoraic. This indicates, according to Hagiwara (personal communication) that phonological length/weight is represented as a slowing of the phonetic movement (lesser stiffness), and since there are two non-stiff gestures in a row, they both get super slow, where in the VCC and VC contexts, there is just a single slow thing, so everything is relatively stiffer. However, if the diagram had a singleton coda, non-moraic/weightless, then that coda would not be moraic since Weight-by-Position (Hayes, 1989) is applicable to non-final coda. Therefore, a geminate is always moraic, even a word-final one, so RJA has trimoraic syllables only when a syllable has a long vowel and a geminate coda. Hayes (1989) posits that consonants at the coda position, not the onset position, are assigned one mora, and he refers to this as Weight-by-Position constraint, and according to him, this may be applicable to non-final codas. The Weight-by-Position supports the representation of the medial geminates in (48) above that the geminate /s:/ is ambisyllabic and contributes a mora to the coda of the first syllable, so it attracts the stress on the first syllable due to heaviness and not the second because as Hayes (1989) made it clear that (non-final) coda consonants contribute a mora while onset consonants do not. Therefore, the mora of the geminate /s:/ in *rassab* in example (48) goes to the preceding syllable since it ends with a coda, leaving the second syllable a mono-moraic one, and thus, it does not attract a stress to be placed on it as opposed to the preceding syllable which is heavier. This also supports what has been mentioned earlier that it is better to represent geminates as weight-bearing and not as prosodic length. Also, in this case treating geminates as weight-bearing helps identify the placement of the stress since heavy syllables attract stress while light syllables do not. In support of this, Topintzi and Davis (2016) assert that if a language has an edge geminate (final or initial geminate), but consonant clusters are not permissible on that edge, then the edge geminate patterns as moraic.

In this chapter, I discussed the acoustic correlates of gemination namely, vowel duration and consonant duration. I also showed that geminates based on word position are different, i.e., word-medial geminates exhibit different durational cues from word-final geminates in RJA. Further, I argued that geminates are best represented in terms of prosodic weight rather than prosodic length in RJA based on two pieces of evidence. First, RJA avoids consonant clusters and allows geminates word-finally. Second, stress assignment is attracted by the syllable that hosts the geminate, which conforms with the prosodic weight. I now turn to summarizing my overall findings and discussing the implications of said finding.

Chapter Seven: Summary and implications

In this chapter, I provide a summary of results from chapters four through six. Then, I discuss the implications of the results namely, the morphological and phonological implications, the dialectal differences and the unique phonetic properties implications, and the implications for Moraic theory.

7.1 Summary

The study provides answers to the three big research questions that were raised in Chapter one namely: Do voicing assimilation and emphatic assimilation across morpheme boundaries behave like assimilation across word boundaries? Does RJA have unique phonetic properties that are not shared with other spoken Arabic dialects in terms of voicing and emphatic assimilation? In what positions does RJA contrast geminates with singletons? And, is there a temporal compensation between consonant duration and the preceding vowel duration? In response to the first question, the results of the assimilation experiments indicate that the behavior of voicing and emphatic assimilation across morpheme boundaries is different from the behavior of assimilation across word boundaries in RJA (see also section 7.2 below for more details). With regards to the second question, the results show that RJA display some assimilatory cases that may not be shared with other spoken Arabic dialects. These cases include the devoicing of obstruents before the phoneme /h/, surfacing of new allophones like /$\theta^{ʕ}$/ and /p/, which are not part of the consonantal inventory in any spoken Arabic dialect, and how the phoneme /l/ in the definite article does not undergo total assimilation when followed by a two consonant cluster-even if it is a coronal. Finally, for the third research question, the acoustic results show that geminates can be contrasted with singletons in both word medial and word final positions, and that there is a temporal compensation only between a geminate and a preceding vowel because they fall within the rhyme of the same syllable.

The primary objectives were described at the beginning of this dissertation. The first goal was to investigate the full extent of assimilation across morpheme boundaries in terms of voicing and emphasis. Therefore, voicing assimilation was investigated in Chapter Four and emphatic assimilation was investigated in Chapter Five. The second objective was to investigate the full extent of gemination word-medially and word-finally in an understudied variety of Arabic, Rural Jordanian Arabic as shown in Chapter Six. The summary of the results is outlined as follows.

First, I investigated the acoustic correlates that help in determining whether or not voicing assimilation occurred across morpheme boundaries. I also showed how voicing assimilation occurs by showing it visually on a spectrogram. The acoustic measurements show that F1 as well as vowel durations are important acoustic correlates for investigating voicing assimilation. The results show that F1 of the vowel preceding a voiced consonant is greatly lowered at the onset, midpoint, and offset of the vowel, and that the duration of the vowel preceding the voiced consonants is significantly longer than that before voiceless consonants. Though these acoustic correlates were found robust in this dissertation, the visualization of voicing assimilation on a spectrogram remains more authentic and reliable. The consonants examined in the voicing experiment were the coronal /t/ as it appears in the coda position of the prefix /mit-/ and the glottal fricative /h/ in the onset position as it appears in the suffixes /-ha/, /-hum/, and /-hin/.

Second, I investigated the acoustic correlates that help in determining whether or not emphatic assimilation occurred across morpheme boundaries. I showed how total emphatic assimilation occurs by showing it visually on a spectrogram. The acoustic measurements show that F1, F2, and F3 are important acoustic correlates for investigating emphatic assimilation. F1 at onset, midpoint, and offset of the vowel was higher in vowels preceding emphatic consonants than in vowel preceding plain consonants. By contrast, F2 at onset, midpoint, and offset of the vowel was substantially lower in vowels preceding emphatic consonants than in vowels preceding plain consonant. F3 at onset, midpoint, and offset of the vowel was higher in vowels preceding emphatic consonants than in vowel preceding plain consonants. Vowel duration was, however, found to be less affected by emphasis, which means that emphasis affects the spectral properties of the vowels surrounding them (at least the preceding ones) rather than the durational ones.

Third, I examined the acoustic durational correlates of gemination word-medially and word-finally. For, gemination word medially, the acoustic correlates that were investigated are the consonant duration of both geminates and singletons, the preceding short and long vowels of both geminates and singletons, and the following long vowels of geminate and singletons. For gemination in word-final position, I investigated the consonant duration as well as long and short vowel durations of both geminate and singleton positions. The results show that consonant duration of geminates is longer than that in singleton consonants, though it is substantially longer in the medial position. This result corroborates what has been reported in the literature by Ladefoged and Maddieson (1996) that the duration of the geminate consonants is one and a half to three times longer than their singleton counterparts. The consonant duration was also found to be the most reliable acoustic correlate to distinguish between a geminate and a singleton in RJA, which agrees with other studies in the literature (e.g. Ham, 2001; Hassan, 2002; Ladd and Scobbie, 2003; Blevins, 2004; Payne, 2005; Ridouane, 2007). Short vowels were found to be shorter in the geminate context than in the singleton one. By contrast, long vowels are longer in the geminate context than in the singleton one. Therefore, vowel duration, at least for short vowels, tends to be shorter before geminates than before singletons. This is in agreement with Ohala, 2007 on (Hindi); Ghai, 1980 on (Dogri); Lahiri and Hankamer, 1988 on (Bengali). Unlike consonant duration, vowel duration seems to be controversial or language/dialect-specific as some languages tend to have longer vowel durations before geminates and shorter vowel durations before singletons as opposed to what has been found in the current study. For example, in Japanese, vowels are shorter before geminates than before singletons whereas they tend to be longer after geminates than after singletons (see Han, 1994; Campbell, 1999; Ofuka, 2003; Hirata, 2007; Idemaru and Guion, 2008, among others). The same thing applies to other languages in other studies, see Ridouane, 2010 on (Berber); Esposito and Di Benedetto, 1999 on (Italian); Ohala, 2007 on Hindi; Local and Simpson, 1999 on (Malayalam). On the other hand, preceding vowel durations before geminates and singletons have no noticeable differences (see Norlin, 1987 on (Egyptian Arabic); Ham, 2001 on (Lebanese Arabic and Hungarian); Engstrand and Krull, 1994 on (Estonian), among others). In short, short vowels in RJA are considered robust acoustic correlates when discriminating geminates from singletons because they show how there is a temporal compensation between the lengthening of the geminate consonant and the shortening of the preceding vowel as presented in section (6.4). So, the general observation or image of the gemination process acoustically in RJA is that geminate consonants become substantially longer whereas the preceding vowels become substantially shorter as a result of temporal compensation, when compared to their singleton counterparts.

Phonologically, the results show that assimilation is best accounted for through the Sonority Hierarchy, Notion of Dominance, and Obligatory Contour Principle. Geminates, on the other hand, are best accounted for through prosodic weight/Moraic Theory rather than prosodic length/CV-tier Phonology.

7.2 Implications for morphological and phonological domains

The consonants examined in the emphatic assimilation experiment were the coronals /t/ and /l/ as they appear in the coda position of the prefix /mit-/ and the coda position of the prefix /ʔil-/, respectively, and the obstruent /h/ in the onset position as it appears in the suffixes /-ha/, /-hum/, and /-hin/. Phonologically, the directionality of emphasis in coronals at the coda position is regressive. This regressive directionality has to do with the position of the phoneme in the syllable and whether it is in the affix position or the stem position in the word. Since the coronals /t/ and /l/ occur in the coda position, and at the same time at the affix position, then they are more vulnerable to change their phonological properties than the emphatic coronals that are at the onset of the syllable and at the stem position of the word. As mentioned earlier, codas are weaker than onsets, and the preceding phoneme is weak as compared with following phoneme, which affects the preceding phoneme and causes it to change its phonological properties to pattern with it. Also emphatic assimilation of this kind is triggered by the Obligatory Contour Principle, which prohibits two adjacent identical elements at the melodic level (Leben, 1973; McCarthy, 1986), and this violation is resolved by delinking the leftmost place feature. On the other hand, emphatic assimilation may have a progressive directionality if the emphatic coronal occurs at the coda position of the stem position of the word. This kind of directionality is triggered by having the obstruent phoneme /h/ at the onset position of the affix position. This leads us to conclude that the position of the phoneme -whether at the stem or affix position- is stronger than the position of the phoneme in the syllable-whether at the coda or onset- to account for the assimilation directionality.

The importance of the position of the phoneme whether in an affix or a stem can be accounted for through some examples in RJA, which show how the behavior of the coronal is different in the two positions and show how morpheme boundaries pattern differently than word boundaries. In the affix position, the phoneme /l/ undergoes total emphatic assimilation while in the stem position it does not. This is not confined to the definite article only; it does apply to other affixes that have the coronal /l/ as well. Consider the following examples (50a) - (50h) for illustration.

(50).

a) /ʔil-sˤandu:g/	[ʔisˤ-sˤandu:g]	‘The box’
b) /bel-tˤari:g/	[betˤ-tˤari:g]	‘On the way’
c) /fil-ðˤaruf/	[fiðˤ-ðˤaruf]	‘In the package’
d) /lil-tˤawle/	[litˤ-tˤawle]	‘For the table’
e) /hal-sˤandu:g/	[hasˤ-sˤandu:g]	‘This/that box’
f) /mal-tˤarig/	[mal-tˤarig]	‘Tarig’s money’

g) /ħil-tˤaraf/ [ħil-tˤaraf] 'Loosen one end'

h) /kul-sˤeid/ [kul-sˤeid] 'Every hunt'

According to the examples above, the coronal /l/ sometimes assimilates to the following emphatic coronal and sometimes it does not. In examples (50a) - (50e), the coronal /l/ assimilates to the following emphatic coronal because the coronal /l/ occurs in the affix position, and all these affixes are bound morphemes that cannot stand alone without being attached to a lexical word. For example, in (50a) [ʔil] is a definite article followed by a lexical word, so /l/ undergoes total emphatic assimilation. Similarly, in (50b) [bel] 'on the' is a bound morpheme followed by a lexical word, so /l/ undergoes total emphatic assimilation, and in (50c) [fil] 'in the' is a bound morpheme followed by a lexical word, so /l/ undergoes total emphatic assimilation. The same thing applies to the (50d) where [lil] 'for the' is a bound morpheme and followed by a lexical word, so /l/ undergoes total emphatic assimilation, and to (50e) where /l/ occurs in [hal] 'this/that' which is a bound morpheme. However, in examples (50f) - (50h), the coronal /l/ does not assimilate to the following emphatic coronals though they are the same coronals that have been used in examples (50a) - (50e). The reason behind this is that the coronal /l/ occurs in a free morpheme and followed by a lexical word, and, in this case, no assimilation takes place. In (50f), the coronal /l/ occurs in the word [mal] 'money', which is a free-standing morpheme and followed by a lexical word, thus it does not undergo emphatic assimilation. Similarly, in (50g), the coronal /l/ does not undergo emphatic assimilation given that it occurs in the free-standing morpheme [ħil] 'loosen one end'. The same thing applies to (50e), where /l/ does not undergo emphatic assimilation since it occurs in a free-standing morpheme. In short, it is important to check the position of the phoneme in the word, whether it occurs in an affix or in a stem. This also explains why assimilation across morpheme boundaries is somehow different from assimilation across word boundaries. Similarly, this observation can be added to Mohanan's dominance model that phonemes in the affix position are weaker and more vulnerable to change their phonological properties than phonemes that occur in the stem position.

Another piece of evidence on the importance of the position of the phoneme whether in the affix of stem position comes from the way the phoneme /h/ behaves in both positions. More specifically, when /h/ is in the affix position, it undergoes total emphatic assimilation, but when it occurs in the onset of a free-standing morpheme, it does not undergo total emphatic assimilation. Consider the following examples for illustration (51a) - (51d).

(51).

a)	/basˤ-hum/	[basˤ-sˤum]	'Their bus'
b)	/ħatˤ-hin/	[ħatˤ-tˤin]	'He put them'
c)	/basˤ-hayil/	[basˤ-hayil]	'Amazing bus'
d)	/ħatˤ-heil/	[ħatˤ-heil]	'He put cardamom'

According to the examples (51a) to (51d), we can notice that in (51a) the phoneme [h] undergoes total emphatic assimilation given that it occurs in the affix position thus it is more vulnerable to changing its phonological properties. The same thing also applied to /h/ in (51b). However, if we look at /h/ in (51c), we can notice that it does not undergo total emphatic assimilation given that it occurs in the free-standing morpheme (affix) position.

The same thing also applied to /h/ in (51d) where /h/ does not undergo total emphatic assimilation.

Similarly, /h/, when occurring in the affix position, it devoices the preceding voiced obstruents, but when it occurs in the stem position it does not devoice preceding voiced obstruents. Consider the following examples (52a) - (52f) for illustration.

(52).

a)	/ruz-ha/	[rus-ha]	'Her rice'
b)	/ɣraðˤ-hum/	[ɣraθˤ-hum]	'Their stuff'
c)	/rud͡ʒ-ha/	[rut͡ʃ-ha]	'You shake it.'
d)	/ruz-hindi/	[ruz-hindi]	'Indian rice'
e)	/haðˤ-hadi/	[haðˤ-hadi]	'This is quiet.'
f)	/rud͡ʒ-huda/	[rud͡ʒ-huda]	'Shake Huda'

As shown in examples (52a) to (52f), the phoneme /h/ behaves differently according to the position in which it occurs. This shows how morpheme boundaries pattern differently than word boundaries. In (52a), /h/, as it occurs in the affix position, devoices the preceding voiced obstruent /z/ that is in the free-standing stem position. In (52b) and (52c), /h/ devoices the voiced obstruents /ðˤ/ and /d͡ʒ/ that occur in the stem position, respectively. However, in example (52d), /h/ does not devoice the preceding obstruent /z/ given that /h/ occurs in a free-standing stem; therefore, no devoicing or weakening of the obstruent takes place. Similarly, in (52e) and (52f), the voiced obstruents /ðˤ/ and /d͡ʒ/, respectively, do not undergo devoicing or weakening given that they are followed by /h/, which occurs in the stem position. All these examples support my observation here that the position of the affix plays a role in the way it behaves/is affected in the phonological processes, especially in RJA. The target consonants at the affix position are target/affected by the preceding or following phoneme that occur in the free-standing morphemes (stems).

Based on the results of the study and the behavior of the investigated phonemes, I argue that emphatic assimilation takes place after place assimilation or as a result of place assimilation, which contradicts Heselwood and Watson, (2013)'s assumption that the definite article in Arabic when followed by a coronal does not assimilate, and that this process is, rather, true or lexical gemination for the coronal that comes after it. My argument here is that since /l/ assimilates in place to other consonants and then picks up the emphasis feature, then /l/ undergoes assimilation, but the assimilated form may become longer in duration but still it undergoes assimilation. Regarding Heselwood and Watson, (2013)'s claim that when /l/ is followed by a coronal, the coronal becomes a true or lexical geminate, I would argue here that in RJA, when the definite article is followed by a two-consonant cluster like in the word *il-trab* 'the soil', RJA speakers tend to resort to epenthesizing the vowel /i/ between the /l/ and the following coronal /t/ in order for them to avoid a three consonant cluster and to facilitate the pronunciation. Therefore, the resulting word reads as *litrab*. That being said, the definite article cannot be a true or lexical geminate because true geminates are immune to epenthesis as opposed to fake geminates which are not. Also, by epenthesizing the vowel /i/ there will be no assimilation, which means assimilation is optional. This might bring up a question over dialectal differences since Heselwood and Watson, (2013)'s study was conducted on Cairene Arabic while the current study is on RJA. Therefore, further investigation should be sought to check whether the phenomenon exists in other dialects or it is just RJA-exclusive. So far, to the best of my knowledge, this phenomenon has not been tackled in the literature, which hinders any generalization on this matter.

The *Notion of Dominance* model by Mohanan (1993) was very compatible with the data to account for the regressive assimilation by showing that when the specification of X overrides the specification of Y, X is the trigger and Y is the target "undergoer". The results show that voicing assimilation across morpheme boundaries does not have the same behavior of that across word boundaries. The directionality of voicing assimilation throughout the data of this dissertation was right-to-left or regressive. The results also indicate that there are some dialectal differences pertaining to the behavior of voicing assimilation across morpheme boundaries especially the phoneme /h/, and how it devoices the preceding voiced obstruents. Even the behavior of the gutturals was different from what has been reported in other studies about other dialects, including the other Jordanian Arabic dialects, namely UJA and BJA.

7.3 Implications for dialectal differences and RJA unique phonetic properties

The results strongly indicate that the behavior of voicing assimilation in RJA is not the same as that in other dialects. Recall that Elramli (2012) shows that the prefix /t/ in Misrata Libyan Arabic does not undergo voicing assimilation when followed by the voiced, 'gutturals', the pharyngeal /ʕ/ and the velar /ɣ/, which is contrary to has been found in the current study. Similarly, the way the phoneme /h/ devoices the obstruents in RJA has only been observed in RJA. Even in the other dialects of Jordan, i.e., UJA and BJA, that does not take place at all. This suggests that there are dialectal differences that trigger phonological and phonetic differences or vice versa, and that phonological and phonetic differences are used to recognize social grouping (i.e. dialects). It is worth mentioning in this regard that devoicing fricatives, plosives, and affricates when followed by the phoneme /h/ is exclusive to the rural dialect in Jordan to the extent that other people who speak other dialects, for instance UJA, recognize rural speakers by the devoicing of the consonants before /h/. This devoicing process has become a stigma in RJA, and speakers of other JA dialects sometimes make fun of the rural people by imitating the way they devoice the consonants before /h/. The salience of this devoicing is clearly recognized auditorily since the lay person can tell the difference and identify Rural speakers through this devoicing process. Further, the behavior of the phoneme /h/ when preceded by the voiced obstruents is interesting, as I found that it sometimes devoices the preceding voiced obstruents and in some other examples it devoices the preceding voiced obstruent but it undergoes total assimilation in many examples by different speakers. Therefore, /h/ sometimes undergoes two phonological processes. It, first, devoices the preceding voiced obstruent as in the example (53a) and (53b) by the speakers (HS), (HD), and (AO).

(53).

a) /rud͡ʒ-ha/ [rut͡ʃ-ha] ‘You shake it.’

b) /bab-hum/ [bap-hum] ‘Their door’

Then, after the devoicing processes, it becomes fully assimilated to the newly-devoiced obstruent. This is the case with examples like /baʕ-hin/ when the /ʕ/ becomes /ħ/ and then /h/ totally assimilates to /ħ/ and becomes /baħ-ħin/. Another example is with phoneme /ð/ in the word /raðað-hin/ when it becomes /θ/ before /h/ and then /h/ totally assimilates to the phoneme /θ/ and the word becomes /raðaθ-θin/ as in examples (54a) - (54c) below.

(54).

a)	/baʕ-hin/	[baħ-ħin]	'He sold them.'
b)	/sˤabaɣ-hin/	[sˤabax-xin]	'He painted them.'
c)	/raðað-hin/	[raðaθ-θin]	'Their spray'

It is worth pointing out here that even when the consonant preceding /h/ is a voiceless obstruent, /h/ totally assimilates to the previous voiceless obstruent and becomes a derived (non-underlying) geminate as in the following examples (55a) - (55c). However, if the preceding consonant is a sonorant no changes occur as in the examples (55d) - (55e).

(55).

a)	/tarak-ha/	[tarak-ka]	'He left her/it.'
b)	/zat-ha/	[zat-ta]	'He threw it away.'
c)	/bas-ha/	[bas-sa]	'He kissed her.'
d)	/lam-ha/	[lam-ha]	'He collected it'
e)	/fan-ha/	[fan-ha]	'Her art'

This result has not been reported in the literature for any Arabic dialect, to the best of my knowledge. Thus, it is worth investigating this phenomenon in other dialects to draw better conclusions and to investigate if it only occurs in RJA.

Moreover, Elramli (2012) reported that the prefix /t/ in Misrata Libyan Arabic does not undergo voicing assimilation when followed by the voiced 'gutturals', the pharyngeal /ʕ/ and the velar /ɣ/ and, accordingly, he classified them as sonorants. However, the current study shows that in RJA the phoneme /t/ in the prefix /mit-/ picks up the voicing feature from /ʕ/ and /ɣ/ when it occurs before them and becomes /d/, which has been shown acoustically in this study. I would also argue here that /ʕ/ and /ɣ/ behave in a similar way when it comes to voicing. To put it differently, they can function as triggers when they give their voicing feature as is the case with the phoneme /t/ when it undergoes voicing when followed by /ʕ/ and /ɣ/. They can also function as targets when they lose their voicing feature as is the case when the /ʕ/ and /ɣ/ become devoiced when they are followed by the phoneme /h/ in the current study. Consequently, classifying /ʕ/ and /ɣ/ as sonorants and describing them as blocking voicing assimilation cannot be generalized since this is not the case in RJA, and since the current study provides instrumental evidence to the contrary. By contrast, Kabrah (2011) reported that /ɣ/ behaves like an obstruent and gets devoiced at the coda position when the followed by a voiceless consonant across word boundaries in Cairene Arabic, which corroborates the results of the current study. However, Kabrah (2011) also reported that /ʕ/ behaves like a sonorant. With that being said, it is clear that there is a controversy over classifying /ʕ/ and /ɣ/ as sonorants or not. Nevertheless, I argue that /ʕ/ and /ɣ are not sonorants as this has been shown acoustically (both can undergo voicing assimilation) and can be observed through the similarities that /ʕ/ and /ɣ/ share, at least for the dialect under investigation. Given that /ʕ/ and /ɣ/ have voiceless counterparts, they undergo devoicing, and their voiceless counterparts can undergo voicing, whereas sonorants do not have voiceless counterparts, which, again, hinder them for undergoing any voicing assimilation. So, sonorants do not undergo voicing assimilation, but may undergo place assimilation.

7.4 Implications for Moraic Theory

Geminates were best accounted for through Moraic Theory and were viewed as weight-bearing units not as prosodic length/timing slots. The evidence that supports this view comes from the fact that in RJA consonants clusters are not allowed word-finally, and that if we treat them as prosodic length then we will not be able to account for the reason why geminates are allowed in RJA but the consonant clusters are not, given that both geminates and consonant cluster have the same representation of prosodic length/timing slots. Therefore, Moraic Theory or treating geminates as weight-bearing segments can account for this issue word-medially as well as word-finally. Another piece of evidence is the stress assignment which geminates receive given that they are heavy-weighed segments, and that heavy syllables attract stress. This is true for both word-medial as well as word-final geminates. Word-medially, geminates are ambisyllabic where they contribute a mora to the preceding syllable and thus making it heavy so it attracts stress, while in final position, geminates can be trimoraic if the syllable has a long vowel and a geminate. In support of this, Topintzi and Davis (2016), in their most recent study on geminates, posit that if consonant clusters are avoided word-initially or word-finally but geminates are allowed on those positions, then geminates are best accounted for as moraic. So, in both positions the syllable where the geminate occurs is a heavy syllable. Finally, based on the gemination results, we can conclude that geminates behavior is language-specific since some languages allow consonant clusters word-finally even within Jordanian Arabic dialects where UJA and BJA do not prohibit consonant clusters word-finally contrary to RJA. Therefore, representing geminates as weight-bearing units or as prosodic length auto-segmentally depends on the morphology or syllable structure, and phonology of the language. However, the phonetic properties especially the temporal ones can be generalized to other Arabic dialects, especially Lebanese Arabic since gemination behavior was studied thoroughly by Khattab, 2007; Khattab and Al-Tamimi, 2008; Khattab and Al-Tamimi, 2014. However, these studies focused on geminates only word-medially while this study handles both word-medial and word-final geminates. In Jordanian Arabic, Al-Tamimi, Abu-Abbas, and Tarawneh, (2010) investigated gemination word-finally, but their study focused on sonorants only. Accordingly, there appears to be a lack of comprehensive studies that investigate gemination word-medially as well as word-finally using all the Arabic consonantal inventory in order to draw better conclusions phonetically and phonologically as this study attempted to do. Further, investigating geminates under the umbrella of regional dialects like Levantine Arabic as Ham (2001) did may provide overgeneralizations to all the dialects within the same region, which is not always the case. For example, RJA, UJA, BJA, Lebanese Arabic, Palestinian Arabic, and Syrian Arabic are considered Levantine Arabic dialects, but as we have seen the gemination behavior of RJA is not the same as these dialects since the syllable structure and the consonantal inventories are somehow different.

7.5 Future research

The research presented in this dissertation has uncovered more questions needing to be addressed. To begin with, studying voicing assimilation, emphatic assimilation and gemination in all the Rural dialects of the Levantine region, and all Urban dialects together, and Bedouin dialects together would give better generalizations about the behavior of these phonological processes and would pave the way towards a typological study that points out the similarities and differences among these dialects. For example, it would make more sense to study the rural dialects of Jordanian, Syrian, Lebanese and Palestinian Arabic and come up with generalizations because these dialects are geographically closer, and the phonetic inventory as well as the morphology are somehow comparable.

Another issue that should be pursued and taken into consideration is the investigation of assimilation across word boundaries in all JA dialects acoustically, as all other studies that investigated them were based on auditory impression. In this study, I uncovered the assimilation behavior across morpheme boundaries through acoustic analysis and in light of the current phonological approaches; thus, doing the same thing when investigating assimilation across word boundaries will help draw better conclusions.

Moreover, investigating gender differences as well as the socioeconomic status appears to be of potential interest. For example, in this dissertation, vowel duration tends to be longer for females than male and F2 tends to be lower for females than males. Therefore, recruiting more female and male participants and emphasizing the gender differences will uncover the potential gender differences and their effects on these phonological processes.

Finally, investigating the acoustic correlates of derived geminates and underived geminates will add much to the literature of gemination since this has not been tackled yet in

Arabic linguistics. In this study, I focused on the true (underived) geminates and their acoustic correlates. Therefore, I am anticipating that there will be some discrepancies between the two types of geminates word-finally, especially that fake (derived) geminates word-finally are not immune to vowel epenthesis, which means that duration of these consonants may be different.

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Appendix A

Participants' Written Consent

This consent form, a copy of which will be left with you for your records and reference, is only part of the process of informed consent. It should give you the basic idea of what the research is about and what your participation will involve. If you would like more detail about something mentioned here, or information not included here, you should feel free to ask. Please take the time to read this carefully and to understand any accompanying information.

My name is Mutasim Al-Deaibes, and I am a graduate student in linguistics at The University of Manitoba. I am conducting a study on how a speech sound in Arabic becomes similar or identical to an adjacent sound in the same word.

If you choose to participate in this study, you will have to be audio-recorded reading some sentences and phrases. You will be asked to read 116 sentences and phrases, which will take approximately 20-30 minutes. At the end of the recordings, you will be offered a $ 15 Starbucks gift card in compensation for your time.

There are no risks associated with this study. The sentences and phrases that will be recorded will be kept anonymous and confidential. Your recordings will be assigned an alphanumeric code and kept password-protected in my computer. After the study is complete, all files containing the recordings will be kept with the author.

Research findings will be disseminated in refereed journal articles, professional conferences and used for PhD generals paper. No names or any potentially identifying information will be included in any oral or written reports. Your confidentiality will not be jeopardized at any stage of the study.

Your signature on this form indicates that you have understood to your satisfaction the information regarding participation in the research project and agree to participate as a subject. In no way does this waive your legal rights nor release the researchers, sponsors, or involved institutions from their legal and professional responsibilities. You are free to withdraw from the study at any time, and /or refrain from answering any questions you prefer to omit, without prejudice or consequence. Your continued participation should be as informed as your initial consent, so you should feel free to ask for clarification or new information throughout your participation.

The University of Manitoba may look at your research records to see that the research is being done in a safe and proper way.

This work is part of my doctoral studies under the supervision of Dr. Nicole Rosen.

This research has been approved by the Joint-Faculty Research Ethics Board. If you have any concerns or complaints about this project you may contact any of the above-named persons or the Human Ethics Coordinator (HEC), Margaret Bowman at 474-7122. A copy of this consent form has been given to you to keep for your records and reference.

If you have any questions regarding the research or you would like to receive a non-technical summary of the results by May 2015, please feel free to contact by email either me aldeaibm@myumanitoba.ca, or Dr. Nicole Rosen: nicole.rosen@umanitoba.ca.

Participant's name and signature:____

Date (DD/MM/YY):_________________________

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APPROVAL CERTIFICATE

January 9, 2015

TO:	**Mutasim Al-Deaibes** (Advisor N. Rosen) Principal Investigator [redacted]	
FROM:	**Susan Frohlick, Chair** Joint-Faculty Research Ethics Board (JFREB)	
Re:	**Protocol #J2014:163** **"Rural Jordanian Arabic Assimilation across Morpheme Boundaries"**	

Please be advised that your above-referenced protocol has received human ethics approval by the **Joint-Faculty Research Ethics Board**, which is organized and operates according to the Tri-Council Policy Statement (2). **This approval is valid for one year only**.

Any significant changes of the protocol and/or informed consent form should be reported to the Human Ethics Secretariat in advance of implementation of such changes.

Please note:

- **If you have funds pending human ethics approval, please mail/e-mail/fax (261-0325) a copy of this Approval (identifying the related UM Project Number) to the Research Grants Officer in ORS in order to initiate fund setup. (How to find your UM Project Number: http://umanitoba.ca/research/ors/mrt-faq.html#pr0)**

- **if you have received multi-year funding for this research, responsibility lies with you to apply for and obtain Renewal Approval at the expiry of the initial one-year approval; otherwise the account will be locked.**

The Research Quality Management Office may request to review research documentation from this project to demonstrate compliance with this approved protocol and the University of Manitoba *Ethics of Research Involving Humans.*

The Research Ethics Board requests a final report for your study (available at: http://umanitoba.ca/research/orec/ethics/human_ethics_REB_forms_guidelines.html) **in order to be in compliance with Tri-Council Guidelines.**

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