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Original Paper

An Acoustic Study of Emphasis Spread in Najdi Arabic

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Abstract

As with other varieties of Arabic, Najdi Arabic (NA), spoken in central Saudi Arabia, contains a set of emphatic consonants, /ṣ – ṭ – ḍ/, which have an uncontrollable phonological effect on neighboring segments whereby the presence of an emphatic in a word entails "emphasis spread" to the adjacent non-emphatic segments. Acoustically, emphasis is manifested by lowering the frequency of the second formant (F_2) of vowels in the vicinity of an emphatic. The purpose of this study is investigate the domain and directionality of emphasis spread in NA and whether it is blocked by any opaque phonemes by measuring and comparing the F_2 frequencies of vowels in minimal pairs contrasting on the basis of the presence/absence of emphatics. The results show that the domain of emphasis spread in NA is the entire phonological word consisting of the stem plus any inflectional/derivational affixes. In addition, emphasis spreads rightward and leftward throughout the phonological word in a gradient manner in an inverse relationship, where emphasis peaks in the syllable containing the emphatic and gradually decreases as it moves into the following/preceding syllables. Finally, the high front phonemes /y – ʃ – ʤ/ act as opaque segments as they block rightward spread but not leftward spread.

Keywords

emphatic consonant, emphasis spread, opaque segment, Najdi Arabic, second formant, frequency

1. Introduction

Arabic contains a set of consonants traditionally known in Arabic as *ʔal-ħuruuf ʔal-mufaxxama,* a term that is loosely translated in the Arabic linguistics literature as "emphatic consonants". Underlying emphatics have an uncontrollable effect on neighboring segments. That is, the presence of an emphatic consonant in a word entails "emphasis spread" (or *tafxiim*) to the adjacent non-emphatic segments. A number of other different terms have been used in the Arabic linguistics literature to refer to this phenomenon, for example, "backing" (Ghazeli, 1977) "velarization" (Obretch, 1968), "uvularization"

(McCarthy, 1994; Shahin, 1997; Zawaydah, 1999), "pharyngealization" (Al-Ani, 1970; Watson, 2002; Dickens, 2007), "dorsalization" (Halle et al., 2000), retracted tongue root [RTR] (Ladefoged, 1975; El-Dalee, 1984) and "tongue root harmony" (McCarthy, 1997).

Emphasis spread is perhaps one of the most controversial issues in Arabic phonology. Phonologists dealing with this phenomenon disagree in almost every aspect. For instance, in addition to the fact that they do not agree on a single term to refer to this process, they also disagree on the feature(s) that should be used to represent emphatic consonants; the number of the primary emphatics (as opposed to secondary emphatics); the source of emphasis (i.e., whether the primary emphatics are consonants or vowels); and finally and perhaps most important of all, they disagree also on the domain of emphasis spread, directionality (i.e., rightward vs. leftward), the factors that control it, and whether it is blocked by opaque segments. The disagreement among phonologists regarding emphasis spread is in part due to the fact that different dialects of Arabic exhibit different patterns of behavior.

The main purpose of this paper is to investigate how emphasis spread operates in Najdi Arabic (NA) by conducting a detailed acoustic analysis. NA is a variety of Arabic spoken in Najd, located in the central region of Saudi Arabia. NA is also probably one of the least studied dialects of Arabic. Thus, another important purpose of this short paper is to document NA itself.

This paper is organized as follows. First, a brief description of Arabic emphatic consonants and the process of emphasis spread is given in Section 2 including its definition and the factors that play a role in the process along with examples of emphasis spread from a variety of Arabic dialects. Section 3 lays out the foundation on which this study is based by discussing the acoustic correlates of emphatic consonants and their effect on neighboring vowels. A description of the present study is given in Section 4, followed by the results and a detailed discussion in Section 5.

2. Arabic Emphatic Consonants and Emphasis Spread

2.1 Emphatic Consonants

Traditional Arab grammarians have generally considered emphasis to be an inherent feature of emphatic consonants and as such they are represented in the Arabic alphabet by four distinct letters. In Classical Arabic, these four inherently emphatic consonants, also known as primary emphatics, are /ṣ – ṭ – ð̣ – ḍ/, whose plain (non-emphatic) counterparts are /s – t – ð – d/. Table 1 below gives examples of minimal pairs containing these contrastive consonants (throughout this paper, emphatic consonants are transcribed with a dot underneath the letter).

Table 1. Arabic Plain/Emphatic Minimal Pairs

Plain	Gloss	Emphatic	Gloss
/saam/	"(he) bid"	/ṣaam/	"(he) fasted"
/tiin/	"fig"	/ṭiin/	"mud"
/ðill/	"humiliation"	/ð̣ill/	"shadow"
/darb/	"path"	/ḍarb/	"hitting"

Most Arabic dialects spoken today have at least three of these primary emphatics. In NA, for example, the primary emphatics are /ṣ – ṭ – ð̣/ where /ḍ/ is lost as it merged with /ð̣/. This is also the case with the Arabic dialects spoken in all the Gulf States and Iraq. Thus, in these dialects any word that underlyingly contains /ḍ/ is pronounced with /ð̣/ instead, e.g., /ḍarb/ → [ðarb] "hitting". In Egyptian Arabic, however, /ð̣/ is lost and is replaced by the newly formed emphatic /ẓ/, e.g., /ðill/ → [ẓill] "shadow".

In addition to the primary emphatics, Arabic also contains a set of secondary emphatics. These include, but are not limited to, /r̤ – l̤ – g̤ – q̤ – x̤ – ɣ̤/. There is a great deal of variation between Arabic dialects with respect to secondary emphatics. The main difference between primary and secondary emphatics is that if a word contains a primary emphatic consonant, then that word will always be pronounced with emphasis as it would be impossible to pronounce it without emphasis and not change the meaning of the word. For example, as far as I know, all Arabic dialects have the following minimal pair:

(1) a. /seef/ "sword"
b. /ṣeef/ "summer"

If (1b) is pronounced without emphasis, then the meaning of the word would change to that of (1a) and vice versa. In contrast, whether the word /gaal/ is pronounced with or without emphasis, it would still mean "(he) said". The pronunciation of this word varies from one dialect to another. In Najdi Arabic it is pronounced with emphasis (i.e., /g̤aal/), whereas in Hijaazi Arabic (spoken in western Saudi Arabia) it is pronounced without emphasis (i.e., /gaal/). In addition, secondary emphatics have different domains and environments and they do not always pattern along with primary emphatics.

2.2 Definition of Emphasis Spread

Emphasis is generally defined as a secondary articulation involving the back of the tongue, which accompanies a primary articulation at another point in the vocal tract (Ghazeli, 1977; Herzallah, 1990; Obrecht, 1968; Norlin, 1987). The second articulation basically involves constriction in the upper pharynx caused by the backing or retracting of the tongue (McCarthy, 1994), hence the terms pharyngealization, backing, and RTR. According to Davis (1995) and Watson (1999), the second articulation may also involve labialization in addition to pharyngealization, where pharyngealization spreads predominantly leftward within the phonological word, while labialization spreads rightward targeting short high vowels. Thus, emphatic consonants share the same point and manner of articulation

as their plain counterparts, however, they differ by having a secondary articulation, which propagates to adjacent segments, particularly vowels.

From an acoustic standpoint, emphasis spread is manifested by lowering the frequency of the second formant (F_2) of vowels in the vicinity of an emphatic consonant (Al-Ani, 1970). In addition, there is also a general lowering of the pitch of the noise spectrum of obstruents and resonants (Harrell, 1957).

A number of factors have been traditionally considered to play a role in emphasis spread. For example, some phonologists have argued that emphasis spread is a syllabic phenomenon (e.g., Ali & Daniloff, 1972; Broselow, 1976; Lehn, 1963; Obrecht, 1968; Sayed, 1981; Shaaban, 1977). That is, emphasis patterns as a constituent on the syllable level and that it is restricted to the syllable in which emphatics occur. Others have emphasized the role of certain phonemes in blocking or permitting emphasis spread resulting in asymmetries in the direction of spread (Card, 1983; Ghazeli, 1977; Herzallah, 1990; Maamouri, 1967; Younes, 1982). Finally, some studies have reported gender as a factor that affects emphasis spread, e.g., Kahn (1975).

2.3 Emphasis Spread in some Arabic Dialects

As mentioned earlier, there is a great deal of variation among Arabic dialects with respect to emphasis spread. In Moroccan Arabic, for example, emphasis spreads only to segments within the syllable that contains the emphatic consonant (Sayed, 1981). Likewise, emphasis in Abha Arabic (spoken in southern Saudi Arabia) rarely spreads beyond adjacent vowels (Younes, 1991). Younes (1993) also examined emphasis spread in Palestinian Arabic and found that the minimum domain of rightward spread is the uninflected word, whereas left-to-right spread is restricted to the first low vowel to the right of the emphatic consonant and is blocked if one of the following high phonemes intervenes /ʃ – ʤ – y – w – i – u/. In Egyptian Arabic, however, emphasis spreads from the emphatic consonant to all segments to the left and right in the same word regardless of the number of segments, with the exception of prefixed words and words which have a short low vowel occurring next to /y/ (Younes, 1993). However, Watson (2002) reports that emphasis in both Cairene and San'ani Arabic may spread even beyond word boundaries. Similarly, emphasis in Qatari Arabic spreads bidirectionally over the whole word and if the first segment of a word is emphatic, then emphasis may even spread leftward across the word boundary into the preceding word (Bukshaisha, 1985).

Algryani (2014) reports that emphasis in Libyan Arabic spreads minimally to the syllable containing the emphatic and maximally to the whole phonological word but may not cross word boundaries. Also, emphasis is blocked from spreading by opaque segments such as /ʃ – y – i – i: – e:/, which are high front phonemes, rendering them antagonistic to pharyngealization. Emphasis spread in Juffin Arabic, spoken in northern Jordan, exhibits a similar pattern to that of Libyan Arabic as it spreads minimally to the syllable containing the emphatic and maximally to the entire word. However, the direction of spread is asymmetrical as leftward spread is unblocked whereas rightward spread is blocked by the following opaque segments /ʃ – y – i – i:/ (Huneety & Mashaqba, 2016).

In addition to differences between Arabic dialects, some differences exist within speakers of the same dialect. For instance, Kahn (1975) found differences between male and female speakers of Cairene Arabic and reports that the speech of male speakers displays more emphasis than female speakers.

As can be seen from this short review, there is considerable variation on many aspects of emphasis spread among Arabic dialects. These variations include the set of primary emphatics the dialect contains, the minimum/maximum domain of emphasis spread, directional spread asymmetries, and also the existence of opaque segments that block emphasis spread.

3. Acoustic Correlates of Emphatic Consonants

As mentioned earlier, on the acoustic level, emphatic consonants affect neighboring vowels by lowering their second formant (F_2). Al-Ani (1970) carried out a detailed acoustic analysis of the effect of emphatics on Arabic vowels by measuring their F_2 frequencies when uttered next to plain/emphatic consonants. Vowels in Arabic consist of the short vowels /i – u – a/ and their long counterparts /ii – uu – aa/. According to Al-Ani, the F_2 frequencies of these vowels when they are next to the plain consonants /s/, /t/, and /ð/ are within the range of 1300-2100 Hz. In contrast, the presence of the emphatic consonants /ṣ/, /ṭ/, and /ð̣/ considerably lowers the F_2 frequencies of neighboring vowels to 900-1200 Hz. Table 2 below gives a comparison of the F_2 frequency values of these vowels in the presence/absence of the emphatic consonants /ṣ/, /ṭ/, and /ð̣/, as reported by Al-Ani.

Table 2. F_2 Frequency Values (in Hz) of Arabic Vowels next to Plain and Emphatic Consonants (Al-Ani, 1970)

Vowel	Environment	
	Next to Plain /s – t – ð/	Next to Emphatics /ṣ – ṭ – ð̣/
/i – ii/, /u – uu/, /a – aa/	1300-2100	900-1300

Since the effect of emphatic consonants is easily observed in vowels, the domain of emphasis spread in a word can be accurately determined by measuring and comparing the frequency values of F_2 of vowels in minimal word pairs contrasting on the basis of the presence/absence of emphatic consonants. If the comparison results show that there is in fact a lowering effect within the frequency ranges shown in Table 2 above, then it can be concluded that emphasis has in effect spread from the emphatic consonant to the vowel in question.

4. The Study

The main goal of this paper is to investigate emphasis spread in NA by conducting a detailed acoustic analysis. Additionally and as mentioned earlier, NA is probably one of the least studied Arabic dialects and not much is known about the dialect. Thus, in addition to studying the similarities and differences

between NA and other Arabic dialects with respect to emphasis spread, this paper is also a modest attempt to record and document NA itself.

The primary emphatics in Najdi Arabic are /sˤ – tˤ – ðˤ/, whereas secondary emphatics include /rˤ – lˤ – gˤ – qˤ – xˤ – ɣˤ/. However, this paper will focus only on the primary emphatics. The following questions are addressed:

(i) What is the domain of emphasis spread in NA?

(ii) Is there a difference between rightward and leftward emphasis spread?

(iii) Are there any opaque phonemes that may block emphasis from spreading in either direction?

4.1 Materials

In order to answer to these questions and to assess to what extent emphasis spread in NA resembles/differs from the various emphasis patterns observed in the different Arabic dialects discussed earlier, I examined data from NA consisting of a variety of minimal word-pairs lists contrasting on the basis of the presence/absence of the three emphatic consonants /sˤ – tˤ – ðˤ/. In cases where no minimal pairs could be found, near-minimal pairs were used, and in the few cases where no near-minimal pairs could be found, non-words that conformed to the phonotactics of NA were used. These minimal pairs were divided into five lists as follows. The first three lists consisted of monosyllabic, disyllabic, and trisyllabic minimal pairs all of which were monomorphemic (i.e., consisting of only the stem with no affixes attached). In order to investigate if there is any difference in the directionality of emphasis spread, each of these three lists were further divided according to whether the plain/emphatic consonant occurred word-initially or word-finally. The fourth list consisted of polymorphemic (i.e., the stem plus affixes both inflectional and derivational) minimal pairs to examine whether emphasis may spread beyond the stem across morpheme boundaries into the affixes or whether affixes act as barriers that block emphasis. As with the previous lists, the plain/emphatic consonant occurred either word-initially or word-finally in the stem to investigate directionality. Finally, a list of minimal pairs containing the segments /y – ʃ – ʤ/, all of which have been reported in previous studies to be opaque (i.e., they block emphasis spread), were included as well. These potentially opaque segments occurred either to the right of the emphatic consonant or to its left. The vowels in the minimal pairs were varied to include all of the Arabic vowels, i.e., /i – u – a/ and their long counterparts /ii – uu – aa/. Table 3 below lists all the minimal pairs used in the study.

Table 3. Minimal Pairs used in the Study

Table 3a. Monosyllabic Monomorphemic Minimal Pairs

Plain/emphatic consonant occurring word-initially			
Plain	Gloss	Emphatic	Gloss
/saam/	“(he) bid”	/ṣaam/	“(he) fasted”
/siix/	“Sikh”	/ṣiix/	“skewer”
/suur/	“fence”	/ṣuur/	“name of a city”
/taab/	“(he) repented”	/ṭaab/	“(he) recovered”
/tiin/	“fig”	/ṭiin/	“mud”
/tuub/	“repent”	/ṭuub/	“brick”
/ðaag/	“(he) tasted”	/ð̣aag/	“(it) narrowed”
/ðiib/	“wolf”	/ð̣iig/	“narrowness”
/ðill/	“humiliation”	/ð̣ill/	“shadow”
Plain/emphatic consonant occurring word-finally			
Plain	Gloss	Emphatic	Gloss
/baas/	“(he) kissed”	/baaṣ/	“bus”
/niis/	“name of a city”	/niiṣ/	“porcupine”
/batt/	“(he) decided”	/batṭ/	“duck”
/xadd/	“cheek”	/xaṭṭ/	“handwriting”
/faðð/	“remained”	/fað̣ð̣/	“rude”
/baʕd/	“after”	/baʕð̣/	“some”

Table 3b. Disyllabic Monomorphemic Minimal Pairs

Plain/emphatic consonant occurring word-initially			
Plain	Gloss	Emphatic	Gloss
/saaħib/	“pulling”	/ṣaaħib/	“friend”
/suduud/	“dams”	/ṣuduud/	“turning away”
/tabbal/	“(he) flavored”	/ṭabbal/	“(he) beat a drum”
/taabiʕ/	“follower”	/ṭaabiʕ/	“stamp”
/ðibbaan/	“flies”	/ð̣ibbaan/	“lizards”
/ðuhuul/	“astonishment”	/ð̣uhuur/	“appearance”
Plain/emphatic consonant occurring word-finally			
Plain	Gloss	Emphatic	Gloss
/nakkas/	“(he) lowered (the flag)”	/naggaṣ/	“(he) subtracted”
/kannaas/	“sweeper”	/gannaaṣ/	“sniper”

/ʕabiid/	“slaves”	/ʕabiiṭ/	“idiot”
/ʃaarid/	“distracted”	/ʃaariṭ/	“to stipulate”
/faarid/	“(he) unrolled”	/faariḍ/	“(he) ordered”
/guruud/	“monkeys”	/quruuḍ/	“loans”

Table 3c. Trisyllabic Monomorphemic Minimal Pairs

Plain/emphatic consonant occurring word-initially			
Plain	Gloss	Emphatic	Gloss
/sawaani/	“water wheels”	/ṣawaani/	“trays”
/sabbaaba/	“index finger”	/ṣabbaaba/	“coffee pourer (f.)”
/tawaabiʕ/	“followers”	/ṭawaabiʕ/	“stamps”
/dawaafiʕ/	“motives”	/ṭawaaʔif/	“factions”
/ðaaʔiqa/	“taste”	/ðaaʔiqa/	“hardship”
/ðaraaʔib/	non-word	/ðaraaʔib/	“taxes”
Plain/emphatic consonant occurring word-finally			
Plain	Gloss	Emphatic	Gloss
/baʕaaris/	non-word	/baʕaariṣ/	“lizards”
/makaanis/	“brooms”	/magaaniṣ/	“hunting trips”
/wasaaʔid/	“pillows”	/wasaaʔiṭ/	“media”
/ʔistanbat/	“(he) cultivated”	/ʔistanbaṭ/	“(he) deduced”
/maʕaarif/	“information”	/maʕaariḍ/	“showrooms”
/kawaariθ/	“catastrophes”	/qawaariḍ/	“rodents”

Table 3d. Polymorphemic (stem + affixes) Minimal Pairs

Plain/emphatic consonant occurring word-initially			
/ʔas-sabbaab-aat/	“the index fingers”	/ʔaṣ-ṣabbaab-aat/	“the coffee pourers”
/ʔa-sidd-ah/	“(I) block it	/ʔa-ṣidd-ah/	“(I) turn him away”
/na-tabbil-ha/	“(we) flavor it”	/na-ṭabbil-ha/	“(we) drum it”
/ta-ðimm-ah/	“(she) slanders him”	/ta-ḍumm-ah/	“(she) hugs him”
Plain/emphatic consonant occurring word-finally			
/ʔa-nakkis-ha/	“(I) lower it”	/ʔa-naggiṣ-ha/	“(I) subtract it”
/na-ħidd-ah/	“(we) force him”	/na-ħiṭṭ-ah/	“(we) put it”
/ʔal-ʔistinbaat-aat/	“the cultivations”	/ʔal-ʔistinbaaṭ-aat/	“the deductions”
/ʔal-muʕarraf-aat/	“the defined (pl.)”	/ʔal-muʕarraḍ-aat/	“the exposed (pl.)”

Table 3e. Minimal Pairs Containing the Potentially Opaque Segments /y – ʃ – ʤ/

Opaque segment occurring to the right of the emphatic			
Plain	Gloss	Emphatic	Gloss
/sayyaaf/	“swordsman”	/ṣayyaad/	“fisherman”
/saddʒa/	“distraction”	/ṣaddʒa/	“noise”
/daayir/	“circulating”	/ṭaayir/	“flying”
/ʕatʃaan/	non-word	/ʕatʃaan/	“thirsty”
/tabaaʃir/	“beginning”	/ṭabaaʃir/	“chalk”
/daadʒin/	“tamed”	/ṭaadʒin/	“frying pan”
/ðayaaʕ/	“spreading”	/ðayaaʕ/	“loss”
/daddʒa/	“darkness”	/ðaddʒa/	“noise”
/mahdʒaʕ/	“barracks”	/maðdʒaʕ/	“bed”
Opaque segment occurring to the left of the emphatic			
Plain	Gloss	Emphatic	Gloss
/ʔaʃħan/	“(I) charge”	/ʔaʃṭan/	“more devilish”
/ʔamʃaat/	non-word	/ʔamʃaaṭ/	“combs”
/naʃiid/	“song”	/naʃiiṭ/	“energetic”
/ʃayaabiin/	“proper noun (pl.)”	/ʃayaaṭiin/	“demons”
/bayaan/	“announcement”	/bayaaðˤ/	“whiteness”
/ʔadʒhad/	“(he) overworked”	/ʔadʒhaðˤ/	“(he) aborted”

4.2 Method

All target words (stimuli) were naturally produced by an adult male native speaker of NA (age 35), who served as the informant for this study. In order to obtain as naturalistic data as possible, all the target words were uttered in the following carrier sentence: /gill _____ marra θaanya/ (“say _____ a second time”). The carrier sentence containing each target word was repeated three times by the informant, recorded digitally, and then transferred to a computer using SoundEdit 16 software. The data were then analyzed acoustically using Praat 6.2.14 software for acoustic speech analysis. The F_2 frequency of every vowel in every syllable in all the target words was measured. Finally, measurements were averaged across all repetitions in preparation for comparison analysis.

5. Results and Discussion

5.1 Monomorphemic Words

5.1.1 Monosyllabic Words

Figure 1 below shows the average F_2 frequency of the vowels in the monosyllabic words containing the plain/emphatic consonant. As can be readily seen, there is significant lowering of the F_2 frequency of

vowels next to emphatic consonants compared to their plain counterparts. On average, there is approximately a 569 Hz drop in the F_2 frequency of the vowel in the vicinity of an emphatic consonant compared to the same vowel in the vicinity of the emphatic's plain counterpart. Moreover, the position of the emphatic in the word (whether it occurred word-initially or word-finally) seems to have no effect on the directionality of emphasis spread. That is, emphasis spreads equally in both directions rightward and leftward.

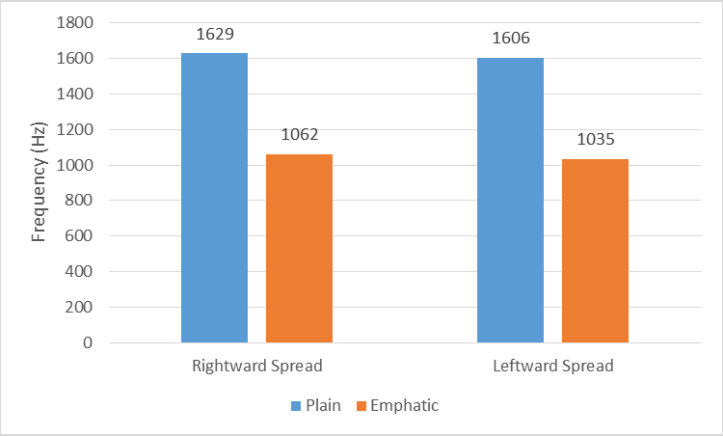

Figure 1. Average F_2 Frequency of Vowels in Monosyllabic Monomorphemic Minimal Pairs

5.1.2 Disyllabic Words

The results of the disyllabic words, given in Figure 2 below, show a similar effect. That is, emphasis spreads from the emphatic source to the vowels in both syllables of the word in both directions; however, the lowering of the F_2 frequency of the vowel in the target syllable containing the emphatic is more significant than that of the vowel in the adjacent syllable. On average, the F_2 frequency of the vowel in the target syllable in the vicinity of an emphatic consonant drops approximately 550 Hz compared to the same vowel in the vicinity of a plain consonant. In comparison, the F_2 frequency of the vowel in the adjacent syllable in the vicinity of an emphatic consonant drops approximately 391 Hz compared to the same vowel in the vicinity of a plain consonant. This seems to suggest that emphasis spread is perhaps a gradient phenomenon. The closer the vowel is to the emphatic source the more its F_2 frequency is lowered, and vice versa.

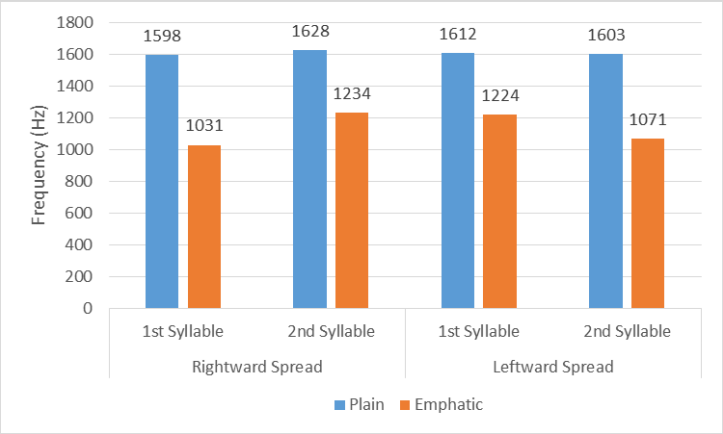

Figure 2. Average F_2 Frequency of Vowels in Disyllabic Monomorphemic Minimal Pairs

5.1.3 Trisyllabic Words

A quite similar effect is also observed in trisyllabic words. Emphasis spreads from the emphatic source throughout the whole word in a gradient manner. For example, the left-hand side of the graph in Figure 3 below (labelled "Rightward Spread") shows that in words where the emphatic consonant occurs word-initially, emphasis is at its peak in the target syllable containing the emphatic consonant, i.e., the first syllable. This is evident by the significant lowering of the F_2 frequency of its vowel from 1576 Hz to 1037 Hz. In other words, the F_2 frequency of the vowel in the target syllable in the vicinity of an emphatic consonant drops on average 539 Hz compared to the same vowel in the vicinity of a plain consonant, which is quite similar to what we have seen earlier in monosyllabic and disyllabic words. The F_2 frequency of the vowel in the immediately following syllable, i.e., the second syllable, drops about 305 Hz, whereas the F_2 frequency of the vowel in the final syllable, i.e., the third syllable, drops about 215 Hz. The same gradient effect is also observed in words where the emphatic consonant occurs word-finally, i.e., leftward spread. The F_2 frequency of the vowels in the third, second, and first syllables drop on average 532 Hz, 353 Hz, and 256 Hz, respectively.

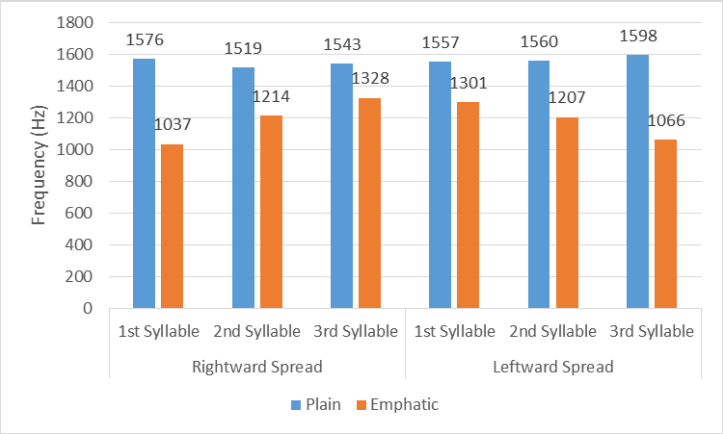

Figure 3. Average F_2 Frequency of Vowels in Trisyllabic Monomorphemic Minimal Pairs

To sum up, the results presented so far show that emphasis spreads from the emphatic source throughout the whole monomorphemic word regardless of the number of syllables. However, emphasis spreads in a gradient manner where it is at its highest in the syllable containing the emphatic and it gradually diminishes as it moves into the following/preceding syllables. Accordingly, emphasis is at its lowest when a plain syllable is separated from the target syllable (containing the emphatic) by one syllable.

5.2 Polymorphemic Words

The results of the polymorphemic words (i.e., stem plus prefixes and suffixes both inflectional and derivational) show that affixes do not act as barriers to emphasis. As shown in Figure 4 below, emphasis does in fact spread from the emphatic source in the stem into the affixes attached to it. The emphasis spread is, however, subject to the same gradient effect observed earlier. For example, the F_2 frequency of the vowel in a prefix attached to a stem beginning with an emphatic consonant drops on average 367 Hz compared to the same prefix vowel attached to a stem beginning with a plain consonant. On the other hand, since the vowel in a suffix that is attached to a stem beginning with an emphatic consonant is farther away from the emphatic compared to the vowel in a prefix, the lowering of F_2 in the vowel of the suffix is less in magnitude as it drops on average 219 Hz compared to the same suffix vowel attached to a stem beginning with a plain consonant. The exact same effect is also observed when the conditions are reversed. That is, when an emphatic occurs stem-finally, the affix closest to the emphatic source displays a greater drop in the F_2 frequency of its vowel (in this case the suffix), whereas the affix farther from the emphatic source displays a smaller drop (in this case the prefix).

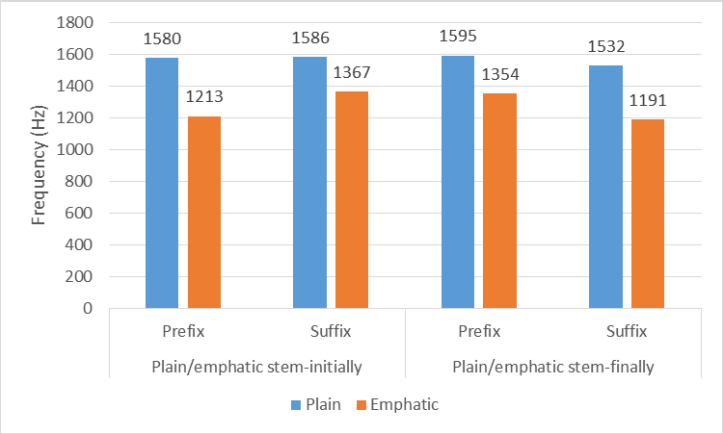

Figure 4. Average F_2 Frequency of Vowels in Affixes

On the basis of the results presented thus far, it can be concluded that the domain of emphasis spread in NA spans the entire phonological word, which consists of the stem plus any affixes. Moreover, although emphasis spreads directionally with no asymmetries observed, the degree of emphasis is not equal in all the syllables of the phonological word. That is, emphasis displays gradiency in an inverse relationship whereby the degree of emphasis decreases as distance from the emphatic source increases, and vice versa.

5.3 Opaque Segments

Aside from the gradient effect, the results presented so far do not show any asymmetries in the directionality of emphasis spread. This is due to the fact that none of the target words analyzed thus far contained any opaque segments that have been reported to block emphasis spread. As mentioned earlier, the segments /y – ʃ – ʤ/ have been widely reported in previous studies on some dialects of Arabic to be opaque where they block rightward spread, but not leftward spread. These potentially opaque segments were tested and the results are shown in Figure 5 below. As can be seen in the left-hand side of the graph (labelled “Rightward Spread”), while the vowel in the target syllable containing the emphatic is emphaticized, as evident by the significant lowering of its F_2, rightward emphasis is blocked when an opaque segments occurs to the right of the emphatic, e.g., /ṣayyaad/ “fisherman”. On the one hand, the F_2 frequency of the vowel in the target syllable containing the emphatic consonant drops on average 573 Hz compared to the same vowel in the vicinity of a plain consonant. On the other hand, the F_2 frequency of the vowel in the following syllable with an opaque segments in its onset remains unaffected as no F_2 lowering is observed.

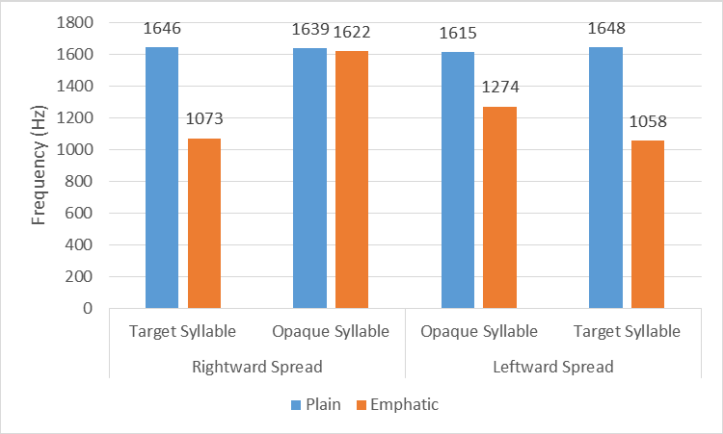

Figure 5. Average F_2 Frequency of Vowels in Target Syllables vs. Opaque Syllables

In contrast, when an opaque segments occurs to the left of an emphatic, e.g., /bayaaḍ/ "whiteness", leftward emphasis spread is unblocked as it spreads freely from the emphatic source to all the vowels to its left despite the presence of an opaque segment in the path of emphasis. This is evident by the fact that the F_2 frequencies of the vowels in all the syllables of the word are lowered in a gradient manner to the same frequency values shown earlier.

The asymmetry in the directionality of emphasis spread in the presence of the phonemes /y – ʃ – ʤ/ is accounted for on physiological grounds. According to Ladefoged & Maddieson (1996) and Watson (1999), given the fact that /y – ʃ – ʤ/ are [+high, -back] phonemes, they block emphasis spread because they are incompatible or "antagonistic" to [RTR] (retracted tongue root), which is the feature that spreads from the emphatic consonant. Furthermore, emphasis spread is considered to be a sort of assimilatory process, where segments in a word assimilate in "backness" to emphatic consonants. As such, leftward spread, which is considered to be regressive assimilation, is less restricted than rightward spread, which is considered to be progressive assimilation, because the feature [RTR] is "anchored" at the beginning of the primary articulation. That is, the spreading of the feature [RTR], which is considered to be the secondary articulation, basically involves constriction in the upper pharynx caused by the backing or retracting of the tongue. This secondary articulation tends to occur more at the beginning of the primary articulation and as a result the feature [RTR] spreads anticipatorily whereby the formants of preceding segments are affected more than the formants of following segments.

5.4 Emphasis across Word Boundaries

To summarize, the results show that emphasis in NA spreads bidirectionally in a gradient fashion throughout the entire phonological word (which consists of the stem and affixes) provided the set of opaque segments /y – ʃ – ʤ/ do not intervene, in which case rightward emphasis spread is blocked. Now, since emphasis has been attested in some Arabic dialects to spread across word boundaries into

the preceding/following word, it is necessary to investigate if this is also the case in NA. Thus, the carrier sentence /gill _____ marra θaanya/ (“say _____ a second time”) in which each target word (or stimulus) was inserted, the F_2 frequencies of the vowels in the words that preceded (i.e., /gill/ “say”) and followed (i.e., /marra/ “time”) each target word were measured. In the preliminary analysis, these measurements were averaged across all repetitions and collapsed across all target words, plain and emphatic. The results are given in Figure 6 below.

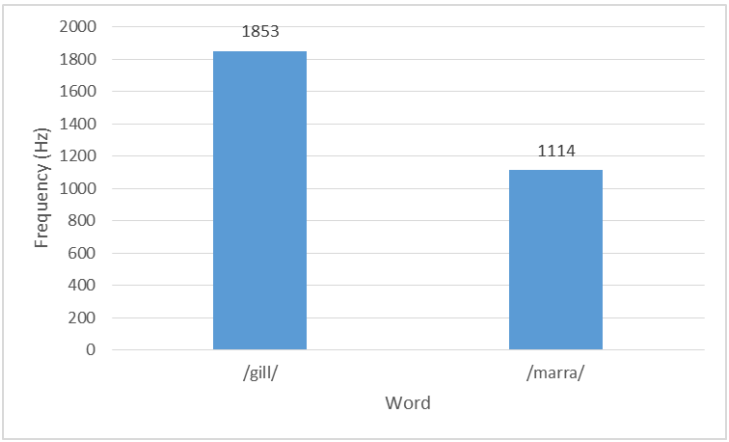

Figure 6. Average F_2 Frequency of Vowels in the Words that Precede/Follow the Target Word

As shown in the graph, the vowels in the preceding and following words show significant differences. On the one hand, the F_2 frequency of the vowel in the preceding word /gill/ averaged 1853 Hz, which strongly indicates that there was no lowering of the vowel’s F_2. On the other hand, the F_2 frequency of the vowels in the following word /marra/ averaged 1114 Hz, which shows significant lowering of the vowels’ F_2. At first glance, these results seem to suggest that leftward spread to the preceding word is blocked, whereas rightward spread to the following word is permitted. To investigate this further, a more detailed analysis was carried out where the F_2 frequencies of the vowels in the preceding and following words were compared separately according to the condition of the target word, i.e., whether it contained a plain or emphatic consonant. As shown in Figure 7 below, the preceding word /gill/ was consistently unemphaticized regardless of whether the target word following it was plain or contained an emphatic segment, even in word-initial position. This clearly and strongly confirms that emphasis does not spread leftward across word boundaries into the preceding word. In contrast, the following word /marra/ was consistently emphaticized regardless of whether the target word preceding it contained an emphatic segment (in word-final position) or no emphatics at all. However, the source of emphasis could not have been from the preceding target word since half of the target words in the data contained no emphatic consonants. Thus, the source of emphasis must have been from a segment within the word itself, namely /r/, which is considered a secondary emphatic. Therefore, as with

leftward spread, rightward emphasis spread across word boundaries into the following word is also not permitted in NA. As a result, the domain of emphasis spread in NA is restricted to the phonological word including affixes.

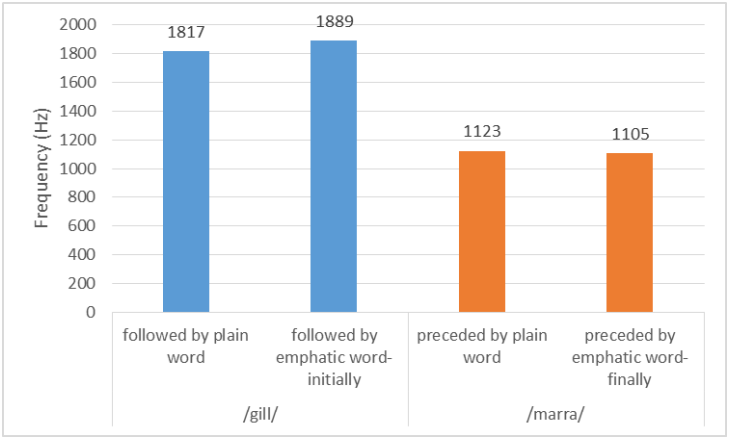

Figure 7. Average F_2 Frequency of Vowels in the Words that Precede/Follow the Target Word according to the Presence/Absence of an Emphatic in the Target Word

6. Conclusion

The paper has presented an in-depth acoustic analysis of emphasis spread in NA in an attempt to investigate its domain and directionality, and whether it is blocked by any opaque phonemes. Based on the results of the analyses carried out, the following conclusions are made. First, the domain of emphasis spread in NA spans the entire phonological word, which consists of the stem and any affixes attached. Thus, morpheme boundaries do not block emphasis. Word boundaries, however, act as barriers as they do block emphasis from spreading into the preceding and following words.

Second, although emphasis spreads rightward and leftward throughout the entire phonological word, it occurs in a gradient manner as the degree of emphasis is not equal in all the syllables of the phonological word. This gradiency shows an inverse relationship whereby the degree of emphasis decreases as distance from the emphatic source increases, and vice versa. Thus, emphasis peaks in the syllable containing the emphatic and gradually decreases as it moves into the following/preceding syllables.

Finally, the set of opaque segments /y – ʃ – ʤ/ block rightward spread but not leftward spread. That is, when these opaque segments occur to the right of an emphatic consonant, emphasis spreads rightward from the emphatic to neighboring vowels up to the opaque segment, however, it is blocked from spreading any further beyond the opaque segment. In contrast, when these opaque segments occur to the left of an emphatic, emphasis spreads freely leftward from the emphatic to all the vowels in the phonological word in a gradient manner.

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