Lebanese Arabic listeners' perception of Australian English vowels

By

Ronda Aboultaif

17043537

30th November 2016

Western Sydney University

Graduate Research School

The MARCS Institute

A thesis submitted to the Western Sydney University as partial fulfilment for the degree of Master of Research.

For my precious angels

Adam, Alana and Arene

Statement of Originality

The work presented in this thesis is to the best of my knowledge and belief, original except as acknowledged in the text. I hereby declare that I have not submitted this material, either in full or in part for a degree at this or any other institution.

X

Abstract

Second language (L2) learning involves more than simply understanding the grammar or writing system of a new language; it also requires the acquisition of a new sound system. In particular, vowels are particularly difficult to perceive due to the influence of the learners' native language vowel inventory (Flege, 1995; Escudero, 2005; Best & Tyler, 2007). The present study investigated the role of acoustic similarity in predicting bilingual Lebanese Arabic-English (LA) listeners' discrimination of Australian English (AusE) vowels. The findings are in line with the predictions based on acoustic similarity in terms of the Second Language Linguistic Perception model (L2LP; Escudero & Boersma, 2004; Escudero, 2005; 2009a). In particular, LA listeners use duration as a cue to facilitate discrimination of AusE vowel contrasts which produces few difficulties. For the LA listeners, discrimination difficulty is only apparent for vowel contrasts where the vowels do not align perfectly with native LA counterparts. Furthermore, when both vowels in the non-native contrast are acoustically similar to or perceived as the same multiple native categories, resulting in an acoustic or perceptual overlap, also contributes to the difficulties in vowel discrimination. Further research is required to test the reliability of the present findings and to establish whether the identified patterns are also detected in speech production.

Acknowledgements

I would like to thank all the staff and students at the MARCS institute for their support. I wish to thank Associate Professor Paola Escudero, Dr Daniel Williams and Dr Alba Tuninetti for all their guidance.

I would like to express my deepest gratitude to Dr Jaydene Elvin for her unfailing support and guidance throughout my post graduate studies, without her the completion of this thesis would not have been possible.

To my family and friends, thank you for your support.

Table of Contents

List of Tables and Figures

Tables

Figures

Chapter 1 Introduction

Second language (L2) learning involves more than simply understanding the grammar or writing system of a new language; it also requires the acquisition of a new sound system. In particular, adult L2 learners often struggle to acquire a new vowel system due to the influence of their native language (L1) vowel inventory (Flege, 1995; Escudero, 2005; Best & Tyler, 2007). Adult L2 learners tend to assimilate or map L2 vowel sounds differently to the native speakers of that language (Flege, Bohn & Jang, 1997). Specifically, L2 learners' perception of L2 vowels is partially determined by the way in which new vowels are related to their native vowel categories and the way that auditory dimensions and properties are integrated during perception (Escudero & Boersma, 2004; Escudero & Williams, 2012). This relationship exemplifies the difficulties that L2 listeners may face when learning L2 speech sounds and the different learning strategies that L2 learners implement in order to distinguish the new L2 vowel sounds when acquiring a particular language or dialect (Williams & Escudero, 2014b)

1.1. Introduction to L2 speech perception

Research in L2 speech perception typically investigates the difficulties adult L2 learners may encounter in perceptually discriminating and categorising non-native sound contrasts different to those in their native language (Williams & Escudero, 2014b). In particular, vowels are generally difficult to acquire due in part to their undefined boundaries between different type vowels (Ladefoged & Johnson, 2011). Additionally, vowel inventories within different languages and dialects differ in the way their vowels are used and not all languages share an equal number of vowels in their inventories. Studies have shown that the acquisition of languages with vowel inventories larger than that of the learners' native language is often difficult for non-native learners. For example, native Spanish language learners who have a smaller native vowel inventory than English and Dutch have been found to have difficulties discriminating the English vowel contrast /i-ɪ/ (Escudero, 2005) and the Dutch vowel contrast /ɑ-a/ (Escudero & Wanrooij, 2010; Escudero & Williams, 2011). On the other hand, other studies have investigated language learners' acquisition of languages with vowel inventories smaller than that of the learners' native language and have suggested that it may be easier. Iverson and Evans (2007) demonstrated that native Norwegian and German listeners, who have a larger L1 vowel inventory than English, were more successful at identifying English vowels than native Spanish and French listeners whose vowel inventory is smaller than that of English. However, language learners with a larger vowel inventory than the target language are not always at an advantage when discriminating non-native vowel contrasts. Elvin & Escudero (2014) showed that Australian English listeners who have a larger vowel inventory than Spanish listeners attained similar discrimination accuracy scores for Brazilian Portuguese vowel contrasts regardless of the size of their vowel inventories. Additionally, Alispahic, Escudero and Mulak (2014) found Australian English listeners' discrimination accuracy of the Dutch vowels to be slightly better than Peruvian Spanish listeners' whose vowel inventory contains fewer vowels than Dutch.

The purpose of this study is to contribute to the line of research in cross-language speech perception by focusing on the role of acoustic similarity between L1 and L2 vowels as well as the use of acoustic cues to perceive L2 speech sounds. Specifically, this thesis investigates how Lebanese-Arabic English bilingual listeners differ to Australian English monolinguals in their perception and discrimination of Australian English (AusE) vowel contrasts. Furthermore, as vowels are differentiated by duration in both languages, this study investigated whether the Lebanese-Arabic English bilingual listeners use duration as a cue to discriminate AusE vowel contrasts. We predict that the Lebanese-Arabic English bilingual listeners will have more difficulties accurately discriminating the AusE vowel contrasts than the native Australian English listeners, especially if they do not use duration as a cue.

1.2. Outline of the thesis

In Chapter 1, we introduced the research area of L2 speech perception and outlined the aim of this present study; including the predicted findings.

In Chapter 2, we present a review of the literature pertaining to speech perception, with a specific focus on non-native L2 speech perception and the use of acoustic cues. An outline of the three prominent theoretical models explaining non-native and L2 speech perception is also presented. Their proposed scenarios on how listeners map the sounds of a non-native language are outlined. Furthermore, this study's purpose, motivation, and a description of the vowel system's acoustic and phonological properties considered in this study are presented. Finally, we discuss the predictions for this present study based on a comparison of the acoustic properties of the native and non-native language vowel inventories.

In Chapter 3 we describe the methodology used to test the predictions for the present study. The two participant groups are presented, namely Lebanese-Arabic bilinguals and native Australian English monolinguals. The sounds used as stimuli for the XAB categorical discrimination task and identification task are explained as well as a description of the procedures used to administer the experiments.

In Chapter 4, we outline the results from the identification task to additionally predict difficulty of discrimination, followed by the XAB categorical discrimination task. We then show whether there are group differences in the perceptual discrimination of the Australian English vowel contrasts.

In Chapter 5 we discuss the results of the XAB categorical discrimination task from chapter 4, and interpret the findings pertaining to the bilingual Lebanese-Arabic listeners' ability to discriminate Australian English vowel contrasts.

In Chapter 6, we conclude by providing a brief summary of the motivation, the research aims, the predictions and findings for the present study. The implications of the findings with possible limitations are discussed. We end the chapter with suggestion for future research on non-native speech perception.

Chapter 2 Literature Review

As mentioned in Chapter 1, this study contributes to the field of L2 speech perception and second language learning by investigating native Lebanese-Arabic English bilingual listeners' discrimination of Australian English (AusE) vowel contrasts. In particular, Lebanese Arabic-English listeners' discrimination accuracy of AusE vowel contrasts was compared to native monolingual Australian English listeners. This study also investigated whether the Lebanese-Arabic listeners' perception of the AusE vowel contrasts is influenced by their native language. Given the fact that both the native and target languages contain vowel contrasts that differ by length only, it is of significance to examine whether or not the Lebanese-Arabic use duration as a cue to accurately discriminate the AusE vowel contrasts.

This chapter presents an overview of the relevant research in non-native and L2 speech perception. Section 2.1 outlines the three prominent theoretical models concerning non-native and L2 speech perception, Speech Learning Model (SLM; Flege, 1995, 2003), the Perceptual Assimilation Model (PAM; Best, 1995), its extension PAM-L2 (Best & Tyler, 2007) and the Second Language Linguistic Perception model (L2LP; Escudero, 2005, 2006, 2009a).

2.1. Theoretical models of speech perception

Prominent theoretical models such as the Speech Learning Model (SLM; Flege, 1995, 2003), the Perceptual Assimilation Model (PAM; Best, 1995), its extension PAM-L2 (Best & Tyler, 2007) and the Second Language Linguistic Perception Model (L2LP; Escudero, 2005, 2006, 2009a) were developed to explain the difficulties in acquiring non-native and L2 sounds. These models emphasize the fact that L2 learners and naïve listeners filter and categorise the sounds according to their L1 and postulate that the perceptual relationship between native and target language vowels can explain the difficulty or ease in acquiring the L2.

2.1.1. Speech Learning Model (SLM)

The SLM (Flege, 1995, 2003) was developed to explain the successes and limitations during acquisition of non-native phonetic segments (vowels and consonants). The model focuses on the production and perception of experienced rather than beginner adult L2 learners. This is based on the notion that the production of beginner L2 learners may reveal differences from native speakers which are a result of learning in progress, rather than a failure to learn the new sounds (Flege, 1995). Speech perception and production difficulties are predicted by comparing the native and non-native vowel inventories and their phonetic properties, such as vowel duration and spectral quality (Flege, 1995). The model posits that the greater the difference between the target L2 sound and the closest native language sound, the more likely that the L2 learner will accurately perceive and produce the new sound. This is a result of the formation of a new L2 phonetic category that does not resemble any native category which facilitates the learning of the non-native language sounds (Flege, 1995). In contrast, when the target L2 sound is similar to the native language sound, the formation of a new L2 sound category is unlikely. This is due to the target L2 sound being equated to an existing native sound category resulting in the L2 learners' inaccurate production and perception of the target sound (Flege, 1995). This scenario is termed *equivalence classification*, and it is predicted that L2 learners will encounter difficulties when learning non-native sounds of this nature. In line with the SLM theoretical claims, Flege (1987) showed that English speaking experienced learners of French were successful at producing a new L2 sound, that is, the French /y/, which has no counterpart in L1, than they are at producing the French /u/ and /t/ which are similar to native English counterparts. In another study, Flege, Takagi and Mann (1996) showed that in line with the SLM, Japanese-speaking English learners (JE) can achieve native-like performance due to the formation of new non-native phonetic categories. Specifically, the JE learners showed accuracy rates comparable to native speakers of English when identifying English /ɹ/ and /l/ due to the absence of any similar native categories which, in turn, facilitated the formation of new non-native sound categories (Flege et al., 1996).

2.1.2. Perceptual Assimilation Model (PAM) and PAM-L2

The PAM and its extension PAM-L2 (Best, 1995; Best & Tyler, 2007) approach to non-native speech perception focuses on adult naïve listeners' ability to discriminate non-native phonological contrasts based on the influence of native language speech sounds. It also accounts for L2 development, in that perceptual learning is affected by L2 learners' language learning experience (Best & Tyler, 2007). Specifically, the model posits that new non-native or L2 sounds will be perceptually assimilated according to the existing sound categories in a listeners' native language. The model predicts discrimination accuracy based on listeners' perceptual assimilation patterns determined by a perceptual assimilation task prior to testing. Additionally, the model highlights three possible assimilation patterns for non-native contrasts and predictions of discrimination accuracy, which are discussed below.

There are three assimilation types in PAM, namely, *categorised, uncategorised* and *non-assimilabl*e. The *categorised* assimilation pattern is where the non-native sound is assimilated to a native sound category. Within this assimilation pattern there are three subtypes. The first is *single-category assimilation*, which describes the situation where two non-native sounds in a contrast are both mapped to a single native sound and are perceived as equally poor or good exemplars of the same native sound. In this scenario, learners are expected to poorly discriminate a vowel contrast of this type because both vowels in the contrast are mapped to the same native sound category (Best, 1995). The second subtype is *two-category assimilation* which occurs when two non-native sounds in a L2 contrast are each mapped to different native sound categories and are perceived as corresponding exemplars of the two distinct native sounds. Learners' discrimination of these non-native vowel contrasts is predicted to be good to excellent (Best, 1995). The third subtype, a *category-goodness difference*, occurs when two non-native sounds in a L2 contrast are mapped to the same native sound category and are each perceived differently. That is, one is perceived as a more acceptable example of the native sound category than the other (Best, 1995). Discrimination is predicted to be moderate to very good depending on the extent of difference in category goodness for each of the non-native sounds (Best, 1995). Best and Strange (1992) confirmed predictions based on the PAM hypothesis in a cross-language comparison study that tested native Japanese learners' perceptual identification and discrimination of the three American English approximant consonant contrasts /w/-/r/,/w/- /j/and /r/-/l/. These English approximants differ phonetically and phonemically across both languages providing a context for examining perceptual influences (Best & Strange, 1992). The authors showed results that were consistent with predictions in terms of the PAM (Best, 1995). That is, the Japanese listeners perceived the English /w/-/r/ as a category goodness difference of the Japanese category /w/. The English /w/- /j/ was perceived as a two category contrast and the English /r/-/l/ was assimilated by the Japanese listeners to a single category as equally poor exemplars of Japanese /r/ or /w/ (Best & Strange, 1992).

The PAM also accounts for *uncategorised* perceptual assimilation patterns which include two subtypes. The *uncategorised-uncategorised* subtype occurs when two non-native sounds in a contrast are perceived within the listeners' native phonetic space and both members of the non-native contrast are similarly mapped to two or more native categories (Faris, Best & Tyler, 2016). Depending on the acoustic proximity of the perceived non-native sound contrasts to each other and to native categories within the native listeners' phonetic space, discrimination is predicted to be poor to very good (Best, 1995). The other subtype is *uncategorised-categorised* describes when one of the sounds in a non-native contrast is mapped to a native category and the other sound to two or more native categories, which in turn predicts good to very good discrimination (Best, 1995). The other type of assimilation pattern is *non-assimilable*, which describes when both non-native sounds in a contrast are perceived as non-speech, or they do not resemble any native speech sound (Faris, Best & Tyler, 2016). Both of the non-native sounds can vary in how they are categorised as speech sounds and discrimination is predicted to be good to very good (Best, 1995).

2.1.3. Second Language Linguistic Perception Model (L2LP)

The Second Language Linguistic Perception model (L2LP; Escudero & Boersma, 2004; Escudero, 2005, 2009a) considers individuals at all stages of learning, from the initial stage (i.e., beginning) of learning until ultimate attainment. Similar to PAM and SLM, the L2LP considers the influence of the native phonological system in non-native speech perception. The model posits that L2 and naïve listeners' perception of non-native sounds is filtered through their native language, which can lead to difficulties in acquiring the new language (Escudero 2005, 2009a). Furthermore the model states that a listeners' perception and production of non-native or L2 sounds at the initial state of learning should match the acoustic properties of the sounds in their native language (Escudero, 2005, 2009a). Additionally like the PAM, the L2LP considers target language sound contrasts rather than individual sound segments as in the SLM. However, unlike the PAM that uses perceptual assimilation patterns from a perceptual assimilation task to predict difficulty, the L2LP makes predictions by considering perceptual mappings based on the results from detailed acoustic comparisons between the native and target language vowel inventories prior to testing (Escudero, 2005, 2009a). The model also considers that predictions would differ depending on the dialect of the target language or the learners' native language, for example, British, American or Australian English. The L2LP refers to the perceptual mappings as learning scenarios that a learner will encounter and overcome when presented with target language sounds, which are further discussed below.

The L2LP theoretical framework identifies the following learning scenarios. The first scenario, known as a *new scenario,* occurs when the two sounds in a non-native contrast are mapped to one single native sound category (Escudero, 2005, 2009a). In this scenario, in order to discriminate between these two sounds a learner needs to split their existing single native category or create a new L2 sound category (Escudero, 2005, 2009a). This scenario generally occurs when learners have a native vowel inventory that is smaller than that of the target language and results in poor discrimination (Escudero, 2005, 2006). For example, the *new scenario* has successfully explained Spanish and Portuguese listeners' difficulties when perceiving the English vowel contrast /i/-/ɪ/, as in these cases listeners perceive this English contrast similarly to their single native vowel category /i/ (e.g., Escudero, 2005; Rauber et al., 2005). In contrast, the second scenario, known as a *similar scenario* occurs when the two sounds in a non-native contrast are individually mapped to two different native sound categories (Escudero, 2005, 2006). In this scenario the learners' existing native categories are reused and shifted so that their boundaries match the non-native sounds and discrimination is generally predicted to be easy (Escudero, 2005, 2006). For example Escudero & Chladkova (2010) showed that Peruvian Spanish listeners will use existing native vowels /i/-/e/ to perceive the American and Scottish English vowel contrast /iː/-/ɪ/, resulting in easy discrimination and L2 learning. The third scenario, known as the *subset scenario* (Escudero, 2005, 2006) occurs when two non-native vowels in a binary contrast are perceived as belonging to more than two native vowel categories, which is common when the non-native vowel inventory is smaller than that of the native vowel inventory. In this scenario, the L2LP model predicts that discrimination may be good or poor if it results in a problem. This is when the learner has realised and learned that some features or categories in their native language do not exist in the target language and find it difficult to stop perceiving a category that does not exist in their L2 (Escudero & Boersma, 2002). Furthermore, cases of the subset scenario may be particularly difficult to discriminate when both vowels in the non-native contrast are acoustically similar to or perceived as the same multiple native categories, resulting in an acoustic or perceptual overlap (Escudero & Boersma, 2002; Vasiliev, 2013; Elvin et al, 2014). For example, Dutch learners of Spanish perceive the Spanish front vowels /i/-/e/ as their three native front vowels /i-ɪ-ɛ/ (Escudero & Boersma, 2002). More specifically, the Dutch learners will sometimes perceive the Spanish /i/ as the Dutch /i/ or /ɪ/ and the Spanish /e/ as the Dutch /ɪ/ or /ɛ/ (Escudero & Boersma, 2002). Additionally, Morrison (2003) showed that Canadian English learners of Spanish perceived the Spanish /a/ as the English /æ/, /ʌ/, /ɛ/ and /ɒ/ and also the Spanish /u/ was perceived as the English /ʊ/ and /u/. However, unlike Escudero and Boersma (2002), the English listeners did not encounter such difficulties categorising the Spanish front vowels /i/ and /e/ (Morrison, 2003) which may be due to the absence of the vowels being perceptually assimilated to an overlapping set of native categories (Vasiliev, 2013). Furthermore, Vasiliev (2013) demonstrated the subset scenario to be responsible for Californian English listeners' low discrimination accuracy of the Brazilian Portuguese vowel contrasts /i-e/, /o-u/ and /a-c/. Specifically, when the subset scenario contributed to the two different Portuguese vowels in a contrast being perceptually assimilated to multiple and same native English categories resulting in a high perceptual assimilation overlap score.

Table 1 below is a summary of the discussed theoretical models that explain L2 speech perception. The table provides an overview of the population that the models account for and the aspects of speech that each model relates too. The manner of predicting difficulty that each model uses and the prediction scenarios that the models consider learners will encounter when presented or learning sounds of a new language is outlined as well.

Model	**Population**	**Aspects of Speech**	**Manner of Predicting difficulty**	**Prediction scenarios**
Speech Learning Model (SLM, Flege, 1995)	Experienced L2 learners	Production & perception	Acoustic comparisons vowel inventories comparisons	Similar sounds (Equivalence Classification): difficult Dissimilar sounds: easy
Perceptual Assimilation Model (PAM, Best, 1995), PAM-L2 (Best &Tyler, 2007)	Naïve listeners Experienced L2 learners	Perception	Perceptual assimilation patterns	Single-Category Assimilation: poor Two-Category Assimilation: good-excellent Category- Goodness Difference: moderate to very good Both Uncategorized: poor to very good Non-assimilable: good to very good Uncategorized - Categorized: very good
Second Language Linguistic Perception Model (L2LP, Escudero, 2005, 2006, 2009; Escudero & Boersma, 2002)	L2 learners from the initial state to final state	Perception, word recognition & production	Acoustic comparisons	New Scenario: poor Similar Scenario: good-excellent Subset Scenario: good or poor depending on whether or not a subset problem is identified.

Table 1: Summary of prominent theoretical models (adapted from Elvin, Vasiliev & Escudero, in press).

2.2. Predicting non-native speech perception in line with the L2LP model

This thesis follows the L2LP framework to predict native Lebanese Arabic-English bilingual listeners discrimination accuracy of the Australian English vowel contrasts. As discussed in the prior section 2.1.3, the L2LP model demonstrates that non-native vowel discrimination can be predicted by considering perceptual mappings based on the results from a detailed acoustic comparison between the native and target language sound categories prior to testing (Escudero, 2005, 2009a). In contrast, the PAM makes predictions based on the listeners' perceptual assimilation patterns determined by a perceptual assimilation task (Best, 1995). In the L2LP model framework, a listener's perception and production of non-native or L2 sounds at the initial state of learning should match the acoustic properties of the sounds in their native language (Escudero, 2005, 2009a). Recent studies have shown the comparison of acoustic properties across native and non-native languages to be a successful predictor of L2 and non-native vowel perception. For example, Elvin et al. (2014) showed that a cross-language comparison of acoustic properties successfully predicted discrimination accuracy for naïve Iberian Spanish (IS) and Australian English (AusE) listeners of the Brazilian Portuguese (BP) vowel contrasts. The BP contrast /a/-/ɛ/ was the easiest to discriminate for both groups and /e/-/i/ and /o/-/u/ were indeed the most difficult to discriminate. This confirms that vowels which are acoustically closer to target vowels are easier to discriminate despite the vowel inventory size, thus confirming predictions in line with the L2LP models acoustic hypothesis (Elvin et al, 2014). Similarly, Escudero and Chladkova (2010) demonstrated that native Spanish learners of American (AE) and Southern British English (SSBE) varieties showed different perceptual assimilation patterns of the English vowels based on the comparison of acoustic properties. The authors predicted that the Spanish listeners would perceive the English vowels like the Spanish vowel with the closest F1 and

F2 values (Escudero & Chladkova, 2010). More specifically, the AE and SSBE vowels with high F2 values such as /i/ and /ɛ/ were mapped to the native Spanish vowels with high F2 values such as /i/ and /e/ and similarly the AE and SSBE vowels with low F2 values such as /ɔ/ and /u/ were mapped to Spanish vowels with low F2 values such as /o/ and /u/ (Escudero & Chladkova, 2010). The results showed that an acoustic comparison of the F1 and F2 values for English and Spanish successfully predicted the perceptual assimilation of non-native vowel sounds. Additionally, Escudero and Vasiliev (2011) investigated non-native perception of the vowel contrast /ɛ/-/æ/ produced in Canadian French (CF) and Canadian English (CE) by monolingual Peruvian Spanish (PS) listeners and showed that the acoustic properties of native sounds successfully predicts listeners perception of non-native sounds. The PS listeners mapped the contrast /ɛ/-/æ/ to two different native categories when it was perceived with CF values, namely to Spanish /e/ and /a/ respectively (similar scenario, L2LP, Escudero, 2005) and to a single Spanish category /a/ (new scenario, L2LP Escudero, 2005) when it was perceived in the CE values (Escudero & Vasiliev, 2011). Therefore the current study will use the L2LP model's method of predicting, given that previous studies have successfully predicted non-native listeners' discrimination accuracy and acquisition difficulty of non-native vowel contrasts based on an acoustic comparison of the L1 and L2.

2.3. Dialect variation in non-native L2 speech perception.

The SLM, PAM and the L2LP models all highlight the influence of native language phonological categories in non-native speech perception; however, only the L2LP emphasises the influence of dialect variation in L2 vowel perception (Escudero & Boersma, 2004; Escudero, 2005). The L2LP model states that the perception of native and non-native sounds should match the acoustic properties of the relevant sounds in the native dialect (Escudero & Boersma, 2004; Escudero, 2005). For example, individuals who are speakers of Lebanese-Arabic will be able to perceive the sounds and contrasts in the Lebanese-Arabic dialect more accurately than those who are speakers of Iraqi Arabic. Therefore, listeners with different language and dialectal backgrounds will differ in how they perceive the same speech sounds (Escudero, 2005, 2009a; Williams & Escudero, 2014a). In line with the L2LP model's learning scenarios, studies have demonstrated the influences of listeners' native and other dialects on L2 vowel perception (e.g., Escudero & Chladkova, 2010; Escudero & Williams, 2012; Escudero et al., 2012). Namely, listeners' perception of both non-native and native sounds should match the acoustic properties (i.e., formant values, duration) of the relevant sounds as they are produced in their native language and/or dialect (Escudero & Boersma, 2004; Escudero, 2005). For instance, naïve Bohemian Czech (BC) and Moravian Czech (MC) listeners perceived the Dutch vowel contrast /i/-/ɪ/ differently based on how these vowels are produced in the two Czech dialects (Chladkova & Podlipsky, 2011). These vowels /ɪ/ and /i/ differ in formant values and duration in BC, as /i/ has a lower F1 and is longer than /ɪ/, whereas in MC they are distinguished by duration alone (Chladkova & Podlipsky, 2011). As a result, the Bohemian Czech listeners mapped Dutch /i/ to their native /iː/ and Moravian Czech listeners' mapped it to their native /ɪ/ (Chladkova & Podlipsky, 2011). Escudero (2005) also demonstrated that different target language dialects affect learners' non-native vowel perception. For example, the different acoustic properties of the vowels /i/ and /ɪ/ when produced by native Scottish English and Southern British English speakers led to monolingual Peruvian Spanish listeners having different perceptual assimilation patterns (Escudero, 2005). Specifically, the Spanish-English learners of Scottish English mapped the

English vowels /i/ and /ɪ/ as Spanish /i/ and /e/, while the learners of British English mapped both vowels to their native Spanish /a/ (Escudero, 2005).

On the other hand, it has been shown that dialect variation may not have an impact on the outcome of speech perception. For instance, Clopper (2012) showed that in different listening conditions, listeners of different native dialectal backgrounds are more inclined towards the standard dialect of that particular language. The study presents results based on a cross-dialectal listening task in which listeners from three American English dialects were presented with three sentences in noisy conditions, produced by talkers from four different American English dialects and had to identify the final word from the sentence. Regardless of the listeners' native dialect, the listeners were more accurate at identifying words in the standard general American dialect than any of the regional dialects (Clopper, 2012). This showed that the listeners preferred the standard American dialect in less favourable listening conditions. Furthermore, the author suggested that the listeners' identification accuracy was due to their high familiarity with the standard American dialect in comparison to the regional dialects.

2.4. Acoustic Cues

Acoustic information is central to perception and is particularly important for the acquisition of speech sounds (Holt & Lotto, 2006). During speech perception, listeners take advantage of acoustic cues in order to make judgments about the phonological categories of sounds in a contrast (Toscano & McMurray, 2010). Many studies have shown L2 learners and non-native listeners from various language backgrounds use different acoustic cues to perceptually discriminate and identify non-native vowel sounds, for example in Japanese (Morrison, 2002), Spanish (Escudero, 2001) and Portuguese (Rauber, Escudero, Bion & Baptista, 2005). Such studies demonstrate that non-native listeners will rely more on one type of acoustic cue e.g., vowel quality or vowel duration than another, in order to distinguish non-native vowel contrasts (e.g., Bohn & Flege, 1992; Iverson & Evans, 2007; Kerbs-Lazendic & Best, 2008). Flege, Bohn and Jang (1997) investigated L2 vowel perception of the English vowel contrasts /ɛ/-/æ/ and /i/-/ɪ/ by native Spanish, German, Korean and Mandarin listeners and compared it to native English listeners. The native English listeners relied on vowel quality to discriminate the vowel contrast /ɛ/-/æ/ and only used vowel duration as a secondary cue to discriminate /i/-/ɪ/. The results indicated that the Mandarin and Korean listeners predominantly relied on vowel duration as a cue to discriminate between the vowel contrasts /ɛ/-/æ/ and /i/-/ɪ/. Moreover, the German listeners relied more on vowel duration as a cue to discriminate /ɛ/-/æ/ than the native listeners (Flege et al., 1997). In the case of the Spanish listeners, they differed from the native listeners in that they relied both on vowel quality and duration equally to discriminate /i/-/ɪ/ (Flege et al., 1997). Furthermore, the results showed that the L2 learners' use of temporal and spectral information was influenced by the amount of L2 experience. In particular, experienced L2 learners were more native-like because they relied more on spectral information and depended less on temporal information than their inexperienced counterparts (Flege et al., 1997).

In another study, Escudero and Boersma (2004) investigated how native Spanish learners of Scottish and Southern British English perceive the English vowel contrast /i/-/ɪ/ and compared it to native speakers' perception of the Scottish and Southern English dialects. The study highlighted the relationship between perception and production. In particular, the study showed that the native English listeners' use of acoustic cues closely resembled the production of their dialect (Escudero & Boresma, 2004). However, the Spanish listeners' use of acoustic cues only partially resembled their production of the particular target English dialect. Furthermore, the results indicated that the Spanish listeners perceived the English contrast /i/-/ɪ/ differently depending on whether their target dialect was Scottish or Southern British English (Escudero & Boresma, 2004). Specifically, the Spanish learners of Southern British English relied mainly on durational cues to distinguish the vowel contrast /i/-/ɪ/, which did not resemble the cues that either of the native dialect listener groups used, whereas the Spanish learners of Scottish English relied more on spectral cues to distinguish the vowel contrast /i/-/ɪ/, similar to the native Scottish English listeners. The study also showed that the Southern British English listeners predominantly used spectral and temporal cues, while the native Scottish listeners preferred only spectral cues (Escudero & Boresma, 2004).

Additionally, Kondaurova & Francis (2008) investigated listeners' use of native language vowel duration as an acoustic cue in non-native vowel perception. The authors examined native Russian, Spanish and American English listeners' identification of the American English vowels /i/-/ɪ/ from a *beat/bit* continuum. While English listeners predominantly rely on spectral properties compared to vowel duration, the Russian listeners were expected to rely more on duration as a cue than the Spanish listeners (Kondaurova & Francis, 2008). The results indicated that native Spanish and Russian listeners did not rely on spectrum and only used duration as a cue. In case of the native English listeners, they used both acoustic dimensions; however they relied more on spectral quality than duration (Kondaurova & Francis, 2008).

Other studies have shown that duration is used as cue to identify non-native vowels by listeners whose native language does not employ duration as a cue. Cerbian (2006) investigated the relative differences of cue weighting between native adult Catalan-English listeners' and native English listeners' identification of the Canadian English vowels /i/, /ɪ/

and /ɛ/. The author showed that while both groups showed a similar reliance on vowel quality to identify the English /ɛ/ vowel, the Catalan listeners differed from native Canadian English listeners as they predominantly relied on vowel duration to distinguish the tense and lax vowels /i/ and /ɪ/, rather than vowel quality (Cerbian, 2006). Furthermore, the Catalan listeners used vowel duration as a cue to distinguish the Canadian English vowels /i/ and /ɪ/ even though vowel duration is a non-native feature.

2.5. Native Arabic listeners' perception of non-native and L2 speech sounds

Many studies investigate L2 and non-native listeners' perception of non-native vowels from various L1 backgrounds including Spanish (Fledge et al., 1997; Escudero & Boersma, 2004), Russian (Kondaurova & Francis, 2008), Portuguese (Rauber et al., 2005) and Mandarin (Fledge et al., 1997) but few studies investigate speakers or listeners from a native Lebanese-Arabic dialectal background (e.g. Abou Haidar, 1979; Cox & Palethorpe (2005); Gouskava & Hall, 2009). Current literature investigating L1 Arabic generally focuses on the high language variety, namely Modern Standard Arabic (MSA) (e.g. Mitleb, 1982; Flege, 1984; Munro, 1993; Alghamdi, 1998) rather than the individuals' native Arabic dialect variety. Ferguson (1959) states that the wide variety of spoken regional Arabic dialects has manifested into varieties of dialectal phonological systems and this may influence the perception of non-native sounds. This notion is in line with Escudero's L2LP model (2005, 2009a) which claims that the variation of speech sounds in spoken dialects plays a significant role in non-native speech perception.

Although studies have examined the perception of vowels in Arabic, very few have examined dialectal variation in Arabic. For example, a recent study (Shafiro, Levy, Khamis-Dakwar & Kharkhurin, 2013) examined the perceptual identification patterns of American-English (AE) vowels by native Arabic-English bilinguals (NA) and native speakers of the English dialect spoken in the United Arab Emirates (NE) who were from various places of origin. The NA group of participants were native speakers of Arabic dialects specific to their region of origin which were Saudi Arabia, Lebanon, Egypt, Bahrain, Palestine and Syria. The study considered MSA rather than the listeners' native Arabic dialect; however, the authors acknowledged that some of their results may have been influenced by the differences in the listeners' native Arabic dialect (Shafiro et al., 2013). In particular, the NE listeners had difficulties distinguishing between the AE /ɔ-ɑ/ which may be due to the phonological proximity of these vowels in AE (Shafiro et al., 2013). Results for the NA group showed that the listeners mapped the AE vowels /ʌ/ and /æ/ to their single native vowel category /a/ which may be a result of the listeners mapping the numerous mid and low phones of AE to the single low MSA /a/ vowel and also struggled to identify the AE /æ/, /ɔ/, /ɑ/ vowels which do not exist in the MSA vowel inventory (Shafiro et al., 2013). In another study, Tuskada (2012) compared the perceptual discrimination of vowel length contrasts in Arabic and Japanese by native Japanese (NJ), Arabic (NA) and Australian English (AusE) speakers with non-native Japanese (NNJ) speakers. Like the mentioned studies above, the vowel length contrasts of MSA /i/-/iː/, /a/-/aː/, /u/-/uː/ were examined rather than the vowels in native language dialectal backgrounds (Egyptian, Lebanese and Iraqi) of the NA group of listeners. The study investigated if familiarity with phonemic vowel length in the native language or later acquired languages influenced cross-language speech perception. The results showed that the NJ and NA listeners were more accurate at discriminating their native language vowel length contrasts than the unknown language contrasts. In contrast, the NNJ listeners did not differ in their discrimination accuracy for either language and in particular they did not differ in the discrimination of the MSA vowel contrasts from the NJ listeners' (82% vs 80%). However, the AusE listeners who had no experience with either language were more accurate at discriminating the vowel length contrasts in Arabic than Japanese, showing discrimination accuracy for MSA (82%) similarly to the NJ and NNJ listeners. The author states that this may be related to the AusE listeners native language dialect, as studies have reported that vowel duration plays a large role in the AusE variety and vowel length is contrastive in particular vowel pairs, such as /i/-/ɪ/ and /ɐ-ɐː/ (Cochrane, 1970; Cox, 2006; Cox & Palethorpe, 2007). This in turn, shows that not only does the listener's native language influence cross-language speech perception, but so does their non-native dialect exposure (e.g., American English, Scottish English, Southern British English) (e.g., Chladkova & Podlipsky, 2011; Williams & Escudero, 2014). Hence, the study found that familiarity with phonemic vowel length in the native language or subsequently acquired languages may not necessarily lead to accurate discrimination of similar vowel length contrasts in a non-acquired language (Tuskada, 2012).

2.6. The present study

This thesis will examine Lebanese-Arabic English bilingual (LA) listeners' discrimination of Australian English (AusE) vowel contrasts in comparison to native monolingual Australian English listeners by focusing on the role of acoustic similarity of vowels.

The varieties of spoken Arabic dialects differ from each other and the MSA variety, phonemically and phonetically. For instance MSA has six vowels namely,/i/, /iː/, /a/, /aː/, /u/ and /uː/ (Holes, 2004), Kuwaiti Arabic has eight vowels /i/, /iː/, /a/, /aː/, /oː/, /eː/, /u/ and /uː/, Lebanese Arabic has ten vowels /i/, /iː/, /a/, /aː/, /e/, /eː/, /o/,/u/ and /uː/ (Amir, Amir & Rosenhouse, 2014) and Syrian Arabic has eleven vowels/i/, /iː/, /a/, /aː/, /e/, /eː/, /o/, /oː/, /ə/,

/u/ and /uː/ (Cowell, 1964). Therefore native Arabic listeners from these dialects have more native vowels available to them than MSA. It is evident that the different dialects of Arabic contain many more vowel than MSA, which if in line with the L2LP model would result in different predictions. Previous speech perception studies have failed to consider this disparity in vowel inventory size which could suggest that L2 acquisition may be harder or easier depending on the close proximity of native and L2 vowels. Hence, the present study will focus on the Lebanese Arabic dialect.

Secondly, a crucial assumption of the L2LP model is that dialectal variation impacts non-native speech perception and studies have depicted differences in discrimination and identification accuracy for individuals with different dialectal backgrounds, which influences the relative success of learning a L2 (Escudero, 2005; Escudero & Williams, 2012; Escudero et al., 2012; Williams & Escudero, 2014). Thus, it seems important to investigate non-native speech perception of native Arabic listeners of different dialectal backgrounds in order to provide insight into the ease and difficulty of acquiring L2 vowels. In particular, the Lebanese migrant community is one of the largest migrant population groups in Australia with 72.4% living in Sydney (Humphery, 1998; Bets & Healy, 2006). It is important to investigate this language group, which could lead to implications for L2 teaching and learning for this understudied language group. Thirdly, the L2LP model (Escudero, 2005, 2009) proposes that L2 and non-native discrimination accuracy can be predicted from a comparison of the acoustic properties of both the native and non-native vowel systems. Given that studies have shown that acoustic similarity between the native and target language successfully predicts vowel discrimination, this method of predicting will be used in the present study (e.g., Escudero & Boersma, 2004; Escudero, 2005; Escudero et al., 2014; Elvin et al., 2014).

Furthermore, as mentioned, many L2 speech perception studies examine how L2 learners with different language backgrounds assign weights to different acoustic dimensions, such as duration or F1 and F2 values in order to discriminate and categorise target language vowel contrasts (e.g., Flege, Bohn & Jang, 1997; Cebrian, 2006; Escudreo & Chladkova, 2010; Williams & Escudero, 2014). Thus, this study will investigate how and if native Lebanese-Arabic (LA) speakers use their native acoustic dimensions as cues to process non-native vowel contrasts.

Additionally, there is minimal speech perception research available pertaining to native LA learners of AusE or native LA listeners of AusE as the target language. For example, Cox and Palethorpe (2006) investigated phonetic differences between native AusE and Australian born, Lebanese-Australian English speakers and found that there are no vowel space differences, minimal diphthongal differences and significant timing effects relating to voice vowel length. Cox & Palethorpe (2011) also compared the durational features between speakers of the AusE dialect and the LA dialect and showed significant dialect specific differences. However, this is just one study of many that have examined native Arabic speakers and unlike previous studies that investigated native Arabic speakers, the individuals in this study were all of the same native dialect, namely LA, and were learners of English as a second language. These two language varieties allowed for an investigation of listeners whose dialectical vowel systems differ phonologically and phonetically (e.g., Escudero & Williams, 2012; Escudero et al., 2012; Williams & Escudero, 2014). Specifically, it allowed for a cross-language acoustic comparison of languages where there are fewer vowels in the native language compared to the target language (e.g., Escudero & Wanrooij, 2010; Escudero & Williams, 2011; Vasiliev & Escudero, 2013). The following section will present and discuss the vowel inventories of these two languages LA and AusE.

2.6.1. Lebanese Arabic

As mentioned, the wide variety of spoken Arabic dialects has manifested into various dialectical phonological systems (Ferguson, 1959). Even though the dialectal varieties differ from that of the Modern Standard Arabic (MSA) high language variety, which unifies the Arabic-speaking world, Ferguson (1959) maintains that the sound system of MSA and the Arabic dialect varieties (low variety) form a single phonological structure of which the phonology of the low language variety is the basic system and the divergent features of MSA phonology are subsystems. The many Arabic dialects differ from each other and are divided into two groups: Western Arabic and Eastern Arabic (Kirchhoff, et. al, 2002). Western Arabic is subdivided into Moroccan, Tunisian, Algerian and Libyan dialects. Eastern Arabic is subdivided into Egyptian, Gulf and Levantine, which includes Iraqi, Syrian, Jordanian, and Lebanese (Haraty & Ariss, 2007) as well as the colloquial Arabic spoken in Israel (Amir et al, 2014). Studies which have analysed vowels of the Eastern dialect group discuss inter-dialect similarities and differences (e.g. Obrecht, 1968; Newman & Verhoeven, 2002). For example, the Jordanian, Lebanese and Syrian dialects have the following five vowel pairs /i, iː, a, aː, u, uː, e, eː, o, oː/ similar to colloquial Israeli Arabic (Rosenhouse, Amir, Amir, 2014).

In a recent study Amir et al. (2014) investigated the acoustic properties of the vowel systems of two dialects of colloquial Arabic spoken in the Galilee and Muthallath regions in Israel. The study provides one of the first complete, comprehensive and recent descriptions of the vowel inventory and acoustic formant values for these dialects. Of particular interest is the Arabic dialect spoken in the Galilee region that borders with the south of Lebanon. The Arabic dialect spoken in the Galilee region reported in Amir et al. (2014) is very similar to the LA variety, comprising of five similar vowel pairs (Rosenhouse, et al., 2014) and the acoustic values reported in this study can therefore be used in the present study to investigate acoustic similarity between LA and AusE. These vowels described in Amir et al. (2014) provide the best available approximation to the LA vowel acoustics including formant values, as the LA dialect is very much understudied and the descriptions which are available are either outdated or incomplete (e.g., Abu Haidar, 1979; Cadora, 1979; Furayhaha, 1938; Lakkis, 1987). The LA vowel inventory consists of ten monophthongs /i/, /iː/, /a/, /aː/, /u/, /uː/, /e/, /eː/, /o/, /oː/. The vowels /i/ and /iː/ are identified as front vowels, /eː/ and /e/ as mid-front vowels, /aː/, /a/, /o/ and /oː/ as mid-back vowels and /uː/ and /u/ as back vowels (Amir et al., 2014). Moreover, LA primarily employs phonemic length to distinguish between short and long vowels similar to Japanese and Thai (Tsukada, 1999, 2009a, 2009b, 2011, 2012) and is contrastive in five LA vowel pairs /i/-/iː/, /aː/-/a/, /uː/-/u/, /e/-/eː/, /o/-/oː/ (Amir et al., 2014; Alghamdi, 1998).

2.6.2. Australian English

Australian English (AusE) differs from the other varieties of English (e.g., American, British, and Scottish) in terms of vowel pronunciation, intonation patterns and consonant modifications (Cox, 2006). The AusE vowel inventory consists of twelve monophthongs, namely /iː/, /ɪ/, /e/, /eː/, /ɜː/, /ɐ/, /ɐː/, /æ/, /oː/, /ɔ/, /ʊ/, /ʉː/ (Elvin, Williams & Escudero, 2016). The vowels /ɪ, e, ɐ, æ, ɔ, ʊ/ are identified as short vowels and the remaining as long vowels (Elvin et al., 2016) and differ in vowel quality and phonemic length. In articulatory terms, AusE /iː/, /ɪ/, /e/, /eː/, /æ/ are described as front vowels, /ɜː/, /ɐ/, /ɐː/, /ʉː/ as central vowels and /oː/, /ɔ/, /ʊ/ as back vowels (Cox, 2006). Also /iː/, /ɪ/, /ʊ/, /ʉː/, /oː/ are described as closed vowels, /ɐ/, /ɐː/ as open vowels, /ɜː/, /e/, /eː/ as half closed vowels and /æ/, /ɔ/ as half open vowels (Cox, 2006).

The present study will be using the following AusE vowel contrasts /æ/-/ɜː/, /e/-/eː/, /iː/-/ɪ/, /ʊ/-/ʉː/, /ɐ/-/ɐː/ and /oː/-/ɔ/. These contrasts are distinguished in terms of duration, as AusE employs phonemic vowel length (Cochrane, 1970) similarly to LA (as mentioned above). More recently Elvin et al. (2016) provided an acoustic vowel analysis of the Western Sydney AusE dialect. The study reports that vowel duration is affected by the consonantal contexts in which vowels are produced and differs across consonantal contexts (Elvin et al., 2016). For example, previous studies concerning AusE vowels use the /hVd/ context (Cox, 2006; Cox & Palethorpe, 2005, 2007) which may be unsuitable because vowels in this context are shown to be the least similar to other consonantal contexts, such as /fVf/, /dVt/, /gVk/, /bVp/ and /sVs/ (Elvin et al., 2016). Furthermore, Elvin et al. (2016, p.581) emphasised that as a result of the differing "vowel duration and formant trajectories" across the consonantal contexts, detailed acoustic comparisons between the native language and L2 that are used to predict non-native and L2 difficulties in speech perception and production will be affected (e.g., L2LP; Escudero, 2005, 2006).

2.6.3. Motivation for target vowels

As mentioned, both LA and AusE employ phonemic length to distinguish short and long vowels. Therefore, the following six AusE vowel contrasts /æ/-/ɜː/, /e/-/eː/, /ɪ/-/iː/, /ʊ/-/ʉː/, /ɐ/-/ɐː/, /ɔ/-/oː/ were specifically chosen. The vowel contrasts /e/-/eː/, /ɪ/-/iː/ and /ɐ/-/ɐː/ correspond to similar short and long vowels in the LA vowel inventory. Also, the contrasts all represent length while some differ by length and quality. These six vowel contrasts will allow investigation of native LA listeners' discrimination accuracy of AusE vowel contrasts in order to determine whether their L2 perception is influenced by their native language acoustic properties. Furthermore, due to the discussed effect of the consonantal context with which

Western Sydney AusE vowels are produced (Elvin et al., 2016); the AusE vowels used in this study are extracted from the /fVf/ context. This is due to the similarity of vowel tokens accurately classified in the consonantal context /fVf/, /dVt/, /gVk/, /bVp/, /sVs/ as reported in Elvin et al. (2016) and also as previous non-native speech perception studies have used the /fVf/ context (e.g., Elvin & Escudero, 2014; Elvin et al., 2014).

2.7. Predictions

As stated, the purpose of this study was to investigate LA listeners' discrimination of the AusE vowel contrasts. Given that the L2LP model proposes that L2 and non-native discrimination accuracy can be predicted from a comparison of the acoustic properties of both the native and non-native vowel systems and that previous studies have successfully shown this, we will also be using an acoustic comparison between LA and AusE for predicting in the current study (e.g., Escudero & Boersma, 2004; Escudero, 2005; Escudero et al., 2014; Elvin et al., 2014).

Figure 1 shows the F1 and F2 values of the twelve AusE (Elvin et al., 2016) and ten LA (Amir et al., 2014) monophthongs. Predictions based on acoustic similarity of the six target AusE vowel contrasts, namely /æ/-/ɜː/, /e/-/eː/, /iː/-/ɪ/, /ʊ/-/ʉː/, /ɐ/-/ɐː/ and /o/ː-/ɔ/, are made by visually comparing the AusE and LA vowels in the acoustic space.

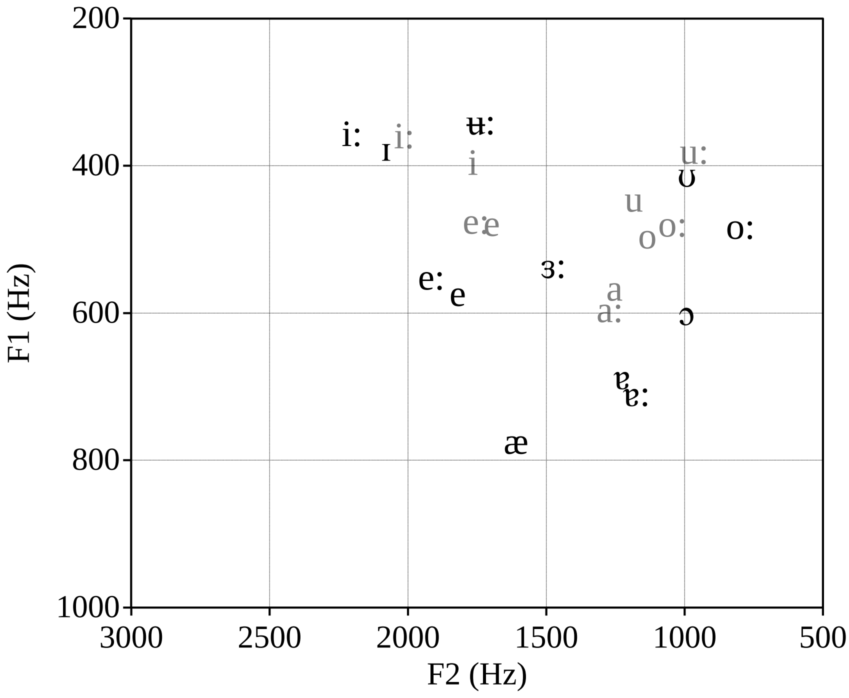

Figure 1: Average F1 & F2 acoustic values for vowels produced by native AusE males in black (Elvin et al., 2016) and LA males in grey (Amir et al., 2014).

As shown in figure 1, when comparing the vowels in the acoustic space for both languages, the LA vowel inventory is made up of fewer vowels than AusE, lacking /æ/, /ɜː/, /ɔ/, /ʊ/, and /ʉː/. The AusE vowel contrasts /ɐ/-/ɐː/ and /e/-/eː/ seem to be acoustically similar to the LA vowel contrasts /aː/-/a/ and /e/-/eː/, which also differ only by length and should facilitate discrimination of these vowel contrasts. For the AusE /æ/-/ɜː/ vowel contrast, although AusE /æ/ seems acoustically distant from most of the LA vowels, it is potentially acoustically similar to the LA vowels /aː/ and /a/. In contrast the AusE /ɜː/ appears to be in close acoustic proximity to LA /aː/, /a/, /e/ and /eː/. As a result of the acoustic overlap between vowels in the AusE vowel contrast /æ/-/ɜː/ and the LA vowel contrast /aː/ and /a/, discrimination accuracy may be lower for this AusE vowel contrast. However, the lip rounding of the AusE vowel /ɜː/ may assist the LA listeners in distinguishing this vowel and if the LA listeners employ duration as a cue to discriminate, the AusE vowel contrast /æ/-/ɜː/ contrast may result in minimal difficulties.

Duration may be used as a cue to facilitate the discrimination of the AusE vowel contrast /iː/-/ɪ/, but both vowels appear to be acoustically closer to LA /iː/ than /i/. This may result in discrimination difficulties for the LA listeners if they perceive both vowels in the AusE vowel contrast /iː/-/ɪ/ as LA /iː/. In the case of the AusE vowel contrast /oː/-/ɔ/, fewer discrimination difficulties are expected, as AusE /oː/ seems to be acoustically close to a similar LA long vowel /oː/ and is also acoustically similar to the LA long vowel /uː/, while AusE /ɔ/ is in acoustic proximity to the LA short vowels /a/ and /o/.

In the case of the AusE vowel contrast /ʊ/-/ʉː/, the LA listeners' may not find this contrast difficult to discriminate because a similar short-long vowel contrast /uː/-/u/ exists in LA. Moreover, AusE /ʊ/ is acoustically close to LA /uː/, /u/, /o/, and /oː/, while AusE /ʉː/ is more fronted. Although AusE /ʉː/ appears acoustically closer to LA /iː/ in terms of F1 and F2 values, it is unlikely that this vowel will be perceived as LA /iː/, as it is a rounded vowel.

According to the L2LP model's learning scenarios (L2LP, Escudero, 2005, 2006), LA listeners should map each vowel in the AusE /ɐ/-/ɐː/ and /e/-/eː/ vowel contrasts to LA /a/-/aː/ and /e/-/eː/ vowel categories respectively in terms of the similar scenario. In the case of AusE

/oː/-/ɔ/ and /ʊ/-/ʉː/, the LA listeners should map each of the two vowels in the contrast to two different LA vowel categories according to the subset scenario. In contrast it is expected that the AusE /iː/-/ɪ/ and /æ/-/ɜː/ to be mapped to the same multiple LA vowel categories based on the subset scenario resulting in an acoustic overlap.

A summary of the possible learning scenarios for bilingual LA English listeners' discrimination of the six AusE vowel contrasts based on the visual acoustic comparison between the AusE and LA vowels in the acoustic space is presented below in Figure 2, in line with the L2LP model (Escudero, 2005, 2009).

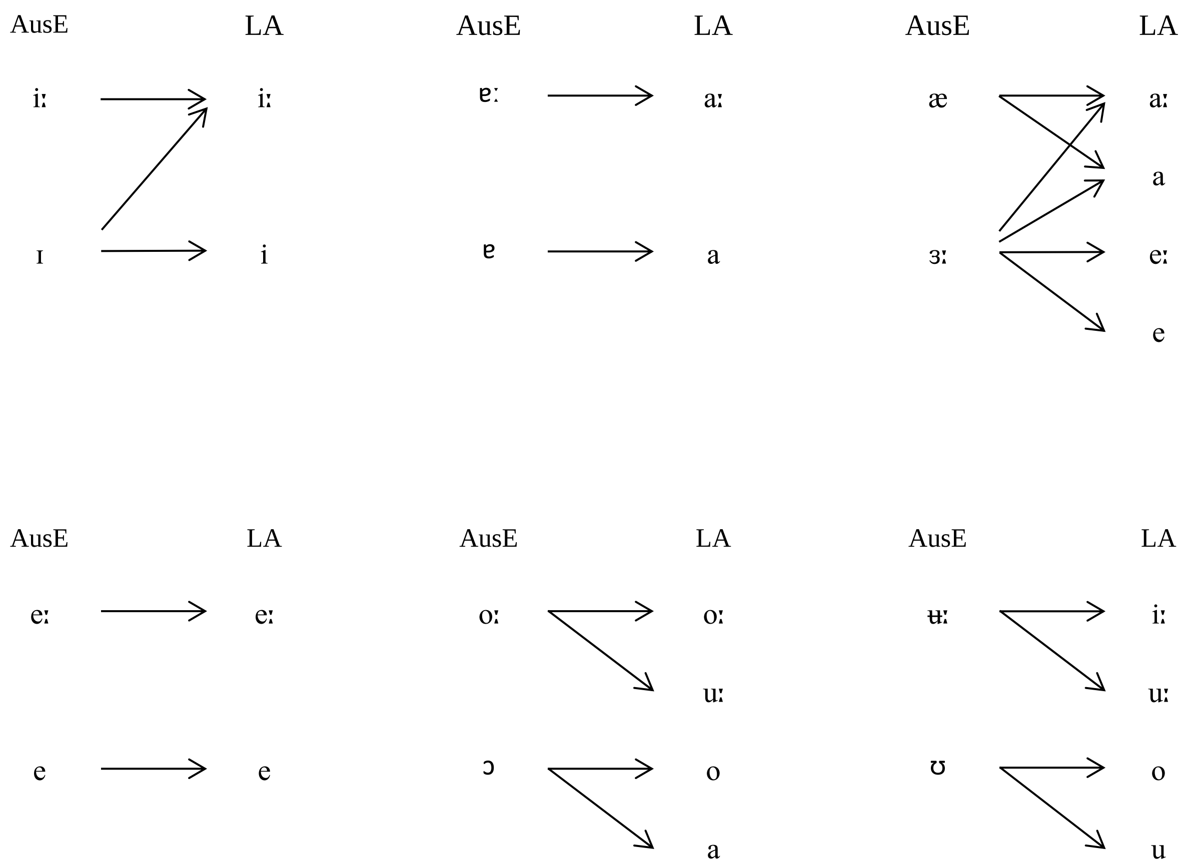

Figure 2: Summary of possible learning scenarios for LA listeners' discrimination of the six AusE vowel contrasts, according to the L2LP model (Escudero, 2005, 2009a) based on visual acoustic comparison.

As shown, the plotting of the vowels for both of these languages shows where the vowels are located within the F1/F2 acoustic space. In addition, the calculation of the Euclidean Distances between the target AusE vowel contrasts and the native LA vowels will provide a quantitative measure of cross-language similarity (Elvin et al., 2014). In speech perception Euclidean Distances (EDs) are used as a measure to define the (dis)similarity of perceptual distances between specific acoustic properties (Pols, 1987). In particular, the greater the measures of distance between the vowels, the farther apart the vowels are located in the vowel space. Table 2 below shows the Euclidean Distances between each of the 12 AusE vowels considered in this study and the first, second and third acoustically closest LA vowels. The Euclidean Distances reported in table 2 provide a quantitative measure for further predicting LA listeners discrimination of the six AusE vowel contrasts.

Closest LA vowel						
AusE vowel	**1st**	**ED**	**2nd**	**ED**	**3rd**	**ED**
iː	iː	0.60	i	1.53	eː	1.88
ɪ	iː	0.27	i	1.11	eː	1.46
e	eː	0.87	e	0.93	i	1.58
eː	eː	0.88	e	1.02	i	1.49
ɜː	e	1.05	a and aː	1.09	eː	1.26
æ	aː	2.05	a	2.27	eː	2.43
ɐ	aː	0.74	a	0.95	o	1.62
ɐː	aː	1.01	a	1.19	o	1.73
ɔ	oː	1.05	o	1.18	a	1.46
oː	uː	1.44	oː	1.55	o	2.07
ʊ	uː	0.33	o	1.12	u	1.13
ʉː	i	0.54	iː	1.01	eː	1.27

Table 2: The Euclidean Distances (ED) between each of the 12 AusE vowels and the first, second and third acoustically closest LA vowels.

The EDs reported in Table 2 for the LA listeners confirm that LA /iː/ is acoustically the closest vowel to AusE /iː/ and /ɪ/, resulting in the two target vowels in the contrast being mapped to the same single LA vowel category, which should lead to difficulty in discrimination. Also, the second closest vowel to both AusE /iː/ and /ɪ/ is LA /i/, but the AusE /ɪ/ may be mapped to LA /i/ if the LA listeners use duration as a cue.

In the case of both AusE /e/ and /eː/, LA /eː/ is the closest vowel category at almost the same ED presenting an acoustic overlap. Even though the second closest LA vowel for both AusE /e/ and /eː/ is LA /e/, inspection of the EDs indicates that LA /e/ is much closer to the similar short vowel AusE /e/, facilitating discrimination of AusE /e/-/eː/. Similarly, the EDs show that both AusE /ɐ/ and /ɐː/ are closest to LA /aː/ and then to LA /a/ suggesting an acoustic overlap. But again, the EDs show that the second closest vowel LA /a/ is much closer to AusE /ɐ/ and is a similar short vowel, which should not lead to discrimination difficulties.

Furthermore, for the AusE /ɔ/, the EDs indicate LA /oː/ to be the closest vowel, LA /o/ to be the second and LA /a/ to be the third closest vowel. However, LA listeners should map the AusE vowel to the closest similar short vowel LA /o/, as phonemic vowel length is distinctive in Arabic. Also, for AusE /oː/, the EDs confirm that the acoustically similar long vowels LA /uː/ and /oː/ are the closest vowels that the LA listeners should map to, resulting in minimal discrimination difficulty.

The EDs reported for AusE /ɜː/ confirms that LA /e/ is the nearest vowel, LA /a/ and /aː/ are equally the second closest vowels and LA /eː/ is the third closest vowel. Also, for AusE /æ/, LA /aː/ is the closest vowel and LA /a/ is the second closest vowel. This represents an acoustic overlap where both vowels in the AusE vowel contrast /ɜː/-/æ/ being mapped to LA /a/ and /aː/, resulting in low discrimination accuracy. However, if the LA listeners use duration as a cue to distinguish between the vowels, discrimination of this AusE contrast may be less difficult.

Additionally for AusE /ʊ/, the EDs show that LA /uː/ is the closest vowel, which is an unlikely selection for the LA listeners due to the difference of duration. However, the second closest vowel LA /o/ and the third closest vowel LA /u/ are both short vowels and are the vowels the LA listeners are expected to select. In contrast for the AusE /ʉː/, the EDs do not confirm the expected mapping by the LA listeners. The LA listeners are unlikely to map the AusE /ʉː/ to the first vowel LA /i/, to the second LA /iː/ or the third closest LA /eː/, due the difference of vowel quality and duration and that a similar long vowel LA /uː/ exists. Thus, the LA listeners may not find this contrast difficult to discriminate because of the available similar long-short vowel contrast LA /uː/-/u/.

In sum, LA listeners whose native vowel inventory includes phonemic length contrasts should use duration as a cue that facilitates vowel discrimination. However, vowel discrimination may be more difficult for those non-native vowel contrasts where there is also vowel quality difference between the AusE and LA vowels and when both AusE vowels in a non-native contrast are mapped to one or more of the same native LA vowel categories.

2.8. Summary

This chapter presented research concerning non-native and L2 speech perception. First, an outline of the three prominent theoretical models which address non-native speech perception including their manner of predicting, assimilation patterns and learning scenarios was presented. The chapter continued on to discuss predicting non-native speech perception in line with the L2LP model, which followed with a discussion relating to dialectal variation in non-native L2 speech perception. An overview of studies concerning non-native and L2 speech perception of various native language backgrounds was also discussed.

Based on the discussed research, the purpose and motivation of the present study was highlighted. This was followed by a presentation regarding the Lebanese-Arabic and Australian English vowel inventories, specifically the monophthongs' acoustic and phonemic characteristics for both languages. The motivation for the target vowels used in this study was also shown. Moreover, based on the discussed acoustic and phonemic characteristics, predictions were then made according to the L2LP model's proposal that L2 and non-native discrimination accuracy can be predicted from a comparison of the acoustic properties of both the native and non-native vowel systems. The LA listeners were predicted to encounter more difficulties discriminating non-native vowel contrasts when there is a vowel quality difference between the LA and AusE vowels and when there is an acoustic overlap in the subset learning scenario. However, the LA listeners should use duration as a cue to facilitate accurate vowel discrimination and minimize discrimination difficulties.

Chapter 3 will follow with an explanation of the method used in designing and administrating the research for this thesis. It will include a detailed description of the selected participants, the stimuli used and the followed procedure for presenting and conducting the tasks used to investigate L2 speech perception in the LA listener group.

Chapter 3 Method

3.1. Participants

The participants in this study were 15 AusE monolinguals and 17 native Lebanese Arabic-English bilinguals aged between 18 and 45 (mean age: 25.6 for AusE and 33.2 for LA). The AusE participants were the control group, born in Australia and reported little to very basic knowledge of any foreign language. The LA listeners were born in Lebanon, from a homogenous Lebanese Arabic first language background and spoke English as their second language. All LA participants migrated to Australia within the last 18 years and currently live in the suburbs of Western Sydney. They reported either low-intermediate or advanced English proficiency. Furthermore, all LA participants reported that they had been exposed to another English dialect (American, British) prior to their arrival in Australia.

All the participants for this study provided informed consent in accordance with the Western Sydney University Human Research Ethics Committee (approval #H11022). Participants were either recruited through Western University's psychology pool and received 6 course credit points for participation or they were recruited from the Western Sydney region and received $20 for their time/travel expenses.

3.2. Stimuli

The auditory stimuli presented in the XAB task consisted of 120 AusE natural isolated vowel tokens produced by five male and five female monolingual speakers of AusE from Western Sydney, selected from the Elvin et al. (2016) corpus. The target stimuli were one of the 12 AusE vowel tokens (/iː/, /ɪ/, /e/, /eː/, /ɜː/, /ɐ/, /ɐː/, /æ/ /oː/, /ɔ/, /ʊ/, /ʉː/) extracted from nonce words of the /fVf/ context produced in isolation. There were 10 tokens for each of the 12

AusE vowel tokens (12 AusE x 10 repetitions). The A and B stimuli were twelve natural AusE vowel tokens, representing each of the same 12 AusE vowels (/iː/, /ɪ/, /e/, /eː/, /ɜː/, /ɐ/, /ɐː/, /æ/ /oː/, /ɔ/, /ʊ/, /ʉː/) produced by different speakers (one female and one male AusE monolingual speaker) than the ones that produced the target vowels.

The same target stimuli from the XAB task were also used in the identification task but with an additional AusE vowel token /ɪə/, produced by the same five male and five female AusE speakers extracted from the same /fVf/ context. This additional vowel was selected as a possible response option due to its reported monopthongal properties reported in Elvin et al. (2016)[1], which makes it a likely option for the participants. Thus, the listeners were presented with 130 tokens, 10 tokens for each of the 13 AusE vowels /iː/, /ɪ/, /e/, /eː/, /ɜː/, /ɐ/, /ɐː/, /æ/ /oː/, /ɔ/, /ʊ/, /ʉː/ and /ɪə/ (13 AusE x 10 repetitions).

3.3. Procedure

Participants were presented with an auditory discrimination task in the XAB format, similar to the task reported in Escudero and Williams (2012) and Elvin et al. (2014). However, it was programmed and run using the E-Prime software (Version, E. P. 10 Computer Software, 2001). Participants completed six blocks which corresponded to each of the six AusE long and short target vowel contrasts, /æ/-/ɜː/, /e/-/eː/, /iː/-/ɪ/, /ʊ/-/ʉː/, /ɐ/-/ɐː/ and /oː/-/ɔ/. In each trial the listeners heard three vowel sounds, one after the other, and were asked to decide whether the first vowel (X) sounded like the second (A) or the third (B) sound, by pressing the corresponding button on the keyboard. There were 40 trials in each block and the order of

[1] Although AusE /ɪə/ is a diphthong, it was selected as a possible response option due to reported monophthongal properties (duration and spectral change) similar to AusE /iː/ and/ɪ/ when produced in a closed context such as /fVf/ (Elvin et al., 2016).

the A and B stimuli were counterbalanced as XAB and XBA across the trials (Elvin et al., 2014). To ensure language-specific phonological processing the inter-stimulus interval was set to 1.2 sec as has been done in previous studies (e.g., Escudero et al., 2009b; Elvin & Escudero, 2014; Elvin et al., 2014). Participants were first presented with a practice trial block for the task using an easy long and short vowel contrast, namely /ɐː-ʊ/ to ensure that they understood the task (see Escudero & Wanrooij, 2010 and Elvin et al. 2014).

An L2 identification task immediately followed the XAB task. In this experiment, participants were required to identify each of the 13 AusE vowels (/iː/, /ɪ/, /e/, /eː/, /ɜː/, /ɐ/, /ɐː/, /æ/ /oː/, /ɔ/, /ʊ/, /ʉː/, /ɪə/) as one of the thirteen corresponding AusE response categories, namely, *had, haired, hard, hawed, head, heared, heed, hid, hod, hood, hud*, *hurd* and *who'd*. These response categories were displayed on a laptop screen and participants used a mouse to make their choice. The participants were also presented with a short practice session, which allowed them to understand and familiarize themselves with the task and to clarify any uncertainties they had.

Participants were tested in a laboratory at the MARCS Institute for Brain, Behaviour and Development, Western Sydney University Bankstown campus. Each participant completed the task individually on a laptop (Acer Travel Mate P653 15 inch Notebook) with the auditory stimuli being presented via headphones (Sennheiser HD650). Oral instructions were provided in English and the entire testing session took approximately 60 minutes to complete including the completion of the Adult Language/Accent Background Questionnaire prior to commencing the practice trial block. After completion of the tasks, the results were extracted from E-Prime and analyzed using IBM SPSS 22.

3.4. Summary

This chapter outlined the methodology used to test the predictions of this study. A total of 32 participants were tested in two experimental tasks, comprising of 17 native Lebanese-Arabic English bilinguals and 15 Australian English monolinguals as the control group. The same AusE natural vowel tokens were used for both listener groups that were selected from the Elvin et al. (2016) corpus in the XAB categorical discrimination task and identification task. Chapter 4 will present an analysis for the results from the experiments.

Chapter 4 Results

In this chapter, the results from the identification task are presented first with a statistical analysis, as the results are used to make additional predictions regarding L2 discrimination difficulty. The results from the XAB categorical discrimination task will then be presented.

4.1. Identification task

The identification task required both listener groups to listen to the AusE vowel sounds one by one and match each vowel they heard with one of the English response labels representing the 13 AusE vowels displayed on a laptop screen. For each AusE vowel token there were 130 responses per listener group, which were averaged across the participants in each group. Table 3 below shows the mean percentage of the number of responses for each AusE with the standard deviation per group. The results clearly indicate that identification of the 13 AusE vowels differed between the AusE and LA listeners.

AusE vowel token	listener groups	heared /ɪə/	hid /ɪ/	heed /iː/	head /e/	haired /eː/	had /æ/	hurd /ɜː/	hud /ɐ/	hard /ɐː/	whod /ʉː/	hawed /oː/	hod /ɔ/	hood /ʊ/
		Identification response category labels for the 13 AusE vowels												
/ɪ/	Aus		**98** (1.81)											
	LA		**63** (2.99)	30										
/iː/	Aus		13	**82** (2.37)										
	LA			**74** (2.95)	20									
/e/	Aus		10	10	**65** (2.61)	14								
	LA				**55** (2.44)	13	20							
/eː/	Aus				19	**61** (3.35)								
	LA				41	**47** (2.23)								
/æ/	Aus						**95** (2.11)							
	LA						**70** (2.43)			26				
/ɜː/	Aus				10			**45** (1.91)		18		10		
	LA	14			16	10	15	**23** (1.67)		17				
/ɐ/	Aus						15		**64** (3.09)	16				
	LA						30		**48** (2.95)	19				
/ɐː/	Aus						11			**78** (2.19)				
	LA						30			**62** (2.80)				
/ʉː/	Aus		10								27 (2.19)			**58**
	LA		21								20 (1.42)			**41**
/oː/	Aus											**72** (3.10)	20	
	LA											**50** (3.79)	45	
/ɔ/	Aus											10	**82** (2.59)	
	LA										16		**74** (2.52)	
/ʊ/	Aus										10			**82** (2.10)
	LA										30			**63** (2.65)
/ɪə/	Aus	**59** (2.50)	20											
	LA	**26** (2.18)		**43**	20									

Table 3: Mean percentage identification score of 13 AusE vowels by native AusE and bilingual LA listeners; and standard deviation in brackets. Results lower than 5% were not included. The mean percentages were rounded up to the nearest whole number.

The data in Table 3 indicates that the AusE listeners had higher identification accuracy overall and that both groups identified each AusE vowel differently in terms of the response labels they select. The majority of the vowel categories with the highest responses were the same across both groups and only differed with the response to the AusE /ɪə/. Such that the LA listeners' highest response for AusE /ɪə/ was the AusE /iː/ at 43%, while the AusE listeners' had 59% accuracy for AusE /ɪə/. The results indicate that AusE listeners had the least difficulty identifying the AusE vowel /ɪ/ (98%) whereas the LA listeners found both AusE /ɔ/ and /iː/ the easiest to identify, each with 74% accuracy. However, both listener groups found the AusE /ʉː/ vowel most difficult to identify (AusE 27% and LA 20%). To test for significant group differences between the two listener groups and across the 13 AusE vowels, a repeated-measures ANOVA was conducted. This statistical analysis was run with language (two levels: LA and AusE) as a between-subject factor and vowels (13 levels: 13 AusE vowels) as a within-subjects factor. The results showed a main effect of language [F (1, 30) = 17.53, $p < 0.001$, ^{n2p} = 0.355) and vowels [F (12, 360) = 15.52, $p < 0.001$, ^{n2p} = 0.341) but no interaction between vowel and language [F (12, 360) = 0.71, ^{n2p} = 0.23). This indicates that the listener groups did differ in their overall identification of the AusE vowels and they also differed based on the selection of the response labels for each of the 13 AusE vowels. Both language groups found the same vowels equally easy or difficult to identify. A Bonferroni-corrected post-hoc test was conducted with a more conservative alpha level (α = 0.0038 from 0.05 alpha level divided by 13 AusE vowels) and showed the significant differences between AusE vowels across both language groups as follows. The analysis indicated reliable significance between AusE /ʉː/ and the remaining 12 vowels ($p < 0.001$)

and between AusE /ɪə/ and the remaining vowels excluding AusE/ɜː/ ($p < 0.001$). A pairwise comparison showed the ranking of difficulty for both listener groups, ranging from the most to the least difficult AusE vowel as follows: /ɪə/ > /ʉː/ ~ /ɜː/ > /eː/ ~/eː/ >/ɐː/~ /ɐ/ > /oː/ ~ /ɔ/ ~ /ʊ/~ /iː/ >/ɪ/ > /æ/, where "~" means equal or comparable difficulty and ">" means higher difficulty.

Based on the presented identification task results it is expected that the AusE listeners will attain overall higher discrimination accuracy of the AusE vowel contrasts than the LA listeners. Additionally, findings show that both listener groups differed in their overall identification of the AusE vowels. It is expected that both listener groups will have similar patterns of discrimination difficulty as findings show that both language groups found the same vowels equally easy or difficult to identify. Furthermore, LA listeners may not encounter discrimination difficulties with AusE /iː/-/ɪ/ as previously predicted, but may find some difficulty distinguishing the AusE /ʉː/ vowel.

4.2. XAB categorical discrimination task

In this task the participants listened to natural AusE vowel tokens and decided whether the first vowel (X) sounded like the second (A) or the third (B) sound. This experiment included six blocks representing the six AusE long and short vowel contrasts, /æ/-/ɜ/, /e/-/eː/, /iː/-/ɪ/, /ʊ/-/ʉː/, /ɐ/-/ɐː/ and /oː/-/ɔ/. The number of correct responses for each of the six AusE vowel contrasts was calculated for each participant in both listener groups. The totals for each participant per vowel contrast were then averaged across all the participants in each listener group. Each groups' discrimination accuracy for each AusE vowel contrast is represented in Figure 3 below, which shows the mean percent correct for each vowel contrast.

LA and AusE listeners' discrimination of AusE vowels

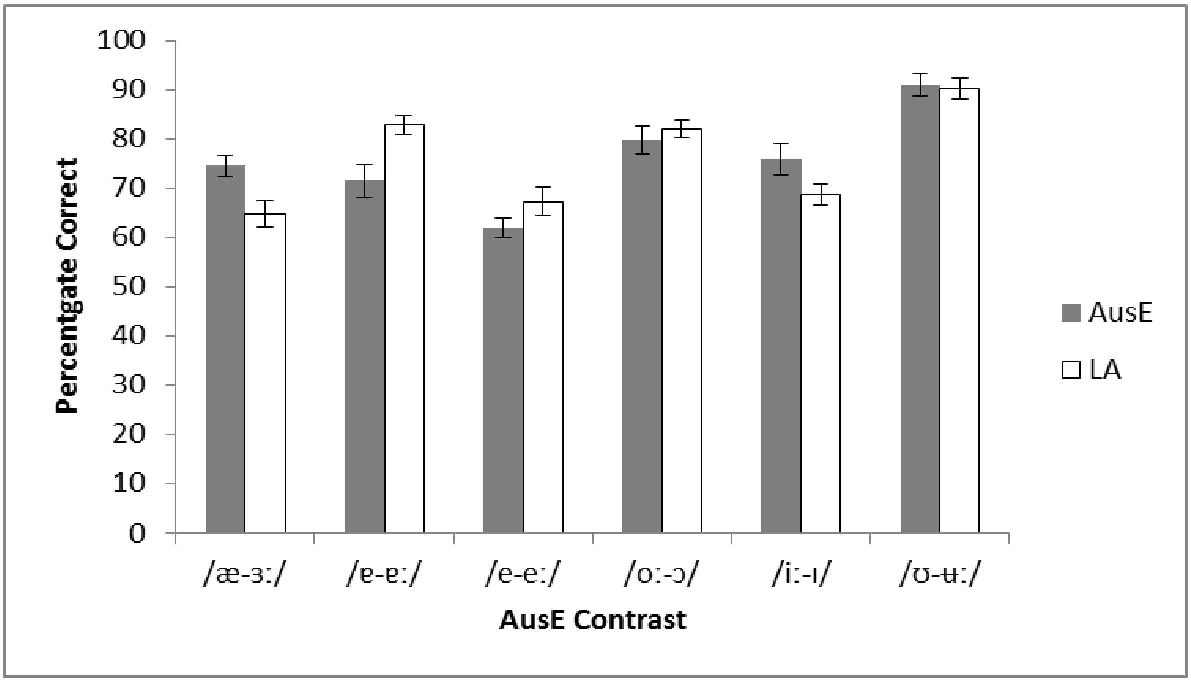

Figure 3: Mean percent correct with standard error of discrimination accuracy for 6 AusE vowel contrasts by native AusE and bilingual LA listeners L2 English listeners.

Figure 3 above shows the accuracy scores for the LA and AusE listeners across the six AusE vowel contrasts. Both listener groups found AusE /ʊ/-/ʉː/ the easiest to discriminate, while the AusE listeners found /e/-/eː/ the most difficult to discriminate. Whereas it seems that the LA listeners found AusE /e/-/eː/ and /æ/-/ɜː/ the most difficult to discriminate. To evaluate whether the listeners' discrimination accuracy scores differed significantly across the two groups and across the six AusE vowel contrasts, a repeated-measures ANOVA was conducted. This repeated measures analysis was run with language (two levels: LA and AusE) as a between-subjects factor and vowel contrast (six levels: 6 AusE vowel contrasts) as a within-subjects factor. The results indicated a main effect of contrast [F (5,150) = 46.34, p < 0.001, $^{\text{n2p}}$ = 0.61] and an interaction between language and contrast [F (5,150) = 8.53, p < 0.001, $^{\text{n2p}}$ = 0.22], but no main effect of language (F >1). This indicates both listener groups did not differ in their overall discrimination accuracy scores, but rather their discrimination accuracy of some of the vowel contrasts did differ based on their language background. We ran a planned comparisons using independent sample T-tests to compare the accuracy between the AusE and LA listeners. We found significant differences for the /æ/-/ɜː/, /ɐ/-/ɐː/ and /iː/-/ɪ/ vowel contrasts. In line with our predictions, LA listeners had significantly lower discrimination accuracy than AusE listeners for /æ/-/ɜː/ (t (28) = -2.66, p = 0.013) and /iː/-/ɪ/ (t (28) = -2.04, p = 0.05), while they had higher accuracy for /ɐ/-/ɐː/ (t (28) = 2.84, p = 0.008). A Bonferroni-corrected post-hoc test was conducted with α = 0.0083 (0.05 alpha level divided by six AusE vowel contrasts) showing the significant discrimination differences of the AusE vowel contrast across both language groups as follows. The analysis indicated reliable significance between AusE /ʊ/-/ʉː/ and the remaining five vowel contrasts (p < 0.001). Reliable differences were also shown between AusE /ɐ/-/ɐː/ and /e/-/eː/ (p < 0.001), between /e/-/eː/ and /oː/-/ɔ/ (p < 0.001), between /iː/-/ɪ/ (p = 0.002), and between /oː/-/ɔ/, /iː/-/ɪ/ (p = 0.001).

As a result of a difference of discrimination accuracy between the listener groups, a pairwise comparison was run to determine the ranking of difficulty for each group. The ranking of difficulty for the LA group, ranging from the most to the least difficult as follows: for LA /æ/-/ɜː/ ~ /e/-/eː/ ~ /iː/-/ɪ/ > /oː/-/ɔ/ ~ /ɐ-ɐː/ > /ʊ/-/ʉː/ and for AusE /e/-/eː/ > /ɐ/-/ɐː/ ~ /æ/-/ɜː/ ~ /iː/-/ɪ/ ~ /oː/-/ɔ/ > /ʊ/-/ʉː/, where "~" means comparable or equal difficulty and " > " means greater difficulty.

A possible explanation for the lack of the overall group effect could be the fact that the LA listeners differed in their levels of English proficiency. Therefore the LA listeners were divided into two groups according to their self-evaluation of L2 English proficiency (e.g. low, intermediate or advanced). Participants were included in the low group (LA_1) if they indicated that their English proficiency was at an intermediate level or lower and participants included in the high group (LA_2) were those who indicated that their English was at an advanced level or higher. The LA_1 group (low proficiency) included 9 listeners and the LA_2 group (high proficiency) included 8 listeners. Each group's discrimination accuracy for each of the six AusE vowel contrast is represented in Figure 4 below, which shows the mean percent correct for each vowel contrast.

LA listeners' discrimination of AusE vowels

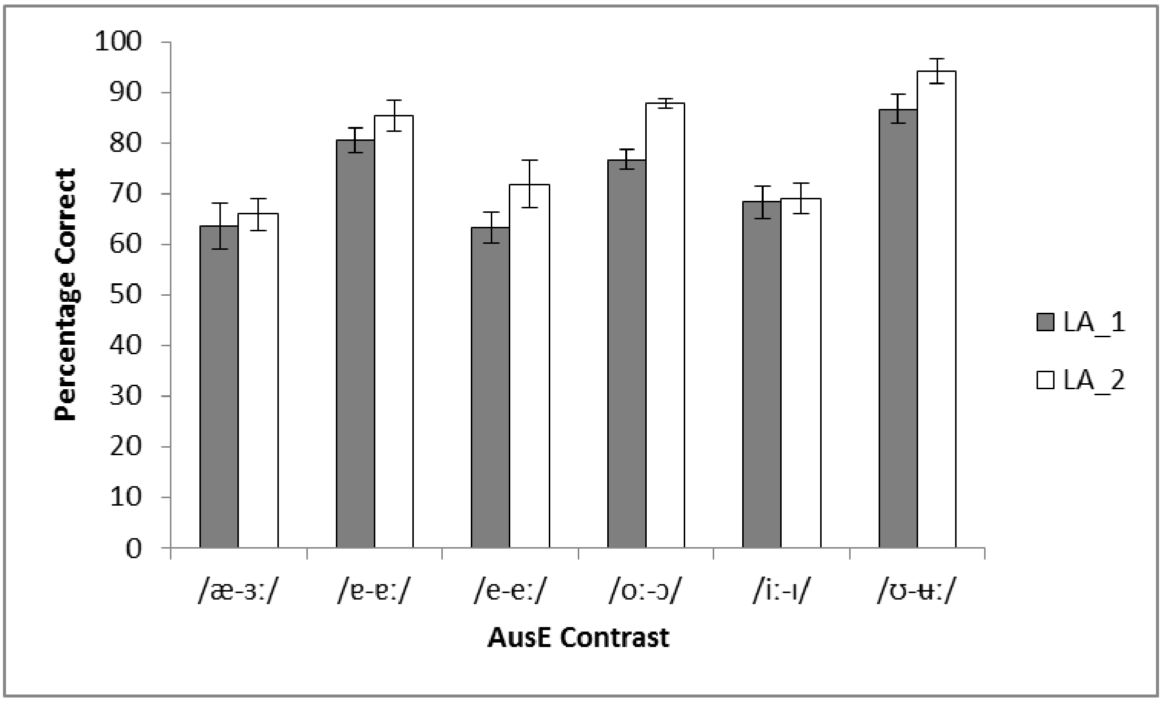

Figure 4: Mean percent correct with standard error of discrimination accuracy for 6 AusE vowel contrasts by 9 LA intermediate L2 English listeners (LA_1) and 8 LA advanced L2 English listeners (LA_2).

Figure 4 above shows that the LA_2 group of listeners had higher overall discrimination accuracy than the LA_1 group of listeners across the six AusE vowel contrasts. Both listener groups had the highest discrimination accuracy score for the AusE vowel contrast /ʊ/-/ʉː/, indicating that this contrast was the easiest to discriminate. As can be seen in Figure 4, the results suggest that the LA_1 group found the AusE vowel contrast /e/-/eː/ the most difficult to discriminate, whereas the LA_2 group found the AusE vowel contrast /æ/-/ɜː/ the most difficult. In order to determine whether or not the results observed in Figure 4 were statistically significant, a repeated-measures ANOVA was conducted. This analysis was run with proficiency (two levels: LA_1 and LA_2) as a between-subjects factor and vowel contrast (six levels: 6 AusE vowel contrasts) as a within-subjects factor. The results indicated a main effect of proficiency [F (1, 15) = 4.75, p = 0.046, ^{n2p} = 0.241] and contrast [F (5, 75) = 29.26, p < 0.001, ^{n2p} = 0.661] and no interaction between contrast and proficiency [F (5, 75) = 1.04, ^{n2p} = 0.65] was detected. This shows that discrimination accuracy of the six AusE vowel contrasts did not differ across the two LA groups based on their L2 English proficiency. However, both groups did differ significantly in their overall discrimination accuracy scores. A Bonferroni-corrected post-hoc test was conducted with α = 0.0083 (0.05 alpha level divided by six AusE vowel contrasts) showing the significant discrimination differences of the AusE vowel contrast across both listener groups as follows. The analyses indicated that there were reliable differences between AusE /æ/-/ɜː/ and /ɐ/-/ɐː/ (p < 0.001) and between /oː/-/ɔ/ (p < 0.001) and /ʊ/-/ʉː/ (p < 0.001). Also, between AusE /e/-/eː/, /oː/-/ɔ/ (p < 0.001) and /ʊ/-/ʉː/ (p < 0.001) and between/e/-/eː/ and /ʊ/-/ʉː/ (p < 0.001). Furthermore reliable differences were found between AusE /oː/-/ɔ/, /iː/-/ɪ/ (p < 0.001) and /ʊ/-/ʉː/ (p < 0.001). A pairwise comparisons analysis showed the ranking of discrimination difficulty for both listener groups as follows: /æ/-/ɜː/ > /iː/-/ɪ/ >/e/-/eː/ > /ɐ/-/ɐː/ >/oː/-/ɔ/ > /ʊ/-/ʉː/, where “>” means greater difficulty. In line with the discrimination accuracy, this confirms that the LA listeners found AusE /ʊ/-/ʉː/ the least difficult and AusE /æ/-/ɜː/ the most difficult to discriminate.

4.3. Summary

This chapter reported the results from the identification task of the 13 AusE vowels by AusE and LA listeners, which were used to make additional predictions regarding L2 discrimination difficulty. There was a main effect of language and contrasts ($p < 0.001$) but no interaction between vowel and language. Additionally, the results from the XAB categorical discrimination task based on 17 Lebanese-Arabic English bilingual listeners and 15 Australian English monolingual listeners were reported. The results showed no language group differences ($p = 0.943$) indicating that the AusE and LA listeners did not differ in their overall discrimination accuracy of the six AusE vowel contrasts. However, an effect of vowel contrast ($p < 0.001$) indicated that both groups found some vowel contrasts more difficult to discriminate than others. Also, a contrast by language ($p = 0.001$) interaction suggested that both groups discrimination accuracy of the vowel contrasts did differ based on their language background. Moreover, the Lebanese-Arabic groups XAB results were analysed as two groups (LA_1/LA_2), based on their L2 English proficiency (intermediate/advanced). The results showed a main effect of contrast ($p < 0.001$) and proficiency ($p = 0.046$) and no contrast by proficiency interaction ($p = 0.398$) indicating that the LA groups L2 proficiency did not play a role in their discrimination accuracy of the AusE vowel contrasts. Both groups differed significantly based on their overall discrimination accuracy and for each AusE vowel contrast.

Chapter 5 entails a discussion that will discuss and relate these results to the presented issues in the literature review to explain the absence of group differences concerning the LA listeners’ discrimination performance in comparison to the AusE control group. Additionally, the influence of the LA listeners' native acoustic properties is highlighted, in particular the use of duration as a cue to facilitate discrimination L2 vowel discrimination. Furthermore, Chapter 5 will also discuss possible ideas that were not outlined in the literature review regarding the lack of impact of the LA listeners' L2 English proficiency in the discrimination of the AusE vowel contrasts.

Chapter 5 Discussion

The previous chapter initially reported the results from the identification task of the 13 AusE vowels by AusE and LA listeners, which were used to make additional predictions regarding L2 discrimination difficulty. There was a main effect of language and contrasts but no interaction between vowel and language. Thus it was expected that the AusE listeners would attain overall higher discrimination accuracy of the AusE vowel contrasts than the LA listeners. Additionally, the predictions stated that both listener groups would find the same AusE vowel contrasts equally difficult/easy to discriminate and that both listener groups would differ in how they discriminated the AusE vowel contrasts. Furthermore, the results for the XAB categorical discrimination task of the AusE vowel contrasts were presented, which compared the vowel perception of bilingual Lebanese-Arabic L2 English listeners to monolingual Australian English listeners. There was no main effect of language group suggesting that Lebanese-Arabic and Australian English listeners did not differ significantly in their overall discrimination of AusE vowel contrasts. However an effect of vowel contrast and an interaction between language group and AusE vowel contrast was shown. Due to the lack of overall effect of language in the discrimination of the AusE vowel contrasts, the L2 English proficiency of the LA participants was considered. The analysis indicated a main effect of contrast, no effect of proficiency and no interaction between contrast and proficiency. This suggests that the LA listeners' L2 English proficiency did not facilitate their discrimination of the AusE vowel contrasts.

5.1. Summary: Aim, predictions and results

This study investigated bilingual Lebanese Arabic-English listeners' discrimination of AusE vowel contrasts. The study also examined whether the Lebanese Arabic-English listeners used duration as a cue to discriminate between the AusE long and short vowels. Following the L2LP model (Escudero, 2005; 2009a) this study compared the acoustic similarity between the native and target language vowel contrasts to predict L2 discrimination difficulty. In particular, Lebanese-Arabic listeners were predicted to use duration as a cue to facilitate non-native vowel discrimination because their native vowel inventory includes similar contrasts that differ by length only. Additionally vowel discrimination was expected to be more difficult for those AusE vowel contrasts that differed in both length and quality and showed an acoustic overlap, than contrasts that differed by length only.

The results indicate that the LA listeners do indeed rely on duration as a cue to facilitate their discrimination between the AusE long and short vowel contrasts. In fact, LA listeners' discrimination performance was significantly better than the native AusE listeners with the /ɐ/-/ɐː/ vowel contrast which differs by phonemic length only. As expected, the LA listeners' accuracy was lower than the AusE listeners on the target vowel contrasts that do not perfectly align to the vowels in their own native length contrasts and in which a partial acoustic overlap was identified, specifically with the AusE vowel contrasts /æ/-/ɜː/ and /iː/-/ɪ/. These findings suggest that LA listeners' discrimination performance is equal to and in some cases, better than native speakers when the vowel contrast is similar to their own native contrasts, with no acoustic overlapping. However, duration as a cue may not be sufficient for the discrimination of L2 vowel contrasts that contain vowel quality differences as well as an acoustic overlap. In addition, the results indicate that the LA listeners' proficiency in AusE did not facilitate their vowel discrimination, suggesting that their perception of the AusE vowel contrasts is indeed strongly influenced by their native language. This will be further discussed further below.

5.2. The influence of the L1 on discrimination accuracy

Unlike previous studies that examine speakers or listeners from a native Lebanese-Arabic dialectal background (e.g. Abou Haidar, 1979; Cox & Palethorpe 2005); Gouskava & Hall, 2009; Tuskada, 2012; Shafiro et al., 2013), the present study considered the influence of the native language on L2 vowel discrimination. In particular, LA listeners found the majority of the AusE vowel contrasts relatively easy to discriminate when compared to native AusE listeners. This is highlighted in the results by the absence of a main effect of language indicating that both listener groups did not differ in their overall discrimination accuracy score. Thus, acquiring AusE as a L2 for native LA learners may not be a difficult task. This is due to the fact that both languages employ phonemic length to distinguish vowel contrasts and the availability of similar native long and short vowels (e.g. AusE /ɐ/-/ɐː/ and LA /a/-/aː/) which facilitated the LA listeners' discrimination in this study. This in turn reflects the prominent theoretical models' (SLM, PAM and L2LP) emphasis on the influence of native language phonological categories in non-native speech perception. Specifically, they highlight that L2 learners' and naïve listeners' perception of non-native or L2 sounds is filtered through their native language because non-native speech sounds will be perceived in terms of the particular native categories found in the listeners' speech environment (Flege, 1995, 2003; Best, 1995; Best & Tyler, 2007; Escudero, 2005; 2006; 2009a). The influence of the LA listeners' native vowel categories on the discrimination of the AusE vowel contrasts is supported by the findings of an interaction between contrast and language and a main effect of contrast. This indicates that listeners' discrimination accuracy of some of the vowel contrasts did differ based on their language background. The following section will discuss the influence of the native language on non-native speech perception.

5.3. The influence of native acoustic duration on non-native speech perception

The findings in this study lend support to the L2LP model's (Escudero, 2005; 2006; 2009a) crucial assumption that the variations of dialectal native language backgrounds influences non-native speech perception which has been depicted by previous studies such as Escudero & Williams (2012), Escudero et al., (2012) and Williams & Escudero (2014). In particular, L2 learners' use of the native acoustic dimension of duration in order to distinguish the non-native vowel contrasts. This type of native language influence has been observed in speakers of L2 English from various native backgrounds such as Thai and Japanese (Tsukada, 1999; 2009). Additionally, it has been shown in the production of English vowel contrasts in Arabic accented English (Flege & Port, 1981; Munro, 1993) and in the perception of Arabic and Japanese vowel contrasts by monolingual native Australian English listeners (Tsukada, 2012). Other studies have shown that native vowel duration may be vital for the identification/discrimination of AusE vowel contrasts such as /ɐ-ɐː/ and /iː-ɪ/ (Cox, 2006; Cox & Palethorpe, 2007). In this study, the LA listeners' use of their native acoustic dimension of duration as a cue to perceive non-native vowel was shown to be beneficial when the non-native vowel contrast differed in length only. However it may not be sufficient when there are length/quality differences and an acoustic overlap. In fact, the results in the present study showed that the LA listeners significantly outperformed the native AusE listeners with the

AusE vowel contrast /ɐ/-/ɐː/, which differs only in length, regardless of their L2 English proficiency.

As highlighted, the significant role that the native language can have in the perception of a non-native language has been emphasised in many studies. In this regard, the present study has shown that native LA learners of English make use of duration as a cue to perceptually discriminate long and short non-native AusE vowel contrasts. Similarly, many previous L2 speech perception studies have shown L2 vowel perception results which demonstrate that learners from a diverse range of L1 backgrounds use duration as a cue to distinguish English vowels (e.g. Korean and Mandarin, Flege et al., 1997; Spanish, Escudero 2001; Catalan, Cerbian 2006). For example, Morrison (2002) demonstrated that native Japanese L2 learners of English perceptually identified stimuli containing the English vowels /i/ or /ɪ/ similarly according to their use of duration in their native language. Additionally, Rauber, Escudero, Bion and Baptsista (2005) showed that native Brazilian Portuguese L2 learners of English obtained native-like perception, relying on acoustic cues such as duration to perceptually discriminate the American English vowel pairs /i/-/ɪ/ and /ɛ/-/æ/. Furthermore, Escudero, Benders and Lipski (2009) demonstrated the crucial role that language background has in vowel perception by investigating the categorisation of the Dutch vowel contrast /aː/-/ɑ/ by three groups of listeners': native Dutch, native German and Spanish L2 Dutch learners. The authors showed that both native Dutch and German listeners rely on vowel spectrum more than duration, while Spanish L2 Dutch learners favor vowel duration. With respect to these studies and the present study, the use of vowel duration appears to be the result of native language influence, that is, as a direct transfer of this acoustic dimension from a learner's native language system (Escudero et al., 2009).

5.4. Predicting non-native speech perception

The findings from the present study are largely consistent with the L2LP model's claim that L2 perceptual difficulty can be predicted by the comparison of acoustic similarity between the native and the target language, or more specifically, a visual acoustic comparison and the Euclidean distances. Previous speech perception studies such as Escudero & Chladkova, (2010); Escudero & Vasiliev, (2011); Escudero & Williams, (2011) (2012); Escudero et al., (2014) and Elvin et al., (2104) have shown that detailed acoustic comparisons and Euclidean distances, result in successful predictions of learning new sounds. In the present study, the LA listeners indeed found the AusE vowel contrast /æ/-/ɜː/ and /iː/-/ɪ/ the most difficult to discriminate. This is explained by the fact that these vowel contrasts do not perfectly align to the vowels in the LA listeners' native length contrast, which in turn exhibit patterns of acoustic overlapping. As a result discrimination difficulties are often identified in vowel contrasts where both target vowels in the contrasts are mapped to the same multiple native vowel categories (Escudero, 2005; 2009). In the case of the AusE vowel contrast /ʊ/-/ʉː/ and /oː/-/ɔ/, the results are consistent with the hypothesis that the LA listeners will encounter minimal discrimination difficulties with these AusE vowel contrasts. This is due to the presence of similar native long and short vowels of close acoustic proximity enabling the LA listeners to perceptually map each of the vowels in the target contrast to different native LA vowel categories in terms of the subset learning scenario (Escudero, 2005; 2009). For the AusE /ɐ/-/ɐː/ vowel contrast, the results indicated that indeed the LA listeners found this contrast easy to discriminate according to the similar learning scenario (L2LP; Escudero, 2005; 2009a). This is most likely due to the existence of acoustically similar native vowel contrasts which differ in length only, enabling the LA listeners to perceptually map each vowel in the contrast to a corresponding native vowel resulting in accurate discrimination. In contrast, the findings were not consistent with the prediction for the LA listeners' discrimination of the AusE vowel contrast /e/-/eː/, even though an acoustically similar native vowel contrast that differs by length exists. However, the discrimination accuracy scores for this vowel contrast showed that it was difficult to discriminate for both the LA and native AusE listeners. This may be explained as a result of the fVf context (*fairf* and *fef)* in which these two vowels were extracted because the length difference between the vowels may be subtle. Another possible explanation, as stated by Strange, Edman and Jenkins (1979) is that vowels are better identified in a "consonantal syllabic context" (p. 643) rather than as an isolated vowel. This is attributed to the lack of acoustic information that cannot be captured and that appears to have a significant influence on the recognition of vowels (Strange, et al., 1979). Moreover, Elvin et al. (2016) emphasised that vowel duration is affected by the consonantal contexts in which vowels are produced, affecting the prediction of difficulty based on a comparison of acoustic similarity between the native and target language. Thus, as this AusE vowel contrast /e/-/eː/ is primarily distinguished by length, the /hVd/ context may be a more suitable due to the observed longer durations for vowels in this context (Elvin et al., 2016) which may result in the LA listeners discriminating this contrast without difficulties.

Furthermore, the identification task which was also used to make predictions relating to the listeners' discrimination of the AusE vowel contrasts is discussed below including probable explanations for the participants' performance.

5.4.1. The identification task

Results from the AusE identification task were used to make additional predictions regarding L2 discrimination difficulty. The results indicated that both listener groups differed in their overall identification of the AusE vowels. They also differed based on the selection of the response labels for each of the 13 AusE vowels and found the same vowels equally easy or difficult to identify. As predicted the AusE listeners' attained overall higher discrimination accuracy of the AusE vowel contrasts than the LA listeners and both listener groups found the same AusE vowel contrasts equally difficult or easy to discriminate. Both groups found AusE /ʊ/-/ʉː/ the easiest to discriminate while LA listeners had difficulties with AusE /iː/-/ɪ/.

An explanation for the group difference in the identification task but not in the XAB task could be related to the number of responses in each task (Elvin, 2012). Recall that the XAB task consisted of only two responses "2" or "3", whereas the AusE identification task had 13 responses orthographically displayed, which offered the participants multiple options. Benders, Escudero and Sjerps (2012) examined this notion of contextual influences on the vowel categorisation of Peruvian Spanish listeners. They measured the influence of the number or responses by presenting half of the listeners with two responses (Spanish /i/ and /e/) and the other half with five (Spanish /i/, /e/, /a/, /o/ and /u/) (Benders et al., 2012). The authors found an influence on the number of response categories for vowel categorisation, where the listeners with five options shifted their boundary between /i/ and /e/ less than listeners with two responses. Hence, future research could be conducted to test whether the number of response categories does influence vowel identification patterns in LA English bilinguals.

Another explanation for the difference between the AusE and LA listeners' performance in the identification task and not in the XAB task may be due to the influence of orthography on vowel identification (Elvin, 2012). Recall that no orthographic labels were used in the XAB tasks, the participants were not aware of the language presented and instructions were provided in English for all participants. Therefore the LA bilinguals could have performed in a similar way to the AusE monolinguals because only English was used or because they are as good as the AusE listeners at discriminating AusE vowel contrasts. However further research would need to be conducted in order to confirm these possible explanations.

In contrast the AusE vowel identification task presented participants with AusE auditory stimuli that were required to be matched with one of the 13 AusE orthographic labels. The AusE and LA listeners' performance in the identification task differed in their selection of the response labels for each of the 13 AusE vowels, but they found the same vowels equally easy or difficult to identify. This may be explained by the difference of vowel context that was used in the identification task for the auditory stimuli and orthographic response labels. That is, the auditory vowel stimuli were vowels extracted from the /fVf/ context and the corresponding 13 AusE response categories were in the /hVd/ context (*had, haired, hard, hawed, head, heared, heed, hid, hod, hood, hud, hurd and who'd*). Therefore this may have influenced the participants' performance because vowels in the /hVd/ context have been shown to be less comparable to other contexts such as /fVf/ (Elvin et al., 2016). However, future research would need to be conducted to confirm this explanation using the same contexts with the same population of participants.

5.5. The role of L2 proficiency in speech perception

The initial findings from the results demonstrated no effect of language in the overall discrimination accuracy of the AusE vowel contrasts between the LA and AusE listener groups. This in turn suggested a possible effect relating to the LA group of listeners' different L2 English proficiency (e.g., Bohn & Flege, 1992). These listeners' discrimination results were divided according to their self-evaluation of L2 English proficiency (e.g. low, intermediate or advanced). Participants were included in the low group (LA_1) if they indicated that their English proficiency was at an intermediate level or lower and participants included in the high group (LA_2) were those who indicated that their English was at an advanced level or higher. The results showed no contrast and proficiency interaction suggesting that their L2 English proficiency did not facilitate discrimination of AusE vowel contrasts.

The lack of difference between the LA and AusE listeners in terms of the LA groups L2 English proficiency is explained by the LA listeners' use of duration as a cue to facilitate discrimination. The LA listeners performed like the AusE listeners in that they found the same vowels difficult or easy to perceptually discriminate as shown by the main effect of contrast, but they did not achieve native-like performance. On the other hand, the LA group of participants could be considered established L2 learners because they have been exposed to and have resided in an AusE language environment for up to 18 years with some form of formal English language instruction prior to arrival. Consequently, the lack of perceptual discrimination difference between the LA_1 and LA_2 in terms of their L2 English proficiency can be attributed to this aspect. However, in order to confirm that the LA listeners are established L2 learners, their proficiency/experience needs to be measured by comparing experienced and inexperienced L2 learners from a LA background and the distance between native and L2 sounds (Flege et al., 1997)

The SLM (Flege, 1995) and PAM (Best, 1995) both maintain that increased L2 experience affects the ability to distinguish the differences between native and L2 sounds which enhances the formation of target language sound categories. Research pertaining to L2 experience and proficiency has demonstrated its positive influence in L2 speech perception and production (e.g. Yamada & Tohkura, 1990; Best & Strange, 1992; Flege, Tagaki & Mann, 1995, 1997). For example, Ingram and Park (1997) showed that monolingual Koreans perceive AusE vowels in terms of their native sound categories, whereas Korean learners of English showed separate categories for the L2 vowel sounds. Moreover, Bohn and Flege

(1992) showed German-L2 English experienced and inexperienced learners differ from each other in the production of the new English vowel /æ/. The experienced group produced this vowel close to native English productions. English language experience did not affect the listeners' production of the similar English vowels /iː/, /ɪ/ and /ɛ/, as no phonetic categories for the similar L2 sounds were formed (Bohn & Flege, 1992).

Other L2 speech perception studies do not lend support for the predicted influence of L2 experience/proficiency. For example, Munro (1993) found no evidence that increased L2 experience with English influenced the relative success of Arabic L2 English speakers' production of English vowels. Similarly, Munro and Fox (1994) showed that experienced Spanish learners of English did not differ significantly from inexperienced learners in perceptually rating the degree of dissimilarity of English and Spanish vowels. Finally, Cerbian (2006) investigated two groups of Catalan learners of English with varying experience in the perceptual categorisation of the non-native vowels /i/, /ɪ/ and /ɜ/. The results failed to indicate that L2 experience has an effect on the ability of listeners to distinguish the differences between native and L2 sound categories (Cerbian, 2006). Thus, the present study's findings lend support to the notion that L2 proficiency and experience do not impact L2 listeners' perception of L2 sounds. The findings from this study's discrimination accuracy analysis based on the LA participants' L2 English proficiency did not show an interaction between contrast and proficiency. This in turn suggests that L2 English proficiency did not influence the LA listeners' perceptual discrimination of the AusE vowel contrasts.

5.6. Summary

Within this chapter, the results presented in Chapter 4 were discussed. In particular, it focused on a discussion explaining the influence of the LA listeners' native language on the discrimination accuracy of the Australian English vowel contrast with regard to acoustic similarity. The prominent theoretical models' (SLM, PAM and L2LP) emphasis on the influence of native language phonological categories in non-native speech perception was highlighted. The influence of the native language was indeed the case for the LA listeners due to the availability of similar native long and short vowels which are similarly distinguished by length (e.g. AusE /ɐ/-/ɐː/ and LA /a/-/aː/) and the fact that both languages employ phonemic length to distinguish vowel contrasts facilitated the LA listeners' discrimination.

This chapter also discussed the influence of the LA listeners' native acoustic dimension of duration as a cue to distinguish the six AusE non-native vowel contrasts. Moreover, the presented results were shown to lend support to the L2LP models' (Escudero, 2005, 2006, 2009a) crucial assumption that variations of dialectal native language backgrounds influence non-native speech perception. Furthermore, this chapter discussed the predictions and confirmed their consistency with the L2LP model's claim that L2 perceptual difficulty can be predicted by the comparison of acoustic similarity between the native and target languages. The identification task which was used to make further prediction was also discussed.

Finally, Chapter 5 discussed the lack of effect of the LA listeners' L2 English proficiency in the perceptual discrimination of the AusE vowel contrasts. The possible explanations presented included the LA listeners' use of their native acoustic dimension duration as a cue and that they can be considered as established L2 English learners due to their period of exposure and residence in an AusE environment. The following chapter consists of an outline of this study's aim, a chapter by chapter summary, the implications and limitations of the findings.

Chapter 6 Conclusion

This L2 speech perception study has investigated native LA L2 English listeners' discrimination accuracy of six AusE vowel contrasts which was compared to native monolingual Australian English listeners. In particular, this study considered the role of acoustic similarity of vowels and acoustic cues and examined whether Lebanese Arabic-English listeners' discrimination accuracy was influenced by the role of duration as a cue to facilitate discrimination.

Predictions were formulated based on a comparison of acoustic properties of the native language LA and the target language AusE and in line with the L2LP models (Escudero, 2005, 2009a) framework. Specifically, we predicted that the Lebanese-Arabic English bilingual listeners will have more difficulties with accurately discriminating the AusE vowel contrasts than the native Australian English listeners if they do not use duration as a cue. This is due to the fact that both languages employ duration as a cue in native phonological contrasts, which in turn highlights the influence of the native language vowel inventory in L2 speech perception.

6.1. Chapter–by-chapter summary

Chapter 1 one presented an introduction to the field of non-native and L2 speech perception and outlined the purpose of this present study, including the predicted findings.

Chapter 2 provided a literature review based on the purpose of the present study including a description three prominent theoretical models which explain non-native and L2 speech perception and how listeners assimilate or map the sounds of a new language. Subsequently, this study’s purpose, motivation, and a detailed description entailing acoustic and phonological properties of the two languages vowel systems, namely Lebanese Arabic and Australian English were presented. To conclude, an outline of the predictions for the present study based on a comparison of the vowel acoustic properties of the native and target language.

Chapter 3 consisted of a description of the methodology used to test the predictions for the present study. The two participant groups are presented, namely Lebanese-Arabic bilinguals and Australian English monolinguals and the sounds used as stimuli are described. The XAB vowel identification task and categorical discrimination task, including the procedures used to administer the experiments were presented.

Chapter 4 initially outlined the results from the identification task to additionally predict difficulty in discrimination, followed by the XAB categorical discrimination task. The results indicated that there were no group differences in the XAB task. An effect of vowel contrast was shown as both groups found some vowel contrasts more difficult to discriminate than others. Additionally, a contrast by language interaction was revealed as both groups discrimination accuracy of the vowel contrasts differed based on their language background. Furthermore, the results did not show a contrast by proficiency interaction; the LA groups’ L2 language proficiency did not play a role in their perceptual discrimination of the AusE vowel contrasts

Chapter 5 provided a detailed discussion of the results from the identification and XAB categorical discrimination task in Chapter 4. It discussed the influence of the LA listeners’ native language on the discrimination accuracy of the Australian English vowel contrasts which was confirmed by the prominent theoretical models. Furthermore, the discussion attempted to explain the lack of overall discrimination accuracy difference between the LA and AusE listeners.

6.2. Implications, limitations and future research

Adult L2 learners very often are unaware that the difficulties encountered with the pronunciation of a target language are attributed to their perception of the speech sounds of a new language, which is influenced by the existing sounds in their native language. This in turn highlights the significant role of learners' native language in the ease or difficulty of acquiring a new language. The findings relating to Lebanese-Arabic L2 English learners from this research can inform second language teaching as they demonstrate some of the potential difficulties that the learners will encounter when learning Australian English. Also, the findings allow for a greater understanding about the learners' ability during acquisition which can be implemented within lessons. For example, it is predicted that Lebanese-Arabic L2 English learners should not have much difficulties with the recognition and production of words that consist of vowels that only differ by phonemic length and are similar to vowels in their native vowel inventory. Conversely, words that consist of vowels that differ by both length and quality are predicted to be difficult to recognise and produce. Furthermore, this study contributed to this field of research by providing insight about a much understudied language group which is one of the largest population groups in Sydney.

However, there are specific issues that arise concerning the improvement of the present study. Firstly, the acoustic predictions were limited because published LA acoustic data was used, which does not entirely reflect the LA dialect of the listeners tested in the present study. Therefore, further research is required entailing a comprehensive acoustic analysis of Lebanese Arabic. This would also consist of individual learners' native production and perception as well as their responsiveness to rapid perception training, in order to make accurate predictions for L2 learning in terms of the L2LP model (Escudero, 2005, 2009a). Furthermore, in order to improve the reliability of the results, a greater number of participants from both groups need to be tested. The effect of the LA groups' L2 proficiency was examined with groups of less than 10 participants each (LA_1 = 9 and LA_2 = 8). A greater sample per proficiency group may yield an influence of L2 proficiency on the accuracy with which the LA listeners discriminate the AusE vowel contrasts.

6.3. Concluding remarks

The present study contributes to the field on non-native and L2 speech perception research and considered the dialectal language background of native Arabic speakers rather than the high language variety Modern Standard Arabic. The study aimed at investigating Lebanese Arabic-English bilinguals' discrimination of Australian English vowel contrasts. The study found that the influence of native LA acoustic dimension of duration was utilised by the group of listeners to facilitate discrimination. These findings inform L2 teaching and learners by highlighting possible issues LA students may encounter and explain the outcomes when acquiring the speech sounds of the Australian English language. Further research is required to test the reliability of the findings and investigate the Lebanese Arabic dialect at the level of speech production.

References

Abu-Haidar, F. (1979). *A Study of the spoken Arabic of Baskinta.* Leiden: Brill.

Alghamdi, M. M. (1998). A spectrographic analysis of Arabic vowels: a cross-dialect study. *Journal of the King Saud University – Arts, 10* (1), 3-24. http://hdl.handle.net/123456789/372

Amir, N., Amir, O., & Rosenhouse, J. (2014). Colloquial Arabic vowels in Israel: A comparative acoustic study of two dialects. *The Journal of the Acoustical Society of America*, *136*(4), 1895-1907. doi: 10.1121/1.4894725.

Amir, N., Amir, O., & Rosenhouse, J. (2014). Vowel systems of quantity languages compared: Arabic dialects and other languages. *Acoustical Society of America*, 2, 1-10. doi:10.1121/1.4880205

Benders, T., Escudero, P., & Sjerps, M. J. (2012). The interrelation between acoustic context effects and available response categories in speech sound categorization. *The Journal of the Acoustical Society of America*, 131(4), 3079-3087.

Best, C. T., & Strange, W. (1992). Effects of phonological and phonetic factors on cross-language perception of approximants. *Journal of phonetics*, *20*(3), 305-330.

Best, C. T. (1995). A direct realist view of cross-language speech perception. *Speech perception and linguistic experience: Issues in cross-language research* (pp.171-204). http://www.haskins.yale.edu/Reprints/HL0996.pdf

Best, C. T., & Tyler, M. D. (2007). Nonnative and second-language speech perception: Commonalities and complementarities. In M. J. Munro & O.–S. Bohn (Ed.), *Second language speech learning: The role of language experience in speech perception and production*, (pp. 13-34). Amsterdam: John Benjamins

Betts, K., & Healy, E. (2006). Lebanese Muslims in Australia and social disadvantage. *People and place*, *14*(1), 24.

Bohn, O. S., & Flege, J. E. (1990). Interlingual identification and the role of foreign language experience in L2 vowel perception. *Applied Psycholinguistics*, *11*(03), 303-328. http://www.jimflege.com/files/Bohn_Flege_interlingual_identification_AP_1990.pdf

Bohn, O. S. (1995). Cross-language speech perception in adults: First language transfer doesn't tell it all. *Speech perception and linguistic experience: Issues in cross-language research*, 279-304.

Cebrian, J. (2006). Experience and the use of non-native duration in L2 vowel categorization. *Journal of Phonetics*, *34*(3), 372-387. doi.org/10.1016/j.wocn.2005.08.003

Cadora, F. J. (1976). Contrastive compatibility in some Arabic dialects and their classification. *Anthropological Linguistics*, *18*(9), 393-407. http://www.jstor.org/stable/30027588

Chládková, K., & Podlipský, V. J. (2011). Native dialect matters: Perceptual assimilation of Dutch vowels by Czech listeners. *The Journal of the Acoustical Society of America*, *130*(4), EL186-EL192. doi.org/10.1121/1.3629135

Clopper, C. G. (2012). Effects of dialect variation on the semantic predictability benefit. *Language and Cognitive Processes*, *27*(7-8), 1002-1020. doi.org/10.1080/01690965.2011.558779

Cochrane, G. R. (1970). Some vowel durations in Australian English. *Phonetica*, *22*(4), 240-250. doi:10.1159/000259325

Colantoni, L., Steele, J., & Escudero, P. (2015). *Second Language Speech*. Cambridge University Press.

Cowel, M. (1964). *A reference grammar of Syrian Arabic.* Washington, DC: Georgetown University Press.

Cox, F. (2006). The acoustic characteristics of /hVd/ vowels in the speech of some Australian teenagers. *Australian Journal of Linguistics*, *26*(2), 147-179. doi: 10.1080/07268600600885494

Cox, F. & Palethorpe, S. (2007). Australian English. *Journal of the International Phonetic Association*, *27*(3), 341-350. http://clas.mq.edu.au/felicity/Papers/CoxPalethorpe_Interspeech08new.pdf

Cox, F. & Palethorpe, S. (2011). Timing differences in the VC rhyme of standard Australian English and Lebanese Australian English. *ICHPhS XV11*, *17*(21), 528-531. http://www.researchgate.net/profile/Felicity_Cox/publication/268431405_timing_differences_in_the_vc_rhyme_of_standard_australian_english_and_lebanese_australian_english/links/549a01e20cf2d6581ab157c4.pdf

Elvin, J., (2012). The perception of Portuguese vowels by Australian English monolinguals and Spanish English Bilinguals. Unpublished Honours thesis, Western Sydeny University.

Elvin, J., & Escudero, P. (2014). Perception of Brazilian Portuguese vowels by Australian English and Spanish listeners. *Concordia Working Papers in Applies Linguistics*, *5* 145-156. http://doe.concordia.ca/copal/documents/12_Elvin_Escudero_Vol5.pdf

Elvin, J., Escudero, P., & Vasiliev, P. (2014). Spanish is better than English for discriminating Portuguese vowels: acoustic similarity versus vowel inventory. *Frontiers in Psychology, Language Sciences*, 5:1188

Elvin, J., & Escudero, P. (2015). Predicting vowel discrimination accuracy through cross-linguistic acoustics analysis. https://www.internationalphoneticassociation.org/icphs.../ICPHS0945.pdf

Elvin, J., Vasiliev, P. & Escudero, P. (in press). ‘Production and Perception in the Acquisition of Spanish and Portuguese’ in M.Gibson & J.Gil (eds) *Romance Phonetics and Phonology,* Oxford University Press.

Escudero, P., & Boersma, P. (2002). The subset problem in L2 perceptual development: Multiple-category assimilation by Dutch learners of Spanish, *Proceedings of the 26th annual Boston University Conference on Language Development,* edited by B. Skarabela, SFish, and A. H. –J. Do. Cascadilla Press, Somerville, MA, pp. 208-19

Escudero, P., & Boersma, P. (2004). Bridging the gap betweenL2 speech perception research and phonological theory. *Studies in Second Language Acquisition.* 26, 551–585. doi: 10.1017/S027226310404002

Escudero, P. (2005). Linguistic perception and second language acquisition: Explaining the attainment of optimal phonological categorization. PhD dissertation, Utrecht University: LOT Dissertation Series 113.

Escudero, P. (2006). Second language phonology: the role of perception. In M.Pennington (Ed). *Phonology in Context* (pp. 109–134). NewYork: Palgrave Macmillan.

Escudero, P. (2009a). The linguistic perception of similar L2 sounds. In P.Boersma and S.Hamann (Ed). *Phonology in Perception* (pp.152–190). Germany: Mouton de Gruyter.

Escudero, P., Boersma, P., Rauber, A. S., & Bion, R. A. (2009b). A cross-dialect acoustic description of vowels: Brazilian and European Portuguese. *The Journal of the Acoustical Society of America*, *126*(3), 1379-1393.doi.org/10.1121/1.3180321

Escudero, P., & Chládková, K. (2010). Spanish listeners’ perception of American and southern British English vowels. *The Journal of the Acoustical Society of America*, *128*(5), 254-260. doi.org/10.1121/1.3488794

Escudero, P., & Williams, D. (2011). Perceptual assimilation of Dutch vowels by Peruvian Spanish listeners. *The Journal of the Acoustical Society of America, 129*(1), EL1-EL7. doi.org/10.1121/1.3525042

Escudero,P., & Vasiliev,P. (2011).Cross-language acoustic similarity predicts perceptual assimilation of Canadian English and Canadian French vowels. *The Journal of the Acoustical Society of America,* 130(5), EL277–EL283. doi:10.1121/1.3632043

Escudero, P., & Wanrooij,K. (2010). The effect of L1 orthography on non-native and L2 vowel perception. *Language and Speech,* 53, 343–365. doi:10.1177/0023830910371447

Escudero, P. & Vasiliev, P. (2011). Cross-language perception of Brazilian Portuguese vowels by Californian English speakers. *The Journal of the Acoustical Society of America, 130*(4), 277-283. doi: 10.1121/1.3632043

Escudero, P. & Williams, D. (2012). Native dialect influences second-language vowel perception: Peruvian versus Iberian Spanish learners of Dutch. *The Journal of the Acoustical Society of America,* 131(5), EL406–EL412. doi:10.1121/1.3701708

Faris, M. M., Best, C. T., & Tyler, M. D. (2016). An examination of the different ways that non-native phones may be perceptually assimilated as uncategorized. *The Journal of the Acoustical Society of America, 139*(1), EL1-EL5. doi.org/10.1121/1.4939608

Ferguson, C. A. (1959). Diglossia. *Word,* (15), 325-340. http://www.mapageweb.umontreal.ca/tuitekj/cours/2611pdf/Ferguson-Diglossia.pdf

Flege, J. & Port, R. (1981). Cross-language phonetic interference: Arabic to English. *Language & Speech*, 24, 125-146. http://jimflege.com/files/Flege_Port_phonetic_interference_L_S_1981.pdf

Flege, J. E. (1984). The Effect of linguistic experience on Arab's perception of the English /s/ vs. /z/ contrast. *Folia linguistica*, *18*(1-2), 117-138. http://jimflege.com/files/Flege_Arabs_perception_FL_1984.pdf

Flege, J. (1995). Second-language Speech Learning: Theory, Findings, and Problems. In W. Strange (Ed) *Speech Perception and Linguistic Experience: Issues in Cross-language research. Timonium* (pp.229-273). MD: York Press.

Fox, R. A., Flege, J. E., and Munro, M. J. (1995). The perception of English and Spanish native vowels by native English and Spanish listeners: a multidimensional scaling analysis. *The Journal of the Acoustical Society of America, 9*, 2450-2551. doi: 10.1121/1.411974

Flege, J. E., Takagi, N., & Mann, V. (1996). Lexical familiarity and English-language experience affect Japanese adults' perception of/ɹ/and/l. *The Journal of the Acoustical Society of America*, *99*(2), 1161-1173. doi.org/10.1121/1.414884

Flege, J. (1997). English vowel production by Dutch talkers: More evidence for the "new" vs "similar" distinction". In A. James & J. Leather (Ed.), *Second-language speech, Structure and process. Studies in second language acquisition,* 13. (pp. 11-52). Berlin: Walter de Gruyter. http://jimflege.com/files/Flege_in_James_1997.pdf

Flege, J., Bohn, O-S., & Jang, S. (1997). The effect of experience on nonnative subjects' production and perception of English vowels. *Journal of Phonetics*, 25, 437-470. http://jimflege.com/files/Flege_Bohn_effect_experience_JP_1997.pdf

Flege, J. E. (2003). Assessing constraints on second-language segmental production and perception. *Phonetics and phonology in language comprehension and production: Differences and similarities, 6*, 319-355. http://jimflege.com/files/Flege_in_Meyer_2003.pdf

Haraty, R. A., & El Ariss, O. (2007). CASRA+: a colloquial Arabic speech recognition application. *American Journal of Applied Sciences*, *4*(1), 23-32.

Holes, C. (2004). *Modern Arabic: Structures, functions and varieties.* Washington, Dc: Georgetown University Press.

Humphrey, M. (1998). Identity and mediated violence: Ethics conflict, the media and globalisation. In D. Bretherton (Ed.) *No Longer Black & White: Media Responsibility in Ethics and Racial Conflict.* Melbourne: International Conflict Resolution Centre, University of Melbourne. pp. 170-180.

Gouskova, M., & Hall, N. (2009). Acoustics of epenthetic vowels in Lebanese Arabic. *Phonological argumentation: Essays on evidence and motivation*, 203-225. http://www.nyu.edu/projects/gouskova/downloads/gouskova_hall_acoustics_of_epenthetic_vowels_lebanese_arabic.pdf

Holt, L. L., & Lotto, A. J. (2006). Cue weighting in auditory categorization: Implications for first and second language acquisition). *The Journal of the Acoustical Society of America*, *119*(5), 3059-3071. doi.org/10.1121/1.2188377

Iverson, P., & Evans, B. G. (2007). Learning English vowels with different first-language vowel systems: Perception of formant targets, formant movement, and duration. *The Journal of the Acoustical Society of America*, *122*, 2842. http://www.phon.ucl.ac.uk/home/paul/IversonEvans2007.pdf

Kondaurova, M., & Francis, A. (2008). The relationship between native allophonic experience with vowel duration and perception of the English tense/lax vowel contrast by Spanish and Russian listeners. *Journal of the Acoustical Society of America*, 124, 3959–3971. doi: 10.1121/1.2999341

Ladefoged, P., & Johnson, K. (2011). *A course in phonetics*. http://bayanbox.ir/view/2038311472801972102/A-Course-in-Phonetics.pdf

Mitleb, F. (1984). Vowel length contrast in Arabic and English: a spectrographic test. *Journal of Phonetics, 12*(3), 229-235. doi: 10.1121/1.2020320

Mayr, R., & Escudero, P. (2010). Explaining individual variation in L2 perception: Rounded vowels in English learners of German. *Bilingualism: Language and Cognition*, *13*(03), 279-297. doi: 10.1017/S1366728909990022

Munro, J. M., (1993). Productions of English vowels by native speakers of Arabic: acoustic measurements and accentedness ratings. *Language and Speech, 36*(1), 39-66. doi: 10.1177/002383099303600103

Newman, D., & Verhoeven, J. (2002). Frequency analysis of Arabic vowels in connected speech. *Antwerp papers in linguistics, 100*, 77-86. http://dro.dur.ac.uk/4419/1/35758.pdf

Pols, L. C. W. (1987). Distance measures: physical and perceptual aspects. *Proceedings (Instituut voor Fonetische Wetenschappen, Universiteit van Amsterdam)*, *11*, 59-66. http://hdl.handle.net/11245/1.423031

Port, R. & Mitleb, F. (1983) Segmental features and implementation in acquisition of English by Arabic speakers, *Journal of Phonetics, 11*, 219-231. Retrieved from the Western Sydney University database.

Rauber, A. S., Escudero,P., Bion, R.A.H., & Baptista, B.O.(2005). The interrelation between the perception and production of English vowels by native speakers of Brazilian Portuguese*, In Proceedings of Interspeech*, Lisbon, 2913–2916. www.nupffale.ufsc.br

Shafiro, V., Levy, E. S., Khamis-Dakwar, R., & Kharkhurin, A. (2013). Perceptual confusions of American-English vowels and consonants by native Arabic bilinguals. *Language and Speech*, *56*(2), 145-161. doi: 10.1177/0023830912442925

Simon, E. & D'Hulster, T. (2012). The effects of experience on the acquisition of a non-native vowel contrast. *Language Sciences, 34*, 269-283. doi:10.1016/j.langsci.2011.10.002

Strange, W., Edman, T. R., & Jenkins, J. L. (1979). Acoustic and phonological factors in vowel identification. *Journal of Experimental Psychology: Human Perception and Performance, 5*(4), 643. doi.org/10.1037/0096-1523.5.4.643

Toscano, J. C., & McMurray, B. (2010). Cue integration with categories: Weighting acoustic cues in speech using unsupervised learning and distributional statistics. *Cognitive science, 34*(3), 434-464. doi: 10.1111/j.1551-6709.2009.01077.x

Tsukada, K. (2009a). An acoustic comparison of vowel length contrasts in Arabic, Japanese and Thai: Durational and spectral data. *International Journal of Asian Language Processing, 19*, 127–138. Retrieved from http://www.researchgate.net/profile/Kimiko_Tsukada/publications

Tsukada, K. (2009b). Durational characteristics of English vowels produced by Japanese and Thai second language (L2) learners. *Australian Journal of Linguistics, 29,* 287–299. http://www.researchgate.net/publication/232992397_Durational_Characteristics_of_English_Vowels_Produced_by_Japanese_and_Thai_Second_Language_(L2)_Learners

Tsukada, K. (2012). Non-native Japanese listeners' perception of vowel length contrasts in Japanese and modern standard Arabic (MSA). *Second Language Research, 28* (2), 151-168. doi: 10.1177/0267658311435870

Vasiliev, P. (2013). *The Initial State for Californian English Learners of Spanish and Portuguese Vowels*. PhD thesis, University of California. http://escholarship.org/uc/item/39k3j8d

Williams, D., & Escudero, P. (2014a). Influences of listeners' native and other dialects on cross-language vowel perception. *Frontier in psychology, 5,* 1065.doi.org/10.3389/fpsyg.2014.01065

Williams, D., & Escudero, P. (2014b). Native and non-native speech perception. *Acoustics Australia*,*42*(2),79-83. http://www.acoustics.asn.au/journal/2014/Vol42No2_WILLAMS.pdf.