THE PRODUCTION OF ARABIC VOWELS BY ENGLISH L2 LEARNERS AND
HERITAGE SPEAKERS OF ARABIC

BY

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DISSERTATION

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ABSTRACT

It is known that adult language learners often struggle to accurately pronounce unfamiliar sounds in the target language, but the extent and duration of the linguistic experience is found to affect native-like production of target segments. In order to explore the variability in speech production between language learners, I compare vowel production between heritage speakers of Arabic (HSs) and English L2 learners. More importantly, this phonetic investigation asks fundamental research questions such as: Whether one or two phonetic/phonological systems coexist in the mental organization of developing bilinguals? If early childhood exposure to the target language as experienced by HSs affects phonetic learning later in life, e.g., when the HS is an adult learner in a traditional classroom setting? Moreover, do bilinguals of varying proficiency levels process their languages in the same way?

Depending on the linguistic experience, prior studies of speech production show that bilingual speakers may possess one or two phonetic/phonological systems for the two languages. Furthermore, exposure to the L2 in early childhood facilitates attainment of native-like L2 phone production. Specifically, Flege (1987), Mack (1989), and Guion (2002) show that early bilinguals are capable of acquiring fine-grained phonetic detail of their L2 more than late learners. In the present study, 12 HSs— 6 experienced (EHSs) and 6 inexperienced (IHSs)—as well as 12 L2 learners— 6 advanced (AL2) and 6 beginner (BL2)—were compared with 6 native speakers of Arabic. Subjects produced 2 repetitions for each of 114 CVC monosyllabic words, embedded medially in a fixed carrier phrase. Formant measures of F1 and F2 were taken (in Bark) at vowel midpoint.

Unlike the L2 learners, the results reveal that HSs have acquired two phonetic/phonological systems for Arabic and English, demonstrating the significance of childhood exposure to target sounds in later phonetic attainment. Specifically, more experience in the target language results in more accurate vowel production as shown by EHSs producing values that are closer to target vowels than IHSs and so is the case for AL2 compared to BL2 learners. Presenting a great challenge for language educators and language programs in the United States, implications from comparing these distinct populations (HSs and L2 learners) are discussed in relation to phonological theory, specifically, the intersection between second language research (SLA) and teaching of heritage language instruction.

To my family

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CHAPTER ONE

INTRODUCTION

1.1 Introduction

The issue of whether bilinguals have one enlarged phonemic system encompassing both of their languages, or if the phonemic systems of the different languages kept separate is highly debated among researchers (Mack 1986; Guion 2003, Godson 2004). Looking at vowel productions by Arabic language learners, this study asks whether one or two systems coexist in the mental organization of developing bilinguals and subsequently what is the nature of such phonetic/phonological system(s). Are there separate domains of knowledge for each language, and if so, do they overlap or do they share? Alternatively, does one basis of knowledge feed into both language systems? What are the main factors that influence L2 acquisition and afterwards shape its production? Furthermore, do bilinguals of varying proficiency levels process their languages in the same way? Through comparing native speakers (NSs) and language learners; specifically, heritage speakers of Arabic (HSs) and second language (L2) learners, I attempt to answer these questions.

Investigating vowel productions of HSs and L2 learners allows us to compare the phonetic/phonological systems for both populations. There are several reasons that lead us to predict variability in vowel production between these groups. First, age of exposure to the target language (TL, viz Arabic) is one of the main factors that differentiates both groups. For the L2 learners, the first intensive exposure to Arabic is in adulthood being language learners in college-level classes. In contrast, HSs are exposed to Arabic since infancy as children born and raised in families who speak Arabic as their first language (L1). Given that HSs are exposed to the TL

earlier, their total exposure over their lifetime is greater, and in addition, their Arabic language experience is expected to be richer. Typically, it is anticipated that the amount and extent of exposure to the target sounds vary between and within these groups. By examining HSs' TL vowel acquisition, this thesis contributes to the growing body of research on heritage language acquisition (Au et al. 2002; Godson 2004; Lee 2006; Montrul et al. 2008; Chang et al. 2008); specifically on phonology acquisition by HSs as well as L2 learners.

Arabic and English have different phonetic and phonological vowel systems in terms of the number of vowels and their acoustic realizations. In this study, stimuli of Modern Standard Arabic elicited from subjects of Palestinian descent whereas English stimuli is collected from speakers of Midwestern American English. In general, Arabic is a 6-vowel system consisting of /i i: u u: a a:/ whereas English is a 12-vowel system consisting of /i ɪ e ɛ æ ɑ ɔ o u ʊ ʌ ə/, of course, excluding diphthongs in both systems. Hence, vowels are selected to compare the speech production for both language groups because we expect cross-language differences in vowel production between Arabic and English. Therefore, we seek to determine to what extent a groups' exposure to the TL influences their vowel production. Through examining vowel contrasts (if any) between HSs and L2 learners, we compare language group variation in vowel arrangement in the acoustic space. Vowels have been widely investigated because they test the segmental aspects of L2 speech production and are reported as a reliable means for detecting foreign accent (Piper & Cansin 1988; Piske et al. 2001). Moreover, vowels enable us to shed light on phonetic category learning which is indicative of whether adults are capable of learning non-native speech sounds in their L2. If they can, then the next question is whether all vowel renditions for different language learners are alike regardless of their TL experience or whether they are different?

To answer the aforementioned questions, among others, several theories have emerged in the last few decades dealing with speech perception as well as production, mainly by non-native speakers. In general, these theories have a common goal and that is to explain why L2 learners do not have native-like speech production. However, each theory is unique in and of itself in its approach and which branch of phonological theory it draws its claims from. In the following section, I review some of the major theories in the field in the effort to characterize vowel systems and compare vowel production of Arabic by HSs and L2 learners.

The Speech Learning Model (SLM) put forth by Flege (1995) generated a lot of research on L2 vowel production. Within his framework, Flege is concerned with the ultimate attainment of pronunciation by individuals who have spoken their L2 for many years. This model claims that L2 sounds that are produced by L2 speakers are not differentiated from their L1 sounds for several reasons. First, L2 sounds that are phonetically distinct are "assimilated" to L1, and second, some features of L2 sounds that are phonetically important are filtered out by L1 phonology. Therefore, what are called perceptual "targets" are important in guiding the learning of L2 sounds and minimizing any L2 production errors. In other words, the linking between L1 and L2 allophones occurs perceptually.

For vowels, the SLM predicts that if L1 has fewer vowels than L2 then new phonetic categories will be established for the new vowels depending on the perceptual distance between the L2 vowel and its closest L1 vowel. In addition, the younger the L2 speaker is, the more advantaged s/he is in establishing a new phonetic category for the new L2 vowel (Jia et al. 2006). This model claims that L1 and L2 sounds are part of one merged system and accordingly the two languages occupy the same "phonological space" (Bohn & Flege 1992). For bilinguals, an L2 vowel category may be "deflected" away from an L1 vowel. Flege (1995) reports that cases of

historical sound change supports his claims where vowels, for example, shift and get pushed out of their usual spaces and subsequently produced differently, yet contrast is maintained between them. Moreover, as the perceived distance between an L2 sound and its closest L1 speech sound increases, it is more likely that a new category will be formed for the L2 speech sound. So, L1 speech sounds block the formation of new phonetic categories for L2 and play the role of attractors for these new L2 sounds. Many studies have shown that the SLM provides an appropriate framework for testing L2 vowel production by non-native speakers (Guion et al. 2000; McAllister et al. 2002; Yoon 2007).

The theoretical framework of the Perceptual Assimilation Model (PAM) (Best et al. 1988; 2001) is another attempt to account for the acquisition of non-native speech sounds. This model incorporates the principles of phonological theory (Best et al. 2001), specifically articulatory phonology (Browman & Goldstein 1986, 1989, 1990a, 1990b, 1992). Articulatory phonology is viewed in PAM's framework as a direct realist (ecological) position which means that listeners detect information in speech through the articulatory gestures and these include the articulatory organs, constriction locations, and constriction manner. Non-native speech sounds are assimilated to native sounds and this process is affected by the listener's knowledge of their native phonological classes. Assimilation occurs based on the commonalities of these articulatory gestures. Assimilation of non-native speech phones into the native system occurs in one of three ways: 1) categorized exemplar of some native phoneme; 2) uncategorized consonant or vowel that falls in between native phonemes; 3) nonassimilable non-speech sound that bears no similarity to any native phonemes (Best et al. 2001). In short, non-native speakers assimilate new phones to their native phonological system through detecting articulatory-phonetic similarities to the phonological units and contrasts of the native language. In sum, for

SLM and PAM, phonetic similarities or differences is viewed in regards to acoustic as well as articulatory characteristics between native and non-native speech sounds.

The Native Language Magnet model (NLM) (Kuhl 2002) instead describes a mechanism by which phonetic perception is altered through language experience. It claims that learning a primary language results in alternations of the underlying perceptual mechanisms that affect the processing of language from that time forward" (Kuhl 1995:122).Under this model, the phenomenon of "perceptual magnet effect" (Kuhl 1991a) is widely discussed. 'The magnet effect' states that exposure to a particular language results in a distortion of the perceived distance between stimuli. In other words, experience warps the acoustic space underlying phonetic perception.

The NLM model argues that the native language (NL) endows its users with a unique linguistic experience which affects the perception and production of new languages. As a result, the acoustic space of the newly acquired language along with its phonetic realization is going to be distorted in both its perception and production (Kuhl 1992a, 1993b, 1993c, 1994, 1995). This is true for both infants who are learning a native language and adults attempting to learn an L2. As a result, adults judge new sounds from L2 based on their NL. L2 learners with varying linguistic backgrounds will judge new sounds differently because of their different L1. It has been attested that linguistic experience plays an important role in the perception, production, and language processing of a new language.

In addition, Kuhl is a pioneer in testing vowels using the notion of phonetic "prototypes"; a concept originally attributable to Eleanor Rosch. Prototypes are "good instances" of categories which might be representative of that category as a whole. Prototypes of certain categories of vowels have a unique perceptual status in that they have a strong magnet effect (Kuhl 1991a).

Kuhl tested prototypes of synthesized /i/ and synthesized nonprototypes of the same vowel. Under her model, it is predicted that a prototype vowel will sound more similar to its variants than the nonprototype in relation to its variants. The magnet effect predicts that the perceptual distance between a vowel prototype and its variants is reduced. In the same study, Kuhl reports that infants and adults demonstrate a strong magnet effect in which variants were shown to be more attracted to prototypes than to nonprototypes.

Several studies attempt to test the claims of the NLM model and to prove whether this magnet effect is affected by the linguistic experience. For example, American English and Swedish 6-month-old infants were tested by identifying variants of the prototype vowels /i/ and /y/ for English and Swedish respectively (Kuhl et al. 1992). The results indicate a stronger perceptual magnet effect for prototype vowels of the NL more than for the foreign language vowel prototype. Infants from each language were better at identifying variants of the prototype of their NL demonstrating that linguistic experience alters the perception of the phonetic units of a language as early as 6 months of age. In sum, SLM, PAM, and NLM claim that L1 influences the perception and subsequently the production of L2 categories.

The abovementioned theories, among others, attempt to explain how the NL experience and the extent of exposure to L2 shape the discrimination and production of L2 speech sounds. Building on these previous research findings, this thesis is going to focus on the comparison of vowel production among groups of L2 learners that have distinct language experience. For a comprehensive picture, the conclusions drawn from this study will evaluate the claims of these models attempting to support some and will be held against others.

1.2 The Nature of Interlanguage Phonology

Most published L2 studies are in the area of syntax while L2 phonology has received much less attention. In the last few decades, investigation of Interlanguage (IL) phonology started to bloom (Tarone 1987 and 1984; Broselow 1983; Ioup & Weinberger 1987, James 1988; James & Leather 1987; Mairs 1989; Rubach 1984; Young-Scholten 1990a, 1990b; Broselow & Finer 1991; and Singh 1991). Therefore, it is vital to examine L2 research progression in order to appreciate the growth in this emerging field and to build on previous findings.

To comprehend the nature of the L2 phonology, the NL should be considered the foundation through which IL rules are established, formalized, and then produced. According to generative phonology and later theoretical models, IL is a set of rules that convert underlying representation into surface representation. On the practical side and within the context of this study, IL refers to foreign or L2 pronunciation through reverting to the similarities and differences between the NL and TL. It has been observed that the similarities and differences between the NL and TL sound systems affect L2 phonological learnability. Selinker (1972) states that this IL grammar is systematic and shares features from both L1 and L2. Moreover, in his study, Flege (1981) explains how foreign accent can be attributed to the establishment of stable phonological representations for sounds and words in the NL, thus resulting in producing similar sounds in the NL and TL according to a dual acoustic model. This model provides a phonological translation in regards to a two-language source of phonetic input. To extend this, Eckman et al. (2001) discuss the 'phonemic split' phenomenon put forth by Lado (1957) and describes a maximum difficulty in L2 pronunciation learnability in which an L2 learner must split the NL allophones into separate TL phonemes.

Lately, phonological theory has been investigating how non-native like segments are acquired by L2 learners. Relatedly, in the effort to answer questions about Arabic vowel acquisition by HSs and L2 speakers, I will build on previous work and present major developments in the field. I will start with a brief historical overview of two major opposing views on the acquisition of L2 segments. One of the earliest attempts was Lado's (1957) Contrastive Analysis (CA) which investigated why L2 learners vary in their pronunciation. CA claims that L2 learners face difficulties while learning a new language. Lado suggests that if the newly acquired segments are similar to ones already available in L1, then their acquisition will be easier. On the other hand, if these segments are different, then their acquisition will be difficult. CA proponents argue for its effectiveness as a credible methodology in foreign language teaching in the classroom (Marton 1979). Later on, Archibald (1998) criticizes CA by claiming that it does not explain why certain L1 and L2 segment differences lead to learning difficulties in certain instances whereas other differences do not.

Alternatively, Eckman's (1977) Markedness Differential Hypothesis was proposed as a later and opposing view to address CA's shortcomings. This hypothesis is based on a phonological theory of markedness which is widely discussed in linguistics literature and utilized in L2 learning. One can view a marked category or form as being rare or unusual whereas an unmarked category or form as being usual and common. One example on this hypothesis is the 'Voice Contrast Hierarchy' proposed by Dinnsen and Eckman (1975) in which they explain a hierarchy of languages that exhibit voicing contrast in initial, medial, and final positions. According to Markedness theory, a language that maintains a voicing contrast word finally also maintains a contrast in all positions but not vice versa. This makes voicing contrast word initially less marked than voicing contrast word finally. This can also be applicable to an L2 learning

situation in which markedness predicts the type as well as degree of difficulty in the learning process. The main premise, here, is that the unmarked segment is easier to learn and retain than the marked one in L2 processing and learning. For example, a native English speaker, whose L1 exhibits a marked voicing contrast (of bilabial stops [b] and [p]), will have no difficulty producing Arabic words that contain the voiced bilabial stop—Arabic does not exhibit a voicing contrast for bilabial stops. However, a speaker of Arabic, a language with a less marked structure, will have difficulty producing the English voiceless bilabial stop and will make pronunciation errors. The same argument is also valid for L2 vowel production by English adult L2 learners of Arabic. In this case, Arabic vowels are seen as unmarked since the English vowel space includes the Arabic vowels (though they are phonetically different) but not vice versa. This suggests that if the L1 lacks certain phonemic contrast, then it will be hard for speakers of that language to learn the new contrast in an L2.

In order to understand how adult L2 learners acquire their L2 phonology, it is crucial to take into account the interplay between the NL system, TL system, and Universal Grammar UG. One important question arises and that is whether adult language learners are guided by UG or not. Clahsen (1988) claims that children are guided by UG principles while adults are guided by general learning principles. Therefore, children and adults are different in their language acquisition, and in order to understand why children, for the most part, are more successful in learning a new language than adults, we need to look beyond UG for explanation. For adults, we expect more variation in language acquisition and we cannot ignore the influence of L1 on the learnability of L2 segments; in this case, Arabic vowels. Stockwell and Bowen (1983) propose a hierarchy of phonological difficulty in acquiring new segments in L2 ordered from most difficult to least difficult as a means of recognizing complexity in comparing languages. For example,

they ordered the most difficult category as one that has differentiation in which the NL has one form whereas the TL has two. Another difference between languages occurs when a category is present in one language and absent in another. These predictions of difficulty were based on whether or not phonological categories are absent or present and, if present, whether they are obligatory or optional. This Hierarchy of Difficulty helps in cross-linguistic comparisons in which the presence or absence of L2 segments in L1 is investigated and the differences in L2 learners' production are better understood. Accordingly, the study of Arabic vowel production by English speakers seems to be particularly well-suited to test whether acquiring a TL contrastive speech sound is easy or difficult based on its presence or absence in the dominant language phone inventory.

Many studies on L2 phonology were conducted to show how L2 learners develop their phonological systems. Some investigated individual segments such as Beebe's (1980) study on the acquisition of the phoneme /r/ by Thai speakers. The literature is also replete with studies on the acquisition of L2 syllable structure, e.g. the Broselow, Chen, & Wang (1998) study on simplification of English syllable codas—forms ending in obstruents— by native speakers of Mandarin Chinese; the Carlisle (1998) longitudinal study on the production of English bilateral and trilateral onsets by native Spanish speakers; the Young-Scholten and Archibald (2000) study on the development of L2 syllable structure by L2 learners and the interface between segmental features and syllable structure. Moreover, it is well-attested that L2 syllable structure is affected by the NL as well as universal tendencies. Anderson (1987) reports that Egyptian-Arabic does not have initial clusters which forces Arabic L2 learners of English to employ epenthesis because of L1 syllable structure interference and produce a word like *floor* as *filoor*.

In sum, it has been shown that the NL and TL sound systems affect the phonological learnability of an L2. Studies that focus on IL phonology attempt to understand the interplay between both language systems. In the last few decades, competing views have been presented on whether acquiring an L2 speech segment is easier or more difficult. In order to answer this, CA and Markedness Differential Hypothesis advocates and opponents strive to explain how each hypothesis is well-suited for an L2 learning situation, has its pedagogical implications, and should be adopted as a language teaching methodology. Next, the discussion is narrowed down to talk about acquiring a specific facet in L2 phonology, viz. an L2 vowel system.

1.3 The Acquisition of Vowel Systems in L2

In this section, I will start with a brief discussion of vowel systems. Next, I will present the theoretical and applied aspects of acquiring an L2 vowel system. Broadly speaking, vowel systems are consequences of similarly universal properties of human speech production, hearing, and speech perception. Crothers (1978) presents a typology of vowel systems that is based on a sample of 209 languages taken from the Phonology Archive of the Stanford Project on Language Universals. Crothers uses what is termed 'classic phonemic method' which places a distinction between marginal phonemes and full phonemes. However, his analyses are based on fully phonemic vowels and their major phonetic realization. Under his model, vowel quality is quantized in terms of 37 categories. Crothers arranges systems that have 3 to 9 vowels in the form of a quasiacoustic vowel chart which shows that [i], [a], and [u] as the preferred vowels. These vowels are preferred because they appear at the extreme points of the acoustic space and are the most frequently occurring vowels in the languages of the world. [e], [ɛ], and [o] are the

peripheral vowels and are in the second place. Next, we find two central vowels, [ɨ] and [ə], two front rounded vowels, [ü], and [ø], and one back unrounded vowel [ɯ]. The knowledge of vowel typology in the world's vowel system helps in cross-linguistic comparisons, especially when two unrelated languages are being investigated. Later on, this discussion will assist us in comparing the language learners' Arabic and English vowel systems.

1.4 The Theoretical and Applied Aspects of Acquiring an L2 Vowel System

This section discusses the theoretical and applied facets of acquiring an L2 vowel system. The cognitive aspect deals with the nature of the phonological system in developing bilinguals, while the applied aspect reports on L2 vowel acquisition research that aims at enhancing classroom language teaching.

As stated above, bilingual studies often raise the question of whether individuals who are exposed to two languages in early childhood possess one or two phonetic/phonological systems. One view is that bilinguals can acquire another phonetic/phonological system and be monolingual-like in both of their languages (Penfield 1953; Penfield & Roberts 1959). A second view is that early bilinguals are disadvantaged compared to late bilinguals (Ekstrand 1976; Baker & Trofimovich 2005; Mindt et al. 2008) and another one in the middle argues that though early bilinguals perceive/produce their phonetic/phonological systems in a monolingual-like manner, their performance is still different from that of monolinguals (Seliger, Krashen, & Ladefoged 1975; Mack 1986; Tees & Werker 1984).

This original debate of one combined or two separate systems of phonological inventories for bilinguals' speech sounds can be extended to describe TL vowel acquisition. For example, Guion (2003) investigates Quichua-Spanish bilinguals differing in age of Spanish acquisition:

early (5-7 years old), mid (9-13), late (15-25) and simultaneous (since birth) bilinguals. The researcher reports that simultaneous bilinguals are able to partition the vowel space of their two languages better than early ones, whereas early and mid bilinguals acquired Spanish vowels and late bilinguals did not. Furthermore, the native vowel system, Quichua, was affected by the L2 vowel system, Spanish, in that native vowels were raised to accommodate new Spanish vowels.

The work on vowels by Sebastián-Gallés and Soto Faraco (1999) argues that L1 affects the perception of L2 phonemic categories even if language exposure to L2 occurs at a very early age. The study shows highly proficient Spanish-dominant Catalan-Spanish bilinguals, who are exposed to Catalan between the ages 3 and 4, performing worse than Catalan-dominant, who are exposed to Catalan from birth, in an on-line processing (gating) task testing vowel contrasts in the native vs. non-native language. Along the same lines and testing Spanish-Catalan bilinguals, Bosch et al., (2000) states that the acquisition of L2 phonemic categories is also compromised even if exposure to L2 happens early in life. This hypothesis is tested through discrimination tasks asking participants to give goodness ratings to Catalan and Spanish vowels. Despite early and extensive exposure to L2 vowels, bilinguals perceived and produced L2 categories differently from their L1, confirming that the mental organization of both languages are not alike.

On the applied aspect, examining Arabic and English vowels allows us to compare the vowel space (for each language and across varying groups) as a whole and identify differences between the two vowel systems. This is a valuable asset for teaching foreign languages and correcting L2 learner's errors. This, in turn, aids in evaluating students' achievements of correct pronunciation skills in L2. Another pedagogical advantage of investigating different vowel systems is to predict the degree of difficulty L2 learners may face when they try to master the TL

vowel system. Hickey, Fisiak, & Puppel (1997) suggest teaching the vocalic sounds of a TL in the form of subtasks in which the simple (quantal) vowels should be taught first, followed by more complex (peripheral) vowels, and finally the most complex (interior) vowels are taught. The Arabic vowel system comprises the set of quantal vowels (the short and long counterparts) which according to Hickey, Fisiak, & Puppel's study ought to be taught first. In addition, this set of vowels is the only one that has to be learnt in the L2. This means that the L2 learners throughout their learning experience will be exposed to a limited set of vowels, will be asked to perform a lot of repetitions, and at the same time they will be exposed to variants of these vowels. Indeed, learning a language with a smaller vowel system than English is expected to be advantageous to the learning process and the acquisition of L2 vowels. It also has pedagogical implications for the language classroom. Conversely, it would have been a different learning experience if the L2 learners were exposed to a larger vowel system. This would have required them to deal with more vowels and if the vowels have allophones, then they would cope with multiple variants. This will result in a harder task for both the language teacher and student. More importantly, I claim that the issue at stake here is how to teach target vowels adopting a methodology that guarantees the learner's production (pronunciation) of the correct targets: an issue concerns language teachers and practitioners. So far, I have presented an overview of the acquisition of nonnative speech sounds. Next, I focus on the acquisition of vowels by HSs, a unique group of language learners with greater than before interest and presence in language classrooms.

1.5 Background: Who are Heritage Speakers?

In recent years, HSs, as a distinct group have received increasing attention from linguists (Godson 2004; Polinsky 2007; Montrul 2008) and language educators (Valdés et al. 2006). Adult HSs are often characterized as lacking significant aspects in their linguistic knowledge compared to NSs (see the thematic issue of *Studies in Second Language Acquisition: Exploring the linguistic abilities of heritage language speakers*, volume 32, to be published in June 2011). Lately, several branches of linguistics have geared up in the effort to study the linguistic abilities of HSs and differentiate this group from other language learners. Despite growing up in the same community and speaking the dominant language, HSs can be considered a distinct group from L2 learners. HSs generally come from immigrant communities. The UCLA Steering Committee (2000: 339) considers a HS as someone who has been exposed to the heritage language at home. In this study, the home language (Arabic) is different from the community language (English) and therefore the language experience of these HSs is distinct from mainstream English native speakers who speak English outside as well as inside their homes. HSs may vary in their proficiency in the heritage language, their attitude towards the language, and their feeling of association with the language, and the HS may or may not have had the opportunity to study the heritage language formally in a classroom setting. The National Council of State Supervisors of Foreign Languages (NCSSFL) advocates for heritage language teaching as part of supporting linguistic and cultural diversity in the US. Building on their linguistic inheritance, HSs are considered a unique element in the linguistic canvas of American society, whose languages and cultures should be preserved. Indeed, HSs are expected to achieve high level of language proficiency that will benefit their society. According to Guadalupe Valdés (1999), a heritage student learner is:

- raised in a home where a non-English language is spoken;

- someone who may speak or merely understand the heritage language;

- to some degree bilingual in English and the heritage language

Increasing number of researchers look into phonological learning of HSs through conducting production and perception experiments, (Au et al. 2002; Knightly et al. 2003; Godson 2003; Oh et al. 2002, 2003; Chang et al. 2008; Chang 2009) examining voice onset time, vowels, and consonants. Most studies find HSs to be advantaged over L2 learners due to their early exposure to the target language. For instance, Godson (2003) explores the production of Armenian vowels by HSs and compares it to English vowels by the same speakers. Godson finds that English (dominant language) vowels affect Armenian (heritage language) vowels, but only when the vowel categories from both languages are close in the acoustic space. From a different respect, Chang et al. (2008) compare fricatives production by HSs, NSs, and English L2 learners of Mandarin. Their findings reveal that HSs were more successful at maintaining phonological contrast for the categories in the heritage language and dominant language than other speaker groups. Interestingly, Mandarin speakers and English L2 learners of Mandarin tend to merge similar English and Mandarin fricatives, providing evidence of their inability to maintain categorical contrasts. In a nutshell, it is agreed upon that HSs are systematically lagging behind NSs (who are often defined as competent speakers of the language) and are referred to in linguistic literature as incomplete acquirers of the language, providing a means of describing their heritage language grammar.

In detail, research has uncovered that HSs surpass L2 learners in their phonetic production of target sounds, but according to Polinsky and Kagan (2007) they also lag behind

NSs in their morphosyntactic abilities. The novelty of this study is that it examines this hypothesis again, focusing on comparing the phonological attainment of both groups as well as contributing new data to confirm this claim. Because heritage language study is an emerging field which has been picking up pace in the last decade, many researchers resort to L2 studies as a well-established branch in the realm of linguistics to understand the differences as well as similarities between the two types of learners. Therefore, L2 studies will often be cited to support findings from the present experiment.

L2 acquisition studies report several influential factors that affect L2 vowel learnability. Language exposure and experience with L2 (Flege, et al. 1997), L1 background (Ingram & Park 1997), and age of exposure to L2 are among the most important factors shown to influence L2 vowel production. For example, Ingram and Park (1997) investigate L2 Australian English vowel production by Korean speakers. The researchers focus on examining cross-generational differences within the Korean speech community. It has been found that vowel overlap for L2 contrast occurs in both the acoustic and perceptual domains. They conclude that L1 vowel quality affects L2 vowel acquisition; in other words, vowel contrasts that are found in the L1 facilitate the acquisition of L2 contrasts. Along the same line, several studies look into combination of factors/variables that affect L2 vowel acquisition (Bosch et al. 2000; Godson 2004).

The role of experience in the L2 and the NL background have been found to affect L2 vowel production. Flege et al. (1997) examines 90 L2 English speakers from various language backgrounds—German, Spanish, Mandarin, and Korean— who differed in their Length of Residence (LoR) in the United States. It is found that experienced L2 speakers who spent more than 25 years in the US were able to produce and perceive the English vowels /i ɪ/ and /ɛ æ/

better than inexperienced ones. In a later study, Baker (2005) reports on a production experiment that examines how English and French of early (exposed to both languages when they were 3 years old) and late (exposed to the L2, English, when they were 8-12 years old) bilinguals influence each other. 40 Korean speakers were divided into four groups based on their experience with English and their age when they were first exposed to their L2. The subjects participated in a picture-naming task of words that contain the target vowels. The goal was to study the effect of cross-language similarity and age (early vs. late bilinguals) at the time of L2 acquisition. The findings suggest that early bilinguals have two phonetic systems for their two languages. It is also shown that even children who acquired their L2 later (around puberty) in their childhood managed to maintain phonetic distinctions that were similar to simultaneous bilinguals than adult L2 learners. However, late bilinguals acquired only one phonetic system even if they spoke or were exposed extensively to their L2. Overall, a common belief is that extended L2 experience enables language learners to produce newly acquired L2 speech sounds more accurately than inexperienced learners.

The effect of L1 use on L2 production (Leather 1990; Guion et al. 1999; Guion et al. 2000; Piske et al. 2000) hasn't been studied until recently. Previous work has found that L1 influences the acquisition and subsequently the production of L2 categories. Starting with Asher & Garcia's (1969) seminal paper on foreign accent in the speech of L2 learners, a large number of studies have investigated this phenomenon. Some studies target a specific factor and investigate its effect on foreign accent by L2 speakers (e.g. Oyama (1979) and Long (1990) looked at age and McAllister et al. (2002) and Flege et al. (1997) looked at the effect of L1 on L2 pronunciation). For example, Suter (1976) and Purcell and Suter (1980) examined the effect of L1 background on the degree of L2 foreign accent. In these two studies, native speakers of

Arabic and Persian were found to have better pronunciation of English than native speakers of Japanese and Thai. This was attributed to the effect of L1 on the degree of L2 foreign accent. In general, such studies show that more research is taking into account the role of L1 in L2 production of speech segments and finds that the NL system interferes with L2 speech production.

The effect of age of arrival to the L2 setting and its influence on L2 vowel production has also been investigated. Flege, Mackay and Meador (1999) reports on native Italian speakers who were selected based on their age when they arrived to the L2 country (Canada) –their ages ranged from 7 to 19 years– and were tested on production tasks of ten English vowels. Subjects who were in the late group received lower intelligibility scores for English /i ɪ u ʊ o ʌ/ than ones obtained from native speakers' productions for the same vowels. In addition, the results indicate that L2 vowel production accuracy ratings correlated with how the L2 vowels were perceived. It is shown that late arrivals to Canada did not perceive the L2 vowels as accurately as those who arrived at younger ages. They concluded that there was a strong evidence of the direct relationship between the production and perception of the L2 vowels than perception of the L1 vowels, which is evident specifically in the case of experienced L2 speakers.

Motivation and the impact of instruction in L2 are factors that also affect attainment of L2 speech sounds. In a study that reports on vowels among other sounds, Moyer (1999) reports on less studied factors that affect the ultimate attainment in L2 phonology and these include: instruction, motivation, suprasegmental training, and self-perception of productive accuracy. In these experiments, the researcher seeks to answer questions about the contrasts between English and German phonological systems through testing highly motivated English-speaking subjects who acquired high proficiency in German. The researcher performs several production tasks that

range from reading a set of isolated words to reading sentences, paragraphs, and free speech. The experiments focus on testing target sounds —e.g. vowels, fricatives, the glottal stop, and the allophonic variation of /r/ according to environment— which are considered difficult to acquire by nonnative speakers. Moyer finds that her subjects performed in a nonnative range in spite of the high motivational—they wanted to sound as native speakers of German—and instructional factors.

In sum, these studies show that several factors affect L2 learners' vowel production. The age of initial exposure to L2, L1 background, LoR in the L2 speech community, as well as motivational factors contribute to L2 vowel proficiency. Based on extensive research demonstrating that learners with more exposure to the TL confer an advantage in language learning and in attaining native-like proficiency, we expect HSs of Arabic to perform better in their oral productions of Arabic vowels over L2 learners.

Evaluating the effect of earlier exposure on later phonetic attainment is achieved through investigating the TL vowel production of several groups. However, before comparing non-native speaker groups with each other or to native-like production, target-like vowel values need to be established. Therefore, the next chapter presents an acoustic experiment that establishes the acoustic properties of vowels in Palestinian Arabic for later comparison with HSs and L2 learners of Arabic.

CHAPTER TWO

STUDY 1: ACOUSTIC CHARACTERISTICS OF PALESTINIAN ARABIC VOWELS

2.1 Introduction

This study investigates the acoustic characteristics of Modern Standard Arabic vowels produced by Palestinian speakers[1]. The goal is to document the acoustic measurements of Palestinian vowels for later comparison with vowels produced by English second language learners (L2) of Arabic and HSs of Arabic (presented in study 2). Palestinian Arabic is chosen for several reasons: first, it is widely represented in the United States in the community where data collection took place. Second, many heritage learners enrolled in the Arabic language program at the University of Illinois at Urbana-Champaign are of Palestinian descent. Third, it is the variety spoken by the Arabic instructor who taught the HSs and L2 learners tested in this study. Therefore, variability and interference is reduced by recruiting subjects (HSs and L2 learners) who are exposed to Palestinian Arabic and later comparing them with native speakers from the same variety of Arabic.

Typically, Modern Standard Arabic is the language of the media and education whereas multiple variants are used in the Arab World. Linguistic differences between the standard language and various dialects (which vary geographically) are found in terms of phonology, morphology, syntax, and lexical choice. In order to appreciate the extent of difference between the Arabic and English sound systems, Tables 1 and 2 below are displayed to show the phoneme inventory for Arabic and English respectively.

	bilabial	labiodental	dental	alveolar	Postalveolar	palatal	velar	uvular	Pharyngeal	glottal
Plosive	b			t d			k g	q		ʔ
Nasal	m			n						
Trill				r						
Fricative		f	θ ð	s z	ʃ ʒ			χ ʁ	ħ ʕ	h
approximant	w			l		j				

Table 1: Inventory of Arabic phonemes.

	bilabial	labiodental	dental	alveolar	Postalveolar	palatal	velar	uvular	Pharyngeal	glottal
Plosive	p b			t d			k g			
Nasal	m			n			ŋ			
Trill				r						
Affricate					tʃ dʒ					
Fricative		f v	θ ð	s z	ʃ ʒ					h
approximant	w			l		j				

Table 2: inventory of American English phonemes.

2.2 Arabic and English Vowels

Vowels are described in terms of two phonetic parameters: vowel quality and vowel quantity.
Quality refers to differences in the place of articulation of the vowel, including the position of
the tongue in the vocal tract, the size of the stricture, the shape of lips, and whether the vowel is
nasalized or not. Quality differences are seen in the acoustic signal in different spectral patterns
for different vowels. On the other hand, vowel quantity refers to the duration of the phonetic
segment (i.e., the vowel) which is considered an intrinsic part of its phonemic identity. Simply
put, the vowels are described as short vs. long.

English and Arabic are languages with phonological contrasts based on vowel quality and
quantity, respectively. English is a 12-vowel system that contrasts tense long vowels and lax

short vowels whereas Arabic is a 6-vowel system that contrasts long and short vowels. English and Arabic are not only differentiated in terms of the size of their vowel systems but also in the phonetic qualities of the vowels. In Figure 1, we see a schematic representation of all 6 Arabic vowels plotted in the vowel space whereas Figure 2 shows American English vowels. These figures are presented as a means of comparing the vowel inventories for the two systems. The placement of the vowels is roughly estimated based on the position of cardinal vowels as shown in the International Phonetic Association (IPA) vowel chart and on published resources of vowel values in both languages.
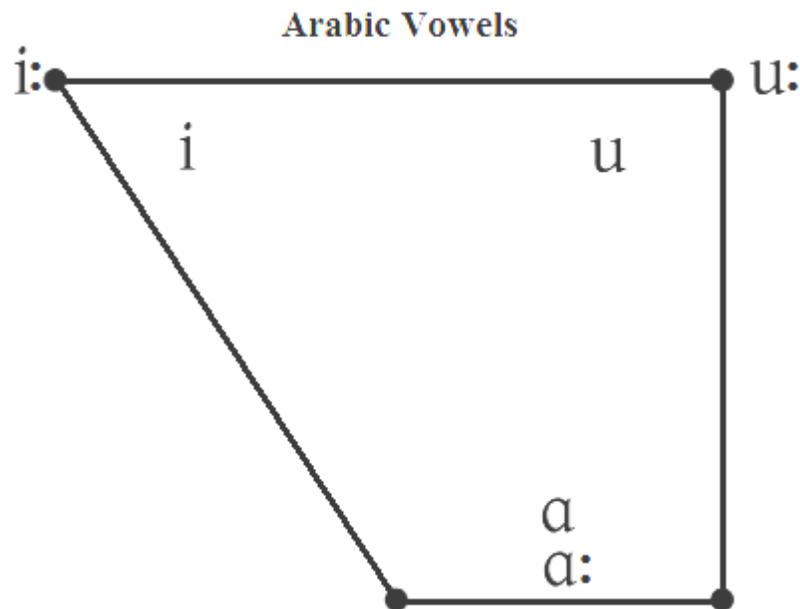
Arabic Vowels

Figure 1: Schematic representation of Arabic vowels /i i: u u: a a:/ plotted in the vowel space.
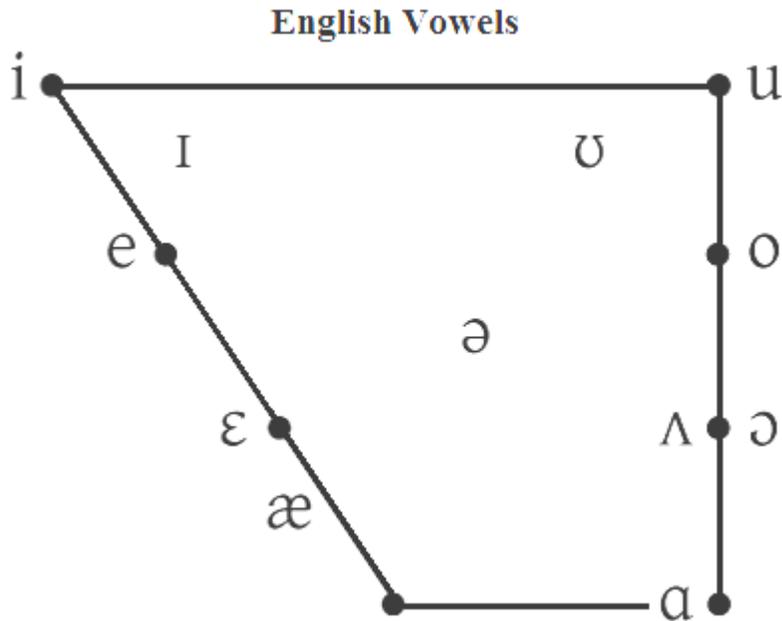
English Vowels

Figure 2: schematic representation of the English vowel monophthongs /i ɪ e ɛ æ ɑ ɔ o u ʊ ʌ ə/ plotted in the vowel space.

In studies that describe vowel systems, English is classified as a centripetal vowel system. This means that vowels have the tendency to move to the center of the vowel space. Other languages, however, are described as a centrifugal vowel system where vowels are located at the periphery of the acoustic space. Spanish, Tamil, and Russian are good examples of languages that belong to the centrifugal pattern. The Arabic vowel system falls in between centripetal and centrifugal patterns. These differences along with major distinctions in vowel quality and quantity allow us to describe English and Arabic as languages that have notably distinct vowel systems.

The English vowel system, mainly, American and British English, has been widely investigated (Chomsky & Halle 1968; Watt 2002, Hillenbrand et al. 1995; Labov et al. 2006) and is described as a large system containing simple vowels as well as diphthongs. In comparison,

Arabic is much less studied (Al-Ani 1970; Alghamdi 1998; Alotaibi & Hussain 2009) and also has both simple vowels and diphthongs. For the purposes of this dissertation, it is important to note that Arabic vowels can be affected by neighboring segments, mainly pharyngealized sounds, often referred to as emphatics, resulting in allophonic variation of such vowels because of coarticulatory effects between the vowel and surrounding emphatics. This phenomenon is described as pharyngealization and happens because of the retraction of the root of the tongue when the emphatic is articulated. This results in a narrower pharyngeal passage and a raised larynx that lasts during the vowel articulation. This added gesture (pharyngealization) is often denoted on transcribed consonants using the diacritic [ˤ] above the consonant. In this case, I follow the IPA practice to describe pharyngealization. In fact, there is a considerable difference between pharyngealized and non-pharyngealized vowels which is shown clearly in the observable acoustic and auditory effects of this gesture on the resultant vowel.

In detail, vowels are described by earlier Arab grammarians (Sibawayh, late 8th C. and Ibn Jinni, 10th c.) as being "sounds originate at the empty space in the throat and mouth, "huruuf al-jawf", i.e., /i, u, a/. These sounds are also called "aerial sounds" because their articulation is caused by the vibrating stream of air coming from the lungs. The classification of the so called "huruuf al-jawf" was an issue of disagreement among Arab philologists. Many agree on considering the empty space in the mouth and throat (the tube extending from the area above the larynx to the lips and parallel to the roof of the mouth and tongue) as a place and an articulation point at the same time (IbnAljazari 15th C.). Another view is advocated by Sibawayh (late 8th c.) and Ash-ShaTibi (late 14th C.) who do not see this space as a place of articulation. The claim is that "huruuf al-jawf" originate from the same places of articulation of other similar sounds. For example, it is proposed that /a/ has the same place of articulation as the glottal stop. These

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sounds do not originate from a specific point in the mouth; rather their production is approximate because there is no definite point of contact between articulators. Mainly, these sounds are produced through changes in tongue position, thus there is no specific place of articulation from which the sound originates and therefore can be described. Hence, these sounds are described as perception based. It is worth mentioning that these acoustic rules have been put as an attempt on the part of early Arab grammarians to describe Arabic sounds to set rules that help in Quran recitation. Having said that, this description reflects Classical Arabic characterization of what we call now vowels.

There are a small number of recent phonetic studies of Arabic vowels (al-Ani 1970; Ghazeli 1979, Belkaid 1984; Abou Haidar 1994; Mitleb 1984, Alghamdi 1998; Newman and Verhoeven 2002, Alotaibi & Hussain 2009). In spite of providing a preliminary description of acoustic correlates of Arabic vowels, most of these studies have major flaws in methodology or design; thus, making them inappropriate for comparison purposes. For example, some studies include several Arabic dialectal variants (Iraqi, Sudanese, Saudi, etc.) or insufficient numbers of informants who belong to various linguistic backgrounds, grouped together and investigated in a single study (Ghazeli 1979, Abou Haidar 1994). As shown, Table 3 below presents major Arabic studies that were undertaken to investigate Arabic vowels. It includes the author(s) name(s), year the study was published, investigated Arabic dialect(s), and number of participants in each study.

Study	year	Dialect	# of subjects
Al-Ani	1970	Iraqi Jordanian	8 2
Ghazeli	1979	Algeria, Tunisia, Libya, Egypt, Jordan, and Iraq	12
Belkaid	1984	Tunisian	
Abou Haidar	1994	Qatar, Lebanon, Saudi Arabia, Tunisia, Syria, Sudan, United Arab Emirates, and Jordan	8
Alghamdi	1998	Saudi Arabia, Sudan, Egypt	15 males (5 per dialect)
Newman-Verhoeven	2002	Quran vowels Cairene	1 1
Alotaibi & Hussain	2009	Saudi Arabia	10 (9 males + 1 child)

Table 3: Comparative data of studies on Arabic vowel classified by author, year, dialect, and number of subjects in each study.

Many reported Arabic experiments have inconsistent and variable phonetic/phonemic environments of the investigated vowels. For example, while Al-Ani investigates vowels in isolation as well as in CV sequences targeting different syllable and stress patterns, Belkaid and Abou Haidar examine vowels in CVC contexts and words. Additionally, the number of vowel tokens and quality of investigated vowels varied extensively. Al-Ani relied on measurements of 2000 vowel spectrograms, Belkaid's study included 110 long vowels and 50 short vowels, whereas Abou Haidar examines a total of 232 vowels. There was some discrepancy in

investigating vowels in pharyngealized contexts where they have been recognized as allophones with different acoustic realizations from plain/non-pharyngealized vowels as shown in some studies. For example, Abou Haidar clearly states that he examines vowels in pharyngealized contexts while most other studies exclude such environments from their investigation.

Through addressing the shortcomings in previous research, this study aims at conducting a methodologically sound experiment with the main objective of documenting acoustic characteristics of Palestinian Arabic vowels; thus, comparing it with vowels from other Arabic dialects. It also has another objective of establishing the formant frequencies of vowels as produced by NSs for later comparison with heritage speakers of Arabic and second language learners of Arabic.

2.3 Experiment and Method

2.3.1 Subjects

A group of six native Palestinian Arabic speakers with equal number of males and females participated in this study. Their ages ranged from 22-35 years. The native speakers (NSs) were recruited from the surrounding local community in Champaign, Illinois. Subjects were chosen based on their age of arrival to the United States. These included subjects who typically arrived after the age of 20. All subjects reported normal speech and hearing. They were asked to fill a language questionnaire to make sure that they all met the selection criteria. All subjects volunteered to participate in the study.

Each subject was asked to read and record all tokens in one session. Each session lasted for 20 minutes. Each subject was tested individually in a sound-proof booth in the Phonetics and

Phonology Lab at the University of Illinois at Urbana-Champaign using a Marantz digital

recorder (Marantz PMD660) and a mounted-headset professional microphone. The recordings

were sampled at 48.0 kHz and using Praat 4.5.16 software (Boersma and Weenink 2007).

2.3.2 Task

Participants were asked to read a list of tokens which appeared in carrier phrases. Target tokens

consisted of 114 items corresponding to 114 carrier phrases which was read and repeated twice

by each subject. There were 1368 vowel tokens in total (114 words x 2 repetitions x 6 subjects).

The carrier phrase translates into 'Say X twice' where 'X' represents one target token.

2.3.3 Materials

Stimuli were presented to participants in the Arabic language orthography and supplemented

with diacritic markings. Subjects were asked to pronounce the list of carrier sentences in the

Arabic language.

The target vowels consisted of the Arabic short vowels /i u a/ and their long counterparts

/i: u: a:/. Materials consisted of two major groups: plain (or non-pharyngealized) and

pharyngealized vowels. In the first group, target tokens consisted of CVC monosyllabic words.

Consonants flanking target vowels were chosen to represent distinct places of articulation on the

left and right sides; bilabial /b/, dental /d/, and velar /k/. The effect of consonant voicing on

vowel formant values was also tested through examining the vowel between voiceless /t/ and /s/

and voiced /d/ and /z/. The fricatives /s/ and /z/ were chosen to be part of the data though the

stop-fricative distinction is not expected to have an effect on the vowel F1 and F2 formant

values.

The second group consisted of CVC monosyllabic words but had pharyngealized vowels. Target tokens in this set had the same set of Arabic vowels but word-initial emphatic consonants /sˤ dˤ tˤ ðˤ/ and their non-emphatic counterparts /s d t ð/ followed by the Arabic long vowels /i: u: a:/ (e.g. / sˤi:b/ and / si:b/) and their short counterparts (e.g. / sˤib/ and /sib/). The final consonant was controlled in all pharyngealized tokens, /b/, i.e., CVb. For both groups (plain and pharyngealized vowels), real words were provided whenever possible, otherwise, nonsense words were used to match the exact same structure of real words. The list of tokens is provided in the appendix.

2.3.4 Procedure

Formant measures of F1 and F2 were taken for target vowels (in Bark) at vowel midpoint using the Praat burg algorithm setting the parameter at maximum formant value of 6500 for females and 5500 for males.

2.4 Results

Table 4 displays the mean formant frequencies of F1 and F2 (in Bark) across the six NSs. For F1, short /i/ has higher formant value than long /i:/ and so is the case for short /u/ having a higher F1 value than long /u:/. This finding indicates that for the high vowels, the long vowels are produced with a more constricted vocal tract (higher tongue body position) than their short counterparts. Conversely, short low vowel /a/ has a lower F1 than long /a: /, indicating that the long vowel is produced as lower (with a lesser constriction). For F2, short /i/ has lower value than long /i: / whereas short /u/ has higher value than long /u:/. In terms of tongue position, /i/ is produced backer than its long counterpart while /u/ is fronter than long /u: /. Long and short low vowels

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have comparable F2 values which show that both segments have similar tongue position (in terms of frontness/backness).

	/i/		/i:/		/u/		/u:/		/a/		/a:/	
Native Palestinians	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2
	4.6	12.56	3.0	14.3	4.6	9.0	3.2	7.1	6.2	10.9	6.69	10.97

Table 4: F1 and F2 mean values (in Bark) for /i i: u u: a a: / for Native Palestinian speakers.

Table 5 presents vowel frequencies (in Hz) as reported by Newman and Verhoeven (2002). These values were transformed into Bark and incorporated in Table 6 below.

	/i:/		/i/		/u:/		/u/		/a:/		/a/	
	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2
Al-Ani	<u>285</u>	2200	<u>290</u>	**2200**	<u>285</u>	<u>775</u>	<u>290</u>	<u>800</u>	675	<u>1200</u>	600	1500
Ghazeli	310	2225	455	1780	330	900	450	1125				
Belkaid	<u>285</u>	2195	355	1830	310	790	340	995	<u>425</u>	1720	<u>400</u>	**1640**
Haidar	315	**2230**	**485**	<u>1750</u>	335	835	500	1120	**690**	**1500**	**675**	1585
Newman-Verhoeven/Quraic	**390**	<u>1725</u>	440	1770	**470**	**1120**	**480**	**1170**	620	1455	616	<u>1460</u>
Newman-Verhoeven/Cairene	290	1940	375	1575	290	830	360	912	610	1500	683	1435
Spread	105	525	195	450	195	345	190	370	275	300	275	180

Table 5: Comparative vowel frequencies (Hz) across different studies on Arabic vowels. Values in bold are the highest in range, those underscored the lowest, blanks indicate absence of data. (Reproduced from Newman and Verhoeven 2002).

Table 6 below shows comparative F1 and F2 mean values (in Bark) of all six vowels /i i:
u u: a a:/ for other dialects of Arabic as cited in studies on Arabic vowels. For comparison
purposes, it also includes the values from the present study. Upon inspecting the values in Table
6, we see the following: first, each Arabic vowel is produced with varying ranges for speakers
from these studies of different dialects of Arabic, though it is hard to tell if these differences are
due to speaker or due to dialect given the small number of subjects. Second, Palestinian vowels
occur with medium range values compared to other dialects. In fact, it is premature to make any
generalizations about the Palestinian dialect in comparison to other Arabic varieties given the
small number of speakers investigated here. In addition, these studies do not provide data on the
variability of the formant measures across the speakers reported in other dialects, making such
comparison much more difficult.

	/i:/		/i/		/u:/		/u/		/a:/		/a/	
	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2
Al-Ani/ Iraqi	2.98	13.53	3.03	13.53	2.98	7.08	3.03	7.25	6.36	9.61	5.78	11.01
Ghazeli/ mixed	3.22	13.61	4.57	12.13	3.42	7.90	4.52	9.21				
Belkaid/ Tunisian	2.98	13.52	3.65	12.31	3.22	7.18	3.51	8.48	4.30	11.90	4.07	11.59
Haidar/ mixed	3.27	13.63	4.83	12.01	3.46	7.48	4.96	9.19	6.47	11.01	6.36	11.37
Newman-Verhoeven/ Quraic	3.98	11.92	4.44	12.09	4.70	9.19	4.79	9.45	5.94	10.82	5.91	10.84
Newman-Verhoeven/ Cairene	3.03	12.69	3.84	11.33	3.03	7.45	3.70	7.98	5.86	11.01	6.42	10.73
Spread	1.13	5.17	2.07	4.52	2.07	3.56	2.02	3.80	2.88	3.13	2.88	1.91
Alotaibi & Hussain/ Saudi	4.19	13.32	4.78	11.20	4.33	7.64	4.86	8.36	6.43	9.57	5.71	9.09
Alghamdi/ Sudanese	2.85	13.70	3.42	13.11	3.30	8.42	3.64	10.1	6.05	10.98	5.16	11.28
Alghamdi/ Egyptian	2.69	13.46	3.66	12.01	3.30	8.16	3.79	10.0	4.62	11.73	4.68	11.03
Alghamdi/ Saudi	3.05	13.79	4.09	12.34	3.60	8.26	4.52	10.1	6.20	11.38	5.57	11.17
Saadah	3.02	14.33	4.63	12.6	3.29	7.16	4.63	9.04	6.69	11	6.2	10.95

Table 6: Comparative F1 and F2 mean values (in Bark) for /i: i u: u a: a/ across different studies.

Figure 3 shows the acoustic space of Palestinian Arabic vowels by all NSs. Long Arabic vowels are produced at the periphery of the vowel space for all three vowel qualities while short ones are more centralized. High long vowels are produced higher than short ones whereas long low /a:/ is lower than short /a/. In terms of frontness/backness, long high front /i: / is fronter than /i / and /u: / is backer than /u/. For the low vowels, long and short ones are aligned at a comparable frontness/backness dimension in the acoustic space.
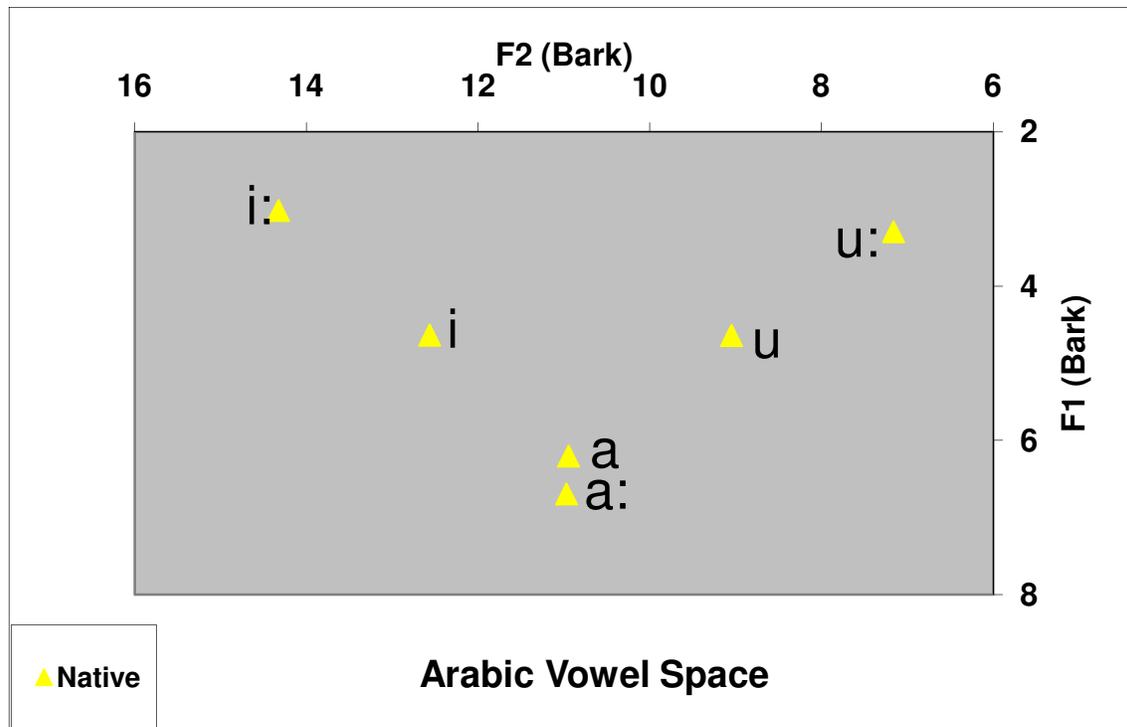
Figure 3: acoustic space of Arabic vowels /i i: u u: a a:/ for native Palestinian speakers.

F1 and F2 measures are presented and treated as the dependent variables in all the ANOVAs that were conducted for this experiment. Vowel quality (a 3-level factor: front, back, and low), vowel length (2-level factor: short and long), Vowel (6-level factor: /i, i:, u, u:, a, a:/), and gender (2-level factor: male and female) are investigated and considered the independent variables.

Pooling formant data from all six speakers, An ANOVA was conducted to test the effect of vowel quality (a three-level factor: front, back, low) on vowel formant frequencies. One-way ANOVA shows that vowel quality has a highly significant effect on F1 and F2, which were [F $(2, 1365) = 1331.2$, $p < 0.001$] and [F $(2, 1365) = 1937.8$, $p < 0.001$] respectively. Since the ANOVA shows significant effects of vowel quality on F1 and F2, Tukey HSD post-hoc tests were conducted. The results indicate significant differences in F1 and F2 measures for all three vowel identities.

Vowel length, a two-level factor that consists of short /i, u, a/ vs. long /i:, u:, a:/ vowels, is the second investigated independent variable. One-way ANOVA was conducted to test the effect of vowel length on F1 and F2 formant values. The results were [$F(1, 1366) = 115.06$, $p < 0.001$] which shows a highly significant effect of vowel length on F1 but were not significant on F2. Because the non-significance of vowel length on F2 seems to be due to the fact that the effect is in the opposite direction for /i: i/ and /u: u/, and there is likely no effect for /a: a/, we performed t-tests between long and short /i/ and /u/ to see if we find significant difference in F2 between them due to length. The results confirmed our expectation and a highly significant difference between long /i:/ and short /i/ [$t = -22.4931$, $p < 0.001$] as well as between long /u:/ and short /u/ [$t = 18.3899$, $p < 0.001$] in F2 is shown due to length. However, the results were not significant for long /a:/ and short /a/. Since the ANOVA shows significant effects of vowel length on F1, TukeyHSD post-hoc tests were conducted. The results indicate highly significant differences in F1 measure only for long and short vowels.

A similar analysis was performed testing the effect of vowel, a six-level factor, /i i: u u: a a:/, on F1 and F2. For F1, ANOVA shows highly significant results for vowel [$F(5, 1362) = 1415.9$, $p < 0.001$] on F1 and F2 [$F(5, 1362) = 1290.4$, $p < 0.001$]. Tukey HSD post-hoc tests were highly significant between all vowels for F1. However, the pair-wise comparison results indicate significant differences in F2 measure for all vowels except between /a/ and /a: /.

Finally, the effect of gender, a two-level factor: male vs. female, on F1 and F2 values was also tested. One-way ANOVA shows a highly significant effect of gender on F1 [$F(1, 1366) = 66.901$, $p < 0.001$] and F2 [$F(1, 1366) = 42.035$, $p < 0.001$]. Pair-wise comparison tests indicate that male and female F1 and F2 measures were highly distinct from each other.

		Native Speakers (NSs)					
		/i/	/i:/	/a/	/a:/	/u/	/u:/
Dur	**M**	84	219	97	247	90	226
	F	93	219	106	253	95	219

Table 7: Mean duration values (in milliseconds) for /i i: a a: u u: /of male (M) and female (F) Native Speakers (NSs).

Table 7 presents the mean duration values in milliseconds of male and female NSs for all six vowels. The numbers show us the following: males and females values are close to each other with males having smaller duration values for short /i a u/. For long vowels, the data do not exhibit a unified pattern for both sexes. In detail, males have slightly longer duration for /u: /, shorter duration for /a: /, and identical duration values for /i:/ when compared to females. Generally speaking, the duration values of males are smaller than females. Another important thing to note is that long vowels are on average two times longer than short vowels.
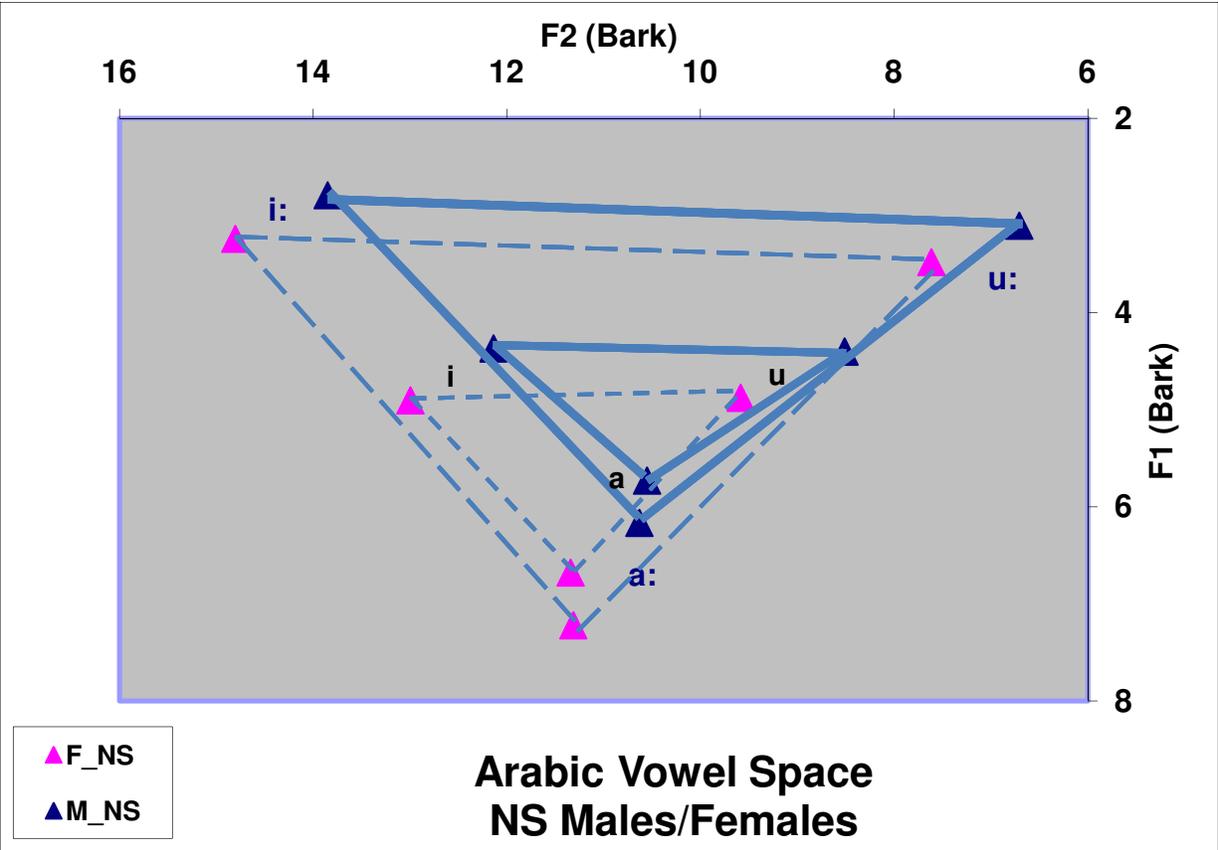
Figure 4: Mean values (in Bark) of the six Arabic vowels /i i: u u: a a: / for male (M) and female (F) native speakers (NS). The acoustic space for each group is indicated by solid lines for males and dashed for females. Two triangles are presented for each group, one for long vowels and the other for short vowels. Long and short vowels are labeled for males and females for each vowel quality.

Figure 4 represents the acoustic space for all six Arabic vowels plotted for male and female NS. Two triangles are plotted for males, one denotes the long vowels and the other for the short vowels and the same is true for females. It is shown that the triangles for the long and short vowels for the male subjects are comparable in size to the ones for the female subjects. However, the triangle of long and short vowels for males is shifted in the F1 X F2 plane, showing lower F1

as well as backer F2 frequencies than the triangles for the females. Moreover, the triangle of the short vowels falls within the larger one of the long vowels for both speaker genders.

As previously shown, we compared vowel duration as produced by male and female NSs, but only the male results will be compared to speakers from three other Arabic dialects: Saudi, Sudanese, and Egyptian (Alghamdi 1998) Arabic. Since all informants in Alghamdi's study were male speakers, it is more informative to compare our results from only male speakers with values from the aforementioned study.

	/i/	/i:/	/a/	/a:/	/u/	/u:/
Palestinians	84	219	97	247	90	226
Saudi	110.8	247.6	132.8	311.4	113.73	237.33
Sudanese	116.53	275.13	128.27	294.8	116.27	304.47
Egyptian	98.4	255	122	315.53	109.53	253.4

Table 8: Mean duration values (in milliseconds) of all six Arabic vowels, /i i: a a: u u:/, for male Palestinian, Saudi, Sudanese, and Egyptian speakers. Palestinian values are obtained from the present study whereas Saudi, Sudanese, and Egyptian values from Alghamdi (1998).

The results show few patterns. First, speakers of various Arabic dialects in Alghamdi's study produce duration values that are close to each other but are distinct from Palestinian speakers. Second, Palestinian values are the smallest among all speakers. Specifically, Palestinians have the smallest durations for short vowels followed by Egyptians, then Saudi and finally Sudanese. For long vowels, Egyptian and Saudi values are close to each other and similar

to Palestinians but distinct from Sudanese. More discussion of these findings will be presented later on but now let us turn to a more detailed analysis of comparing pharyngealized and non-pharyngealized vowels.
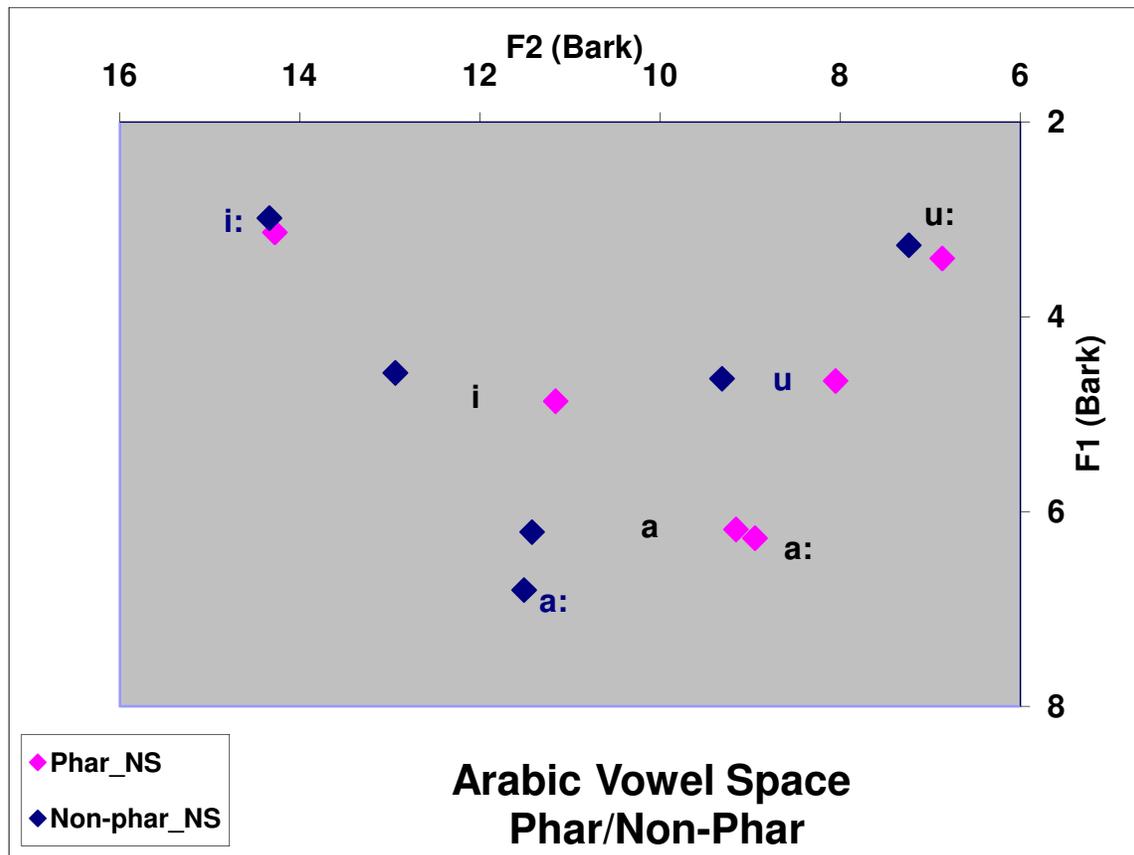
Figure 5: Acoustic space of Arabic pharyngealized (phar) and non-pharyngealized (Non-phar) vowels for native Palestinian speakers (NS).

Figure 5 presents the acoustic space of Arabic pharyngealized vowels compared with vowels in a non-pharyngealized and a pharyngealized context. Vowel pharyngealization refers to a vowel when it is preceded by one of the emphatic segments /sˤ dˤ tˤ thˤ /. As can be seen, the figure displays several patterns. Pharyngealized and non-pharyngealized high long vowels are

closer to each other than short and low vowels. ANOVA did not display a significant effect of pharyngeal vs. non-pharyngeal factor on F1. Conversely, ANOVA shows a highly significant effect of pharyngealization on vowel F2 frequencies [$F_{(1, 1366)} = 70.905$, $p < 0.001$]. Clearly, we see that pharyngealized vowels have a backer position compared to their non-pharyngealized counterparts. It is evident that the high long vowels have stable positions in the acoustic space for pharyngealized as well as non-pharyngealized vowels. The pharyngealized high short vowels are backer with short /i/ located in a central position in the F1 X F2 plane, having the same horizontal position as non-pharyngealized low vowels. The high short back pharyngealized /u/ has a similar horizontal position to non-pharyngealized long /u:/. In addition, we have an interesting case for the low vowels with pharyngealized versions being significantly backer and more similar to each other on the F1 dimension than the non-pharyngealized counterparts. However, non-pharyngealized low vowels have similar F2 positions to each other which in turn aligns with pharyngealized short /i/ F2 dimension as mentioned earlier. Moreover, the pharyngealized low /a: / has a similar trend to other pharyngealized long vowels as being located backer in the acoustic space. There is also a significant shift of the vowel triangle for short plain vowels from a central position in the acoustic space to a more peripheral backer position when pharyngealized. For long non-pharyngealized segments, the vowel triangle is similar to the pharyngealized one except for a shift in the low vowels. In sum, pharyngealization causes the shift of the vowel triangle from a central to a more peripheral backer position in the F1 X F2 space.

2.5 Discussion

In this section, I will briefly present the results and discuss it in light of other research in the field. For F1, it has been shown that high short vowels have formant frequencies that are lower than long ones whereas short low /a/ has higher values than long /a: /. It is interesting to note that /i/ and /u/ have identical F1 frequencies whereas /i: / and /u: / are very close in values. So, this shows that both vowels are differentiated in terms of their frontness/backness rather than height. In fact, /u:/ has a slightly lower formant frequencies than /i:/ and that can be due to lip rounding during /u:/ production. This means that a NS places his/her tongue at a comparable distance from the roof of the mouth when producing front and back Arabic high vowels. This is true for other Arabic dialects in which speakers produce the same or close F1 values for high vowels (Al-Ani 1970 and Alotaibi & Hussain 2009). In other words, high long vowels have very close F1 dimensions and so are high short vowels. As for F2, long /i: / is fronter than /i/ and /u:/ is backer than /u/ making longer segments at the periphery of the vowel space while shorter vowels occupy more centralized positions. However, the low vowels have the same F2 dimension for both segments. This shows that short segments have a significantly smaller vowel triangle than the one for longer vowels.

For a more comprehensive picture, Palestinian vowels are compared with vowels from other dialects of Arabic. This comparison with other Arabic varieties is undertaken to show that differences among vowel qualities between Arabic varieties do exist, emphasizing the importance of careful examination of homogenous groups of subjects as representatives from certain dialects. In general, this comparison reveals a pattern of variation in vowel values among Arabic dialects with Palestinian vowels having medium ranges when compared with other varieties. For F1, Palestinian vowels have lower values than most other Arabic dialects. We see

that Iraqi speakers (Al-Ani 1970) and Tunisians (Belkaid 1984) have the highest F1 formant values. However, the data does not show a trend for speakers of a specific dialect producing consistently higher or lower F1 for all vowels. For example, Egyptians produce highest values for /i: / which is 2.69 (Alghamdi 1998) but they also have the lowest values for /a/ at 6.42 (Newman-Verhoeven 2002). For F2, Palestinian has midway values compared to other Arabic dialects. This shows that though Arabic vowels are phonemically the same, their phonetic realization is somewhat variable for different Arabic dialects. Establishing formant frequencies should take into consideration many factors. The most important one is examining talkers who are from the same geographic region and who have had a comparable language experience. It suffices to say that though the phonetic realization (production) of phonemic segments (i.e., vowels) is variable in Arabic, it is still close and falls within boundaries that allow speakers of different dialects to perceive these different renditions as the target segment.

Moreover, the acoustic space provides another way of representing vowels in Arabic. The vowel triangle of the short vowels is significantly smaller than the triangle of longer ones. This shows that long vowels occupy points that are in opposition to each other more than short segments. It could be that the short vowels do not reach such peripheral targets because of their shorter duration, relative to the long vowels. Along with orthography in which long vowels are realized as part of the Arabic alphabets, Arabs also have to significantly lengthen vowel duration to achieve target production of long vowels.

In this study, F1 and F2 are considered the dependent variables and vowel quality, vowel, and gender are the independent variables. When vowel quality is tested, the ANOVA and post-hoc Tukey results above show that it is a highly significant factor on F1 and F2. This means that speakers have differentiated vowels producing distinct places which are front for /i/ and /i: /,

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back for /u/ and /u: /, and low for /a/ and a: /. Likewise, previous work on Arabic has established that NSs have different vowel identities and they place vowels at distinctive places in the acoustic space (Alghamdi 1998 and Newman & Verhoeven 2002).

Vowel length as a second independent variable was also investigated. Since ANOVA and pair-wise comparison tests indicate a highly significant effect on F1only, t-tests were also performed to examine the length contrast between long and short /i/ and /u/. The results reveal that long and short vowels are mainly distinct based on their F1 value; that is vowel height. This means that long and short vowels are mainly differentiated based on how high/low NSs place their tongue in the mouth. The results also show that long and short vowels were, in fact, significantly different on F2 where long /i/ is fronter and long /u/ is backer in the vowel space. In addition, high vowels are affected by tongue body position in the vocal tract where long /i:/ has a fronter tongue position than short /i/ and /u:/ has a backer tongue position than /u/. Vowel length is considered the most prominent phonetic correlate of the long-short contrast. Prior research has established that vowel length is associated with 'formant frequency displacement' (Moon and Lindblom 1994). This finding seems to be true for the data in this study, but not as much for /a/. This means that at the phonemic level, vowel length affects formant frequencies causing them to shift from their hypothetical targets. Hirata and Tsukada (2004) report that vowel length affects F1 and F2 formant frequencies causing Japanese long vowels to occupy a more peripheral position in the vowel space than short vowels as is the case in /i:/ and /e:/ being more peripheral in the F2 dimension than their shorter counterparts. Hirata and Tsukada also found that long /a:/ has higher F1 and F2 frequencies than short /a/ whereas long /u:/ has higher F2 and lower F1 regions than its short counterpart.

All three long Arabic vowels /i: u: a: / occupy outer positions in the vowel space. The high vowels were produced with lower F1 frequencies than their shorter counterparts. This indicates that the tongue was placed higher and/or the jaw was wider during the articulation of long vowels compared to their shorter counterparts. The high vowel /u: / has lower F2 frequencies than /u/ whereas /i:/ is more fronted and higher in values than /i/ but it is worth noting that none of the vowel pairs were found statistically significant in the F2 region. Furthermore, the low vowel /a/ is more centralized with lower F1 frequencies suggesting that it is articulated with higher tongue placement than long /a:/ and the length factor seems not to affect the low vowels in the dimension of F2.

Vowel, a six-level factor, was also investigated with ANOVA and pair-wise tests showing highly significant effects of vowel on F1 and F2 dimensions. However, the results show no statistical effect between /a/ and /a: / on F2 indicating that the two vowels were produced with comparable placement of the highest part of the tongue during the production of /a/ and /a:/. Arabic is characterized as a small vowel system which means that vowels have more space to spread in the F1 X F2 plane without encroaching on each other. This hypothesis has been attested through the spread between Arabic vowels in both dimensions except in the case of the low vowels F2 dimension. The universal tendency of triangular three-vowel systems to achieve the front-back contrast and durational distinctions has been long discussed in the literature (Lindblom 1986) showing that such languages aim to increase the perceptual saliency through maintaining sufficient contrast between its vowels.

Gender is the final independent variable being tested in this experiment. The results of the ANOVA and post-hoc tests show a highly significant effect of gender on F1 and F2 formant frequencies. Male/female formant differences have been established in earlier work and this

distinction is mainly attributed to differences in vocal tract size between both genders (Fant 1973). Johnson and Martin (2001) report that F1 for females has higher formant frequencies than males resulting in a larger acoustic space for women compared to men. Like Johnson and Martin's study, the results here show higher F1 frequencies for females and both genders have the short vowel triangle within the long vowel triangle. For males and females, we also see that the vowel triangle of long vowels for each speaker group contains the short one.

Males and females have close duration values for their Arabic vowels. Specifically, males have shorter values for short vowels whereas there is no specific pattern for long vowels. Earlier work has shown females having longer durations for their vowels than males in different American dialects (Clopper, Pisoni, & de Jong 2005 and Jacewicz, Fox, & Salmons 2007). There are several reports regarding the effect of gender on vowel duration. While some studies report no statistical significance of gender on vowel duration (Jacewicz, Fox, and Salmons 2007), others find gender a main factor that affects vowel duration with females having longer durations than males (Adank, van Hou, & van de Velde 2007). Though females have slightly longer duration measurements than males, these differences did not reach statistical significance especially if the measurements for short and long vowels were taken into account. The stronger claim is that dialect and not gender attributes to the discrepancy between males and females vowel duration measurements.

Regarding duration measurements, men have shorter duration values for short vowels and longer values for long vowels than women. As a matter of fact, short vowel duration values for men and women are very small but the difference for long vowels is greater. Johnson and Martin (2001) have a similar finding for Creek men and women showing long vowels being significantly greater in duration between men and women than short vowels. They contribute this

to gender difference and the women's attempt in using duration as an acoustic cue that signals a stronger linguistic contrast; a strategy they often resort to more than men (Byrd 1992).

There is a strong evidence of the effect of dialect as a reliable measure of vowel duration (Jacewicz, Fox, & Salmons 2007). Further support of the previous hypothesis is the data presented here showing duration variation across different dialects of Arabic. Palestinians were shown having shorter measurements compared to Saudi, Sudanese, and Egyptian speakers. It is worth noting that Alghamdi's subjects though represent different regional dialects of Arabic were all residents in Saudi Arabia for few years prior to their testing time. Accordingly, this explains the close durational values obtained from speakers who originally come from different regions but reside in the same place for some time showing that dialect is indeed an influential factor that affects vowel duration.

Pharyngealized vowels have a noticeably darker sound quality which results from the overlap between a pharyngeal and a vowel. From a gestural perspective, a pharyngeal affects a preceding and a following vowel, but here we focus on investigating only vowels when preceded by pharyngeals. As seen above, the vowel space underwent a significant change, especially a shift causing the retraction of pharyngealized vowels in the F2 dimension. This shift in the acoustic space between for plain and pharyngealized vowels is also documented in other languages (cf. Hongyan, a variety of Northern Qiang spoken in China (Evans 2006). Along the same lines, Gallagher (2007) investigates West Greenlandic and reports that pharygealization causes F1 lowering and F2 retraction either when the vowel precedes or follows a pharyngeal. Though others report that pharyngealization affects vowels' F1, F2 dimensions (Ghallagher 2007; Anonby 2006), this study finds significant effects of pharyngealization on F2 only. Testing the impact of emphatic consonants on Arabic low vowels, Kahn (1975) finds slightly lower and

backer vowels for pharyngealized vowels compared to their plain counterparts. Wahba (1996) in a sociolinguistic study reports that the Arabic low vowel /a/ is produced further back in a pharyngealized context. In sum, earlier literature provides support for the phonetic behavior of Palestinian Arabic speakers who produce backer/more retracted pharyngealized vowels than their plain counterparts. This is justified by the articulatory narrowing in the pharynx during the production of a pharyngeal which is maintained during the production of the following vowel. Thus, this pharyngeal/plain difference results in a phonetic level distinction for Arabic vowels.

CHAPTER THREE

STUDY 2: THE PRODUCTION OF ARABIC VOWELS BY ENGLISH L2 LEARNERS AND HERITAGE SPEAKERS OF ARABIC

3.1 Introduction and Background

Study 2 investigates vowel production in two groups: heritage speakers (HSs) and second language learners (L2 learners), comparing both to native speakers of Arabic (NSs). The goal is to understand the effect of early language exposure, as experienced by HSs, on later phonetic and phonological learning and to contribute new data on the question of whether language learners acquire an independent phonological system for their L2. The broader goal of this study is to explain how multiple languages are organized in the mind of bilinguals.

In this study, HSs of Arabic are identified as individuals who have grown up in the United States, and who have had early exposure to Arabic from their parents, for whom Arabic is a native language, and from the smaller ethnic community in which they lived during childhood. HSs in this study are native speakers of American English, which remains their dominant language. L2 learners in this study are also native speakers of American English. Furthermore, NSs are individuals who have spoken Arabic since birth and continue to use it in their daily interactions with other NSs of Arabic.

In examining the production of Arabic vowels by HSs who are English dominant, as well as L2 learners whose native language is English, I expect to observe the influence of English phonetics and phonology on the acquisition of Arabic. This comparison is especially interesting in light of the substantial differences between English and Arabic vowel systems. The two vowel systems differ in size, in complexity, and in the phonetic dimensions of contrast. English is a 12-

vowel system whereas Arabic is a 6-vowel system, and English contrasts tense and lax vowels whereas Arabic contrasts short and long vowels.

In a recent study on HSs, Godson (2004) claims that age of initial exposure to the dominant language (i.e., English), among other factors, plays an important role in the production of Western Armenian vowels. Testing subjects who differ mainly in their age of exposure to the dominant language (ones who learned English before age 8 vs. ones who learned it in adulthood); Godson reports that English affects Armenian vowels even when exposure occurs in adulthood. On the other hand, the influence of the dominant language (i.e. English) on heritage language (i.e. Western Armenian) vowels is also documented. This is true for English and Western Armenian vowels that are close in the acoustic space whereas distant vowels do not undergo any change. It is shown that English has a stronger effect on vowel production for individuals who were exposed to it as children as opposed to those who were exposed to it as adults. The researcher concludes that language change is an ongoing process that extends beyond childhood. Hence, the dichotomy in the phonetic realizations of vowels for both groups of speakers represents two distinct linguistic abilities.

Considering the results from Godson's study, strong evidence leads us to expect HSs and L2 learners to produce vowels that differ from each other, suggesting different phonetic/phonological systems. This shows the importance of the mental representation of language in the minds of bilinguals, attesting to varying processing mechanisms for different groups of bilingual speakers. Becoming a field in its own, heritage language studies is increasingly attracting the attention of researchers by asking how HSs are different from L2 learners?

3.2 Heritage Speakers as Language Learners

In general, HSs are second or third generation immigrants who were exposed to the family language as well as the community language since birth or early in life. In many cases, the home language is used extensively in early childhood and its use typically decreases as the bilingual speaker starts using the society language more in daily interactions as s/he grows up in the host community. As described in linguistic literature, the decrease in using the heritage language leads to loss, erosion, attrition, or incomplete acquisition of the L1 features which might have been already acquired or were developing when exposure to the L2 surpassed that of the heritage language. In these bilingual contexts, several factors determine and affect the level of heritage language competence. Linguistic input provided by the family, specifically from parents and/or from surrounding ethnic community plays an important role in preserving the heritage language. Conversely, lack of such input of the heritage language during these critical stages of language development leads to deficient acquisition of main areas of linguistic knowledge such as lexical, morphological, semantic, syntactic and, of course, phonetic and phonological.

In addition, the interest in investigating the heritage population is driven mainly by exploring the extent of linguistic variability shown by its members where native-like attainment of the heritage language might be reached in different linguistic aspects. Where this is true, such individuals are described as ones possessing high proficiency in their heritage language. By contrast, the commonly occurring scenario is for the community language to prevail over the home language. This happens when children start formal schooling in the host community, mainly in lower grade levels, resulting in the loss of what was previously acquired from their L1 or simply not acquiring any new features. Depending on the use of the heritage language and participation with other members from their speech community, the performance of such

individuals can vary from low, intermediate, or advanced levels of language proficiency. Far from being a homogenous linguistic population, HSs is not the sole linguistic group characterized as so. L2 learners are also diverse in their linguistic performance; however, they diverge from HSs in the extent and nature of their linguistic experience with the target language. Investigating both populations will examine the prediction that HSs should be more accurate on their Arabic vowel production than L2 learners.

3.3 Heritage Speakers of Arabic

As published by the US census 2010, Arab HSs are recognized as a linguistic group speaking one of the main immigrant languages, and comprising a major demographic group. Based on counts conducted in 2000, it is shown that approximately 1.6 million Americans of Arab descent lived in the US. This number has significantly increased to 3.5 million in 2010 as cited by the Arab American Institute (based on American Community Survey data). Hence, the increasing numbers of Arabs residing in the US has naturally led to the increase in numbers of Arab HSs. In addition to political considerations, especially after 9/11 which has sparked a lot of interest in learning languages other than English, much attention in the academic arena is directed to the study of the Arabic language in general the investigation of Arabic speakers in particular.

The interest in studying HSs of Arabic is motivated by the increased attention to the Arabic-speaking population in the US. For example, campaign materials were published in Arabic during US 2010 census. This public interest in Arabic encourages influxes of HSs to (re)learn their parents' language which might have been abandoned for the sake of the dominant language. Arabic in major educational institutions is offered within language programs as one of the less commonly taught languages. Often, HSs and L2 learners share the same classroom and

are exposed to similar instruction in Arabic. However, because of the heterogeneity of the Arabic heritage student population, their needs in the language classroom vary extensively. Unlike NSs, the heritage population is characterized by variable knowledge of Arabic ranging from oral and literacy skills that are equivalent to the native level, to individuals who seek to acquire/improve their various linguistic abilities (speaking, reading, writing, etc.). Despite variation in their Arabic proficiency levels, heritage learners have a common goal and that is to become more capable speakers of Arabic. It is true that HSs have uneven skills in speaking, listening, reading, and writing; nevertheless, they are expected to learn the language at an accelerated, or at least faster pace than other learners because of their prior language experience in Arabic. Though this assumption is considered common sense, it merits evidence from objective measures. The following are a set of research questions motivated by prior work as well as from the author's observation and experience with learners in the language classroom. This study seeks to answer these questions by providing phonetic and phonological evidence which is based on an acoustic experiment and supported by claims drawn from recent theories in L2 acquisition.

3.4 Research Questions

3.4.1 Early exposure vs. dominant language interference

Does *early childhood exposure* to Arabic as experienced by HSs affect phonetic learning later in life, e.g., when the HS is a learner in a traditional classroom setting? What is the effect of the dominant language, English, on Target Language acquisition (TL)?
Numerous studies investigating phonetic/phonemic acquisition with second language learners show that exposure to the TL sound system in the early developmental stages of life is a key

factor in determining learning outcomes. In addition to testing this claim, the current study

investigates whether HSs are advantaged and possess phonemic awareness (Fowler 1991) of the

TL vowel system, hence facilitating native-like acquisition at sub-phonemic levels (Au et al.

2002; Knightly et al. 2003; Au et al. 2008).

On the other hand, cross-language phonetic interference with TL acquisition is also widely

documented (e.g. Flege & Port 1981 and Major & Kim 1999) and its effect on the attainment of

native-like TL pronunciation (Flege 2007) has been shown to influence the degree of accuracy in

producing TL vowels (Flege et al. 1997). Hence, HSs are similar to L2 learners in that they have

typically not attained production competency (Lee 1997) in Arabic. On the other hand, prior

work conducted at the morphsyntactic level has showed that HSs are advantaged in comparison

to L2 learners mainly because of early childhood exposure to the heritage language (Kondo-

Brown 2003; Montrul 2005, 2006; Montrul, Foote, & Perpiñán 2008). Given that, this study

seeks to examine whether HSs have phonemic advantage, meaning that they are able to produce

the phonological features of Arabic vowels unlike L2 learners, over L2 learners because of their

earlier experience with Arabic.

3.4.2 One vs. two systems

Will HSs and L2 learners match their Arabic vowel values to already existing English ones,

thus indicating that one phonological system is used for the two languages, or will they

have a distinct phonological system for their Arabic vowels? In other words, what is the

nature *of the phonological system in developing bilinguals***?**

Linguistic research on monolingual-bilingual acquisition of phonological systems of human

languages presents two opposing views. On the one hand, Swadesh (1941) claims that bilinguals

have one enlarged phonological system compared to monolinguals. On the other, Weinreich [1974 (1953)] proposes that bilinguals have two separate phonemic systems for their coexisting languages. A substantial body of research argues that monolingual and bilingual phonological inventories are different and therefore supports the claim that bilinguals possess two separate phonetic systems for their languages (Penfield 1953; Penfield & Roberts 1959; Lenneberg 1967). More specifically, many studies report that bilinguals have two separate phonological systems for the vowels of the two languages (Bosch & Sebastian-Galles 2001; Johnson & Wilson 2002; Kehoe 2002). By targeting HSs and L2 learners as two distinct linguistic groups, this research attempts to examine the aforementioned claims and validate whether both groups have one or two phonological systems for Arabic and English.

If either of the language groups, HSs and L2 learners, acquires a second phonological system for their Arabic vowels, a further question is whether they will be successful in matching their vowel values to ones produced by NSs. Even more, will the newly acquired system be the same for both groups or not? In other words, do we expect the variation in linguistic input (as raised in research question # 1) to result in a different vowel output for each group?

It has been claimed that L2 learners will add a new phonetic category to an already existing inventory to accommodate new L2 sounds that do not exist in their L1 (Flege 1992a, b). However, similar L2 sounds that are related to ones in L1 are blocked by the 'perceptual mechanism of equivalence classification' and are not expected to be mastered by adult L2 learners (Flege 1991). Though the three Arabic vowels already exist in the English vowel inventory, they differ acoustically from their English counterparts. If HSs diverge from L2 learners by having two phonological systems, then we may conclude that the extent of exposure to L2 is the main factor behind this variation.

3.4.3 Role of experience

Do we expect the vowels of experienced HSs (EHSs) to more closely resemble NSs of Arabic than inexperienced heritage speakers (IHSs)? Also, will the vowels of advanced L2 learners (AL2s) be closer to NSs than beginner L2 learners (BL2s)?

A common belief is that adult learners cannot produce L2 sounds that match NSs' values. However, with sufficient input, highly experienced L2 learners are found to produce target sounds that are closer to L1 sounds than inexperienced learners (Flege et al. 1997). Examining experienced and inexperienced L2 learners producing English vowels, Jun and Cowie (1994), Flege et al. (1997) and Bohn & Flege (1992) report that German, Spanish, Mandarin, and Korean subjects learning English and who had more experience in L2 did produce more accurate English vowels than inexperienced speakers.

Due to lack of phonetic/phonological studies reporting on the heritage population, we cite research undertaken in syntax. Recently, in a study investigating American Russian HSs' knowledge of gender assignment, Polinsky (2008) finds that the variation in proficiency in Russian among HSs leads to significant division of gender categorization where the more experienced subjects have a three-gender system—as is the case in Russian—and the less experienced subjects have a two-gender system. Hence, the amount of experience in the TL affects learners' production of target forms. Whether it is phonological cues/rules or grammatical concepts, compelling evidence points that more experienced learners are more knowledgeable and proficient and therefore outperform their peers with less experience.

To summarize, recent linguistic research in many areas such as phonetics/phonology and syntax among others has investigated the role of experience in TL acquisition and supported the notion that HSs incur benefit over L2 learners due to their earlier exposure to the heritage

language. Motivated by earlier findings, this study aims at examining the production of Arabic

vowels by two groups of English speakers differing in their Arabic language experience: HSs

and L2 learners. More specifically, each group is further broken into two groups: EHSs vs. IHSs

and BL2s vs. AL2 learners.

3.4.4 Vowel space

Do we expect the vowel arrangement for HSs to be packed (contracted) or dispersed in the

acoustic space compared to L2 learners and NSs?

Both the Quantal Theory of speech (Stevens 1972 1989) and the Theory of Adaptive Disperstion

(Liljencrants and Lindblom 1972; Lindblom 1986) provide contradictory accounts of the effect

of the vowel inventory size on the distribution of elements in the vowel systems. The Quantal

Theory of Speech claims that vowel distribution in the acoustic space is determined based on

stable regions, or 'hot spots', which are in the regions of 'quantal' vowels /i/, / u /, and / a /.

These vowels are preferred, occupy stable spaces, and are approximately in the same region in

all languages regardless of the vowel inventory size. This theory claims that speech production

does not have to be precise to produce certain output—articulatory space is continuous—and

sloppiness in articulating the vowels won't affect their perceptibility. Based on this, since Arabic

vowel production for HSs and L2 learners are of quantal vowels, then it is predicted that their

values will be produced with certain degrees of variability but still be within with the range of

values of the quantal vowels.

On the other hand, the Theory of Adaptive Dispersion claims that languages with large

vowel inventories tend to disperse the regions between point vowels more than languages with

small vowel systems. The point vowels occur at the extremes of the physiologically possible

vowel space. Unlike English, Arabic has a small vowel inventory size and therefore there is no

need for a lot of dispersion between point vowels. In the acoustic space, Arabic vowels will be

sufficiently contrasted, but without being necessarily very far apart. Accordingly, if HSs and L2

speakers' vowel production is affected by the dominant language vowel space (i.e. English) then

they are predicted to produce more dispersed point vowels.

3.4.5 Phonetic features (pharyngealized vowels)

Will HSs and L2 learners be able to acquire and consequently produce pharyngealized

vowels?

In addition to the difference in articulatory bases between plain and pharyngealized vowels,

phonological distinction has been noted in several of the world's languages (cf. Traill 1985 on

Khoisan languages). It has been shown that when an emphatic sound occurs in a word,

pharygealization or emphasis spreads to a neighboring segment. There are different accounts on

the extent of this spread in varying Arabic dialects. For example, Younes (1991) reports that

pharyngealization in Saudi Arabic rarely spreads beyond an adjacent vowel whereas it extends to

the entire word in the Cairene dialect. Interestingly, Herzallah (1990) has noted a unique pattern

of pharyngealization spread in words in Palestinian Arabic where leftward spread is documented

from the emphatic consonant to the beginning of the word whereas leftward spread is restricted

to a following low vowel. Likewise, Davis (1995) shows evidence that southern and northern

dialects of Palestinian Arabic behave alike in that opaque phonemes, /i/, /y/, /š/, and /j/, block

only the rightward spread of emphasis. Both Younes (1993) and Herzallah (1990) provide

different accounts on pharygealization of nonlow vowels. While Herzallah (1990) and Davis

(1995) claim that plain vowels are not phonologically pharyngealized after an emphatic

consonant, Younes argues in favor of pharygealization of nonlow vowels in a similar

environment. Based on what has been presented, it is shown that the spread of pharygealization

is documented in various dialects of Arabic. The goal in this study is not to establish the

directionality of pharygealization in Palestinian Arabic—it is known that an emphatic consonant

in Arabic affects neighboring segments—rather what is of interest is to investigate whether non-

native speakers are capable of producing such phonological features and match the values of

NSs. More importantly, comparing the production of pharyngealized vowels by HSs and L2

learners is another strong indicator of the similarities/differences of proficiency level in the TL

between both groups.

3.5 Hypotheses

3.5.1 Early exposure vs. L1 interference

In this study, the early exposure factor is investigated through comparing two populations who

differ in their exposure to TL. Originally, the Critical Period Hypothesis (CPH) as advanced by

Lenneberg (1967) had claims concerning first language acquisition, stating that language

acquisition should occur before puberty for the language to be developed in a native-like manner.

Later on, it was extended to show that age of exposure to an L2 also affects attainment of native–

like proficiency in the TL (Johnson and Newport 1989). HSs were exposed to Arabic early in

life, and according to the claims of the CPH they will be advantaged compared to L2 learners

who were adults when the first exposure to L2 occurred (Montrul 2005, 2006; Montrul, Foote, &

Perpiñán 2008).

It has been shown that exposure to L2 in childhood affects sub-phonemic (a level of representation describing features and is used to measure phoneme similarity based on the degree of featural overlap, thus providing a good prediction of confusability between vowels) target segments later in life (Escudero 2000a & Maye 2007). Additionally, it is a main factor in reducing foreign accent when pronouncing L2 sounds for adult language learners (Piske et al. 2001; Munro & Derwing 1999).

Hypothesis 1

HS in the language classroom are advantaged compared to their L2 learner classmates because of childhood exposure to the TL, which helped in establishing their Arabic vowel categories before starting formal instruction of the language as adults. However, because of cross-language phonetic interference between Arabic and English, it is hypothesized that HSs will not achieve native-like pronunciation in Arabic because they fall short of native speaker level when compared to Arabs residing in the Arab World and ones who have spoken Arabic for the entire period of their life. Still, it is expected that their performance in Arabic will be superior to the L2 learners, hence, producing intermediate values for target vowels.

3.5.2 The phonological systems of different groups of developing bilinguals

Bilinguals have two phonetic/phonological systems for their languages as documented in studies of children (e.g., Paradis (2001) on French/English syllables; Jusczyk (1997); Lleo & Kehoe (2002); Keshavarz & Ingram (2002) on Farsi/English; Johnson & Wilson (2002) on English/Japanese VOT production) and adults (e.g., Flege & Hillenbrand (1984) on French/English VOT values; Guion (2003) on Quichua/Spanish vowel systems; and Marian et al. (2003) on Russian/English word recognition). Bilingual speakers who differ in their proficiency

levels and age of exposure to L2 have different L2 phonetic/phonological systems from each other. Guion (2003) shows that various groups of bilinguals (simultaneous, early, mid, and late bilinguals) have acquired different L2 Spanish vowels as a result of the variation in the amount of exposure to L2. It is concluded that simultaneous bilinguals were the most successful in creating phonemic categories for all the vowels in their two languages.

Hypothesis 2

The phonetic/phonemic system of HSs will be different from the one produced by L2 learners because of their varying experience in the TL. HSs will have distinct English and Arabic vowels, thus producing two phonetic/phonological systems whereas L2 learners will produce English and Arabic vowels with comparable values; hence, they will have one vowel system for the two languages.

3.5.3 Role of experience

In cases of phonological similarity between L1 and L2, as with English and Arabic (non-pharyngeal) vowels, it is predicted that inexperienced/beginner learners will have greater L1 interference in L2 pronunciation (Major & Kim 1999), with L2 phonetic categories assimilating to the similar L1 categories (MacKay et al. 2001). Alternatively, experienced/advanced learners may attain distinct TL phonetic categories by dissimilating L1 and L2 categories, maintaining two distinct phonetic systems (Flege & Eefting 1987), showing that the extent of experience in the TL is a key factor in producing phonetic realizations that are close to target-like values. Along the same lines, Nguyen and Ingram (2005) report that beginning and advanced Vietnamese learners of English produce significantly different vowel durations. It is shown that advanced learners are different from NSs whereas beginners are also distinct from both NSs and

advanced learners, providing strong evidence on the importance of early exposure to the TL on later phonological acquisition.

Hypothesis 3

Vowels produced by EHSs are expected to be similar/closer to NSs than the ones produced by IHSs. Likewise, it is hypothesized that AL2 learners will produce vowels that are closer to target values than will vowels produced by BL2 learners.

3.5.4 Arabic/English vowel space

In languages with small vowel inventories, speakers do not need to disperse their vowels to enhance phonetic distinctiveness, because the vowel space is sparsely utilized. Alternatively, in languages with large vowel inventories, speakers have to allow sufficient space between vowels to maintain phonological contrast between various vowel categories. Bullock et al. (2006) investigates low vowels in the speech of one bilingual Frenchville/ American English AE speaker. The researchers argue that the AE low vowels were dispersed whereas the Frenchville (Pennsylvania) French vowels were more centralized in order to preserve distinction between the two languages phonologies, concluding that this speaker did not map his French vowels to English ones in spite of his long contact with English. In addition, Hacquard et al. (2007), in an MEG study, investigate the effect of vowel inventory size on perception through examining it in French and Spanish. It is concluded that 'speakers of languages with larger vowel inventories perceive the same sounds as less similar than speakers with smaller inventories.'

In addition to vowel inventory size, the issue of vowel identity is another important factor that is often investigated in studies on bilingual language acquisition. Though it is predicted that bilingual speakers are affected by the size of vowel inventories of their languages, they are

constrained by the quality/identity of these vowels. Stevens (1972) claims that less variation in vowel assignments is expected at the center of the vowel space where vowel production is constrained by physiological limitations. Therefore, /i/, /u/, and /a/ have flexibility to move (disperse) in the vowel space more freely than do central vowels such as /e/ and /o/.

HSs and L2 learners are English-dominant and therefore both have a larger English vowel inventory than Arabic NSs because English has more vowels than Arabic. As a result, it is predicted that they will not attempt to disperse their TL vowels to enhance phonological contrasts. On one end, L2 learners are expected to produce vowels that are more dispersed in the vowel space because they are influenced by their L1. On the other end, NSs are expected to have the most contracted vowel space as a result of the small Arabic vowel inventory. In between, HSs' vowels are expected to occupy intermediary values between both groups. To support this, the expansion hypothesis (Hacquard et al. 2007) states that speakers will attempt to expand their perceptual and production acoustic spaces to accommodate more segments in languages with larger number of vowels. Indeed, neither HSs nor L2 learners need to expand their acoustic space to accommodate their Arabic vowels which are already part of the English vowel system.

Hypothesis 4

The size of the vowel triangle will be different for all three language groups with the most expanded one for the L2 learners and most contracted for the NSs. However, the HSs will have intermediary values (size) between both groups.

3.5.5 Pharyngealized vowels

Earlier accounts on pharyngealization in Arabic show that emphatics affect an adjacent segment causing lowering in F2 (Ghazeli 1977; Younes 1982; and Herzallah 1990). Investigating

Ammani-Jordanian Arabic, Zawaydeh (1997) reports a slight raise in F1 for segments that are affected by the spread of pharygealization–this feature was referred to as 'uvularization' though was noted to be the same as 'pharygealization'–compared to plain segments. For F2, Zawaydeh shows that F2 values of pharyngealized vowels for low as well as high segments are consistently lowered compared to plain environments. Another study by Al-Masri and Jongman (2004) focuses on the acoustic correlates of emphasis in Jordanian Arabic, providing more evidence of F2 lowering in pharyngealized vowels. The drop is around 500 Hz, compared to plain ones, especially when the emphatic consonant and vowel occur in the same syllable. Recently, Embarki et al. (2007) find differences between Modern Standard Arabic and dialectal Arabic in pharygealization effects in CV sequences with more variation among regional dialects (Yemni, Jordanian, Kuwaiti, and Moroccan Arabic). The researchers report differences in acoustic correlates in pharyngeal segments using the locus equation concept (Lindblom 1963), showing variation between different Arabic dialects. Finally, Girgis (2009) shows that Egyptian Arabic HSs did not produce significant differences in pharyngealized fricatives than L2 learners, though HSs results have greater standard deviation than L2 learners in similar contexts.

Hypothesis 5

HSs will show greater coarticulatory pharyngealization effects on vowels adjacent to emphatic segments than L2 learners. Nevertheless, they are not expected to match NSs pharyngealized vowel values.

3.6 Experiment and Method

3.6.1 Subjects

Thirty subjects divided into three main groups participated in this study: native speakers of Arabic (6 subjects), HSs of Arabic (12 subjects) and L2 learners (12 subjects). The heritage group consisted of inexperienced (IHSs) and experienced (EHSs) speakers of Arabic and the L2 group consisted of beginner (BL2s) and advanced learners (AL2s). Each subgroup had three male and three female participants. Subjects' ages ranged from the 18-35.

HSs and L2 learners were graduate and undergraduate students recruited from the Arabic language program at the University of Illinois at Urbana-Champaign, a major Midwestern university. BL2s were typically students at the end of their first semester or the start of the second semester in the Arabic program. AL2s were students in the third year in the program or those who had taken Arabic classes up to the advanced level.

The HSs were recruited based on their linguistic profile from the same language program. This is achieved through reducing variability as much as possible and choosing subjects who belonged to Palestinian descent, only because this is one of the largest Arabic-speaking groups represented in the geographic region where the data was collected. In this group, the focus was on subjects who were born or came to the United States before the age of five and attended preschool onward in English-speaking schools. To reduce variability, only subjects to Arab parents were included in this research and all such subjects were assumed to have comparable exposure to Arabic. All subjects reported speaking the same variety of Arabic (Palestinian) and had similar linguistic experience. Subjects reported conversing or code-switching between Arabic and English with their parents, siblings, and Arabic/English bilingual friends whereas

they used English for all other interactions in their daily lives. The HSs were enrolled in the same language classes as the L2 learners.

To estimate language proficiency, as in Polinsky (2007), the speakers were asked to translate 100 words of the basic vocabulary list 'the Swadesh list'. The subjects translated the words from English to Arabic. Since all recruited subjects were learners in the Arabic language classrooms and they were able to read and write in Arabic, the translations were elicited in writing. The number of correct translations was taken as a measure of an individual's proficiency in Arabic. One point was deducted for each incorrect or missing translation. If the word was translated to a close root form, it was still considered correct. The cut off rates for different groups of learners was set at 65% (65 correct responses out of the 100) for the EHSs, 40% for the IHSs, 30% for the AL2s, and below 20% for the BL2s.

Arabic monolingual speakers were recruited from the surrounding local community. This group consisted of Palestinian Arab adults who were chosen based on their age of arrival to the United States. These included subjects who typically arrived after the age of 20. All subjects reported normal speech and hearing.

All subjects (L2 learners, HSs, and NSs) were asked to fill a language questionnaire to make sure that they all met the selection criteria. All subject volunteered to participate in the study.

Each subject was asked to read and record all the Arabic tokens in one session. Each session lasted for 20 minutes. The English tokens were collected in another day in one session that lasted for 15 minutes. Each subject was tested individually in a sound-proof booth in the Phonetics and Phonology Lab at the University of Illinois at Urbana-Champaign using a Marantz digital recorder (Marantz PMD660) and a mounted-headset professional microphone. The

recordings were analyzed at 48.0 kHz, and using PRAAT 4.5.16 software (Boersma and Weenink 2007).

3.6.2 Task

The subjects were asked to read two lists of Arabic and English word tokens which appeared in carrier phrases. Arabic target word tokens consisted of 114 items corresponding to 114 carrier phrases which were read and repeated twice by each subject. There were 6840 word tokens in total (114 words x 2 repetitions x 30 subjects), with each target word contributing measurements from a single vowel. The carrier phrase translates into 'Say X twice' where 'X' represents one target token.

English target tokens consisted of 85 items corresponding to 85 carrier phrases which were read and repeated twice by HSs and L2 learners. There were 4080 vowel tokens in total (85 words x 2 repetitions x 24 subjects). The carrier phrase is 'Repeat X twice' where 'X' represents one target token.

3.6.3 Materials

Arabic stimuli were presented to participants in the Arabic language orthography and supplemented with diacritic markings whereas English stimuli were presented in English. Subjects were asked to pronounce the list of Arabic carrier sentences in the Arabic language and English carrier sentences in the English language.

The target vowels consisted of the Arabic short vowels /i u a/ and their long counterparts /i: u: a: /. English target vowels consisted of /i ɪ u ʊ æ/. Arabic Materials consisted of two major groups: plain and pharyngealized vowels. In the first group, target tokens consisted of CVC

monosyllabic words. Consonants flanking target vowels were chosen to represent distinct places of articulation on the left and right sides; bilabial /b/, dental /d/, and velar /k/. The voice/voiceless effect on vowel values were also tested through examining the vowel between voiceless /t/ and /s/ and voiced /d/ and /z/. The fricatives /s/ and /z/ were chosen to be part of the data though the stop-fricative distinction is not expected to have an effect on the vowel F1 and F2 formant values. English material consisted of CVC monosyllabic words where the vowels were flanked by the same set of bilabials and fricatives used for the Arabic tokens.

The second group consisted of CVC monosyllabic words with pharyngealized vowels. Target tokens in this set had the same set of Arabic vowels but word-initial emphatic consonants /sˤ dˤ tˤ ðˤ/ and their non-emphatic counterparts /s d t ð/ followed by the Arabic long vowels /i: u: a:/ (e.g. / sˤi:b/ and / si:b/) and their short counterparts (e.g. / sˤib/ and /sib/). The final consonant was controlled in all other tokens, /b/, i.e., CVb. For both groups (plain and pharyngealized vowels), real words were provided whenever possible, otherwise, nonsense words were used to match the exact same structure of real words. The list of tokens is provided in the appendix.

3.6.4 Procedure

Formant measures of F1 and F2 were taken for target vowels (in Bark) at vowel midpoint using the Praat burg algorithm setting the parameter at maximum formant value of 6500 for females and 5500 for males. Vowel duration was also measured in milliseconds (ms.) and calculated from the end of the stop/fricative and start of periodic phonation of the vowel to the end of periodic phonation of the vowel and start of the next stop/fricative.

3.7 Results

3.7.1 Arabic results

The Arabic results of this acoustic study are discussed in the following subsections. F1 and F2 measures and duration are presented and treated as the dependent variables in all the ANOVAs that were conducted for this experiment. Language group is considered a fixed independent variable in all ANOVAs. In subsection 1, vowel quality is the second investigated independent variable while vowel length is treated as the second variable in section 3. Vowel and gender are the second independent variables in subsections 3 and 4 respectively. Next, the role of experience on vowel production is investigated by comparing more experienced vs. less experienced language learners. Finally, pharyngealized and plain vowels are also compared across all language groups.

VOWEL QUALITY

Language group (experience) is treated as a 3-level factor and classified according to subjects' experience with Arabic: the HSs, L2 learners, and NSs. Vowel quality is also a 3-level factor that is classified into front /i i:/, back /u u:/, and low /a a:/. To test the effect of language group on vowel production, 2-way ANOVAs were conducted with F1 and F2 measures as dependent variables, and language group and vowel quality as independent variables. Where the ANOVA were significant, TukeyHSD post-hoc tests were performed. The results show highly significant effects of language group on F1 [$F_{(2, 6837)} = 31.451$, $p < 0.001$] and F2 [$(2, 6837) = 18.440$, $p < 0.001$]. ANOVA also found highly significant effects of vowel quality on F1 [$F_{(2, 6837)} = 6772.173$, $p < 0.001$] and F2 [$(2, 6837) = 7745.437$, $p < 0.001$]. As well, the interaction between

language group and vowel quality was highly significant on F1 [$F_{(4, 6835)} = 4.6858$, $p < 0.001$] and F2 [$F_{(4, 6835)} = 4.8684$, $p < 0.001$]. Tukey HSD post-hoc tests indicate that the three language groups are distinct for F1 and F2 measures. As expected, the three vowel qualities were also found distinct for F1 and F2. For interaction results, Tukey HSD post-hoc tests indicate distinct differences in F1 for all vowel identities across all language groups except between L2 learners and HSs for the low vowels, and between NSs and HSs for the front and back vowels. For F2, Tukey HSD post-hoc interaction results indicate distinct differences for all vowel identities across all language groups except between NSs and HSs for the low vowels, and between L2 learners and HSs for the back vowels. However, there were no distinct differences between different language groups for the front vowels.

Figure 6 below presents mean values for the Arabic vowels /i i: u u: a a: / across the three language groups: HSs, L2 learners, and NSs. It is shown that the long vowels occur at the periphery of the acoustic space whereas short ones are more centralized. High long vowels have lower mean F1 values than their shorter counterparts whereas low /a: / has higher mean F1 value than low /a/. NSs and HSs have almost comparable F1 and F2 values for front /i:/ producing a slightly lower F1 and higher F2 values than L2 learners. This shows that NSs and HSs have a lower and fronter tongue body position for /i:/ compared with L2 learners. /u:/ is produced with similar F1 values across the three groups indicating a comparable vocal tract constriction. While HSs and L2 learners match their F2 values for /u:/, it is clear that NSs produce significantly lower F2 than the other groups suggesting a backer tongue position for NSs. For low /a:/, NSs produce the highest F1 value whereas HSs and L2 learners have lower matched values indicating a lower tongue body for NSs compared to non-native speaker groups. Moreover, NSs have the

lowest F2 value showing a backer tongue position than HSs who have higher value followed by L2 learners producing the highest F2 and most front value.

As shown, the short vowels have a different pattern than their longer counterparts based on mean formant values. Long high vowels have lower F1 and higher F2 for front /i:/ and lower F2 for /u:/ than short /i/ and /u/. Short /a/ is more centralized in the vowel space than long /a:/ with lower F1 and comparable F2. For /i/, L2 learners produce a higher F2 value than matched NSs and HSs suggesting a fronter body tongue position for L2 learners than the other two groups. NSs have the highest F1 value indicating a lesser constricted vocal tract than HSs who produce lower F1 whereas L2 learners have the lowest values for /u/ among the three groups. For F2, NSs and HSs have comparable values indicating a similar tongue body position whereas L2 learners produce higher value. For low /a/, NSs have slightly higher F1 than matched HSs and L2 learners. For F2, L2 learners have the highest value, followed by HSs who have lower value, and finally NSs producing the lowest value indicating a backer tongue body position for NSs compared to the other groups.

In sum, all investigated groups produce distinct Arabic vowels. It is clear that HSs align with NSs in F1 (vowel height) and in F2 (vowel frontness/backness) for /i: i/. For /u:/, HSs are more similar to NSs in F1 (and to L2 learners) but more similar to L2 learners in F2. For /u/, all three groups have similar F2 values with HSs producing intermediary F1 value between NSs and L2 learners. The low vowels present a unique case with HSs matching L2 learners in F1 (though this is more true for /a:/ than /a/) whereas they have intermediary values for F2 between NSs and L2 learners.
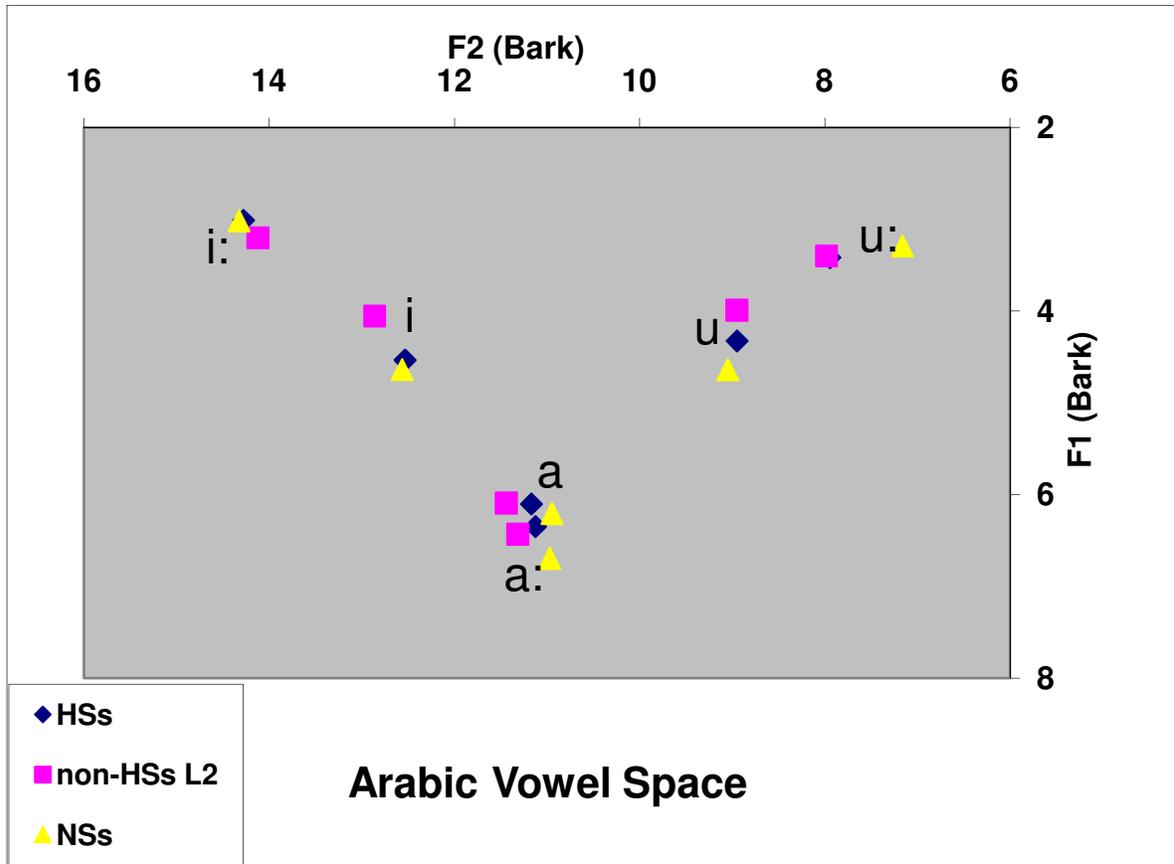
Figure 6: F1 and F2 mean values (Bark) of the Arabic vowels /i, i:, u, u:, a, a:/ for the three different language groups: heritage speakers, L2 learners, and native speakers of Arabic.

VOWEL LENGTH

Next, the effect of language experience (group type) and vowel length (2 levels: short /i u a/ vs. long /i: u: a:/) on F1 and F2 were investigated. ANOVA found highly significant effects of language group on F1 [F (2, 6834) = 11.075, $p < 0.001$] and F2 [F (1, 6834) = 5.6499, $p < 0.001$]. However, the results indicate highly significant effects for vowel length only on F1 [F (1, 6834) = 309.918, $p < 0.001$]. The interaction between language group and vowel length was significant only on F1 [F (2, 6834) = 16.269, $p < 0.05$].

Since the ANOVA showed significant effects of language experience and vowel length on F1, Tukey HSD post-hoc tests were conducted. The results indicated highly significant effects

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between all groups: L2 learners and HSs, NSs and L2 learners and NSs and HSs. For vowel length, the pair-wise comparison test indicated significant differences in F1 measure. For F2, the Tukey HSD post-hoc tests found distinct differences between NSs and L2 learners only. For vowel length, there were no significant differences in F2 measure. Since the ANOVA found significant effects of the interaction between language experience and vowel length only on F1, post-hoc tests were performed and showed significant differences between all speaker groups and vowel length except for long vowels between L2 learners and HSs, NSs and HSs, NSs and L2 learners, and for short vowels between NSs and HSs. In sum, all speaker groups were successful in producing distinct vowels from each other and in differentiating Arabic long and short vowels. However, NSs and HSs are found to produce their long and short vowels with comparable duration.

The results in Table 9 show that long vowels have significantly longer mean durations than short ones. There is a consistent pattern across the three groups in that NSs produce the shortest duration values for short vowels followed by HSs and finally L2 learners with longest durational values. NSs have the longest durations for high long /i:/ and /u:/ whereas HSs produce low /a:/ similar to NSs. These findings indicate that NSs have produced a greater durational contrast between long and short vowels which is shown in shorter short vowels and longer long vowels than HSs and L2 learners.

		/i/	/i:/	/a/	/a:/	/u/	/u:/
Dur	**NSs**	88	219	101	250	93	223
	HSs	97	202	116	250	101	199
	L2 learners	106	208	144	258	115	207
F0	**NSs**	203	202	190	183	204	207
	HSs	167	169	158	152	165	169
	L2 learners	174	174	157	152	172	175
F1	**NSs**	463	289	655	721	463	317
	HSs	445	290	629	658	423	328
	L2 learners	401	308	653	705	393	331
F2	**NSs**	1903	2474	1484	1490	1094	787
	HSs	1880	2423	1531	1529	1065	898
	L2 learners	2015	2434	1616	1573	1090	923
F3	**NSs**	2816	3243	2790	2827	2804	2805
	HSs	2806	3045	2761	2747	2786	2773
	L2 learners	2824	3050	2727	2698	2729	2704

Table 9: Mean duration values (in ms.), and mean F0, F1, F2, and F3 (in Hz) for the Arabic vowels /i i: a a: u u:/ across different language groups: Native speakers (NSs), Heritage speakers (HSs), and second language learners (L2 learners).

VOWEL

A similar analysis was performed testing the effect of language experience (group) and vowel (/i i: u u: a a:/) on F1 and F2 measures. For F1, ANOVA shows highly significant results for language group [$F_{(2, 6822)} = 46.152$, $p < 0.001$] and vowel [$F_{(5, 6822)} = 4562.848$, $p < 0.001$]

on F1. There was also a highly significant effect of the interaction between language experience and vowel [F (10, 6822) = 26.884, $p < 0.001$] on F1. In terms of F2, ANOVA were also highly significant for language group [F (2, 6822) = 22.3764, $p < 0.001$], vowel [F (5, 6822) = 4035.1893, $p < 0.001$], and the interaction between language group and vowel [F (10, 6822) = 9.3512, $p < 0.001$].

Since the ANOVA analysis showed highly significant results for both language group and vowel, Tukey HSD post-hoc tests were performed. The results indicate highly significant differences between all language groups: L2 learners and HSs, NSs and HSs, and NSs and L2 learners in F1. Likewise, highly significant results were also shown between all 6 investigated vowels. For the interaction between language group and vowel, all the combinations were significant except for /a/ between L2 learners and HSs, NSs and HSs, NSs and L2 learners, and for /a/ and /a:/ between HSs and NSs, and for long /a:/ between L2 learners and HSs. No differences were also shown for /i/ between NSs and HSs, between /i/ and /u/ for NSs and HSs, between /i/ and /u/ for L2 learners, for long /i:/ between NSs and L2 learners, and for long /u:/ between L2 learners and HSs, NSs and HSs, and NSs and L2 learners. For F2, Tukey HSD post-hoc tests show highly significant differences between all three language groups: L2 learners and HSs, NSs and HSs, and NSs and L2 learners. Likewise, there were highly significant differences in F2 for all 6 vowels except between /a/ and /a:/. The interaction between language group and vowel was also significant between all language groups and vowels except for /a/ between L2 learners and HSs, NSs and HSs, and for /a/ and /a:/ between HSs, L2 learners and HSs, HSs and NSs, L2 learners, and NSs. There were also no significant differences for /a:/ between L2 learners and HSs, NSs and HSs, NSs and L2 learners. For /i/, the differences were not significant between NSs and HSs, NSs and L2 learners and for /i:/, the differences were not significant

between L2 learners and HSs, NSs and HSs, NSs and L2 learners. Finally, /u/ did not show

significant differences between L2 learners and HSs, NSs and HSs, NSs and L2 learners, and for

/u:/ between L2 learners and HSs.

In sum, the interaction results for F2 measure show that NSs and HSs were not different

for /a a: i i: u/ whereas L2 learners and HSs were not different for /a a: i: u u:/. NSs and L2

learners were not different for /a: i i: u/.

GENDER

Though gender was not presented earlier as one of the research questions or hypotheses, the

results obtained from investigating this factor are relevant to this research. The aim is to provide

a more inclusive discussion of whether we find systematic similarities and/or differences

between subjects from one gender or another as members who belong to a certain language

group or another. The effect of language group (3-level factor) and the gender of the subject (2-

level factor) and their interactions on F1 and F2 were investigated. ANOVA analysis shows

highly significant results for both independent variables on F1. The results were [F (2, 6834) =

11.2543, $p < 0.001$], [F (1, 6834) = 447.1090, $p < 0.001$], and [F (2, 6834) = 5.6494, $p < 0.001$]

for language group, gender, and the interaction between language experience and gender on F1

respectively. Likewise, the results were highly significant for F2 with [F (2, 6834) = 5.9078, $p <$

0.001] for language experience and [F (1, 6834) = 315.5921, $p < 0.001$] for gender. However, the

interaction between language experience and gender was not significant on F2 measure.

			/i/	/i:/	/a/	/a:/	/u/	/u:/
			__Native Speakers (NSs)__					
Dur		M	86	212	97	248	89	212
		F	91	159	115	194	90	164
F0		M	157	157	151	147	158	161
		F	198	213	186	168	215	220
F1		M	437	277	575	620	439	313
		F	465	332	702	764	445	372
F2		M	1673	2263	1321	1309	973	707
		F	1984	2634	1560	1584	1347	1067
F3		M	2647	3114	2573	2654	2576	2678
		F	2916	3189	2981	3038	2937	3018

Table 10: Mean values of /i i: a a: u u:/ for Arabic Native speakers (NSs). Average duration (in ms.), F0, F1, F2, and F3 (in Hz) for male (M) and female (F) speakers.

Heritage Speakers (HSs)							
		/i/	/i:/	/a/	/a:/	/u/	/u:/
Dur	M	82	178	94	216	86	171
	F	116	203	128	274	121	204
F0	M	124	122	116	113	124	124
	F	206	223	189	168	199	216
F1	M	409	271	573	628	417	297
	F	499	310	661	700	449	350
F2	M	1759	2182	1454	1453	1070	893
	F	2018	2598	1718	1634	1232	1150
F3	M	2648	2940	2476	2441	2574	2548
	F	2984	3191	2968	2969	2941	2806

Table 11: Mean values of /i i: a a: u u:/ for Heritage speakers of Arabic (HSs). Average duration (in ms.), F0, F1, F2, and F3 (in Hz) for male (M) and female (F) speakers.

L2 Learners (L2)							
		/i/	/i:/	/a/	/a:/	/u/	/u:/
Dur	M	132	275	163	337	140	293
	F	139	248	192	295	152	237
F0	M	146	146	131	128	146	145
	F	223	227	206	205	227	229
F1	M	396	288	701	720	343	305
	F	476	407	734	775	517	441
F2	M	1886	2252	1378	1379	1070	902
	F	2277	2577	1808	1835	1286	1196
F3	M	2730	2933	2687	2651	2619	2610
	F	2940	2994	2887	2896	2930	2978

Table 12: Mean values of /i i: a a: u u:/ for second language learners (L2 learners). Average duration (in ms.), F0, F1, F2, and F3 (in Hz) for male (M) and female (F) speakers.

Since the results were highly significant for both language group and gender and the interaction between language group and gender, pair-wise comparison tests were performed. The results indicate highly significant differences in F1 measure for all three language groups as well as between males and females. Moreover, the interaction results between language groups and gender indicate significant differences for all combinations except for females between NSs and HSs, L2 learners and HSs, NSs and L2 learners, and for males between NSs and HSs.

For F2, the results indicate significant differences only between NSs and L2 learners whereas the results were not distinct between L2 learners and HSs and between NSs and HSs. Male-female results were highly significant for F2. The interaction between language groups

and gender was significant except for females between NSs and HSs and between L2 learners and HSs. For males, the results indicate significant differences in F2 measure between L2 learners and HSs, NSs and HSs, and NSs and L2 learners. Tables 10, 11, and 12 show that F1 and F2 values for female NSs, HSs, and L2 learners are higher than the males' values across all vowel identities.

MORE EXPERIENCED VS. LESS EXPERIENCED

The role of experience on phonetic attainment of Arabic vowels was tested by examining how speakers of varying proficiency levels performed in producing Arabic vowels. HSs were broken into two groups that included experienced heritage speakers (EHSs) as well as inexperienced heritage speakers (IHSs). Likewise, L2 learners were broken into two groups of beginner L2 learners (BL2s) and advanced L2 learners (AL2s). Two-way ANOVAs testing F1 and F2 for the effects of language group (5-level factor: IHSs, EHSs, BL2s, AL2s, and NSs), and vowel (6-level factor) and the interaction between language group and vowel were conducted. The results show highly significant effects of language group on F1 [F $(4, 6810)= 53.639$, $p< 0.001$] and F2 [F$(4, 6810)= 19.096$, $p< 0.001$], as well as highly significant effects of vowel on F1 [F$(25, 6810)= 967.040$, $p< 0.001$] and F2 [F$(25, 6810)= 1270$, $p< 0.001$]. However, the interaction between language group and vowel were not significant on F1 or on F2. Tukey HSD post-hoc tests show significant differences in F1 between all language groups except between AL2s and EHSs, and between NSs and EHSs. For F2, the findings indicate significant differences between all groups except between BL2s and AL2s, IHSs and AL2s, BL2s and IHSs, and NSs and EHSs. For vowel, no consistent pattern for the effect of vowels as produced by different language groups was found on F1 and F2 measures.

Figure 7 below displays the acoustic space of the six Arabic vowels for the five different groups: EHSs, IHSs, AL2s, BL2s, and NSs. The Arabic long vowels occupy peripheral positions in the vowel space whereas the short vowels are centralized. For a detailed description, it is shown that NSs productions of /i:/ are closely matched with those of EHSs and IHSs in the F1 measure, where NSs produce the lowest values in the acoustic space. AL2s produce slightly higher F1 and the highest value is produced by BL2s indicating the lowest tongue body position for the BL2s than the other speaker groups. For F2, NSs, EHSs, and IHSs have comparable values whereas AL2s have slightly lower value and the lowest value is produced by BL2s. Short /i/ is produced with matched F1 values for NSs and EHSs whereas IHSs have lower values, followed by AL2s and the lowest values produced by BL2s. For F2, all groups have similar F2 for /i/ except for BL2s who have higher value indicating a fronter tongue position than the other groups.

For long /u:/, all speaker groups have slightly higher F1 values than NSs indicating comparable tongue height across all speaker groups. For F2, NSs have the lowest values whereas EHSs have higher values, followed by AL2s, then BL2s, and finally IHSs have the furthest F2 from native-like targets. /u/ shows an opposite pattern in that NSs have the highest F1 whereas EHSs and AL2s have lower matched values. IHSs have lower F1 than all groups except for BL2s who produce the lowest value suggesting a more constricted vocal tract (higher tongue body position by BL2s for this vowel. For F2, all groups produce close values but IHSs and BL2s have slightly backer F2 than the other talkers with more experience.

Long and short /a a:/ are more crowded in the vowel space than other vowels. Long /a:/ is more peripheral than its shorter counterpart with NSs producing the highest F1 in the acoustic space. EHSs, BL2s, and AL2s have lower values than NSs whereas IHSs have the lowest values

indicating a higher tongue position than other speakers. F2 has a different pattern in which NSs and EHSs produce similar values whereas the other groups have higher values suggesting a fronter tongue position than NSs and EHSs. NSs, EHSs, and AL2s produce comparable F1 for /a/ and so are IHSs and BL2s who have lower F1. Again, NSs and EHSs match their F2 whereas the rest of the groups produce fronter values. These findings indicate that for the long and short low vowels, NSs and EHSs have a backer tongue position than other speaker groups.

Clearly, it is shown that EHSs have the closest values to NSs, especially for the short vowels, followed by AL2s, then IHSs, and finally BL2s. For the long vowels, we see that EHSs produce values that are closest to NSs. Moreover, it is shown that L2 learners produce values that are closer to target-like pronunciation for /u:/ and /a:/ than IHSs who have the most distant values from NSs. For high front /i:/, EHSs and IHSs have comparable values to NSs followed by AL2s, and the farthest values are produced by BL2 learners. Generally, vowel production by various groups is viewed as a continuum where EHSs' values fall on one end and are the closest to NSs and BL2 learners fall at the other end and are the farthest from NSs' renditions.
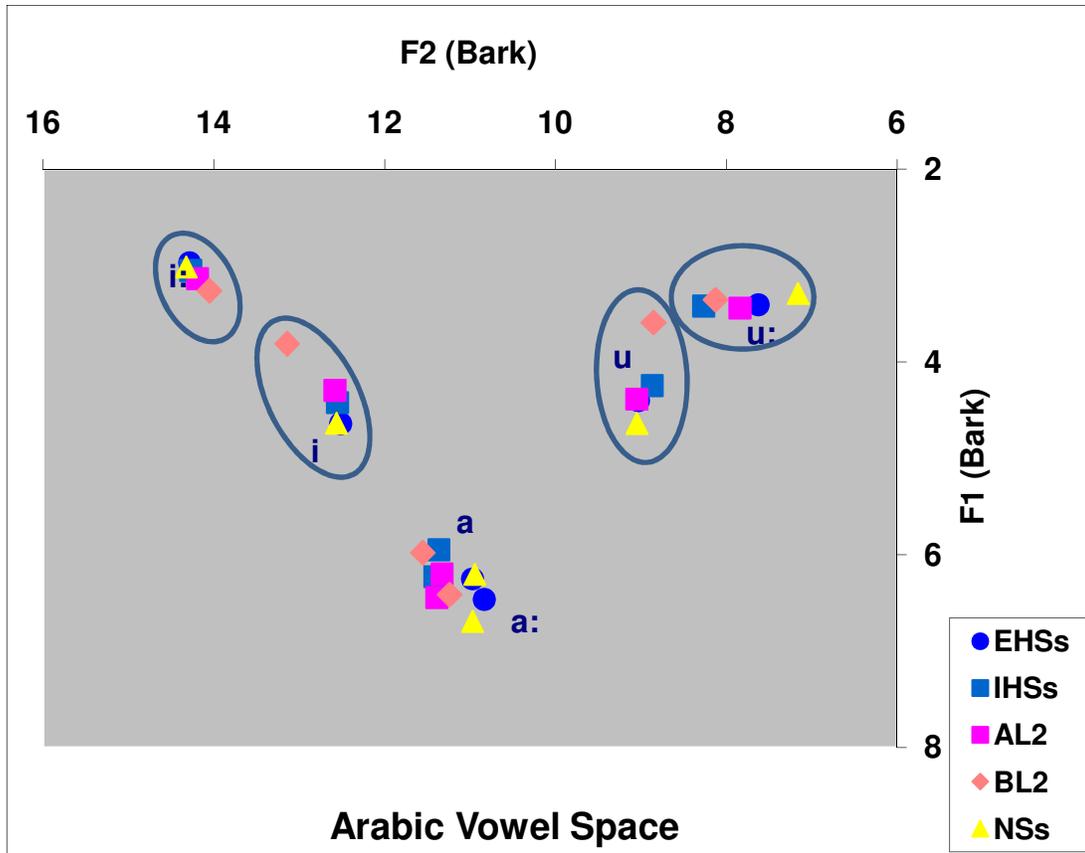
Figure 7: F1 and F2 mean values (in Bark) of the Arabic vowels /i, i:, u, u:, a, a:/ for the five different language groups: experienced HSs (EHSs), inexperienced HSs (IHSs), advanced L2 learners (AL2s), beginner L2 learners (BL2s), and native speakers of Arabic (NSs).

PLAIN VS. PHARYNGEALIZED VOWELS

Two-way ANOVA was performed to test the effect of language experience (3-level factor) and vowel pharygealization (2-level factor: pharyngealized vs. non-pharyngealized (plain) vowels) and their interaction on F1 and F2. ANOVA shows a highly significant effect of only language experience [$F_{(2, 6834)} = 10.5469$, $p < 0.001$] on F1. For F2, the results were highly significant for language experience [$F_{(2, 6834)} = 5.8643$, $p < 0.001$] and vowel pharyngealization [$F_{(1, 6834)} = 263.9714$, $p < 0.001$] whereas their interaction was not found significant. Post-hoc tests indicate significant differences in F1 measure for all three language groups. For F2, it is found

significant only between NSs and L2 learners. These findings indicate that all language groups were different in F1 and F2 measures (though only between NSs and L2 learners). However, vowel pharygealization is found significant only in F2 measure suggesting that this feature is distinct in terms of tongue position (frontness/backness) in the vocal tract.

Figure 8 presents the acoustic space of pharyngealized (Phar) and non-pharyngealized (non- phar) vowels of all six vowels across the three speaker groups. This visual representation shows several patterns. It is noticeable that there are distinct groupings for pharyngealized and plain vowels. The most important distinction between pharyngealized and plain vowels is the shift in F2 for pharyngealized vowels showing lower values for all vowels across various groups. Specifically, it is interesting that all groups have consistently slightly higher F1 (except for the low vowels which shows the opposite trend of having lower F1) and distinctly lower F2 for pharyngealized vowels. Moreover, there is no overlap between vowel categories and speaker groups suggesting that all groups have produced distinctive vowels from each other.
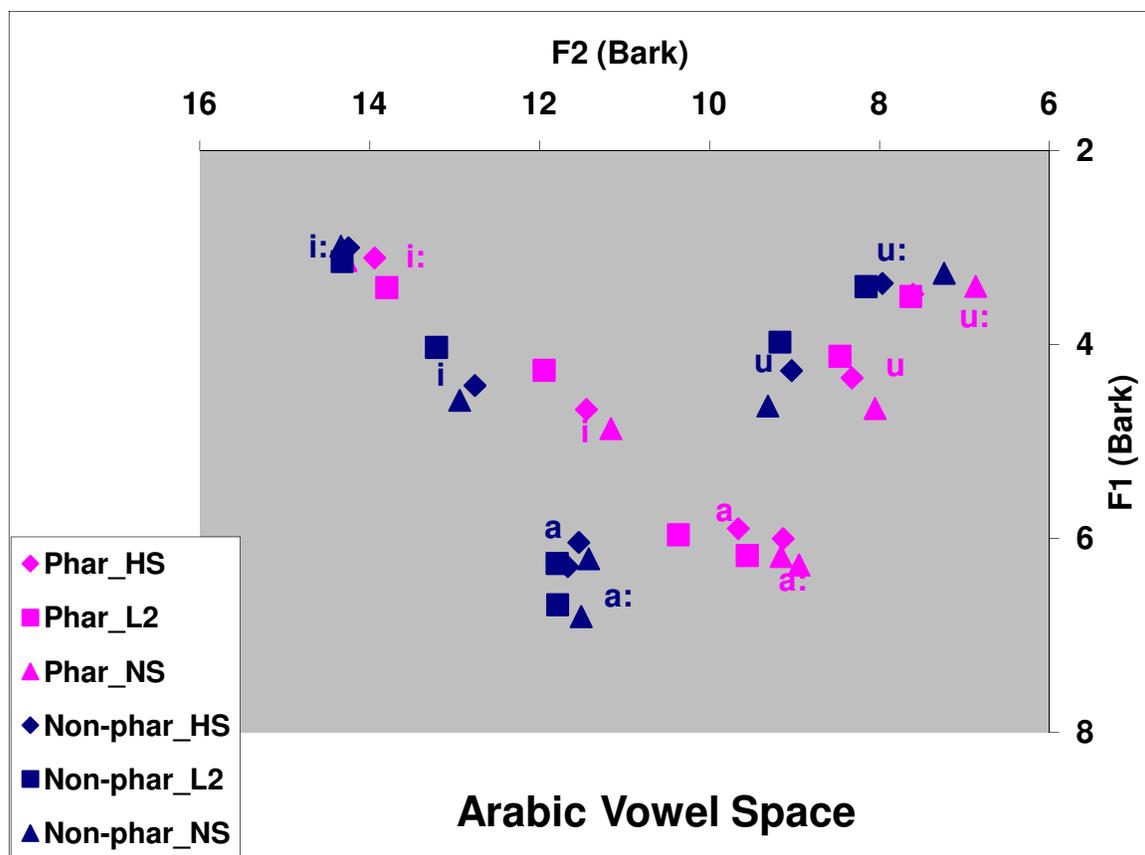
Figure 8: Acoustic space of pharyngealized (phar) and non-pharyngealized (non-phar) Arabic vowels /i i: u u: a a:/ for heritage speakers (HS), second language learners (L2), and native speakers (NS). Mean formant values are plotted for each vowel.

3.7.2 English results

Prior work established that Arabic has a different vowel system from English. In order to verify this claim for Arabic and English varieties spoken by the subjects in this study, English and Arabic are compared by eliciting speech from native speakers of both languages.

English vowel system (L2 learners) vs. Arabic vowel system (NSs)
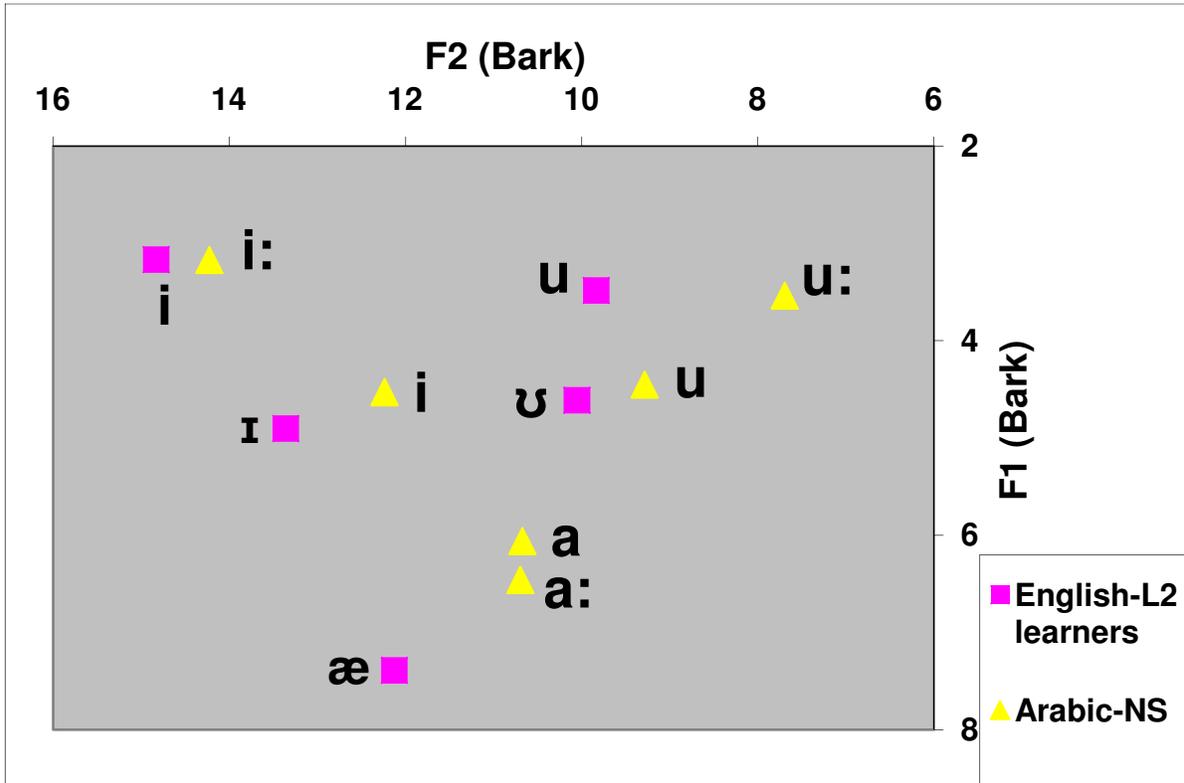
Figure 9: Acoustic apace of English vowels /i ɪ u ʊ æ/ (in Bark) for L2 learners (English-L2) and Arabic vowels /i i: u u: a a:/ (in Bark) for Arabic native speakers (Arabic-NS). Mean formant values are plotted for each vowel.

Figure 9 above presents the vowel space for English and Arabic vowels. The English vowels here are collected from the English-speaking L2 learners in this study and compared with the Arabic vowels collected from NSs. It is clear that the Arabic vowels produced by NSs of Arabic and the English vowels produced by English L2 learners of Arabic are distinct in the acoustic space. Two-way ANOVAs were conducted to test the effect of language (a two-level factor: Arabic and English) and language group (a three-level factor: HSs, L2 learners, and NSs) and their interactions on F1 and F2. For F1, the results show highly significant effects of language [$F_{(1, 8875)} = 27.8005$, $p < 0.001$] and language groups [$F_{(2, 8875)} = 8.8557$, $p < 0.001$].

ANOVAs also indicate significant effects of the interaction between language and language groups [F (1, 8875) = 4.0960, $p < 0.05$] on F1. Post-hoc tests indicate significant differences in F1 measure for Arabic and English. For language groups, the results were significant between NSs and HSs, and NSs and L2 learners. Interaction results between language and language groups indicates significant differences in F1 measure between English and Arabic for HSs whereas both systems were not distinct for L2 learners.

For F2, the results show highly significant effects of language [F (1, 8875) = 104.9723, $p < 0.001$], language groups [F (2, 8875) = 9.9279, $p < 0.001$], and significant effects of the interaction between language and language groups [F (1, 8875) = 4.4791, $p < 0.05$]. Tukey HSD indicates significant differences in F2 between Arabic and English vowels. For language groups, the results show significant differences between L2 learners and HSs, and NSs and L2 learners. Interaction results indicate significant differences in F2 measure between Arabic and English for HSs and L2 learners.

Generally speaking, as shown in Figure 9, the English vowel space is shifted to the left suggesting fronter vowels for English. In terms of F1, English and Arabic high vowels are close in values with slightly lower mean values for Arabic /i u/ than English /ɪ ʊ/. This finding indicates that Arabic short vowels are produced with a slightly lower tongue body position than English lax vowels. Moreover, English /æ/ has significantly higher F1 value than Arabic short and long /a a: /, pointing to a more constricted vocal tract (higher tongue body position) for the English vowel as opposed to Arabic low vowels. For F2, all English vowels have higher mean values than Arabic ones showing that they are produced fronter in the vocal tract. Overall, the findings show significant differences in F1 and F2 measures for English vowels produced by L2

learners and Arabic vowels produced by NSs of Arabic, confirming that Arabic and English have different vowel systems.

English vowel system vs. Arabic vowel system for L2 learners

Next, we will compare the Arabic and English vowel systems produced by the L2 learners.
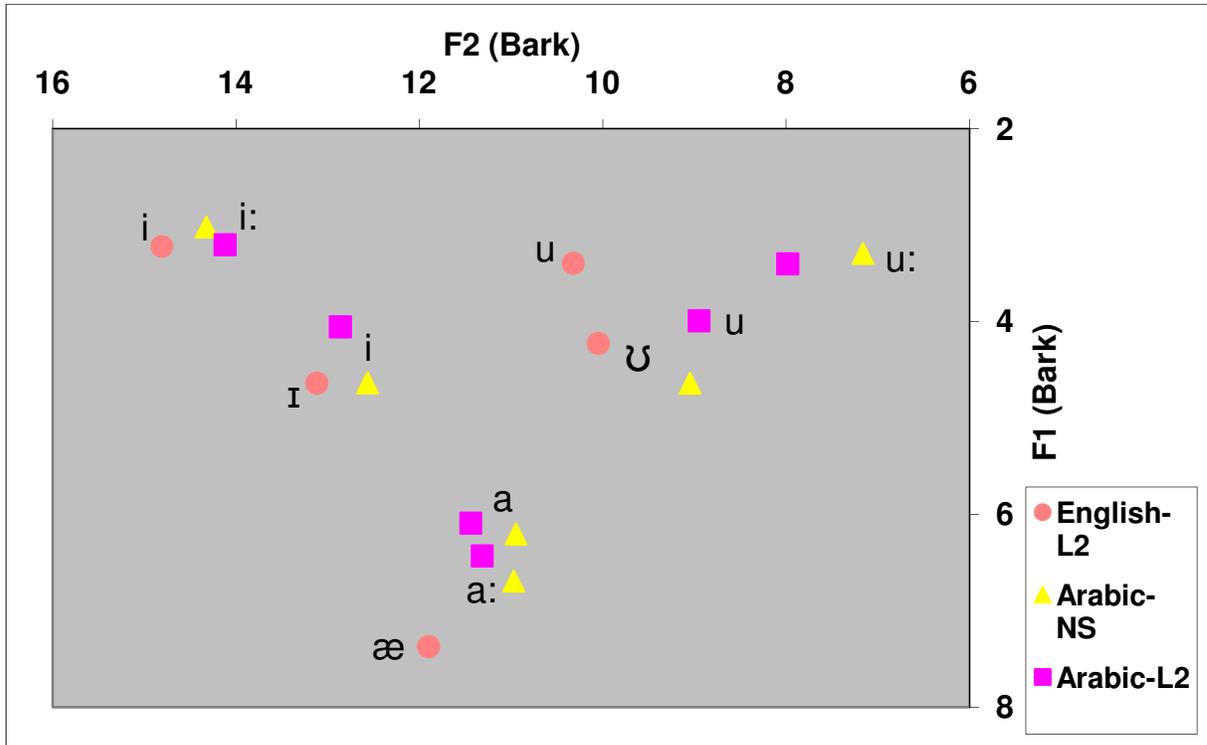
Figure 10: Acoustic apace of English vowels /i ɪ u ʊ æ/ (in Bark) for L2 learners (English-L2) and Arabic vowels /i i: u u: a a:/ (in Bark) for native speakers of Arabic (Arabic-NS) and L2 learners (Arabic-L2).

Figure 10 presents the acoustic space of Arabic and English vowels for the L2 learners and compares it with NSs. For F1, earlier reported ANOVAs show a distinct difference between Arabic and English vowels. In detail, the results from the interaction between language and language groups show that the Arabic and English vowel systems of L2 learners were not found

statistically significant. It is shown that L2 learners have comparable values for Arabic /i: u:/ and English tense vowels. Short Arabic /u/ has lower values than English /ʊ/, indicating a more constricted vocal tract (higher body position) for the English vowel than the Arabic one. Likewise, English /ɪ/ has higher values than Arabic /i/. Moreover, English /æ/ has significantly higher F1 mean values than Arabic long and short vowels, showing a lesser constricted vocal tract when producing the English vowel than the Arabic vowels.

For F2, Post-hoc tests reported on the interaction between language and language groups indicate significant differences between Arabic and English vowels for L2 learners. Figure 10 shows that all English vowels have higher F2 mean values than Arabic vowels except between English lax /ɪ/ and Arabic short /i/, suggesting that English vowels are generally produced fronter in the vocal tract than Arabic vowels. Overall, the results show that the L2 learners were not fully successful in attaining separate vowel systems for their L1 and L2. In particular, vowel renditions by L2 learners are aligned with those of NSs for vowel height but not for vowel frontness/backness.

English vs. Arabic vowel systems for HSs
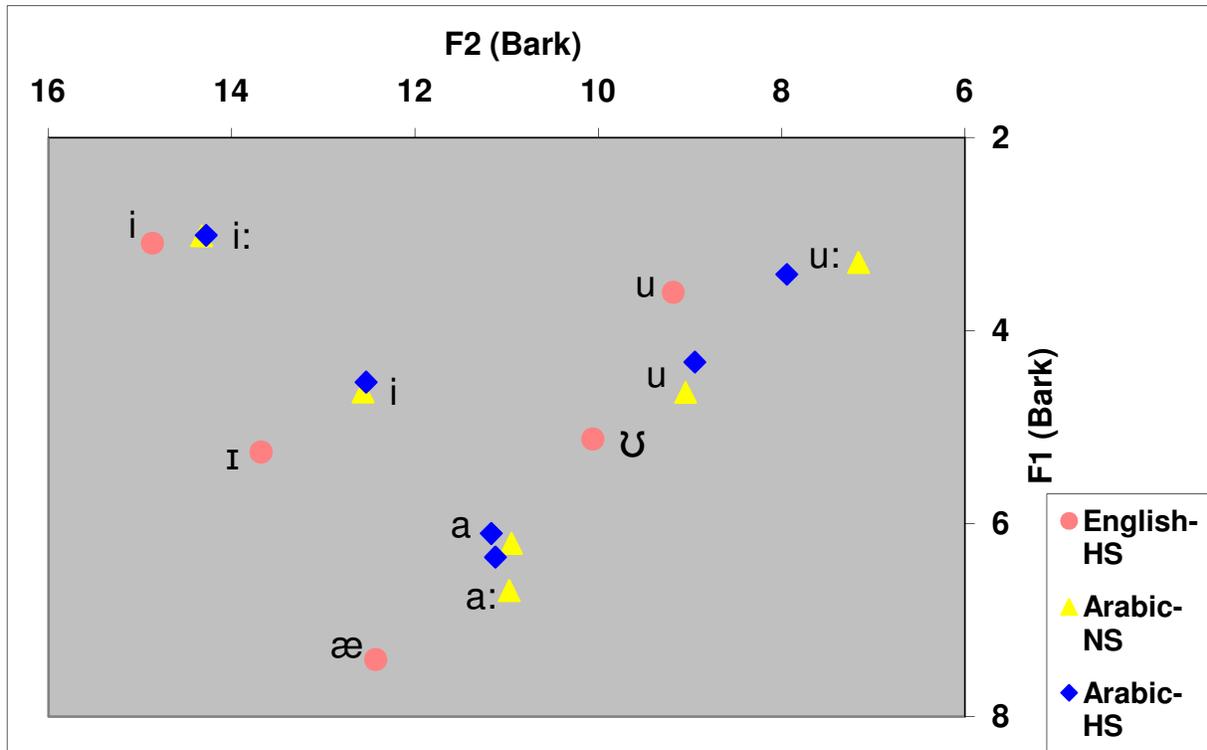
Figure 11: Acoustic apace of English vowels /i ɪ u ʊ æ/ (in Bark) for heritage speakers (English-HS) and Arabic vowels /i i: u u: a a:/ (in Bark) for Arabic native speakers (Arabic-NS), heritage speakers (Arabic-HS).

Figure 11 shows the vowel space of the English and Arabic vowels produced by HSs and compared with the Arabic vowels of NSs. Visual inspection of the data shows that Arabic vowels produced by HSs are more closely aligned with vowels produced by NSs. By contrast, it is clear that HSs produce two separate vowel categories for both languages and there is no L1-L2 interaction between any English vowel and its closest Arabic segment.

Now, let's turn to comparing Arabic and English vowel systems for HSs. In terms of F1, HSs have comparable or slightly higher mean values for English tense vowels compared to

Arabic long vowels. Additionally, it is worth noting that although Arabic vowels are close in F1 to English ones, this pattern is similar to NSs' values who produce their vowels at a comparable height as English ones as shown earlier in Figure 11. Interestingly, HSs have their Arabic short /i u/ more similar to NSs' values but distinct from English lax /ɪ ʊ /, creating more distinction between the two-vowel systems for short and lax vowels than long and tense vowels. In general, English vowels have higher F1 mean values than Arabic ones. Likewise, English low /æ/ is significantly higher in the acoustic space than Arabic /a a:/, indicating a lesser constricted vocal tract for the English vowel compared to Arabic ones. Earlier results show that Arabic and English vowel systems were highly distinct from each other for various language groups. However, detailed post-hoc tests reveal significant differences in F1 measure for HSs' Arabic and English vowel systems. Furthermore, the analyses also show that the Arabic vowels of NSs and HSs were not found distinct for the same measure.

Comparisons in F2 measure show that Arabic and English vowels are more differentiated in vowel frontness/backness than in their height dimension. At first glance, it is evident that HSs produce vowels that are closer to Arabic NSs' vowels than their English vowels in F2. Moreover, HSs have a tendency to produce fronter F2 values for Arabic vowels than NSs, except for /i:/ which is slightly backer and for /u/ which matches NSs' F2 dimension. However, long Arabic /u:/ presents an interesting case showing values intermediary between English and Arabic. HSs' /u:/, in particular, was the furthest from its Arabic target value, pointing to the effect of the dominant language vowel system on the target vowel system. Likewise, post-hoc tests reveal that Arabic and English vowel systems for HSs are significantly different in F2 measure. Interestingly, the results show that NSs and HSs did not produce distinct F2 values from each other for Arabic vowels.
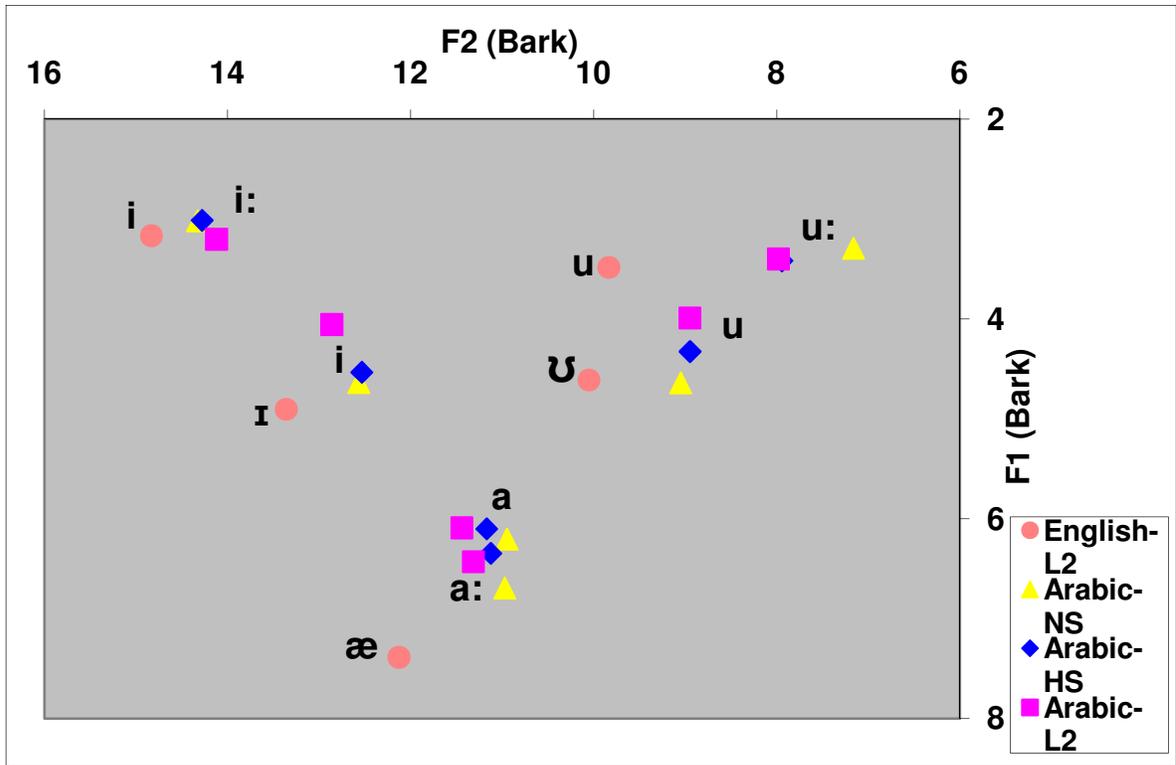
Figure 12: Acoustic apace of English vowels /i ɪ u ʊ æ/ (in Bark) for English second language learners of Arabic (English-L2) and Arabic vowels /i i: u u: a a:/ (in Bark) for Arabic native speakers (Arabic-NS), heritage speakers (Arabic-HS), and second language learners (Arabic-L2).

Figure 12 presents an overall picture of Arabic and English vowel systems produced by various groups from the respective languages. Arabic vowels produced by NSs and English ones produced by L2 learners occupy positions that are most distant from each other in the acoustic space. However, the figure shows that language learners have intermediary values for their target Arabic vowels between ones produced by NSs from each language. Several patterns emerge upon careful inspection of this figure. First, it is clear that HSs have values that are closer to NSs' Arabic vowels than L2 learners. Second, both language groups—HSs and L2 learners—produce target vowels closer to Arabic than English values. Finally, HSs and L2 learners are more similar in their production of Arabic vowel frontness/backness for /i: u: a a:/ and height for

/i/ whereas /u / has close values in both dimensions. Overall, the findings from comparing

Arabic and English vowels produced by HSs indicate that these bilingual speakers produce

Arabic vowels closer to NSs, but differ from English vowels. In general, HSs' Arabic vowels are

produced lower and backer in the vowel space than English vowels. So far, Arabic and English

results of vowels produced by HSs, L2 learners, and NSs are presented. The next section will

discuss these findings and interpret them in light of phonological theory and L2 acquisition

research.

3.8 Discussion

In this section, I will briefly present the results from the previous section and discuss them in

light of other research in the field. As for language group and vowel quality, the results show

main effects of language group, vowel quality, and the interaction between language groups and

vowel quality on F1 and F2. This means that each language group produces each vowel identity

with distinct F1 and F2 from the other two groups. Moreover, the interaction between the two

factors was distinct for vowel height as well vowel frontness/backness. In terms of vowel height

(F1), L2 learners and HSs produce similar low vowels whereas NSs and HSs have similar front

and back vowels. For vowel backness (F2), NSs and L2 learners produce various vowel identities

distinctively from each other whereas NSs and HSs were not distinct in the low vowels and L2

and HSs were not distinct in the back vowels. Overall, HSs have attained a hybrid phonetic

system: their formant values of front and back vowels are similar to NSs and their low vowels

are similar to L2 learners in F1 (V height). In F2 measure (V backness), HSs are more similar to

L2 learners for back vowels and to NSs for low vowels.

Previous work has shown that language learners produce different target vowel renditions for a certain segment due to varying experience in the TL as well as the effect of L1 vowel system on L2. Godson (2004) in a study on Western Armenian vowel production by heritage speakers shows that L1 vowels of interrupted acquirers (subjects who moved to the United States in early childhood) and uninterrupted acquirers (those who moved to the US as adults) have been affected by L2. The front vowels /i/, /ɛ/, and /a/ of interrupted acquirers were closer to English than those of the uninterrupted acquirers whereas the back vowels /o/ and /u/ were not. The researcher concludes that L1 back vowels were not affected by L2 because L1 and L2 vowels are acoustically distant in the F2 dimension in the vowel space suggesting that an L2 might not necessarily affect all L1 vowels.

Bohn and Flege (1990) and Flege et al. (1997) document difference in the realization of English vowels for speakers from different linguistic backgrounds (Spanish, Mandarin, and Korean) and who differ in their English experience (experienced vs. inexperienced). It is found that the speakers have produced vowels that differ in quality, creating allophony in the target vowel system. Additionally, Tsukada et al. (2005) show that native Korean speakers have difficulty in correctly realizing vowels that differ in vowel quality such as English /æ/ and / ɛ /. The researchers suggest that this is due to speakers' confusing vowels differing in quality in the TL.

As shown in Figure 6, NSs and non-native speakers have produced vowels that differ in quality. Moreover, non-native speakers also diverged in their production patterns by realizing segments as more closely similar or different from each other. We see that HSs and L2 learners have produced similar vowel quality for /u:/ but differed for /i/. It is quite challenging to predict the trend of L1-L2 interaction patterns by speakers who have comparable experience in the

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dominant language but differ in earlier exposure (experience) with the TL. Ultimately, HSs are expected to produce vowels that are closer to target-like values than L2 learners. However, predicting the variation in vowel quality between the two groups and the pattern of L1-L2 interaction–mainly, with languages sharing vowels that are similar phonemically but differ phonetically–is difficult noting that research targeting Arabic in general and HSs in particular is scarce.

For language group and vowel length, the results show a highly significant effect of language group on F1 (V height) and F2 (V backness). However, it is found that vowel length and the interaction between language group and vowel length is highly significant on F1 only. HSs produce short and long Arabic vowels more similar to NSs in terms of vowel height (F1) and more similar to L2 learners in terms of its frontness/ backness (F2), suggesting that their values are intermediary between the two groups. As for the interaction between language group and vowel length, the NSs and HSs long and short values were comparable in duration providing evidence that HSs are successful in attaining monolingual-like durational values for their target vowels. Also, the NSs and HSs produce their short vowels similar to the L2 learners' long and short ones.

Gendrot and Adda-Decker (2005) show that vowel duration has significant effect on F1 and F2 oral vowels by investigating broadcast news corpora in French and German. They report that short vowels are typically reduced because they have a tendency to be coarticulated with neighboring segments thus affecting their F2 values. The researchers conclude that segments which are longer than 90ms (longer vowels) are typically close to reference values and formed in a triangular shape while shorter ones have a shrunk triangle in which vowels tend to be organized centrally. Indeed, a similar conclusion can be reached upon inspecting the arrangement of the

acoustic space of Arabic vowels. We see that short and long vowels form triangular shapes where longer vowels are arranged in the outer triangle and short ones are centralized in a smaller inner triangle.

An important question that arises is whether language learners' production of target features are dependent on cues that are or are not available in their L1. So, do Arabic language learners attend to spectral and/or temporal cues in their effort to produce target vowels? Previous researchers report that L2 cues that are not readily available in L1 will not be perceived and subsequently L2 learners will fail to produce them in their L2. The "feature hypothesis" mentioned by Flege (1995 1998) seems highly relevant to evaluate the success of non-native Arabic speakers attempting to acquire the long-short vowel contrast present in Arabic. Temporal information is language specific and the acquisition of durationally based contrast shows that L2 learners have successfully mastered this feature (McAllister et al. 1999; Bohn 1995; Miller & Grosjean 1997). The presented results earlier show that although all language groups differed from one another in producing the length feature, the durational values for each group on its own provide evidence that all speakers have successfully contrasted the long and short Arabic vowels. Many studies have shown that English native speakers are sensitive to the durational feature because English vowels have the tense-lax contrast. McAllister et al. report that Estonian speakers were the most successful in producing the long-short vowel contrast in Swedish because of L1-L2 similarity in exploiting the durational feature whereas Spanish subjects were less successful because of the absence of such feature from Spanish. It appears that all speaker groups have used the durational information to learn the Arabic short-long contrast.

Several patterns are noted upon examining the vowel space. For long vowels, Figure 6 shows that they occupy more peripheral positions in the acoustic space than their short

counterparts. NSs produce more dispersed high long vowels than HSs and L2 learners. Moreover, HSs' long vowels pattern with NSs' long vowels in terms of height and with L2 learners' in term of frontness/backness. The short vowels are centralized and display an opposite pattern to short vowels. The L2 learners have more dispersed short vowels than the other two groups. In general, HSs produce short vowels with intermediary values between L2 learners and NSs. As shown, HSs' short low vowel is close to NSs in terms of vowel height and with L2 learners in terms of backness.

The results for language group and vowel reveal main effects for language group, vowel, and interaction between language group and vowel on F1 and F2. Post hoc analyses also show significant group differences (L2 learners-HS, NS-HS, NS-L2 learners) in F1 and F2 across the six vowels. The interaction between language groups and vowels are also highly significant on F1 and F2 measures except on certain vowels and for specific groups (cf. the detailed results are presented in the results section above). The significant differences in F1 and F2 between language groups and for various vowels show different production patterns which has been affected by varying proficiency levels. Nonetheless, the results do not pinpoint a consistent pattern for the effect of vowels as produced by different language groups on F1 and F2 measures. More importantly, it is shown that HSs have vowel production that is more similar to NSs for high front vowels and to L2 learners for /u:/ whereas they fall in between for /u a a:/. This suggests that HSs were more successful in achieving target-like categorical representation of some target vowels but not for others.

Assessing target vowel categorization by non-native speakers is documented in prior work. It is reported that the phonological relevance between L1 and L2 tunes the phonetic features and ultimately the production of L2 vowels. As discussed earlier, the Arabic vowel

system comprises a set of vowels that is similar to English ones phonemically but differs phonetically. This resemblance between L1 and L2 makes it more difficult for L2 learners to discern differences between the two systems (Flege 1995), especially in the case of adult learners. Hence, the production of target-like vowels is hindered as shown by the differences in vowels between NSs and non-native ones. However, with more exposure to L2, language learners are reported to produce vowels that are closer to NSs.

Considering all vowels, both groups (HSs and L2 learners) were non-native like in their production. However, these differences are attributed to age of initial exposure as well as amount of exposure to the TL phonological system which might have affected the accuracy of vowel production. Recent models investigating the role of experience on L2 vowel categorization have shown that adult L2 learners assimilate newly acquired sounds to native ones as proposed by Best's PAM (Best & Strange 1992; Best 1995). Furthermore, the SLM argues that L2 sounds are established when the differences between L1 and L2 sounds are successfully detected. Both models call for the importance of detecting differences between L1 and L2 sound categories claiming that the more experience adult L2 learners have with L2 the more successful they tend to be in forming target-like categories. L2 learners are predicted to produce phonetic features that might or might not resemble native-like categories utilizing their linguistic competence in detecting the presence or absence of such features in their phonological inventory. Lee et al. (2006) report that although early Japanese and Korean bilinguals are able to produce close to native-like vowel quality features, they failed to match those of NSs. Such finding is attested in the present study showing HSs producing closer values to NSs than L2 learners.

This study shows that all six target vowels were distinguished for all groups. This suggests that the non-native speakers have successfully perceived differences between target

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vowels and have utilized this knowledge in producing vowels that are distinct in their spectral cues. However, the acquisition of Arabic vowels varies as a result of the amount of exposure to L2 phonological system rendering distinct vowel categories between HSs and L2 learners. Another important factor that might affect the acquisition of a separate phonemic representation of L2 vowels is the inventory size. It has been claimed that speakers dealing with a 3-vowel system (i.e., small inventory size) will perceive languages differently than speakers with larger inventories. Indeed, inventory size affects the crowdedness of vowels in the acoustic space (Bradlow 1995; Jongman, Fourakis, & Sereno 1989). For example, it is claimed that speakers of languages with large inventory size tend to disperse the phonemes in the acoustic space (Hacquard et al 2007).

Hacquard et al. argues that speakers of languages with larger inventories such as English tend to perceive the same sounds as less similar than speakers with smaller inventories. Based on this, if L2 learners were dealing with a large vowel system, then they would have been expected to disperse their vowels. Since Arabic has a small vowel inventory then one claim would be that L2 learners are expected to expand their vowel space to the extent that makes vowel categories distinctive from one another. Another claim is that non-native speakers are also influenced by their dominant language vowel space which has numerous vowels with large inventory. This makes us assume that they will produce a more dispersed vowel space. Interestingly, previous work has shown that languages with larger vowel inventories do not necessarily disperse vowels in the acoustic space more than languages with smaller inventories (Recasens & Espinosa 2009).

Contrary to prediction, the vowel qualities of NSs' long vowels are more dispersed in the vowel space compared to other speakers' groups. On the other hand, HSs and L2 learners produce short vowels that are more dispersed than the NSs. This trend for NSs to produce long

vowels at the periphery of the acoustic space and to have the most shrunk triangle for the short vowels suggests that creating maximum contrast for long and short vowels is a strategy employed by NSs. Thus, this allows the production of point vowels which are characterized with less acoustic variation than other vowels (Stevens 1972) at the extremities of the acoustic space and maximizing the distinctiveness between vowels that are different in quality as well as between vowels that are distinguished based on their temporal features. This strategy employed by NSs makes use of the physical boundaries of the vowel space utilizing it at the extremes (take into account the articulatory mechanism and physical constraints which prohibits the production of formants beyond certain values) and distinguishes vowels in regards to their physical bases in order to achieve phonological distinction.

Furthermore, the results reveal a highly significant effect of language group and gender on F1 and F2 and a significant interaction between these factors. Tukey HSD indicate significant differences between L2 learners-HSs and NSs-L2 learners on F1and significant differences between NSs- HSs and NSs-L2 learners on F2. The interaction between language group and gender was significant for almost all male and female talkers across language groups except for females between NSs-HSs and males between L2 learners-HSs, NSs-HSs and NSs-L2 learners on F1 and for females between NSs-HSs and males between L2 learners-HSs and NSs-L2 learners on F2.

The difference between male and female vowel formant values is well documented. While some studies attribute such a difference to female's shorter vocal tract size, Fant (1966 1975) reports that the scale between male and female formant values is nonuniform across different vowels and formants. For example, Yang (1990 1992) shows that F2 for /i/ and F1 for /a/ of Korean females are different from the male versions whereas female /u/ is similar to the

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male version of the vowel. Therefore, anatomical differences between the sexes present a convincing claim for male-female formant differences (Fant 1966 1975) but do not describe the entire picture. For a more complete description, Fant, Nordström (1977), and Goldstein (1980) claim that articulatory behavior explains how female talkers produce formant values that are similar to males. A female talker achieves this by manipulating her tongue and lips to produce vowels with formant values that match those of males (Sachs, Lieberman & Erickson 1973; and Henton 1992a, b). Ryalls and Lieberman (1982) show that females tend to disperse vowels more in the acoustic space compared to males to compensate for sparser spectral envelopes that causes poorer resolution of their spectral peaks.

Furthermore, The "sufficient contrast hypothesis" (Ryalls & Lieberman 1982) presupposes that females have higher F0 values than males which tends to decrease the acoustic and perceptual distance between vowels in the acoustic space resulting in reduced vowel intelligibility. This is true for female talkers because female have sparser harmonic sampling of spectral envelopes. In addition to verifying this hypothesis, Diehl, et al. (1996) claim that female vowels tend to be more dispersed than males as a means of offsetting the deleterious perceptual effects on vowel identifiability because of higher F0. Supporting male-female differences, this study provides evidence that formant values are different between the two genders for all vowels regardless of language group. Overall, this leads us to conclude that anatomical differences between men and women as well as social factors result in significant differences in formant values.

Two-way ANOVAs testing the effect of language group (5-level factor: IHSs, EHSs, BL2s, AL2s, and NSs), and vowel (6-level factor) and their interaction on F1 and F2 were performed. The results show highly significant differences between all language groups in F1

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except between AL2s-EHSs, and NSs-EHSs, and in F2 except between BL2s-AL2s, IHSs-AL2s, BL2s-IHSs, and NSs-EHSs. Various language groups did not show a consist pattern in their production of Arabic vowels. Generally speaking, the significant differences between all language groups provide evidence that the amount of experience in the TL is a good indicator of proficiency level. Earlier research finds more experienced subjects to be more capable of producing native-like targets than inexperienced ones (Flege 1984b; Flege & Hillenbrand 1984). This study provides support for this claim through presenting results in which NSs and EHSs produce comparable F1 and F2 values. Indeed, this also shows evidence that early childhood exposure affects later phonetic attainment. In general, this pattern is shown by the EHSs matching NSs' F1 and F2 values whereas L2 learners (regardless of their experience) diverge by having distinct differences from native-like renditions.

The CPH claims that adults will retain a foreign accent if exposure to L2 sounds occurs around or after the critical period. Said differently, acquiring new sounds is more successful if exposure happens before the establishment of hemispheric specialization for language function. Proponents for this hypothesis have found ample evidence confirming that adult learners are disadvantaged (Oyama 1976, Flege, Yeni-Komshian, & Liu 1999; Stevens 1999) and language learning becomes compromised with age (Johnson & Newport 1989 1991, Hakuta et al. 2003). The acoustic results of vowels formant values reveals that EHSs are the closest to native-like targets attesting the significance of early childhood exposure on developing the phonetic categories of Arabic vowels.

Recent models on L2 acquisition argue that more experience with L2 results in enhanced L1-L2 discrimination abilities. "Perceptual Assimilation Model" (Best et al. 1988; Best & Strange 1992; Best 1995) and "Speech Learning Model" (Flege 1995) propose that adults with

increased exposure to L2 categories tend to discern L1-L2 categorical differences more successfully than language learners with less experience. From a production perspective, this study finds that AL2 learners and EHSs produce comparable F1 values whereas BL2s and IHSs were not different in their F2 measure, providing evidence that with more contact/exposure to the TL, adult learners are able to compensate for the phonetic/phonemic disadvantages of a late start. Overall, this study shows that EHSs have acquired native-like phonetic categories whereas HSs and L2 learners with less exposure to Arabic have not attained target-like vowels. Hence, more experience in the TL is reflected through significant improvement in vowel production by all language groups.

For pharyngealized vowels, two-way ANOVAs testing language groups (3-level factor) and vowel pharygealization (2-level factor: pharyngealized vs. non-pharyngealized vowels) and their interaction show significant differences in F1 and F2 measures between different groups of speakers. F1 mean values for pharyngealized and non-pharyngealized vowels are not found significant, showing that both vowels are produced with similar tongue height position in the vocal tract. For F2, pharyngealized mean values across all vowels are lower than their non-pharyngealized counterparts. Zawaydeh (1997) reports that pharyngealization in Jordanian Arabic affects formant frequencies of vowels following emphatic consonants causing a slight F1 raise and F2 lowering. It is claimed that during the production of pharyngealized segments the dorsum of the tongue approximates the upper part of the pharynx or is becomes retracted as described by Davis (1993 1995) causing the shift in F2 measure. In terms of tongue position, this finding indicates that pharyngealized vowels are produced backer in the vocal tract than non-pharyngealized vowels.

Like non-heritage speakers, Girgis (2009) reports that Egyptian Arabic HSs are found successful in acquiring emphatics and pharyngealized vowels, demonstrating native-like accuracy but producing greater F2 ranges and standard deviations for tested segments compared to non-heritage speakers in similar contexts. In general, supported by previous work, this study shows that the vowel space of Arabic pharyngealized vowels undergo significant change in F2 compared to non-pharyngealized (plain) contexts causing the shift of the vowel triangle to the left. Examining Figure 6 above, it is shown that each group of speakers have a slight F1 raise (was not significant) for pharyngealized vowels whereas F2 is significantly lowered in similar environments, demonstrating a backer tongue position in the vocal tract in such contexts. In the following section, vowel production is compared between speakers with varying experience in Arabic, a language that exhibit pharyngeal vs. non-pharyngeal contrasts in its sound inventory.

Language experience and Arabic/English vowel systems

The three Arabic vowels already exist in the English vowel inventory but differ acoustically from their English counterparts. Also, vowel duration is contrastive in Arabic. Flege (1979) finds that the duration of Arabic long /a:/ but not short /a/ as produced by Arab Saudi speakers resembles the duration of English /æ/, confirming that the newly acquired L2 phonetic category is mapped to the closest L1 segment in the acoustic vowel space. Motivated by similar findings on language learners' abilities to map L2 segments to ones already exist in their L1, this study aims at examining the linguistic behavior of HSs and L2 learners: two groups differing in their extent and duration of exposure to Arabic. If both HSs and L2 learners produce their Arabic vowel values similarly to one another and are the same as English vowels, then it suffices to claim they have mapped a newly acquired segment to an already existing one in their inventory. By

contrast, if the vowel values for each group are different from each other and are also different from the English ones, then they did not match L2 to L1 segments and they were able to create new categories for their L2 vowels.

The results obtained from comparing the vowel systems of Arabic and English show that both languages have indeed distinct vowel systems. Indeed, Arabic and English exhibit significant differences in F1 and F2 measures, meaning that vocal tract constriction (vowel height) and tongue frontness/backness are distinct. Earlier research has found that adult L2 learners can vary in their language acquisition and their phonetic system(s) can be organized differently inside the brain. There is a consensus that language learners who are exposed to L2 earlier in life are more apt than late learners to master the language later in life. This does not mean that late learners will not be successful in acquiring L2 phonetic categories. Specifically, late L2 learners are reported to organize their language systems differently (cf. Flege 1991 on Spanish-English bilinguals VOT production), suggesting that significant interactions between the two languages influence the production of L2 segments, viz., vowels (Baker & Trofimovich 2005).

One way to examine the degree of L1-L2 interaction is to perform monolingual-bilingual comparisons; comparing vowels would be an informative means of evaluating the two language systems. This requires multiple comparisons in which systems belonging to different unrelated languages are compared with each other. Later on, speakers/learners categorized under separate groups are investigated to show how difference in speaker group would result in distinct vowel systems. The results from this acoustic study provide strong evidence that L1 vowel system influences newly acquired L2 phonetic segments. Generally, L2 learners did not produce significant differences in F1 measures for English and Arabic vowels, suggesting that they had

similar vocal tract constriction for the vowels of the two languages. Specifically, the production of Arabic short /i/ by L2 learners with values that more closely resemble English lax /ɪ/ shows that an L2 vowel is mapped to its closest L1 phonetic counterpart (Best 1995; Flege 1995; Kuhl & Iverson 1995). However, for vowel frontness/backness, it is shown that L2 learners have successfully acquired the F2 measure and are able to differentiate L1 and L2 vowels by placing the body of tongue at relatively native-like front/back positions in the mouth. Kuhl (2000) suggests that adult L2 learners might circumvent L1 interference effects if they receive abundant L2 linguistic input such as extensive experience hearing and listening to L2 speech sounds. Kuhl states that interference effects can be minimal if two separate categories were created early in life for both languages; this is shown through activating overlapping regions in the brain when learners attempt to process their languages. However, when adult L2 learners attempt to process their languages, two separate regions are activated in the brain for the two languages. So, interference effects are minimized when separate mappings for language categories are created in the brain and this is achieved as the language is acquired early in development. Such claims find ample support from HSs' performance which shows that Arabic vowels are realized target-appropriately, attesting to two-vowel systems. The successful formation of the Arabic vowel system is mainly attributed to early exposure effects on vowel acquisition.

For L2 learners, the successful categorization of F2 for target vowels but not F1 shows that L2 learners are more attentive to certain acoustic cues more than others. Earlier studies have found that learners attend to different strategies and acoustic information to categorize L2 sounds. In a perception experiment, Strange et al. (2004) report that American English and North German vowel space have different patterns of spectral similarity. It is reported that where mid long and high-mid short vowels overlapped in F1, these vowels differentiated in F2. On a

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different respect, Underbakke et al. (1988) report that duration is the main cue used by Japanese learners of English to achieve / ɹ/ - /l/ distinction whereas English learners rely on F2 and F3 to recognize distinction between L2 sounds. This strategic difference in perceiving and producing target sounds is due to feature availability in L1. This means that if acoustic cues or features are readily available in L1, this will result in successful detection of such features in L2 (McAllister et al. 2002). Building on this, it suffices to hypothesize that L2 learners have attended to F2 as a more prominent acoustic cue for L1-L2 vowel discrimination.

By contrast, Cebrian (2006), in a study focusing on the role of experience in L2 vowel categorization, reports that L2 learners might revert to a non-L1 feature to establish L1-L2 vowel contrasts. Cebrian shows how Catalan learners of English were successful in acquiring duration, a temporal feature not available in Catalan, and concludes that learners were able to perceive tense-lax contrast regardless of their L2 experience. Back to this study, though F1 and F2 are spectral cues that differentiate Arabic and English vowels, L2 learners attended to F2 as more prominent in categorizing target sounds, a finding that has been attested by earlier work.

HSs are expected to produce different vowel values from L2 learners because of the extent of exposure to the TL. The findings from this study show that while HSs differentiated Arabic and English vowels in terms of F1and F2, the same measures were not distinct between HSs and NSs for Arabic vowels. Chang et al (2008) compare consonantal production of five Mandarin fricatives among HSs, English L2 learners, NSs of Mandarin. Their experiment reveals that NSs and L2 learners tended to merge Mandarin and English sounds whereas HSs kept them separate, maintaining better contrast. It is reported that HSs are advantaged because of their childhood exposure to both languages which enabled them producing fricatives closer–though not quite identical–to target-like sounds. Another explanation is that HSs have a shared

phonological system for similar sounds of their two languages, allowing such sounds to dissimilate from each other (Laeufer 1997). Similar findings are reported here showing that HSs are more successful in achieving native-like Arabic vowels than L2 learners. Furthermore, HSs are able to maintain contrast between Arabic and English vowels, suggesting two-vowel systems for the heritage language and dominant language.

In conclusion, testing contrasting/similar phonological systems between different groups of learners has been realized through looking at acoustic measures such as VOT (Kim & Lotto 2002; Godson 2004; Chang et al. 2008), perceptual measures (Chang 2009; Au et al. 2002; Knightly et al. 2003; Oh et al. 2002, 2003), and articulatory measures (Godson 2003). Extending the same line of inquiry investigating HSs' phonological competence, this study reveals that early exposure to target sounds results in phonological advantage later in life when the TL is taught in a classroom setting. It is shown that language learners—HSs as well as L2 learners— have produced intermediary values for target vowels. However, it is shown that more experience results in more accurate production of target vowels as demonstrated by HSs' closer values to NSs' as opposed to L2 learners. Furthermore, EHSs are found to produce values that are closer to target vowels than IHSs and so does AL2 learners compared to BL2 learners, attesting to the notion of incomplete acquisition by language learners.

3.9 Conclusion

This study is significant for understanding the potential for language learners to attain native-like fluency in both of their languages at levels that are non-distinct from monolingual speakers. Unveiling fine-grained phonetic detail through studying the vowel space of developing bilinguals is crucial in understanding how the brain processes and reorganizes multiple phonetic systems.

HSs constitute a separate unique cultural and linguistic resource in the United States which

presents particular challenges for language educators and language programs. Because of a

unique language experience beyond the walls of the classroom, it is shown that HSs have a

linguistic advantage through possessing a degree of elasticity shown with a more packed vowel

space than NSs but is more dispersed than L2 learners.

CHAPTER FOUR

DISCUSSION AND CONCLUSIONS

4.1 What Does Phonetics/Phonology Tell Us about Heritage Language Learners?

This study addresses major questions raised in the emerging field of heritage language acquisition and early bilingualism, focusing on Arabic vowel acquisition. In this thesis, I investigate the highly debated issue concerning the mental encoding of the grammatical information in the mind of the bilingual speaker. Specifically, drawing from current research on phonetics and phonology and examining HSs and L2 learners, I propose that Arabic and English vowel systems for both speaker groups are, in fact, interacting.[1] More interestingly, the nature of this interaction varies in regards to the extent of experience with the TL phonetic/phonological system. The goal is to review evidence examining the linguistic performance of developing bilinguals and evaluate it in light of issues pertaining to bilingualism, phonology, and L2 acquisition.

The field of heritage language acquisition has received increased attention, mainly in the United States, during the last decade. This is motivated by the willingness to identify this unique group as HSs who show more interest in (re)learning their ancestral language(s). Upon investigating the landscape of language classes, it is clear that HSs comprise a good percentage of learners—as is the case for some languages more than others—enrolled in those classrooms. Because of their prior exposure to the heritage language in the family home and in the smaller ethnic communities, HSs seem to be advantaged over other learners with no such knowledge. In the meantime, for most language programs and for several reasons, it is not feasible to set up separate classes tailored to HSs, so they are typically placed in the same setting receiving the same instruction as other learners. Therefore, their presence constitutes a real challenge to

language teachers who face divergent populations in one educational setting. To date, most research on HSs as language learners has focused on minorities who are widely represented in the American community (cf. Montrul's line of research on Spanish heritage speakers). However, this thesis examines HSs of Arabic in the attempt to broaden the scope of investigation and draws attention to Arabs as a distinct minority group, and Arabic language instruction, which is witnessing an increase in colleges and universities at this time.

This study presents a phonetic investigation testing the Arabic vowels of HSs as well as L2 learners. Vowels are tested because they are found to be good predictors of foreign language pronunciation. The broader goal is to see whether similar or different phonological systems exist for both speaker groups. Comparing F1 (vowel height) and F2 (vowel frontness/backness) through examining several variables, it is shown that HSs do, in fact, pronounce Arabic vowels differently from L2 learners. Not only this, HSs are also found to have a distinct vowel system from NSs of Arabic. This shows that HSs have achieved partial command of the target vowel system, falling between NSs and L2 learners.

4.2 Incomplete Acquisition, Attrition or Language Loss?

Several notions such as "incomplete acquisition", "attrition", and "language loss" have been proposed to describe and categorize the linguistic knowledge of various language learners. In the literature, language loss is used as a more general term encompassing incomplete acquisition and language attrition. Typically, language attrition is used to describe the case of adult language learners living in an immigrant community for an extensive period of time and who are exposed to the L2 as adults. As a result, the L1 suffers from one form of linguistic loss or another (Major 1992; Polinsky 1997; Sorace 1999, 2000a; Montrul 2005). On the other hand, incomplete

acquisition describes the linguistic knowledge of bilinguals who grow up using two languages; the family (home) language and the dominant language. Later in life, the linguistic ability of such bilinguals is shown to be lagging behind native-like attainment in one or the two languages. The linguistic knowledge of L2 learners is either characterized as incomplete acquisition or language attrition of target-like linguistic categories (Montrul 2008). This is based on the fact that the two groups are different in terms of their linguistic experience with the TL and we need to understand the factors affecting their language acquisition. Whether the TL is learnt before or after the critical period is reached is found to be a crucial factor in the linguistic development necessary for L2 acquisition. The data presented here shows the state of acquisition for both populations at this time, therefore, it is premature to determine if it represents, mainly for HSs, incomplete, failed acquisition, or subsequent language loss. In order to arrive at informed judgments, a longitudinal study in which the linguistic output of developing bilinguals is regularly examined will provide a good insight into the nature of how language is acquired by bilinguals.

4.3 Interacting Systems in the Mind of the Bilingual

The issue of the mental encoding in the mind of the bilingual speaker has been widely discussed in the literature. In the domain of phonology, the first view stresses the existence of a single enlarged system for the two languages of bilinguals. An alternative viewpoint calls for the coexistence of two separate systems in the mind of bilinguals. In between, a third view claims that the two systems interact, suggesting that a bilingual's languages are not entirely separate. Focusing mostly on the third view, I argue that a bilingual's two systems influence each other. In the following, I will elaborate on this assumption and discuss its implications for phonological

theory, specifically as it concerns the intersection between second language acquisition (SLA) and the teaching of heritage language. Also, I discuss other implications in relation to various communities of language users drawing from recent SLA theories as well as from professional considerations within the boundaries of L2 pedagogical practices.

Whether bilinguals have one enlarged phonemic system for their languages or whether these systems are kept separate is highly debated among language researchers. On one end, it has been claimed that bilinguals can acquire another phonetic system and be monolingual-like in both of their languages (Penfield 1953; Penfield and Roberts 1959). In other words, there are two separate phonemic systems for bilinguals (Weinreich 1974 [1953]). On the other end, Swadesh (1941) argues that bilinguals have one enlarged system compared to monolinguals. In the middle, another view proposes that though early bilinguals may perceive/produce their phonetic systems in a monolingual-like manner, their performance is still different from that of monolinguals (Seliger, Krashen, & Ladefoged 1975). The main premise here is that there is interaction between the two systems and the sounds of the two languages would be in complementary distribution. Lately, extensive linguistic work is couched within a theory that supports a dual mental encoding in the mind of the bilingual but at the same time argues that overlap and interaction between both systems is evident and supported by phonetic-acoustic evidence.

Recently, rigorous research concerning the difference in the linguistic behavior between HSs as well as L2 learners is examining, among other things, the phonological systems of both groups. There is consensus in considering HSs a unique group with linguistic abilities and needs that differs from other language learners. HSs and L2 learners, as presented in the current study, have similar linguistic experience growing up speaking the dominant language, i.e., English.

However, they diverge in one important aspect and that is HSs' childhood exposure to Arabic, the TL investigated here, prior to studying it in the language classroom. I have chosen to compare Arabic and English because of the extensive similarities and differences between both vowel systems. Arabic and English have vowels that are similar in their vowel quality but differ phonetically. Conversely, Arabic has a small vowel system which contrasts long vs. short vowels whereas English is described as a large vowel system contrasting tense vs. lax vowels. This thesis shows that though HSs have demonstrated more advanced fluency in their production of the TL phonological system, nevertheless, their vowel systems displays signs of non-target like productions.

In this study, testing language group is a fixed independent variable, whereas vowel quality, length, vowel, gender, experience, and vowel pharyngealization are the second independent variables in all the ANOVAs conducted here. These factors serve as a means of quantifying vowel differences between various groups of language learners and comparing it with NSs' renditions. F1 and F2 were the dependent variables. It is shown that each language group produces distinct vowel qualities for F1 and F2. In detail, interaction results focusing on vowel height revealed that HSs were more similar to L2 learners for low vowels and to NSs for front and back vowels. Interestingly, HSs were closer to NSs' low vowels and L2 learners' back vowels in the frontness/backness dimension. When vowel length was investigated, the results revealed distinct differences between NSs, HSs, and L2 learners, but vowel length and the interaction between vowel length and language group was distinct on F1 only. HSs produced intermediary long and short vowel values between native and nonnative-like targets. Their vowels resembled NSs in vowel height and L2 learners in vowel backness. Importantly, all speaker groups were successful in acquiring the long/short contrast for Arabic vowels. This is

achieved because such temporal distinction does exist in the dominant language, English, facilitating the acquisition and production of this feature for the TL.

Direct evidence points to consistent patterns that characterize nonnative speech pronunciation. Acoustic measurements of vowel duration examining vowel length for all subjects indicate a tendency towards creating contrasts between long and short vowels for all language groups. However, though HSs and L2 learners did not reach native vowel targets, they each have a vowel system that is shaped differently from the other. This shows that a single phonetic representation does not suffice to characterize nonnative vowel productions in HS and L2 learner groups. Serving as further evidence for the variable representation of phonological systems in the mind of bilinguals, HSs and L2 learners in and of themselves demonstrate that phonological proficiency as shown in TL production of the stimuli does not follow a unified pattern for speakers who have comparable language experience.

Looking at individual vowels, we face a recurring scenario in which NSs' targets fall on one end and L2 learners' on the other. Vowel productions of HSs seem to fluctuate by being closer to native-like targets as shown for high front vowels or to L2 learners for the long back vowel or having medium values between both groups for the rest of the vowels. This suggests that HSs demonstrate measurable native as well as nonnative pronunciation of Arabic vowels. Indeed, even when NSs display an opposite pattern to L2 learners by having more dispersed long vowels and more contracted short vowels, HSs show a consistent pattern producing vowel triangles (for long and short vowels) that are intermediate in the vowel space between the two opposing groups. In general, several factors were examined in order to quantify the linguistic potential of HSs and compare it to NSs and L2 learners. There is no question that HSs have a unique phonetic/phonological system that that is characterized by shared properties with optimal

target-like linguistic competence displayed by NSs. Their phonological system also shares properties with less than optimal targets as displayed by nonnative speakers.

4.3.1 Linguistic studies of bilingualism

To understand how language learners acquire their L2, several theories have emerged to explain how language is processed in the mind of bilinguals. This is of special interest because the aim of such theories is to detect the extent of difficulty facing L2 learners in regards to vowel acquisition and to examine how newly acquired phonemes are categorized in relation to native ones. For example, Flege (1995) proposed the Speech Learning Model (SLM) arguing that the phonetic/phonological systems of a bilingual's two languages exist in one merged system. In addition, according to Best's (1995) Perceptual Assimilation Model (PAM), language learners tend to assimilate similar L2 vowels to their closest L1 vowel category. Based on PAM premises, we expect nonnative speakers, mainly L2 learners, to produce Arabic vowels with English values because of the similarity between them in vowel quality and there will be difficulty in acquiring the TL vowel system. However, my data showed that the L2 learners did learn to retract their vowels, though Arabic and English vowels are similar phonemically. This might be due to the fact that they were successful in acquiring the Arabic "base of articulation". Though SLM and PAM stress the effect of native speech sounds on the perception and production of L2 segments, this study shows that adult language learners are moving towards attaining TL phonetic realizations despite the resemblance in vowel categories between the two systems.

More specifically, prior studies on vowels (Godson 2004) and Voice Onset Time (VOT) (Khattab 2002 and Saadah 2010) report that a bilingual's languages interact with each other providing evidence from acoustic measures on such interaction. Khattab and Saadah investigated

VOT in Arabic/English bilingual children and found that they were successful in acquiring

VOTs that were close though did not exactly match monolingual-like production. Khattab (2007)

on another study investigating Arab children raised in an English-speaking community report

that Arab bilingual children's realizations of English vowels are more similar to English targets

even though there is a great extent of variability in their English speech. For example, the

children tended to accommodate their English speech to their monolingual English-speaking

friends in some instances and to their parent's foreign-accented English when they code-

switched with them in others.

Current models investigating non-native speech production share a common goal; that is

to explain how bilinguals organize and process their languages. Following different approaches,

these models acknowledge that L1 and L2 segments influence one another. This study builds on

this by posing major questions such as *how, why,* and to *what extent* do the vowel systems of

bilinguals interact? In any attempt to answer these questions, it is crucial to evaluate the factor(s)

affecting language acquisition by non-native speakers. In general, the production of intermediate

vowels between English and Arabic targets by HSs and L2 learners is a good example of the

interaction between the dominant language and TL vowel systems. This results in one merged

enlarged phonetic/phonological space for both systems and in which interaction has been shown

to affect levels beyond the segmental representation (Tarone 1976, 1980). If this is not the case,

then it is hard to explain how L2 speakers retain L1 features which are transferred and noticeably

detected in their L2 speech production. As an example, L1-Korean L2-English learners are

reported to have difficulty differentiating between /r/ and /l/ because this distinction is lacking in

their L1. The fact that L1 phonemes influence L2 sounds is supported by Korean speakers'

inability to master this phonemic distinction. One might argue that if their phonological systems

are kept separate, then language learners would face no difficulty acquiring the new speech segments. For the same reason, L1-English L2-Arabic learners are challenged when they attempt to produce the phonemic distinction between the glottal stop /ʔ/ and the pharyngeal / ʕ/ even after years of instruction and exposure to Arabic. The impact of such interaction is, in fact, quantified and clearly displayed through the detailed description of the characteristics of vowel systems which is evident from the previous discussion on vowel quality and length for nonnative speakers.

4.4 On the Role of Proficiency Level

This study shows that bilinguals of varying proficiency levels have different mental organization for their languages. Likewise, recent research reports that early bilinguals have two phonetic systems whereas late ones or adult learners have one system.[2] In addition, this experiment confirms that age of exposure is confounded with amount of exposure (and variety of exposure). Nevertheless, HSs are found to be more successful in approximating NSs than L2 learners. Hence, the extent of exposure is a key factor in facilitating the production of native-appropriate targets. So, subjects with more exposure to Arabic could, in fact, produce vowels that that are closer to NSs' targets than less experienced ones regardless of their age of initial exposure to the TL. In detail, it is found that extended experience as well as more exposure to the TL enabled EHSs and AL2 learners to produce target speech sounds more accurately than IHSs and BL2 learners.

This discussion leads us to conclude that the deviations from native-like production result from interaction between different languages assuming that the extent of such interaction is

mandated by the proficiency level of the bilingual. In addition to acoustic data shown in the present study, the literature provides ample evidence of overlapping activation for a bilingual's languages, even when both languages are unrelated (e.g. Arabic and English). This overlap is shown in the form of acoustic evidence, as reported here, and can be in the neural activation for the two languages which is mainly attributed to transfer effects due to L1 and L2 processing mechanisms. It has been reported that brain activation differs for proficient and non-proficient bilinguals. For example, brain imaging has shown that multiple areas in the brain are activated when low proficiency bilinguals try to access their multiple languages. As their proficiency level increases, bilinguals are shown to activate similar or the same neural regions to access their L1 and L2 (Perani et al. 1996). This is similar to activation areas for native speakers where they access only certain regions for their L1.

The role of early exposure to target sounds on later phonetic attainment is reported as one of the most influential factors. In addition to acoustic evidence, neurological studies show that extensive early exposure to L2 sounds affects various domains of cognition for bilinguals and subsequently enhances their cognitive abilities (Kovelman 2006; Vaid & Hull 2001). Here, EHSs exhibit more native-like pronunciation than IHSs whereas AL2s produce vowels that are closer to native-appropriate targets than BL2s (see Figure 7). All in all, because of their earlier exposure to target segments, HSs conferred advantage to L2 learners as shown in the present thesis. This has also been confirmed in earlier studies investigating phonological competence (Au et al. 2002) as well as morphosyntactic knowledge (Montrul 2010; Montrul, Foote & Perpiñán 2008).

This study investigates the development of language acquisition by examining how adult learners modify their linguistic output after extensive exposure and experience with the TL. This

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provides further evidence that the two language systems are not completely separate. More importantly, such progress in language acquisition has consequences for the way we think of a critical period for learning a language. The long held claims that experience as well as age are both crucial for L2 acquisition are both confirmed here. However, I argue that a critical period is not the only factor that promotes or inhibits language acquisition. By examining the linguistic knowledge of HSs and L2 learners, it is evident that AL2s surpass IHSs in their production of Arabic vowels, presenting a real challenge to proponents of CPH. Such a claim has important implications in that the view that L2 learners will never be able to utilize the same linguistic mechanisms available for NSs is highly questioned. The evidence shown here strongly suggests that L2 learners are able to acquire the TL at levels that are closer to native-like vowels than HSs who are less experienced in Arabic. Further research will require serious investigation of the way we think of the critical period and its role in SLA.

4.5 Implications for SLA

The acquisition of L2 Phonology is one of the most important and complex areas that is in need of a considerable amount of exploration within a theory of SLA. The study of pronunciation or foreign accent, as it is noticeably detected in the speech of non-native speakers, requires the knowledge drawn from phonological theories and consideration of developmental and universal facts about language. It has been shown that learners are capable of transferring their L1 phonological parameter setting, which involves among other aspects phonotactic constraints and stress patterns. Moreover, many L2 phonology studies focus on the segmental or individual aspects of speech sounds (Beebe 1980), whereas recent investigations extend to the acquisition

of L2 syllable structure (Broselow, Chen, & Wang 1998; Young-Scholten & Archibald 2000). For example, Young-Scholten and Archibald argue that both NL and universal tendencies are driving forces that shape L2 phonological acquisition. Therefore, this thesis as devoted to the study of the HS population is touching on fundamental theoretical reasons for why the study of HSs is relevant for SLA. Moreover, the comparison between two distinct language groups and languages responds, even if partially, to several theoretical questions raised by any investigation on SLA. Such issues include the significant role of exposure to the target language in explaining linguistic gaps for non-native language users, range and variation of linguistic knowledge between speakers with different proficiencies, and finally, evaluating the role of universal tendencies in non-native language acquisition through exposing transfer errors from the dominant language by conducting systematic comparisons as the one done here focusing on vowels.

SLA theories should be concerned with addressing how the NL and TL systems interact and explaining the nature of the linguistic behavior of bilinguals. We know that L1 and L2 interact in the bilingual's brain and as a result IL rules are shaped differently for learners from different languages. Understanding the nature of the discrepancy between the NL and TL will expose these differences. Therefore, a more inclusive theory should predict the type of difficulties that an L2 learner will face and attempt to address them. Since language acquisition is different for L2 learners and heritage learners, a new framework/or theory that is primarily concerned with how to address the needs of heritage language education should be actively pursued.

4.6 Implications for Heritage Language Study

Linguists have long attempted to answer questions pertaining to the grammatical systems of multiple language learners. In doing so, linguistic theorists have tried to relate to broader issues concerning how and why languages are shaped the way they are and what affects language acquisition under different circumstances. An increasing body of research has successfully addressed heritage language acquisition (Montrul 2008; Polinsky & Kagan 2007) in order to inform linguistic theory and describe differences between adult/bilingual and child/monolingual acquisition of language. Prior work has also addressed pedagogical concerns to inform the practices of language teachers.

Kondo-Brown's line of research on heritage language development and instruction brings much needed insights into this newly investigated subfield in the social sciences. It draws much attention to differences between various groups of language learners and targets students from immigrant backgrounds. In addition, Kondo-Brown's research aims at addressing challenges facing teachers who cater to students from heritage backgrounds and proposing recommendations for heritage language instruction. Kondo-Brown (2003) points to the importance of adopting an appropriate proficiency measure for evaluating language skills for HSs. The researcher argues that neither self assessment nor standardized language proficiency measures (viz., OPI with ACTFL guidelines) are sufficient for such evaluation. Instead, these can be modified and tailored to address the needs of the heritage population or, even better, new measures must be devised to evaluate adult heritage language learners. This issue is raised because many heritage learners are not placed in level-appropriate language classes even after going through some form of evaluation or another.

Challenges facing language practitioners are in fact tremendous in light of the variable population enrolled in their language classes. This is true for Arabic language instructors who assume teaching responsibilities in classes where heritage and L2 learners are assigned to the same classroom. Not only do teachers need to teach Modern Standard Arabic, but in many cases they need to deal with HSs of Arabic speaking/exposed to different Arabic varieties. Such differences entail variability in phonological, morphological, syntactic, and lexical aspects which introduce challenges for the teachers in designing a common set of teaching materials, and in many cases also cause confusion to such learners. If these heritage learners have not been exposed to Standard Arabic before, then they will be similar to L2 learners in that they need to learn and acquaint themselves with it. This will seem to them as if they are acquiring a new language, resulting in the need for more effort inside and outside the language classroom.

4.7 Pedagogical Implications

A compelling question is what are the pedagogical concerns that underlie teaching a heritage language in the educational setting? In their attempts to promote language development, teachers need to be wary of step-by-step pedagogical goals that cater to every level in the learning process. Every language department/program must have a workable plan with clearly articulated set of objectives for students in various levels. These must respond to students' needs and have the flexibility to expand or shrink according to political, social, and psychological factors. Admittedly, such goals can be hard to evaluate but a careful examination of the student population at periodic intervals can be an excellent means towards successfully assessing their needs. There is no doubt that the ultimate goal is to allow students to become more proficient

language users. Success in achieving such objectives depends on the approach and vision as devised by language programs in their efforts to promote language learning.

Since the focus here is on language interaction in the mind of the bilingual and its implications on heritage language pedagogy, learning in a formal classroom setting is of primary relevance. Broadly speaking, an inclusive theory on heritage language learning should inform language classroom practices in ways that guide language teachers in understanding the factors aiding or suppressing students' acquisition of language. Learners can have linguistic input from several mediums, mainly involving verbal and written contexts. However, in the language classroom, the written context is the main source of linguistic input. As a result, language learners will be exposed to linguistic input that mainly advances their syntactic and morphological linguistic competence targeting reading and writing skills. By contrast, the extent of the oral input is often compromised because of several obstacles such as time limitations, number of participants, and in many cases the quality of presented material. Because of this, the acquisition of TL phonology only through the written medium highly affects the linguistic development because L2 learners will be deprived of oral input.

A typical language classroom in the United States has learners from different linguistic backgrounds. Language educators should have the goal to train language teachers and prepare them to instruct students of various L1s when they are present in the same educational setting. Moreover, through targeted input and understanding the variability of the student population in the classroom, the language teacher should construct a set of activities that are tailored towards the needs of certain groups. For example, in an Arabic language classroom with diverse populations, L1-English L2-Arabic learners will need more input on how to produce pharyngeals (/ħ/ and /ʕ/ are often produced as /h/ and /ʔ /respectively), L1-Urdu L2-Arabic learners need

targeted instruction on dentals (/ð/ and /θ / are confused and produced as /z/). In addition, L1-Japanese L2-Arabic learners require extensive drilling on the laterals /r/ and /l/ since these are in free variation in Japanese and contrastive in Arabic. The final set of examples presents a plausible scenario of how the phonetic/phonological systems for bilinguals interact and unfortunately cause hindrance to L2 acquisition.

Above all, some pedagogical practices adopted by language educators in many institutions are deemed appropriate for language seekers in general but these might endanger heritage learners' acquisition of their immigrant languages. More importantly, interest in Arabic from a linguistic and second language acquisition perspective is picking up momentum, and therefore work on HSs of Arabic is much needed to cover any gaps in this newly explored area in linguistics.

It is known that heritage learners are motivated by cultural, personal, or even academic aspirations in their heritage language pursuit. For L2 learners, some of these might not be at play as pertinent factors driving their choice of foreign language study. In recent years, the weight of a job seeker in many fields is measured by the number of languages s/he knows, so bilingualism has an increasing value in the global job market. Therefore, this investigation comparing different language populations informs us on the phonological abilities of heritage language learners and guides the language teacher practices in supporting such populations for later language development.

In sum, this thesis presents empirical data pertaining to SLA, heritage language, and bilingualism research and contributes to the emerging field of heritage language study. Its importance is evident with respect to, 1) shedding light on Arabic linguistics, in general, and its phonetics and phonology, in specific, as well as comparing it to English, 2) targeting heritage

language learners as a unique population; sharing attributes with but at the same time diverging from mainstream L2 learners and, 3) revealing the significance of extent of language experience as a crucial factor contributing to proficiency level assignment. This experimental study is another attempt to evaluate language-specific linguistic knowledge in the effort to better understand universal mechanisms of human speech production.

Notes

1. The focus will be on only on point vowels (long and short segments), and no investigation will be undertaken for diphthongs or mid vowels, which are be present in the colloquial version of this dialect of Arabic.

2. Though bilinguals are found to have two phonetic/phonological systems, the nature and organization of these two systems are dependent on several factors, serving as evidence on their interaction.

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APPENDIX A

Complete list of real and nonsense words used to elicit the Arabic data

bib	biib	bub	buub	bab	baab
bid	biid	bud	buud	bad	baad
bik	biik	buk	buuk	bak	baak
dib	diib	dub	duub	dab	daab
did	diid	dud	duud	dad	daad
dik	diik	duk	duuk	dak	daak
kib	kiib	kub	kuub	kab	kaab
kid	kiid	kud	kuud	kad	kaad
kik	kiik	kuk	kuuk	kak	kaak
did	diid	dud	duud	dad	daad
tit	tiit	tut	tuut	tat	taat
sis	siis	sus	suus	sas	saas
ziz	ziiz	zuz	zuuz	zaz	zaaz

sˤib	sˤiib	sˤub	sˤuub	sˤab	sˤaab
sib	siib	sub	suub	sab	saab
dˤib	dˤiib	dˤub	dˤuub	dˤab	dˤaab
dib	diib	dub	duub	dab	daab
tˤib	tˤiib	tˤub	tˤuub	tˤab	tˤaab
tib	tiib	tub	tuub	tab	taab
ðˤib	ðˤiib	ðˤub	ðˤuub	ðˤab	ðˤaab
ðib	ðiib	ðub	ðuub	ðab	ðaab

Complete list of real and nonsense words used to elicit the English data

bib	biib	bub	buud	bab
bid	biid	bud	buud	bad
bik	biik	buk	buuk	bak
dib	diib	dub	duub	dab
did	diid	dud	duud	dad
dak	diik	duk	duuk	dak
kib	kiib	kub	kuub	kab
kid	kiid	kud	kuud	kad
kik	kiik	kuk	kuuk	kak
did	diid	dud	duud	dad
tib	tiib	tut	tuut	tat
sis	siis	sus	suus	sas
ziz	ziiz	zuz	zuuz	zaz
sib	siib	sub	suub	sab
dib	diib	dub	duub	dab
tib	tiib	tub	tuub	tab
ðib	ðiib	ðub	ðuub	ðab