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Effects of Gender on the Production of Emphasis in Jordanian Arabic: A Sociophonetic Study

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Abstract

Emphasis, or pharyngealization, is a distinctive phonetic phenomenon and a phonemic feature of Semitic languages such as Arabic and Hebrew. The goal of this study is to investigate the effect of gender on the production of emphasis in Jordanian Arabic as manifested on the consonants themselves as well as on the adjacent vowels. To this end, 22 speakers of Jordanian Arabic, 12 males and 10 females, participated in a production experiment where they produced monosyllabic minimal CVC pairs contrasted on the basis of the presence of a word-initial plain or emphatic consonant. Several acoustic parameters were measured including Voice Onset Time (VOT), friction duration, the spectral mean of the friction noise, vowel duration and the formant frequencies (F1-F3) of the vowels. The results of this study indicated that VOT is a reliable acoustic correlate of emphasis in Jordanian Arabic only for voiceless stops whose emphatic VOT was significantly shorter than their plain VOT. Also, emphatic fricatives were shorter than plain fricatives. Emphatic vowels were found to be longer than plain vowels. Overall, the results showed that emphatic vowels were characterized by a raised F1 at the onset and midpoint of the vowel, lowered F2 throughout the vowel, and raised F3 at the onset and offset of the vowel relative to the corresponding values of the plain vowels. Finally, results using Nearey's (1978) normalization algorithm indicated that emphasis was more acoustically evident in the speech of males than in the speech of females in terms of the F-pattern. The results are discussed from a sociolinguistic perspective in light of the previous literature and the notion of linguistic feminism.

1 Introduction and literature review

Emphasis is a distinctive phonetic phenomenon and a phonemic feature of Semitic languages such as Arabic, Hebrew, Aramaic and Ethiopic Ge'ez. Most modern dialects of Arabic are characterized by features of emphasis except for a few dialects including Chadian, Maltese, Nigerian, Juba, Ki-Nubi and Cypriot Arabic, which, according to Hetzron (1998), have lost this feature over time. Even though emphasis is preserved and actively employed in most modern dialects of Arabic, it may not necessarily have the same articulatory, acoustic and perceptual correlates in all of these dialects. Moreover, Arabic dialects do not necessarily share the same set of emphatic sounds.

The term emphasis, or emphaticness, stands for what early Arab grammarians referred to in articulatory terms as the 'spreading and raising/covering of the tongue', 'elevation of the back of the tongue (dorsum)', and 'thickness and heaviness' (Lehn, 1963; Wahba, 1993). According to Wahba (1993), the third term motivated the Western term "emphasis". There has been much debate in the literature on the articulatory nature of emphatic sounds, resulting in a multiplicity of terms standing for different configurations of the vocal tract during the production of emphatic sounds. While pharyngealization has been the most reported articulatory configuration of emphasis in different dialects of Arabic (Laufer and Baer, 1988; Wahba, 1993; Davis, 1995; Hassan, 2005; Al-Tamimi et al., 2009), other configurations have also been proposed either besides or instead of pharyngealization. Among the proposed configurations are labialization (Watson, 1999), velarization (Norlin, 1978; Hetzron, 1998), uvularization (Zawaydeh, 1999), tongue retraction (Lehn, 1963) glottalization (Ladefoged, 1971) and, less frequently, heaviness, strong articulation and u-resonance (Lehn, 1963). Wahba (1993) attributed the multiplicity of terms for emphasis to the articulatory complexity of emphasis.

Lehn (1963) echoed the articulatory complexity of emphasis in his definition of emphasis. He argued that the most crucial feature of emphasis in Cairene Egyptian Arabic was a "slight retraction, lateral spreading, and concavity of the tongue and raising of its back" (p. 30) in a manner similar to velarization. He explained that this articulatory configuration may be accompanied by the occurrence of one or more of the following features: pharyngealization, labialization, and "increased tension of the entire oral and pharyngeal musculature" (p. 31). The latter is responsible, according to Lehn, for the more fortis nature of emphatics relative to their plain counterparts. Hetzron (1989) described the vowels adjacent to emphatic consonants (emphatic vowels) as being lower, retracted, or more centralized than their plain counterparts. Walter (2006) provided a perceptual definition of emphatics. She stated that emphatic consonants are perceived as darker and heavier than their non-emphatic counterparts.

1.1 Acoustic studies of emphasis

The acoustic investigation of emphasis has received the least attention in the literature in comparison to articulatory and phonological investigations (Al-Masri and Jongman, 2004). Despite the fact that Arabic is one of the major world languages, relatively few studies have attempted to investigate the acoustic correlates of emphasis in different dialects of the Arabic language. Moreover, most of the acoustic studies were devoted to the vocalic acoustic analysis, neglecting the consonantal acoustic analysis. The majority of acoustic studies of emphasis compared the formant frequencies of emphatic vowels, mostly F2, to those of plain vowels. To the best of my knowledge, only one study, Khattab et al. (2006), examined VOT as a potential acoustic correlate of emphasis in Arabic. Jongman et al. (in press) is a pioneering study where F1-F3 frequencies of pre-consonantal and post-consonantal plain and emphatic vowels were examined at the vowel onset, midpoint, and offset in addition to the spectral mean of emphatic obstruents as potential acoustic correlates of emphasis in Jordanian Arabic.

Card (1983) examined the acoustic correlates of emphasis in Palestinian Arabic. Her results showed that F2 values of the emphatic vowels were considerably lower than those of the plain vowels. Moreover, she found that emphasis spreads in both directions; rightward and leftward, in the entire word. Card (1983) reported that the vowels adjacent to the emphatic consonants exhibited more F2 lowering than their neighboring vowels, whose F2 values were sometimes as high as those of the plain vowels.

Wahba (1993) investigated the acoustic correlates of emphasis in Alexandrian Egyptian Arabic. His data consisted of monosyllabic and disyllabic minimal (or near minimal) pairs containing the plain and emphatic opposition in the environment of the eight Alexandrian Egyptian Arabic vowels. The first two formant frequencies were measured at the onset and midpoint of the vowel. Wahba (1993) reported no significant difference for F1. However, he found that emphasis is manifested in the lowering of F2 both at the transition (onset) and at the midpoint of emphatic vowels relative to the corresponding values of the plain vowels. His findings were qualitatively consistent across all subjects and across the eight vowels investigated. However, Wahba (1993) observed that emphasis is best manifested on low central vowels in terms of F2 lowering for which he provided an articulatory account in terms of the positions of vowels in the phonetic space.

Similar acoustic results were reported for Jordanian Arabic. Al-Masri and Jongman (2004) investigated the acoustic correlates of emphasis in the northern dialect of Jordanian Arabic. Their data consisted of monosyllabic, bisyllabic and trisyllabic minimal pairs, the words in each of which were contrasted in terms of the presence of a plain or an emphatic consonant. The latter two types, the disyllabic and the trisyllabic minimal pairs, were used to assess the role of the position of the emphatic consonant as well as the spread/blocking of emphasis into adjacent syllables. Al-Masri and Jongman (2004) did not report any significant difference between the duration of the target plain and emphatic consonants, nor did they find any significant differences between the duration of the plain and emphatic vowels regardless of whether the vowel occurred in the same syllable as the target consonant or not. However, Al-Masri and Jongman (2004) reported significant F2 lowering in the emphatic vowels relative to the plain vowels whether vowels occurred in the same syllable as the target consonant or in an adjacent syllable. However, the lowering of F2 in the emphatic vowel was most pronounced for vowels occurring in the same syllable as the emphatic consonant (500 Hz) in comparison to vowels occurring in syllables adjacent to the emphatic syllable. As for the spread of emphasis, Al-Masri and Jongman (2004) found that emphasis spread to the adjacent syllables in both directions though to a lesser degree, in terms of F2 lowering, than that shown by vowels in the target syllables. However, Al-Masri and Jongman (2004) reported that the presence of the vowels /i/ and /u/ in the target syllables blocked the spread of emphasis to other vowels in right-adjacent syllables, in which case there was no significant lowering of F2 in the emphatic vowels relative to the plain vowels.

Khattab et al. (2006) examined the productions of the phonemic contrast between the plain coronal plosive /t/ and its emphatic counterpart /tˤ/ in Jordanian Arabic in the environment of the high vowel /i/ and the low vowel /æ/. They reported F1 raising and F2 lowering at the onset of the emphatic vowels (no other vowel positions were measured) relative to their corresponding values in the plain vowels for both high and low vowels. Moreover, Khattab et al. (2006) found that VOT of emphatic consonants was significantly shorter than VOT of plain consonants.

More recently, Jongman et al. (in press) explored the acoustic correlates of emphasis in the northern dialect of urban Jordanian Arabic. They found that emphatic vowels, whether short or long, were characterized by higher F1, lower F2 and higher F3 in comparison to plain vowels. However, there was a significant interaction between emphasis and both vowel duration and vowel quality. Emphasis was more pronounced in short vowels than long vowels. F2 lowering was greater and more persistent in the vowel /æ/ compared to /i/ and /u/. Jongman et al. (in press) reported that the closer the vowel to the emphatic consonant in the word, the more the vowel formants were affected, suggesting that emphasis spread is gradient. As for the spectral mean, their results showed that the emphatic stops, but not the emphatic fricatives, were characterized by a lower spectral mean relative to their plain counterparts. Moreover, emphasis spread to the non-target stop consonants in terms of their lower spectral mean. Jongman et al. (in press) reported that their results were consistent regardless of whether the vowels followed or preceded the target consonants.

In sum, the studies reviewed here report several acoustic differences between plain and emphatic segments. In general, F2 of the vowels adjacent to emphatic consonants is considerably lower than that of the vowels adjacent to plain consonants. Though less often reported, F1 and F3 of the vowels in the emphatic environment are higher than their counterparts in the plain environment. At least one study found that the VOT of emphatic voiceless stops is shorter than the VOT of their plain counterparts. Furthermore, the spectral mean of emphatic stops was reported to be lower than that of their plain counterparts.

1.2 Gender studies of emphasis

Anatomically-related acoustic differences in the speech of males and females are well-established in the literature (Fant, 1966). The vocal tract of adult males is longer than that of adult females, which is in turn longer than that of children. Fant (1966) reported that the average formant frequency values of an adult female are related to those of an adult male by a simple scale factor that is inversely proportional to the vocal tract length. He pointed out that female formant frequency values are 20% higher on average than those of males. In their well-known paper, Peterson and Barney (1952) found that adult females had higher formant frequency values, in general, than adult males and that children had higher formant frequencies than adults. However, it has been reported that the speech of males and females can be acoustically distinguished by more than what the difference in their vocal tract length predicts (Fant, 1966; Kahn, 1975; Wahba, 1993; Khattab et al., 2006; Clopper, 2009). Studies that are interested in differences beyond these physiological differences, such as the contribution of social factors (gender, age, class, etc.), face the burden of isolating the social and/or phonological differences (Clopper, 2009) from differences resulting from the non-uniform scaling of the vocal tract length of males, females and children.

Several normalization techniques and algorithms have been proposed to normalize data for talker differences resulting from factors such as sex (I will be using ‘sex’ as opposed to ‘gender’ to refer to the anatomically-related speech differences between males and females). Although none of these techniques claim to totally eliminate ‘physiologically-induced differences’ (Fant, 1966), these techniques help reduce these effects to the minimum, allowing for valid direct visual and statistical comparisons between male and female data (Clopper, 2009). Among these techniques are Fant’s (1966) K sex-factor, S-transformation and other vowel-extrinsic and vowel-intrinsic computational vowel formant normalization algorithms such as Gerstman (1968), Lobanov (1971), Nordstrom & Lindblom (1975), Nearey (1978), Bladon et al. (1984), Syrdal & Gopal (1986), Miller (1989), and Watt & Fabricius (2002) (See Clopper, 2009 for a detailed description of these algorithms).

Ahmad (1979) investigated the production of emphasis by two male and two female educated native speakers of Cairene Egyptian Arabic. Her data consisted of minimal pairs that contained the contrast between /d/ and /dˤ/, both word-initially and word-finally, in the environment of the three long vowels /i/, /æ/ and /u/. She reported the approximation of F1 and F2 in the emphatic vowels relative to their plain counterparts, especially for the back vowels /æ/ and /u/. However, Ahmad (1979) observed that the degree of F2 lowering was greater for the male speakers than for the female speakers. Ahmad (1979) concluded that the female speakers produced fewer cues to emphasis than the male speakers.

Royal (1985) examined the potential interaction between the production of emphasis and social factors (gender, age, and social class) in the speech of 29 native speakers of Cairene Egyptian Arabic only in the environment of the vowel /i/. She collected her data through field work in Cairo where she conducted recorded informal interviews with people from two areas representing the two ends of the social continuum in Cairo with one area representing the lower class and the other representing the westernized high class. In her study, Royal (1985) differentiated between two types of pharyngealization: strong (audible) pharyngealization and weak pharyngealization. The former, according to her, is sensitive to the listeners' age and gender, and thus is more relevant when extra-linguistic factors are considered. In terms of F2 lowering, Royal's (1985) results suggested that females produced fewer cues to emphasis, weaker pharyngealization, to use Royal's term, than males. However, Royal (1985) explained that the situation is more complicated when other factors, such as social class and age, came into play. While men and women from the upper class produced different degrees of emphasis with women exhibiting less emphasis, only younger women and men from the less privileged area showed a similar tendency. Older men and women from the lower class reversed the pattern, i.e., older women from the lower class produced a greater degree of emphasis than older men from the same class.

Wahba (1993) examined the effect of gender on the variation in the production of emphasis in the speech of educated adult native speakers of Alexandrian Egyptian Arabic. Wahba (1993) compared the regression slopes of plain and emphatic vowels obtained by locus equation for males and females. He concluded, given that the females' plain and emphatic slopes were closer to each other relative to those of the males, that male speakers showed a greater degree of emphasis than female speakers.

Al-Masri and Jongman (2004) examined the male and female productions of the plain/emphatic contrast in Jordanian Arabic. They argued that the females' productions were more emphatic than those of the males in terms of F2 lowering of the vowel adjacent to the emphatic consonant. However, Al-Masri and Jongman (2004) did not normalize their data for the effect of gender.

Khattab et al. (2006) investigated potential gender-related acoustic and auditory differences in the production of the phonemic contrast between the plain coronal plosive /t/ and its emphatic counterpart /tˤ/ in Jordanian Arabic in the environment of the high vowel /i/ and the low vowel /æ/. The results of the perceptual rating showed that while all of the intended plain tokens were rated as plain, the female productions of /tˤ/ were rated as less emphatic in general than those produced by males, whose emphatic productions were all rated as emphatic. As for the acoustic correlates of emphasis, Khattab et al. (2006) reported F1 raising and F2 lowering at the onset of the emphatic vowels (no other vowel positions were measured) relative to their corresponding values in the plain vowels for both high and low vowels, regardless of gender. Although the raw formant frequency values in this study were S-transformed, the authors did not conduct any statistical analysis on the normalized data. Instead, they plotted the transformed data in an $F1 \times F2$ space. They observed considerably more overlap between the female plain and emphatic vowels when F1 was plotted as a function of F2, which was not true for males whose plain and emphatic vowels were much more distinct. Interestingly, the authors reported that 33% of the female vowels following the emphatic consonant were characterized by the front-quality onsets observed in the vowels following the plain consonant.

Moreover, Khattab et al. (2006) found that VOT of emphatic consonants was significantly shorter than VOT of plain consonants for both males and females. In addition, the authors reported that the males' emphatic VOT was significantly shorter than the females' emphatic VOT. It's not clear, though, how the authors attributed the difference between the male emphatic VOT and the female emphatic VOT to the production of emphasis as the female plain VOT was also found in this study to be longer than the male plain VOT. In other words, the difference between the male and the female emphatic VOT may be influenced by a factor other than emphasis such as gender. Due to discrepancies resulting from inter-dialectal variation in their female data, Khattab et al. (2006) were not able to draw firm conclusions about the interaction between gender and emphasis in Jordanian Arabic. However, they suggested that Royal's (1985) formulation of the interaction between emphasis, gender and social class for Cairene Arabic may be valid for Jordanian Arabic as well.

Almbark (2008) examined the effect of gender and regional dialect on the production of emphasis in Syrian Arabic. The results of the production experiment did not show any statistically significant differences related to gender or region between plain and emphatic VOTs. However, emphasis was more acoustically evident in the speech of females in terms of F2 lowering and F1-F2 approximation following emphatic stops whereas the opposite was true following emphatic fricatives, i.e. males showed more F2 lowering and F1-F2 approximation. Regional dialects, on the other hand, did not have any significant effect on the production of emphasis. Almbark (2008), attempting to account for her gender findings that contradicted those of Khattab et al. (2006) and partially those of Jongman et al. (2007) on Jordanian Arabic as well as those of Kahn (1975) on Cairene Egyptian Arabic, argued that the effect of gender on the production of emphasis varies from one Arabic dialect to another.

In sum, all of the reviewed studies indicated a gender effect on the production of emphasis in a variety of dialects of Arabic. The majority of these studies (e.g., Kahn, 1975; Ahmad, 1979; Royal, 1985; Wahba, 1993; Khattab et al., 2006) reported that emphasis was more acoustically evident in the speech of males than in the speech of females. A few studies (e.g., Al-Masri & Jongman, 2004; Almbark, 2008) reported an opposite direction. However, some of these studies recruited subjects from different dialects of Arabic (e.g., Kahn, 1975) and many of them did not normalize data for gender (e.g., Kahn, 1975; Royal, 1985; Al-Masri & Jongman, 2004; Almbark, 2008). Regardless of the directionality, the effect of gender was reported only in terms of F-patterns. Two conflicting findings have been reported for Jordanian Arabic. While Khattab et al. (2006) found that the males' productions of /$t^ʕ$/ were more emphatic than those of females, Al-Masri & Jongman (2004) reported the opposite for the set of emphatic consonants in Jordanian Arabic.

1.3 Focus of the present study

The goal of the current study was to examine the potential effect of gender on the production of the plain/emphatic contrast in Jordanian Modern Standard Arabic (MSA). To the best of my knowledge, only two studies (Al-Masri & Jongman, 2004 and Khattab et al., 2006) investigated the potential effect of gender on the production of emphatic consonants in Jordanian Arabic. On the one hand, Al-Masri & Jongman (2004) reported that the degree of emphasis, as manifested by the lowering of F2 in the adjacent vowels, was greater for female speakers than for male speakers. Khattab et al. (2006), on the other hand, found that emphasis was more pronounced in the speech of males than in the speech of females. Their results were based on the amount of overlap between the plain and emphatic formant frequency data. While Khattab et al. (2006) examined only one pair of sounds (/t, $t^ʕ$/) and did not report any statistical analyses on their normalized data, Al-Masri & Jongman (2004) did not normalize their formant frequency data. Instead, their findings were based on the amount of change in absolute formant frequency values.

The results reported by Khattab et al. (2006) on Jordanian Arabic and by the majority of studies on other dialects of Arabic lead to the hypothesis that adult female native speakers of Jordanian Arabic show less acoustic evidence of emphasis in their speech than adult male native speakers of Jordanian Arabic. More precisely, the questions of the current study were:

1) What are the acoustic correlates of emphasis in Jordanian Arabic?
2) Does emphasis differ for the vowels /i/, /u/, and /æ/?
3) Is there any gender-related effect in the production of emphatic sounds by native speakers of Jordanian Arabic?

In order to handle the research questions, the following hypotheses were formulated for testing:

1) There are acoustic differences between plain and emphatic productions for both males and females. More specifically, F1 and F3 of emphatic vowels are higher than their plain counterparts while emphatic F2 is considerably lower than plain F2.
2) The difference between plain and emphatic vowels is greater for F2 than for F1 and F3 and is more pronounced for /æ/ than for /i/ and /u/.
3) Males produce tokens that are more emphatic than those of females in terms of formant frequencies and VOT.

2 Experiment

2.1 Methodology

2.1.1 Participants

Twenty-two native speakers of Jordanian Arabic, 12 males and 10 females, aged between 19 and 23, participated in the production experiment. All of the subjects were attending undergraduate programs at Al al-Bayt University (AABU), located in the northern part of Jordan, at the time of the experiment. The subjects were selected randomly and no characteristics, other than being native speakers of Jordanian Arabic, were used to exclude participants from the study. None of the subjects suffered from visual or hearing impairment as self-reported.

2.1.2 Stimulus materials

The production stimuli in the present experiment consisted of a list of monosyllabic minimal pairs containing the plain/emphatic opposition. The target consonants consisted of the emphatic consonants /$t^ʕ$, $d^ʕ$, $s^ʕ$/ and their plain counterparts /t, d, s/. In all of these tokens, the target consonant occurred initially followed immediately by one of the following long vowels: /i/, /u/, or /æ/ (see Table 1). All of the words, except for one, were real words taken from modern standard Jordanian Arabic (MSA). The non-word was phonologically licensed in Jordanian Arabic.

Plain	Gloss	Emphatic	Gloss
/dær/	House	/$d^ʕ$ær/	Harming
/diq/	Nonword	/$d^ʕ$iq/	Narrowness
/duʔ/	Taste!	/$d^ʕ$uʔ/	Light
/tæb/	Repented	/$t^ʕ$æb/	He recovered

/tin/	Figs	/tˤin/	Mud
/tub/	Repent!	/tˤub/	Brick
/sæm/	Poisonous	/sˤæm/	He fasted
/sib/	Leave	/sˤib/	Touch!
/sur/	Fence	/sˤur/	Name of a city

Table 1: Production stimuli

2.1.3 Procedures

The participants in the production experiment were seated in a quiet room in the British Studies Unit (BSA) at AABU and were instructed to read the complete list of words once in a normal tone and rate. The words were presented in random order with none of the target words occurring at the beginning or end of the list. The recordings were performed using a portable computer (Toshiba, Satelite A305-S6905) and a microphone (Sony F V220). Sampling rate was 44.1 kHz. All speakers were recorded by the investigator himself. KU consent forms were used. The speech files were only labelled with M (male) or F (female). The digitized recordings were imported to Praat speech analysis software (Boersma &Weenink, 2009) and various acoustic measurements were performed.

2.1.4 Acoustic measurements

PRAAT was used to perform the acoustic measurements in this study. These measurements consisted of voice onset time (VOT) of the plain/emphatic stops, friction duration of plain/emphatic fricatives, the spectral mean of fricatives, the duration of the target vowels as well as the measurements of the first 3 formant frequencies (F1-F3) of the vowels following the target plain/emphatic consonants. The VOT of voiceless stops was measured as the duration between the release of the consonant (burst) and the onset of voicing of the following vowel. The VOT of voiced stops, defined as the period of prevoicing (Reetz & Jongman, 2009), was measured as the temporal interval between the onset of consonantal voicing (during the closure phase) and the release of the consonant. Duration measurements for /s/ were based on the band of high-frequency energy associated with the sibilant fricative, which is clearly visible in the spectrogram. As in Jongman et al. (in press), the spectral means were measured over a 20-ms Hamming window in the middle of the friction. Prior to the measurement, the energy below 400 Hz and above 22,050 Hz had been filtered out from the friction portions in order to reduce the effect of background noise produced by the laptop used for recording. The duration of the vowels was measured from the onset of the first formant to the offset of the second formant as visible in the spectrograms. Formant frequency measures (F1-F3) were taken from LPC spectra calculated over a 20-ms Hamming window at the onset, midpoint, and offset of the vowel following the target plain/emphatic consonant.

2.2 Results

2.2.1 Consonant data

In this section the results of the acoustic measurements of the plain and emphatic consonants are presented. One-way Repeated Measures Analyses of Variance (ANOVAs) were conducted to assess the effect of Emphasis on VOT, frication duration, VOT to vowel duration ratio, and spectral mean of fricatives. Moreover, potential interactions between Emphasis and the other independent variables (Vowel Quality, Manner, Voice, and Gender) were evaluated using two-way and three-way Repeated Measures ANOVAs.

2.2.1.1 Voice Onset Time (VOT)

An example spectrogram of words starting with a plain and emphatic stop is shown in Figure 1. There was a main effect of Emphasis on VOT [F(1, 20) = 109.59, p = .000] as mean emphatic VOT (21 ms) was significantly shorter than mean plain VOT (37 ms).

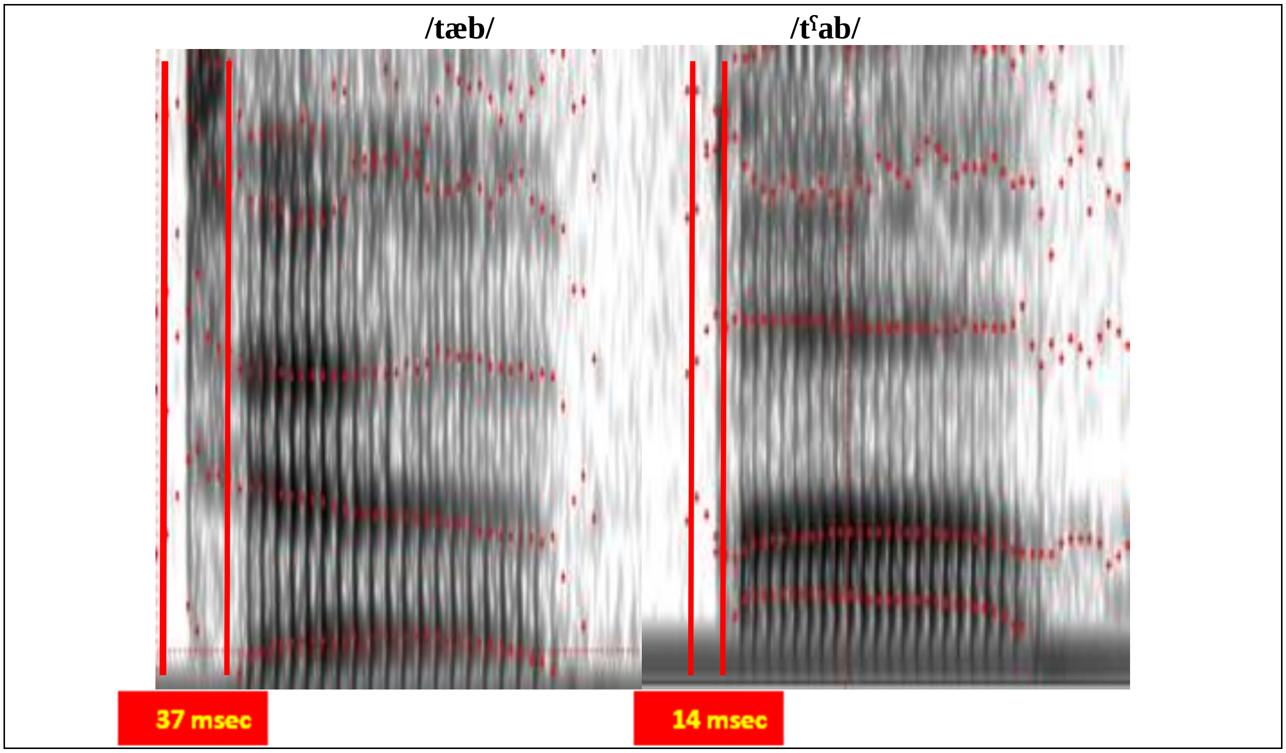

Figure 1: VOT of voiceless plain and emphatic stops

As expected, there was a main effect of Voice on VOT [F(1, 20) = 165.81, p =.000]. VOT of voiceless stops (44 ms) was significantly longer than VOT of voiced stops (14 ms). Moreover, a two-way Repeated Measures ANOVA indicated that there was a significant Emphasis by Voice interaction for VOT [F(1, 20) = 93.65, p =.000]. Emphasis had a significant effect on VOT for the voiceless stops /t/ and /tˤ/ but not for the voiced stops /d/ and /dˤ/. While the mean VOT of /d/ was 15 ms, the mean VOT of /dˤ/ was 13 ms. The difference between the emphatic VOT and the plain VOT did not reach significance for the voiced stops [$F(1, 20) = 2.50$, $p > .130$]. On the other hand, the mean VOT of /t/ was 59 ms whereas the mean VOT of /tˤ/ was 28 ms. This difference was statistically significant [$F(1, 20) = 118.39$, $p = .000$].

There was no main effect of Gender on VOT [$F(1, 20) = 4.18$, $p > .054$], showing that the females' VOT (32 ms) and the males' VOT (26 ms) were not significantly different. A two-way Repeated Measures ANOVA indicated that there was no significant Gender by Voice interaction for VOT [$F(1, 20) = 3.95$, $p > .061$]. There was no significant interaction between Gender and Emphasis for VOT [$F(1, 20) =.074$, $p >.788$], meaning that the effect of Emphasis on VOT was not significantly different between the males and the females. The difference between plain and emphatic VOT was significant only for voiceless stops for both males and females.

2.2.1.2 Vowel duration

A one-way Repeated Measures ANOVA showed that there was a main effect of Emphasis on Vowel Duration [$F(1, 20) = 11.07$, $p =.003$] as emphatic vowels (224 ms) were significantly longer on average than plain vowels (216 ms). Moreover, there was a main effect of Voice on Vowel Duration [$F(1, 20) = 8.56$, $p = .008$]. The mean duration of the vowels following the voiceless stops (215 ms) was significantly shorter than that of the vowels following the voiced stops (225 ms). However, a two-way Repeated Measures ANOVA indicated that there was no significant interaction between Emphasis and Voice in terms of Vowel Duration [$F(1, 20) =2.69$, $p > .116$]. There was no significant interaction between Gender and Emphasis for Vowel Duration [$F(1, 20) =.28$, $p > .606$]. However, a significant Emphasis x Voice x Gender interaction [$F(1, 20) = 7.15$, $p = .015$] indicated that the difference between the vowel duration following a plain voiceless stop (192 ms) and the vowel duration following an emphatic voiceless stop (209 ms) was significant only for males.

2.2.1.3 VOT to vowel duration ratio

A one-way Repeated Measures ANOVA indicated that there was a main effect of Emphasis on the VOT to Vowel Duration ratio [$F(1, 20) = 119.72$, $p = .000$] as the emphatic ratio (0.098) was significantly lower than the plain ratio (0.182). There was no main effect of Gender on VOT to Vowel Duration ratio [$F(1, 20) =.181$, $p >.675$] nor was there a significant interaction between Gender and Emphasis [$F(1, 20) = 2.43$, $p >.135$].

2.2.1.4 Friction duration

A one-way Repeated Measures ANOVA indicated that there was a main effect of Emphasis on Friction Duration [$F(1, 20) = 7.68$, $p =.012$]. Plain fricatives (167 ms) were longer on average than emphatic fricatives (158 ms). There was a main effect of Gender on Friction Duration [$F(1, 20) = 8.77$, $p = .008$], indicating that the friction duration was greater for females (177 ms) than for males (150 ms). However, a two-way Repeated Measures ANOVA indicated that there was no significant interaction between Emphasis and Gender for Friction Duration [$F(1, 20) = 1.27$, $p >.273$].

2.2.1.5 Spectral mean

A one-way Repeated Measures ANOVA indicated that there was no main effect of Emphasis on Spectral Mean [$F(1, 20) = .61$, $p > .444$]. The spectral mean of the plain fricatives (5456 Hz) was not significantly different from that of the emphatic fricatives (5344 Hz). This replicates the results reported by Jongman et al. (in press) for plain and emphatic fricatives. As anatomically predicted, there was a main effect of Gender on Spectral Mean [$F(1, 20) = 7.85$, $p = .011$] as the spectral mean of the females' fricatives (5832 Hz) was significantly higher than the spectral mean of the males' fricatives (4968 Hz). However, a two-way Repeated Measures ANOVA indicated that there was no significant interaction between Emphasis and Gender for Spectral Mean [$F(1, 20) = 3.65$, $p > .071$].

2.2.2 Vowel data

One-way Repeated Measures ANOVAs were conducted to assess the effect of Emphasis on the formant frequencies (F1-F3) at the onset, midpoint and offset of the vowel. Two-way and three-way Repeated Measures ANOVAs were also conducted to evaluate the effect of any potential interactions between the independent variables (Emphasis, Vowel Quality, Manner, and Voice) on the formant frequencies.

2.2.2.1 First formant frequency (F1)

As shown in Figure 2 below, the average F1 values of the vowels adjacent to the emphatic consonants (emphatic vowels henceforth) were significantly higher than those of the vowels adjacent to the plain consonants (plain vowels henceforth) at the vowel onset [$F(1, 20) = 50.62$, $p = .000$] and midpoint [$F(1, 20) = 23.97$, $p = .000$]. Although emphatic F1 was also higher than plain F1 at the offset of the vowel, the difference did not reach significance [$F(1, 20) = 3.35$, $p > .082$].

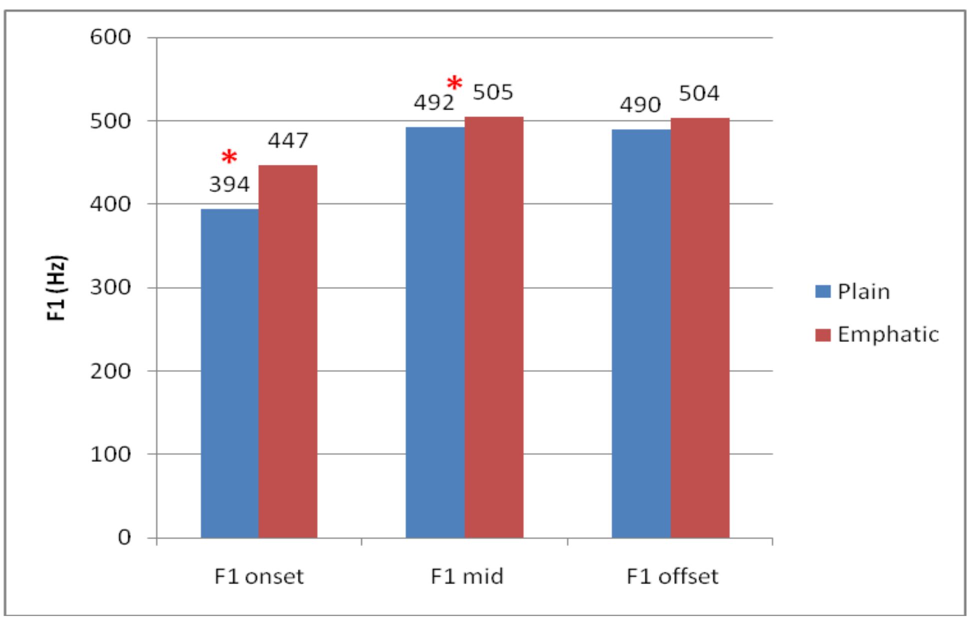

Figure 2: Average F1 values of plain and emphatic vowels

As expected, a one-way Repeated Measures ANOVA indicated that there was a main effect of Vowel Quality on F1 throughout the vowel: at the onset [F(2, 40) = 281.45, p =.000], midpoint [F(2, 40) = 442.79, p =.000], and offset [F(2, 42) = 66.03, p =.000]. A Bonferroni post hoc analysis determined that F1 of /æ/ was significantly higher than F1 of /u/, which in turn was significantly higher than that of /i/. However, a two-way Repeated Measures ANOVA indicated that there was no significant interaction between Emphasis and Vowel Quality for F1 at the onset [F(2, 40) = 2.02, p >.146], midpoint [F(2, 40) =.04, p >.964], and offset [F(2, 40) = .66, p >.521]. A Bonferroni post hoc analysis indicated that the degree of F1 increase as measured at the onset of the vowel was not significantly different among the vowels /æ/ (46 Hz), /u/ (42 Hz), and /i/ (66 Hz). The proportion of F1 increase at the vowel onset was 0.08 Hz for /æ/, 0.12 Hz for /u/, and 0.23 Hz for /i/. The difference between these proportions was not significant probably due to the small degree of increase. At the midpoint of the vowel, the degree of F1 increase was not significantly different among the vowels /æ/ (14 Hz), /u/ (16 Hz), and /i/ (17 Hz). The proportion of F1 increase at the vowel midpoint was 0.02 Hz for /æ/, 0.04 Hz for /u/, and 0.05 Hz for /i/. At the offset of the vowel, the difference in the degree of F1 increase was not statistically different among the vowels /æ/ (7 Hz), /u/ (24 Hz), and /i/ (9 Hz). The proportion of F1 increase at the offset was 0.01 Hz for /æ/, 0.05 Hz for /u/, and 0.02 Hz for /i/.

As mentioned earlier in this study, direct statistical and visual comparisons between male and female formant frequency values are not valid due to the physiological differences that affect their formant frequencies. However, it is possibly useful to examine the plain and emphatic F-patterns for males and females separately in order to determine whether they shared the same patterns or not. The results, as presented in Figure 3 below, showed that the mean F1 values of the male emphatic vowels were significantly higher than those of their plain vowels at the onset [F(1, 11) = 74.15, p =.000], midpoint [F(1, 11) = 28.58, p =.000], and offset of the vowel [F(1, 11) = 10.21, p =.009]. In terms of magnitude, F1 increase was greater at the vowel onset (66 Hz) than at the vowel midpoint (22 Hz) or offset (27 Hz). A two-way Repeated Measures ANOVA indicated that there was no interaction between Emphasis and Vowel Quality for males at the vowel onset [F(2, 22) = 1.82, p >.185], midpoint [F(2, 22) = .20, p >.819], or offset [F(2, 22) = 1.15, p >.336].

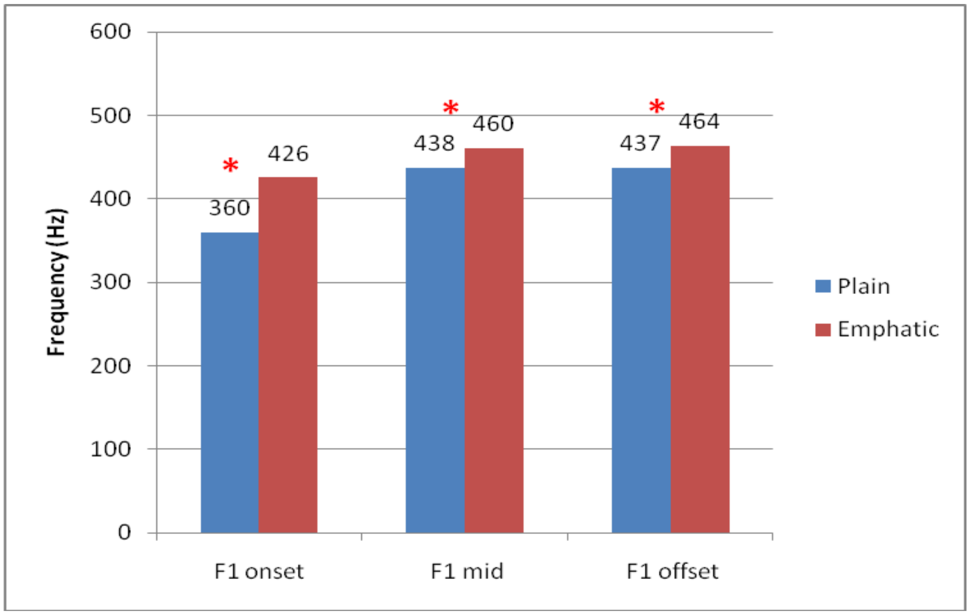

Figure 3: Average F1 values of male plain and emphatic vowels

As presented in Figure 4, the female speakers produced emphatic vowels whose mean F1 (473 Hz) was significantly higher than that of their plain vowels (436 Hz) only at the vowel onset [F(1, 9) = 8.25, p =.018]. The female mean F1 values of emphatic and plain vowels were almost the same at the vowel midpoint and offset. In other words, the female speakers did not significantly raise the F1 of their emphatic vowels relative to those of their plain vowels at the vowel midpoint [F(1, 9) = 2.68, p >.136] or offset [F(1, 9) =.02, p >.900]. A two-way Repeated Measures ANOVA indicated that there was no interaction between Emphasis and Vowel Quality for females at the onset [F(2, 18) = 1.23, p >.316], midpoint [F(2, 18) = .23, p >.801], or offset [F(2, 18) = 2.74, p >.092].

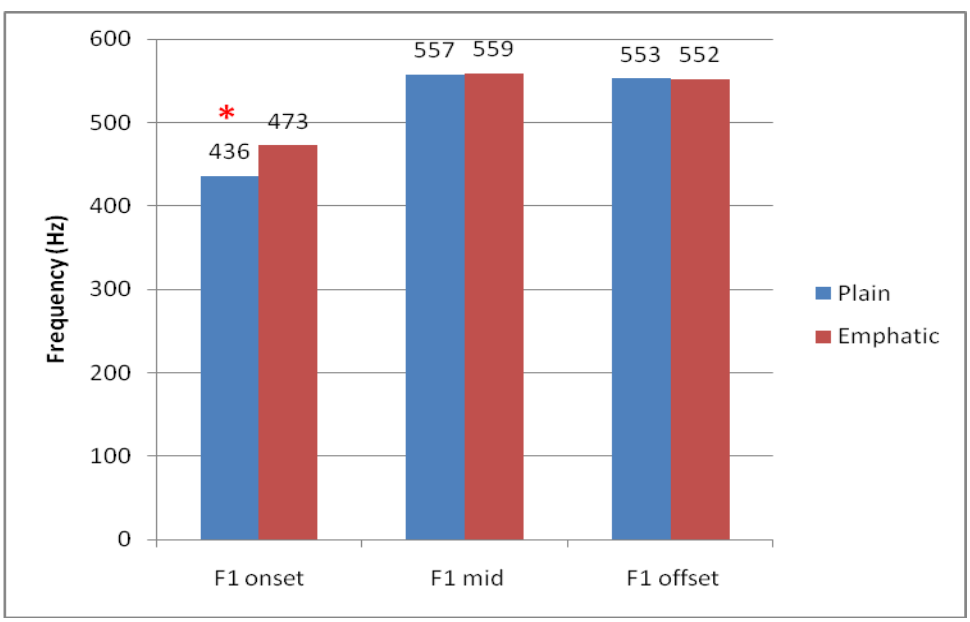

Figure 4: Average F1 values of female plain and emphatic vowels

2.2.2.2 Second formant frequency (F2)

As found in previous research and presented in Figure 5 below, the average F2 values of emphatic vowels were significantly lower than those of the plain vowels at the vowel onset [F(1, 20) = 165.36, p =.000], midpoint [F(1, 20) = 105.49, p =.000], and offset [F(1, 20) = 51.86, p =.000]. Relative to the corresponding values in the plain vowels, emphatic F2 was around 400 Hz lower at the onset, 130 Hz lower at the midpoint and 80 Hz lower at the offset. Clearly, the lowering of emphatic F2 was more pronounced at the onset of the vowel.

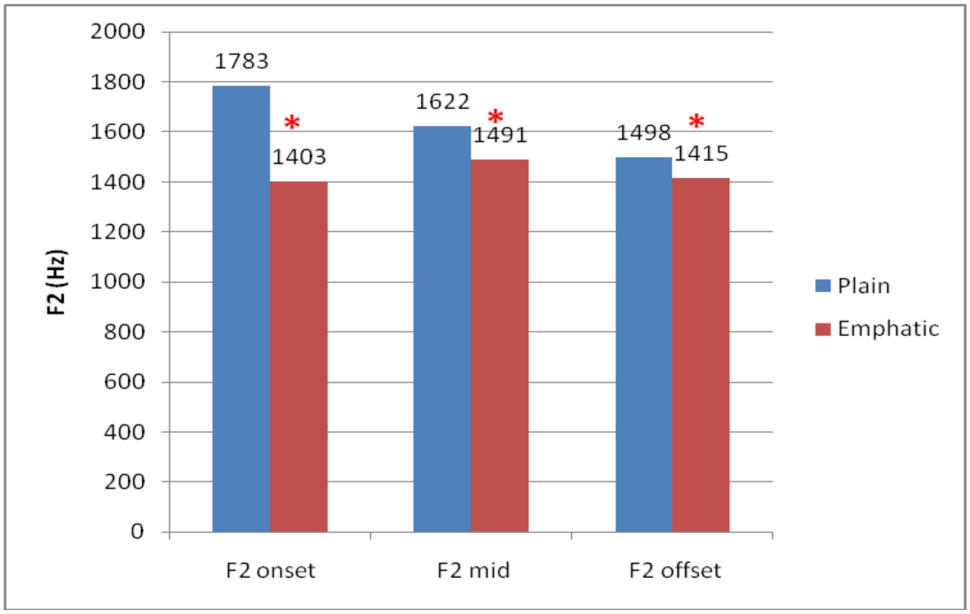

Figure 5: Average F2 values of plain and emphatic vowels

As expected, a one-way Repeated Measures ANOVA indicated that there was a main effect of Vowel Quality on F2 at the onset [F(2, 40) = 414.99, p =.000], midpoint [F(2, 40) = 1028.89, p =.000], and offset [F(2, 40) = 362.67, p =.000]. A Bonferroni post hoc analysis indicated that F2 of /i/ was significantly higher than F2 of /æ/, which in turn was significantly higher than F2 of /u/. A two-way Repeated Measures ANOVA showed that there was a significant interaction between Emphasis and Vowel Quality for F2 at the vowel onset [F(2, 40) = 7.34, p =.002], midpoint [F(2, 40) = 37.07, p =.000], and offset [F(2, 40) = 13.07, p =.000], indicating that the effect of Emphasis, though significant for all of the vowels, was more pronounced for some vowel(s) than for other vowel(s). A Bonferroni post hoc analysis indicated that the degree of F2 lowering as measured at the onset of the vowel was significantly greater for the emphatic vowels /i/ (437 Hz) and /æ/ (422 Hz) than for the emphatic vowel /u/ (268 Hz). When the amount of F2 decrease was taken as a proportion, a Bonferroni post hoc analysis determined that the proportion of F2 decrease for /æ/ (0.25) was greater than the proportion of F2 decrease for /u/ and /i/ whose proportions of decrease were (0.2) and (0.19) respectively. However, only the difference between /æ/ and /i/ was significant. The proportion of decrease for the vowel /u/ was not significantly higher than that of /i/. At the midpoint of the vowel, emphatic /æ/ experienced significantly more F2 lowering (248 Hz) in comparison to emphatic /i/ (70 Hz) and emphatic /u/ (74 Hz). In terms of the proportion of F2 decrease, /æ/ (0.16) was lowered significantly more than /u/ (0.08) and /i/ (0.03). The proportion of decrease for /u/ was significantly greater than that of /i/. At the offset of the vowel, the magnitude of F2 lowering for emphatic /æ/ (175 Hz) was significantly greater than that of emphatic /u/ (56 Hz) and emphatic /i/ (18 Hz). At the offset of the vowel, the proportion of F2 decrease for /æ/ (0.12) was significantly greater than the decrease proportions for /u/ (0.04) and /i/ (0.01) which were not significantly different from each other.

As the male and female F2 values cannot be compared directly, their F2 values were examined separately. A one-way Repeated Measures ANOVA showed that the mean F2 values of emphatic vowels, for both males and females, were significantly lower than those of the plain vowels throughout the vowel. Male emphatic F2 was significantly lower than male plain F2 at the vowel onset [$F(1, 11) = 81.99$, $p = .000$], midpoint [$F(1, 11) = 68.48$, $p = .000$], and offset [$F(1, 11) = 16.94$, $p = .002$]. However, the degree of F2 lowering was most pronounced at the onset of the vowel (404 Hz) followed by the midpoint (138 Hz) and the offset (73 Hz). Female emphatic F2 was significantly lower than female plain F2 at the onset [$F(1, 9) = 98.51$, $p = .000$], midpoint [$F(1, 9) = 40.40$, $p = .000$], and offset [$F(1, 9) = 55.70$, $p = .000$] of the vowel. The degree of F2 lowering was most pronounced at the onset of the vowel (350 Hz) followed by the midpoint (122 Hz) and the vowel offset (96 Hz).

2.2.2.3 Third formant frequency (F3)

A one-way Repeated Measures ANOVA revealed that there was a main effect of Emphasis on F3. The results, as presented in Figure 6 below, show that the mean F3 values of emphatic vowels were significantly higher than the corresponding values of the plain vowels at the onset [$F(1, 20) = 11.26$, $p = .003$] and at the offset of the vowel [$F(1, 20) = 13.66$, $p = .001$]. At the midpoint of the vowel, the mean emphatic F3 was not significantly higher than its corresponding value in the plain vowel [$F(1, 20) = .877$, $p > .360$]. The increase in emphatic F3 was 80 Hz at the onset, 30 Hz at the vowel midpoint, and 65 Hz at the offset of the vowel. Clearly, the mean F3 value at the onset of the emphatic vowel showed the greatest increase.

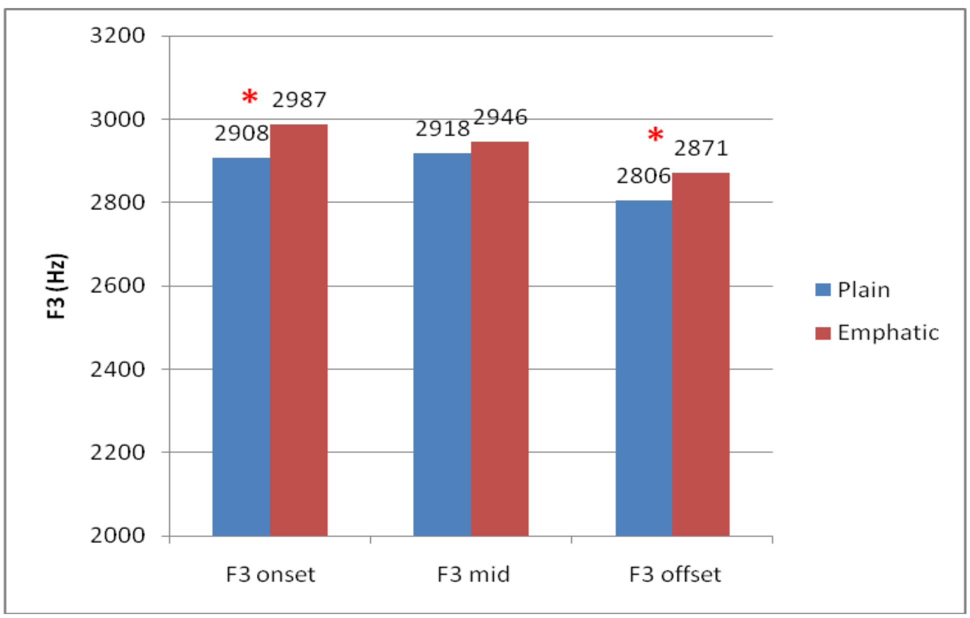

Figure 6: Average F3 values of plain and emphatic vowels

There was a main effect of Vowel Quality on F3 at the vowel onset [F(2, 40) = 4.81, p =.013] and midpoint [F(2, 40) = 6.70, p =.003], but not at the vowel offset [F(2, 40) = 4.17, p >.055]. At the onset of the vowel, a Bonferroni post hoc analysis indicated that F3 of /i/ (3028 Hz) was significantly higher than that of /u/ (2894 Hz). The difference between F3 of /æ/ (2974 Hz), on the one hand, and F3 of /i/ and /u/, on the other hand, was not statistically significant. At the vowel midpoint, a Bonferroni post hoc analysis indicated that F3 of /i/ (3083 Hz) was significantly higher than F3 of /æ/ (2867 Hz) and /u/ (2892 Hz), which were not significantly different from each other.

In addition to the main effect that both Emphasis and Vowel Quality had on F3, a two-way Repeated Measures ANOVA showed a significant interaction between Emphasis and Vowel Quality for F3 at the vowel onset [F(2, 40) = 16.44, p =.000] and midpoint [F(2, 40) = 13.01, p =.000], but not at the vowel offset [F(2, 40) = 1.84, p >.172]. The results showed that F3 of emphatic /u/ was significantly more raised at the vowel onset (200 Hz) and at the vowel midpoint (130 Hz) than emphatic /æ/, which was raised around 100 Hz and 45 Hz respectively. F3 of emphatic /i/ was not statistically different from F3 of plain /i/ at both the onset and the midpoint. Proportionally, the increase in F3 at the onset of emphatic /u/ (0.08) was significantly greater than at the onset of emphatic /æ/ (0.03), which in turn was significantly greater than the F3 change at the onset of emphatic /i/ (-0.02). At the midpoint of the vowel, the proportions of F3 increase for emphatic /u/ (0.05) and emphatic /æ/ (0.02) was significantly greater than that of emphatic /i/ (-0.03). On the other hand, there was no significant interaction between Emphasis and Manner for F3.

As the F3 values of males and females cannot be compared directly, they were examined separately as presented in Figures 7 and 8. A one-way Repeated Measures ANOVA indicated that the increase in emphatic F3 was significant only at the onset of the vowel for both males [F(1, 11) = 5.74, p =.036] and females [F(1, 9) = 5.84, p =.039], and at the offset of the vowel only for males [F(1, 11) = 14.27, p =.003]. While both male and female speakers raised their emphatic F3 around 70 Hz at the offset, the increase was significant only for male speakers because the proportion of change was greater for males than for females.

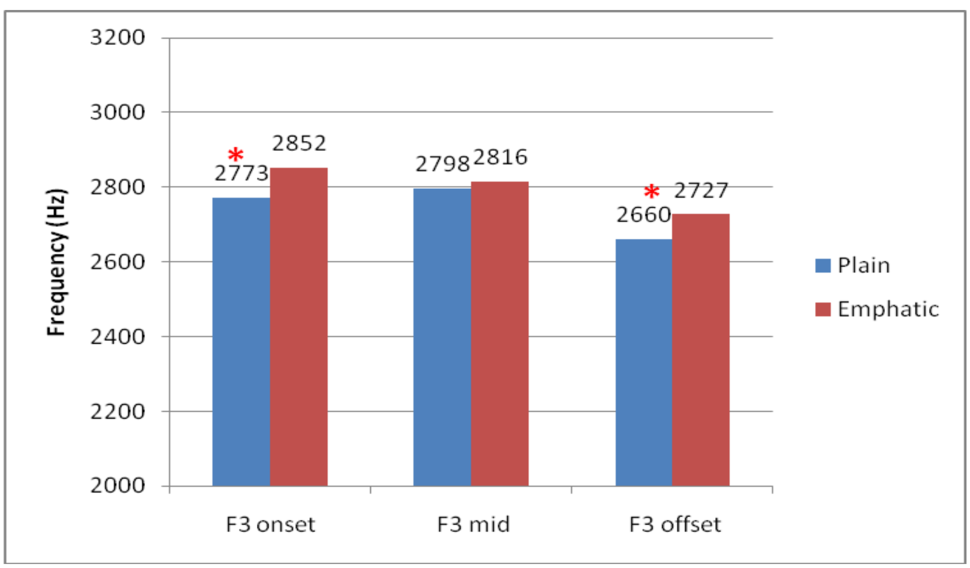

Figure 7: Average F3 of male plain and emphatic vowels

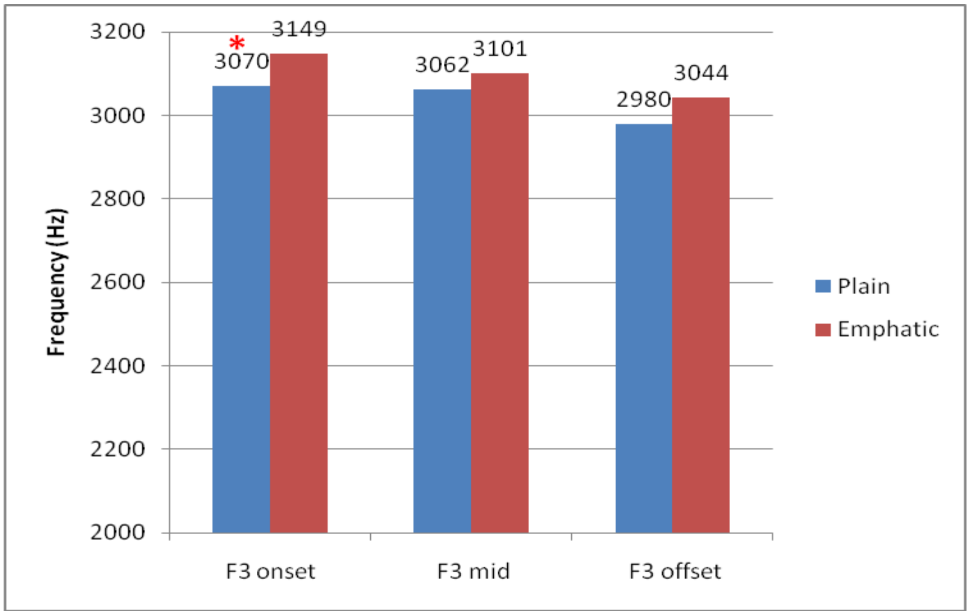

Figure 8: Average F3 of female plain and emphatic vowels

2.2.2.5 Data normalization

A two-way Repeated Measures ANOVA indicated a lack of significant interaction between Emphasis and Gender in terms of the vowel formant frequencies. However, this should not lead to the conclusion that gender did not affect the production of emphasis. As reported earlier in this study, direct visual and statistical comparisons between the vowel formant frequencies as produced by males and females are not desirable due to the anatomically and physiologically-related formant frequency differences that exist between males and females. To overcome this problem, several normalization techniques have been suggested.

Clopper (2009) reviewed several vowel-intrinsic and vowel-extrinsic computational methods for normalizing acoustic vowel data for talker differences. While none of those methods and algorithms claims to totally eliminate differences, due to the non-uniform scaling of the vocal tract length and shape, they aim at reducing such differences across talkers while keeping differences attributed to other factors such as gender, age and social class. Among those methods is Nearey's (1978) algorithm, which is a vowel-extrinsic scale-factor normalization algorithm. Clopper (2009) reported that this is the most widely used vowel-extrinsic scale-factor method and the most popular one among sociolinguists. According to Clopper (2009), the idea in this algorithm is to align the vowel spaces of each speaker at a single anchor point. To this end, each talker's individual raw formant frequency values were first log-transformed. Next, the mean log formant value across all vowels for each talker was subtracted from his/her individual formant values as in the following equation:

1) $f = g - r$

Where f is the normalized formant frequency, g is the log-transformed formant frequency, and r is the mean log formant value (scaling rate).

Figures 9-12 show the effect of the application of Nearey's (1978) normalization method on both plain and emphatic formant frequencies of /i/, /æ/ and /u/. For the sake of clarity, only the vowel onsets are plotted. The comparison between plain values before and after normalization following Nearey's (1978) method, as presented in Figures 9 and 10, shows that the vowel spaces of males and females yielded more overlap after normalization in terms of both F1 and F2, suggesting that the anatomically-related formant frequency difference between the males and the females was reduced.

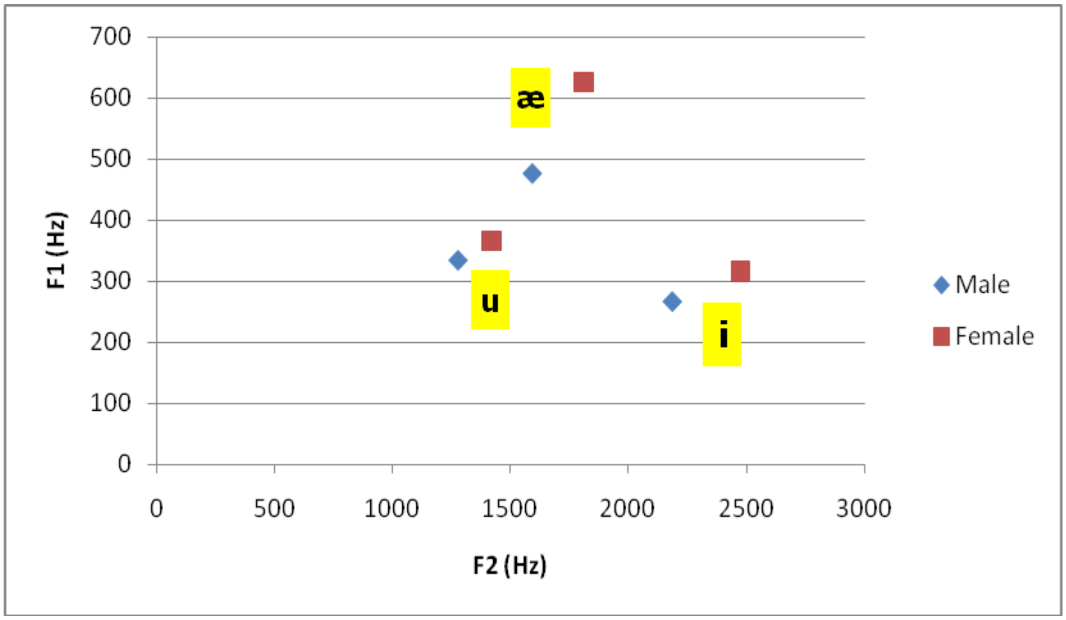

Figure 9: Plain values before normalization

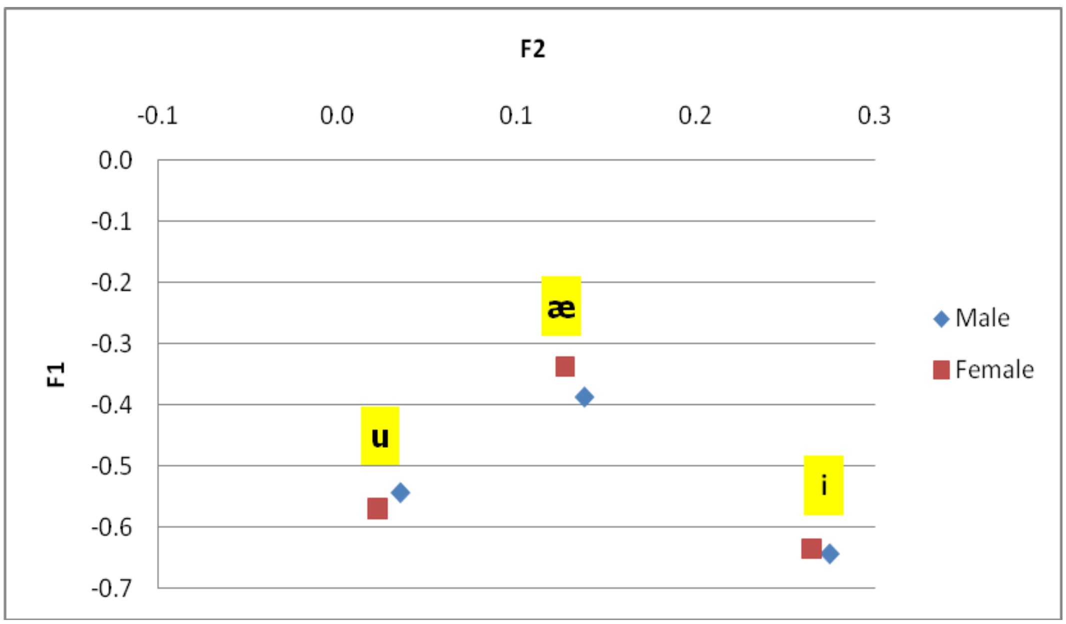

Figure 10: Plain values after normalization

As presented in Figures 11 and 12 below, the emphatic vowel spaces of the male and the female speakers also show an increase in overlap between the male and female emphatic values at the vowel onsets following Nearey's (1978) normalization method. The approximation is clearer for the vowel /i/ than for /u/ and /æ/. The emphatic vowel spaces show a relative approximation between male and female F1 values after normalization. Actually, the male speakers have higher F1 than the female speakers for the vowels /u/ and /i/. Moreover, the normalized emphatic vowel space shows that the males have lower F2 values than the females for all of the vowels, especially for /æ/ and /u/.

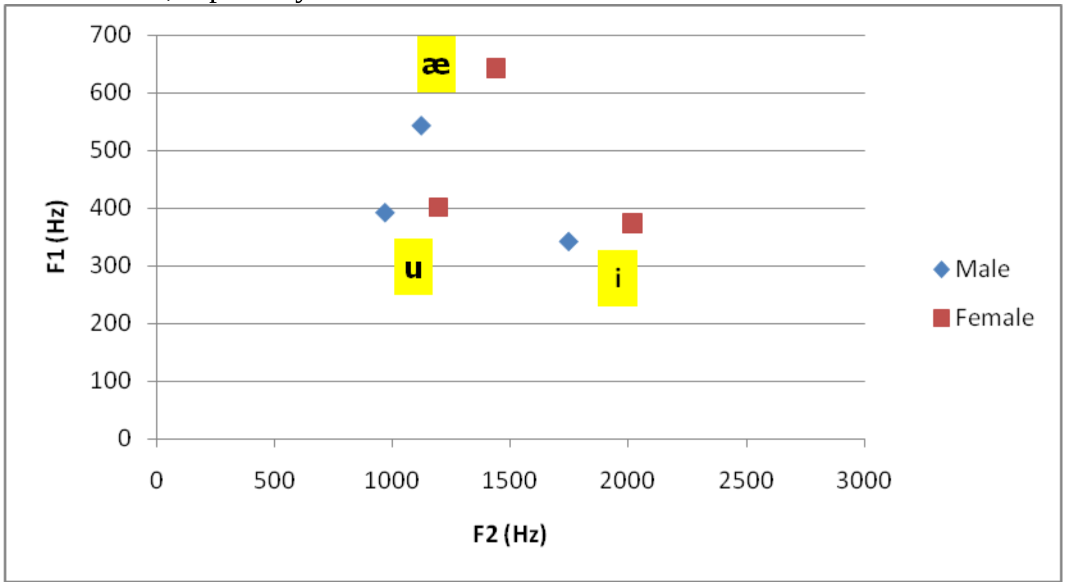

Figure 11: Emphatic values before normalization

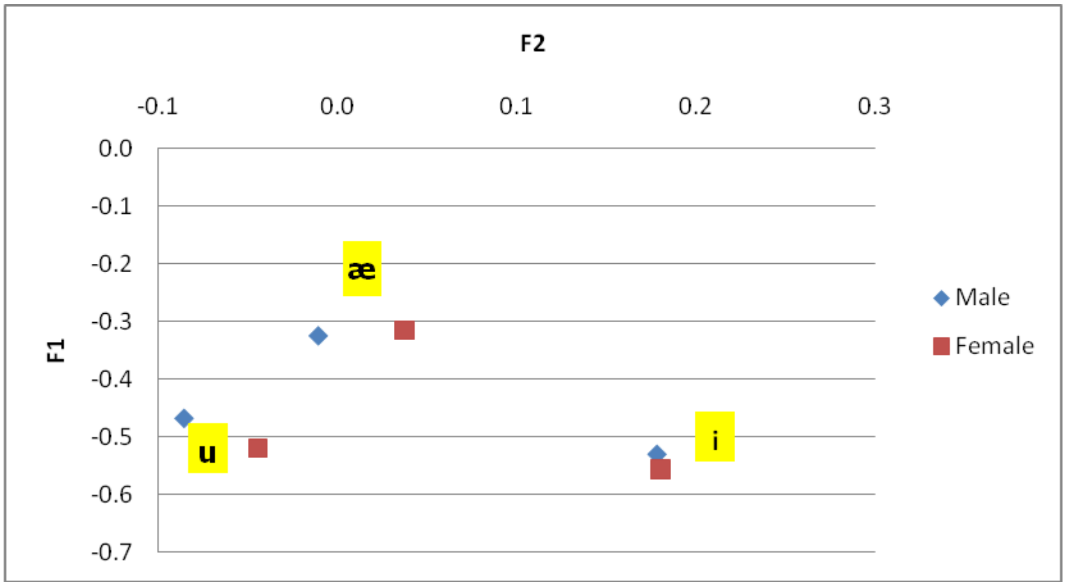

Figure 12: Emphatic values after normalization

The effectiveness of Nearey's (1978) normalization method was evaluated by examining the amount of overlap between the male and the female vowel spaces in both the plain and the emphatic environments as well as by assessing the main effect of gender on the formant frequencies. First, the comparison between the male and the female formant frequencies in the normalized plain vowel space (Figure 10) and in the normalized emphatic vowel space (Figure 12) suggests that Nearey's (1978) normalization method was more effective (in terms of the amount of overlap) in the plain environment than in the emphatic environment, especially for the vowels /æ/ and /u/. This suggests that there are factors other than the anatomical factor affecting the emphatic productions, probably gender (as opposed to sex). Second, the comparison between the normalized plain space and the normalized emphatic space for the male speakers (Figure 13) and for the female speakers (Figure 14) reveals the difference between the plain and the emphatic vowel space was greater for males than for males.

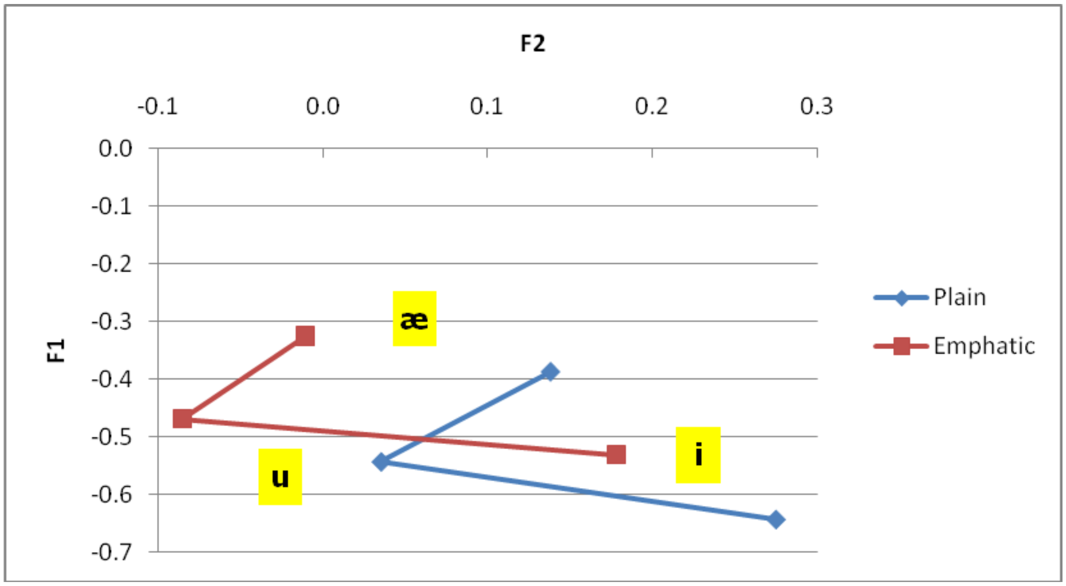

Figure 13: Normalized male plain and emphatic values at the vowel onset

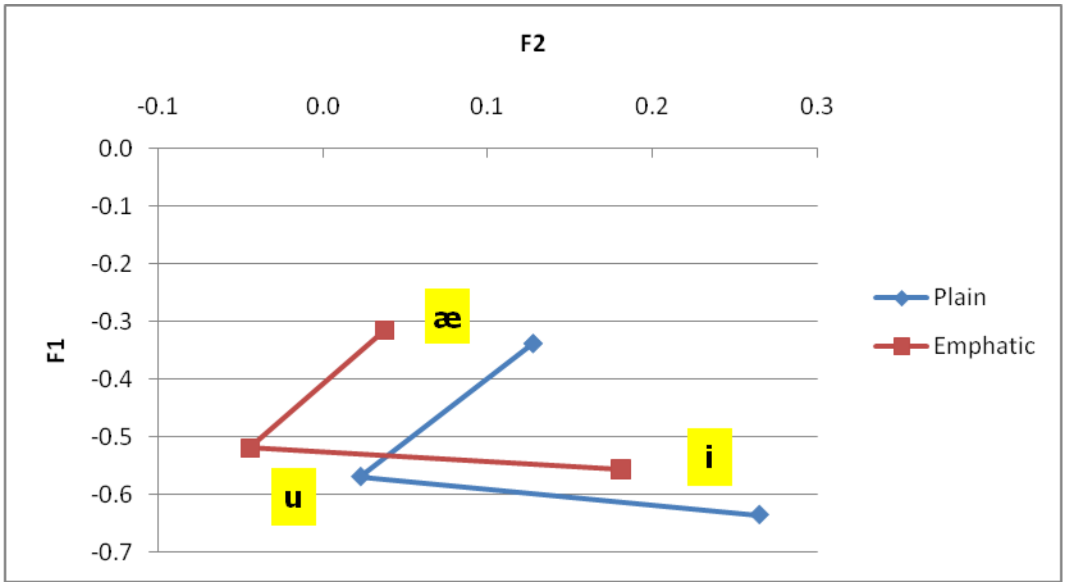

Figure 14: Normalized female plain and emphatic values at the vowel onset

Contrary to the results found prior to normalization, multiple Repeated Measures ANOVAs indicated that Gender, a between-subjects factor, did not have a significant main effect on the normalized F1 and F2 values throughout the vowel. A one-way Repeated Measures ANOVA indicated that the difference between the male and the female F1 values was not significant at the vowel onset [$F(1, 20) = .03$, $p > .865$], midpoint [$F(1, 20) = 2.51$, $p > .129$], and offset [$F(1, 20) = 2.62$, $p > .121$]. Also, the difference between the male and the female F2 values was not significant at the vowel onset [$F(1, 20) = .27$, $p > .613$], midpoint [$F(1, 20) = .36$, $p > .555$], and offset [$F(1, 20) = .61$, $p > .446$]. This result suggests that normalization indeed eliminated the anatomically-related formant frequency differences between the male and the female speakers in terms of F1 and F2. However, there was still a main effect of Gender on F3 at the vowel onset [$F(1, 20) = 6.16$, $p = .022$] and midpoint [$F(1, 20) = 9.72$, $p = .005$], but not at the offset [$F(1, 20) = 4.08$, $p > .057$], suggesting that Nearey's (1978) normalization algorithm was less effective for F3.

Two-way Repeated Measures ANOVAs were conducted to evaluate the interaction between Emphasis and Gender for the normalized plain and emphatic F1-F3 values at the vowel onset, midpoint, and offset. There was a significant interaction between Emphasis and Gender for F1 at the onset [$F(1, 20) = 5.35$, $p = .032$] and midpoint [$F(1, 20) = 5.77$, $p = .026$], but not at the offset [$F(1, 20) = 3.15$, $p > .091$]. At both the onset and midpoint, emphasis was more pronounced (in terms of F1 raising) for the male speakers than for the female speakers. Moreover, there was a significant interaction between Emphasis and Gender for F2 at the vowel onset [$F(1, 20) = 6.47$, $p = .019$] and midpoint [$F(1, 20) = 7.29$, $p = .014$], but not at the offset [$F(1, 20) = .50$, $p > .488$]. At both the onset and midpoint, emphasis was more pronounced (in terms of F2 lowering) for the male speakers than for the female speakers. Finally, there was no significant interaction between Emphasis and Gender for F3 at the onset [$F(1, 20) = .07$, $p > .794$], midpoint [$F(1, 20) = 1.7$, $p > .207$], and offset [$F(1, 20) = .11$, $p > .740$].

3 General discussion

The results of this study showed that VOT is a reliable acoustic correlate of emphasis in Jordanian Arabic only for voiceless stops. Emphatic VOT of voiceless stops was significantly shorter than plain VOT of voiceless stops regardless of gender. This confirms the results reported by Khattab et al. (2006) that VOT of /tˤ/ was significantly shorter than VOT of /t/ in Jordanian Arabic for both males and females. As for voiced stops, no significant difference between plain and emphatic VOT was found. The relatively shorter emphatic VOT in the case of voiceless stops is an acoustic consequence of the articulatory configuration of emphatic consonants, which are characterized by an increased contraction of the pharyngeal muscles (Lehn, 1963). Khattab et al. (2006) argued that "[g]reater delay in the onset of voicing strongly indicates that the forces of tension around the glottis are weaker during the hold phase of the plosive and the vocal folds are further apart, taking longer to come together for the commencement of voicing" (p. 156). Taking this together, it seems that the pharyngeal constriction, a secondary articulation of emphasis, increases the tension of the vocal tract during the closure phase of the voiceless emphatic stop resulting in a shorter delay in the commencement of voicing, i.e. shorter VOT. Moreover, emphatic fricatives were shorter than plain fricatives. However, the spectral mean of fricatives was not a reliable acoustic correlate of emphasis. This result is in line with the results of Jongman et al. (in press), who reported that the spectral mean of fricatives was not a reliable acoustic correlate of emphasis in Jordanian Arabic.

To summarize the vocalic acoustic correlates of emphasis in Jordanian Arabic, as recorded in this study, the results showed emphatic vowels were longer in duration than plain vowels. Also, the emphatic vowels were characterized, in general, by a raised F1, lowered F2, and raised F3 relative to the corresponding values of the plain vowels. More specifically, F1 at both the onset and midpoint of the vowel, F2 throughout the vowel, and F3 at the onset and offset were characterized by F-patterns in the directions predicted by emphasis. These results, especially F2 lowering, are in line with the findings reported in the literature for Jordanian Arabic (Al-Masri and Jongman, 2004; Khattab et al., 2006; and Jongman et al., in press) and are in accordance with the acoustic consequences of the backing effect associated with emphatics (Royal, 1985; Wahba, 1993). Among the different vowel positions, the vowel onset experienced the greatest magnitude of change. In terms of the magnitude of change and the consistency across the two subject groups, F2 lowering was the most reliable acoustic correlate of emphasis in Jordanian Arabic.

When the male and female F-patterns were examined separately, it was clear that while both maintained overall acoustically distinct productions of plain and emphatic vowels, the male speakers showed statistically significant trends in the directions predicted by emphasis for F1 and F3, which were not present in the female data. While the male subjects increased their F1 significantly in the emphatic environment throughout the vowel, the increase was significant only at the onset of the emphatic vowel for the females. Moreover, while the emphatic F3 values were significantly higher than the corresponding plain values at both the vowel onset and offset for the male speakers, the difference was significant only at the vowel onset for the female speakers. In terms of the proportions of change in the formant frequencies, the male tokens showed statistically significant higher proportions of change in the directions predicted by emphasis for F1 throughout the vowel and for F2 at the onset and midpoint of the vowel. However, after the normalization of the data, the results indicated that emphasis was more pronounced in male speakers' vowels than in the female speakers' vowels in terms of F1 and F2 at both the vowel onset and midpoint.

In conclusion, the results of this study showed that emphasis was more acoustically evident in the speech of males than in the speech of females. In terms of the direction of the gender effect, the results of the current study are in line with the results reported by the majority of studies that investigated the gender effect on the production of emphasis in different dialects of Arabic such as Ahmad (1979), Royal (1985), and Wahba (1993) for Egyptian Arabic as well as Khattab et al. (2006) for Jordanian Arabic.

3.1 Sociolinguistic Account

In this section, the sociolinguistic implications and potential motives of the gender-related variation in the production of emphasis in Jordanian Arabic will be discussed. Gender-related variation in the production of emphasis in different dialects of Arabic, especially Egyptian Arabic, has been reported in a number of studies (Kahn, 1975; Ahmad; 1979; Royal; 1985, Wahba, 1993, Al-Masri and Jongman, 2004; Khattab et al., 2006; Almbark; 2008). The Arab woman's tendency to avoid fully emphatic or total pharyngealized segments, to use Royal's (1985) term, was found in most of these studies (e.g., Ahmad; 1979; Royal; 1985, Wahba, 1993; Khattab et al., 2006). Having shown that emphasis was more acoustically evident in the speech of males than in the speech of females, this section will evaluate some of the possible sources of this variation. The potential sources to be reviewed here are: the interplay of extra-linguistic factors, a universal tendency for women to front back segments, social expectations and stereotyping, aspiration to prestigious forms, and feminism.

Variationist sociolinguistic research shows that gender may interplay with other extra-linguistic factors such as age, education, class, and regional affiliation (Labov, 1972; Royal, 1985). The variables age and education, which have been reported to affect the production of emphasis and other linguistic variables in Arabic (e.g., Royal, 1985; El Salman, 2003), are not expected to have an impact on the variation in the production of emphasis in the present study as all of the participants fell into the same age group (19-23 years) and shared the same level of formal education at the time they were recruited for the experiment. As for the regional dialect, the participants were speakers of the Northern Urban dialect of Jordanian Arabic and were recruited from Al al-Bayt University in the north of Jordan. Moreover, given that the participants' task was to read a list of words, most of which were taken from Jordanian MSA, it seems legitimate to propose that the participants opted away from their regional dialect(s) into a more standard variety of Arabic following Ferguson's (1959) original formulation of diglossia in Arabic. Ferguson (1959) argued that the Arabic standard (H) and non-standard (L) variants are in complementary distribution. He stated that reading is one of the settings that trigger the use of the standard variant. Thus, I argue that the observed differences in the production of emphasis between males and females in the current study can be solely, or at least mainly, attributed to gender rather than to age, education, regional dialect, or style (formal vs. informal).

The fronting of back segments had been earlier reported by Labov (1972) as a universal sociolinguistic marker of women's speech. However, Labov's (1972) universal account may fall short in accounting for linguistic practices, such as those reported by Abd-el-Jawad (1981), who documented the well-known linguistic practice of the speakers of Jordanian Arabic to opt away from the production of pharyngeal /q/ into /ʔ/ for females and into /g/ for males. Results such as those reported by Abd-el-Jawad (1981) and El Salman (2003) reveal a tendency for Arab men to front back segments even more than Arab women. Therefore, it seems that Labov's (1972) universal account may not be the best account for the gender differences in the production of emphasis as reported in this study.

The social expectations of the speech of women and men are different given the stereotypes associated with each of them. While the speech of men is viewed as tough, formal, and rural, the speech of women is socially expected to be softer, less formal, and more urban (Eckert & McConnell-Ginet, 1999; El Salman, 2003). Previous studies argued that emphasis is socially viewed as part of the masculine stereotype or as a characteristic of the male-dominated language in the Arab World (Royal, 1985; Wahba, 1993). Wahba (1993) reported that the variation in the production of emphasis in Egyptian Arabic was mostly correlated with gender stereotypes, with the greater degree of emphasis reflecting masculinity and the lack, or lower degree, of emphasis reflecting femininity. Badawi (1973), glossed in Khattab et al. (2006), Royal (1985) and Wahba (1993), argued that there is a negative correlation between the degree of emphasis, thickness according to him, on the one hand, and fashion as well as the "degree of cultural attainment and conformity of modern age" (p. 158) on the other hand. According to Badawi (1973), as reported in Khattab et al. (2006), this negative correlation reaches its maximum for women, who show the most dramatic tendency to front emphatic segments.

There is a reliable body of literature reporting the woman's tendency to aspire to prestigious variants, a tendency which is less evident in the speech of men. Labov (2001) argued that "women show a lower rate of stigmatized variants and a higher rate of prestige variants than men" (p. 266). Eckert & McConnell-Ginet (1999) argue that women are more status conscious than men. The sociolinguistic investigations of the variation in the use of Arabic have shown patterns that support this conservative practice of women (e.g., Abd-el-Jawad, 1981; El Salman, 2003; Sadiqi, 2005). Given that less emphatic variants (i.e., lesser degree of emphasis) are perceived socially as more modern and urban, it seems plausible to argue that Jordanian female speakers favor less emphatic productions seeking for prestige. However, a number of studies reported that women may adopt a local variant or even a heavily stigmatized variant (e.g., Milroy et al., 1994; Daher, 1997). Even though these studies argued that women grant prestige to their adopted variants by associating them with higher norms, it is still unclear how prestige would be the motive for them to adopt stigmatized variants. It may seem more plausible to argue that the prestige associated with women's variants is a byproduct of their linguistic choice rather than the motive for their choice. This proposal may gain support from Milroy et al.'s (1994) argument on the role of women in creating prestigious norms in their speech communities.

An alternative account for the observed patterns in the speech of women is to argue for a woman's tendency to favor variants different from those of males whether these forms are standard, local or even stigmatized. This argument is maintained by Sadiqi (2005) and feminist linguists such as Cameron (1985). The feminism account of gendered speech, as outlined by Cameron (1985) and Crawford (1995), attributes the women's linguistic practices that are different from those of men to two interrelated sources: gender social identity and women's oppression. Al-Ali (2006) documented "the dominance of the masculine authority in Jordanian society, in the sense that the roles of men and women are not distributed equally between them, as men remained the guardians of women before and after marriage" (p. 710). Cameron (1985) argues that women, feeling unequal and unsafe in their speech communities, have an urgent need to project their distinct social identity, which drives their distinct linguistic practices. Cameron (1985) explains that "[t]he differing speech of the two sexes is thus seen as a function of their differing roles; it derives from, and expresses, a whole complex of factors associated with social maleness/femaleness, including particular personality traits (e.g. in our culture, masculine aggression and feminine passivity) and identity markers which derive from the sexual division of labour" (p. 167). A similar argument was made by Sadiqi (2005), who argues that the Moroccan women's aspiration to varieties different from those of men, among which is French, is due to their feeling of oppression and inequality. Sadiqi (2005) explained that Moroccan women are excluded from domains where Standard Arabic is used, such as public media and politics, and hence their linguistic decision to opt away from the Standard Arabic, a male-dominated language according to her. This argument is supported by the proponents of the 'difference theory' and the 'dominance theory' (Uchida, 1992).

With the perceptual realization of emphatic sounds as heavy and dark (Walter, 2006), and the tendency for females to talk more delicately and softly than males (Crawford, 1995), the woman tendency, documented hereby in this study, to produce fewer cues to emphasis may be accounted for in terms of their tendency to keep their speech urban and, at the same time, avoid male-dominated linguistic norms should alternative norms exist. In doing so, women use fine acoustic details to project their distinct social identity. This tendency may provide an example of extending feminism as a political, economical and cultural movement into a linguistic movement where women opt to distinguish themselves linguistically from men. This account attempts, by no means, to rule out the role of prestige in driving women's linguistic choices. It just attempts to provide new insights in the gender-related variation in the production of emphasis as reported in this study. This study was an attempt to bridge the gap in studies investigating the effect of gender on the production of emphasis in Jordanian Arabic. Future studies may address issues, such as the interaction between emphasis productions, on the one hand, and other extra-linguistic factors such as social class, education, and age on the other hand.

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