The Effects of Experience on the Perception of German Rounded Vowels by Native Speakers of American English

Bradley J. York
Brigham Young University - Provo
THE EFFECTS OF EXPERIENCE ON THE PERCEPTION
OF GERMAN ROUNDED VOWELS
BY NATIVE SPEAKERS OF AMERICAN ENGLISH

by
Bradley Jay York

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of a thesis submitted by

Bradley Jay York

This thesis has been read by each member of the following graduate committee and by majority vote has been found to be satisfactory.

________________________________________
Date     Laura Catharine Smith, Chair

________________________________________
Date     C. Ray Graham

________________________________________
Date     Wendy Baker
As chair of the candidate’s graduate committee, I have read the thesis of Bradley Jay York in its final form and have found that (1) its format, citations, and bibliographical style are consistent and acceptable and fulfill university and department style requirements; (2) its illustrative materials including figures, tables, and charts are in place; and (3) the final manuscript is satisfactory to the graduate committee and is ready for submission to the university library.

________________________  __________________________________________
Date                      Laura Catharine Smith
                          Chair, Graduate Committee

Accepted for the Department

________________________  __________________________________________
Date                      Michael D. Bush
                          Graduate Coordinator, Center for Language Studies

Accepted for the College

________________________  __________________________________________
Date                      John R. Rosenberg
                          Dean, College of Humanities
ABSTRACT

THE EFFECTS OF EXPERIENCE ON THE PERCEPTION OF GERMAN ROUNDED VOWELS BY NATIVE SPEAKERS OF AMERICAN ENGLISH

Bradley Jay York
Center for Language Studies
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This study examines the effects of experience in German on the categorical perception of German rounded vowels, namely /uː/, /ʊ/, /oː/, /ɔ/, /yː/, /ʏ/, /øː/, and /œ/, by native speakers of American English (AE). Of special interest is whether more experience in German leads to more accurate perception of German front rounded vowels, namely /yː/, /ʏ/, /øː/, and /œ/, which do not have correlates in American English and are well known to cause perceptual problems for native AE speakers (Strange, Bohn, Trent, & Nishi, 2004). Subjects in this study were students at Brigham Young University that were divided into 4 experimental groups: students at the end of first-semester German with no residency in a German-speaking country (101 group); students at the end
of third-semester German with no residency (201 group); students in third-year or higher
German courses with less than 4 months of residency (300+ group); students in third-year
or higher courses with 16 or more months of residency (300+Resi group). A control
group of native German speakers also participated. Subjects completed a forced-choice
identification task in which they selected the German word they thought they heard. The
results of the task indicate that experience in German did affect native AE-speaking
subjects’ overall identification accuracy of German rounded vowels. In particular, a
statistically significant difference was found between the 101 and 300+Resi groups for all
German rounded vowels except /uː/ and /ʊ/, suggesting that experience significantly
affected AE subjects’ perception of all of these vowels except /uː/ and /ʊ/.
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I would like to dedicate this thesis to the memory of my grandparents, Dr. Rulon L. Bradley and Cleo Bradley Haroldsen. They did not live to see me finish my studies at Brigham Young University, although I continue to feel their influence in my life to this day.
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List of Abbreviations

AE = American English
ANOVA = Analysis of variance
BYU = Brigham Young University
C = Consonant
FLA = Foreign Language Acquisition
IPA = International Phonetic Alphabet
L1 = First language, native language
L2 = Second language, foreign language
LDS = (The Church of Jesus Christ of) Latter-day Saints
LOR = Length of residence
PAM = Perceptual Assimilation Model
RT = Response time
SLA = Second Language Acquisition
SLM = Speech Learning Model
V = Vowel
/_/ = phoneme
[[_]] = allophone
<_> = spelled form
:: = lengthening of a vowel
Chapter 1
Introduction

“Simply phonetics. The science of speech. That’s my profession; also my hobby. Happy is the man who can make a living by his hobby! You can spot an Irishman or a Yorkshireman by his brogue. I can place any man within six miles. I can place him within two miles in London. Sometimes within two streets.”

—Professor Henry Higgins, *Pygmalion*, Act I

1.0 Introduction

Many recent studies in the field of Second Language Acquisition (SLA) have focused on the perception of second language (hereafter L2)¹ speech sounds. Some of these studies (e.g., Best & Tyler, 2007; Bohn & Flege, 1990, 1997; Flege & Liu, 2001) have specifically examined how the perception of L2 speech sounds (i.e., vowels and consonants) is affected by a learner’s first, or native language (hereafter L1) background and by a learner’s experience in the L2. The results of these studies have provided researchers with many insights into the process of SLA, such as how L2 learners differ from native speakers of the L2 (Flege, 2003b; Flege & MacKay, 2004; Levy & Strange, 2008) as well as how the perception and production of L2 sounds are related (Flege, 1991; Rochet, 1995).

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¹ The terms “second language” and “L2” refer to any foreign language learned or acquired in addition to the first, or native language.
It has been widely accepted in SLA research that an L2 sound must be accurately perceived before it can be accurately produced (cf. Flege, MacKay, & Meador, 1999; Werker & Pegg, 1992; Wode, 1996). Some SLA researchers (e.g., Flege, 1992, 1995; Rochet, 1995) have extended this claim, saying that many errors in L2 production are the result of inaccurate L2 perception. Some studies (e.g., Goto, 1971; Sheldon & Strange, 1982) have shown, however, that L2 learners display greater accuracy in L2 production than in L2 perception, and other studies (e.g., Borden, Gerber, & Milsark, 1983; Bradlow, Pisoni, Akahane-Yamada, & Tohkura, 1997; Lambacher, Martens, Kakehi, Marasinghe, & Moholt, 2005) have shown that L2 learners can improve their L2 production after training in L2 perception. These studies suggest that the relationship between perception and production is not as direct as many researchers have supposed, and that “production can proceed independently of perception” (Smith, 2001:3).

Many researchers (e.g., Bohn & Flege, 1990; Flege, Bohn, & Jang, 1997; Levy & Strange, 2008; Trofimovich, Baker, & Mack, 2001) have examined the perception of L2 vowels by learners at different levels of L2 experience. Such studies have focused on vowels that are well known to be difficult for L2 learners to acquire. Bohn and Flege (1990), for example, examined the perception of the English vowel /æ/ (as in the word *bat*) by native speakers of German. The vowel /æ/ does not exist in German, and many Germans in Bohn and Flege’s study, particularly those with little experience in English, showed difficulty perceiving this vowel. Germans with more experience, however, showed increased accuracy in perceiving it.

Several additional studies (e.g., Kingston, 2003; Polka, 1995; Schultheiss, 2008) have examined the perception of German vowels by experienced and inexperienced
native English speakers learning German. Few if any studies, however, have examined the categorical perception (i.e., the ability to correctly identify) of all eight German rounded vowels, namely /uː/, /ʊ/, /oː/, /ɔ/, /ɣ/, /ɣ/, /øː/, and /œ/, by native English-speaking learners of German at multiple levels of experience. The present study intends to fill this gap in the research.

1.1 Statement of the Problem

It is well known that few L2 learners successfully learn to perceive and produce every L2 sound. Some SLA researchers (e.g., Flege, 1991; Polka, 1992; Trubetzkoy, 1939/1969) suggest that this is due to interference from the learner’s L1 phonology, or sound system. Trubetzkoy (1939/1969), who was one of the first modern researchers to formally study L2 perceptual difficulties, explained that “the phonological system of a language is like a sieve through which everything that is said passes” (p. 51). It is only natural, Trubetzkoy claimed, for L2 learners to perceive L2 sounds through the “‘phonological sieve’ of [their] mother tongue” (p. 52). Because every language has a different set of speech sounds, L2 learners are expected to have perceptual (and production) difficulties with at least some L2 sounds.

Many native Japanese speakers learning English, for example, struggle to discriminate the English /ɹ/-/ɾ/ contrast (Bradlow et al., 1997; MacKain, Best, & Strange, 1981; Mochizuki, 1981; Miyawaki, Strange, Verbrugge, Liberman, Jenkins, & Fujimura, 1975). Japanese speakers have only one liquid consonant, /ɾ/, while English speakers have two liquid consonants, /ɹ/ and /ɾ/. In order to establish a contrast between English /ɹ/
and /l/, native Japanese speakers must create new “phonetic categories,” or representations of these English sounds.

Although many studies of L2 perception have focused on L2 consonants (e.g., Best & Strange, 1992; Flege & Eefting, 1987b; MacKain et al., 1981), L2 vowels carry “more phonetic information than consonants,” including “pitch, length, amplitude, . . . stress, . . . and the fundamental frequency of the speaker’s voice” (O’Brien, 2003:36). Because of this, Scovel (1995) claims that vowels are better indicators of a foreign accent than consonants. Many studies of German vowel perception have focused on German rounded vowels, including the front rounded vowels /yː/, /ʏ/, /øː/, and /œ/. These front rounded vowels do not have correlates in English and are well known to be difficult for native English speakers learning German to perceive and produce (Strange, Bohn, Nishi, & Trent, 2005; Strange, Bohn, Trent, & Nishi, 2004). Consequently, these vowels are part of the focus of this thesis.

1.2 Research Questions

The present study examines the categorical perception of German rounded vowels by native speakers of American English (hereafter AE) at four different levels of experience in German. This study is guided by the following research questions:

1. How accurately do native AE-speaking learners of German across all levels of experience perceive the German rounded vowels /uː/, /ʊ/, /ʊː/, /ɔː/, /yː/, /ʏ/, /øː/, and /œ/?

2. Does the level of experience in German affect the accuracy with which AE learners identify German rounded vowels? In particular, do AE learners become
more accurate in their ability to perceive these vowels with more experience? Which vowels, if any, are more likely to be misperceived at the four different levels of experience examined here? and

3. When AE learners (across all levels of experience) misidentify German rounded vowels, which vowels do they select in place of the correct vowel? Do patterns of misidentification change for each vowel as AE learners gain more experience in German?

1.3 Delimitations

The research design of the present study had several delimitations. First, the effects of consonantal context were not considered in examining subjects’ perception of German rounded vowels. All 16 surrounding consonantal contexts (see Chapter 3, Table 3) were collapsed when the identification results of each rounded vowel were determined. Second, the four native speakers of German who provided recordings of vowel tokens for this study had lived in the United States between 1 and 5 years (mean = 3.19). Previous research of immigrants living in an L2 environment (e.g., Godson, 2003; Major, 1987) has shown that the quality of L1 vowels can change over time, particularly for L1 vowels that are perceptually similar to L2 vowels. Whether or not the native speakers in the present study differed in their production of German rounded vowels from other native speakers living in a German-speaking country was not examined, however.

Also, certain AE subject differences, such as age, gender, and native dialect were not examined in this study. Finally, differences between in country experiences, e.g., study abroad experiences, internships, and Latter-day Saint proselyting missions in
German-speaking countries were not considered, nor was the amount of German spoken by AE subjects while residing abroad.

1.4 Thesis Overview

This thesis contains five chapters. The literature review in the next chapter will provide the necessary background by introducing the underlying concepts of the present study, including the properties of German and AE vowels, the predictions of Best’s (1995) Perceptual Assimilation Model (PAM) and Flege’s (1995, 2003b) Speech Learning Model (SLM), and the effects of experience and consonantal context on L2 speech perception. Chapter 3 describes the methodology of the experiment that was conducted, and Chapter 4 presents the results of the experiment. In Chapter 5, the results of the experiment are discussed in relation to the research questions of this study and the results of other studies. The implications and limitations of this study are also discussed in Chapter 5, and suggestions are given for future research.

With this in mind, I now turn to a review of the concepts and relevant literature of this study.
2.0 Introduction

This chapter provides a context for the present study by reviewing background information and relevant literature in second language (L2) speech perception. Specifically, this chapter defines the linguistic terms used in this study, compares the vowel inventories of German and American English, explains the differences between categorical and cross-language speech perception, describes two major models of L2 speech perception, and demonstrates the effects of experience and phonetic context on the perception of L2 vowels. This chapter concludes with predictions for the results of this study.

2.1 Overview of German and American English Vowel Inventories

As mentioned in the previous chapter, this study examines the perception of German rounded vowels by native speakers of American English (AE) at different levels of experience in German. In order to understand the interaction of German rounded vowels with the AE vowel system, it is necessary to briefly describe and compare the vowel systems of both languages. First, however, the linguistic terms used in this thesis to describe vowels and consonants will be explained.


2.1.1 Phonemes and Phonetic Categories

Phonemes are “the distinctive ‘speech sounds’ . . . of a language” (Strange & Jenkins, 1978:126; see also Ladefoged, 2001, 2005). Many Second Language Acquisition (SLA) researchers also refer to phonemes as “phonetic categories, the smallest segments of spoken language that combine and contrast to make up the words of the lexicon” (Strange, 1995:5). Each language possesses a unique set, or inventory, of phonemes. Individual phonemes are categorized by the features that set them apart from other sounds in the language. All phonemes and phonetic categories are contrastive, as demonstrated by the English examples /ɹ/ in the word rake, and /l/ in lake. When the /ɹ/ in rake is replaced by /l/ to create lake, the result is a minimal pair, a pair of words differing by one sound, yet which have a distinct meaning. Variants of a phoneme, on the other hand, such as the two instances of /p/ in pit ([pʰɪt], with a burst of air, known as aspiration) and spit ([spɪt], with no aspiration), are called allophones³ (cf. O’Grady & Dobrovolsky, 1987; Rogers, 1991).

The phonemes of relevance to this thesis are vowels. I now turn to a discussion of the relevant vowels for the present study, namely German rounded vowels.

2.1.2 Vowel Inventory of German

Vowels are produced by passing air through the vocal tract “without a closure or narrowing of the organs of speech sufficient to cause audible friction” (Hall, 2003, p. 72).

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2 Phonemes are written between forward slashes, as shown in this example, and are represented symbolically by the International Phonetic Alphabet (IPA). IPA characters will be used to describe phonemes and allophones throughout this thesis.

3 Allophones are written between square brackets, as shown in these examples.
The area inside of the mouth acts as a resonance chamber, and modifications to the size and shape of this area create differences in vowel quality. This area is called the vowel space, or acoustic space (Ladefoged, 2001, 2005). A chart depicting the vowel space for the production of German vowels is shown in Figure 1. This chart represents a cross-section of the oral cavity, with the top portion showing the highest position of the tongue and the bottom portion showing the lowest position of the tongue. The left side represents the front of the mouth and the right side represents the back. The position of each German vowel on the chart corresponds to the approximate position of the arch of the tongue as the vowel is being articulated (Hall, 2003; see also Handbook of the International Phonetic Association, 1999). Each vowel is shown by its corresponding IPA symbol.

![Figure 1. Monophthongs of the German vowel inventory (adapted from Hall, 2003). Rounded vowels (e.g., /uː/, /oː/) are shown with open circles. Unrounded vowels (e.g., /iː/, /aː/) are shown with dark circles.](image)

According to the chart shown in Figure 1, the vowel inventory of Standard German includes 16 monophthongs, or pure vowels: /iː/, /ɪː/, /ɛː/, /ɛː/, /aː/, /aː/, /uː/, /ʊː/, /ɔː/, /ɔː/, /æ/, /æ/, /aɪ/, /aɪ/, /ʊ/.
/ʊ/, /ɔ/, /ʊː/, /ɣ/, /ɜː/, and /œ/. These monophthongs\(^4\) are the focus of this study and are distinguished by the following articulatory features: height, tongue position (i.e., frontness vs. backness), lip rounding, and tenseness (Hall, 2003; see also Ladefoged, 2001). Vowel height refers to the vertical position of the tongue as the vowel is being articulated (Handbook of the International Phonetic Association, 1999). Vowel height ranges from high or “close” (e.g., /iː/ as in the German word **viel** “many”), to low or “open” (e.g., /aː/ as in **Vater** “father”). Frontness and backness refer to the horizontal position of the tongue within the vowel space. German vowels are distinguished according to this parameter by three tongue positions: front (e.g., /iː/), central (e.g., /ə/ as in the final syllable in **ohne** “without”), and back (e.g., /uː/ as in **Bruder** “brother”). Lip rounding refers to the position of the lips during vowel articulation, which in German can be spread, neutral, or rounded (Hall, 2003). Vowels produced with rounded lips (i.e., rounded vowels) are represented on the vowel chart in Figure 1 with open circles (e.g., /yː/ as in **fühlen** “to feel”). Vowels produced with no lip rounding (i.e., unrounded vowels) are represented in Figure 1 with dark circles (e.g., /eː/ as in **gehen** “to go”).

Tenseness refers to the muscular tension of the speech organs used to produce vowels (Hall, 2003). Tense vowels require greater muscular tension than lax vowels, and they are produced higher and more toward the edges of the vowel space than their lax counterparts. Examples of tense vowels include /uː/ and /oː/ (as in **Sohn** “son”), and examples of lax vowels include /ʊ/ (as in **Mutter** “mother”) and /ɔ/ (as in **offen** “open”).

Most German vowels comprise tense-lax pairs, such as /iː/-/i/ and /yː/-/ɣ/. Tense vowels

\(^4\) Unlike monophthong vowels, which consist of only one element, diphthong vowels consist of “a relatively stable first element followed by a glide towards a second element” (Hall, 2003:102). As German diphthongs (e.g., /au/ as in **klein** “small”) are not the focus of this study, they will not be examined.
in a stressed position in German are long and represented symbolically by the diacritic “ː” (e.g., /uː/; see Hall, 2003).

2.1.2.1 Rationale for Examining German Rounded Vowels

The German vowels of interest in the present study are the back rounded vowels /uː/, /ʊ/, /oː/, and /ɔ/; and the front rounded vowels /yː/, /ʏ/, /øː/, and /œ/. These vowels are very common in the everyday speech of native German speakers and they serve an important function in German in terms of both grammatical and lexical contrasts. It is important for native and non-native speakers to be able to identify and distinguish German rounded vowels because different rounded vowels can establish lexical contrasts, such as schon “already” (with /ɔː/) and schön “beautiful” (with /œː/). Also, umlaut, or vowel fronting,\(^5\) is a common feature of German grammar, affecting noun, adjective, and verb stems. For instance, umlaut marks the plural form of numerous nouns, such as Brüder (with /yː/), the plural of Bruder “brother” (with /uː/), and Vögel, (with /øː/), the plural of Vogel “bird” (with /oː/). Umlaut also occurs in the comparative and superlative forms of some adjectives, such as groß “big” (with /oː/). The comparative and superlative of this adjective are größer “bigger” and größt- “biggest” (both with /œː/). Umlaut is also found in the stems of some verbs marking important contrasts, as in the case of werden “to become”. The simple past form of this verb is wurde (with /ʊ/), while the present subjunctive form is würde (with /ʏ/). Thus the sentences, Ich wurde Lehrer “I became a teacher” and Ich würde Lehrer “I would become a teacher” differ by only one vowel

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\(^5\) German umlaut also involves the mutation of a to ä which is better characterized as a raising and fronting process. However, the sounds under investigation in this study, namely the front rounded vowels, are indeed the result of fronting of the back rounded vowels also under examination.
sound, while differing greatly in meaning. These examples of contrasts based on umlaut demonstrate the importance of being able to perceive differences between the rounded vowels to mark these important grammatical and lexical contrasts. Failure to perceive these differences can hinder a listener’s correct understanding of an utterance.

2.1.3 Vowel Inventory of American English

While some variation exists among the different dialects of American English, this study will define the AE vowel inventory to include 12 monophthongs: /ɪ/, /ɛ/, /æ/, /ʌ/, /ʊ/, /ə/, /a/, /u/, /o/, /ɔ/, and /ɑ/ (Hall, 2003; Labov Ash, & Boberg, 2006; Trudgill & Hannah, 2002). These vowels are charted in Figure 2.

![Figure 2. Monophthongs of the American English vowel inventory (adapted from Hall, 2003). Rounded vowels (e.g., /u/, /o/) are shown with open circles. Unrounded vowels (e.g., /i/, /a/) are shown with dark circles.](image)

AE vowels are diphthongized in stressed positions, meaning that they move from one vowel element to another during articulation (e.g., /e/ becomes [ei] or [eɪ] and /o/...
becomes [ou] or [ou]). Lip rounding occurs only for the back vowels /u/, /ʊ/, /o/, and /ɔ/ and is thus a redundant feature of these vowels, as there are no distinguishing rounded-unrounded vowel contrasts in American English. The back rounded vowels, particularly /u/, have a more fronted tongue position in American English than in German (Hall, 2003; Moulton, 1962; Strange, Bohn, Nishi, & Trent, 2005; Strange, Bohn, Trent, & Nishi, 2004), and /u/ is currently undergoing additional fronting in most AE dialects (O’Brien & Smith, submitted). In many dialects of American English, the perception and production of /ɔ/ (as in caught) have merged with /ɑ/ (as in cot). Thus for many AE speakers, /ɔ/ does not exist in their vowel inventory and is instead typically perceived and produced as /ɑ/ (Labov et al., 2006; Majors, 2005).

2.1.4 Comparison of American English and German Vowel Inventories

The vowel inventories of German and American English differ in several important ways. For instance, rounding in American English occurs only in the back vowels /u/, /ʊ/, /o/, and /ɔ/, and is thus not a distinguishing feature of any AE vowel. Rounding in German, on the other hand, occurs in back and front vowels, and is a distinguishing feature of front vowels (e.g., /iː/-/yː/). Additionally, the German front rounded vowels /yː/, /ɟ/, /oː/, and /œ/ do not exist as phonemes in American English. Rounding in German occurs with a more extreme lip position than in American English (Hall, 2003). German and AE vowels also differ in the position occupied by phonemes shared by both languages in the vowel space. In general, German vowels are more peripheral than AE vowels; in other words, German vowels are produced closer to the edges of the vowel space (Delattre, 1965). German /uː/, for example, is produced further
back than AE /u/ while German /iː/ is produced further forward. Due to the extreme fronting of AE /u/, the front rounded vowel [y] may exist as an allophone of AE /u/ in the dialects of some AE speakers. This is demonstrated, for example, in some AE speakers’ productions of the word *dude* (Ash, 1996; Habick, 1993; see also O’Brien & Smith, submitted). Tense German vowels are also generally longer in duration than tense AE vowels (Hall, 2003). Finally, all German monophthongs retain their pure vowel quality even when they are in stressed positions, while many AE monophthongs, as already noted, are diphthongized (e.g., /i/ becomes [ij], /o/ becomes [ou], etc.; see Ladefoged, 2001, 2005).

Having explained how German and AE vowels are classified and how they differ from each other, I now turn to a discussion of how these and other L2 vowels are perceived.

2.2 L2 Speech Perception

Many perceptual studies have focused on two types of L2 speech perception: categorical perception and cross-language perception. Although this thesis tests categorical perception, it also draws on studies of cross-language perception to predict results. Thus, both types of L2 speech perception will be described in the following sections.

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6 O’Brien and Smith (submitted) point out, however, that the location of /u/ in the vowel space varies in many dialects of American English. In the North Central area of the United States, for example, AE /u/ is produced further back, matching the vowel space of German /uː/.
2.2.1 Categorical Perception

Categorical perception examines how L2 learners perceive L2 sounds in terms of the phonetic categories of the L2, as in the case of native English speakers perceiving German sounds in terms of German phonetic categories (e.g., Jacewicz, 1999; Kingston, 2003; O’Brien, 2003; Polka, 1995). Assessments of categorical perception determine if L2 learners have successfully created new phonetic categories and where these categories are located. Two frequently used methods to assess categorical perception are discrimination tasks and identification tasks. In a discrimination task, listeners must distinguish between two sounds, such as English /ɹ/ and /l/ (cf. MacKain, Best, & Strange, 1981; Miyawaki, Strange, Verbrugge, Liberman, Jenkins, & Fujimura, 1975). The purpose of a discrimination task is to determine if L2 learners establish the boundary between two L2 sounds at the same point as do native L2 speakers (e.g., do learners of German draw the boundary between German /yː/ and /uː/ at the same point as native German speakers do). Researchers are able to observe through discrimination tasks which sounds L2 learners perceive as similar or distinct (Strange & Jenkins, 1978).

Discrimination of L2 sounds can be tested by a variety of means, including an AXB (or ABX) test, where listeners are asked whether the sound “X” is the same sound (or a variant of the same sound) as either “A” or “B.” MacKain et al. (1981) used an AXB test to assess native Japanese speakers’ discrimination of English /ɹ/ and /l/. While a group of native Japanese speakers with no experience in English performed poorly on this test, discriminating /ɹ/ and /l/ with low accuracy, another group with more experience in English discriminated /ɹ/ and /l/ with better accuracy. The more experienced group did not perform as well as a group of native English speakers, however, which discriminated
/ɹ/ and /l/ with near perfect accuracy. This study suggested that the inexperienced Japanese subjects had not yet created new phonetic categories for English /ɹ/ and /l/, while the experienced Japanese speakers had.

In identification tasks, researchers use symbols, letters, words, or pictures to ask listeners to actually identify the sounds that they hear (Strange & Jenkins, 1978). Identification tasks are typically “forced-choice,” where listeners are given a set of two or more response choices before or after hearing the sound stimuli. The purpose of an identification task is to determine if L2 learners have established new phonetic categories in the L2 and whether L2 learners can identify L2 sounds based on these categories. Additionally, when L2 sounds are misidentified by L2 learners, patterns of perceptual confusions “provide insight into how the L2 learners’ perception [differs] from that of L2 native speakers” (Flege, 2003a:22).

Bohn and Flege (1990, 1997), for example, used forced-choice identification tasks to assess native German speakers’ identification of the English vowels /ɛ/ (as in bet) and /æ/ (as in bat). Like MacKain et al. (1981), Bohn and Flege (1990) found that native German speakers with more experience in English identified each of these English vowels more accurately than native Germans with less experience. Again, the more experienced learners had more likely created new phonetic categories for English /ɛ/ and /æ/, while the less experienced learners had not.

Because the purpose of this study was to determine if experience in German affected the ability of AE learners to identify German rounded vowels, a forced-choice identification task was used in the experiment, as described in the following chapter. A forced-choice identification task provided an opportunity not just to determine whether
native AE speakers had created new phonetic categories for these vowels, but also to observe patterns of misidentification as the incorrect responses gave insight into which vowels were perceptually confused for one another.

2.2.1.1 Categorical Perception of German Vowels

Only a few published studies to date have examined the categorical perception of German vowels by native speakers of American English. Such studies have often focused on vowels known to be difficult for native AE speakers learning German to perceive, such as the front rounded vowels /yː/, /ʏ/, /øː/, and /œ/. For example, Polka (1995) examined the ability of native monolingual English speakers to discriminate the German vowel contrasts /yː/-/uː/ and /ʏ/-/ʊ/. Polka found that these English speakers discriminated the tense /yː/-/uː/ contrast with native-like accuracy (98.6%) and the lax contrast /ʏ/-/ʊ/ with less than native-like accuracy (86.9%). Jacewicz (1999) assessed the perception of German /ɪ/, /ɛ/, /ʏ/, and /ʊ/ by native AE speakers beginning to learn German. In this identification study, AE speakers perceived /ʏ/, the one vowel with no phonemic correlate in American English, most accurately. Jacewicz concluded that these AE speakers had successfully created a new phonetic category only for German /ʏ/.

Additionally, O’Brien (2003) compared how the perception of /iː/, /yː/, and /uː/ changed over the course of a year among a group of AE speakers who had studied German in Germany and another group who studied German in the United States. AE speakers from both groups showed little difference even after a year in the perception of

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7 Polka (1995) and some other researchers represent tense German vowels without the length marker “ː” (e.g., “/u/” instead of “/uː/,” etc.). For the sake of consistency, this thesis will refer to all German and AE vowels as they have been described earlier in this chapter.
/iː/ and /uː/, although both groups showed significant improvement in the perception of /yː/.

Finally, Kingston (2003) examined the categorical perception of L2 German vowels, including the four back rounded vowels, the four front rounded vowels, and the front unrounded vowels /iː/, /ɪ/, /eː/, and /ɛ/ by native speakers of American English with no experience in German. AE speakers were found to distinguish the lax vowels /ʏ/ and /œ/ more accurately than the tense vowels /yː/ and /œː/, but were also equally accurate in distinguishing vowel pairs of different height but with the same amount of tenseness, frontness/backness and lip rounding (e.g., /iː/-/eː/ and /yː/-/œː/).

2.2.2 Cross-Language Perception

Unlike categorical perception, cross-language perception examines how L2 learners perceive L2 sounds in terms of the phonetic categories of their native language (L1). Cross-language perception is a means of measuring the perceptual distance between the sounds of different languages and a means of predicting potential difficulties in L2 perception (Strange, 1995; Strange et al., 2004, 2005). Studies of cross-language perception (e.g., Schultheiss, 2008; Strange, Akahane-Yamada, Kubo, Trent, Nishi, and Jenkins, 1998) do not attempt to examine “correct” or “incorrect” categorizations of L2 sounds to L1 phonemes, but rather how similar or dissimilar L2 sounds are perceived to be from a learner’s L1 phonemes.

One of the most frequently used methods to assess cross-language perception is a perceptual assimilation task. In a perceptual assimilation task, listeners map, or categorize L2 sounds to L1 phonetic categories. Such tasks are also often forced-choice, where
listeners are given response choices in terms of familiar symbols, sounds, or words (cf. Flege, 2003a). These cross-language tasks give researchers insights into how different L2 sounds are perceived by non-native speakers of the L2 in terms of their L1. Strange et al. (1998), for example, used a perceptual assimilation task to determine how native speakers of Japanese identify English vowels in terms of Japanese vowels. Strange et al. found that the English vowels /i/, /ɛ/, /a/, /oʊ/, and /u/ were most frequently identified as their close acoustic counterparts in Japanese: /i/, /ɛ/, /a/, /oʊ/, and /u/, respectively.

Another frequently used method to assess cross-language perception is a category goodness rating task, which is often used together with a perceptual assimilation task (e.g., Schultheiss, 2008; Strange et al., 1998, 2004, 2005). In a category goodness rating task, listeners rate an L2 sound as an exemplar of an L1 phonetic category (e.g., often a correlating L1 phonetic category, or the phonetic category to which they previously mapped the L2 sound). Like perceptual assimilation tasks, category goodness rating tasks provide insights into how non-native speakers of the L2 perceive L2 sounds, and specifically how L2 sounds differ from L1 phonemes. For example, Strange et al. (1998) also used this task in their cross-language similarity study of English and Japanese vowels. Strange et al. found that native Japanese speakers gave English /i/, /ɛ/, /oʊ/, and /u/ the highest goodness ratings, indicating that these English vowels were perceived to be most like their Japanese correlates.

2.2.2.1 Cross-Language Perception of German Vowels

In two studies, Strange et al. (2004, 2005) used a perceptual assimilation task and a category goodness rating task to determine how native speakers of American English
with no experience in German perceive 14 German vowels, including the eight rounded vowels /uː/, /oː/, /oː/1, /ʊ/, /ɔː/, /ɤː/, /ʊ/ and /œ/. The German back rounded vowels /uː/ and /oː/ were mapped to their respective AE correlates, /u/ and [ou], at high rates (86% and 89%, respectively) when presented aurally as syllables. When collapsed with AE /ɑ/,

German /ɔ/ was also mapped to its AE correlate at a high rate (90%). However, the back rounded vowel /u/ and the front rounded vowels /ɤː/, /ɤ/, /œ/, and /œ/ were not consistently mapped to any one AE vowel. Average goodness ratings for these five vowels were also low, indicating that AE listeners did not consider these vowels good exemplars of any AE vowel (see also Schultheiss, 2008).

Because of these inconsistent patterns of cross-language perception, Strange et al. (2004, 2005) predicted that native AE speakers beginning to learn German would have difficulty discriminating several vowels, including /uː/ and /ɤː/, as well as /ɤ/, /œ/, and /ʊ/. Because front rounded vowels were frequently mapped to /uː/ and /ʊ/, Strange et al. also predicted that front rounded vowels will be confused with back rounded vowels.

As previously noted, the present study examines the categorical perception, not the cross-language perception, of German rounded vowels. The results of Strange et al.’s (2004, 2005) and Schultheiss’ (2008) cross-language perception studies will, however, inform the present predictions of this study for patterns of categorical perception.

2.3 Models of L2 Speech Perception

Several models have been proposed in recent years to systematically explain the patterns in L2 speech perception and production. Two of the most frequently used models in studies of L2 perception are Best’s (1995) Perceptual Assimilation Model (PAM) and
Flege’s (1995, 2003b) Speech Learning Model (SLM). Each of these models is described in the following sections.

2.3.1 Perceptual Assimilation Model

Best’s (1995) Perceptual Assimilation Model of cross-language speech perception is intended mainly for “ naïve” non-native listeners with little or no previous exposure to L2 sounds (Best & Tyler, 2007). PAM predicts that non-native listeners will perceive L2 sounds “according to their similarities to, and discrepancies from, [L1 sounds] that are in closest proximity to them in native phonological space” (Best, 1995:193). PAM uses L2 sound pairs, or contrasts, to describe assimilation patterns of L2 sounds to L1 phonetic categories. Six assimilation patterns are possible for each contrast: two-category (TC) assimilation, category-goodness (CG) difference, single-category (SC) assimilation, both uncategorizable (UU), uncategorized versus categorized (UC), and nonassimilable (NA).

Two-category assimilation occurs when each sound in an L2 contrast is assimilated very well into a different L1 phonetic category. In Best (1995), for example, native English speakers perceived the Zulu lateral fricatives /ɬ/ and /ɮ/ as the English consonant clusters <shl> and <zhl>, respectively. A category goodness difference occurs when both sounds of an L2 contrast are assimilated to the same L1 category, although one sound is considered a better exemplar of the L1 category than the other. The Zulu consonants /k/ and /k’/, for example, were both perceived by native English listeners as English /k/, although the Zulu /k’/ was judged less native-like to English /k/ than Zulu /k/ (Best, 1995; Best, McRoberts, & Goodell, 2001). Single-category assimilation occurs when both L2 sounds are assimilated to the same L1 category and are both considered
equally good or bad exemplars of that category. Best and Strange (1992), for example, observed poor discrimination of the English /ɹ/-/l/ contrast by native Japanese listeners. When both sounds of an L2 contrast are uncategorizable, neither assimilate to any existing L1 category, although they are still considered speech sounds. Best, McRoberts, and Sithole (1988) found, for example, that native English listeners discriminated Zulu click contrasts very well, even though there are no click categories in English. Strange et al. (2004) described the German vowel contrasts /øː/–/uː/ and /øː/–/yː/ as examples of uncategorized versus categorized assimilation because German /uː/ and /yː/ were perceptually assimilated most often to English /u/ while German /øː/ was perceptually assimilated irregularly to several different English vowels, including /u/, /uː/, and /ɪ/. Finally, nonassimilable contrasts are not considered speech sounds and they range in discrimination from good to very good. Examples of such contrasts, however, are rare.

PAM is often used in cross-language perception studies to predict patterns of perceptual assimilation by non-native listeners. Polka (1995), for instance, found that native English speakers with no experience in German had more difficulty discriminating German /ʏ/ and /ʊ/ than German /yː/ and /uː/. Polka noted that German /ʏ/ and /ʊ/ were closer in category goodness ratings and thus constituted a category-goodness difference assimilation pattern.

2.3.2 Speech Learning Model

Unlike PAM, which focuses on the cross-language perception of inexperienced L2 listeners, Flege’s (1995, 2003b) Speech Learning Model focuses on the ultimate attainment of L2 perception and production and can apply to L2 learners of all experience
levels. One of the SLM’s main tenets is that the ability to create new phonetic categories and modify existing ones remains in place throughout an L2 learner’s life span. The SLM claims that phonetic categories can be realigned or reorganized over time through exposure to L2 sounds. This process is difficult, however, and does require effort.

Like PAM, the SLM claims that the acquisition of each L2 sound is based on its perceptual similarity to the closest L1 sound. Thus in relation to L1 sounds, L2 sounds can be perceived in terms of their similarity to L1 sounds. The greater the perceived distance between an L2 sound and its L1 counterpart, the more likely it is that L2 learners will create a new phonetic category for the L2 sound and thereby perceive and produce it accurately. For example, native English speakers learning German would be more likely to create a new phonetic category for German /yː/ (as in Güte “goodness”) if they perceive it as a new L2 sound, distinct from English /u/ (as in flute) or /i/ (as in beet). Conversely, the SLM predicts that such learners would be less likely to create a new phonetic category for German /uː/ (as in Bruder “brother”), which is perceptually similar to English /u/.

Several studies have tested the SLM and its hypothesis that phonetic categories will be more likely formed for new L2 sounds than similar L2 sounds. Bohn and Flege (1990), for example, found that a group of native German listeners with an average of 7.5 years in an English-speaking environment identified the English vowel /æ/ with greater accuracy than another group of native Germans with an average of 0.6 years in an

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8 Flege originally used the terms “identical,” “similar,” and “new” to describe how L2 sounds differ from L1 sounds (e.g., Bohn & Flege, 1990; Flege, 1997). Due to criticism about the reliability of classifying L2 sounds as “new” or “similar” (cf. Rochet, 1995), Flege (2003b) has since revised his explanation of the SLM and no longer uses these terms to compare L1 and L2 sounds. Currently, the SLM compares L1 and L2 counterparts in terms of “perceived phonetic [similarity]” (Flege, 2003b:328).
English-speaking environment. The English vowel /æ/ has no counterpart in German, and Bohn and Flege concluded that with more experience in English, native Germans could successfully create a new phonetic category for it. In terms of the perception of the English vowels /i/ (as in *beet*) and /u/ (as in *bit*), which have close phonemic counterparts in German, subjects did not differ significantly. Bohn and Flege concluded that even with experience in English, the native German-speaking learners had not created new categories for these English vowels.

The results of this study and many other studies (e.g., Aoyama, Flege, Guion, Akahane-Yamada, & Yamada, 2004; Guion, Flege, Akahane-Yamada, & Pruitt, 2000) suggest that L2 learners in the long run will have more perceptual difficulties with L2 sounds that have phonemic correlates in the L1. The present study also tested this prediction of the SLM, namely, that native speakers of American English will have more perceptual difficulties with the German back rounded vowels /uː/, /ʊ/, /oː/, and /ɔ/ (which, with the exception of /ɔ/, do have phonemic counterparts in most dialects of American English) than the German front rounded vowels /yː/, /ʏ/, /øː/, and /œ/ (which do not exist as phonemes in American English).

2.4 Effects of Experience on L2 Perception

Results published in the literature regarding the effects of experience are often contradictory. Many studies in L2 phonological acquisition suggest that experience in an L2 is a significant factor in the perception of new, but not similar, L2 sounds. As mentioned earlier, Bohn and Flege (1990) found that native German learners of English with more experience in an English-speaking environment identified the English vowel
/æ/ more accurately than Germans with less experience. A phonemic correlate to English /æ/ does not exist in German. However, while experience was shown to affect perception of this vowel, experience was not shown to have an impact on other vowels in this study. Neither the experienced nor the inexperienced learners differed significantly in their identification of the English vowels /i/ and /ɪ/. These two English vowels do have phonemic correlates in German. Thus experience had an impact on the native German speakers in this study only with regards to improvement in learning to perceive the new English vowel /æ/, but it had no effect on their ability to acquire the similar English vowels /i/ and /ɪ/.9

Contradictory evidence for the effects of experience has also been found by Flege, Takagi, and Mann (1996). They found that more experienced native Japanese learners of English identified the consonants /ɹ/ and /l/ more accurately than less experienced learners, but when it came to the consonants /w/ and /d/, neither the experienced nor the inexperienced learners differed significantly in their identification of these consonants.10 Japanese has phonemic correlates of English /w/ and /d/ but not English /ɹ/ and /l/. Again, the seemingly contradictory effects of experience on perception are related to whether the L2 sounds have correlates in the L1. In particular, native Japanese subjects with more experience in English showed more improvement with English sounds that were new than familiar to them.11 Like in this study and in Bohn and Flege’s (1990) study, subjects

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9 Bohn and Flege found similar results in another study (1992) that tested production.
10 Bohn and Flege (1990) and Flege et al. (1996) did point out that other factors could have affected the results of their studies, including vowel duration as a perceptual cue (for the native German speakers) and word familiarity (for the native Japanese speakers).
11 Flege et al. (1996) and Bohn and Flege (1990) used identification tasks in their studies, although experience effects have also been found in discrimination tasks (cf. Flege & MacKay, 2004; Flege, MacKay, & Meador, 1999).
in the present study with more experience in German were expected to show more improvement in perceiving German rounded vowels that do not exist as phonemes in American English (i.e., the German front rounded vowels) than ones that do exist in American English (i.e., the German back rounded vowels).

The above discussion notwithstanding, experience in an L2 is difficult to define because different studies use different criteria for “experienced” and “inexperienced” L2 learners (Best & Tyler, 2007). Many perceptual studies measure experience in terms of an L2 learner’s length of residence (LOR) in an L2-speaking country. These studies often differ, however, in the amount of time they use to distinguish between levels of L2 experience. Studies by Aoyama et al. (2004) and MacKain et al. (1981), for example, compare groups with six months LOR and little to no LOR. Other studies, according to Best and Tyler (2007), “have defined the cut-off for ‘experienced’ as 2, 3, 5 or even 10+ years in an L2 environment” (p. 21). Best and Tyler recommend that the cut-off for experienced L2 learners be set at 6 to 12 months in the L2 environment, as this is when the most significant perceptual learning has been observed to occur.

O’Brien (2003) observed the effects of an extended stay in Germany on the perception and production of the German vowels /iː/, /yː/, and /uː/. A group of native English speakers studying German for one academic year at a German university were found to produce but not perceive /yː/ in a more native-like manner than another group of English speakers studying German at a university in the United States. O’Brien’s results agree with those of Bohn and Flege (1997), who concluded that “L2 experience seems to have a more profound impact on the production than on the perception of a new vowel category” (p. 67).
Formal instruction in an L2 is another means by which learners can gain L2 experience. Few studies on L2 perception, however, measure L2 experience in this way. Two such studies, one by Gottfried and Beddor (1988) and one by Levy and Strange (2008), used L2 French speakers that had studied French in school for several years. None of these speakers was currently residing in a French-speaking country, although several had previously done so for a year or more. Both studies found that the more experienced learners perceived French vowels more like native French speakers than the less experienced learners.

2.5 Effects of Phonetic Context on L2 Perception

Another factor that has been shown in many studies to affect the perception of L2 sounds is phonetic context. Many studies (e.g., Lively, Logan, & Pisoni, 1993; Logan, Lively, & Pisoni, 1991; Sheldon & Strange, 1982; Strange & Dittmann, 1984) examining the perception of English /ɹ/ and /l/ by native Japanese speakers, for instance, have found that listeners vary in their identification and discrimination of these sounds based on the surrounding phonetic environment. Another cross-language perception study by Strange et al. (2005), on the other hand, found that native AE listeners did not perceptually assimilate German vowels differently based on consonantal context. They found that “listeners appeared to adopt a context-independent strategy for judging the perceptual similarity of [German] vowels to native categories” (p. 1761).

In a cross-language perception study similar to Strange et al. (2005), Schultheiss (2008) found that consonantal context did affect native English listeners’ perception of many German vowels, including the rounded vowels /u/, /y/, and /ʏ/. The consonants
that were found to most affect the cross-language perception of these vowels were post-vocalic [ɾ] and post-vocalic /n/. Schultheiss observed, however, that listeners with more experience in German were less affected by context than listeners with less experience.

Trofimovich, Baker, and Mack (2001) made similar observations to Schultheiss (2008) in their cross-language study of native Korean learners of English. Learners with more experience in English were more likely to map English vowels to phonemically similar Korean vowel categories. Learners with more experience were also less affected by consonantal context in their mapping of English vowels. Trofimovich et al. suggested that L2 experience helps learners “ignore non-meaningful context-dependent phonetic variants in L2 sounds” (p. 181).

In light of the fact that German rounded vowels are the focus of this study, and because consonantal contexts may or may not affect the perception of these vowels, the effects of the surrounding consonantal contexts were not examined in this study.

2.6 Need for the Current Study

While many studies to date have assessed the categorical perception of L2 vowels in multiple consonantal contexts, few published studies have examined the categorical perception of German rounded vowels, let alone comparing more than two levels of experience (i.e., “inexperienced” and “experienced” L2 learners). Strange et al. (2005) explain that additional studies are needed to examine the relationship between native English speakers’ perceptual assimilation patterns of German vowels and their discrimination of these vowels. “It is important,” Strange et al. state, “that perceptual performance be assessed using materials in which vowels are produced and presented in
multiple consonantal contexts and contain the acoustic variability normally encountered in language learning situations” (p. 1760). Thus the vowels in this study were presented in 16 consonantal contexts and were produced by four different native speakers of German.

Another important difference between this study and many other categorical perception studies is that this study examines the acquisition of a foreign language, as opposed to a second language. Foreign Language Acquisition (FLA) is the learning of any language in addition to the L1 while not living in the community where the target language is spoken and used (cf. Lalleman, 1996), e.g., learning German in the United States, whereas Second Language Acquisition refers to learning an additional language in the target language community, e.g., learning German in Germany. Most studies examining the effects of experience have investigated its effects on second language learners, in particular focusing on L2 acquisition by immigrants. For example, Flege and MacKay (2004) and Flege et al. (1999) examined the perception of English vowels by native Italian speakers living in Canada. Conversely, the present study examines learners in a foreign language environment, even though many AE subjects in this study had spent some time in a German-speaking country. Nevertheless, all subjects were tested in their perception of German rounded vowels while living and studying German in the United States, i.e., in a foreign language environment. Thus, this study assessed not only the effects of in-country residency but also the effects of formal instruction outside of the target community.
2.7 Predictions of Results

Predictions as to the results of this study are based on the hypotheses of the aforementioned L2 speech acquisition models, PAM and the SLM, and previously observed patterns of perceptual assimilation. Predictions are arranged and presented according to the research questions of this study.

2.7.1 How Will German Rounded Vowels Be Perceived by AE Speakers?

The following predictions apply to Research Question #1: “How accurately do native AE-speaking learners of German across all levels of experience perceive the German rounded vowels /uː/, /ʊ/, /oː/, /œ/, /yː/, /ʏ/, /øː/, and /œ/?”

1. The German back rounded vowels /uː/, /oː/, and /œ/ will be identified accurately more than 50% of the time.

Cross-language similarity studies (e.g., Schultheiss, 2008; Strange et al., 2004, 2005) have shown that native AE speakers map German /uː/, /oː/, and /œ/ to corresponding AE vowels at high rates. Native AE speakers in the present study were thus expected to show similar patterns in their categorical perception of these vowels.

2. The German back rounded vowel /ʊ/ will not be identified accurately more than 50% of the time.

The German vowel /ʊ/ has not been consistently identified correctly in categorical perception studies (e.g., Jacewicz, 1999; Polka, 1995) nor consistently mapped to its corresponding AE vowel in cross-language similarity studies (e.g., Schultheiss, 2008; Strange et al., 2004, 2005). AE speakers in the present study were also expected to identify German /ʊ/ with low consistency and consequently low accuracy.
3. The German front rounded vowels /yː/, /ɨː/, /øː/, and /œ/ will not be identified accurately more than 50% of the time.

Cross-language similarity studies (e.g., Schultheiss, 2008; Strange et al., 2004, 2005) have shown that German front rounded vowels are mapped to several different AE vowels by native AE speakers. This, and the fact that German front rounded vowels do not exist as phonemes in American English, suggest that AE learners in this study will not identify these German vowels accurately over half of the time.

2.7.2 How Will Experience in German Affect Perception?

The identification accuracies for each vowel in this study, as perceived by groups at different levels of experience in German, will be compared to answer Research Question #2: “Does the level of experience in German affect the accuracy with which AE learners identify German rounded vowels? In particular, do AE learners become more accurate in their ability to perceive these vowels with more experience? Which vowels, if any, are more likely to be misperceived at the four different levels of experience examined here?”

1. AE groups’ overall identification accuracy (i.e., of all vowels combined) will improve with increased experience in German.

As discussed earlier in this chapter, many studies (e.g., Bohn & Flege, 1990, 1997; Flege et al., 1996; Gottfried & Beddor, 1988; Levy & Strange, 2008) have shown at least marginal perceptual improvements for many L2 sounds with increased L2 experience. Thus it is expected in this study that the more experienced groups will
identify all German rounded vowels more accurately and, as a result, obtain higher overall identification accuracies.

2. The overall identification accuracy of each experimental group will be significantly lower than the overall identification accuracy of the control group of native German speakers.

Other studies examining ultimate attainment in L2 categorical perception (e.g., Bohn & Flege, 1990, 1997; Gottfried, 1984) and production (e.g., Bohn & Flege, 1992; Moyer, 1999; Munro, 1993) have found similar discrepancies between native L2 speakers and advanced L2 learners. In each of these studies, the perception and production of L2 sounds generally improved as L2 learners gained experience, although most L2 learners did not perform with near-native accuracy.

3. The identification accuracies of the back rounded vowels /uː/, /ʊ/, and /oː/ will not differ significantly between any of the four experimental groups.

Several categorical perception studies (e.g., Bohn & Flege, 1990, 1997; Flege, 1995; Jacewicz, 1999; O’Brien, 2003) have failed to find statistically significant differences in the perception of L2 sounds with correlates in the L1, including the perception of German back rounded vowels by native English speakers, across groups at different levels of experience. These studies have found significant differences in the perception of L2 sounds with no correlates in the L1, such as German front rounded vowels, by native English speakers.
2.7.3 How Will German Rounded Vowels Be Misperceived?

The identification responses of each group for each vowel will be compared to answer Research Question #3: “When AE learners (across all levels of experience) misidentify German rounded vowels, which vowels do they select in place of the correct vowel? Do patterns of misidentification change for each vowel as AE learners gain more experience in German?” The following misperception patterns are expected in this study:

1. AE learners, regardless of experience in German, will frequently misidentify German /ʊ/ as other German back rounded vowels, namely /uː/, /oː/, and /ɔ/. As explained earlier, native AE listeners in cross-language similarity studies (e.g., Schultheiss, 2008; Strange et al., 2004, 2005) frequently map German /ʊ/ to several English vowels, including most often the back rounded vowels /u/, [ou], and /ɔ/. Native AE speakers in this study were also expected to follow this pattern of misidentification.

2. AE learners, regardless of experience, will frequently misidentify German /yː/ as /uː/, while German /ʏ/, /øː/, and /œ/ will be frequently misidentified as /ʊ/ or each other. German /yː/ is frequently perceptually assimilated to English /u/ in cross-language similarity studies (e.g., Schultheiss, 2008; Strange et al., 2004, 2005) while German /ʏ/, /øː/, and /œ/ are often mapped in the same way to English /ʊ/. If German /ʏ/, /øː/, and /œ/ are perceived by AE speakers in a similar way (e.g., as the same sound), these vowels may be confused for one another.

3. AE groups with more experience in German will misidentify the German front rounded vowels /yː/, /ʏ/, /øː/, and /œ/ as back rounded vowels less frequently than groups with less experience.
This prediction is based on the results of cross-language similarity studies (e.g., Rochet, 1995; Strange et al., 2004, 2005), in which naïve L2 listeners perceptually assimilated L2 front rounded vowels to L1 back rounded vowel categories, and the tenets of the SLM (Flege, 1995, 2003b), which claim that L2 learners will perceive L2 sounds with no L1 correlates more accurately with increased L2 experience.

### 2.7.4 Summary of Predictions

The predictions of this study, as listed in the previous three sections, are summarized in Table 1:

<table>
<thead>
<tr>
<th>Research Question</th>
<th>Prediction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1. /uː/, /oː/, and /ɔ/ will be identified accurately more than 50% of the time &lt;br&gt; 2. /ʊ/ will not be identified accurately more than 50% of the time &lt;br&gt; 3. /yː/, /ʏ/, /øː/, and /œ/ will not be identified accurately more than 50% of the time</td>
</tr>
<tr>
<td>2</td>
<td>1. overall identification accuracy will improve with increased experience &lt;br&gt; 2. overall identification accuracy of each experimental group will differ significantly from the control group &lt;br&gt; 3. identification accuracies of /uː/, /ʊ/, and /oː/ will not differ significantly between any of the four experimental groups</td>
</tr>
<tr>
<td>3</td>
<td>1. /ʊ/ will be frequently misidentified as /uː/, /oː/, and /ɔ/ &lt;br&gt; 2. /yː/ will be frequently misidentified as /uː/, /ʏ/, /øː/, and /œ/ will be frequently misidentified as /ʊ/ or each other &lt;br&gt; 3. more experienced groups will misidentify German front rounded vowels as back rounded vowels less frequently than less experienced groups</td>
</tr>
</tbody>
</table>

Having reviewed the fundamental concepts underlying this study, I now turn to a description of the experiment used to test the predictions and answer the research questions.
Chapter 3
Research Design

3.0 Introduction

This chapter describes the experiment that was conducted to determine how native speakers of American English (AE) at different levels of experience in German perceive German rounded vowels. The following sections of this chapter describe the subjects, stimulus materials, and instruments of the experiment, as well as the procedures used for collecting and analyzing the experimental data.

3.1 Subjects

Subjects in the experiment were native speakers of American English and German. All native AE-speaking subjects were students at Brigham Young University (BYU) who were currently enrolled or had been previously enrolled in a German course within the past five years. AE subjects were divided into one of the following four experimental groups based on their experience with German:

101 group: Students at the end of first-semester German (i.e., German 101) with no residency in a German-speaking country;

201 group: Students at the end of third-semester German (i.e., German 201) with no residency in a German-speaking country;
300+ group: Students currently or previously enrolled in third-year or higher German courses (i.e., German 300 or higher) with less than four months of residency in a German-speaking country;\textsuperscript{12} and

300+Resi group: Students currently or previously enrolled in third-year or higher German courses with at least 16 months of residency in a German-speaking country.

Native German-speaking subjects (which included current and former BYU students as well as a BYU professor\textsuperscript{13}) participated as members of the control group. AE speakers with experience in Chinese, Dutch, French, or Scandinavian languages (e.g., Danish, Swedish, Norwegian, and Icelandic) were excluded from participation in this study because the vowel inventories of these languages also include front rounded vowels.\textsuperscript{14}

A total of 96 subjects (36 M, 60 F) participated in this study, including 89 native AE speakers (34 M, 55 F) and 7 native German speakers (2 M, 5 F). Subjects were between 18 and 61 years of age (mean = 23.74). The results of 27 subjects were not included in the data analysis due to one or more disqualifying factors. Three AE subjects, for instance, had studied other languages with front rounded vowels. Eighteen subjects in

\textsuperscript{12} Several subjects from the 300+ group had participated in study abroad programs in German-speaking countries, which last approximately 3 to 4 months. According to Best and Tyler (2007), 3 to 4 months of residency in an L2 environment is insufficient to significantly improve L2 perception. Most studies observe significant perceptual improvements after 6 to 12 months of residency (see also Aoyama, Flege, Guion, Akahane-Yamada, & Yamada, 2004).

\textsuperscript{13} One of the native German speakers in the control group was a BYU professor who had lived in the United States for approximately 30 years at the time of this study. This professor reported that he still spoke mostly German at home with his family, he corresponded occasionally with German-speaking friends and family by letters and by telephone, and he visited Germany about once every 5 years.

\textsuperscript{14} Although the phonetic category boundaries of front rounded vowels in German differ slightly from front rounded vowels in other languages (cf. Strange, Weber, Levy, Shafiro, Hisagi, & Nishi, 2007), knowledge of these vowels in other languages would increase a listener’s overall experience with front rounded vowels and could thus affect a listener’s perception of front rounded vowels in German.
first- and third-semester German did not fit the definitions of either the 101 or the 201 group because they had studied German for between 3 and 9 years. Two subjects in third-semester German had lived in a German-speaking country for more than four months. One subject was enrolled in fourth-semester German (i.e., German 202) and thus could not be categorized into either the 201 or the 300+ group. Also, the results of one subject were lost because of a computer error during the administration of the experiment. One subject took considerably more time to complete the experiment than all the other subjects, indicating that he did not follow the instructions to select his “gut” reaction to the stimuli. Finally, one of the native German speakers from the control group had grown up bilingual, speaking English and German at home, and was thus set aside.

After these 27 subjects were excluded from the data analysis, the total number of subjects in all groups was 69 (27 M, 42 F). Information about these subjects, including their age at the time of the experiment, age of first exposure to German, amount of time learning German, and length of residency in a German-speaking country is shown in Table 2:

---

15 While the average duration of the forced-choice identification task was 34.43 min. for all subjects, this subject took 91.71 min. to complete the task. The response times (RTs) of this subject were also generally longer than those of the other subjects (e.g., 10 s. or longer, in many instances), and this may have affected the subject’s responses. Previous studies examining the effects of increased intervals in identification and discrimination tasks suggest that auditory memory decays after long RT delays. Crowder (1982), for instance, showed that the discrimination and identification accuracy of listeners decreases dramatically about 3 seconds after hearing a vowel stimulus. Cowan and Morse (1986) and Repp, Healy, and Crowder (1979) also suggested that the memory representation of a vowel may shift in the vowel space as it decays with the passage of time.

16 Previous studies (e.g., Flege & Eefting, 1987b; Williams, 1977) of bilingual speakers who began learning a second language (L2) between the ages of 5 and 7 years have shown slight differences from native L2 speakers in phonetic category boundaries.
Table 2. Demographic Information of Subject Groups.

<table>
<thead>
<tr>
<th>Group</th>
<th>Number of Subjects (M/F)</th>
<th>Age (Range)</th>
<th>Age of Exposure (Range)</th>
<th>Time Studied in Years (Range)</th>
<th>Residency in Months (Range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>101</td>
<td>11 (5 M, 6 F)</td>
<td>20.73</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>201</td>
<td>9 (2 M, 7 F)</td>
<td>21.67</td>
<td>20.00</td>
<td>1.44</td>
<td>N/A</td>
</tr>
<tr>
<td>300+</td>
<td>19 (19 F)</td>
<td>20.63</td>
<td>14.00</td>
<td>5.16</td>
<td>2.03</td>
</tr>
<tr>
<td>300+Resi</td>
<td>24 (18 M, 6 F)</td>
<td>24.33</td>
<td>15.04</td>
<td>7.58</td>
<td>26.75</td>
</tr>
<tr>
<td>Control</td>
<td>6 (2 M, 4 F)</td>
<td>35.83</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>All</td>
<td>69 (27 M, 42 F)</td>
<td>24.64</td>
<td>16.35</td>
<td>4.73</td>
<td>14.39</td>
</tr>
</tbody>
</table>

Note. The information in this table was obtained from biographical questionnaires (See Appendix C) that were completed by subjects in this study.

The number and gender breakdown of each group, as shown in Table 2, is as follows: 101 group: 11 subjects (5 M, 6 F); 201 group: 9 subjects (2 M, 7 F); 300+ group: 19 subjects (0 M, 19 F); 300+Resi group: 24 subjects (18 M, 6 F); control group: 6 subjects (2 M, 4 F). The unusually disproportionate male-to-female ratios in the 300+ and 300+Resi groups can be attributed to the fact that many subjects in the 300+Resi group had served a full-time proselyting mission for The Church of Jesus Christ of Latter-day Saints, and more males tend to serve missions than females. Of the 24 subjects in the 300+Resi group, 17 males and 4 females had served missions in a German-speaking country. The other male and 2 females in the 300+Resi group had lived in a German-speaking environment is much like a work internship, where L2 speakers communicate with native L2 speakers on a daily basis. Full-time missions in a German-speaking country comprise approximately 22 months of in-country residency for Latter-day Saint (LDS) young men and approximately 16 months of in-country residency for LDS young women. Full-time missionaries serving in a German-speaking country receive formal instruction in German at the LDS Missionary Training Center for about eight weeks at the beginning of their mission (Kohler, 1998).

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17 A full-time proselyting mission in an L2-speaking environment is much like a work internship, where L2 speakers communicate with native L2 speakers on a daily basis. Full-time missions in a German-speaking country comprise approximately 22 months of in-country residency for Latter-day Saint (LDS) young men and approximately 16 months of in-country residency for LDS young women. Full-time missionaries serving in a German-speaking country receive formal instruction in German at the LDS Missionary Training Center for about eight weeks at the beginning of their mission (Kohler, 1998).
speaking country with family members or as part of a student exchange program. Two subjects in this group (1 M, 1 F) had served missions and spent an additional year as exchange students. In the 300+ group, 11 out of 19 subjects had studied abroad in a German-speaking country for about four months.

Most subjects in the 300+ and 300+Resi groups had completed or had nearly completed German 310, in which they received formal instruction on the phonetics and pronunciation of German as well as the sound-to-spelling correspondences of German. All subjects participated in this study during the last four weeks of their current semester of enrollment. This was especially critical for the first-semester students, who needed enough experience in German to be able to read German orthography and understand the differences between words presented to them as possible choices on the computer screen during the experiment (e.g., to know that the spelling <uht> represents the long vowel /u:/ while <utt> represents the short vowel /ʊ/).

3.2 Speakers

Four native speakers (2 M, 2 F) of Northern German dialects\(^{18}\) provided recordings of the stimulus materials used in the experiment. The speakers were between 22 and 37 years of age (\(mean = 27.75\)). Three speakers were students at BYU and the other speaker was a professor in the BYU German Department. The speakers had all lived in the United States between 1 and 5 years (\(mean = 3.19\)) and all spoke American English as their primary second language (L2).

\(^{18}\) Three speakers were from North Rhine-Westphalia and one speaker was from Hamburg.
3.3 Stimulus Materials

Stimulus materials were 128 tokens with the eight German rounded vowels /uː/, /ʊ/, /oː/, /ɔ/, /yː/, /ʏ/, /øː/, and /œ/, in both real and nonsense words. These vowels were produced in 16 consonantal contexts in the shape [C_Cə]. The consonantal contexts are shown in Table 3:

Table 3. Consonantal Contexts of German Rounded Vowel Stimuli.

<table>
<thead>
<tr>
<th>[C_ʃa]</th>
<th>[f_ʃa]</th>
<th>[g_ʃa]</th>
<th>[p_ʃa]</th>
<th>[s_ʃa]</th>
<th>[t_ʃa]</th>
</tr>
</thead>
<tbody>
<tr>
<td>[C_sɔ]</td>
<td>[f_sɔ]</td>
<td>[g_sɔ]</td>
<td>[p_sɔ]</td>
<td>[s_sɔ]</td>
<td>[t_sɔ]</td>
</tr>
</tbody>
</table>

Note. Consonantal contexts are shown using International Phonetic Alphabet (IPA) symbols. “C” represents the consonants shown in this table. The underscore character (“_”) shows where one of the eight German rounded vowels, namely /uː/, /ʊ/, /oː/, /ɔ/, /yː/, /ʏ/, /øː/, and /œ/, would be inserted.

Word stimuli, which consisted of these consonantal contexts followed by a schwa (/ə/), were based on the German syllabic trochee, a sequence of a stressed and unstressed syllable, which is the most common structure of German words (O’Brien & Smith, submitted; Wiese, 2000). Contexts were selected to provide subjects with a diverse sample of real and familiar-looking words that were easily recognizable orthographically. For example, several tokens with rounded vowels in the [g_tə] context are real words in German (e.g., gute “good”, Gote “Goth”, Güte “goodness”, and Goethe, a famous German author).

Vowels under investigation appeared in post-consonantal (i.e., CV) and pre-consonantal (i.e., VC) positions. The acoustic effects of pre-vocalic consonants, according to an acoustical analysis by Kawasaki (1982), are minimal on following

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19 For example, the vowel /uː/ in the environment [f_ʃa] was written as “Fuhle.” (See Appendix A for a complete list of stimuli in their German orthographic representations.)
vowels. Hillenbrand, Clark, and Nearey (2001), however, found acoustical effects on vowels preceded by alveolar consonants, such as /d/ and /t/. O’Brien and Smith (submitted) likewise found substantial fronting of English /u/ following these alveolar stops. On the other hand, Kawasaki found that the acoustical effects of post-vocalic consonants were greater on the vowel than pre-vocalic consonants.

Kawasaki (1982) and Hillenbrand et al. (2001) also note that place of articulation has a greater impact on vowel production and perception, respectively, than does manner of articulation. With the exception of the velar /g/, all initial consonants were anterior, e.g., /p/, /f/, /t/, /s/. Likewise, the post-vocalic consonants were alveolar, i.e., /s/, /t/, and /l/, with the exception of the German “r”, which was produced as a uvular fricative [ʁ] by the native German informants. As with all following consonants, [ʁ] (which was represented orthographically as <r> after long vowels and <rr> after short vowels) occurred in the onset of the second syllable, never in the coda of the first syllable. Consequently, it was produced by the native German speakers as a consonantal “r”, never as its non-syllabic counterpart [ɣ]. To minimize these acoustical effects in the present study, all vowels in the test stimuli were produced in open syllables (CV). In other words, all consonants following the target vowels occurred at the onset of the following syllable and thus were less likely to influence the quality of the vowel.

The long tense rounded vowels /uː/, /oː/, /yː/, and /øː/ were represented orthographically in this study as <u>, <o>, <ü>, and <ö>, respectively, followed by an <h> and a single consonant (e.g., Fuhle). The short lax rounded vowels /ʊ/, /ɔ/, /ʏ/, and /œ/ were also represented in this study as <u>, <o>, <ü>, and <ö>, respectively, but were followed by a double consonant (e.g., Fülle).
It should also be noted that not all of the possible environments from the preceding and following consonants were used in this study. One of the native speakers providing stimuli failed to produce \([p_s\_\text{ə}]\) tokens with good vowel quality, even after a second recording was completed. Because of this, all \([p_s\_\text{ə}]\) tokens from all four speakers were removed and replaced with \([g_t\_\text{ə}]\) tokens, which were desired because of the high proportion of real words this environment produced.

Stimuli were recorded by each native speaker in a sound-attenuated chamber using Peak Pro 5.2.1 software and 2 Sennheiser MKH 40-P48 microphones. Speakers were given a randomized list of the 128 words written in German orthography and were instructed to read each word in the carrier phrase, *Ich sage das Wort _____* “I say the word _____”. Speakers were asked to speak as though they were speaking to another native speaker.

Recordings were stored on a computer as 16-bit stereo AIFF files at a 44.10 kHz sampling rate. Stimuli were extracted from the carrier phrases of the recordings using Audacity 1.2.6 software, and were saved as 16-bit stereo \textit{wav} files at a 44.10 kHz sampling rate. In total, 512 stimuli were used, including 128 words from the four native speakers (128 words \times 4 speakers = 512 stimuli). Stimuli were downsampled for presentation in E-Prime using GoldWave 5.23 software and saved as PCM unsigned 8-bit \textit{mono} \textit{wav} files at 22.05 kHz.

3.4 Procedure

The experiment was conducted in the Collaborative Computer Lab on the campus of BYU during the winter semester of 2008. Each computer in the Collaborative Lab
included a Plantronics DSP stereo headset that could be adjusted by the participants to a comfortable listening level. Before proceeding with the experiment, all subjects received a unique identification number to ensure their anonymity while processing their data.

3.4.1 Forced-Choice Identification Task

For the experiment, subjects completed a forced-choice identification task presented to them using E-Prime 1.2 software. Via headphones, subjects heard a single word presented once while a focus screen, a blank screen with a “+” in the middle, was displayed on the computer. After the word was presented, a new screen, like the one shown in Figure 3, appeared with the possible choices for the word just presented aurally to them.

```
Fuhle  1  Fühle  5
Fulle  2  Fülle  6
Fohle  3  Föhle  7
Folle  4  Fölle  8
none of the above  0
```

*Figure 3.* Sample selection screen from the forced-choice identification task.

Subjects were asked to select the word on the screen they thought they had just heard. For instance, if subjects thought they heard the word *Fohle*, they pressed 3 on their keyboard. If subjects thought that the word they heard matched none of the eight options,
they pressed 0 for “none of the above.” After making the selection, a new focus screen appeared and the next word was presented.

To begin the task, subjects completed 10 practice exercises to familiarize themselves with the procedure and to allow them to adjust the volume on their headsets. Responses to these practice tokens were not analyzed statistically.

The 512 test stimuli were presented in random order. The words on the selection screens always matched the consonantal environments of the words subjects heard. For instance, if a subject heard a word with a \[p_t \text{ə}\] environment, the subject would see words on the screen with only \[p_t \text{ə}\] environments. (For images of the instructions and all 16 selection screens, see Appendix B.) Subjects were instructed to give their first “gut” answer to each word and then move on to the next word. Subjects were told to not linger on any one word for too long.

3.4.2 Biographical Questionnaire

After subjects completed the perception task, they filled out a biographical questionnaire (see Appendix C) regarding their age, gender, and experience with foreign languages, including German. Information from the questionnaire was used to obtain demographic information about the subjects and to ensure their eligibility to participate in this study.

3.5 Data Analysis

Subjects’ identification responses were tabulated and will be presented by group and vowel in the following chapter. A two-way (group × vowel) analysis of variance
(ANOVA) was performed with subjects’ identification accuracies for each German rounded vowel to determine the effect of group, vowel, and the group × vowel interaction. Also, a series of one-way ANOVAs was performed to determine if subject groups differed significantly in their accurate identification of each vowel. Post-hoc Tukey HSD tests were performed with the one-way ANOVAs to determine which groups differed significantly. Due to the high level of comparisons, the alpha level (i.e., probability value) was set at .01 (1%) and the confidence interval was 99%.
4.0 Introduction

The results of the forced-choice identification task are presented in this chapter in the following order: First, the identification accuracies of all native speakers of American English (AE) combined and all native speakers of German are presented for each German rounded vowel, and trends in the perception of front and back rounded vowels are reviewed. Second, differences in the overall identification accuracies between subject groups are compared, and the effects of experience on the perception of front and back rounded vowels are examined. Finally, patterns of misidentification by native AE subjects are shown for each German rounded vowel. How these patterns differ between groups with increased experience in German is also discussed.

4.1 Overall Identification Results

Percentages of correct word identifications were calculated for each subject for each German rounded vowel. The average percentages for each vowel of all AE subjects in the four experimental groups are shown in contrast to the native German-speaking subjects in the control group in Table 4. These percentages will be referred to hereafter as identification accuracies. The ranking of each identification accuracy (e.g., 1 = most accurate; 8 = least accurate) is shown in parentheses.
Table 4. Identification Results of AE and German Subjects.

<table>
<thead>
<tr>
<th>Vowel</th>
<th>Identification Accuracies (Rank)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AE Subjects</td>
</tr>
<tr>
<td>/uː/</td>
<td>25.32% (7)</td>
</tr>
<tr>
<td>/ʊ/</td>
<td>25.23% (8)</td>
</tr>
<tr>
<td>/oː/</td>
<td>51.41% (2)</td>
</tr>
<tr>
<td>/ɔ/</td>
<td>54.03% (1)</td>
</tr>
<tr>
<td>/yː/</td>
<td>40.77% (3)</td>
</tr>
<tr>
<td>/ɻ/</td>
<td>27.51% (5)</td>
</tr>
<tr>
<td>/œ/</td>
<td>30.21% (4)</td>
</tr>
<tr>
<td>/œ/</td>
<td>25.78% (6)</td>
</tr>
</tbody>
</table>

Note. Percentages represent how many times the correct response was selected out of the total word stimuli for each vowel. Percentages of AE speakers were collapsed across the four AE subject groups. The ranking of each percentage (e.g., 1 = most accurate; 8 = least accurate) is shown in parentheses.

The identification accuracies of the native German-speaking control group were used as a benchmark against which all AE subjects and subject groups could be compared. No German rounded vowel in the forced-choice identification task was identified accurately by the control group 100% of the time, although most of these vowels were identified with high degrees of accuracy. For instance, native German subjects identified stimuli with the vowels /ɔ/, /uː/, and /œ/ accurately more than 95% of the time (98.44%, 96.61%, and 96.09%, respectively). German subjects identified stimuli with /oː/, /yː/, and /œ/ accurately between 90% and 95% of the time (94.53%, 94.01%, and 91.93%, respectively). Germans identified the vowels /ʊ/ and /ɻ/ accurately less than 90% of the time (88.28% and 84.38%, respectively).

The identification accuracies of all native AE speakers, collapsed across the four experimental groups, were relatively low for all German rounded vowels, ranging from 25.23% (for /ʊ/) to 54.03% (for /ɔ/). Only the two mid back vowels /oː/ and /ɔ/ were identified accurately by AE speakers more than 50% of the time (54.03% and 51.41%, respectively). The high front vowel /yː/ was identified accurately in 40.77% of instances,
the highest percentage of the four front rounded vowels. Five vowels, /ʊ/, /ø/ , /œ/, and /œ/ , ranged in accuracy from about 25% to 30%.

Setting these percentages aside, the differences in how the identification accuracies ranked from highest to lowest are also revealing: The ranking of AE subjects’ identification accuracies did not always coincide with the ranking of German subjects’ identification accuracies. The vowel /ɔ/, for instance, was identified most accurately by both AE and German speakers (54.03% and 98.44%, respectively). The vowel /ʊ/, on the other hand, which was identified with high accuracy by native German speakers (96.61%) and which ranked second to /ɔ/, ranked seventh out of eight by native AE speakers (25.32%). Another discrepancy was with the vowel /œ/, which ranked second to /ɔ/ by AE speakers (51.41%). For the Germans, /œ/ ranked near the middle of the eight rounded vowels, in fourth place (94.53%). The vowel /œ/ was also problematic for AE subjects, as it ranked in sixth place (25.78%). For German subjects, however, the identification accuracy of /œ/ ranked in third place (96.09%).

Overall response trends by AE subjects, collapsed by the four experimental groups, were analyzed to answer Research Question #1: “How accurately do native AE-speaking learners of German across all levels of experience perceive the German rounded vowels /ʊ/, /ø/, /œ/, /œ/ , /œ/ , /œ/ , and /œ/?” The response trends are summarized as follows:

1. The mid back vowels /œ/ and /œ/ were identified more accurately than all other German rounded vowels and were the only vowels in the forced-choice identification task to be identified accurately more than 50% of the time (54.03% and 51.41%, respectively).
2. The high back lax vowel /ʊ/ was identified least accurately of all German rounded vowels (25.23%).

3. The high front tense vowel /yː/ was identified with the highest accuracy of all four front rounded vowels (40.77%).

4. The high back vowels /uː/ and /ʊ/ and the front vowels /ʏ/, /øː/, and /œ/ were identified with about 25% to 30% accuracy (25.32%, 25.23% 27.51%, 30.21%, and 25.78%, respectively).

These trends show that native AE speakers learning German, regardless of experience, identify all German rounded vowels with low accuracy. The next section of this chapter will also examine the perception of German rounded vowels, but will consider the differences between the native speaker control group and the four experimental groups at different levels of experience in German.

4.2 Overall Identification Results by Subject Group

Results of the forced-choice identification task were analyzed for all subjects in the four experimental groups, namely the 101 group (students at the end of first-semester German with no residency in a German-speaking country), the 201 group (students at the end of third-semester German with no residency), the 300+ group (students in third-year or higher German courses with less than four months of residency) and the 300+Resi group (students in third-year or higher courses with 16 or more months of residency), and the native speaker control group to answer the first part of Research Question #2: “Does the level of experience in German affect the accuracy with which AE learners identify German rounded vowels? In particular, do AE learners become more accurate in their
ability to perceive these vowels with more experience?” The overall identification accuracies (i.e., all correct identification responses regardless of vowel) of each group are shown in Table 5:

<table>
<thead>
<tr>
<th>Group</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>101</td>
<td>20.72%</td>
</tr>
<tr>
<td>201</td>
<td>31.34%</td>
</tr>
<tr>
<td>300+</td>
<td>39.04%</td>
</tr>
<tr>
<td>300+Resi</td>
<td>49.03%</td>
</tr>
<tr>
<td>Control</td>
<td>93.03%</td>
</tr>
</tbody>
</table>

*Note.* Percentages represent the total number of word stimuli correctly identified by each subject group on the forced-choice identification task.

The 101 group, which had the least amount of experience in German, obtained the lowest overall score on the forced-choice identification task (20.72%). The 201 and 300+ groups performed progressively better (31.34% and 39.04%, respectively), and the 300+Resi group, which had the most German experience of all AE subjects, obtained the highest overall identification accuracy of the four experimental groups (49.03%). No AE subject group approached the score of the control group, however, which identified 93.03% of the word stimuli correctly.

To determine if the differences in the overall identification accuracies between subject groups were statistically significant, the overall identification accuracies of each group, with the results of all vowels combined, were analyzed using a one-way analysis of variance (ANOVA) with a Bonferroni adjustment to a $p$-value of .01, due to the high number of comparisons. The ANOVA revealed that the differences between all groups were significant, $F(4, 68) = 25.73, p < .0001$. Post-hoc Tukey HSD tests were run to
determine which groups differed from one another. The results of this analysis revealed that only the difference between the 101 and 300+Resi groups was significant.

4.3 Effects of Experience

The identification accuracies of each AE subject group for each German rounded vowel were compared to answer the second part of Research Question #2: “Which vowels, if any, are more likely to be misperceived at the four different levels of experience examined here?” To answer this question, the identification accuracies of each AE subject for each German rounded vowel were submitted to a two-way (group × vowel) ANOVA, which revealed a significant effect of group, $F(3, 59) = 41.41, p < .0001$; and vowel, $F(7, 413) = 18.46, p < .0001$. The group × vowel interaction was not found to be statistically significant, $F(21, 413) = 1.48, p = .0783$. Simply the most experienced group in German perceived the German rounded vowels most accurately.

The identification accuracies of each AE subject group for each vowel are shown in Table 6. The ranking of each percentage is shown in parentheses.

---

20 The two-way ANOVAs were analyzed as follows: the effect of group was calculated with the identification accuracies of all vowels collapsed (cf. Table 5) and the effect of vowel was calculated with the identification accuracies of all groups collapsed for each vowel (cf. Table 4).
Table 6. Identification Results of AE and German Subject Groups for Each Vowel.

<table>
<thead>
<tr>
<th>Vowel</th>
<th>101 Group</th>
<th>201 Group</th>
<th>300+ Group</th>
<th>300+Resi Group</th>
<th>Control Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>/uː/</td>
<td>14.63% (6)</td>
<td>15.63% (8)</td>
<td>29.61% (6)</td>
<td>41.41% (6)</td>
<td>96.61% (2)</td>
</tr>
<tr>
<td>/ʊ/</td>
<td>24.15% (3)</td>
<td>21.18% (6)</td>
<td>28.37% (7)</td>
<td>27.21% (8)</td>
<td>88.28% (7)</td>
</tr>
<tr>
<td>/ɔ/</td>
<td>30.26% (2)</td>
<td>40.10% (2)</td>
<td>61.92% (1)</td>
<td>73.37% (1)</td>
<td>94.53% (4)</td>
</tr>
<tr>
<td>/σ/</td>
<td>36.36% (1)</td>
<td>54.69% (1)</td>
<td>59.46% (2)</td>
<td>65.63% (2)</td>
<td>98.44% (1)</td>
</tr>
<tr>
<td>/yː/</td>
<td>22.02% (4)</td>
<td>39.93% (3)</td>
<td>47.94% (3)</td>
<td>53.19% (3)</td>
<td>94.01% (5)</td>
</tr>
<tr>
<td>/ʏ/</td>
<td>16.34% (5)</td>
<td>25.35% (5)</td>
<td>30.84% (4)</td>
<td>37.50% (7)</td>
<td>84.38% (8)</td>
</tr>
<tr>
<td>/øː/</td>
<td>9.80% (8)</td>
<td>34.20% (4)</td>
<td>30.10% (5)</td>
<td>46.74% (5)</td>
<td>91.93% (6)</td>
</tr>
<tr>
<td>/œ/</td>
<td>12.22% (7)</td>
<td>19.62% (7)</td>
<td>24.10% (8)</td>
<td>47.20% (4)</td>
<td>96.09% (3)</td>
</tr>
</tbody>
</table>

Note. Percentages represent how many times each response was correctly selected out of the total word stimuli for each vowel. The ranking of each percentage (e.g., 1 = most accurate; 8 = least accurate) is shown in parentheses.

Groups with more experience in German identified /uː/, /oː/, /ɔ/, /yː/, /ʏ/, and /œ/ more accurately than groups with less experience. This was not always the case for /ʊ/ and /øː/, however. For example, the 300+Resi group clearly obtained the highest identification accuracies of all the experimental groups for each German rounded vowel except /ʊ/. The 300+ group identified /ʊ/ marginally more accurately than the 300+Resi group (28.37% and 27.21%, respectively). The 201 group identified /ɔ/ marginally more accurately than the 300+ group (34.20% and 30.10%, respectively). Only the vowels /ɔ/ /ʌ/, /σ/, and /yː/ were identified accurately by the 300+Resi group more than 50% of the time (73.37%, 65.63%, and 53.19%, respectively). The 101 group obtained the lowest identification accuracies of all groups for all vowels except /ʊ/. None of the vowels were identified accurately by the 101 group more than 50% of the time. The vowel /σ/ was the only vowel that was identified accurately by the 201 group more than 50% of the time (54.69%), while /ɔ/ and /ʌ/ were the only vowels that were identified accurately by the 300+ group more than 50% of the time (61.92% and 59.46%, respectively).
Because statistical significance was found when comparing the four experimental groups, a series of one-way ANOVAs was run for the identification accuracies of each vowel to determine how these groups differed from one another. The dependent variable was the identification accuracy of each AE subject for each German rounded vowel on the forced-choice identification task. Table 7 shows the $F$- and $p$-values of these ANOVAs.

**Table 7. Statistical Significance of Differences between Each Experimental Group’s Identification Accuracy for Each German Rounded Vowel.**

<table>
<thead>
<tr>
<th>Vowel</th>
<th>$F$-value</th>
<th>$p$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>/ɔː/</td>
<td>4.43</td>
<td>.0071*</td>
</tr>
<tr>
<td>/ʊ/</td>
<td>0.61</td>
<td>.6135</td>
</tr>
<tr>
<td>/ʊ/</td>
<td>11.03</td>
<td>&lt;.0001*</td>
</tr>
<tr>
<td>/ɔ/</td>
<td>4.59</td>
<td>.0059*</td>
</tr>
<tr>
<td>/yː/</td>
<td>4.78</td>
<td>.0048*</td>
</tr>
<tr>
<td>/yː/</td>
<td>5.96</td>
<td>.0013*</td>
</tr>
<tr>
<td>/œː/</td>
<td>8.66</td>
<td>&lt;.0001*</td>
</tr>
<tr>
<td>/œː/</td>
<td>8.79</td>
<td>&lt;.0001*</td>
</tr>
</tbody>
</table>

*Note. For all vowels: $p$-level = .01; $df = (3, 62)$. Significant $p$-values are marked with an asterisk (*).*

The differences between the four experimental groups were found to be statistically significant for all vowels in the forced-choice identification task except /ʊ/, $F (3, 62) = 0.61, p = .6135$. Thus the level of experience significantly affected AE subjects’ perception of all German rounded vowels except /ʊ/ based on results from the one-way ANOVAs.

The ranking of each rounded vowel’s identification accuracy also differed between the native AE experimental groups and the native German control group. These differences are shown in greater detail in Table 8. In Table 8, the identification accuracies are highlighted in a different color for each vowel. Vowels are connected by lines from one group to another, showing whether the ranking moves up, down, or stays constant.
### Table 8. Identification Accuracy Rankings of AE and German Subject Groups.

<table>
<thead>
<tr>
<th>Rank</th>
<th>101 Group</th>
<th>201 Group</th>
<th>300+ Group</th>
<th>300+Resi Group</th>
<th>Control Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>/ɔ/ (36.36%)</td>
<td>/ɔ/ (54.69%)</td>
<td>/ɔ/ (61.92%)</td>
<td>/ɔ/ (73.37%)</td>
<td>/ɔ/ (98.44%)</td>
</tr>
<tr>
<td>2</td>
<td>/ɔː/ (30.26%)</td>
<td>/ɔː/ (40.10%)</td>
<td>/ɔː/ (59.46%)</td>
<td>/ɔː/ (65.63%)</td>
<td>/ɔː/ (96.61%)</td>
</tr>
<tr>
<td>3</td>
<td>/ʊ/ (24.15%)</td>
<td>/yː/ (39.93%)</td>
<td>/yː/ (47.94%)</td>
<td>/yː/ (53.19%)</td>
<td>/œ/ (96.09%)</td>
</tr>
<tr>
<td>4</td>
<td>/yː/ (22.02%)</td>
<td>/ɔː/ (34.20%)</td>
<td>/ɔː/ (30.84%)</td>
<td>/ɔː/ (47.20%)</td>
<td>/œ/ (94.53%)</td>
</tr>
<tr>
<td>5</td>
<td>/y/ (16.34%)</td>
<td>/ɔ/ (25.35%)</td>
<td>/ɔ/ (30.10%)</td>
<td>/ɔ/ (46.74%)</td>
<td>/ɔ/ (94.01%)</td>
</tr>
<tr>
<td>6</td>
<td>/uː/ (14.63%)</td>
<td>/ʊ/ (21.18%)</td>
<td>/ʊ/ (29.61%)</td>
<td>/ʊ/ (41.41%)</td>
<td>/œ/ (91.93%)</td>
</tr>
<tr>
<td>7</td>
<td>/œ/ (12.22%)</td>
<td>/œ/ (19.62%)</td>
<td>/œ/ (28.37%)</td>
<td>/œ/ (37.50%)</td>
<td>/œ/ (88.28%)</td>
</tr>
<tr>
<td>8</td>
<td>/œ/ (9.80%)</td>
<td>/uː/ (15.63%)</td>
<td>/œ/ (24.10%)</td>
<td>/œ/ (27.21%)</td>
<td>/œ/ (84.38%)</td>
</tr>
</tbody>
</table>

*Note.* Percentages represent how many times each response was correctly selected out of the total word stimuli for each vowel. Lines connect each vowel across groups.

The rankings of several rounded vowels remain fairly constant (or within one or two places) across all subject groups and particularly across the four experimental groups. The vowel /ɔː/, for example, was the most accurately identified vowel by the 300+ and 300+Resi groups (61.92% and 73.37%, respectively). The 101, 201, and control groups identified /ɔ/ most accurately (36.36%, 54.69%, and 98.44%, respectively). The vowel /yː/ also remains fairly consistent across all groups; subjects from the 101 group ranked /yː/ in fourth place (22.02%) while subjects from the 201, 300+, and 300+Resi groups ranked /yː/ in third place (39.93%, 47.94%, and 53.19%, respectively). Subjects from the control group ranked /yː/ in fifth place (94.01%).

#### 4.3.1 Experience and the Perception of Back Rounded Vowels

For each of the four back rounded vowels, a summary of the post-hoc Tukey HSD tests, run concurrently with the ANOVAs presented above, will be given below.

*High back tense rounded vowel /uː*. A comparison of the identification accuracies of all four AE groups for German /uː/ is shown in Figure 4. The identification accuracies of the 101 and 201 groups differ by approximately one percentage point (14.63% and
15.63%, respectively), which post-hoc Tukey HSD tests did not show to be statistically significant. The identification accuracies are higher for the 300+ and 300+Resi groups (29.61% and 41.41%, respectively. Although the initial results of the one-way ANOVA that was run with the AE groups’ identification accuracies for this vowel did find statistical significance, $p = .0071$, the post-hoc Tukey HSD tests did not show statistically significant differences between any of these groups in the final analysis for this vowel.

*High back lax rounded vowel /ʊ/. As previously discussed, /ʊ/ is the only German rounded vowel where the results of the one-way ANOVA did not show significant differences in identification accuracy between experimental groups, $p = .6135$, as is evident in Figure 5.*
**Mid back tense vowel /o/.** Figure 6 shows the identification accuracies of each experimental group for /o/. The 300+ and 300+Resi groups identified /o/ more accurately than any other German rounded vowel (61.92% and 73.37%, respectively).

![Figure 6. Experimental groups’ identification accuracies for /o/.](image)

The 101 and 201 groups identified /o/ more accurately than any other vowel besides /ɔ/ (30.26% and 40.10%, respectively). Post-hoc Tukey HSD tests revealed, however, that only the 101 and 300+Resi groups (a 43.11% difference) differed significantly from each other.

**Mid back lax vowel /ɔ/.** The identification accuracies of all four AE groups for /ɔ/ are shown in Figure 7. Unlike most of the other vowels, the identification accuracy of /ɔ/

![Figure 7. Experimental groups’ identification accuracies for /ɔ/.](image)
differs little between the 201 and 300+Resi groups (54.69% and 65.63%, a 10.94% difference). Post-hoc Tukey HSD tests again revealed that only the difference between the 101 and 300+Resi groups (36.36% and 65.63%, a 29.27% difference) was significant.

4.3.2 Experience and the Perception of Front Rounded Vowels

This section describes the results of the experimental groups for the front rounded vowels. Again, a description of the differences between the four groups will be given, along with the results of the post-hoc Tukey HSD tests run concurrently with the one-way ANOVAs described above.

*High front tense rounded vowel* /y/. Figure 8 shows that the identification accuracy for /y/ almost doubles between the 101 (22.02%) and 201 groups (39.93%).

![Figure 8](image)

*Figure 8. Experimental groups’ identification accuracies for /y/.*

The identification accuracies of the 201, 300+ (47.94%), and 300+Resi (53.19%) groups for /y/ are the highest identification accuracies of these groups for any of the four front rounded vowels. However, post-hoc Tukey HSD analyses revealed that only the 101 and 300+Resi groups (a 31.17% difference) differed significantly in their identification accuracies.
High front lax rounded vowel /\textit{y}/. As shown earlier in Table 6, /\textit{y}/ was the front rounded vowel that was least accurately identified by the 300+Resi group (37.50%). Only the identification accuracies of the 101 and 300+Resi groups (a 21.16% difference) differed significantly, according to the post-hoc analysis. The identification accuracies of each AE group for /\textit{y}/ are shown in Figure 9.

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{figure9.png}
\caption{Experimental groups’ identification accuracies for /\textit{y}/.}
\end{figure}

Mid front lax rounded vowel /\textit{ø}/. Figure 10 shows that, as with /\textit{y}/, the identification accuracy for /\textit{ø}/ differs sharply between the 101 (9.80%) and 201 groups (34.20%). Post-hoc Tukey HSD pairwise comparisons, however, showed a significant difference only between the 101 and 300+Resi groups (a 36.94% difference).

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{figure10.png}
\caption{Experimental groups’ identification accuracies for /\textit{ø}/.}
\end{figure}
As shown in Figure 11, the identification accuracy of the 300+Resi group for /œ/ (47.20%) was almost double that of the 300+ group (24.10%). Post-hoc Tukey HSD pairwise comparisons found that the 300+Resi group differed significantly from the 101 (a 34.98% difference), 201 (a 27.58% difference), and 300+ groups (a 23.10% difference).

Figure 11. Experimental groups’ identification accuracies for /œ/.

4.3.3 Summary of the Effects of Experience

The results of the one-way ANOVAs, run for each German rounded, as well as the post-hoc Tukey HSD tests, can be summarized as follows:

1. Based on the one-way ANOVAs, differences in the identification accuracies of all experimental groups for all German rounded vowels except /ʊ/, \( p = .6135 \), were found to be statistically significant, suggesting that amount of experience in German affected AE subjects’ accurate perception of all rounded vowels except /ʊ/.

2. Post-hoc analyses of two back rounded vowels, (/ɔː/, and /ɔ/), and two front rounded vowels (/yː/ and /ɣ/) revealed statistically significant differences between
the identification accuracies only between the 101 and 300+Resi groups. Post-hoc analyses for /u:/ revealed no effect for group.

3. For the front rounded vowel /œ/, the 101 and 201 groups were less accurate than the 300+ group and all three of these groups were less accurate than the 300+Resi group.

4. For the front rounded vowel /øː/, the 101 group was less accurate than the 300+ and 300+Resi groups.

A further note should be added to clarify the results. As the charts illustrate, there was a gradual increase in the identification accuracies across the four AE groups from the 101 to the 300+Resi group. However, despite this gradual increase, the only significant difference was between the 101 and the 300+Resi groups.

Although not statistically significant, some trends were also found in the identification results:

1. AE subject groups with more experience in German perceived all German rounded vowels except /ʊ/ generally more accurately than groups with less experience.

2. Few vowels were identified accurately by the AE groups more than 50% of the time. The 300+Resi group identified /oː/ (73.37%), /ɔ/ (65.63%), and /yː/ (53.19%); the 300+ group identified /oː/ (61.92%) and /ɔ/ (59.46%); and the 201 group identified /ɔ/ (54.69%) accurately more than 50% of the time.
4.4 Vowel Misidentification Patterns

In addition to subjects’ identification accuracies, subjects’ patterns of misidentification were analyzed for each German rounded vowel on the forced-choice identification task. No statistical tests were run for these misidentification patterns because the number of subjects in each group was insufficient to produce significant results. Therefore, only brief descriptive trends for each vowel will be discussed. The following sections first examine how all AE subjects combined misidentified each rounded vowel, and which incorrect selections were most frequent. Then, patterns of misidentification for each vowel are compared between AE groups.

4.4.1 Overall Results by All AE Subjects Combined

The overall results of the forced-choice identification task were collapsed across the four experimental groups to answer the first part of Research Question #3: “When AE learners (across all levels of experience) misidentify German rounded vowels, which vowels do they select in place of the correct vowel?” Table 9 shows the responses of all AE subjects, regardless of experience level, for each German rounded vowel. As shown in this table, there were nine possible responses: the eight German rounded vowels and “none of the above” (which was never a correct option on the identification task). Responses are arranged from left to right in order of most frequent to least frequent. The percentage of each response is shown in parentheses. The vowels and percentages showing the correct responses (i.e., the identification accuracies) are highlighted.
Table 9. Identification Responses of All AE Subjects.

<table>
<thead>
<tr>
<th>Vowel</th>
<th>1&lt;sup&gt;st&lt;/sup&gt;</th>
<th>2&lt;sup&gt;nd&lt;/sup&gt;</th>
<th>3&lt;sup&gt;rd&lt;/sup&gt;</th>
<th>4&lt;sup&gt;th&lt;/sup&gt;</th>
<th>5&lt;sup&gt;th&lt;/sup&gt;</th>
<th>6&lt;sup&gt;th&lt;/sup&gt;</th>
<th>7&lt;sup&gt;th&lt;/sup&gt;</th>
<th>8&lt;sup&gt;th&lt;/sup&gt;</th>
<th>9&lt;sup&gt;th&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>/u/</td>
<td>/u:/</td>
<td>/ɣ:/</td>
<td>/y:/</td>
<td>/u:/</td>
<td>/ʊ:/</td>
<td>/ʊ:/</td>
<td>/ø:/</td>
<td>/ø:/</td>
<td>/N</td>
</tr>
<tr>
<td></td>
<td>(25.32%)</td>
<td>(21.08%)</td>
<td>(18.29%)</td>
<td>(17.04%)</td>
<td>(6.46%)</td>
<td>(5.83%)</td>
<td>(2.77%)</td>
<td>(2.55%)</td>
<td>(0.68%)</td>
</tr>
<tr>
<td>/o/</td>
<td>/ɔ:/</td>
<td>/ɔ:/</td>
<td>/ɛ:/</td>
<td>/ɛ:/</td>
<td>/ɛ:/</td>
<td>/ɛ:/</td>
<td>/ɛ:/</td>
<td>/ɛ:/</td>
<td>/N</td>
</tr>
<tr>
<td></td>
<td>(25.23%)</td>
<td>(20.75%)</td>
<td>(14.73%)</td>
<td>(11.83%)</td>
<td>(11.73%)</td>
<td>(6.73%)</td>
<td>(4.48%)</td>
<td>(3.62%)</td>
<td>(0.91%)</td>
</tr>
<tr>
<td>/ɔ/</td>
<td>/ɔ:/</td>
<td>/ɔ:/</td>
<td>/ɛ:/</td>
<td>/ɛ:/</td>
<td>/ɛ:/</td>
<td>/ɛ:/</td>
<td>/ɛ:/</td>
<td>/ɛ:/</td>
<td>/N</td>
</tr>
<tr>
<td></td>
<td>(51.41%)</td>
<td>(16.07%)</td>
<td>(14.61%)</td>
<td>(6.85%)</td>
<td>(3.61%)</td>
<td>(3.00%)</td>
<td>(2.55%)</td>
<td>(1.54%)</td>
<td>(0.36%)</td>
</tr>
<tr>
<td>/ɛ/</td>
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<td>/ɛ:/</td>
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<td>/ɛ:/</td>
<td>/ɛ:/</td>
<td>/N</td>
</tr>
<tr>
<td></td>
<td>(54.03%)</td>
<td>(21.26%)</td>
<td>(7.05%)</td>
<td>(6.42%)</td>
<td>(5.00%)</td>
<td>(2.26%)</td>
<td>(1.63%)</td>
<td>(1.30%)</td>
<td>(1.05%)</td>
</tr>
<tr>
<td>/y/</td>
<td>/ɣ:/</td>
<td>/ɣ:/</td>
<td>/u:/</td>
<td>/u:/</td>
<td>/u:/</td>
<td>/u:/</td>
<td>/u:/</td>
<td>/u:/</td>
<td>/N</td>
</tr>
<tr>
<td></td>
<td>(40.77%)</td>
<td>(28.86%)</td>
<td>(12.21%)</td>
<td>(9.84%)</td>
<td>(4.12%)</td>
<td>(2.61%)</td>
<td>(0.66%)</td>
<td>(0.48%)</td>
<td>(0.45%)</td>
</tr>
<tr>
<td>/ɣ/</td>
<td>/ɔ:/</td>
<td>/ɣ:/</td>
<td>/ɣ:/</td>
<td>/ɣ:/</td>
<td>/ɣ:/</td>
<td>/ɣ:/</td>
<td>/ɣ:/</td>
<td>/ɣ:/</td>
<td>/N</td>
</tr>
<tr>
<td></td>
<td>(28.46%)</td>
<td>(27.51%)</td>
<td>(16.19%)</td>
<td>(7.24%)</td>
<td>(7.23%)</td>
<td>(7.20%)</td>
<td>(2.94%)</td>
<td>(2.44%)</td>
<td>(0.80%)</td>
</tr>
<tr>
<td>/ø/</td>
<td>/ɔ:/</td>
<td>/y:/</td>
<td>/γ:/</td>
<td>/γ:/</td>
<td>/γ:/</td>
<td>/γ:/</td>
<td>/γ:/</td>
<td>/γ:/</td>
<td>/N</td>
</tr>
<tr>
<td></td>
<td>(30.21%)</td>
<td>(18.96%)</td>
<td>(16.07%)</td>
<td>(11.63%)</td>
<td>(9.28%)</td>
<td>(8.32%)</td>
<td>(3.08%)</td>
<td>(1.75%)</td>
<td>(0.70%)</td>
</tr>
<tr>
<td>/œ/</td>
<td>/ø:/</td>
<td>/œ:/</td>
<td>/œ:/</td>
<td>/œ:/</td>
<td>/œ:/</td>
<td>/œ:/</td>
<td>/œ:/</td>
<td>/œ:/</td>
<td>/N</td>
</tr>
<tr>
<td></td>
<td>(26.81%)</td>
<td>(25.78%)</td>
<td>(10.04%)</td>
<td>(9.42%)</td>
<td>(8.30%)</td>
<td>(6.41%)</td>
<td>(5.79%)</td>
<td>(3.73%)</td>
<td>(3.72%)</td>
</tr>
</tbody>
</table>

*Note.* Responses and percentages shown in table were collapsed across the four AE subject groups. Percentages of each response are shown in parentheses. Percentages represent how many times each response was selected out of the total tokens for each vowel. Correct vowel responses and their percentages are highlighted in yellow. “N” represents responses marked as “none of the above.”
As Table 9 shows, the most frequent responses to stimuli with the vowels /u:/, /o:/, /ɔː/, /ɻ, /ɣ/, and /œ/ were also the correct responses. Conversely, the most frequent responses to /ɣ/ and /œ/ stimuli were words with /ʊ/. In neither case, however, did the total percentage of /ʊ/ responses differ from the total percentage of correct responses (i.e., /ɣ/ and /œ/) by more than approximately one percentage point (0.95% for /ɣ/, 1.03% for /œ/).

The top four responses to /u:/ stimuli, /u:/ (25.32%), /ɣ/ (21.08%), /ɣː/ (18.29%), and /ʊ/ (17.04%), are high vowels, indicating that AE subjects perceived /u:/ more in terms of its vowel height than its backness. AE subjects perceived /ʊ/, on the other hand, more in terms of its backness than its vowel height, as /ʊ/ was perceived as a back rounded vowel 65.19% of the time. Despite their poor identification of /ʊ/ (25.23%), AE subjects still selected /ʊ/ tokens most frequently for /ʊ/ stimuli. The vowels /ɔː/ and /ɔ/ were perceived primarily as mid-level vowels; /ɔː/ was identified as either /ɔː/, /ɔ/, /œː/, and /œ/ 88.94% of the time while /ɔ/ was identified as one of these same four vowels 88.76% of the time.

Like /u:/, the perception of /ɣː/ was based primarily on vowel height: The top four responses to /ɣː/ stimuli, the high vowels /ɣː/ (40.77%), /ɣ/ (28.86%), /ʊ/ (12.21%), and /u:/ (9.84%), represent 91.68% of all /ɣː/ responses. Conversely, the top four responses to /ɣ/ stimuli, /ʊ/ (28.46%), /ɣ/ (27.51%), /œ/ (16.19%), and /œː/ (7.24%), are relatively scattered in the vowel space. The vowels /ɣ/, /œː/, and /œ/ showed similar misidentification patterns as these vowels were frequently misidentified as /ʊ/ and as each other. The lax vowels /ɣ/ and /œ/ were identified as lax vowels 75.10% and 70.31% of the time. The vowel /œː/ was perceived as a front rounded vowel 74.53% of the time. The
vowel /œ/ was misidentified as “none of the above” 3.73% of the time, the most frequent occurrence of this option for any of the vowels in the identification task.

4.4.2 Overall Results by Experimental Group

As was the case with the identification accuracies, each experimental group of native AE speakers differed in their patterns of misperception for each German rounded vowel. Misidentification patterns among more advanced AE speakers, particularly the 300+ and 300+Resi groups, reflect many of the misidentification patterns described previously with all AE groups collapsed. The identification responses of each AE subject group for all rounded vowels are shown in Tables 11 and 12 in Appendix D. These tables show the responses of the back rounded vowels and front rounded vowels, respectively, with the correct identification response for each vowel highlighted.

4.5 Summary of Results

This chapter has presented the results of the forced-choice identification task, including the identification accuracies of all AE subjects combined, the identification accuracies of each AE subject group and the control group, and the misidentification patterns of all AE subjects combined and all AE subject groups. These results show that more experienced AE subject groups identified German rounded vowels more accurately. Statistically significant differences were found in the identification accuracies between the 101 and 300+Resi groups for all rounded vowels except /uː/ and /oː/.
The next chapter will use the results of this experiment to answer the research questions, discuss how they relate to the findings of other similar studies, and explain what the implications are in the field of second language speech perception.
Chapter 5

Discussion

5.0 Introduction

Having presented the results of the forced-choice identification task, I now discuss how these results answer the research questions of this study. The research questions are as follows:

1. How accurately do native AE-speaking learners of German across all levels of experience perceive the German rounded vowels /uː/, /ʊ/, /oː/, /ɔː/, /yː/, /ʏ/, /øː/, and /œ/?

2. Does the level of experience in German affect the accuracy with which AE learners identify German rounded vowels? In particular, do AE learners become more accurate in their ability to perceive these vowels with more experience? Which vowels, if any, are more likely to be misperceived at four different levels of experience? and

3. When AE learners (across all levels of experience) misidentify German rounded vowels, which vowels do they select in place of the correct vowel? Do patterns of misidentification change for each vowel as AE learners gain more experience in German?

An overview of the results of the forced-choice identification task is presented in Table 10. Based on these results, the subsequent sections of this chapter address each of
the research questions before turning to a discussion of the implications and limitations of this study. Finally, suggestions for future research are given.

Table 10 lists each prediction presented in Chapter 2 (see Table 1) together with an evaluation as to whether or not the prediction held, based on the results given in Chapter 4. The predictions and results are grouped by each research question.

Table 10. Summary of Predictions and Results.

<table>
<thead>
<tr>
<th>Research Question</th>
<th>Prediction</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>/u/, /o/, and /ɔ/ will be identified accurately more than 50% of the time</td>
<td>partly true; /o/ and /ɔ/ were identified accurately 51.41% and 54.03% of the time, /u/ 25.32% of the time</td>
</tr>
<tr>
<td></td>
<td>/ʊ/ will not be identified accurately more than 50% of the time</td>
<td>true; /ʊ/ was identified accurately 25.23% of the time</td>
</tr>
<tr>
<td></td>
<td>/yː/, /ʏ/, /øː/, and /œ/ will not be identified accurately more than 50% of the time</td>
<td>true; /yː/ was identified accurately 40.77% of the time; /ʏ/, /øː/, and /œ/ each about 25%-30% of the time</td>
</tr>
<tr>
<td>2</td>
<td>overall identification accuracy will improve with increased experience</td>
<td>true; groups with more experience obtained a higher overall identification accuracy</td>
</tr>
<tr>
<td></td>
<td>overall identification accuracy of each experimental group will differ significantly from the control group</td>
<td>true; pairwise comparisons showed that each experimental group differed significantly from the control group</td>
</tr>
<tr>
<td></td>
<td>identification accuracies of /u/, /ʊ/, and /o/ will not differ significantly between any of the four experimental groups</td>
<td>partly true; /ʊ/ did not differ significantly between the four experimental groups in a one-way ANOVA; post-hoc tests revealed no significant differences between groups for /u/</td>
</tr>
<tr>
<td>3</td>
<td>/ʊ/ will be frequently misidentified as /u/, /o/, and /ɔ/</td>
<td>false; /ʊ/ was misidentified as /u/, /o/, and /ɔ/ 4.48%, 14.73%, and 20.75% of the time, respectively</td>
</tr>
<tr>
<td></td>
<td>/yː/ will be frequently misidentified as /uː/; /yː/, /oː/, and /œ/ will be frequently misidentified as /ʊ/ or each other</td>
<td>partly true; /yː/ was misidentified as /uː/ 9.84% of the time; /yː/, /oː/, and /œ/ were frequently misidentified as /ʊ/ and each other</td>
</tr>
<tr>
<td></td>
<td>more experienced groups will misidentify German front rounded vowels as back rounded vowels less frequently than less experienced groups</td>
<td>true; groups with more experience did misidentify front rounded vowels as back rounded vowels less frequently</td>
</tr>
</tbody>
</table>
As Table 10 shows, the results of the forced-choice identification task mostly supported the predictions in Chapter 2. However, several statistical trends, as presented in the previous chapter, were contrary to expectations. In the next three sections, I discuss the predictions and how the results answer each of the research questions.

5.1 Research Question #1: How accurately do native AE-speaking learners of German across all levels of experience perceive the German rounded vowels /uː/, /ʊ/, /oː/, /ɔː/, /yː/, /ʏ/, /øː/, and /œ/?

The first prediction of Research Question #1 was that the German back rounded vowels /uː/, /oː/, and /ɔ/ would be identified accurately by AE subjects more than 50% of the time. The results of the forced-choice identification task, collapsed by experimental group, partially supported this prediction. Stimuli with the vowels /oː/ and /ɔ/ were identified accurately slightly more than 50% of the time (51.41% and 54.03%, respectively). Stimuli with the vowel /uː/, however, were identified accurately only 25.32% of the time.

The identification results of this study for /uː/, /oː/, and /ɔ/ demonstrate that the findings of cross-language perception studies do not necessarily extend to categorical perception. For instance, in two cross-language perception studies, Strange, Bohn, Trent, and Nishi (2004) and Strange, Bohn, Nishi, and Trent (2005) found that AE speakers with no experience in German mapped German /uː/, /oː/, and /ɔ/ to their phonemic correlates in American English (i.e., /u/, [oo], and /ɔː:/, respectively). Strange et al. (2004) predicted that native AE speakers beginning to learn German would have few difficulties with the perception of these back rounded vowels. While the identification
results of the present study for German /oː/ and /ɔ/ seem to follow Strange et al.’s findings, the identification results for German /uː/ do not.

According to the second prediction for Research Question #1, AE subjects across all levels of experience in German would not identify German /ʊ/ accurately more than 50% of the time. This prediction was also based on the findings of cross-language perception studies by Strange et al. (2004, 2005), who found that German /ʊ/ was perceptually assimilated to AE /ʊ/ less than half of the time and was frequently categorized as other AE back rounded vowels, including [ou] and /u/. In the present study, German /ʊ/ had the lowest identification accuracy of all the rounded vowels (25.23%), although /ʊ/ words were still the most frequent responses for /ʊ/ stimuli. Thus this prediction was supported.

The categorical perception of German /ʊ/ was also problematic in Polka’s (1995) discrimination study, where native English speakers with no experience in German frequently confused this vowel with /ʏ/. Polka also speculated that problems with German /ʊ/ resulted from its perceptual similarity to other English vowels, in this case, /ʊ/ and /u/. Polka based this speculation on an additional cross-language mapping task, in which subjects mapped German /ʊ/ to English /ʊ/ and /u/ each about the same number of times.

In this instance, the cross-language findings of Strange et al. (2004, 2005) do appear to extend to categorical perception. Strange et al. (2004) indicated that the acoustic similarity of German /ʊ/ and AE /ʊ/ may have been a factor in AE listeners’ mapping patterns of German /ʊ/. AE listeners in Strange et al.’s cross-language task, as opposed to AE listeners in Polka’s (1995) cross-language task, had mapped German /ʊ/
most frequently to AE [ou]. In an acoustic analysis, Strange et al. found that the production of AE /u/, /ʊ/, and [ou] were all further forward in the vowel space than German /uː/, /ʊ/, and /oː/. While German /uː/ and /oː/ did not overlap with any AE vowels in the AE vowel space, German /ʊ/ did overlap with AE [ou]. It is possible in the present study that AE subjects, particularly those with less experience in German, had not yet created a new phonetic category for German /ʊ/ and were confusing it with other German vowels, including /oː/.

It is interesting to note that the native German-speaking control group in the present study also identified German /ʊ/ with relatively low accuracy. Out of the eight German rounded vowels, native Germans identified /ʊ/ with the second least accuracy (88.28%). Thus the difficulty of perceiving German /ʊ/ may not be unique to second language (L2) German learners.

English /ʊ/ has also been shown to be difficult to perceive by native and non-native English speakers elsewhere in the literature. Cutler, Smits, and Cooper (2005), for instance, found that native speakers of American English, Australian English, and Dutch identified AE /ʊ/ with low accuracy. While AE /ʊ/ was not the most poorly perceived vowel by these three groups, it was still poorly perceived in comparison to other vowels that were well perceived.21 This underscores the perceptual problem that AE /ʊ/ poses for native and non-native AE speakers alike.

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21 In an identification task, native speakers of American English identified AE /ʊ/ with 65.6% accuracy, in comparison with AE /i/, which they identified with 92.2% accuracy. In the same task, native speakers of Australian English identified AE /ʊ/ with 77.5% accuracy, in comparison with AE /u/, which they identified with 100% accuracy. Other vowels which posed difficulties for the native speakers of American and Australian English may very well not exist as separate phonemes in these particular dialects or they may occupy substantially different portions of the vowel space. The L2 learners in this study, namely the native
The third prediction of Research Question #1 was that the German front rounded vowels /yː/, /ʏ/, /øː/, and /œ/ would not be identified accurately more than 50% of the time. This prediction was also supported. According to the results of the forced-choice identification task, the identification accuracy of all AE subjects combined for /yː/ was 40.77%, and the identification accuracies for the vowels /ʏ/, /øː/, and /œ/ were lower: 27.51%, 30.21%, and 25.78%, respectively. These results also seem to follow the findings of Strange et al. (2004), who state that because German front rounded vowels do not exist as phonemes in American English, and because AE listeners tend to map these vowels as AE back rounded vowels, German front rounded vowels will be difficult for native AE-speaking learners to perceive.

Based on the results of the last three predictions, we can now answer Research Question #1: Native speakers of American English at all levels of experience in German identified the back rounded vowels /oː/ and /ɔ/ most accurately, although in each instance it was only slightly more than 50% of the time (51.41% and 54.03%, respectively). AE speakers identified the back rounded vowel /ʊ/ and the front rounded vowels /yː/, /ʏ/, /øː/, and /œ/ less than 50% of the time: /yː/ was identified accurately 40.77% of the time, while /ʊ/, /ʏ/, /øː/, and /œ/ ranged in accuracy from about 25% to 30% (25.23%, 27.51%, 30.21%, and 25.78%, respectively).

5.2 Research Question #2: Does the level of experience in German affect the accuracy with which AE learners identify German rounded vowels? In particular, do AE learners Dutch speakers, identified AE /o/ with 65.6% accuracy, as opposed to AE /ɪ/, which they identified with 96.9% accuracy, reinforcing the fact that both L1 and L2 speakers encounter difficulties with this vowel.
become more accurate in their ability to perceive these vowels with more experience?

Which vowels, if any, are more likely to be misperceived at the four different levels of experience examined here?

The first prediction of Research Question #2 was that AE groups with more experience in German would obtain higher overall identification accuracies on the forced-choice identification task. The results of the identification task, collapsed by vowel, and compared this time by group, confirmed this prediction. The 101 group obtained the lowest overall identification accuracy (20.72%), and each group with more experience scored progressively higher (31.34%, 39.04%, and 49.03%, respectively). Post-hoc Tukey HSD pairwise comparisons showed that only the difference between the 101 and the 300+Resi groups was statistically significant. As stated in Chapter 4 and as illustrated in the tables, the accurate perception of German rounded vowels gradually increased with experience in German, although the differences in improvement between groups only become significant between the 101 group and the 300+Resi group. Based on these findings, we can now hypothesize as to the amount of experience necessary for significant improvement to occur. All subjects in the 300+Resi group had lived in a German-speaking country for at least 16 months. As explained in Chapter 3, many subjects in the 300+ group had lived in a German-speaking country for no more than four months. The fact that the results of the 300+Resi group differ significantly from the results of the 101 group, while the results of the 300+ group do not differ significantly from the 101 group, suggests that the threshold for statistical significance is somewhere between four and 16 months.
Other studies (e.g., Aoyama, Flege, Guion, Akahane-Yamada, & Yamada, 2004; MacKain, Best, & Strange, 1981) have shown significant perceptual improvements after six months of residency in a second language (L2) environment. Best and Tyler (2007) suggest, based on the results of multiple perceptual studies, that significant improvement in the perception of L2 sounds begins to occur between 6 and 12 months in an L2 environment.

The results of the present study also suggest that increased formal instruction in German can lead to increased accuracy in the perception of German rounded vowels. This agrees with studies by Gottfried and Beddor (1988) and Levy and Strange (2008), who found that formal instruction in French, along with residency in a French-speaking country, improved learners’ overall perception of French vowels.

The second prediction of Research Question #2 was that the overall identification accuracy of each experimental group would be significantly lower than the overall identification accuracy of the native German-speaking control group. This prediction was also confirmed. The overall identification accuracy of the control group (93.03%) differed significantly from all four experimental groups and was almost double that of the 300+Resi group (49.03%). This strongly indicates that even 16 months of in-country residency may not help most second language (L2) learners attain native-like L2 perception.

The third prediction of Research Question #2 was that the identification accuracies of the German back rounded vowels /uː/, /oː/, and /oː/ would not differ significantly between the four experimental groups. This prediction was based on the tenets of Best’s (1995) Perceptual Assimilation Model (PAM) and Flege’s (1995, 2003b)
Speech Learning Model (SLM), both of which claim that the acquisition of an L2 sound is based on its perceptual similarity to the closest sound in the native language (L1). The German vowels /uː/, /ʊ/, and /oː/ have been shown in cross-language similarity studies (e.g., Schultheiss, 2008; Strange et al., 2004, 2005) to be perceptually similar to AE /u/, /ʊ/, and [ou], respectively; thus according to the SLM, experience in German should not have affected the perceptual accuracy of these German back rounded vowels, as much as the German front rounded vowels. However, the results of a series of one-way analyses of variance (ANOVAs) for each vowel, based on AE subjects’ identification accuracies, did not entirely uphold this prediction. The differences in the identification accuracies of all experimental groups for all rounded vowels except /ʊ/ were found to be statistically significant. In addition, post-hoc Tukey HSD tests did find a significant difference between the identification accuracies of the 101 and 300+Resi group for /oː/ but not for /uː/. Thus, experience in German affected AE subjects’ perception of all front rounded vowels and all back rounded vowels except /uː/ and /ʊ/.

Despite the fact that German /uː/, /ʊ/, and /oː/ have phonemic correlates in American English, Strange et al.’s (2004) acoustic analysis shows differences in the position of these vowels in the vowel space. As mentioned earlier, AE /u/, /ʊ/, and /o/ are further forward in the vowel space than German /uː/, /ʊ/, and /oː/, thus suggesting that these German vowels could behave more like dissimilar vowels for native AE speakers. Flege (2003b) admitted that the SLM “does not provide a metric for determining when cross-language phonetic differences will be too small to support category formation” (p. 329). It is possible that the phonetic differences between the German vowel /oː/ and its
AE counterpart were large enough to allow AE subjects to create new a phonetic category for German /ɔː/ after gaining experience in German.

To answer Research Question #2, the results of the forced-choice identification task, collapsed by vowel, clearly show that experience in German significantly affects AE learners’ accuracy in the perception of German rounded vowels overall. Each AE group with more experience in German obtained a progressively higher overall score for all vowels on the identification task (ranging from 20.72% for the 101 group to 49.03% for the 300+Resi group). However, none of the AE groups approached the overall score of the native German-speaking control group (93.03%). Despite this, one of the central tenets of the SLM (Flege, 1995, 2003b) was still upheld by the results of the present study. The SLM claims that the capacity for perceptual learning, including the ability to create new phonetic categories, remains intact after the acquisition of the L1. The fact that each experimental group performed progressively better on the forced-choice identification task suggests that experience in German, whether it be through formal instruction or in-country residency, leads to an improvement in AE learners’ overall German perception.

Additionally, in examining AE groups’ identification accuracies of individual German rounded vowels, it was found that experience in German affected the perception of all of the rounded vowels except /uː/ and /ʊ/.

5.3 Research Question #3: When AE learners (across all levels of experience) misidentify German rounded vowels, which vowels do they select in place of the correct vowel? Do
patterns of misidentification change for each vowel as AE learners gain more experience in German?

The first prediction of Research Question #3 was that AE learners across all levels of experience in German would frequently misidentify German /ʊ/ as /uː/, /oː/, and /ɔ/. This prediction was not supported by the results of the forced-choice identification task. The most frequent responses to /ʊ/ stimuli by all AE learners combined were words with /ʊ/ (25.23%). The second and third most frequent responses to /ʊ/ stimuli were words with /ɔ/ (20.75%) and /oː/ (14.73%), respectively. Words with /uː/ were the seventh most frequent responses (4.48%). The combined total of /uː/, /oː/, and /ɔ/ responses (39.96%) is less than half of the responses to all /ʊ/ stimuli.

Because of the varied perceptual assimilation of /ʊ/, Strange et al. (2005) determined that this vowel was uncategorizable according to PAM (Best, 1995) and not assimilated to any L1 category according to the SLM (Flege, 1995, 2003b). Strange et al. predicted that /ʊ/ would be easily discriminated from /uː/ and /oː/, which would constitute uncategorized versus categorized assimilation according to PAM. Strange et al. also predicted that with experience in German, AE speakers would eventually create a new phonetic category for /ʊ/. As explained in the previous section, however, the identification results of this study suggest that even advanced learners with at least 16 months of residency in a German-speaking country have difficulty identifying German /ʊ/. Looking at the ranking of the identification accuracies of the eight German vowels, /ʊ/ ranked second least accurate (28.37%) for the 300+ group and least accurate (27.21%) for the 300+Resi group.
It should be pointed out that /ʊ/ stimuli in the forced-choice identification task were also misidentified as words with one of the four front rounded vowels 33.90% of the time. Words with the front rounded vowel /æ/, for instance, were the fourth most frequent responses for /ʊ/ stimuli, in 11.83% of instances.

Words with /u:/ were the most frequent responses to /u:/ stimuli (25.32%). The fact that the percentages of the second, third, and fourth most frequent identification responses for /u:/ stimuli (/ʏ/, 21.08%; /yː/, 18.29%; and /ʊ/, 17.04%; respectively) were relatively close to the percentage of /u:/ responses suggests that, according to the tenets of the SLM (Flege, 1995, 2003b), most AE subjects had not created a new phonetic category for this vowel and instead may have confused it with several other vowels. According to the tenets of PAM (Best, 1995), German /u:/ would be considered an “uncategorizable speech sound” (p. 194) in this case.

The second prediction of Research Question #3 was that AE learners at all levels of experience in German would frequently misidentify German /ʏ/ as /u:/, and German /ʏ/, /œ/, and /æ/ as /ʊ/ or each other. This prediction was partially supported. The most frequent responses to /ʏ/ and /œ/ stimuli were words with /ʊ/ (28.46% and 26.81%, respectively). Words with /ʊ/ were also the fourth most frequent responses to /œ/ stimuli (11.63%). The top four responses to /ʏ/, /œ/, and /æ/ stimuli, in fact, were words containing /ʊ/ or a front rounded vowel. For /y:/ stimuli, however, words with /u:/ were the fourth most frequent responses (9.84%).

As mentioned earlier, Strange et al. (2004, 2005) observed that German front rounded vowels were most often perceptually assimilated to AE back rounded vowel categories, and they predicted that AE learners would confuse German front rounded
vowels with German back rounded vowels. In the present study, however, AE subjects, collapsed across experience level, did not identify any of the front rounded vowels as a back rounded vowel more than 50% of the time. While the identification accuracies of each front rounded vowel were low, ranging from 25.78% for /œ/ to 40.77% for /yː/, AE subjects at all levels of experience seemed to recognize the frontness of these vowels more than 50% of the time.

The third prediction of Research Question #3 was that AE groups with more experience in German would misidentify the front rounded vowels /yː/, /ʏ/, /øː/, and /œ/ as back rounded vowels less frequently than groups with less experience in German. Again, this prediction was based on the results of cross-language similarity studies (Schultheiss, 2008; Strange et al., 2004, 2005) in which native AE listeners perceptually assimilated German front rounded vowels to AE back rounded vowel categories. This prediction was also based on the tenets of the SLM (Flege, 1995, 2003b), which claims that L2 learners will perceive new L2 sounds (i.e., L2 sounds without L1 correlates) more accurately with increased L2 experience. The results of the forced-choice identification task generally supported this prediction. The 101 group, as expected, identified the front rounded vowels /yː/, /ʏ/, /øː/, and /œ/ with the least amount of accuracy (22.02%, 16.34%, 9.80%, and 12.22%, respectively) compared to the other more advanced groups. The most frequent response by the 101 group for all of these vowels was the back rounded vowel /ʊ/. Another back rounded vowel, /uː/, was among the top four responses by the 101 group for /yː/, /ʏ/, and /øː/. The 101 group misidentified more than half of /ʏ/ and /œ/ stimuli as words with one of the four back rounded vowels, but the same pattern did not hold for /yː/ and /øː/ stimuli. The 201 group misidentified more than half of /œ/ stimuli as
words with back rounded vowels. The 201 group also misidentified /ɣ/ and /œ/ most frequently as /ʊ/, although their most frequent responses for /ɣ:/ and /œ:/ were the correct responses. The 300+ and 300+Resi groups generally identified the front rounded vowels more accurately than the 101 and 201 groups, and the 300+ and 300+Resi groups did not misidentify any of the front rounded vowels as back rounded vowels more than half of the time.

The tense vowels and /yː/ and /øː/ did not quite follow the perceptual patterns suggested by the cross-language similarity studies and the SLM. The 101 and 201 groups identified more than half of the stimuli of each of these vowels as words with front rounded vowels. This suggests that experience in German, at least beyond initial exposure, may not have as great an effect on these vowels as on the lax front rounded vowels /ɣ/ and /œ/. Polka (1995) showed that, despite the fact that AE speakers tend to perceptually assimilate German /ɣ:/ to AE /u:/, AE speakers can still discriminate German /ɣ:/ and /u:/). In her study, AE subjects with no experience in German discriminated these vowels with near-native accuracy. AE subjects failed to discriminate German /ɣ/ and /u/, however, with the same high accuracy.

Based on the results of these predictions, the answer to Research Question #3 is that native speakers of American English, collapsed across all levels of experience, show patterns of perceptual confusion for several German rounded vowels. AE learners, for instance, select /ʊ/ words most frequently for /ʊ/ stimuli (25.23%) but also frequently misidentify /ʊ/ as /ɔ/ (20.75%) and /œ/ (14.73%). AE learners do not misidentify /ɣ:/ as /u:/ very frequently (9.84%), although they do misidentify /ɣ/, /œ/, and /œ/ as /u/ or each other very frequently (See Chapter 4, Table 9). AE groups with more experience in
German showed less frequent misidentification of front rounded vowels as back rounded vowels. Misidentification patterns of the back rounded vowels did not change much as experience increased, although the identification accuracies of these vowels improved.

5.4 Implications

This study has demonstrated native AE speakers’ ability to perceive German rounded vowels, showing that some vowels (e.g., /œ/, /ʊ/) are more difficult to perceive than others (e.g., /oː/, /ɔ/). The results of this study can be useful for perceptual training in classroom instruction, as the results indicate which German rounded vowels are difficult for AE learners at different levels of experience in German. For example, the results of this study would suggest that training and instruction at the beginning levels should focus on the perception of the front rounded vowels and /ʊ/, while /œ/ should be emphasized at every experience level. Specifically, perceptual training exercises for the lower levels should include all rounded vowels, but should focus particularly on discriminating /ʊ/ from the front rounded vowels /yː/, /ʏ/, /øː/, and /œ/. Perceptual training for the lower levels should also focus on discriminating the front rounded vowels from one another. Perceptual training for more advanced learners, including those with residency experience in a German-speaking country, could then focus on identifying /uː/, which was shown to still be difficult for advanced learners in this study, and discriminating the front rounded vowels from /ʊ/ and each other. Vowel tokens for all levels could include real and nonsense words, similar in structure to the tokens used in the present study, but with a wider variety of consonantal contexts. These tokens could be recorded by several native

22 I am grateful to Laura Catharine Smith for our discussions and her insights on this topic.
German speakers to provide phonetic variability. For all levels, words with a variety of contexts could be used in identification tasks, and minimal pairs could be used in discrimination tasks.

The second implication of this study relates to the effects of L2 experience. Experience in German was found to significantly affect the accurate perception of all German rounded vowels in this study except /ʊ/. Thus this study suggests that L2 experience, whether it is gained through formal instruction or in-country residency, does result in improved perception of many L2 sounds, suggesting the creation of new phonetic categories for these sounds. Despite these perceptual gains, however, not even 16 months of in country residency helped AE speakers attain native-like identification accuracy in any of the German vowels. This finding is not unusual, as several other studies (e.g., Bohn & Flege, 1990; Flege, Bohn, & Jang, 1997; Gottfried, 1984) have also reported significant perceptual differences between experienced and native L2 speakers. This study nevertheless shows the importance of immersion in an L2 environment; that residency in a German-speaking country, especially 16 months or more, can be beneficial in helping AE speakers develop more accurate perception of German rounded vowels (particularly for /œ/, which was perceived significantly more accurately only by the 300+Resi group). Thus extended study abroad programs and work internships in German-speaking countries should be encouraged for AE speakers wishing to improve their perception of these vowels. Regular interaction with native speakers of German will

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23 In a perceptual training study, Lively, Logan, and Pisoni (1993) found that non-native listeners who had been exposed to tokens produced by several native L2 speakers identified new tokens produced by new L2 speakers more accurately than other non-native listeners who had been exposed to tokens produced by only one native speaker. Lively et al. concluded that the phonetic variability provided by multiple native L2 speakers helped non-native speakers learn L2 sounds.
be necessary during these immersion experiences to provide sufficient L2 input (cf. Flege & Liu, 2001; O’Brien, 2003).

The third implication of this study is that the findings of cross-language perception studies do not necessarily extend to categorical perception studies. For instance, Strange et al. (2004) made several predictions, based on their perceptual assimilation results, as to how AE learners would perceive German vowels. Some of their predictions were confirmed by the results of the present study, such as the poor identification of /ʊ/, while other predictions were not confirmed, such as the highly accurate identification of /uː/. Thus there is not always a direct relationship between cross-language perception and categorical perception.

5.5 Limitations

The research design of the present study had several limitations. For instance, the sample size of this study was smaller than originally desired. As described in Chapter 3, 96 subjects participated in the forced-choice identification task, yet the results of only 69 subjects were included in the data analysis (i.e., 11 in the 101 group, 9 in the 201 group, 19 in the 300+ group, 24 in the 300+Resi group, and 6 in the control group). While adjustments were made in the data analysis of this study to compensate for small and uneven group sizes, larger and more even group sizes would have produced more robust statistical results.

The format of the forced-choice identification task may also have affected the results to some extent. As the reader will recall, the possible options for each stimulus on the task included German words with the eight rounded vowels and “none of the above.”
There were no additional vowel options. It has been noted that German /ɔ/ was the vowel most accurately identified by AE subjects. AE /ɔ/, however, does not exist in most AE dialects and is instead perceived and produced as /ɑ/ (Labov, Ash, & Boberg, 2006; Majors, 2005; Strange et al., 2004, 2005). If other German vowels, such as /a/ or /ə/, had been included as possible options, the perception of German /ɔ/ by AE subjects may have been different.

Another aspect of the identification task that was not examined was native speaker variability. Four native German speakers provided the tokens used in the task, and some of these speakers distinguished some of their tokens more clearly than others. One of the female speakers, for instance, reduced many of her vowels, producing tokens that were less perceptually distinct than the tokens of the other native German speakers (as reported by some subjects, the advisor, and the author). The identification results, however, were not analyzed based on speaker of tokens. Also, the effects of the native German speakers’ length of residence in the United States were not considered, nor were the effects of the native speakers’ L2 English on their German production (cf. Flege & Eefting, 1987a). This has been shown elsewhere to potentially influence pronunciation. For instance, Major (1987) found that the L1 vowels of L2 learners shifted in the vowel space after living in an L2 environment.

Also, as explained in Chapter 3, many subjects in the 300+Resi group had served full-time proselyting missions for the Church of Jesus Christ of Latter-day Saints (LDS) in a German-speaking country. Most of these subjects had returned to the United States within the previous two years at the time of this study. Attrition of perceptual ability, based on how long it had been since AE subjects had returned from a German-speaking
environment, was not considered in this study. This is a potential limitation, based on work by researchers such as Raffaldini (1987), who have found that the general proficiency, including pronunciation, of many L2 learners decreased after returning home from a study abroad experience. These results also leave room for a possible attrition of perception as well, although it was not explicitly studied. This attrition was found, Raffaldini stated, even for learners who returned home and continued to receive formal instruction in the L2.

Finally, the influence of local dialects and regional pronunciation of German was not considered. Many subjects, for instance, had served LDS missions in Northern Germany, Southern German, Austria and Switzerland. The production of German vowels differs in these areas, and not all native inhabitants speak Standard German. This could have had an impact on the perception of at least some subjects.

5.6 Future Directions

Building on the implications and limitations of the present study, the following suggestions are offered for future research:

1. As explained in Chapter 1, one of the major limitations of this study was that the consonantal contexts of the word stimuli were collapsed. Other studies examining the categorical (e.g., Gottfried, 1984; Jacewicz, 1999; Levy & Strange, 2008) and cross-language (e.g., Schultheiss, 2008; Trofimovich, Baker, & Mack, 2001) perception of L2 vowels have observed significant effects of consonantal context, particularly by beginning L2 learners. If the results of this study are reexamined, taking the contexts of each German rounded vowel into consideration, additional
insights into categorical perception and the effects of experience could very well be obtained.

2. Another area in which this study could be improved is the sample size. A larger sample size would yield more statistically reliable data. It is therefore suggested that the present study be replicated with at least 20 subjects in each subject group. A larger sample size would also allow additional subject variables to be considered, such as age, gender, and native dialect.

3. Subjects’ native dialects are particularly worth examining in light of new research on the effects of L1 dialect on L2 perception and production (e.g., O’Brien & Smith, submitted; Smith & Gardner, 2007; Smith, Gardner, Whitlock, & Fitzner, 2007). AE subjects in the present study differed in their native dialect and in the dialects to which they had been exposed (e.g., Utah English, California English, etc.), and a reexamination of their vowel identification results by dialect could yield additional differences in perception. For example, O’Brien and Smith (submitted) found that native AE speakers differed in their production of German /u:/ and /y:/ based on their native AE dialect, specifically by how far their AE /u/ was fronted.

4. Subjects’ perception of L2 sounds has been shown in some studies (e.g., Lambacher, Martens, Kakehi, Marasinghe, & Molholt, 2005; Lively et al., 1993) to differ according to the informant that produced the stimuli. If the results of the present study were reexamined, comparing AE subjects’ perception of the four native German speakers that provided the stimuli of the forced-choice identification task, additional insights could be obtained. For example, dialect
differences among the native speakers could be shown to affect AE subjects’ perception of some German vowels.

5. Future studies could also examine additional factors in AE subjects’ perception of the German rounded vowel stimuli, such as vowel duration and spectral features (cf. Bennett, 1968; Bohn & Flege, 1990; Gottfried & Beddor, 1988). Also, as many of the stimuli in the present study were nonsense words in German, the effects of real versus nonsense words could be examined (cf. Ganong, 1980; Pitt & Samuel, 1993; Walley & Flege, 1999).

6. Finally, as suggested24 in Schultheiss (2008), a future study could compare native AE speakers’ categorical perception of German rounded vowels with their cross-language perception of these vowels. Interesting insights could be gained by observing how AE speakers at different levels of experience in German identify these vowels and then map them to AE vowel categories. For example, Frieda and Nozawa (2007) conducted such a study with experienced and inexperienced Japanese and Korean learners of American English, and found that the patterns of categorical perception suggested by the results of a perceptual assimilation task were upheld only for the inexperienced learners.

5.7 Conclusion

The results of the present study provide many valuable insights into the categorical perception of German rounded vowels by native speakers of American English. The results demonstrate that native AE speakers perceive some German rounded

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24 This suggestion originated with Laura Catharine Smith and Wendy Baker.
vowels better than others (e.g., /ɔ/ vs. /ʊ/), and that experience in German does lead to more accurate perception of each of these vowels except /uː/ and /ʊ/. It is hoped that the results of this study, as well as the suggestions for future research, encourage researchers to continue examining the categorical perception of German rounded vowels by native AE speakers. Future research in this area could uncover additional insights that may help German language instructors improve their teaching of the perception and production of these vowels.
References


Appendix A

List of Stimulus Materials

Listed here are the stimuli used in the forced-choice identification task. Consonantal environments are shown in International Phonetic Alphabet (IPA) symbols, and word tokens are shown in German orthography.

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Appendix B

Screenshots of Forced-Choice Identification Task

Introductory Screens:

GERMAN VOWEL PERCEPTION STUDY
In what follows, you will hear a series of German vowel sounds and some nonsense words via headphones. You will then see a list of words on the screen with corresponding numbers such as the one below:

Fühle 1  Fühle 5
Fühle 2  Fühle 6
Fühle 3  Fühle 7
Fühle 4  Fühle 8
none of the above 0

Your task is to select the number of the word that you think you heard as "Fühle" for none of them, if that is the case.

For instance, after you think the word you heard was "Fühle," you would press "5" on the keyboard.

Press SPACE BAR to continue.

To familiarize you with the task, we will start with 10 practice questions. Your answers to these questions will not be recorded by the computer.

When you are ready, press SPACE BAR to start the set of practice questions.

You have now completed the practice questions and are ready to begin the perception test. Your responses to the remaining questions will now be recorded by the computer.

If you have any questions at this point, please ask the researcher. Otherwise, when you are ready, please press SPACE BAR on your keyboard to begin.

Selection Screens:

Fühle 1  Fühle 5
Fülle 2  Fülle 6
Fohlle 3  Föhle 7
Folle 4  Fölle 8
none of the above 0

Führe 1  Führe 5
Furre 2  Fürre 6
Fohre 3  Föhre 7
Forre 4  Förre 8
none of the above 0

Fuhsse 1  Fuhsse 5
Fusse 2  Füsse 6
Fohsse 3  Fösse 7
Fosse 4  Fösse 8
none of the above 0

Fuhte 1  Fuhte 5
Futte 2  Fütte 6
Fohnte 3  Föhte 7
Fotte 4  Fötte 8
none of the above 0

Guhte 1  Gühte 5
Gutte 2  Gütte 6
Gohnte 3  Göhte 7
Gotte 4  Götte 8
none of the above 0

Puhle 1  Pühle 5
Pulle 2  Pülle 6
Pohle 3  Pöhle 7
Polle 4  Pölle 8
none of the above 0
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Goodbye Screen:

This concludes the experiment. Thank you for participating.
Have a nice day.
Appendix C

Biographical Questionnaire

BIOGRAPHICAL QUESTIONNAIRE
Perception of German Study

This questionnaire concerns your language experiences over the course of your lifetime. Feel free to elaborate where you think it would be helpful to the study. All responses are confidential.

Thank you again for your participation.

Name: ______________________________________ Gender: M___ F___           Age: _____
Telephone: ______________________   Email: ______________________________

1. Where were you born? _____________________ When? _____________________________

2. Are you a native speaker of German? Yes___ No___
   *If not, please continue with question #3.*
   If so, how long have you been living in the United States? __________
   What percentage of each day do you spend speaking German? __________
   What percentage of each day do you spend speaking English? __________
   *Please continue with question #4.*

3. If you answered ‘no’ to the above, how long have you been speaking German? __________
   What is your native language? __________
   How would you rate your overall ability in German?  
   beginner     intermediate     advanced     near-native
   How would you rate your ability to speak German? 
   beginner     intermediate     advanced     near-native
   How would you rate your ability to read German? 
   beginner     intermediate     advanced     near-native
   How would you rate your ability to understand spoken German? 
   beginner     intermediate     advanced     near-native
   How would you rate your German writing ability? 
   beginner     intermediate     advanced     near-native

4. How often do you speak German? 
   never___ sometimes___ often___

5. In which languages other than English and German do you have proficiency?

6. At what age(s) did you start learning each of your foreign languages? (‘Start learning’ = first exposure of 6 months or more, or first study of one semester or more)

7. On a scale of 1 (least nativelike) to 10 (most nativelike), rate your oral proficiency in each of your languages, including your native language.
8. In the boxes below, indicate the use of German and other languages during the past 6 months.

Check the percentages that apply to your personal experience. The numbers should total 100%.

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Check the percentages that apply to your personal experience. The numbers should total 100%.

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Check the percentages that apply to your personal experience. The numbers should total 100%.

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<th>70%</th>
<th>80%</th>
<th>90%</th>
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Check the percentages that apply to your personal experience. The numbers should total 100%.

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</table>

9. Where have you lived? (six months’ stay minimum) Indicate ALL the cities (or states) and periods below.

**ENGLISH-SPEAKING**

I lived in ____________________________ from __________________ to __________________

I lived in ____________________________ from __________________ to __________________

I lived in ____________________________ from __________________ to __________________

**GERMAN-SPEAKING**

I lived in ____________________________ from __________________ to __________________

I lived in ____________________________ from __________________ to __________________

I lived in ____________________________ from __________________ to __________________
10. At what age were you first exposed to your non-native language in school or college? ___

11. Please indicate the approximate periods in which you studied German. Circle “school” or “college” as appropriate.

   In school / college, I studied German from____________________ until ____________________
   In school / college, I studied German from____________________ until ____________________
   In school / college, I studied German from____________________ until ____________________

12. Have you taken specialized courses taught in German, such as German history, literature, or linguistics? If so, please list them below:

13. All told, for how many years have you been studying German? ___

14. At what age were you first exposed to the German language on a daily basis? (If this has not yet been the case, please write “N/A”) ___

15. Did you learn German by “ear” or by “eye”? That is, did you rely more on reading or on listening? Please try to quantify this relationship by estimating the relative contributions of:
   Reading: _____ %   Listening: _____ %

16. I would appreciate any comments or other information you feel would be useful.
### Appendix D

**Identification Responses of Experimental Groups**

#### Table 11. Identification Responses for German Back Rounded Vowels.

<table>
<thead>
<tr>
<th>Vowel</th>
<th>Rank</th>
<th>101 Group (Percentage)</th>
<th>201 Group (Percentage)</th>
<th>300+ Group (Percentage)</th>
<th>300+Resi Group (Percentage)</th>
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</table>

**Note.** Correct responses and their percentages are highlighted in yellow. Lines connect each correct vowel across groups. “N” represents responses marked as “none of the above.” Vowels that are tied in ranking are marked with an asterisk (*).
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<th>Vowel</th>
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<tr>
<td></td>
<td>9</td>
<td>N (3.27%)</td>
<td>/œː/ (2.95%)</td>
<td>/œː/ (2.22%)</td>
<td>N (2.54%)</td>
</tr>
</tbody>
</table>

*Note. Correct responses and their percentages are highlighted in yellow. Lines connect each correct vowel across groups. “N” represents responses marked as “none of the above.” Vowels that are tied in ranking are marked with an asterisk (*)*.