THE PRODUCTION OF EMPHASIS BY SECOND LANGUAGE LEARNERS OF ARABIC

BY

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Abstract

The purpose of this study was to examine the production of emphasis by American L2 learners of Arabic. Nineteen participants, 5 native speakers and 14 L2 learners participated in a production experiment in which they produced monosyllabic CVC pairs that were contrasted in terms of whether the initial consonant was plain or emphatic. The acoustic parameters that were investigated are VOT of voiceless stops, COG of fricatives, and the first three formant frequencies (F1-F3) of the target vowels. The results of the native speakers showed that VOT is a reliable acoustic cue of emphasis in Modern standard Arabic. The results also showed that vowels in the emphatic context have higher F1 and lower F2. As for F3, the results showed that vowels have higher F3 in the context of emphatic fricatives only. The results of the L2 learners showed that the L2 learners produced comparable VOT values to those of native Arabic speakers. The beginning learners did not differ from the intermediate learners on the VOT measure. The results also showed that the L2 learners produced a significantly lower F2 of the vowels in the emphatic context. The results of F2 also showed that the effect of emphasis was larger for /æ/ than /i/ and /u/; however, /i/ and /u/ did not differ from each other with regard to the effect of emphasis. Proficiency in Arabic played a role on the F2 measure; the intermediate learners tended to be more native-like than the beginning learners. As for F3, the results of the L2 learners unexpectedly showed that the beginning learners produced a higher F3 in the context of fricatives only.

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Chapter One

Introduction and Literature Review

1.1. Debates on the Articulatory Correlates of Emphasis

Emphasis is a phonetic and phonemic feature characteristic of Semitic languages such as Arabic, Hebrew, and Ethiopic-Ge'ez. For example, the words /tæb/ "he repented" and /tˤæb/ "he recovered" contrast in terms of whether the first consonant is plain or emphatic. Card (1983) reported that "the term 'emphasis' refers to a secondary articulation common in Arabic" (1). According to Jongman, Herd, Al-Masri, Sereno, and Combest (2010), the primary constriction usually occurs in the dental or alveolar region, and the secondary constriction occurs in the back of the vocal tract. Although much articulatory research has been done on emphasis in Arabic, there is still no consensus on the precise nature of the secondary constriction occurring in the back of the vocal tract. This might be due to the different dialects that have been studied, experimental limitations, and the articulatory complexity of emphasis. In fact, articulatory research on emphasis was first conducted by the medieval grammarians of Arabic, Sibawayh and Ibn Sina. For a detailed description of their claims about emphasis see Card (1983: 7-14) and Zawaydeh (1999: 24-25).

All the different articulatory definitions of emphasis proposed agree that an articulation in the back of the vocal tract is involved. Lehn (1963) defined emphasis in Cairene Arabic as:

> the cooccurrence of the first and one or more others of the following articulatory features: (1) slight retraction, lateral spreading, and concavity of the tongue and raising of its back (more or less similar to what has been called velarization), (2) faucal and pharyngeal constriction (pharyngealization), (3) slight lip protrusion or rounding (labialization), and (4) increased tension of the entire oral and pharyngeal musculature resulting in the emphatics being noticeably more fortis than the plain segments. (30-31)

Lehn's (1963) definition reflects the articulatory complexity of emphasis in Cairene Arabic. It also shows that there are different types of emphasis existing in Cairene Arabic. According to him, the first two articulatory features listed above, namely velarization and pharyngealization, are the most crucial features for all emphatic segments in all contexts in Cairene Arabic. Lehn's (1963) definition of emphasis is, to some extent, compatible with that of Watson (1999) where she claimed that in Sˤænʕæ:ni Arabic spoken in Yemen, emphatic sounds are labialized and pharyngealized simultaneously. It should be noticed here that the above mentioned definitions are rather impressionistic and not based on physiological studies of the articulation of emphasis.

To examine the precise nature of the secondary constriction occurring in the back of the vocal tract during the production of emphasis, Laufer and Baer (1988) conducted both a physiological and acoustic study of the pharyngeal and emphatic consonants in Arabic and Hebrew. Laufer and Baer used a fiberscope in the physiological part of the study. The four dialects of Arabic studied were those spoken in Beirut, Lebanon and Nablus, Israel. The other two dialects of Arabic were spoken in Baghdad, Iraq and Beer-Zeit, Israel. Laufer and Baer's findings showed that pharyngeal and emphatic consonants exhibit the same articulatory gestures in the pharynx. The epiglottis makes a constriction against the pharyngeal wall, and the tongue root retracts backwards. However, in the production of emphatic consonants, the constriction is less than that involved in the production of pharyngeal consonants. This may be due to the fact that the pharyngeal constriction in the production of pharyngeals proper is primary, not secondary. In their analysis of the acoustic correlates of emphasis, Laufer and Baer compared the formant values of vowels in the context of plain and emphatic consonants. According to their acoustic results, the pharyngeal constriction in the production of emphatic consonants was accompanied by a lowered second formant frequency (F2) and a slightly raised first formant frequency (F1) of the vowel.

Laufer and Baer's (1988) findings provided evidence against previous and subsequent claims that emphasis involves velarization (Lehn, 1963; Norlin, 1978; Hetzron, 1998). According to Laufer and Baer's (1988: 196) biomechanical account, "if there is a primary articulation at the front of the mouth and the root of the tongue bulges backwards, then velarization cannot occur simultaneously, due to the fact that tongue volume remains constant. On the contrary, it is likely that the tongue dorsum in the velar region will lower rather than rise." In fact, their biomechanical account refuted Lehn's (1963) claim that some emphatic consonants in Cairene Arabic involve velarization and pharyngealization at the same time.

McCarthy (1994) provided a definition of emphasis that deviated from all the ones discussed above. He argued that emphatic sounds are uvularized, not pharyngealized (or velarized). McCarthy's argument is supported by Zawaydeh's (1999) study of the phonology and phonetics of gutturals of Jordanian Arabic spoken in Amman, the capital city. On the other hand, Al-Tamimi, Alzoubi, and Tarawnah (2009) conducted a videofluoroscopic study of the emphatic consonants in Jordanian Arabic and argued against Zawaydeh's (1998, 1999) results. The results showed that emphatic consonants are produced with pharyngealization. The tongue root moves back into the oropharynx causing the elevation of the hyoid bone and raising of the larynx.

1.2. Acoustic Studies of Emphasis

Much research exists on the acoustic correlates of emphasis in Arabic. Each study concentrated on a specific dialect of the Arabic language. In the following section, I will review some of the major studies in the field that made efforts to describe the acoustic correlates of emphasis in Arabic. It is worth mentioning here that the consensus of all the acoustic studies that investigated the acoustic correlates of emphasis in Arabic is that the second formant frequency (F2) of vowels in the emphatic environment significantly lowers.

Card (1983) conducted a phonetic and phonological investigation of emphasis in Palestinian Arabic. The participants in the acoustic experiment of emphasis were four male native speakers of Palestinian Arabic spoken in rural and urban regions of Jerusalem. Two of the participants were from rural areas, and the other two participants were from urban areas. According to Card, no variation in emphasis spread existed between urban and rural dialects. The stimulus words consisted of monosyllabic, bisyllabic, and trisyllabic nonsense words and real words. The results of the acoustic experiment showed that lowering of the second formant frequency (F2) was the only major acoustic cue for emphasis in Palestinian Arabic regardless of whether the emphatic consonant was in word-initial or word-final position. The first formant frequency (F1) and the third formant frequency (F3) were not affected by emphasis. According to Card (1983), emphasis mostly affected the low and back vowels, i.e., /æ/ and /u/, and their long versions /æ: / and /u: / as well as the long back vowel /o:/. However, Card did not mention where in the vowel she measured the formant frequencies.

In an acoustic investigation of another dialect of Arabic, Wahba (1993) examined the acoustic correlates of emphasis in Egyptian Arabic spoken in Alexandria. Wahba used monosyllabic and disyllabic word pairs. F1 and F2 were measured at the onset and middle of the vowels. The results showed that there was no significant difference in F1 values in the emphatic and non-emphatic environments. As for F2, it was significantly lowered in the emphatic environment at the onset and middle of the vowels. The vowels that were mostly affected by emphasis in terms of lowering of F2 were the low central vowels / æ, æ: /. These results are compatible with Card's (1983) in that F2 lowers significantly in the environment of emphatic sounds, but not F1. However, Card (1983) reported that the back vowel /u/ is mostly affected by emphasis in addition to the vowel /æ/.

In a more recent investigation, Al-Masri and Jongman (2004) examined the acoustic correlates of emphasis in the northern dialect of Jordanian Arabic. The participants were five male and three female speakers living in Lawrence, Kansas. Their list of words consisted of monosyllabic, bisyllabic, and trisyllabic words and nonwords. The emphatic consonants occurred in word-initial, word-medial, and word-final position. The results showed again that F2 of the vowel was significantly lowered in the emphatic context.

More converging evidence that supported the findings of previous studies was provided by Khattab, Al-Tamimi, and Heselwood (2006). They addressed the acoustic correlates of /tˤ/ in the speech of males and females. The participants were five male and five female speakers of Jordanian Arabic. All male and two of the female speakers were from Irbid, a city in the northern part of Jordan. The other three female speakers were from the capital city of Jordan, Amman. Khattab et al. (2006) reported that F2 of vowels was significantly lowered in the emphatic environment of /tˤ/, and F1 was significantly raised. F1 and F2 were measured at the onset of the vowel. As for VOT, /t/ has a significantly longer VOT than /tˤ/.

Recently, Al-Masri (2009) addressed the acoustic and perceptual correlates of emphasis in urban Jordanian Arabic. The participants in the study were four male and four female speakers. The word pairs were either monosyllabic or bisyllabic where the emphatic consonants occurred word-initially, word-medially, or word-finally. All formant frequencies were measured at the onset, middle, and offset of the vowel in the emphatic and non-emphatic environments. For monosyllabic words, the findings showed that F1 was raised in emphatic contexts at all three positions; however, the effect of emphasis was gradient. In other words, the closer the vowel measurement to the emphatic consonant, the higher F1 was. Concerning F2, the results showed that it was lowered in emphatic environments at all three vowel positions. The results also showed that the high back vowels /u, u:/ are less affected by emphasis than high front and low front vowels /i, i:/ and /æ, æ:/, respectively; According to Al-Masri, the low front vowels /æ, æ:/ showed the largest drop of F2 at the midpoint. This supported Wahba's (1993) findings in that high back vowels are among the least affected by emphasis. This also supported Card (1983) in that the low vowels are among the most affected by emphasis. In terms of F3, the results showed that it was raised in emphatic environments. The results also showed that the center of gravity for the emphatic stops was higher than that for the non-emphatic stops, and the emphatic fricatives had a lower center of gravity than the plain ones.

Regarding bisyllabes, Al-Masri (2009) reported that F1 generally increased when the vowel was the in same syllable as the emphatic consonant, and to a lesser degree when the vowel was not in the same syllable as the emphatic consonant. As for F2, the results showed a significant drop in the environment of emphatic consonants. F3 was significantly raised in emphatic contexts. For a more detailed account of the three vowel positions in monosyllables and bisyllabes, see Al-Masri (2009: 113-116). Al-Masri's (2009) results supported Khattab et al.'s (2006) in that F1 is a potential acoustic cue for emphasis and provided further evidence that F2 is the main acoustic cue of emphasis in Arabic. His results also provided more acoustic cues for emphasis, i.e., center of gravity.

In another recent study, Abudalbuh (2010) examined the effects of gender on the production of emphasis in Jordanian Arabic. The participants were twelve male and ten female native speakers of Jordanian Arabic. The word pairs were monosyllables with the target consonants in word-initial position. The results showed that, as in Khattab et al. (2006), VOT of the emphatic plosives was shorter than that of the plain plosives .As for F1, the results showed that it was raised in the emphatic environment at the beginning and middle of the vowel. This provided support for Khattab et al. (2006) and Al-Masri (2009). Concerning F2, it was lowered in the emphatic environment in all three vowel positions. F3, as in Al-Masri (2009), was raised in the emphatic context at the beginning and end of the vowel. F2 lowering provided support for the claim that emphasis spread is gradient (e.g., Al-Masri, 2009). F2 lowering was gradual from the beginning to the end of the vowel where the onset of the vowel exhibited the greatest F2 lowering. As in most of the studies that are reviewed, the low vowels /æ, æ: / were the most affected by F2 lowering at the midpoint. Unlike Al-Masri (2009), there was no significant difference in terms of spectral mean for emphatic and plain fricatives.

In the latest phonetic study of Jordanian Arabic, Jongman et al. (2011) dealt with the acoustics and perception of emphasis in urban Jordanian Arabic. The subjects were six male and six female speakers of urban Jordanian Arabic spoken in the city of Irbid. The stimulus words were monosyllabic words and nonsense words. The emphatic consonants were either in word-initial or word-final position. The formant frequencies (F1-F3) were measured at the onset, middle, and offset of the vowel. The results showed that F1 and F3 were raised, and F2 was lowered in the emphatic environment at the three vowel positions. The results were highly consistent regardless of whether the emphatic consonant was in word-initial or word-final position. The vowel most affected by emphasis was the low vowel /æ/ where emphasis is maintained throughout its entirety. However, vowel quantity had no effect on emphasis except for F3 at the beginning of the vowel. This is consistent with the previous studies (Card, 1983; Wahba, 1993; Al-Masri, 2009; Abudalbuh, 2010). As for spectral mean (center of gravity), Jongman et al. (2011) reported results that were inconsistent with those of Al-Masri (2009). The spectral mean of emphatic plosives was significantly lower than that of non-emphatic ones; this held true regardless of whether the target consonant occurred word-initially or word-finally. Emphatic fricatives were not significantly different in spectral mean from plain ones, as in Abudalbuh (2010).

In sum, most previous acoustic studies on emphasis showed that the first three formant frequencies (F1-F3), especially the second formant (F2), and VOT are reliable acoustic cues for emphasis; F1 and F3 are raised and F2 is lowered in the vowel occurring in emphatic environments. VOT of emphatic plosives is shorter than that of plain counterparts. In addition, spectral mean, especially that of plosives, might also serve as an acoustic cue for emphasis. Finally, among all vowels, /æ/ and /æ:/ are most affected by emphasis.

1.3. Second Language Acquisition and L2 Speech

There are numerous studies that examined the acquisition of second language grammar and the phonetic/phonological system. However, this review will largely focus on those studies that establish the groundwork for this study. I will first review some of the studies that dealt with the Critical Period Hypothesis (CPH), and I will then review some of the major studies that addressed the pronunciation of second language.

Lenneberg (1967) established the critical period hypothesis as a working hypothesis arguing that acquiring first language in a native-like manner depends on the L1 learner's age of acquisition. He maintained:

> "We are, therefore, suggesting as a working hypothesis that the general, nonspecific states of the maturation of the brain constitute prerequisites and limiting factors for language development." (169)

Lenneberg suggested that there is a critical stage starting at the age of two and ending at about thirteen years in which a learner is able to acquire his/her first language from mere exposure in a native-like manner. Due to neurological changes in the brain, learning a first language after this phase is a lot harder and will never reach perfection. It is worth mentioning here that according to Lenneberg, language acquisition has to be implicit and unconscious.

A great deal of research has been conducted by second language researchers to test the effect of maturation on learning the grammar of a second language. It has been shown that early exposure to second language input is a prerequisite for attaining native-like proficiency in the L2 grammar (Johnson and Newport, 1989; DeKeyser, 2000). However, it has often been cited in the literature that a few adult L2 learners can also attain native-like proficiency in their L2 grammar despite having learned the L2 after the offset of the critical period (Boxtel, Bongaerts, and Coppen, 2003; Reichle, 2010).

According to Bley-Vroman's (1988) Fundamental Difference Hypothesis (FDH), Universal Grammar (UG) serves a key guidance role in child language acquisition. Adults, on the other hand, do not have access to UG. In other words, children have been claimed to rely on domain-specific mechanisms in language acquisition, whereas adults have been claimed to rely on domain-general mechanisms, i.e., general problem-solving skills. Therefore, the level of verbal analytical ability predicts the ultimate proficiency an adult can attain in L2.

Research on the critical age effects has led to the conclusion that there are multiple critical periods affecting various aspects of L2 acquisition at different times, and the ability to produce L2 with a native-like accent is the first ability to be lost around the onset of puberty (Seliger 1978; Walsh and Diller 1981). According to Scovel (1988), pronunciation is the only aspect affected in L2 acquisition by a critical period. Scovel predicted that after age 12, foreign accent in the L2 is inevitable. Flege (1981) argued that there is no fundamental difference existing between adult and child L2 learners in the ability of phonetic learning; neurological changes (in the brain) might not be the cause of foreign accent in the speech of late L2 learners. According to Flege (1981: 443), “phonological translation provides a two-language source of phonetic input that may ultimately limit progress in learning to pronounce a foreign language.”

1.4. The Speech Learning Model (SLM)

The Speech Learning Model (SLM) was developed by Flege (1995) as a model of L2 speech acquisition. Flege (1995) reported that SLM attempts to model the level of success highly-experienced L2 learners will achieve in the perception and production of L2 sounds. Therefore, SLM makes predictions about how L2 learners will perform in L2 speech perception and production based on the perceived phonetic distance that exists between the L1 and L2 sounds. The SLM accounts for L2 speech learning and how it affects the phonetic categories formed during L1 acquisition. The predictions made by SLM regarding the degree of accuracy with which highly experienced learners will perceive and produce L2 sounds can be tested empirically. The SLM posits that the speech learning mechanisms (e.g., the ability to form phonetic categories) that are employed in the acquisition of L1 can also be exploited in L2 acquisition. The SLM also makes the hypothesis that L2 learners are capable of forming new phonetic categories depending on whether they detect adequate phonetic dissimilarities existing between L1 and L2 sounds; discernibility of phonetic differences between L2 and L1 sounds depends on the perceived phonetic distance existing among them. In terms of SLM, establishing new phonetic categories will enable L2 learners to perceive and produce L2 sounds in a native-like fashion with significantly less interference from the L1.

1.5. Second Language Speech Production Studies

Flege (1980) investigated the production of the English voiceless stops /p t k/ and the voiced English stops /b d g/ by native speakers of Saudi Arabic who are L2 learners of American English. The acoustic contrast between voiced and voiceless stops in English is different from that in Arabic. Lisker (1957) studied the contrast between English /b/ and /p/ in intervocalic position and reported that vowels preceding a voiced stop are much longer than those preceding a voiceless stop. Concerning the closure duration, English voiceless stops have longer closure duration (120 ms) than voiced stops (75 ms).

According to Lisker, Abramson, Cooper, and Schvey (1969), English voiceless and voiced stop consonants are differentiated in various sentence positions according to whether vocal fold vibration is present or absent during the hold phase. Flege (1979) found that the Saudi Arabic voiced and voiceless stop consonants differed word-finally in terms of whether voicing was present or absent during closure. Flege also found that the voiced and voiceless Arabic stops did not differ in closure duration, and the vowels did not differ in length before voiced and voiceless stops. Moreover, Saudi Arabic stops were found to have a shorter voice onset time (VOT) than the English ones word-initially.

The participants in Flege's study were twelve male Saudi Arabians divided into two groups – experienced vs. inexperienced. The third group consisted of six native speakers of American English. The task was to pronounce CVC word pairs.

The results showed that the Saudi Arabians produced the English stop voicing contrast in a way that was relatively similar to the stop voicing contrast found in Saudi Arabic. For example, the vowels preceding word-final voiceless and voiced stops did not differ in duration. VOT values of the English stops also resembled those of Arabic ones. However, it was clear that the more experienced participants' production of the voicing correlates was more English-like than that of the less experienced participants. The results were not consistent across all participants, and there was no individual speaker who equally produced all voicing correlates in an English-like fashion. Flege (1980) concluded that the Saudis' production of the voicing contrast was not simply a reflection of interference between Arabic and English. If it was interference, then the L2 learners, especially the more experienced ones, would not be able to produce values that deviated from the phonetic norm of Arabic and approximated those of English. According to him, the acoustic cues of the voicing contrast produced by the L2 learners were the product of an "interlanguage" where pre-existing phonetic patterns are continually modified to accommodate to the new ones in the L2.

Flege (1987) reported acoustic measurements of the VOT of /t/ and F1-F3 of the English vowel /u/ and French vowels /u/ and /y/ in French and English words. The purpose of the study was to investigate the production of new and similar sounds in L2. The English and French u-vowels are considered similar, and the French /y/-vowel is considered new to American L2 learners of French. Six groups of female speakers participated in the study. Two groups consisted of monolingual speakers of American English and French to establish the phonetic norms of both languages. Three groups consisted of native speakers of American English; most of them had their massive exposure to French in early adulthood in France. The three groups differed according to four factors. These were: experience in French, amount of education in French, length of residence in France, and the frequency French was spoken prior to the study. The last group consisted of native speakers of French who were highly experienced L2 learners of American English. At the time of the study, they had lived in the US for more than twelve years.

The stimulus material consisted of phrases beginning with the English word “two” and the French words “tous” and “tu”.

The results showed that the participants in all three groups of L2 learners of French produced the French vowel /y/ with an F2 that was only slightly lower than that for the group of French monolinguals. Only the least experienced group of L2 learners of French produced F2 values that differed significantly from the French monolinguals. However, all three groups of English native speakers produced significantly higher F2 values for the French vowel /u/ than the French monolingual speakers. Only the most experienced participants showed approximation of the F2 norm of French /u/. The least experienced group produced French /u/ with F2 value that was even higher than that for the English /u/. The participants who had experience in the middle range, seemed to replace the French /u/ with the English one. They produced the French /u/ with an F2 value that was almost identical to that produced in English /u/ by the monolinguals of English. Participants in the group of highly experienced L2 learners of English behaved differently than those in the group of L2 learners of French who had the same amount of L2 experience. Their English /u/ had an F2 value that was significantly higher than that of the /u/ of monolinguals of French and not significantly lower than that of the /u/ of English monolinguals. The author explained that this should not be taken as evidence against equivalence classification; the native French speakers produced an English /u/ that was only higher by 121 Hz when they switched to English. Flege reported that the variation in F2 values in American English is greater. According to him, the English monolinguals who participated in this study had not produced /u/ in the same way as the English speakers whose English the French participants in the most experienced group had been exposed to.

As for VOT results, the native French subjects produced the English stop /t/ with a VOT that was significantly shorter than that of the English monolingual speakers, and the native English participants produced the French stop /t/ with longer VOT; the participants who were the least experienced in French produced the French /t/ with a slightly shorter VOT than the English monolinguals. The participants with greater French-language experience produced more authentic French /t/; however, they differed significantly from monolinguals of French. The participants who were the most experienced with French did not differ significantly from French monolingual speakers. The author doubted that speakers of English who are the most experienced in French were native-like in their production of French /t/. He pointed out that his English-accented French might have influenced the French monolinguals that as a result accommodated their production of VOT to that of his by increasing VOT of French /t/. The results indicate that adult L2 learners are capable of establishing phonetic categories for new L2 sounds, and hence they can produce them in a native-like manner. However, equivalence classification blocks establishing phonetic categories for similar L2 sounds that are perceptually related to L1 sounds. As a result, the previously established phonetic categories in the L1 are constantly modified reflecting input from a two-language source. Accordingly, pronunciation of similar L2 sounds will approximate that of native speakers as more experience in L2 is gained.

Very recently, Saadah (2011) conducted a phonetic study to investigate the production of Palestinian-accented Modern Standard Arabic vowels by English L2 learners and heritage speakers of Arabic. For the purpose of this study, the focus will be on only the production of plain and emphatic Arabic vowels. The stimulus tokens consisted of real and nonsense CVb words. The target vowels that were investigated were the short Arabic vowels /i, u, æ/ and the long counterparts /i: u: æ/. The word-initial consonant was either emphatic or plain. The plain consonants were / ð t d s /, and the emphatic consonants were / ðˤ tˤ dˤ sˤ /. The first two formant frequencies (F1 and F2) were measured in the middle of the vowel. Three groups participated in the study. These were native speakers (6 participants), heritage speakers (12 participants), and L2 learners (12 participants). The heritage group consisted of 6 experienced and 6 inexperienced speakers of Arabic. The L2 learners group consisted of 6 advanced and 6 beginning learners. Each group included 3 males and 3 females. According to Saadah (2011), the native and heritage speakers spoke Palestinian Arabic, and the L2 learners of Arabic were taught Arabic by an Arab teacher who spoke Palestinian Arabic as well.

Saadah (2011) conducted only two-way ANOVAs where language experience and vowel pharyngealization were the independent variables. The results showed that F1 for the vowels /i i: u u:/ was slightly raised in the emphatic context across the three groups; the difference, however, did not reach significance. F1 for the low vowels /æ/ and /æ:/ was slightly lower in the emphatic environment. As for F2, it was significantly lower in the emphatic environment across the three groups. However, there was no interaction between language experience and vowel pharyngealization. In other words, the three groups patterned the same. It is worth mentioning here that this study did not look at the effect of other independent variables on emphasis, such as vowel quality, vowel quantity, manner of articulation, and voicing.

In light of the findings of the previous studies, more experienced L2 learners are expected to be more native-like in their production of emphasis than the less experienced L2 learners. In other words, the more experienced L2 learners' acoustic cues to emphasis are expected to be closer to those of native speakers.

1.6. Focus of the Present Study

This study aims at investigating the production of emphasis by native American-English speakers who are L2 learners of Arabic. To the best of my knowledge, only Saadah (2011) examined the production of emphasis by American L2 learners of Arabic. The acoustic cues that were examined in that study were F1 and F2 of the vowels in the context of emphatic and plain consonants. Moreover, only language experience and vowel pharyngealization were the independent variables. The present study is more comprehensive in terms of the acoustic cues to be examined; in addition to measuring F1-F3 values in emphatic and plain environments, the characteristics of the consonants are also examined by measuring the VOT of the voiceless emphatic and plain stops and the spectral mean of emphatic and plain fricatives. In addition, the effect of more independent variables on emphasis will also be examined in the production of emphasis by the L2 learners of Arabic; these are vowel quality, vowel quantity, manner of articulation, and voicing. The findings of the current study will be interpreted in light of the predictions of the Speech Learning Model (SLM).

The questions of the current study are:

1. Do native speakers and L2 learners maintain a contrast between plain and emphatic consonants in the following acoustic parameters: VOT of voiceless stops, COG of fricatives, and F1, F2, and F3 of the following vowels?
2. Is the production of emphasis influenced by experience with Arabic?
3. Is learners' production of the vowels in the emphatic context based on already existing English phonetic categories or on new phonetic ones?

To address the research questions, the hypotheses of the study regarding the acoustic cues of the emphatic vowels in the production of the L2 learners were made in light of a visual examination of Figure 1 which represents the acoustic space of both Arabic and English vowels.[1]

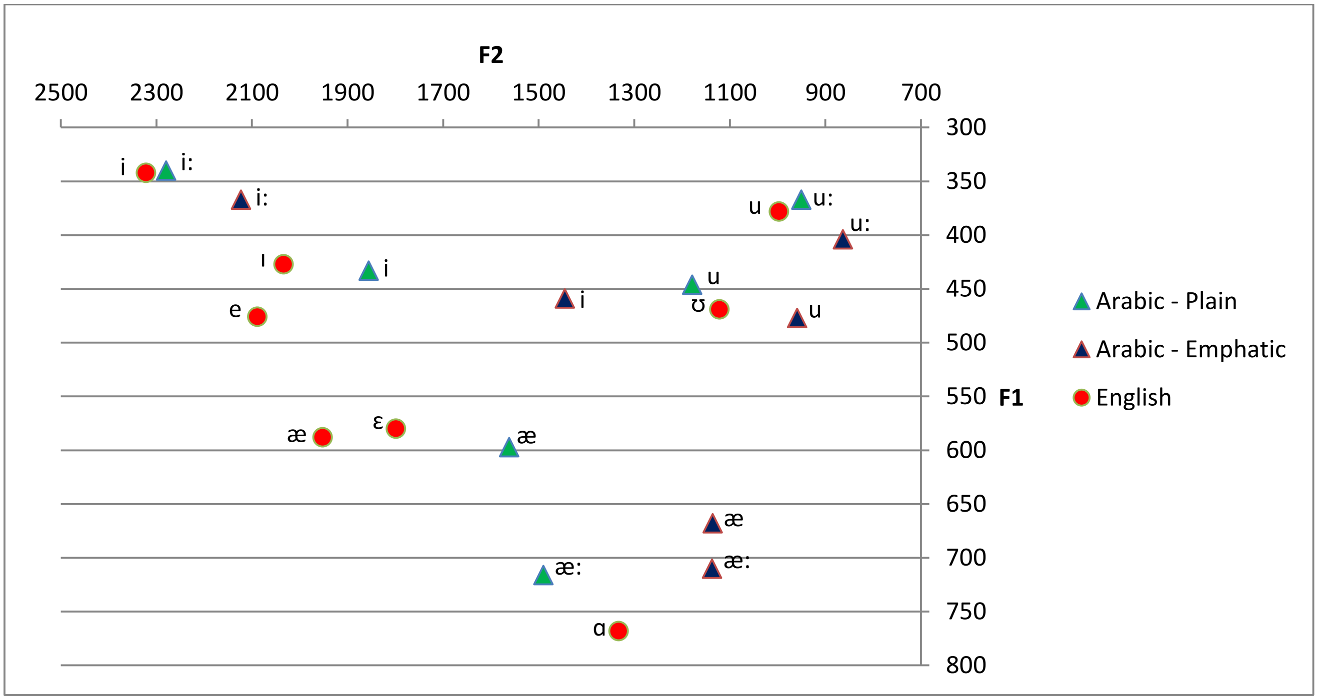

Figure 1: Acoustic space of Arabic and English vowels. Mean first and second formant frequency values (in Hz) are plotted for each vowel. English means are taken from Hillenbrand et al. (1995).

Based on the acoustic space, the distance between the Arabic vowels in the emphatic context and the English vowels is, to some extent, greater than the distance between the Arabic vowels in the plain context and the corresponding English vowels. Moreover, the Arabic vowels in the plain and emphatic contexts are fairly distant from each other. Therefore, the claim made in this study is that the Arabic vowels in the context of emphatic consonants should be perceived as phonetically different from the English vowels as well as from the Arabic vowels in the plain context.

[1] The values of the Arabic vowels (and consonants) collected from the native speakers in the present study were used before any of the measurements of the values of the Arabic vowels produced by the L2 learners were taken.

As for Arabic /tˤ/, it should also be perceived as phonetically dissimilar from English /t/ because the secondary articulation in the back of the vocal tract results in acoustically distinct properties (e.g., significantly shorter VOT and significantly lower F2 of the following vowel). Another likely scenario is that the L2 learners of Arabic assimilate the Arabic emphatic stop /tˤ/ into the English voiced stop /d/ which is produced with either negative VOT or short-lag VOT[2]. If Arabic /tˤ/ is perceived in terms of English /d/ and accordingly is produced as a short-lag stop, the L2 learners will still be able to distinguish the Arabic plain /t/ from the Arabic emphatic /tˤ. As for Arabic /ðˤ/ and /sˤ/, these also should be perceived as phonetically dissimilar from English /ð/ and /s/ because the secondary articulation in the back of the vocal tract also results in acoustically distinct properties (e.g., a significantly lower F2 of the following vowel).

In light of the above discussion, the following hypotheses are made:

1. Native speakers will produce vowels in the emphatic context with higher F1 and F3 and considerably lower F2.
2. Native speakers will produce /tˤ/ with considerably shorter VOT.
3. Native speakers might produce /sˤ/ and /ðˤ/ with significantly lower COG.
4. The production of emphasis by intermediate learners will be closer to that of native speakers than the beginning learners. However, they are not expected to match native speakers' emphatic values.
5. L2 learners will show evidence of establishing a new phonetic category for Arabic /tˤ/. Therefore, VOT of /tˤ/ will be shorter than that of /t/.
6. L2 learners might produce /sˤ/ and /ðˤ/ with significantly lower COG than /s/ and /ð/.

[2] VOT of /tˤ/ in the present study as produced by the native speakers of Arabic was 11 ms on average.

7. L2 learners will show evidence of establishing new phonetic categories for the vowels in the emphatic context. Therefore, L2 learners will be able to maintain the difference between plain and emphatic vowels' F1, F2, and F3.
8. Arabic /i/, /æ/, and /æ:/ in the emphatic context are more distant than /i:/, /u:/, and /u/ in the emphatic context from the corresponding English vowels; therefore, learners should produce /i/, /æ/, and /æ:/ in the emphatic context more native-like than /i:/, /u:/, and /u/.

Chapter Two

Acoustic Study

2.1. Methodology

2.1.1. Participants

The participants in this experiment were 14 learners of Arabic who had been studying Arabic for 1-4 years and 5 native speakers of Arabic[3]. The participants were 18-33 years old. The native Arabic speakers were recruited from the local community in Lawrence, Kansas. They were all native speakers of Saudi Arabic. All the native speakers of Arabic reported that Arabic was their dominant language at the time of the study. All of the American participants were students at the University of Kansas. All subjects reported normal speech and hearing. The participants were asked to fill out a background language questionnaire. All participants voluntarily participated in the study.

To estimate proficiency, a paper-and-pencil lexical decision task was administered. This task was designed to quickly test vocabulary knowledge for beginning and intermediate speakers of Arabic as a second language. The lexical decision task was adapted from Lemhöfer and Broersma's (2012) LexTALE test. The task consisted of 100 items selected from *Al-Kitaab fii Ta^{c}allum al-^{c}Arabiyya Part One*. It is the textbook for beginning Arabic that is used by students of Arabic in the Department of African & African-American Studies at the University of Kansas.

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[3] Nineteen L2 learners were first recruited. However, after the proficiency test was administered, three participants were excluded from the study; in the background language questionnaire, two of them indicated that they grew up learning Arabic, and the third one indicated that he was a graduate student in the Department of Linguistics at the University of Kansas. The other two participants were excluded because their D-prime scores fell right in the middle when the D-prime scores were ordered from the highest to the lowest score.

Fifty items were first taken from units 1 through 4. Most of these items were highly likely to be known by both beginner and intermediate L2 learners because units 1 through 4 are taught throughout the first semester of studying Arabic. The remaining 50 items were taken from units 5 through 8. These were more likely to be recognized by the intermediate L2 learners, but not beginners. These items were then ordered on the basis of their frequency of occurrence per 100,000 according to the Arabic corpus search tool (arabiCorpus) from Brigham Young University. The highest frequency items have a frequency between 206.93 and 31.08 (M = 57.16) per 100,000 occurrences, and the lowest frequency items have a frequency between 7.1 and 0.01 (M = 2.67) per 100,000 occurrences. Every other word was made into a nonword by changing one or two letters. However, all the nonwords are orthographically legal and pronounceable. The task was to draw a circle around "yes" if the test item was a word and around "no" if the test item was a nonsense word. The participants were instructed to draw a circle around "yes" for any word they thought was a real word even if they did not know its meaning. The D-prime statistic for performance in the lexical decision task was calculated to tease biases from sensitivity to real words. The d-prime scores for the 14 participants ranged from 1.056 to 2.485. L2 learners were then divided into two groups based on their d-prime scores. The group of intermediate learners consisted of the 7 participants whose d-prime scores were the highest (M = 2.3, SD = .20), and the group of beginning participants consisted of the 7 participants whose d-prime scores were the lowest (M = 1.32, SD = .24). In the group of intermediate learners, 1 participant had studied Arabic for 4 years, 2 participants for 1 year, and 4 participants for 2 years. In the group of beginning learners, 4 participants had studied Arabic for 1 year and 3 participants for 2 years.

2.1.2. Stimulus Materials

The production stimuli of this study consisted of a word list of 24 monosyllabic minimal pairs. All of them contained one of the long and short vowels /i: æ: u: i æ u /. The minimal pairs were contrasted in terms of whether the initial consonant was emphatic or plain. The target consonants in this study were /ð ðˤ/, /t tˤ/, /d dˤ/, and /s sˤ/ (e.g. /tæ:b/ and / tˤæ:b/. The minimal pairs that were used in this experiment are taken from Modern Standard Arabic (MSA). Nonwords were also used; all of the nonwords obeyed the phonological phonotactics of MSA. The list of tokens is provided in the appendix.

2.1.3 Procedures

The recording was performed in the anechoic chamber at the University of Kansas with a Marantz PMD-671 solid state recorder and an Electro Voice 767 microphone. The participants were provided with a written list of the minimal pairs used in this study. They were asked to read the randomized minimal pairs at a normal rate. Each stimulus was read once. The words were presented to participants in the Arabic language orthography supplemented with diacritic markings. The target word pairs were recorded in the carrier phrase [ˈʔiħki___ˈmær:æh] ("Say____once").

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 voiceless plain and emphatic stops, the spectral mean of plain and emphatic fricatives, and the first 3 formant frequencies (F1-F3) of the vowels following the target plain and emphatic consonants. The VOT of voiceless plain and emphatic stops was measured as the duration between the release of the consonant (burst) and the onset of voicing of the following vowel. As in Jongman et al. (2011), the spectral mean was measured over a 20-ms Hamming window in the middle of the friction. Formant frequency measures (F1-F3) were taken from LPC spectra calculated over a 20-ms Hamming window at vowel midpoint.

2.2. Results

2.2.1. Voice Onset Time (VOT) for Voiceless Stops

The VOTs were analyzed using a mixed analysis of variance (ANOVA) with the within-subjects factors Emphasis (2 levels: plain, emphatic), Vowel Length (2 levels: long, short), Vowel Context (3 levels: /æ/, /i/, /u/), and the between-subjects factor Proficiency (3 levels: native, intermediate, beginner). For this and the following analyses, the Greenhouse-Geisser correction was used for tests of effects with more than one degree of freedom in the numerator. The ANOVA revealed significant main effects of Emphasis (F (1, 16) = 28.97, p < .001) and Vowel Length (F (1, 16) = 23.57, p < .001), as well as a marginal Vowel Length * Proficiency interaction (F (2, 16) = 3.34, p = .061). The effect of Emphasis indicated that VOT was longer for plain (49ms) than emphatic (33 ms) consonants (see Figure 2 below). The effect of Vowel Length indicated that VOT was longer for consonants preceding long vowels (48 ms) than those preceding short vowels (34 ms). The Vowel Length * Proficiency interaction indicated that the difference in VOT for stops preceding long vowels compared to short vowels was small for native speakers (3 ms), but larger for intermediate (17 ms) and beginning learners (19 ms). Post-hoc comparisons of the vowel length effects (the difference scores for the Long condition minus the Short condition) revealed that the effect for native speakers was smaller than for intermediate learners (t (6.6) = -2.09, p = .077) and beginners (t (8.23) = -4.91, p = .001), but that the effect did not significantly differ between intermediate learners and beginners (t (8.75) = 0.47, p =

.652).[4] Most importantly for the hypotheses of the present study, no interactions between Emphasis, Proficiency, and other variables reached significance (*F*s < 1.90, *p*s > .182), indicating that learners did not differ from native speakers in terms of their production of the VOT correlates of emphasis.

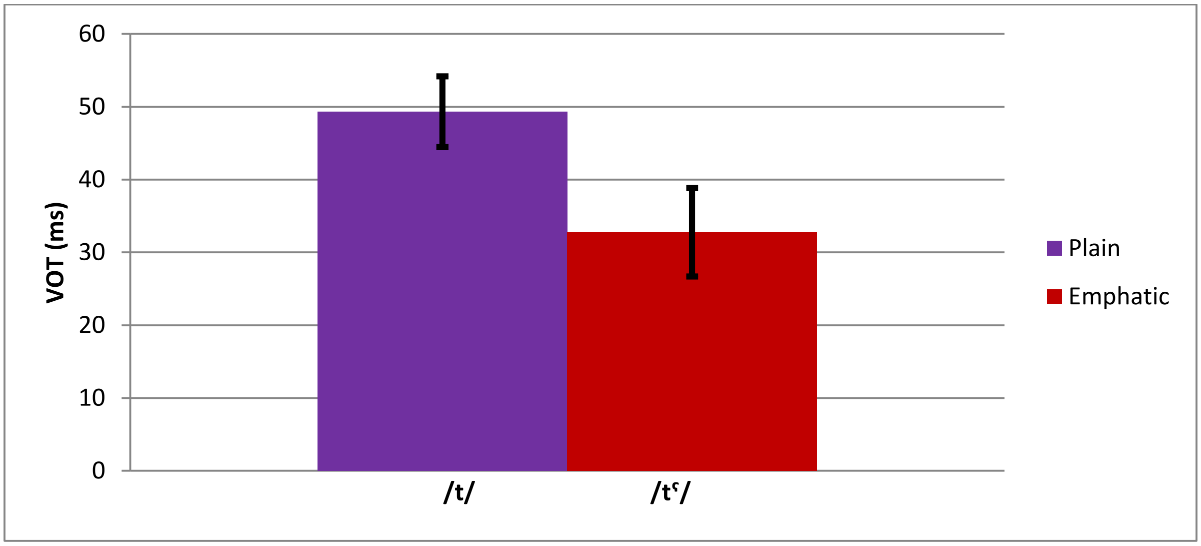

Figure 2: Difference in VOT for plain and emphatic /t/. Error bars represent standard errors.

Although the Emphasis * Proficiency interaction did not approach significance, the effect of Emphasis for intermediate speakers was numerically more native-like than for beginners: native speakers showed an 18.2 ms difference between plain and emphatic consonants, intermediate learners showed a 22.88 ms difference, and beginners showed a 9.12 ms difference. To test this difference, for each learner a difference score was computed representing the absolute value of how much that speaker's Emphasis effect (plain – emphatic) differed from the average Emphasis effect for native speakers: $difference = |18.2 - (plain_{speaker} - emphatic_{speaker})|$. An independent samples t-test showed that these scores did not significantly differ between intermediate learners and beginners (t (10.58) = 0.53, p = .606).

[4] Degrees of freedom for this test are adjusted because equal variances were not assumed.

2.2.2. Center of Gravity (COG) for Fricatives

COGs were analyzed using a mixed analysis of variance (ANOVA) with the within-subjects factors Emphasis (2 levels: plain, emphatic), Vowel Length (2 levels: long, short), Vowel Context (3 levels: /i/, /u/, /æ/), and Voicing (2 levels: voiced, voiceless), and the between-subjects factor Proficiency (3 levels: native, intermediate, beginner). The ANOVA revealed a significant effect of Vowel Context (F (2, 32) = 3.62, p = .047), indicating that COG was significantly affected by whether the fricative preceded /i/ (3760 Hz), /u/ (3554 Hz), or /æ/ (3680 Hz). There was also a significant effect of Voicing (F (1, 16) = 1854.58, p < .001), indicating that COG was substantially higher in voiceless (6983 Hz) than voiced fricatives (347 Hz). Finally, there was a significant Vowel * Voicing interaction (F(2,32) = 5.64, p = .014), indicating that the difference in COG between voiceless and voiced fricatives was somewhat smaller before /u/ (6322 Hz) than before /æ/ (6768 Hz) and /i/ (6819 Hz). Most importantly for the hypotheses of the present study, no interactions between Emphasis, Proficiency, and other variables reached significance (Fs < 1.88, ps > .185), indicating that learners did not differ from native speakers in terms of their production of the COG correlates of emphasis in fricatives.

Although the Emphasis * Proficiency interaction did not approach significance, the non-significant effect of Emphasis for intermediate speakers was numerically more native-like than for beginners: native speakers showed a 147.25 Hz difference between plain and emphatic fricatives, intermediate learners showed a -78.8 Hz difference, and beginners showed a -93.9 Hz difference. These differences were examined using a difference score calculated according to the formula described in section 2.2.1. An independent samples t-test showed that these scores did not significantly differ between intermediate learners and beginners (t (11.68) = 0.69, p = .504).

2.2.3. First Formant Frequency (F1)

F1 was analyzed using a mixed analysis of variance (ANOVA) with the within-subjects factors Emphasis (2 levels: plain, emphatic), Vowel Length (2 levels: long, short), Vowel Context (3 levels: /æ/, /i/, /u/), Manner (2: stop, fricative), and Voicing (2 levels: voiced, voiceless), and the between-subjects factor Proficiency (3 levels: native, intermediate, beginner). The results of the omnibus ANOVA are shown in Table 1.

Effect	**F1**
Proficiency	F (2,16) = 2.24, p = .139
Emphasis Emphasis * Proficiency	F (1,16) = 0.01, p = .913 F (2,16) = 6.38, p = .009**
Length Length * Proficiency	F (1,16) = 20.45, p < .001*** F (2,16) = 0.4, p = .677
Vowel Vowel * Proficiency	F (2,32) = 507.14, p < .001*** F (4,32) = 2.06, P = .141
Manner Manner * Proficiency	F (1,16) = 1.93, P = .184 F (2,16) = .37, P = .697
Voice Voice * Proficiency	F (1,16) = 9.93, P = .006** F (2,16) = 2.08, P = .157
Emphasis * Length Emphasis * Length * Proficiency	F (1,16) = 7.77, P = .013** F (2,16) = .58, P = .571
Emphasis * Vowel Emphasis * Vowel * Proficiency	F (2,32) = 5.91, P = .017** F (4,32) = 1.90, P = .165
Length * Vowel Length * Vowel * Proficiency	F (2,32) = 84.76, P < .001*** F (4,32) = 1.84, P = .167
Emphasis * Length * Vowel Emphasis * Length * Vowel * Proficiency	F (2,32) = 8.60, P = .004** F (4,32) = 1.34, P= .286
Emphasis * Manner Emphasis * Manner * Proficiency	F (1,16) = .70, P=.415 F (2,16) =.95, P = .408
Length * Manner Length * Manner * Proficiency	F (1,16) = .03, P = .874 F (2,16) = 1.41, P = .274
Emphasis* Length * Manner Emphasis * Length * Manner * Proficiency	F (1,16) = 1.02, P = .328 F (2,16) = .26, P = .772
Vowel * Manner Vowel * Manner * Proficiency	F (2,32) = .70, P = .464 F (4,32)= 1.089, P =.372
Emphasis * Vowel * Manner Emphasis * Vowel * Manner * Proficiency	F (2,32) = 2.70, P = .095* F (4,32) =1.01, P = .409
Length * Vowel * Manner Length * Vowel * Manner * Proficiency	F (2,32) = .67, P = .488 F (4,32) = 2.03, P = .132
Emphasis * Length * Vowel * Manner Emphasis * Length * Vowel * Manner * Proficiency	F (2,32) = 2.12, P = .138 F (4,32) = 2.86, P = .04**

Emphasis * Voice Emphasis * Voice * Proficiency	*F* (1,16) = .44, *P* = .515 *F* (2,16) = .74, *P* = .492
Length * Voice Length * Voice * Proficiency	*F* (1,16) = 1.08, *P* = .314 *F* (2,16) = .31, *P* = .739
Emphasis * Length * Voice Emphasis * Length * Voice * Proficiency	*F* (1,16) = 3.45, *P* = .082* *F* (2,16) = .74, *P* = .491
Vowel * Voice Vowel * Voice * Proficiency	*F* (2,32) = 1.60, *P* = .217 *F* (4,32) = 1.30, *P*= .291
Emphasis * Vowel * Voice Emphasis * Vowel * Voice * Proficiency	*F* (2,32) = .383, *P* = .642 *F* (4,32) = .537, *P* = .675
Length * Vowel * Voice Length * Vowel * Voice * Proficiency	*F* (2,32) = .39, *P* = .654 *F* (4,32) = 2.40, *P* =.081*
Emphasis * Length * Vowel * Voice Emphasis * Length * Vowel * Voice * Proficiency	*F* (2,32) = .002, *P* = .994 *F* (4,32) = .98, *P* = .424
Manner * Voice Manner * Voice * Proficiency	*F* (1,16) = 3.74, *P* = .071* *F* (2,16) = .97, *P* = .400
Emphasis * Manner * Voice Emphasis * Manner * Voice * Proficiency	*F* (1,16) = .24, *P* = .631 *F* (2,16) = 1.01, *P* = .631
Length * Manner * Voice Length * Manner * Voice * Proficiency	*F* (1,16) = .86, *P* = .369 *F* (2,16) = .14, *P* = .870
Emphasis * Length * Manner * Voice Emphasis * Length * Manner * Voice * Proficiency	*F* (1,16) = 4.99, *P* = .040** *F* (2,16) = .34, *P* =.718
Vowel * Manner * Voice Vowel * Manner * Voice * Proficiency	*F* (2,32) =.51, *P* =.596 *F* (4,32) =1.32, *P* =.284
Emphasis * Vowel * Manner * Voice Emphasis * Vowel * Manner * Voice * Proficiency	*F* (2,32) = 1.29, *P* = .287 *F* (4,32) = .24, *P* = .889
Length * Vowel * Manner * Voice Length * Vowel * Manner * Voice * Proficiency	*F* (2,32) = 1.63, *P* = .217 *F* (4,32) = .93, *P* = .448
Emphasis * Length * Vowel * Manner * Voice Emphasis * Length * Vowel * Manner * Voice * Proficiency	*F* (2,32) = .12, *P* = .831 *F* (4,32) = 1.54, *P* = .229

Table 1: Results of the omnibus ANOVA for F1
* .1 > *p* > .05; ** *p* < .05; *** *p* < .001

The following report focuses on effects that include the Emphasis or Emphasis * Proficiency as these are the interactions that test the hypotheses. Effects of interest that reached significance were Emphasis * Proficiency, Emphasis * Length * Manner * Voicing, Emphasis * Length * Vowel * Manner * Proficiency, and Emphasis * Length * Vowel.

Most importantly for the present hypotheses, the Emphasis * Proficiency interaction reached significance. The nature of this interaction is shown in Figure 3, indicating that while native speakers showed higher F1 for emphatic (514 Hz) than plain (483 Hz) tokens, learners showed the opposite effect. Beginners showed lower F1 for emphatic (453 Hz) than plain (478 Hz), and the intermediate learners also showed lower F1 for emphatic (460 Hz) than plain (464 Hz).

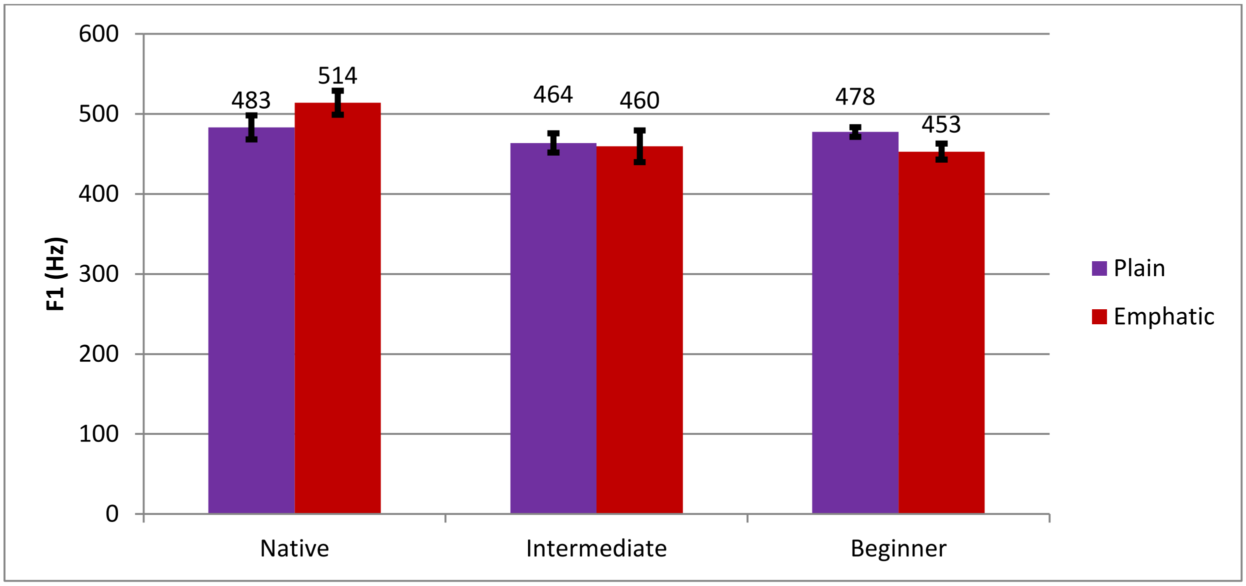

Figure 3: Differences in plain and emphatic F1 across levels of proficiency. Error bars represent standard errors.

In order to test how different each group of speakers was from native speakers, difference scores were calculated according to the procedure described above. An independent samples t-test showed that the difference between beginners and intermediate learners from native speakers was not significant. Intermediate learners were not significantly more native-like than beginners (t (10.49) = 1.2, p = .256). Furthermore, the Emphasis * Proficiency interaction in the omnibus ANOVA was no longer significant when native speakers were removed (F (1, 12) = 1.67, p = .221). These results indicate that learners and beginners both differed significantly from native speakers, but not from each other.

Resolving the interaction Emphasis * Length * Vowel * Manner * Proficiency by Manner showed that, for the stops, there was a marginal interaction of Emphasis * Proficiency (F

(1, 16) = 6.68, *p* = .008).[5] For fricatives, there were significant to marginal interactions of Emphasis * Length * Vowel * Proficiency (*F* (4, 32) = 4.23, *p* = .023), Emphasis * Vowel * Proficiency (*F* (4, 32) = 2.77, *p* = .081), and Emphasis * Proficiency (*F* (2, 16) = 3.16, *p* = .07).[6] These higher-order interactions are beyond the scope of this thesis.

As for the relationship between emphasis and vowel, stops and fricatives each showed interactions of Emphasis * Length * Vowel (stops: *F* (2, 32) = 7.89, *p* = .004; fricatives: *F* (2, 32) = 4.86, *p* = .031). They also each showed interactions of Emphasis * Vowel (stops: *F* (2, 32) = 8.33, *p* = .003; fricatives: *F* (2, 32) = 4.86, *p* = .031). (In the omnibus ANOVA the Emphasis * Vowel * Manner interaction was marginal, indicating that these latter interactions should be resolved separately for stops and fricatives). To resolve these interactions, the absolute value of the emphasis effect (plain – emphatic) was calculated for each cell and pairwise comparisons across vowels were made using t-tests. For stops, /æ/ had a larger effect of emphasis (F1 plain = 700 Hz, F1 emphatic = 662 Hz) than /u/ (F1 plain = 366 Hz, F1 emphatic = 385 Hz). This effect was significant, *t* (18) = 2.67, *p* = .016. There was also a larger effect of emphasis for /æ/ than /i/ (F1 plain = 371 Hz, F1 emphatic = 372 Hz). Again, the effect reached significance, *t* (18) = 3.2, *p* = .005. However, /u/ and /i/ did not significantly differ, *t* (18) = .79, *p* = .441. The same was true for fricatives, /æ/ had a larger effect of emphasis (F1 plain = 675 Hz, F1 emphatic = 659 Hz) than /u/ (F1 plain = 369 Hz, F1 emphatic 378 Hz). This effect was significant, *t* (18) = 2.72, *p* = .014. There was also a larger effect of emphasis for /æ/ than /i/ (F1 plain = 363 Hz, F1 emphatic = 373 Hz), *t* (18) = 2.84, *p* = .011. However, /u/ and /i/ did not significantly differ, *t* (18) = 0.39,

[5] There were also several significant or marginal effects that did not include Emphasis * Proficiency or Emphasis * Vowel interactions. These were as follows: Length * Vowel (*F* (2, 32) = 61.2, *p* < .001), Vowel * Proficiency, (*F* (4, 32) = 2.49, *p* = .092) Vowel (*F* (2, 32) = 461.68, *p* < .001), Length (*F* (1, 16) = 21.64, *p* < .001).

[6] There were also several significant or marginal effects that did not include Emphasis * Proficiency interactions. These were as follows: Emphasis * Length (*F* (1, 16) = 9.92, *p* = .006), Vowel (*F* (2, 32) = 403.71, *p* < .001), Length (*F* (1, 16) = 14.04, *p* = .002).

p = .699). The Emphasis * Length * Vowel interaction was solved in the same way. For long vowels, the emphasis effect was significantly larger for /æ/ (F1 plain = 735 Hz, F1 emphatic = 679 Hz) than for /u/ (F1 plain= 341 Hz, F1 emphatic = 354 Hz), t (18) = 21.87, $p < .001$. There was also a larger effect of emphasis for /æ/ than /i/ (F1 plain = 309 Hz, F1 emphatic = 429 Hz), t (18) = 18.07, $p < .001$. Moreover, the emphasis effect for /u/ was larger than that for /i/ (t (18) = 4.14, $p = .001$). For the short vowels, the emphasis effect for /æ/ (F1 plain = 640 Hz, F1 emphatic = 642 Hz) was numerically smaller than that for /u/ (F1 plain = 394 Hz, F1 emphatic = 410 Hz), but the difference was not significant, t (18) = -1.51, $p = .150$. The emphasis effect for /i/ (F1 plain = 425 Hz, F1 emphatic = 429 Hz) was smaller than those for both /æ/, t (18) = 3.05, $p = .007$, and /u/, t (18) = 5.29, $p < .001$.

2.2.4. Second Formant Frequency (F2)

F2 was analyzed using a mixed analysis of variance (ANOVA) with the within-subjects factors Emphasis (2 levels: plain, emphatic), Vowel Length (2 levels: long, short), Vowel Context (3 levels: /æ/, /i/, /u/), Manner (2 levels: stop, fricative), and Voicing (2 levels: voiced, voiceless), and the between-subjects factor Proficiency (3 levels: native, intermediate, beginner). The results of the omnibus ANOVA are shown in Table 2.

Effect	**F2**
Proficiency	F (2,16) = .52, p = .607
Emphasis Emphasis * Proficiency	F (1,16) = 108.99, P < .001*** F (2,16) = 4.91, P = .022**
Length Length * Proficiency	F (1,16) = 46.56 , p < .001*** F (2, 16) = .37, p =. 695
Vowel Vowel * Proficiency	F (2,32) = 534.28, p <.001*** F (4,32) = 1.15, p = .351
Manner Manner * Proficiency	F (1,16) = .84, p = .373 F (2,16) = .95, p = .407
Voice Voice * Proficiency	F (1,16)= .40, p = .538 F (2,16) = 2.27, p = .136
Emphasis * Length Emphasis * Length * Proficiency	F (1,16) = 4.13, p = .059* F (2,16) = 3.38, p = .060*

Emphasis * Vowel Emphasis * Vowel * Proficiency	*F* (2,32) = 25.72, *p* < .001*** *F* (4,32) = 2.10, *p* = .118
Length * Vowel Length * Vowel * Proficiency	*F* (2,32) = 188.50, *p* < .001*** *F* (4,32)= .95, *p* = .447
Emphasis * Length * Vowel Emphasis * Length * Vowel * Proficiency	*F* (2,32) = 1.73, *p* = .196 *F* (4,32) = 2.47, *p* = .071*
Emphasis * Manner Emphasis * Manner * Proficiency	*F* (1,16) = .41, *p* = .533 *F* (2,16) = .29, *p* = .756
Length * Manner Length * Manner * Proficiency	*F* (1,16) = .863, *p* = .367 *F* (2,16) = .23, *p*= .797
Emphasis* Length * Manner Emphasis * Length * Manner * Proficiency	*F* (1, 16) = .002, *p* = .963 *F* (2,16) = .16, *p* = .855
Vowel * Manner Vowel * Manner * Proficiency	*F* (2,32) = .95, *p* = .382 *F* (4,32) = .07, *p* = .982
Emphasis * Vowel * Manner Emphasis * Vowel * Manner * Proficiency	*F* (2,32) = .66, *p* = .488 *F* (4,32) = .88, *p* = .469
Length * Vowel * Manner Length * Vowel * Manner * Proficiency	*F* (2,32) = 2.04, *p* = .149 *F* (4,32) = .494, *p* = .733
Emphasis * Length * Vowel * Manner Emphasis * Length * Vowel * Manner * Proficiency	*F* (2,32) = .58, *p* = .541 *F* (4,32) = .22, *p* = .908
Emphasis * Voice Emphasis * Voice * Proficiency	*F* (1,16) = .17, *p* = .682 *F* (2,16) = 2.61, *p* = .104
Length * Voice Length * Voice * Proficiency	*F* (1,16)= .31, *p* = .583 *F* (2,16) = 2.05, *p* = .161
Emphasis * Length * Voice Emphasis * Length * Voice * Proficiency	*F* (1,16) = 1.62, *p* = .221 *F* (2,16) = .022, *p* = .978
Vowel * Voice Vowel * Voice * Proficiency	*F* (2,32) = .02, *p* = .978 *F* (4,32) = .95, *p* = .443
Emphasis * Vowel * Voice Emphasis * Vowel * Voice * Proficiency	*F* (2,32) = .40, *p* = .668 *F* (4,32) = .60, *p* = .659
Length * Vowel * Voice Length * Vowel * Voice * Proficiency	*F* (2,32) = 1.51, *p* = .238 *F* (4,32) = .19, *p* = .934
Emph * Length * Vowel * Voice Emphasis * Length * Vowel * Voice * Proficiency	*F* (2,32) = .53, *p* = .580 *F* (4,32) = .50, *p* = .721
Manner * Voice Manner * Voice * Proficiency	*F* (1,16) = 1.33, *p* = .266 *F* (2,16) = .17, *p* = .849
Emphasis * Manner * Voice Emphasis * Manner * Voice * Proficiency	*F* (1,16) = 1.50, *p* = .240 *F* (2,16) = .69, *p* = .515
Length * Manner * Voice Length * Manner * Voice * Proficiency	*F* (1,16) = .13, *p*= .722 *F* (2,16) = 1.05, *p* = .372
Emphasis * Length * Manner * Voice Emphasis * Length * Manner * Voice * Proficiency	*F* (1,16) = .82, *p* = .379 *F* (2,16) = 2.23, *p* = .140
Vowel * Manner * Voice Vowel * Manner * Voice * Proficiency	*F* (2,32) = 3.61, *p* = .040** *F* (4,32) = .85, *p*= .502
Emphasis * Vowel * Manner * Voice	*F* (2,32) = .23, *p* = .712

Emphasis * Vowel * Manner * Voice * Proficiency	F (4,32) = .61, p = .603
Length * Vowel * Manner * Voice Length * Vowel * Manner * Voice * Proficiency	F (2,32) = .39, p = .670 F (4,32) = 1.93, p = .134
Emphasis * Length * Vowel * Manner * Voice Emphasis * Length * Vowel * Manner * Voice * Proficiency	F (2,32) = .14, p = .849 F (4,32) = .97, p = .432

Table 2: Results of the omnibus ANOVA for F2
* $.1 > p > .05$; ** $p < .05$; *** $p < .001$

The following report focuses on effects that include the Emphasis or Emphasis * Proficiency as these are the interactions that test the hypotheses. Effects of interest that reached significance were Emphasis * Proficiency, Emphasis * Length, Emphasis * Length * Vowel * Proficiency, and Emphasis * Vowel, Emphasis * Length * Proficiency.

Most importantly for the present hypotheses, the Emphasis * Proficiency interaction reached significance. The nature of this interaction is shown in Figure 4, indicating that native speakers showed lower F2 for emphatic (1277 Hz) than plain (1553 Hz) tokens, and intermediate learners showed lower F2 for emphatic (1279 Hz) than plain (1547 Hz) tokens. However, beginners showed a similar but smaller affect with lower F2 for emphatic (1388 Hz) than plain (1521 Hz) tokens.

In order to test how different each group of speakers was from native speakers, difference scores were calculated according to the procedure described above. An independent samples t-test showed that the difference between beginners and intermediate learners from native speakers was marginally significant; beginners tended to be less native-like than intermediate learners (t (10.041) = 2.003, p = .073).

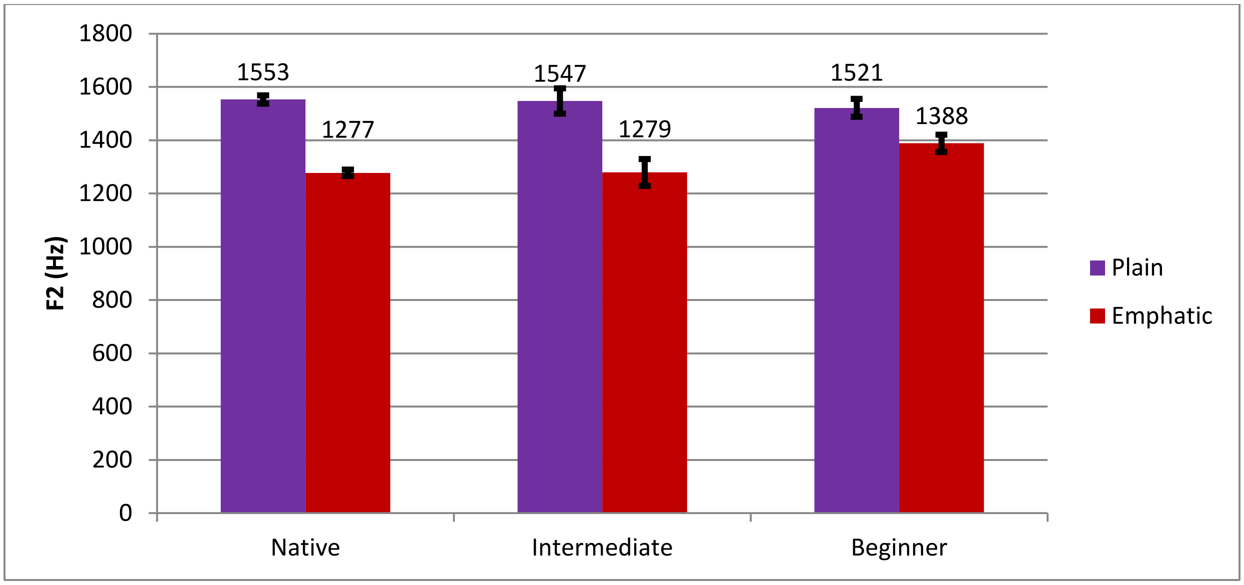

Figure 4: Differences in plain and emphatic F2 across levels of proficiency**.** Error bars represent standard errors.

As shown in Figure 5 below, the effect of emphasis seems larger for the vowel /æ/ (F2 plain = 1514 Hz, F2 emphatic = 1122 Hz) than /i/ (F2 plain = 2064 Hz, F2 emphatic = 1932 Hz) or /u/ (F2 plain = 1040 Hz, F2 emphatic 902 Hz). The effect of emphasis was significantly larger for /æ/ than for /u/ (t (18) =6.279, p< .001) and for /i/ (t (18) =5.293, p< .001). However, /i/ and /u/ did not significantly differ from each other (t (18) =.146, p=.886). As for the higher-order interactions, they are beyond the scope of this study.

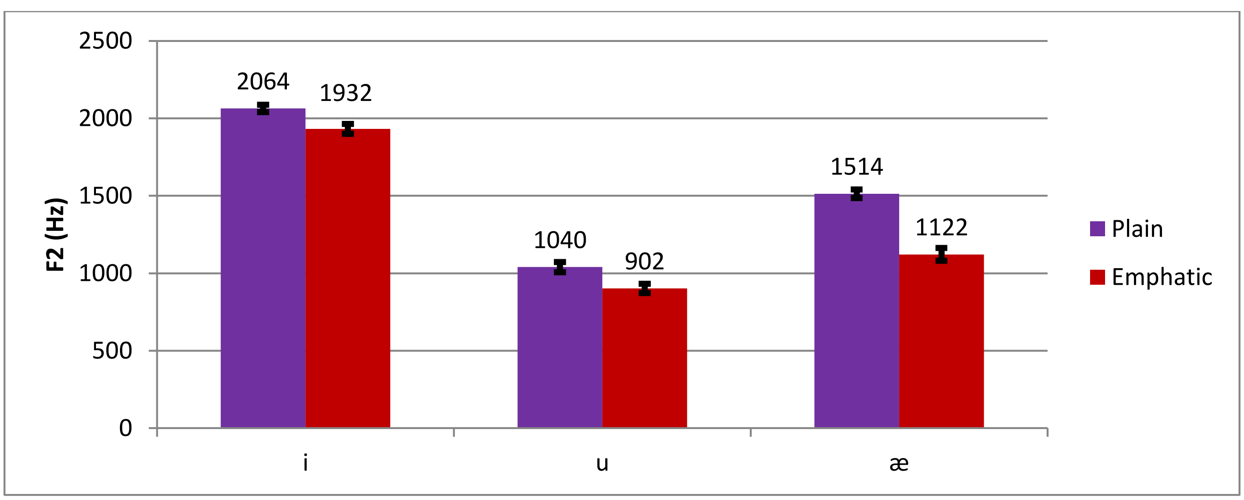

Figure 5: Differences in plain and emphatic F2 across vowel types. Error bars represent standard errors.

2.2.5. Third Formant Frequency (F3)

F3 was analyzed using a mixed analysis of variance (ANOVA) with the within-subjects factors Emphasis (2 levels: plain, emphatic), Vowel Length (2 levels: long, short), Vowel Context (3 levels: /æ/, /i/, /u/), Manner (2: stop, fricative), and Voicing (2 levels: voiced, voiceless), and the between-subjects factor Proficiency (3 levels: native, intermediate, beginner). The results of the omnibus ANOVA are shown in Table 3.

Effect	**F3**
Proficiency	*F* (2, 16) = 1.24. *p* = .315
Emphasis Emphasis * Proficiency	*F* (1,16) = 6.24, *P* = .024** *F* (2,16) = 2.46, *P*= .117
Length Length * Proficiency	*F* (1,16) = 7.64, *P*=.014** *F* (2,16) = 2.84, *P* = .88*
Vowel Vowel * Proficiency	*F* (2,32) = 34.14, *P* < .001*** *F* (4,32) = 6.03, *P* < .001***
Manner Manner * Proficiency	*F* (1,16) = 3.58, *P* = .077* *F* (2,16) = 2.30, *P* = .133
Voice Voice * Proficiency	*F* (1,16) = 13.85, *P* = .002** *F* (2,16) = .53, *P* = .596
Emphasis * Length Emphasis * Length * Proficiency	*F* (1,16) = .49, *P* = .493 *F* (2,16) = .56, *P* =.584
Emphasis * Vowel Emphasis * Vowel * Proficiency	*F* (2,32) = 11.83, *P* < .001*** *F* (4,32) = 1.76, *P* =.162
Length * Vowel Length * Vowel * Proficiency	*F* (2,32) = 23.81, *P* < .001*** *F* (4,32) = 5.04, *P* = .004**
Emphasis * Length * Vowel Emphasis * Length * Vowel * Proficiency	*F* (2,32) = 2.24, *P* =.123 *F* (4,32) = 1.45, *P* = .243
Emphasis * Manner Emphasis * Manner * Proficiency	*F* (1,16) = 4.72, *P* = .045** *F* (2,16) = 2.92, *P* = .083*
Length * Manner Length * Manner * Proficiency	*F* (1,16) = 1.81, *P* = .198 *F* (2,16) = .67, *P* = .527
Emphasis* Length * Manner Emphasis * Length * Manner * Proficiency	*F* (1,16) = 2.15, *P* =.162 *F* (2,16) = .30, *P* =.745
Vowel * Manner Vowel * Manner * Proficiency	*F* (2,32) = 2.19, *P* = .134 *F* (4,32) = 1.45, *P* = .246
Emphasis * Vowel * Manner Emphasis * Vowel * Manner * Proficiency	*F* (2,32) = .51, *P* =.600 *F* (4,32) = 1.38, *P* = .265
Length * Vowel * Manner Length * Vowel * Manner * Proficiency	*F* (2,32) = .06, *P* = .943 *F* (4,32) = .655, *P*=.619
Emphasis * Length * Vowel * Manner Emphasis * Length * Vowel * Manner * Proficiency	*F* (2,32) = 4.00, *P* = .028** *F* (4,32) = .57, *P* = .685

Emphasis * Voice Emphasis * Voice * Proficiency	*F* (1,16) = .54, *P* = .475 *F* (2,16) = .86, *P* = .443
Length * Voice Length * Voice * Proficiency	*F* (1,16) = 5.71, *P* = .030** *F* (2,16) = 3.82, *P* = .044**
Emphasis * Length * Voice Emphasis * Length * Voice * Proficiency	*F* (1,16) = .46, *P* = .510 *F* (2,16) = .689, *P* = .517
Vowel * Voice Vowel * Voice * Proficiency	*F* (2,32) = 3.24, *P* =.052* *F* (4,32) = .87, *P* = .494
Emphasis * Vowel * Voice Emphasis * Vowel * Voice * Proficiency	*F* (2,32) = 1.61, *P* =.215 *F* (4,32) = .33, *P* =.855
Length * Vowel * Voice Length * Vowel * Voice * Proficiency	*F* (2,32) = .95, *P*=.381 *F* (4,32) = 1.39, *P* = .267
Emphasis * Length * Vowel * Voice Emphasis * Length * Vowel * Voice * Proficiency	*F* (2,32) = 2.69, *P* = .083* *F* (4,32) = .947, *P* = .448
Manner * Voice Manner * Voice * Proficiency	*F* (1,16) = .19, *P* = .670 *F* (2,16) = .61, *P* = .554
Emphasis * Manner * Voice Emphasis * Manner * Voice * Proficiency	*F* (1,16) = .23, *P* = 642 *F* (2,16) = .53, *P* =.598
Length * Manner * Voice Length * Manner * Voice * Proficiency	*F* (1,16) = .02, *P* = .886 *F* (2,16)= 1.19, *P* = .331
Emphasis * Length * Manner * Voice Emphasis * Length * Manner * Voice * Proficiency	*F* (1,16) = .09, *P* = .772 *F* (2,16) = 3.27, *P* = .065*
Vowel * Manner * Voice Vowel * Manner * Voice * Proficiency	*F* (2,32) = 1.43, *P* = .255 *F* (4,32) = .59, *P* = .669
Emphasis * Vowel * Manner * Voice Emphasis * Vowel * Manner * Voice * Proficiency	*F* (2,32) = .88, *P* = .419 *F* (4,32) = .46, *P* = .757
Length * Vowel * Manner * Voice Length * Vowel * Manner * Voice * Proficiency	*F* (2,32) = 1.17, *P* = .324 *F* (4,32) = 1.11, *P* =.365
Emphasis * Length * Vowel * Manner * Voice Emphasis * Length * Vowel * Manner * Voice * Proficiency	*F* (2,32) = 4.11, *P* = .040** *F* (4,32) = 1.29, *P* = .300

Table 3: Results of the omnibus ANOVA for F3
* .1 > *p* > .05; ** *p* < .05; *** *p* < .001

The following report focuses on effects that include the Emphasis or Emphasis * Proficiency as these are the interactions that test the hypotheses. Effects of interest that reached or approached significance were Emphasis * Vowel, Emphasis * Manner * Proficiency, Emphasis * Length * Vowel * Manner, Emphasis * Length * Vowel * Voice, Emphasis * Length * Manner * Voice * Proficiency, and Emphasis * Length * Vowel * Manner * Voice.

Most importantly for the present hypotheses, the Emphasis * Proficiency interaction did not reach significance, but the Emphasis * Manner * Proficiency did, suggesting that there may have been a relationship between emphasis and proficiency in just the stops or just the fricatives. The nature of this three-way interaction is shown in Figures 6 and 7, suggesting that for stops, native speakers showed lower F3s for plain (2636 Hz) than for emphatic (2720 Hz) stops whereas learners showed little effect of emphasis; beginning learners showed higher F3s for plain (2613 Hz) than for emphatic (2603) stops, and intermediate learners showed lower F3s for plain (2634 Hz) than for emphatic (2647 Hz) stops. For fricatives, native speakers showed much lower F3s for plain (2670 Hz) than emphatic (2788 Hz) fricatives, beginners showed somewhat lower F3s for plain (2613 Hz) than emphatic (2670 Hz) fricatives, and intermediate learners showed little difference between plain (2627 Hz) and emphatic (2629 Hz) fricatives. The interaction was resolved by Manner, revealing that there was not a significant Emphasis * Proficiency interaction for stops (F (2, 16) = 2.08, p = .158) but there was a marginal Emphasis * Proficiency interaction for fricatives (F (2, 16) = 2.95, p = .081). Plain fricatives had significantly higher F3 for native speakers (t (4) = -3.21, p = .033) and beginners (t (6) = -2.76, p= .033), but not for intermediate learners (t (6) = -0.05, p = .964).

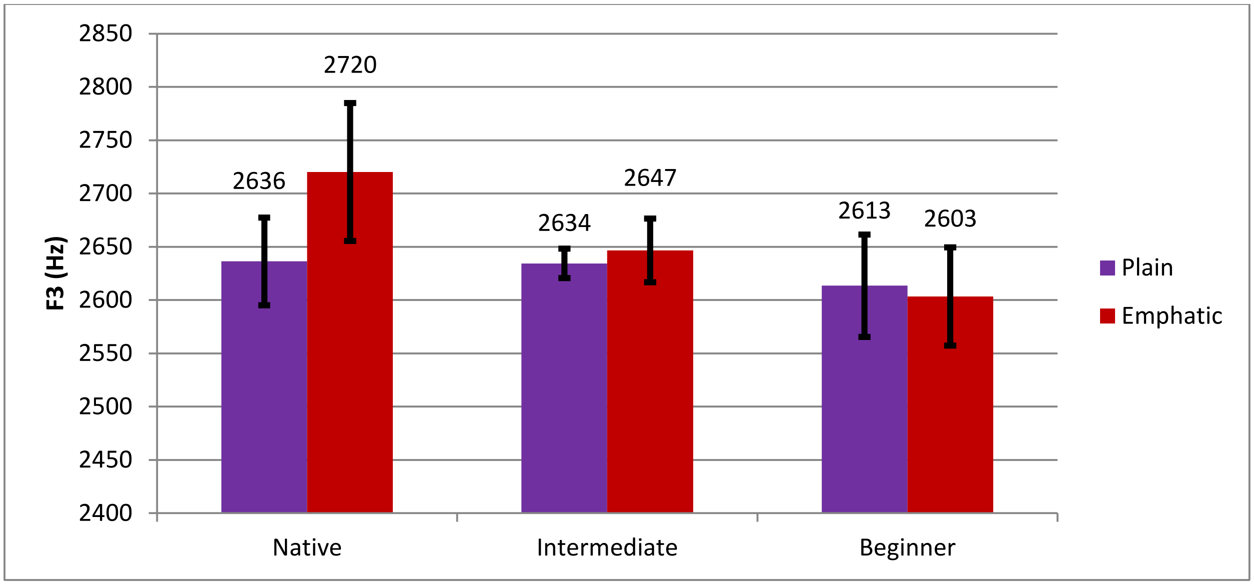

Figure 6: Differences in plain and emphatic F3 in the context of stops. Error bars represent standard errors.

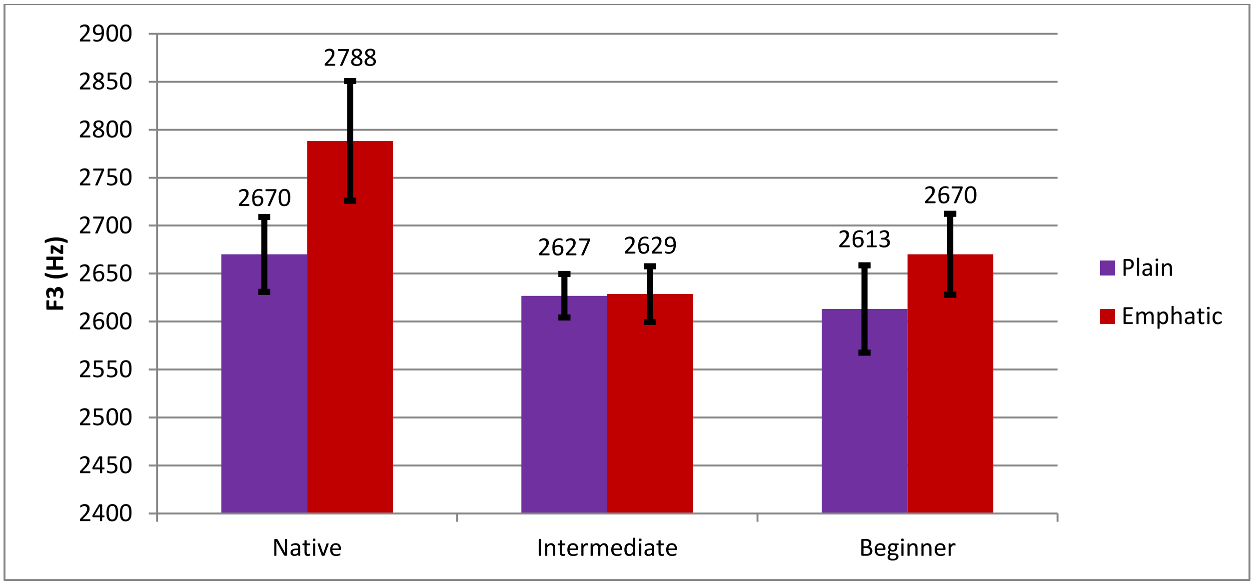

Figure 7: Differences in plain and emphatic F3 in the context of fricatives. Error bars represent standard errors.

As shown in figure 8 below, the effect of emphasis seems larger for the vowel /æ/ (plain F3 = 2602 Hz, emphatic F3 = 2665 Hz) and /u/ (plain F3 = 2494 Hz, emphatic F3 = 2585 Hz) than for /i/ (plain F3 = 2794 Hz, emphatic F3 = 2754 Hz). For /æ/, plain F3 was marginally lower than emphatic F3 (t (18) =-1.971, p=.064). For /u/, plain F3 was significantly lower than emphatic F3 (t (18) =-4.164, p=.001). As for /i/, plain F3 was marginally higher than emphatic F3 (t (18) =2.042, p=.056). The higher-order interactions are beyond the scope of this study.

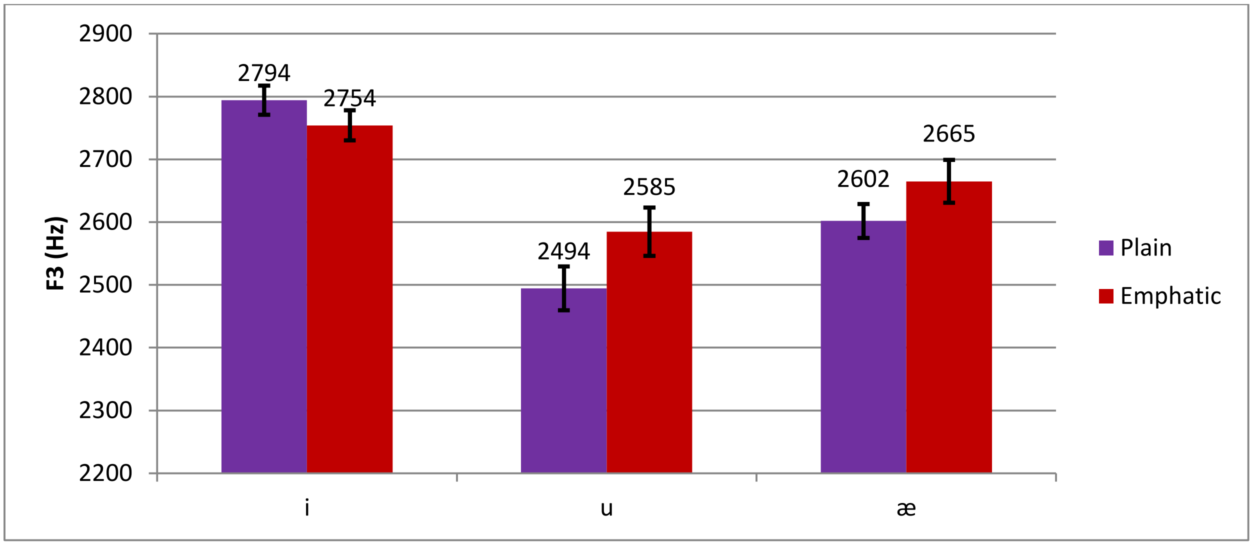

Figure 8: Differences in plain and emphatic F3 across vowel types. Error bars represent standard errors.

Chapter 3: Discussion

3.1. Discussion of Acoustics Results

The aim of the present study was to provide an account of the acoustic correlates of emphasis in Modern Standard Arabic (MSA) as produced by native monolinguals and native speakers of American English who are L2 learners of Arabic. Five native speakers and 14 L2 learners who differ according to their experience and proficiency in MSA produced monosyllabic stimuli with plain and emphatic consonants in initial position. The plain and emphatic consonants /ð ðˤ/, /t tˤ/, /d dˤ/, and /s sˤ/ and the vowels /i: æ: u: i æ u / of MSA were included in the study. The results of the native speakers will be first discussed in terms of previous studies (e.g., Jongman et al., 2011). The results of the L2 learners will be discussed in terms of the Speech Learning Model (Flege, 1995) and then compared to the findings of Saadah (2011).

3.1.2. Discussion of the Results of the Native Speakers

The results of the present study indicated that VOT is a reliable acoustic correlate of emphasis in Modern Standard Arabic for voiceless stops. VOT of /t/ was significantly longer than that of /tˤ/. This confirms the results reported by previous studies (Khattab et al., 2006; Abudalbuh, 2010) that /tˤ/ has a significantly shorter VOT than /t/. Articulatory speaking, Lehn (1963) maintained that, during the articulation of emphatic stops, the magnitude of tension of the oral as well as the pharyngeal muscles is greater. According to Khattab et al. (2006), the articulation of plain stops is characterized by weaker tension of the glottis during the hold phase causing the vocal folds to take longer to come together for vibration. As for COG, the findings provided more converging evidence that COG is not a reliable acoustic correlate of emphasis for fricatives; emphatic fricatives did not significantly differ from plain ones. This finding is in line with some previous studies (Abudalbuh, 2010; Jongman et al., 2011) that emphatic and plain fricatives do not significantly differ in terms of COG. Only Al-Masri (2009) reported that emphatic fricatives had a lower center of gravity than the plain ones.

For F1, the results showed that emphatic vowels had a significantly higher F1 than plain vowels (see Figure 1).This is in line with the findings of a number of previous studies (e.g. Khattab, Al-Tamimi, and Heselwood, 2006; Al-Masri, 2009, Abudalbuh, 2010, Jongman et al., 2011) that F1 is affected by emphasis. As for F2, the results showed that F2 was substantially lowered in the emphatic context. This corroborated the findings reported by previous studies on the acoustic correlates of emphasis (Card, 1983; Wahba, 1993; Al-Masri and Jongman, 2004; Khattab et al., 2006; Al-Masri, 2009; Abudalbuh, 2010; Jongman et al., 2011; Saadah, 2011). Therefore, the results provided converging evidence that F2 is a highly reliable acoustic cue of emphasis in Arabic. As for F3, the results showed that emphatic vowels had a marginally significant higher F3 than plain ones in the context of fricatives only. In the context of stops, although emphatic F3 was higher than plain F3, the difference was not significant. Abudalbuh (2010) reported that the difference between plain and emphatic F3 did not reach significance at the vowel midpoint; however, Abudalbuh (2010) did not report any significant interaction between Emphasis and Manner of articulation for F3.

3.1.3. Discussion of the Results of the L2 learners

In this section, the results of the L2 learners will be compared to those of Saadah (2011), and they will also be discussed within the framework of the Speech Learning Model (SLM) developed by Flege (1995). It is worth mentioning here that SLM makes clear predictions about the perception of and production of L2 speech by highly experienced second language learners who have spoken their L2 for many years. However, in this study, SLM will be used to account for the production of L2 speech by two groups differing in their experience with L2; these are a group of intermediate L2 learners and a group of beginning L2 learners. Although the L2 learners of varying experience had been studying Arabic for no longer than 4 years, SLM can still be used to generate predictions about learning in progress; the more proficient group is expected to produce values that are closer to those of the native speakers than the less experienced/proficient group.

According to the second hypothesis of the SLM (H2), the likelihood of forming a new phonetic category is greater when an L2 sound is judged to be perceptually distant from the closest L1 sound than when an L2 sound is judge to be perceptually close to an L1 sound. L2 research provided empirical evidence that (adult) L2 learners need many years to establish new phonetic categories for L2 sounds that are perceptually distinct from the closest L1 sounds. For example, Flege, Takagi, and Mann (1995) reported that Japanese speakers established new phonetic categories for the English liquids /ɹ/ and /l/ after living 21 years in the US; however, the Japanese speakers who had lived for 2 years in the US at the time of the study did not show evidence of forming phonetic categories for the English liquids.

One limitation of the present study is that the L2 learners recruited had been learning Arabic for only a few years in the US, and they did not use Arabic very frequently on a daily basis. According to Guion, Flege, Akahane-Yamada, and Pruitt (2000), the results provided by inexperienced L2 learners might not be in line with the predictions generated by the SLM; however, their results might reflect learning in progress since forming a new phonetic category for an L2 sound depends on the perceived phonetic distance from the closest L1 sound. Therefore, the production of emphasis by the intermediate learners in the present study is expected to be more accurate than the production of emphasis by the beginning learners.

The present results indicated that L2 learners produced comparable VOT values to those of native speakers; neither the intermediate nor the beginners were different from native speakers in terms of the production of the VOT correlates of emphasis. In terms of SLM, this suggests that the L2 learners were able to detect at least some of the perceptual differences between the Arabic /tˤ/ and the perceptually closest L1 and L2 sounds, i.e., English and Arabic /t/. Therefore, it is likely that the L2 learners had established a new phonetic category for the Arabic /tˤ/. Because the results showed that COG was not an acoustic correlate of emphasis (natives did not differentiate between fricatives in terms of COG), it appears that the distinction between plain and emphatic fricatives is not based on COG. This suggests that the distinction might be in the acoustic cues carried by the following vowel. Saadah (2011) did not look at the production of VOT and COG by L2 learners of Arabic. Therefore, this study provided more detailed information about the production of VOT and COG by L2 learners of Arabic who are native speakers of American English.

As for F1, the results indicated that while native speakers produced a significantly higher F1 in the emphatic context, the L2 learners showed the opposite effect; they produced a lower F1 in the emphatic environment. However, the intermediate and beginning learners were not different from each other on the F1 measure. This supports the findings of Saadah (2011) in that L2 learners did not produce a significantly different emphatic F1. Concerning F2, the results showed that all the L2 learners produced a lower F2 in the emphatic context. Again, this supports the findings of Saadah (2011) in that all language groups produced a lower F2 in the emphatic environment. However, the present study provided more information about the effects of proficiency, i.e., the intermediate L2 learners tended to be more native-like than the beginners on the F2 measure.

Saadah (2011) found that the distinction between Arabic and English vowels is largely based on F2; this might explain why the L2 learners in the present study differed significantly from native speakers in terms of the F1 value. Previous studies also showed that second language learners adopt different strategies and attend to certain acoustic information to categorize L2 speech sounds. Strange et al. (2004) reported that the North German and American English vowel space have various patterns of spectral resemblance. Strange et al. (2004) reported that where mid long and high-mid short vowels overlapped in F1 these vowels were discriminated using F2. In another study, Underbakke et al. (1988) found that Japanese learners relied on duration distinctions to distinguish English /ɹ/ from /l/; English speakers, on the other hand, relied on F2 and F3. Therefore, the L2 learners of Arabic might have relied on F2 as a more robust acoustic cue for the Arabic-English vowel distinction. In terms of F3, the beginning and intermediate learners patterned differently; only beginners and native speakers produced a significantly higher F3 in the emphatic context of fricatives. All groups produced numerically higher F3 in the emphatic context of stops. Again, Saadah (2011) did not look at the production of F3 by L2 learners of Arabic. Therefore, this study provided more information about the production of F3 by L2 learners of Arabic who are native speakers of American English. Overall, the results are in line with those of Flege (1980 and 1987) in that adult L2 learners are capable of establishing phonetic categories for new L2 sounds. Since the intermediate and beginning learners were marginally different on the F2 measure, this suggests that the intermediate learners were a somewhat more successful in achieving target-like categorical representation of the Arabic vowels in the emphatic context. This corroborates the claim of the SLM that more experience in L2 results in more accurate production of L2.

The results of F2 showed that the effect of emphasis was larger for /æ/ than /i/ and /u/. However, /i/ and /u/ did not differ from each other with regard to the effect of emphasis. The results of F3 showed that the relationship between emphasis and proficiency depended on whether the preceding consonant was a stop or fricative. In the context of stops, beginning learners produced a numerically higher F3 in the plain context, and intermediate learners produced a numerically lower F3 in the plain context. In the context of fricatives, only beginning learners produced a higher F3 in the emphatic context, whereas the intermediate learners produced a numerically higher F3 in the emphatic context.

This study provided a more complete understanding of the linguistic behavior of L2 learners of Arabic than that provided by Saadah (2011). The acoustic cues that were examined in Saadah (2011) were only F1 and F2 of the vowels in the context of emphatic and plain consonants. In addition, only language experience and vowel pharyngealization were the independent variables in the statistical analyses of the data. The present study was more comprehensive in terms of the acoustic cues that were examined; in addition to measuring F1-F3 values in emphatic and plain environments, the characteristics of the consonants were also examined by measuring the VOT of emphatic and plain stops and COG of emphatic and plain fricatives. More independent variables were also used; these are vowel quality, vowel quantity, manner of articulation, and voicing.

The present acoustic findings raise the question about how the learners' productions are perceived by native Arab listeners. Future perception experiments are planned to determine if learners' emphatic productions are indeed perceived as emphatic. Our acoustic results suggest this may be the case for the intermediate learners but not for the beginning learners. By relating the perceptual results to the acoustic measurements, we will also be able to determine the extent to which different acoustic properties contribute to the perception of emphasis.

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Appendix A

Production Stimuli

Word Plain	Gloss	Word Emphatic	Gloss
tæ:b	He repented.	tˤæ:b	He recovered.
dæ:l	Letter D	dˤæ:l	Astray
sæ:d	He dominated.	sˤæ:d	He hunted.
ðæ:b	Melted.	ðˤæ:b	He is keeping.
tu:b	Repent!	tˤu:b	Brick
du:ʔ	Taste!	dˤu:ʔ	Light
su:r	Fence	sˤu:r	Name of a city
ðu:b	Melt!	ðˤu:b	Nonword
ti:n	Figs	tˤi:n	Mud
di:f	Nonword	dˤi:f	Add!
si:b	Leave!	sˤi:b	Touch!
ði:b	Wolf	ðˤi:b	Nonword
tæb	He definitely lost!	tˤæb	He arrived.
dæb	He dropped.	dˤæb	A desert animal
sæb	He insulted.	sˤæb	He poured.
ðæb	Nonword	ðˤæb	He kept.
tub	Repent!	tˤub	Medicine
dub	Bear	dˤub	Keep!
sub	Insult!	sˤub	Pour!
ðub	Melt!	ðˤub	Keep!

tib	Tape	tˤib	Medicine
dib	Drop	dˤib	Nonword
sib	Insult!	sˤib	Nonword
ðil	Humiliate!	ðˤil	Shadow