PERCEPTUAL PROCESSING OF VARIABLE INPUT IN SPANISH:
AN EXEMPLAR-BASED APPROACH TO SPEECH PERCEPTION

DISSERTATION

Presented in Partial Fulfillment of the Requirements for
the Degree Doctor of Philosophy in the
Graduate School of The Ohio State University

By

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ABSTRACT

The effects of linguistic experience on the perceptual processing and identification of phonological dialect variation were investigated in a series of psycholinguistic experiments with native speakers of Spanish from Mexico and Puerto Rico. Perceptual processing of dialect variation was assessed using bisyllabic words produced by female speakers of Mexican and Puerto Rican Spanish with a speeded naming task and a lexical decision task. Identification of dialect variation was assessed using bisyllabic words with a two-alternative forced-choice classification task. The test stimuli used in all three tasks contained either a word-final /n/, a syllable-final /r/, or a syllable-final /s/. These phonological variables were chosen because they exhibit phonological variation to different degrees in the two dialects being studied here.

The results from the speeded naming task show a significant main effect for phonological variable, with words containing syllable-final /s/ resulting in the slowest naming (reaction) time. Factors that significantly interacted with other factors were sex, listener dialect, and speaker dialect. The results from the lexical decision task show a significant effect for phonological variable, where words containing syllable-final /s/ resulted again in the slowest reaction times. Interestingly, both Mexican and Puerto Rican participants were biased to label Mexican stimuli as a word, even when the stimuli were nonwords. This bias was not found for the Puerto Rican stimuli. The dialect identification
task’s results show that overall listeners most accurately identified the speaker’s dialect when they produced words containing syllable-final /s/, while the dialect of speakers producing words containing syllable-final /r/ was least accurate. The Mexican listeners were more accurate at identifying their own dialect than they were identifying a dialect other than their own, as were the Puerto Rican listeners.

These results are easily modeled and accounted for within an exemplar-based approach. In an exemplar model, such as the one presented in Chapter 6, there are interactions and activations between several categories during speech perception and production. A listener’s linguistic experience is stored as exemplars in the lexicon that are connected to other linguistic and extra-linguistic information that the listener has experienced. This way, input is stored as detailed exemplars, which activate, and in turn are activated by, other categories such as stereotypes (e.g. age, gender, dialect, etc.) and phonological generalizations (e.g. word-final nasals are velar). The findings of the current study add to the growing literature on the effects of linguistic experience on the perception of variable input, as well as to the growing literature on exemplar-based models of perception and production.
Dedicated to my loving husband and best friend

Will Boomershine

who has always supported me in every endeavor
ACKNOWLEDGMENTS

First and foremost, I wish to thank my husband, Will, for all of the love and support he has given me throughout my time as a graduate student. Without him, this would not have been possible.

I also thank my advisors, Terrell A. Morgan and Keith Johnson, for their support, encouragement, and enthusiasm which made this research possible. I must thank them also for their patience and their criticism, both for which I am very grateful.

I thank my committee member, Scott Schwenter, for his helpful discussions and support throughout the years. His creation and organization of the Friday afternoon Hispanic Linguistics Colloquium series was immensely helpful to me as it provided a friendly forum for me to present my research.

I also thank Robert Fox for the many hours that he worked with me to analyze my results. Without his support and instruction, there would be no dissertation (at least the results chapter!). Even though he was not on my committee, he selflessly shared his time (and chocolate candy) to explain statistical analyses to me, often several times. I am grateful for his time and patience with me, more so than I am able to express.

I’d like to thank Chad Howe and Marc Smith for their wonderful friendship throughout my five years in Columbus. We’ve shared laughs and tears, and been there for each others’ weddings (and a couple of divorces). I could always count on them for a
good laugh and good food. We would all agree that our time here in the Department of Spanish and Portuguese would not have been the same without the friendship of Melinda Robinson. She was always there to lend a helping hand and to spread cheer. Her friendship will always be remembered.

I thank Mary Beckman, Shari Speer, and Beth Hume for the knowledge they shared with me during their seminars. Without their wisdom of and enthusiasm for the field of Linguistics, I would not be as motivated as I am today.

I thank Jim Harmon, the Department of Linguistics’ systems administrator, for providing me with all of the technical assistance that I needed throughout the years. I also thank Paul and Scott in the College of Humanities Studio B for providing technical assistance with recordings. Without all of their patience and expertise, I would not have been able to conduct my research.

I thank the members of OSU Phonies, the Phonetics and Phonology research group in the Department of Linguistics, who supported me and provided stimulating discussions during various stages of my research.

I thank my fellow Spanish Linguistics graduate students, including Chad Howe and Gilberto Velázquez-Aponte, for putting me in touch with the participants in Mexico and Puerto Rico, respectively. Their help and friendship is greatly appreciated.

This research was funded by an Ohio State University College of Humanities Small Grant and by an Ohio State University Alumni Grant for Graduate Research and Scholarship. Without these funds, I would not have been able to travel to Puerto Rico and
Mexico to conduct my experiments, nor would I have been able to pay the participants for taking part in my study.

Last but not least, I would like to thank my family for their continuous support and encouragement throughout my time at the Ohio State University. Their friendship and understanding these past five years helped me to reach my goals and to pursue my interests. Their dedication to their own fields reminds me that there is more to life than linguistics.
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# TABLE OF CONTENTS

Abstract .............................................................................................................................................................................. ii  
Dedication ............................................................................................................................................................................... iv  
Acknowledgments .................................................................................................................................................................... v  
Vita ......................................................................................................................................................................................... viii  
List of Figures ....................................................................................................................................................................... xii  

Chapters:

1. Introduction ........................................................................................................................................................................ 1  
   1.1 Introduction ................................................................................................................................................................. 1  
   1.2 Advances in sociophonetic speech perception ......................................................... 3  
   1.3 Dissertation overview ................................................................................................................................. 8  

2. Speech perception and usage-based models ................................................................................................................ 9  
   2.1 Usage-based vs. abstractionist accounts ................................................................................................. 10  
   2.2 Perception of dialect and talker variation ........................................................................................... 18  
      2.2.1 American English vowels .............................................................................................................. 18  
      2.2.2 English vowels and fricatives ......................................................................................................... 24  
      2.2.3 Stimulus variability and perception ............................................................................................... 25  
      2.2.4 Variation in vowel perception ......................................................................................................... 27  
   2.3 Cross-linguistic speech perception .......................................................................................... 28  
      2.3.1 Spanish-English bilinguals and English monolinguals ..................................................... 29  
      2.3.2 Russian-English bilinguals ....................................................................................................... 31  
      2.3.3 English learners of Spanish ................................................................................................. 33  
   2.4 Summary ................................................................................................................................................................. 38  

3. Language Background ............................................................................................................................................... 39  
   3.1 Dialect imitation study ................................................................................................................................. 39  
   3.2 Mexican Spanish ....................................................................................................................................................... 42  
      3.2.1 Overview ......................................................................................................................................................... 42  
      3.2.2 Variable /n/ ................................................................................................................................................... 44  
      3.2.3 Variable /s/ ................................................................................................................................................ 45  
      3.2.4 Variable /r/ ............................................................................................................................................... 46  
      3.2.5 Conclusion ............................................................................................................................................... 46  
   3.3 Puerto Rican Spanish ........................................................................................................................................... 47  
      3.3.1 Overview ............................................................................................................................................... 47
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>XMOD: Johnson’s Model of Exemplar Theory</td>
<td>14</td>
</tr>
<tr>
<td>2.2</td>
<td>Beckman, Munson, Edwards model</td>
<td>17</td>
</tr>
<tr>
<td>2.3</td>
<td>Clustering results for forced-choice categorization</td>
<td>20</td>
</tr>
<tr>
<td>2.4</td>
<td>Clustering results for free classification task</td>
<td>22</td>
</tr>
<tr>
<td>2.5</td>
<td>Exemplar-based model of sociolinguistic variation</td>
<td>23</td>
</tr>
<tr>
<td>2.6</td>
<td>Rating responses</td>
<td>35</td>
</tr>
<tr>
<td>2.7</td>
<td>Discrimination results</td>
<td>36</td>
</tr>
<tr>
<td>3.1</td>
<td>Imitation results of a native speaker from Mexico</td>
<td>42</td>
</tr>
<tr>
<td>3.2</td>
<td>Map of Mexico</td>
<td>43</td>
</tr>
<tr>
<td>3.3</td>
<td>Illustration of nasal assimilation process in Spanish</td>
<td>44</td>
</tr>
<tr>
<td>3.4</td>
<td>Map of Puerto Rico</td>
<td>47</td>
</tr>
<tr>
<td>3.5</td>
<td>Realization of /s/ in Puerto Rican Spanish</td>
<td>52</td>
</tr>
<tr>
<td>3.6</td>
<td>Realization of /t/ (%) in Puerto Rican Spanish, based on Figueroa and Hislope (1999)</td>
<td>55</td>
</tr>
<tr>
<td>3.7</td>
<td>Map of Puerto Rico illustrating realization of /t/ in Puerto Rico, based on Canfield (1981:77)</td>
<td>56</td>
</tr>
<tr>
<td>4.1</td>
<td>Predicted results for the lexical decision task</td>
<td>60</td>
</tr>
<tr>
<td>4.2</td>
<td>Sources of variability in speech, based on Klatt 1986 and Pisoni 1997</td>
<td>63</td>
</tr>
<tr>
<td>4.3</td>
<td>Example stimuli for Experiments 1, 2, and 3</td>
<td>64</td>
</tr>
</tbody>
</table>
4.4 Mean age of participants by gender and dialect ............................................. 72
4.5 Travel history by dialect and gender ................................................................. 73
4.6 Revised travel history by dialect and gender ..................................................... 74
4.7 Mexican participant background information .................................................. 75
4.8 Puerto Rican participant background information ............................................. 76
5.1 Median reaction time results by speaker and listener dialect, presented in ms ... 86
5.2 Main effect for phonological variable .............................................................. 87
5.3 Significant interaction between listener gender and phonological variable ...... 88
5.4 Significant interaction between speaker dialect and phonological variable ...... 89
5.5 Significant interaction between speaker dialect, listener dialect, and phonological
   variable, shown here for phonological variable /n/ ............................................ 90
5.6 Significant interaction between speaker dialect, listener dialect, and phonological
   variable, shown here for phonological variable /r/ ............................................ 91
5.7 Significant interaction between speaker dialect, listener dialect, and phonological
   variable, shown here for phonological variable /s/ ............................................ 92
5.8 Significant interaction between speaker dialect, listener gender, and phonological
   variable, shown here for phonological variable /n/ ............................................ 93
5.9 Significant interaction between speaker dialect, listener gender, and phonological
   variable, shown here for phonological variable /r/ ............................................ 94
5.10 Significant interaction between speaker dialect, listener gender, and phonological
    variable, shown here for phonological variable /s/ ........................................... 95
5.11 Average word duration (ms) by speaker ......................................................... 97
5.12 Average median reaction time by speaker and listener dialect ......................... 98
<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.13</td>
<td>Main effect for phonological variable</td>
<td>99</td>
</tr>
<tr>
<td>5.14</td>
<td>Mean accuracy and d’ responses by speaker dialect for the PR listeners</td>
<td>100</td>
</tr>
<tr>
<td>5.15</td>
<td>Mean accuracy and d’ responses by speaker dialect for the Mexican listeners</td>
<td>101</td>
</tr>
<tr>
<td>5.16</td>
<td>Overall accuracy by speaker dialect for words and nonwords</td>
<td>102</td>
</tr>
<tr>
<td>5.17</td>
<td>Proportion of hits for speaker dialect by listener dialect</td>
<td>103</td>
</tr>
<tr>
<td>5.18</td>
<td>Proportion of false alarms for speaker dialect by listener dialect</td>
<td>104</td>
</tr>
<tr>
<td>5.19</td>
<td>Mean accuracy responses by speaker dialect and phonological variable for the Puerto Rican listeners</td>
<td>106</td>
</tr>
<tr>
<td>5.20</td>
<td>Mean accuracy responses by speaker dialect and phonological variable for the Mexican listeners</td>
<td>107</td>
</tr>
<tr>
<td>5.21</td>
<td>Main effect for phonological variable</td>
<td>108</td>
</tr>
<tr>
<td>5.22</td>
<td>Significant interaction between listener dialect and speaker dialect for proportion correct</td>
<td>109</td>
</tr>
<tr>
<td>5.23</td>
<td>Significant interaction for phonological variable by listener dialect</td>
<td>110</td>
</tr>
<tr>
<td>5.24</td>
<td>Significant interaction for phonological variable by speaker dialect for proportion correct</td>
<td>111</td>
</tr>
<tr>
<td>5.25</td>
<td>Familiarity results for stimuli for all participants</td>
<td>114</td>
</tr>
<tr>
<td>5.26</td>
<td>Lexical decision accuracy by listener dialect</td>
<td>115</td>
</tr>
<tr>
<td>6.1</td>
<td>Simplified example of perception and production loop for the word <em>esta</em> ‘this’</td>
<td>127</td>
</tr>
<tr>
<td>6.2</td>
<td>Model of Exemplar Theory for <em>costa</em> ‘coast’</td>
<td>130</td>
</tr>
<tr>
<td>6.3</td>
<td>Model of Exemplar Theory for <em>arte</em> ‘art’</td>
<td>132</td>
</tr>
<tr>
<td>6.4</td>
<td>Model of Exemplar Theory for semantic activation of <em>pastel</em></td>
<td>133</td>
</tr>
</tbody>
</table>
A.1 Test words containing syllable-final /n/ by dialect ........................................... 140
A.2 Test words containing syllable-final /r/ by dialect .............................................. 141
A.3 Test words containing syllable-final /s/ by dialect .............................................. 142
A.4 Filler stimuli by dialect ......................................................................................... 143
A.5 Nonwords by dialect ............................................................................................ 144
B.1 Post-experiment questionnaire in Spanish ............................................................ 147
B.2 Post-experiment questionnaire in English ............................................................. 149
C.1 Mexico 1 (male, 28) ........................................................................................... 152
C.2 Mexico 2 (female, 24) ........................................................................................ 152
C.3 Mexico 3 (female, 31) ....................................................................................... 153
C.4 Mexico (male, 27) .............................................................................................. 153
C.5 Mexico 5 (female, 30) ....................................................................................... 154
C.6 Mexico 6 (female, 58) ....................................................................................... 154
C.7 Mexico 7 (male, 36) .......................................................................................... 155
C.8 Mexico 8 (male, 57) .......................................................................................... 155
C.9 Mexico 9 (female, 45) ...................................................................................... 156
C.10 Mexico 10 (female, 31) ................................................................................... 156
C.11 Mexico 11 (female, 47) .................................................................................... 157
C.12 Mexico 12 (male, 55) ....................................................................................... 157
C.13 Mexico 13 (female, 43) .................................................................................... 158
C.14 Mexico 14 (female, 32) .................................................................................... 158
<p>| C.15  | Mexico 15 (male, 25)                      | 159 |
| C.16  | Mexico 16 (female, 21)                   | 159 |
| C.17  | Mexico 17 (male, 24)                    | 160 |
| C.18  | Mexico 18 (male, 18)                    | 160 |
| C.19  | Mexico 19 (male, 46)                    | 161 |
| C.20  | Mexico 20 (female, 65)                   | 161 |
| C.21  | Puerto Rico 1 (male, 29)                | 162 |
| C.22  | Puerto Rico 2 (female, 23)              | 162 |
| C.23  | Puerto Rico 3 (female, 27)              | 162 |
| C.24  | Puerto Rico 4 (male, 28)                | 163 |
| C.25  | Puerto Rico 5 (female, 30)              | 163 |
| C.26  | Puerto Rico 6 (male, 25)                | 163 |
| C.27  | Puerto Rico 7 (female, 24)              | 164 |
| C.28  | Puerto Rico 8 (female, 24)              | 164 |
| C.29  | Puerto Rico 9 (male, 36)                | 164 |
| C.30  | Puerto Rico 10 (female, 22)             | 165 |
| C.31  | Puerto Rico 11 (male, 21)               | 165 |
| C.32  | Puerto Rico 12 (male, 18)               | 165 |
| C.33  | Puerto Rico 13 (male, 21)               | 166 |
| D.1   | Reaction time results for naming task by listener gender | 168 |</p>
<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>D.2</td>
<td>Reaction time results for naming task by listener age</td>
<td>168</td>
</tr>
<tr>
<td>D.3</td>
<td>Reaction time results by listener dialect by listener gender</td>
<td>169</td>
</tr>
<tr>
<td>D.4</td>
<td>Reaction time results for speaker dialect by listener gender</td>
<td>169</td>
</tr>
<tr>
<td>D.5</td>
<td>Reaction time results for listener dialect by phonological variable</td>
<td>170</td>
</tr>
<tr>
<td>D.6</td>
<td>Reaction time results for listener age by phonological variable</td>
<td>170</td>
</tr>
<tr>
<td>E.1</td>
<td>Average median reaction time (ms) by listener age</td>
<td>172</td>
</tr>
<tr>
<td>E.2</td>
<td>Average median reaction time (ms) by listener gender</td>
<td>172</td>
</tr>
<tr>
<td>E.3</td>
<td>Average median reaction time (ms) by listener dialect</td>
<td>173</td>
</tr>
<tr>
<td>E.4</td>
<td>Average median reaction time (ms) by speaker dialect</td>
<td>173</td>
</tr>
<tr>
<td>E.5</td>
<td>Mean (arcsine transformed) accuracy results by listener age</td>
<td>174</td>
</tr>
<tr>
<td>E.6</td>
<td>Mean (arcsine transformed) accuracy results by listener dialect</td>
<td>174</td>
</tr>
<tr>
<td>E.7</td>
<td>Mean (arcsine transformed) accuracy results by listener gender</td>
<td>175</td>
</tr>
<tr>
<td>E.8</td>
<td>Mean (arcsine transformed) accuracy results by phonological variable</td>
<td>175</td>
</tr>
<tr>
<td>F.1</td>
<td>Stimulus set for familiarity judgment study</td>
<td>177</td>
</tr>
<tr>
<td>F.2</td>
<td>Standardized familiarity judgments by word for all participants</td>
<td>178</td>
</tr>
<tr>
<td>F.3</td>
<td>Standardized familiarity judgments by word for participant 1</td>
<td>178</td>
</tr>
<tr>
<td>F.4</td>
<td>Standardized familiarity judgments by word for participant 2</td>
<td>179</td>
</tr>
<tr>
<td>F.5</td>
<td>Standardized familiarity judgments by word for participant 3</td>
<td>179</td>
</tr>
<tr>
<td>F.6</td>
<td>Standardized familiarity judgments by word for participant 4</td>
<td>180</td>
</tr>
<tr>
<td>F.7</td>
<td>Standardized familiarity judgments by word for participant 5</td>
<td>180</td>
</tr>
<tr>
<td>F.8</td>
<td>Standardized familiarity judgments by word for participant 6</td>
<td>181</td>
</tr>
</tbody>
</table>
F.9 Standardized familiarity judgments by word for participant 7 ................. 181
F.10 Standardized familiarity judgments by word for participant 8 ................. 182
F.11 Standardized familiarity judgments by word for participant 9 ................. 182
F.12 Standardized familiarity judgments by word for participant 10 ............... 183
F.13 Standardized familiarity judgments by word for participant 11 ............... 183
G.1 Naming task preliminary instructions in Spanish .................................. 185
G.2 Naming task preliminary instructions in English ................................. 185
G.3 Naming task post-practice continuation prompt in Spanish ....................... 185
G.4 Naming task post-practice continuation prompt in English ....................... 185
G.5 Lexical decision task instructions in Spanish ........................................ 186
G.6 Lexical decision task instructions in English ........................................ 187
G.7 Dialect identification task instructions in Spanish .................................. 187
G.8 Dialect identification task instructions in English .................................. 187
G.9 Experiment termination in Spanish ..................................................... 187
G.10 Experiment termination in English .................................................... 187
CHAPTER 1
INTRODUCTION

1.1 Introduction

This dissertation investigates the effects of native dialect on the perception of variable input in Spanish. Recent studies from speech perception research suggest that listeners store input as exemplars containing detailed information about the talker and the acoustic signal. For instance, it has been shown that listeners use stereotypes about speakers in perceiving speech (cf. Strand 1999, 2000). Listeners also have been found to have more difficulty with input produced by multiple talkers than with input produced by a single talker. This difficulty included slower naming times as well as more errors (cf. Mullennix and Pisoni 1990, Mullennix et al. 1989). Researchers have also found that listeners’ experience with sounds and sound patterns affects their perception. For instance, native English speakers of Spanish have been found to use their native phonologies when discriminating between sounds that occur in both languages (cf. Boomershine et al. 2005).

There is also evidence from recent studies in dialectology and language classification that suggests that listeners store information about the talker, including
extralinguistic factors such as socioeconomic status, gender, ethnicity, education level, and origin. Listeners use the information that they collect from their stored exemplars to make judgments about talkers, including where they are from and how much education they have (cf. Boomershine 2004). Listeners also use their experiences to determine the origin of talkers (cf. Clopper 2004). Listeners are able to make these judgments and associations about talkers that they have never seen or heard before by comparing the input with that which they have heard previously and stored in their lexicon. This input is stored as exemplars, where each exemplar is connected to linguistic and extralinguistic information, including talkers, social relationships, and socioeconomic factors such as education and race.

Most of the research on speech perception has been conducted on American English, and typically does not include variation in the stimuli. The studies conducted by the researcher and the results from the study presented in this dissertation differ from most studies in that the language being examined is not English, but Spanish. The current studies also differ in that the researcher purposefully used stimuli that contained variation in order to test the perceptual processing of variable input. A final difference between the current studies and those conducted by most researchers is that this study can be considered to fall within the area of sociophonetic speech perception research. The results are considered from a variationist point of view, where listeners from two dialects of Latin American Spanish are compared. Social factors that are included in the study include age, gender, and travel history.
In the following section, attention will be given to previous research within the field of sociophonetic speech perception. Following that, an overview of the dissertation will be given.

1.2 Advances in sociophonetic speech perception

A growing area within the field of speech perception is that of sociophonetic studies. Sociophonetics is considered the study of phonetics with respect to extra-linguistic and social factors, such as gender, sexuality, socioeconomic status, and education background. Traditionally, linguists who considered these types of factors focused almost exclusively on production rather than perception, but recently there has been a push to expand this focus to include speech perception (cf. Thomas 2002). The current section will look at advances in sociophonetic speech perception research, as it applies to the current research.

Following Thomas’s work (2002) on the application of speech perception experiments in the field of sociophonetics, I will outline the major contributions to this field. Several studies have been conducted on the identification of regional dialects of speakers, although almost solely relating to English. One of the first experiments of this type was that of Bush (1967). She looked at listeners’ identification of American, Indian, and British English. Her stimuli were sentences, words, and nonsense items that were in original form, (low-pass and high-pass) filtered, or clipped in order to test whether listeners based their identification of dialect on prosodic factors. The low-pass filtered stimuli were filtered at 500 to remove any fluctuations above that level. The high-pass filtered stimuli were filtered at 1500 to remove any fluctuation below that level. She
found that listeners were able to identify the dialect of the speakers using the filtered stimuli around 75% of the time.

Similar experiments have been conducted more recently that test whether listeners can identify the origin of speakers from within their country and from around the world. Preston (1993) played tapes of nine speakers who lived between Michigan and Alabama to listeners in both southeastern Michigan and southern Indiana. The listeners were asked to show where the speakers were from using a map. While both groups of listeners were fairly accurate at the task, there was a slight difference between the two groups based on the listeners’ origin. The participants from Indiana heard one minor and two major southern distinctions, while the Michigan participants condensed the south and outer south distinction made by the Indiana listeners into just one south. Stephan (1997) and Williams, Garrett, and Coupland (1999) did similar studies, but included stimuli from both non-native languages and speakers from outside the listeners’ home countries, respectively.

Speech perception experiments have also been used to determine how much a person’s speech changes after they move to a new dialect region. Munro, Derwing, and Flege (1999) conducted research on Canadians who had moved to Alabama, comparing them to non-mobile residents of Canada and non-mobile residents of Alabama. Listeners from Alabama and Canada were asked to judge the speakers on how much they sounded like a person from one of those regions. Munro et al. found that the Canadians that had moved to Alabama were judged to sound somewhat in between the Canadians and the Alabama natives. Thus, the mobile Canadians had undergone some dialect shifting, and concluded that the most perceptual cue to this shift was probably the diphthong quality.
Sociophoneticians have also conducted speech perception experiments to see if listeners can determine the ethnicity of speakers. While most of these studies have dealt with the identification of African Americans and European Americans, Wolfram (2000) recently conducted a three-way identification study on European, African, and Native Americans in North Carolina. In Hyde County, North Carolina, African Americans show a considerable amount of assimilation to the local European American dialect, while in Robeson County there is a three-way distinction among the English dialects of European, African, and Native (Lumbee) Americans. He found that outsiders misidentified Lumbees and older African Americans, but Lumbees almost always distinguished other Lumbees. While Wolfram’s results show that some listeners can identify ethnicities, he was unable to determine which features were used by the listeners in this identification task.

Other researchers have attempted to address this issue. Hawkins (1993) conducted a study to determine the role of F0 as a cue in ethnicity identification. Male and female African and European Americans produced [æ] and [i] in isolation, in words, and in sentences. Listeners, of both sexes and ethnicities, were then asked to identify the ethnicity of the speaker producing the stimuli. All speakers were able to identify the ethnicity of the speakers with better than chance accuracy. To determine which cues were being used by the listeners to determine the ethnicity of the speakers, Hawkins synthesized the stimuli at nine F0 levels. He then conducted the same study, only this time with the synthesized stimuli. He found that the listeners consistently labeled stimuli with a low F0 as being produced by an African American speaker. Hawkins posits that this cue is related to stereotypes rather than to physiology.
Speech perception research has also been conducted by sociophoneticians to determine whether listeners can determine the socioeconomic level of speakers (cf. Harms 1963, Shuy et al. 1969, Sebastian and Ryan 1985). Shuy et al. (1969) found that the socioeconomic level of lower-class African and European American speakers were identified more accurately than higher-class speakers. Sebastian and Ryan (1985) found that lower-class and middle-class English speakers with a Spanish accent received lower status ratings than did their monolingual English speaking counterparts. Within the group of speakers that spoke English with a Spanish accent, those that had a heavy (or high, according to Sebastian and Ryan) Spanish accent were rated lower for social class than those with a slighter (or lower) accent.

Research has also been conducted on dialectal differences in the categorization of sounds, although the number of such studies is much lower than one might expect. Willis (1972) had listeners categorize synthetic vowels according to phoneme. His participants were from Buffalo, New York and Fort Erie, Ontario. His results showed that some of the phoneme boundaries differed by the listeners’ residence, and that the most different boundaries were reflected in production differences between those two communities. Thomas (2000) also found dialectal differences in sound categorization. He presented monolingual English listeners from central Ohio and bilingual listeners from southern Texas with synthesized stimuli representing a continuum from *tide* to *tight*. While he found that both groups used the glide difference as a perceptual cue, they did so in different ways. The Ohioans used the glide height as a cue in the identification of the following [t] and [d], while the Texans used the height of the glide as a cue in the identification of the following [d] versus null (*tide* vs. *tie*).
Other researchers looking at cross-dialectal speech perception found that listeners had difficulty identifying and categorizing speech from their own dialect. Flanigan and Norris (2000) asked students in several universities in southeastern Ohio to identify words that they heard. The words were produced by a speaker from southeastern Ohio, and were extracted from their context, or left in their original phrases or sentences. They found that the listeners had considerable difficulty identifying the words that were played in isolation and the words that were played in phrases (but not entire sentences), even though the listeners and the speaker were members of the same dialect. Labov and Ash (1997) played vowels, words, phrases, and sentences produced by speakers from Chicago, Philadelphia, and Birmingham to listeners from these three cities. Listeners were asked to identify vowels and words from the stimulus set. Listeners tended to have difficulty identifying some of the vowels and words produced by speakers from cities other than their own. But, surprisingly, they also had difficulty identifying vowels from their own city.

The current research is related to the studies mentioned in this section in that it falls within the field of sociophonetic speech perception. The current study is similar to the studies described above in that one of the central goals of the study is to determine whether listeners can perceive dialect variation and if it affects their perceptual processing time. Not only will listeners participate in perception experiments, but the results of these experiments will provide cues as to what factors listeners rely on when perceiving speech and identifying the ethnicities of speakers. The dissertation outline will be presented below.
1.3 Dissertation overview

In this dissertation, Chapter 2 will be a review of representative research that discusses cross-dialectal and cross-linguistic perception, as well as exemplar models of speech perception. Chapter 3 will be a description of the two dialects of Spanish being studied in the current experiments, namely Mexican Spanish and Puerto Rican Spanish. Following the chapter on language background, Chapter 4 will be a description of three experiments involving the perception of variable input, where participants hear stimuli containing word-final nasals, syllable-final /s/, and syllable-final /r/. The results of those three experiments will be presented in Chapter 5, and will be discussed with regard to several issues in speech perception, including the role of variable input in speech perception, the weighting of variables in dialect classification, and whether there is support for exemplar-based models of perception in Chapter 6. I conclude with an overview of future work that needs to be done concerning cross-dialect perceptual processing, specifically relating to Spanish.
CHAPTER 2

SPEECH PERCEPTION AND USAGE-BASED MODELS

Processing and perception of variable input, or talker variability, has been researched by a number of linguists, especially in the late 20th century. There are two main views on how variable input is processed and stored. One view, which is more conventional or traditional, argues for a simple representation of the input, usually as abstract phonemes, with a complex mapping of acoustic information onto these phonemes. This abstractionist view is often referred to as the mental dictionary assumption, which states that the lexicon is comprised of one representation of each word that the listener has heard and uttered. This representation has been stripped of all phonetic and speaker variation and information, and only retains the contrastive elements of speech (i.e. phonemes).

The other view which allows input to be stored with detailed phonetic information is the view that will be adopted in this research. Supporters of this view have argued that the representation of input and output is not simple, but rather a complex unit that stores information about the talker’s voice, speaking rate, and any variation in the speech signal. Therefore, the mapping from this input onto the stored units in the lexicon, or exemplars,
is simple. This dichotomy will be discussed below, including findings of recent studies on perception and processing of variation, as well as models of each of these views.

2.1 Usage-based vs. abstractionist accounts

The traditional view, termed ‘the analytic approach’ by Pisoni (1997), posits that input is stored as a very simple representation in the lexicon and has been supported by many for years. In fact, it is the basis for most traditional phonological theories. One point of evidence for this view is that listeners receive input that is extremely variable, yet have very little difficulty processing it. The two primary features of such a traditional approach are that there is a dissociation between the linguistic and indexical properties of the speech signal and that stimulus variability is not informative to the listener and should be treated as a source of noise (cf. Pisoni 1997). The former refers to the distinction made between the linguistic properties of speech that carry the speaker’s intended message and the features of the signal that carry information about the talker’s voice.

Proponents of such abstractionist accounts argue that this variable input undergoes a process of normalization, which eliminates any context- or talker-specific information in the input. The result, then, is a string of segments, or phonemes, which is void of details and particulars about the talker and the context in which that sequence was uttered. Each time the listener hears variable or complex input, it is stripped down to a string of phonemes, and compared with the entry in the lexicon containing that same string of phonemes. Variation or variability in speech, according to this account, is considered to be noise in the signal.
One prominent processing model that represents this view is the TRACE model (Elman and McClelland 1986). This is a neural network model in which processing occurs through connections among numerous processing units, called nodes. Distinctive features, phonemes, and words constitute nodes, which represent different levels of processing. Each of these nodes has three levels: a resting level, a threshold, and an activation level. These nodes are connected, and if a given node is activated, it may activate other nodes that it is connected to. This activation across nodes can lower activation or raise activation of connected nodes. For instance, given the input <Pam> [pʰæm], the phoneme nodes for /p/, /æ/, and /m/ would be activated. By activating these phoneme nodes, other phoneme nodes representing competing sounds, such as /b/ or /d/ for the first phoneme, would have lower activation levels. This activation would then activate word nodes containing these phonemes.

Another, similar model of word recognition is the Cohort model (Marslen-Wilson 1987). In this model, the first stage is an acoustic-phonetic stage in which the sounds in the input are matched to words in the lexicon. For instance, if the word in the input is <sit>, all words beginning with /s/ will be activated (i.e. Sam, son, city, etc.). The second stage of recognition deals with eliminating the activated words, until the target word is the only one left activated. This elimination is based on semantic, syntactic, and further phonetic-acoustic information. The word in the lexicon is activated once it is the only candidate remaining in the cohort. The Cohort and the TRACE models of word recognition both require that all detail be removed from the input in order to match a string of abstract phonemes that is stored in the lexicon. This view, as mentioned earlier,
contrasts with that which allows detailed phonetic and talker/contextual information to be stored in the lexicon.

Exemplar Theory, or exemplar-based models of speech perception and processing, is a framework that allows for detailed representations of input to be stored in the lexicon. This theory or model is used by several linguists, including Goldinger (1990, 1991, 1996, 1997), Johnson (1990, 1997), Pierrehumbert (2001, 2002, 2003), and Pisoni (1985, 1990, 1992, 1997). Within this framework, detailed information from the speech signal is processed by the listener and becomes part of the stored representation in the lexicon. Therefore, listeners encode this very specific, detailed information rather than discard it.

Pisoni has conducted research on talker processing, where he looks at how talker variation affects listeners’ perception and processing. In one such experiment, he presented one subject group with stimuli spoken by only one talker, and the other subject group with stimuli presented by 15 different talkers. The subjects’ task was to identify the words that they heard. This identification performance was significantly better for words produced by a single talker (Pisoni 1992). In another experiment, he tested the reaction time in naming these words, both produced by a single talker and produced by multiple talkers. The results showed that when the listeners were presented with multiple talkers, they responded much more slowly and produced more errors.

Strand (2000) has also conducted research on talker processing, in relation to stereotypes. She conducted experiments where she presented participants with words produced by several speakers. They were asked to repeat the word as quickly as possible. In some of the trials, they were only presented with words, while in other trials they were
presented with a picture of a speaker and then the word. Sometimes the gender of the speaker and the person in the picture matched, and other times the gender was not what the participant would expect. She found a significant effect of voice stereotypicality, where words produced by speakers with stereotypical voices were processed and repeated faster. She also found a significant effect of face stereotypicality for female voices. The results indicate an interaction of face gender and voice stereotypicality of the face-primed female voices. So, for some voices, gender face information significantly facilitates the processing of speech information.

Her results show us that a native speaker’s competence in a language includes the knowledge of how a phonological category is manifested. This knowledge is not only linguistic, such as its realization in a certain position of an utterance or its surrounding sounds, but also extralinguistic. Native speakers have and use knowledge about the gender of a speaker, their socio-economic status, and other socially-mediated factors. Since speakers have this linguistic and extralinguistic competence, it must be coded in the lexical representation of categories, as it is used in speech perception and processing. Thus, a model of a speech processing system must include talker information, such as gender.

If the speech processing system were organized as proponents of the abstractionist approach have claimed, where the input is void of all talker and context variability, these results would be very difficult, if not nearly impossible, to interpret. Within that model, listeners should have no difficulty in processing speech by various talkers, as their process of normalization would convert that variable input into strings of phonemes. But, within an exemplar-based model of speech perception and processing, these findings are
more easily explained. The listener is storing this talker-specific information in the lexicon, with each exemplar being encoded with this information. Therefore, when a listener is presented with input from a specific talker, that talker’s category is activated, along with the category of exemplars that matches the input phonetically. An example of such activation, based on my interpretation of Johnson’s XMOD, is given below, in Figure 2.1.

In this figure, the speech input is the word ‘sosa’. Exemplars in the lexicon are activated according to their phonetic similarity to the input. Exemplars retain auditory and phonetic details of the talker. These activated exemplars in turn activate categories.
such as talkers (María vs. José) and lexical categories, which in this case are words. The weight of the line corresponds to the amount of activation for each item. Therefore, in the figure above, the second exemplar has the highest activation based on the input. Examplars 3 and 4 are not activated at all, as they have no phonetic similarity with the input ‘sosa’. The talker with the highest activation level is José, as the talker-specific details in the input best match those stored for José. The talker María is also activated because she has produced strings similar to those stored in the second exemplar. In fact, some of her utterances are stored in the second exemplar, which is more like an exemplar cloud than a single exemplar. Then, the category that has the highest activation level is the word ‘sosa’. Activation lines are weighted according to the strength of the activation, where stronger activations are marked with thicker lines and weaker activations are marked with thinner lines. It should be noted that this merely is a rough simulation of how XMOD works.

In exemplar-based approaches to speech perception and processing, such as XMOD, the item to be stored (i.e. the input) is compared to all existing exemplars in the lexicon. If it is very similar to an item already stored, then it will be stored as an instance of that exemplar. If it is dissimilar enough, then it will be stored as its own exemplar. The auditory properties of the input are compared with the auditory properties of the exemplars in the lexicon. The similarity between the input and the exemplars’ auditory properties determines the activation level of each exemplar. If a given exemplar receives a very high activation level, then the input will be stored as part of that exemplar.

Pierrehumbert’s model of the lexicon (cf. Pierrehumbert 2001) contains lexical, phonological, and phonetic levels of representation. Words are linked to phonemes,
which are then linked to components at the phonetic level. This model includes a phonological level with abstract units, such as phonemes, in order to account for the presence of systematic phonological processes, such as phonotactic regularities and allophony. Her model is able to account for frequency effects, phonological change, and non-native phonetic instantiations. Like the Johnson model, Pierrehumbert’s model has categories, with exemplars associated with each category. An exemplar is chosen from a given category to serve as the target during production. During perception, a goodness score is assigned to candidate categories, and the category with the highest score is where the exemplar is assigned. This is very similar to Johnson’s XMOD, which searches for the best fit between the input exemplar and stored exemplars.

Beckman et al. (in press) posit a lexical model with multiple layers, similar to those described earlier. In this model, the ‘parametric phonetic representations’ are linked to voices (i.e. talkers), the lexicon, and intonations. These levels are in turn linked to the phonological grammar and indexical stereotypes about the talkers, including origin, gender, and sexual orientation. Their research is focused on vocabulary growth in young speakers, where children are learning to speak based on what they have encoded in their lexicon from the input they have received. For instance, the indexical stereotypes level is an important inclusion because listeners store speaker input that contains information relating to social identity and social relationships between the speaker and listener (cf. Strand 2000). There are bi-directional interactions across levels (i.e. between the phonological grammar and the lexicon) in this model, where the lexicon affects phonetics, and phonetics affects the lexicon. The model is shown in the following figure.
An exemplar-based approach, rather than an abstractionist approach, will be tested in the current research. The present studies will test this approach by looking at the effect of variable input on naming and lexical decision tasks in Spanish. Given this type of model, the listeners who are native speakers of a dialect that exhibits the same phonological processes as the input (e.g. nasal velarization, /s/ reduction/deletion, and /r/ lateralization) will respond faster and more accurately to the task than those listeners of a different dialect. This is expected because the dialect-specific information in the input will raise activation of those similar exemplars in the listener’s lexicon, assuming that the listener and talker are speakers of the same dialect. Such a listener will have exemplars with a higher resting activation level, as they are not only used to process the input, but also in production of output. Given input of a different dialect, the exemplars will take
longer to reach that high activation level, and will therefore result in longer reaction times and possibly less accuracy. The following sections will look at research concerning cross-linguistic and cross-dialectal speech perception and processing.

2.2 Perception of Dialect and Talker Variation

There has been some recent research on cross-dialectal perception and also the role of talker variation on perception. Most of this research is based on data from speakers of American English and almost exclusively deals with perception of vowels. This is undoubtedly the case because vowels are typically what vary across dialects of English. In Spanish, however, the opposite is the case. Vowels are relatively invariable across the dialects of Spanish, except for those cases in which unstressed vowels, particularly /e/, are raised and rendered non-syllabic in unstressed position in contact with a non-high vowel (e.g. /teatro/ → [tjatro]). Consonants, on the other hand, tend to vary across dialect regions, with weakening or deletion being a marker in the coastal areas, and preservation marking the highland areas (for a more complete picture of the generalization presented here, cf. Lipski 1994). Because the existing research does not look at cross-dialectal perception in Spanish, or for the most part, consonants, it will be useful to examine this data to see what is known about cross-dialectal perception in general.

2.2.1 American English vowels

Very recently, Clopper (2004) and Clopper and Pisoni (2004) conducted research on the perception of American English vowels by speakers of various dialects. They
designed two behavioral experiments which they ran on naive speakers from both the Northern and Midland regions of the United States. The experiments were a six-alternative forced-choice categorization task and a free classification task. In the forced-choice experiment, the participants heard a sentence produced by a speaker from one of the following regions: New England, Mid-Atlantic, North, Midland, South, and West. They were asked to identify the origin of the speaker by clicking on the region on the map. For instance, if they thought the person they heard was from California, they would click on the West region of the U.S.

In the free classification task, they were presented with a grid on a computer monitor. To the left of the monitor were blue squares that contained videos of male speakers from the six regions mentioned above. They were to listen to each video and then move that blue square onto the grid. They were instructed to group the blue squares according to the dialect of the speaker. This task was repeated again, this time with both male and female talkers. Participants for both experiments were divided into groups based on their residential history (mobility and location).

Overall, the participants in the forced-choice categorization task were able to correctly identify the origin of the talker with 26% overall accuracy. Clopper found that the residential history of the participants did not affect the overall performance in this task, but their location and mobility did produce patterns in categorization. For instance, the non-mobile Northerners perceived a greater similarity between the Northern and Midland speakers than the mobile Northerners did. In other words, their linguistic experience in other dialect regions affected their perceptual similarity space. This is shown in the following figure, taken from Clopper 2004.
Figure 2.3. Clustering results for forced-choice categorization, taken from Clopper 2004:110.

In all three panels (i.e. all three listener groups) of Figure 2.3 above, the southern and mid-Atlantic speakers are farthest from the base, which Clopper states suggests that those dialects are the most distinctive dialects perceptually. The New England and mid-Atlantic speakers consistently cluster together, although the New England speakers are less distinct from the other groups than the mid-Atlantic speakers are. The western and midland speakers cluster together perceptually for all three listener groups. All of the
listener groups have perceptual categories for southern, northeastern (New England and mid-Atlantic), and unmarked (midland and western) talkers.

The results of the free classification tasks are similar to those of the forced-choice classification task. The overall accuracy for all participants was 28%. Again, there was no significant main effect for residential history, but there were some trends based on mobility and location. Specifically, mobile participants created more categorization groups than non-mobile participants. Clopper attributes this difference to the fact that mobile participants have finer-grained perceptual categories than non-mobile participants. The mobile participants considered the more marked dialects of the South and the Mid-Atlantic to be more distinct, and the mobile Northern participants considered the Northern talkers to be less marked perceptually, and grouped them closer to the Midland and West speakers. The mobile Midland participants, however, considered the Northern speakers to be more similar to the Mid-Atlantic speakers. These results are shown in the following figure, taken from Clopper 2004.
While Clopper did not find any significant differences between the participants based on their residential location and mobility, she did find (non-significant) trends based on native dialect and residential history. Therefore, to account for these extra-linguistic factors, she modifies Pierrehumbert’s (2001, 2002) original exemplar-based model. She adds three levels of representation in order to account for individual talker differences, dialects, and social categories, such as friendliness and intelligence. In the
following figure taken from Clopper 2004, Clopper’s addition is shown in white, while Clopper’s interpretation of Pierrehumbert’s original version is shown in grey.

![Diagram](image)

Figure 2.5. Exemplar-based model of sociolinguistic variation, taken from Clopper 2004:193.

Note that in Clopper’s model of sociolinguistic variation, shown above in Figure 2.5, the dialect representations are not directly associated with the phonetic or phonological representations. Also, there seems to be a strict hierarchy, where input must go through certain representations or categories before reaching others. Clopper’s analysis allows for phonological representations, although it is not clear whether these representations are in the form of underlying, abstract unit, such as phonemes, or are merely phonological generalizations over the phonetic representations. These points will
be discussed further in Chapter 6, where the results of the current study will be modeled using an exemplar-based approach to perceptual processing.

2.2.2 English vowels and fricatives

Makashay (2003) studied the perception and production of vowels and fricatives in English. Unlike Clopper, Makashay conducted studies on dialectally homogenous speakers of English in order to rule out any dialect differences in perception and production. He investigated whether there were individual differences in the perception of frequency and duration cues for vowels and fricatives in one dialect of American English. The vowels that he manipulated were the vowels in ‘hid’ and ‘heed’. The fricatives he manipulated were the ones found in ‘bath’ and ‘bass’.

In order to test whether there are individual differences in perception, he conducted an AX discrimination task. He used four sets of stimuli: sine wave vowels, synthetic vowels, narrowband fricatives, and synthetic fricatives. The duration and frequency of the stimuli were manipulated. Seventeen native speakers of Northern Columbus English participated in the discrimination task. They heard a pair of sounds that contained either the fricatives or the vowels being studied. They were asked to push the left-most button on the response box if they were the same sounds, and the right-most button on the response box if they were different. The participants always heard the non-speech stimuli before the speech stimuli, so as not to bias them toward speech.

Makashay found a main effect for speech type and for segment type. He found that overall the participants discriminated the speech pairs (88.5%) with more accuracy than the non-speech pairs (85.6%). Participants also performed significantly more
accurately with the vowel pairs (90.3%) than with the fricative pairs (83.8%). However, the vowels that were manipulated with respect to duration (68.9%) were more difficult to discriminate than the fricatives whose duration (76.4%) was manipulated. Aside from these overall trends, he also found differences among individuals when only one speech cue was manipulated (i.e. either duration or frequency), which cannot be attributed to their individual hearing levels. He concluded that while all of the participants were from one dialect of English, they still exhibited individual differences in perception. He argues that it is important to take individual differences into account when looking at perception, rather than assuming that all speakers of a given dialect use the same perceptual cues when perceiving and processing speech.

2.2.3 Stimulus variability and perception

Pisoni and his colleagues looked at the effects of stimulus variability on speech perception in English. Most researchers have avoided introducing variation in speech input as it was traditionally considered to be just noise in the signal. Pisoni, however, deliberately introduced variability from the speech of different talkers. Along with Mullennix and Martin (1989), Pisoni conducted a study in which participants were presented with stimuli produced by a single talker and stimuli produced by 15 different talkers. They found that identification of the stimuli was always better for words that were produced by a single talker than for those produced by multiple talkers. They also conducted a study (Mullennix et al. 1989) where they measured naming latencies in single-talker and multiple-talker test conditions. The results from that task showed that
the participants were both slower at naming words and produced more errors in the multiple-talker condition.

In order to determine whether speakers store detailed information about the talker in long-term memory, recall experiments were conducted (Martin et al. 1989, Goldinger et al. 1991, Goldinger 1992). The results of these studies showed that specific details of a talker’s voice are encoded in long-term memory. Pisoni and his colleagues (Palmeri et al. 1993) also conducted an experiment to see if participants use stored talker information to make judgments when there is a lot of competition from other talkers. They found that listeners encode detailed episodic information about a talker, which they use for explicit judgments.

Mullennix and Pisoni (1990) assessed whether attributes of a talker’s voice were perceived independently from the phonetic form of the word using a speeded classification task. The participants were asked to attend selectively to one stimulus dimension while ignoring another stimulus dimension. Two of the dimensions that they used were talker and phone. They found an increase in the interference from both dimensions when the participants were asked to only attend to one of them. These results suggest that the perception of one dimension (voice) affects classification of the other dimension (voice), and vice-versa. In other words, listeners process words or sounds and voices as integral dimensions, where each dimension affects the other dimension. These findings will prove important in the discussion of the current model of speech perception in Chapter 6.

To determine whether experience with a specific voice (i.e. talker) affects perception, Pisoni and his colleagues conducted a perceptual learning experiment in
which the participants were trained to identify a set of unfamiliar voices over a 9-day period. The participants were then asked to identify the novel words they heard, which for half of the participants were produced by the same voices mentioned above, and for the other half they were produced by unfamiliar (i.e. new) voices. They found that the group that heard novel words produced by familiar voices performed significantly better than the group that heard words produced by unfamiliar voices. Thus, perceptual processing of novel words is facilitated by exposure to a talker’s voice. The only way that this can be explained is if listeners store talker-specific information in their memory, and use it when perceiving and processing speech. Pisoni (1997) argues for the need for instance-based models of cognition, such as an exemplar-based model, in the field of speech perception and spoken-language processing.

2.2.4 Variation in vowel perception

Fox (1974) conducted a study that was intended to answer a question similar to that posed by Terbeek and Harshman a few years earlier: “To what extent is one’s vowel perception related to one’s native language?” (1971:26). Rather than looking at cross-linguistic differences in perception, Fox studied cross-dialectal perception in two dialects of American English. The stimuli were produced by a speaker of General American English [sic] (Chicago) and a speaker of Southern American English (Oklahoma). The stimulus set consisted of seven vowels produced in the context /___t/. The vowels used in the stimuli were /i eɪ, æ, u, ai, o, œ/. After analyzing the production of the stimuli, Fox found that the Southern AE speaker produced vowels with more diphthongization and centralization than did the General AE speaker.
Nineteen native AE speakers participated in the experiment in total, with 11 of them being General AE speakers and 8 being Southern AE speakers. The participants judged 168 vowel pairs on a nine-point similarity scale, where 1 was very similar and 9 very dissimilar. Fox found that the listeners used three cues when perceiving the Southern vowels: frontness, height, and glide frontness. When perceiving the General AE vowels, four cues were posited: rounding, offset frontness, glide frontness, and a possible cluster (height & offset frontness). For both groups of stimuli, he did not find a group difference, but rather a large amount of individual variation. Fox argues that one possible reason why there was no significant difference between the two groups of participants is that the two dialects being studied did not differ enough in the seven vowels selected. He adds that the amount of individual variation may have masked any differences that exist between the two groups.

2.3 Cross-linguistic Speech Perception

In the last few decades quite a bit of research has been done on cross-linguistic perception of speech. This research has looked primarily at bilingual speakers, or near-bilingual speakers, and the role of language experience on perception. The findings from these studies suggest that there is parallel activation of stored exemplars across languages, and that these exemplars are stored in the same space (i.e. the same lexicon or grammar). Some of these studies will be discussed in the following sections, and will be referred to when discussing the results of the current studies.
2.3.1 Spanish-English bilinguals and English monolinguals

Fox, Flege, and Munro (1994) conducted a study on the perception of Spanish and English vowels by native Spanish and English speakers. Their study was a multidimensional scaling (MDS) analysis of the perceptual responses to three Spanish and seven English vowels. The Spanish vowels that were used were the non-back vowels /i/, /e/, and /a/. The English vowels that were used were /i/, /ɪ/ (as in hotel), /eɪ/ (as in black), /æ/ (as in make), /ʌ/ (as in up), and /ɑ/ (as in dark). The vowels were in the first syllable of a bisyllabic (non)word, either /pVto/ for Spanish (such as pito), or /bVC-to/ for English (such as belto), where V refers to vowels and C refers to consonants. The words were embedded in the carrier phrases ‘Digo ahora ___’ (Spanish stimuli) and ‘Now I say ___’ (English stimuli). The Spanish stimuli were recorded by three monolingual Spanish speakers from Texas, and the English stimuli were recorded by three monolingual American English speakers. The vowels were then extracted from the words to create the stimulus set used in the study.

Thirty monolingual American English speakers and thirty bilingual Spanish (L1) and English (L2) speakers participated in the study. The bilingual participants were divided into two groups based on their proficiency in English (proficient vs. non-proficient). The participants were presented with two vowels and were asked to rate how similar they were on a 9-point scale. The researchers hypothesized that the monolingual English speakers would use more underlying dimensions (i.e. duration and diphthongization) in perceiving the vowels than the bilingual Spanish speakers would, since the English vowel system is more complex than the Spanish system.

The researchers found that the bilingual participants used two dimensions in perceiving vowels, while the monolingual participants used three dimensions. One of the
features posited for the bilingual participants is vowel height, while the other dimension was more difficult for the researchers to define. The bilinguals’ proficiency in their L2 (English) made a slight difference in the weighting of the dimensions, with vowel height accounting for 73% of the variance for the proficient participants and only 69% of the variance for the non-proficient participants. The three dimensions that the monolingual participants used when perceiving vowels are vowel duration, front/back, and central/non-central.

Fox et al. found that the bilingual participants’ proficiency in their L2 affected their perception of native and non-native vowels. The perception of the vowels by the more proficient speakers was more similar to the perception of the vowels by the monolingual English speakers, than it was to the perception of the non-proficient bilingual speakers. In other words, the proficient bilinguals were hearing the non-native vowels similar to native speakers, whereas the non-proficient bilinguals were still hearing them with their native sound system (i.e. Spanish). Neither group of bilinguals, however, used three dimensions when perceiving the English vowels, like the monolingual English speakers did. This provides some indication that even proficient bilinguals still hear sounds with their native phonologies, although they are affected by their L2 phonology to some extent. This discussion of language experience and perception will be relevant to other studies conducted on perception, as well as to the findings of the current study, which will look at the amount of variation a speaker is accustomed to hearing and the effect that experience will have on the perception of variable input.
2.3.2 Russian-English bilinguals

Recently, Marian and Spivey (2003) conducted research on Russian-English bilinguals using eye-tracking experiments. Their study looks at spoken language processing and whether there is selective processing or parallel activation in bilinguals. Selective processing refers to a single language being stored in a lexicon, where only one language is activated at a time. On the other hand, parallel activation allows for simultaneous activation of exemplars from two languages. Therefore, two languages can be activated at the same time, and can therefore take part in the processing of input.

In order to test how bilinguals process spoken language, Marian and Spivey conducted two eye-tracking experiments on Russian-English bilinguals. The first experiment was designed to place bilinguals as close as possible to a monolingual state in their second language (English), while the second experiment was designed to place bilinguals as close as possible, given the circumstances, to a monolingual state in the first language (Russian). In Experiment 1, the entire study was conducted in English, and the participants had no idea that the researchers knew that they spoke Russian. In Experiment 2, the study was conducted in Russian, but the participants knew that the researchers were aware that they were bilinguals, since they were studying at an American university.

For Experiment 1, four objects were arranged in the corners of a whiteboard containing nine squares. The participants heard a word, and the number of looks to a given object was recorded. A stimulus set consisted of filler objects, the target object, a competitor object in English whose name overlapped with the name of the target object in English, and a competitor object in Russian whose name overlapped with the name of the
target object in English. There were ten stimulus sets for Experiment 1 and fourteen bilinguals participated in the study. The stimuli were recorded by a monolingual English speaker.

Marian and Spivey found a significant amount of L1 overlap during between-language competitor trials, as the participants looked at the Russian competitor object 18% of the time, and at the filler object only 7% of the time. They also found a significant amount of within-language competition, as the participants looked at the English competitor object 18% of the time and at the filler object 7% of the time. These results suggest that participants experience interference from L1 as well as from L2 when there is considerable phonological overlap between the target object and the competitor object.

For Experiment 2, four objects were again placed in the corners of a whiteboard containing nine squares. Again there were ten stimulus sets. This time, a stimulus set consisted of the target object in Russian, a competitor object whose name in Russian was similar to the Russian name of the target object, a competitor object whose name in English was similar to the Russian name of the target object, and a filler object. Unlike in Experiment 1, the stimuli for Experiment 2 were recorded by a monolingual Russian speaker. The fourteen participants heard a word and the number of looks an object received during that time was recorded.

The results from Experiment 2 show that bilinguals experience competing activation from phonologically overlapping items in that same language, and less activation from items in the other language. This was the case in Experiment 2, as the within-language competitor received looks 14% of the time while the between-language
competitor received looks only 8% of the time across all trials. Their results suggest that in this task, the second language (English) did not compete significantly with the first language (Russian).

Marian and Spivey argue that these results support parallel activation for bilinguals, as there was significant activation from the between language competitor, particularly in Experiment 1. They argue that in the initial few hundred milliseconds, bilingual lexical access may be language-independent. But, with time to process more information, inappropriate meanings are eliminated. They add that language mode is most likely a significant factor in determining the amount of activation in the second language, as some participants are more likely to overcompensate in their L2 and therefore have a higher resting activation for L2 than L1.

Marian and Spivey’s results can be considered evidence for parallel activation where a bilingual speaker has both L1 and L2 exemplars stored in one lexicon. If bilinguals do in fact store both languages’ exemplars in one space, then the results showing between-language competition can be easily explained. The bilingual hears input that is phonetically similar to various exemplars stored in the lexicon. Once the bilingual hears the entire word, this ambiguity or similarity is resolved and only the input is activated.

2.3.3 Language experience and perception

Boomershine, Hall, Hume and Johnson (2005) conducted research on the perception of three phones [d], [r], and [ð] by speakers of English and Spanish. While both Spanish and English have these three sounds, only two are phonemic in each
language. In American English, both [d] and [ð] are phonemic, as in the words *doe* and *though*, respectively, and [r] is an allophone of /d/ and /t/ in certain intervocalic contexts, as in *butter* and *ladder*. In Spanish, however, [d] and [r] are phonemic but not surface contrastive, as in *faldas* ‘skirt’ and *para* ‘for’, while [ð] is an allophone of /d/ in certain phonological contexts, such as in *dedo* ‘finger’. Interestingly, only [ð] and [r] contrast on the surface in Spanish, as in *cada* ‘each’ and *cara* ‘face’, respectively.

In order to test the effect of language experience on the perception of these three sounds, two experiments were conducted. The first experiment is a rating task in which the participants were asked to rate the similarity of a pair of sounds using a scale of 1-5. The second experiment is a discrimination task in which the participants were asked to decide whether the pair of sounds they heard was exactly identical or different in some way. The stimuli used in the two experiments were VCV sequences, where the vowels were either [a], [i], or [u] and the consonant was one of the three described above. The same stimuli were used in both experiments, and were recorded by trained phoneticians who were native English speakers.

Both native English and native Spanish speakers participated in the experiments. The native Spanish speakers were all advanced speakers of English. The native English speakers were either monolingual speakers, beginner speakers of Spanish, or intermediate speakers of Spanish. No native English, advanced speakers of Spanish participated in the study. The researchers predicted that the more experience a participant had in the L2, the more their responses would be similar to native speakers in that language. In other words, it was predicted that the intermediate speakers of Spanish would perform differently from
the beginner speakers of Spanish and from the monolingual native speakers of English due to their experience with the Spanish language.

The results of the rating task show that the native Spanish speakers pattern differently from the native English speakers. There was no significant difference between the English speakers with varying degrees of Spanish knowledge or experience. There was a significant interaction for pair and group. Because the native English speakers pattern the same, their responses were collapsed. The following figure shows a significant interaction for the pairs [d]/[ɾ] and [d]/[ð] by group.

The results from the discrimination task were very similar to those from the rating task. There was a significant main effect for both Pair (F[1,57]=35.84, p<0.001) and Group (F[1,57]=8.58, p<0.01). Some pairs were harder to discriminate than others. For
instance, the native English speakers had a difficult time discriminating [d]/[r], while the native Spanish speakers had a difficult time discriminating [d]/[ð]. There is also a significant interaction between Pair and Group, as the pattern of pair interactions differs by what group the participants are in. In other words, the native Spanish speakers and the native English speakers pattern differently. For the native Spanish speakers, there was no significant difference between [d]/[r] and [d]/[ð], but there was a significant difference between the other pair combinations ([d]/[r] and [r]/[ð], [r]/[ð] and [d]/[ð]). For the native English speakers, all of the pairs were significantly different. These findings are shown below.

Figure 2.7. Discrimination results.
Boomershine et al. found that the three groups of English listeners pattern the same way. Their slowest responses were to [d]/[r], which are allophonic, while their fastest responses were to [d]/[ð], which are phonemic. The Spanish listeners had a different pattern. Their slowest responses were to [d]/[ð], which are allophonic, and to [d]/[r], which are phonemic but not surface-contrastive. Their fastest responses were to [r]/[ð], which show a surface contrast. This is consistent with the results from the rating experiment where [r]/[ð] were rated most dissimilar by Spanish listeners.

These findings are significant to the study of cross-dialectal perception for several reasons. The results seem to indicate that a speaker’s experience with sounds and sound patterns influences their perception of those sounds. Minimal exposure to or experience with non-native sounds or patterns does not affect perception of those sounds. This is evidenced by the fact that the intermediate Spanish speakers of English patterned the same as the monolingual English speakers. Many of the intermediate speakers had lived in a Spanish-speaking environment for at least three months, yet their perception was not influenced by that language experience. However, it is assumed that more exposure to non-native sounds and patterns will affect one’s perception of those sounds. This is currently being tested by Boomershine and her colleagues.

Another aspect of this study that is relevant is the finding that underlying contrast does not affect perception, and what does affect perception is what is found on the surface. In the case of Boomershine et al.’s study, the pair that was most difficult to discriminate for the Spanish speakers was the one that does not have a surface contrast ([d]/[r]), while the pair that does contrast on the surface was much easier to discriminate.
([ð]/[ɾ]). In other words, the surface realization of a sound in a given dialect or language is what is most important in perception.

2.4 Summary

In this chapter, I have discussed background issues relating to speech perception and processing that are important for understanding the processing and perception of variable input. I have summarized the most recent research on cross-dialectal and cross-linguistic perception and processing, and highlighted the principal differences between abstractionist and usage-based approaches. I have suggested that the perception of variable input can best be represented in an exemplar model approach, where auditory input contains detailed talker-specific information. Such a model will be presented and described in Chapter 6.

In the following chapter, I will present information on the two dialects of Spanish being studied in the current experiments. I will also discuss the variables which are used in the testing of variable input perceptual processing.
CHAPTER 3

LANGUAGE BACKGROUND

In this study, three phonological variables in two dialects of Latin American Spanish are used to determine the effects of dialectal variation and linguistic experience on speech perception and processing. The two dialects being studied are Puerto Rican Spanish (San Juan metro area) and Mexican Spanish (Cuernavaca, Morelos). These dialects were chosen because they exhibit significant phonological variation relative to each other, as well as syntactic and prosodic variation, and were therefore considered to be distinct dialects that could be distinguished by naïve speakers of Spanish. The three variables in question are word final /n/, syllable-final /s/, and syllable-final /ɾ/. The following sections will provide an overview of a dialect imitation study that was conducted earlier, and will end by discussing the three variables within each dialect that are being studied in this research project.

3.1 Dialect Imitation Study

In order to determine the most salient phonological variables in several dialects of Spanish, an imitation and attitudinal study was conducted (cf. Boomershine 2003). In this
study, participants (naive speakers) from Latin America and Spain were asked to listen to sentences previously recorded by speakers from Argentina, Mexico, Puerto Rico, and Spain. Each speaker had recorded the same sentences so as to avoid syntactic and lexical differences across dialects. The participants were asked to say where the speaker was from, their education level, and their age. After completing that task, the participants were asked to read a series of phrases, each time attempting to imitate a speaker from Argentina, Mexico, Puerto Rico, and Spain. The participants in the study had all been living in the U.S. for approximately two years, and had contacts in the local community that were Spanish-speaking.

The results of the attitude questionnaire regarding education level showed that certain dialects were considered to be less ‘standard’ by the participants. The speaker from Puerto Rico was judged by every participant to have a low level of education (high school or less) when actually she has a PhD. The speaker from Argentina was judged by several participants to have a low education level when he also has a PhD. The results show that listeners use linguistic cues to form opinions about speakers, even when no information is known about those speakers.

The goal of the imitation task was to determine the most salient phonological features of the dialects being studied. It was hypothesized that the participants would imitate those sounds or sound patterns that were most distinct or prominent in the dialects they were emulating. While not all of the participants were capable of replicating or producing the different dialects, some were extremely successful. When imitating a Puerto Rican Spanish speaker, the participants deleted or aspirated all of the /s/, regardless of the phonological context (i.e. [Ø]illa or [h]illa for ‘silla’). They also
lateraled many of the /r/, again regardless of the context (i.e. f[l]ancia for ‘Francia’).

Some of the participants voiced several of the /s/ when imitating Mexican Spanish speakers (i.e. animale[z] comen for ‘animales comen’), particularly the participants that would normally delete or aspirate /s/ in their own dialect. Also, the participants adjusted their prosody when imitating the different dialects. The sentences that the participants were asked to imitate are given below.

(1)  El yunque es enorme.
    ‘The forest is enormous.’

(2)  La silla y el anillo son de Francia.
    ‘The chair and the ring are from France.’

(3)  Las mujeres son generosas.
    ‘The women are generous.’

(4)  Los animales comen el pan.
    ‘The animals are eating the bread.’

(5)  Zaragoza es una ciudad bonita.
    ‘Zaragoza is a pretty city.’

The following chart contains sounds of a native speaker from Mexico, imitating a person from Spain, Puerto Rico, and Argentina.
Because the participants adjusted both /s/ and /t/ when imitating Puerto Rican Spanish speakers, I decided to use these two variables in the current study. Because not many participants velarized /n/, I chose to include that variable to see if its lack of saliency would affect cross-dialectal processing and perception. These phonological variables will be described in more detail below.

### 3.2 Mexican Spanish

#### 3.2.1 Overview

When compared to most dialects of Latin American Spanish, Mexican Spanish is generally considered to be a consonant preserving dialect. That is, speakers of most varieties of Mexican Spanish tend to conserve consonants and weaken unstressed vowels,
especially the mid front vowel /e/ when adjacent to the sibilant fricative /s/. This conservation or preservation of consonants is strikingly different from that of Puerto Rican Spanish, and will be addressed in the following sections, particularly regarding the three phonological variables being studied in the experiments conducted in this research project. The dialect of Mexican Spanish used in this study is that of Cuernavaca, Morelos, and can be considered to be representative of Central Mexican Spanish. The location of Cuernavaca is marked on the following map with a rectangle.

Figure 3.2. Map of Mexico
3.2.2 Variable: /n/

Mexican Spanish, like other dialects of Spanish, has a non-variable nasal assimilation rule that applies to nasals preceding consonants. This assimilation process requires the coda nasal to assume the place specification of the following consonant. For instance, the masculine indefinite article *un* ‘a/an’ has various realizations, depending on the following environment. The following figure illustrates this process of assimilation with the underlying form /un/ ‘a/an’.

<table>
<thead>
<tr>
<th>Following Context</th>
<th>Surface Form</th>
<th>Example</th>
<th>Gloss</th>
</tr>
</thead>
<tbody>
<tr>
<td>[b] (bilabial)</td>
<td>[m] (bilabial)</td>
<td>u[m] beso</td>
<td>‘a kiss’</td>
</tr>
<tr>
<td>[l] (labiodental)</td>
<td>[n] (labiodental)</td>
<td>u[n] flaco</td>
<td>‘a thin person’</td>
</tr>
<tr>
<td>[t] (dental)</td>
<td>[n] (dental)</td>
<td>u[n] taco</td>
<td>‘a taco’</td>
</tr>
<tr>
<td>[s] (alveolar)</td>
<td>[n] (alveolar)</td>
<td>u[n] sol</td>
<td>‘a sun’</td>
</tr>
<tr>
<td>[k] (velar)</td>
<td>[ŋ] (velar)</td>
<td>u[ŋ] caso</td>
<td>‘a case’</td>
</tr>
</tbody>
</table>

Figure 3.3. Illustration of nasal assimilation process in Spanish.

While all dialects of Spanish have a nasal assimilation rule for coda nasals (illustrated in Figure 3.3 above), there is also a word-final neutralization process in effect in all dialects of Spanish. In the dialect of Mexican Spanish being discussed here, this word-final neutralization rule results in word-final alveolar nasals, preceding a pause or a vowel (in the cases of word-final nasals preceding consonants, the nasal assimilation rule mentioned above applies). This is illustrated in example (6) below, where the word-final
nasal that is followed by a vowel-initial word is realized as the alveolar nasal [n], while the nasal followed by a word beginning with the bilabial consonant [b] is realized as the bilabial nasal [m].

(6) Los Alvarado so[n] americanos pero los otros so[m] bolivianos.
   ‘The Alvarados are Americans but the others are Bolivians.’

This notion of contextual word-final neutralization to alveolar, rather than to velar or bilabial, is a crucial difference between the dialects being studied here. It should be noted that other regions in Mexico have a neutralization process that can result in bilabial nasals rather than alveolar nasals word finally. For instance, the Spanish spoken in the Yucatan Peninsula is known for word-final bilabial neutralization (cf. Alvar 1969, García Fajardo 1984, Lipski 1994).

3.2.3 Variable: /s/

The voiceless sibilant fricative /s/ has several contextually-determined realizations in Spanish. The fricative /s/ can undergo deletion, aspiration, voicing, or can be retained as /s/. In Spanish, there is a general regressive voicing assimilation rule where the fricative /s/ is voiced before a voiced consonant. This widespread process of voicing assimilation is illustrated in the following examples containing the word es ‘it is’, where voicing assimilation applies in (7) but does not in (8).

(7) e[z] grande
   ‘it is big’

(8) e[s] alto
   ‘it is tall’
The processes of deletion and aspiration, mentioned above, do not occur in the dialect of Mexican Spanish discussed here. These processes do, however, occur in many dialects of Spanish, including Puerto Rican Spanish, and will be discussed below.

3.2.4 Variable: /ɾ/

All dialects of Spanish have the flap phoneme /ɾ/, or the *vibrante simple* in Spanish. In many dialects of Spanish, this rhotic in syllable-final position is generally realized as a flap (i.e. does not undergo any phonological changes). This is the case for the dialect of Mexican Spanish being studied here. It is not, however, the case for Puerto Rican Spanish, and this difference will be discussed below.

3.2.5 Conclusion

As illustrated in the preceding sections, Mexican Spanish is considered to be a conservative dialect, particularly regarding /s/, /n/, and /ɾ/. There is very little variation in the production of these phonemes in this dialect of Mexican Spanish. In other words, the word *este* ‘this’ is invariably produced as [este] in this dialect. The word *pan* ‘bread’ is consistently produced as [pan] phrase-finally, while the word *arte* ‘art’ is produced as [arte] customarily. This uniformity in consonant realization is an important marker of Mexican Spanish. This invariance is essential for this study because it sharply contrasts with the other dialect being studied, Puerto Rican Spanish.
3.3 Puerto Rican Spanish

3.3.1 Overview

In contrast to Mexican Spanish, Puerto Rican Spanish is considered to be a more consonant-weakening dialect of Spanish due to its tendency to weaken or delete consonants. In an imitation study conducted by the researcher, when speakers of other dialects of Spanish were imitating Puerto Rican Spanish, they consistently modified the phones /r/ and /s/, and occasionally the phone /n/ (see §3.1). These sounds as a whole undergo variable processes that are representative of the Caribbean in general and Puerto Rico more specifically. They will be described individually below. The dialect of Puerto Rican Spanish being discussed here is the Spanish spoken in the metropolitan San Juan area, which is marked with a rectangle in the following figure.

Figure 3.4. Map of Puerto Rico
3.3.2 Variable: /n/

The nasal assimilation rule discussed in §3.2.2 above applies in Puerto Rican Spanish for most speakers. It has been claimed that speakers of Puerto Rican Spanish do not obey this nasal assimilation rule, but rather all nasals preceding obstruents are velarized (cf. Bjarkman 1989). This is shown below in (9), where the expected form in a more conservative variety would be [m] because of the process of place assimilation to the following bilabial.

(9) Los nietos so[ɲ] buenos.
‘The grandchildren are good.’

If what Bjarkman states is in fact the case for some speakers of Puerto Rican Spanish, it does not seem to be the case for those speakers that participated in the current study. However, because the environment of pre-consonantal nasals is not going to be used in the stimuli in the current study, Bjarkman’s claim is not relevant. Instead, word-final nasals followed by a vowel or a pause will be used. In Puerto Rican Spanish, like most other Caribbean dialects, word-final nasals before pauses and vowels are velarized. This is illustrated below in (10) and (11), respectively.

(10) Yo prefiero comer pa[ɲ].
‘I prefer to eat bread.’

(11) Los estudiantes so[ɲ] inteligentes.
‘The students are intelligent.’
3.3.3 Variable: /s/

As noted earlier, there are several realizations of syllable-final /s/. Puerto Rican Spanish speakers aspirate and delete syllable-final /s/. Examples of retention, aspiration, and deletion are given below, respectively.

(12) Lo[z] gato[s] comen pe[s]cado. (retention)
‘The cats eat fish.’

(13) Lo[h] gato[h] comen pe[h]cado. (aspiration)
‘The cats eat fish.’

(14) LoØ gatoØ comen peØcado. (deletion)
‘The cats eat fish.’

Both aspirated and deleted /s/ are widespread throughout the island, and Lipski states that elision of /s/ has its origins in the capital (San Juan) and appears to be spreading outward (cf. Lipski 1994). While there is surely some correlation between social factors and /s/ realization, both aspiration and elision span socio-economic classes and age categories, and neither is specific to one group of speakers. In fact, the speakers that participated in the production study for this experiment both aspirated and deleted /s/.

Navarro Tomás conducted an extensive study on Puerto Rican Spanish (1948, 1999). He reports that syllable-final /s/ is aspirated in all of Puerto Rico, regardless of social status and geographic location (highlands/lowlands, urban/rural). He does note that speakers tend to retain /s/ as [s] when speaking in formal situations, such as at conferences or in other academic settings. He adds that in word-final position before a pause, /s/ tends to delete in all parts of the island.
The most complete study done on the realization and perception of coda /s/ in Puerto Rican Spanish is that of Figueroa (2000). She was studying whether speakers of PR Spanish compensated for their /s/ deletion by lengthening or laxing the preceding vowel. She looked at pairs of words such as pecado ‘sin’ and pescado ‘fish’ that differed only in that one had an underlying coda /s/ and the other did not. When produced by PR Spanish speakers, the /s/ was deleted, resulting in possible confusion. She did an acoustic analysis (length and quality of vowels) of these pairs to see if there was some phonetic difference between the word with an underlying /s/ and the word without an /s/. She found a large increase in the length of the syllable for the combination V + Ø (deleted /s/), especially when the vowel was [a] or [e]. However, she did not find a difference in vowel quality when comparing vowels before a deleted /s/ and vowels alone (i.e. the [e] in the examples given above).

She then used these words as the stimuli in an identification task. The participants were asked to write the word that they heard. The results showed that listeners were able to perceive a difference between pescado and pecado, even though both were produced segmentally as [pekaðo] with shorter or longer vowels. The participants were able to distinguish these pairs with an accuracy of 93.8%. She concludes that because listeners are still able to distinguish between nearly-identical pairs once the /s/ is deleted, these hearers must be paying attention to cues such as vowel duration.

Hochberg (1986a, 1986b) has also researched /s/ deletion in Puerto Rican Spanish. She was also looking at compensation for this deletion, but focuses on pronoun overtness rather than acoustic cues. She conducted sociolinguistic interviews with 10 Puerto Rican Spanish speakers living in Boston. She found what she called “extensive
deletion” of /s/ (1986b : 612). Of the nearly 4,000 instances of underlying /s/, over 53% were deleted. Of the word final /s/’s on 2^nd^ singular verb forms, 84% were deleted. It is important to note that these percentages are only instances of deletion; those segments that were aspirated are not part of these percentages. She found that 40% of the verbs that could have been used with a pronoun did in fact have an overt pronoun. Her deletion rates show that /s/ deletion is extremely common and widespread in Puerto Rican, especially when compared with Mexican Spanish, which was discussed above in §3.2.3.

Finally, Lipski in his 1986 article discusses reduction of word-final /s/ and /n/ in Spanish. He provides data for most of the dialects of Spanish. His results are very different from those of Hochberg. He reports that in Puerto Rican Spanish, preconsonantal syllable-final /s/, as in *pescado* ‘fish’, has an aspiration rate of 92% and a deletion rate of only 5%. Preconsonantal word-final /s/, as in *los gatos* ‘the cats’, has an aspiration rate of 69% and a deletion rate of 27% in Puerto Rican Spanish. These percentages and realizations are unlike those of Hochberg, and I feel are conditioned by extralinguistic factors. The following figure summarizes the findings of /s/ realization in Puerto Rican Spanish.
3.3.4 Variable: /ɾ/

In Puerto Rico, syllable-final /ɾ/ is realized as a flap [ɾ] or is lateralized to [l], or some combination of the two. This process of lateralization has been noted for decades, and was described by Navarro Tomás in 1948. Navarro Tomás found considerable regional variation, but the lateralized /ɾ/ seems to be more pervasive now, as evidenced by the fact that speakers from other regions use this sound as a marker of Puerto Rican Spanish. In fact, when imitating Puerto Rican Spanish speakers, other Latin American Spanish speakers refer to them as being from Pue[ɾ]to Rico, rather than Pue[l]to Rico. In the imitation study discussed earlier, many of the participants used this process when mimicking Puerto Ricans.

Several researchers have looked at lateralization in Puerto Rico in relation to extralinguistic factors. Gloria Prósper-Sánchez (1995) conducted a sociolinguistic study in Puerto Rico, where participants from three socioeconomic classes were interviewed and recorded. She based socioeconomic class on the level of education and the profession.
of the informants. Prósper-Sánchez found lateralization in all three socioeconomic classes and across all age groups and sexes. She concluded that lateralization is a feature of the dialect as a whole, and cannot be used to further distinguish dialect groups within Puerto Rico.

Medina-Rivera (1994, 1997) also examined the role of socioeconomic and stylistic variables in the production of /ɾ/ in Puerto Rican Spanish. He recorded 20 young adults from Caguas, Puerto Rico in two settings: individual (one-on-one) and group (more than two). He found that the group setting favored lateralization (58%) more so than the individual setting did (49%). He also found that /ɾ/ lateralized most often before voiced obstruents (64%) and phrase-finally (69%), and least often before voiceless continuants (28%). Rivera also observed that lateralization was favored when speakers were discussing topics such as their childhood (63%) or friends (66%), and was disfavored when discussing formal topics, such as church (38%).

Rivera also conducted a language attitudes survey, where he asked seventy-four native speakers from Puerto Rico how they felt about lateralizing /ɾ/. In total, only 4% of the participants had a positive attitude toward lateralization, while 25% were neutral and 71% had a negative attitude toward lateralization. The 4% who had a positive attitude toward lateralization were all college graduates, and considered lateralization to be a marker of national identity. Those participants who responded negatively to lateralization said that it was a marker of low education and low socio-economic status, but admitted that they lateralized, especially when they were speaking quickly.
Figueroa and Hislope (1999) studied the effects of gender and speech style on the realization of coda /r/ in Puerto Rican Spanish. They recorded five females and five males from Puerto Rico between the ages of 20 and 29, reading a text and in conversation. The text served as a formal speech style and the conversation as an informal speech style. They transcribed the /r/ as either [r], [l], or other. They found that there was a difference in production depending on gender and speech style. Overall, females tended to be more conservative than males, and the text resulted in the most conservative speech for both females and males. In the text, females produced /r/ as [r] 94.2% of the time, while the males produced /r/ as [r] only 66.7% of the time. In the conversation, however, the /r/ was produced as [r] by females only 48.5% of the time and by males only 24.8% of the time. The males had a much higher rate of lateralization in the conversation (47.9%) than did the females (8.5%). Clearly, lateralization is a process that occurs more often in conversational style than in formal or read speech. It is also a widespread process in Puerto Rican Spanish, among both males and females. Their results are summarized in the following table.
Figure 3.6. Realization of /r/ (%) in Puerto Rican Spanish, based on Figueroa and Hislope (1999).

<table>
<thead>
<tr>
<th></th>
<th>Females</th>
<th></th>
<th>Males</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[r]</td>
<td>[l]</td>
<td>other</td>
<td>[r]</td>
</tr>
<tr>
<td>Conversation</td>
<td>48.5%</td>
<td>8.5%</td>
<td>43.0%</td>
<td>24.8%</td>
</tr>
<tr>
<td>Reading</td>
<td>94.2%</td>
<td>0.0%</td>
<td>7.7%</td>
<td>66.7%</td>
</tr>
</tbody>
</table>

Other researchers have looked at lateralization of /r/ without considering extralinguistic factors. One such researcher is Canfield (1981). He reports that “there is a strong tendency toward acoustic equivalence of /l/ and /r/ syllable final” (1981: 76). The following map is based on the map found in Canfield (1981: 77).
Lipski reports that lateralization occurs with 50% of the pre-consonantal and pre-pausal flaps in Puerto Rican Spanish (cf. Lipski 1994). He also notes that lateralization is more prevalent among older speakers and speakers of lower social classes. This, however, does not seem to be the current situation in Puerto Rico. Figueroa and Hislope found that young speakers (20-29) of Puerto Rican Spanish lateralized /ɾ/, even in formal situations. Rivera found that young speakers lateralize /ɾ/ in conversation. Also, based on my own experience in Puerto Rico interacting with speakers from all sociolinguistic backgrounds, lateralization seems to be a marker of social identity, and is not stigmatized by speakers of Puerto Rican Spanish. This seems to indicate that lateralization is not
uncommon among young speakers, but rather that young speakers are using lateralization actively in discourse.

3.3.5 Conclusion

As shown above, Puerto Rican Spanish and Mexican Spanish sharply contrast with respect to the three phonological variables being considered in this study. While Mexican Spanish is considered to be a conservative dialect of Spanish, Puerto Rican Spanish is considered to be a more radical dialect. This is in part due to variation within Puerto Rican Spanish, but also due to the fact that syllable-final and word-final consonants undergo weakening in the Caribbean, unlike in Mexico. This weakening and variation is stigmatized by some speakers of other dialects of Spanish, but is used as a marker of social identity within Puerto Rico. These differences will be explored and discussed in the following chapters.

3.4 Summary

The three phonological variables mentioned above, /n/, /r/, and /s/, have different realizations in Mexican and Puerto Rican Spanish. They also have variable realizations within the dialects. For instance, in Puerto Rican Spanish, syllable-final /s/ is realized as [z], [s], [h], or is deleted. In the dialect of Mexican Spanish being studied here, syllable-final /s/ is always realized as [s] or [z], based on the phonological context (i.e. due to voicing assimilation). In Puerto Rican Spanish, syllable-final /r/ can either be realized as [r] or as [l], or according to some accounts, a combination of the two sounds (i.e. an alveolar lateral flap [l]). In Mexican Spanish, however, syllable-final /t/ is not realized as
a lateral. The word-final /n/ followed by a vowel or a pause is neutralized to a velar nasal [ŋ] in Puerto Rican Spanish, but is realized as an alveolar nasal [n] in the dialect of Mexican Spanish being discussed here.

In other words, Puerto Rican Spanish speakers are accustomed to variation and variable input, particularly with respect to coda /s/ and coda /r/. The Mexican Spanish speakers, on the other hand, are not accustomed to variation, particularly with these three phonological variables. Since both Mexican and Puerto Rican Spanish have a process of nasal assimilation, the speakers are used to hearing variation in their word-final nasals, what differs is the realization of the word-final nasals before a pause or a vowel.

It is hypothesized, then, that the word-final nasals will not be as difficult to process as the other two variables will be. It is also hypothesized that the Puerto Rican speakers will not have as much difficulty in processing the Mexican Spanish input, since they are familiar with variation, both within their own dialect and through contact with speakers of other dialects. The amount of contact a listener has with speakers of other dialects will be discussed in Chapter 4. The Mexican Spanish speakers will have more difficulty perceiving and processing Puerto Rican Spanish, since they are not as accustomed to this kind of variation as the Puerto Rican speakers are.
CHAPTER 4

METHOD

In order to measure the effect of native dialect on speech perception and processing, three experiments were conducted on native Spanish speakers from Mexico and from Puerto Rico (following OSU research protocol #2004B238). For the first two tasks, a naming task and a lexical decision task, native dialect effect is considered to be correlated with reaction time. In the third task, the actual response is taken to represent the native dialect effect. Words containing the phonological variables discussed in Chapter 3 were used as the stimuli for the tasks.

4.1 Predictions

Previous studies have shown that one’s native language affects speech perception (cf. Trubetzkoy 1939, Best 1994, Kuhl et al. 1992). However, the current study does not look at cross-linguistic differences of perception, but rather cross-dialectal effects on the perception of Latin American Spanish. Following from the results of the language attitudes study discussed in Chapter 3, the author predicts that speakers of Spanish are able to hear differences across dialects, and it follows, from an exemplar standpoint, that these differences are used when perceiving and processing speech.
Thus, if there are differences across the dialect groups in this study, then we would expect for the Puerto Rican and Mexican Spanish speakers to have different patterns of results. Each dialect group should respond faster to speakers of their own dialect than to speakers of the other (non-native) dialect. This is because exemplar-based approaches assume that weights to a given exemplar strengthen the more the listener is exposed to that string of phones. This is not to say that everyone in a given dialect has the same exemplars with the same weighting, but rather that the weighting and strength of exemplars will be more similar within a dialect group than when compared to another dialect group. Groups within a dialect group are expected, as each listener experiences different exemplars throughout their lifetime. The following graph predicts the reaction time results for the lexical decision task, in which they must access their lexicon (i.e. exemplars) to respond.

![Discrimination Task: Predicted RT](image)

Figure 4.1. Predicted results for the lexical decision task.
The predicted results for the lexical decision task, given above, show that the Mexican Spanish participants respond very quickly to the stimuli produced by Mexican Spanish speakers, while they respond much slower to the stimuli produced by Puerto Rican Spanish speakers. The Puerto Rican participants, on the other hand, respond relatively quickly to Puerto Rican Spanish speakers, and somewhat slower to Mexican Spanish speakers. The difference between the predicted ability of the Mexican participants to respond to Puerto Rican Spanish speakers and the ability of the Puerto Rican participants to respond to the Mexican Spanish speakers lies in the assumption that Puerto Rican Spanish speakers have more experience with Mexican Spanish, and therefore more stored exemplars of Mexican Spanish, while speakers of Mexican Spanish have less experience with Puerto Rican Spanish. This is because Mexican Spanish is found on popular television shows and radio programs which are broadcast throughout the Spanish-speaking world. In addition, with respect to the three phonological variables being discussed in this study, Puerto Rican Spanish speakers are more accustomed to variable input than Mexican Spanish speakers are. Puerto Rican Spanish speakers have at least three realizations of syllable-final /s/, whereas the Mexican Spanish speakers typically only have one (in addition to the voiced realization). The same is true for word-final /n/ and syllable final /l/, only to varying degrees. These results would of course be dependent on the amount of dialect contact each participant has had (i.e. radio, television, travel, friends, etc.).

However, if there are no differences in perception in this study, then that would mean that variable input would undergo some sort of speaker normalization. Normalization, as it is understood within the field of speech science, has three
consequences for speech perception. First, normalization converts different tokens into a common representation and stores those standardized representations in memory. Second, normalization involves a loss of information and a reduction in stimulus variability. Finally, normalization treats variability as a source of noise that is affecting the idealized abstract forms that are assumed by abstractionists to be the true objects of perceptual analysis (cf. Pisoni 1997). In this case, the detailed phonetic information in the input is filtered out or stripped away. If it is the case that input is stored in the lexicon as abstract speech units, such as phonemes, then we would expect all of the speakers, regardless of their native dialect and dialect contact experience, to have results that pattern in the same way.

4.2 Stimuli

The same stimulus set is used for experiments 1, 2, and 3. Experiments 1 and 3 use only the real words from the stimulus set, while experiment 2 uses both the real words and nonwords from the stimulus set. While all three experiments use stimuli from the same stimulus set, the experimental task differs from experiment to experiment. The first experiment consists of a naming task in which the participants must repeat the word that they hear as quickly as possible. The second experiment involves a lexical decision task in which the participants must decide, as quickly as possible, whether the word they hear is a real word or a nonword. The final experiment is an identification task in which the participants have to determine whether the word they heard was produced by a speaker of their own dialect or another dialect.
The stimuli in these experiments exhibit possible phonological variation in the two dialects being studied. While variation is generally considered to be treated as noise in the signal (cf. Pisoni 1997), variation was intentionally introduced into the stimulus set in the current study in order to test the effects of variable input on speech perception and processing. There are several types of variation, depending on the source of the variability. Possible types and sources of variability are presented in the figure below, which is based on a figure presented in Pisoni 1997, which was based on a figure in Klatt 1986.

<table>
<thead>
<tr>
<th>Type of variability</th>
<th>Sources of variability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambient conditions</td>
<td>Background noise, microphone and telephone characteristics, etc.</td>
</tr>
<tr>
<td>Within-speaker variability</td>
<td>Variable degrees of articulatory undershoot, imperfect repetition across tokens of same gesture, shifting formants, changing speaking rate, etc.</td>
</tr>
<tr>
<td>Cross-speaker variability</td>
<td>Dialectal differences, vocal tract length and shape differences, etc.</td>
</tr>
<tr>
<td>Segment realization variability</td>
<td>Coarticulatory changes, optional deletions or simplifications in fluent speech, etc.</td>
</tr>
<tr>
<td>Word environment variability</td>
<td>Cross-word-boundary coarticulation, changes in word duration due to syntax, etc.</td>
</tr>
</tbody>
</table>

Figure 4.2. Sources of variability in speech, based on Klatt 1986 and Pisoni 1997.

The three variants that are being examined are syllable-final /s/, word-final /n/, and syllable-final /t/. These three phonemes have variable realizations depending on many factors, one of which is dialectal region. The stimulus set also contained non-variable words, which were used as fillers in the experiments. Figure 4.3 provides examples of the stimuli for the experiments.
Figure 4.3. Example stimuli for Experiments 1, 2, and 3.

<table>
<thead>
<tr>
<th>variable</th>
<th>word</th>
<th>gloss</th>
<th>Mexico</th>
<th>Puerto Rico</th>
</tr>
</thead>
<tbody>
<tr>
<td>/s/</td>
<td>astro</td>
<td>‘astro’</td>
<td>[astro]</td>
<td>[astro], [ahtro], [atro]</td>
</tr>
<tr>
<td>/n/</td>
<td>canción</td>
<td>‘song’</td>
<td>[kansjon]</td>
<td>[kansjon], [kansjon]</td>
</tr>
<tr>
<td>/t/</td>
<td>porque</td>
<td>‘because’</td>
<td>[porke]</td>
<td>[polke], [porke]</td>
</tr>
<tr>
<td>filler</td>
<td>oso</td>
<td>‘bear’</td>
<td>[oso]</td>
<td>[oso]</td>
</tr>
<tr>
<td>nonword</td>
<td>cuande</td>
<td>---</td>
<td>[kwande]</td>
<td>[kwande]</td>
</tr>
</tbody>
</table>

There are 45 test words arranged into three groups of fifteen based on the variable they contain (/s/, /n/, or /t/). These three phonological variables have different degrees of variability in their realization, as discussed in Chapter 3. In Puerto Rico, syllable-final /s/ can be retained, aspirated, or deleted, while in this dialect of Mexican Spanish it is generally retained. Word-final /n/ is produced as an alveolar in this phonological context in this dialect of Mexican Spanish, but as either a velar or alveolar in Puerto Rican Spanish. Finally, syllable-final /t/ can be lateralized in Puerto Rican Spanish, but is never lateralized in Mexican Spanish. The degree of variability in the pronunciation of these variables is determined by linguistic and extralinguistic factors, such as gender, speech rate and style, and age.
There are 21 filler words that do not exhibit variation of the three variables being studied in the two dialects in question. There are 32 nonwords which were used only in the lexical decision task. The complete stimulus set contains 98 words, all of which are bisyllabic. The stimuli are further described in the following sections: Section 4.2.1 describes the test words; Section 4.2.2 describes the nonwords; while Section 4.2.3 describes the filler words. Section 4.2.4 describes the production of the stimuli. Appendix A contains a complete list of the stimulus set, divided into the groups described above.

4.2.1 Test Words

As mentioned above, the test words can be divided into three groups depending on the type of phonological variation that they exhibit. The first group contains fifteen words that have a word-final nasal. In this phonological context, word-final nasals are neutralized either as alveolars [n] or velars [ŋ]. In most of Mexico, including the region under study here, word-final nasals that are followed by a vowel or a pause are realized as alveolars. In most of Puerto Rico, and in the area related to this study, word-final nasals followed by a vowel or a pause are realized as velars. Therefore, the word pan ‘bread’ is produced as [pan] by a Mexican Spanish speaker and as [panŋ] by a Puerto Rican Spanish speaker. It should be noted that in some areas of Mexico, in particular the Yucatan Peninsula, word-final nasals are realized as bilabial nasals rather than alveolar nasals. Speakers from this region did not participate in the study.

The second set of test words contains fifteen words with an underlying syllable-final /t/. In coda position, /t/ is realized as /ɾ/ or undergoes lateralization, resulting in /l/. Lateralization of /ɾ/ is frequent in the Caribbean, and is very common in Puerto Rico,
especially among younger, less educated speakers. Coda /ɾ/ is usually realized as /ɾ/ in Mexico. Therefore, Gilberto ‘Gilbert’ is pronounced as [xilβerto] in Mexico but may be [hilβelto] in Puerto Rico. It should be noted here that syllable-final rhotics are often produced as trills in Mexico, but never as laterals. Therefore, the contrast here is between rhotics and laterals, and not taps and trills.

Fifteen words containing syllable-final /s/ comprise the final set of test words. There are several realizations of syllable-final /s/ in Spanish. Coda /s/ is voiced [z] when followed by a voiced consonant. It is a voiceless alveolar fricative [s] in all other cases in many dialects of Spanish, including Central Mexican Spanish. Coda /s/ can be aspirated [h] or deleted in other dialects of Spanish, including Caribbean Spanish. Therefore, the final set of test words was either produced with a voiceless alveolar fricative [s] by the Mexican Spanish speakers or with an aspirated or deleted /s/ by the Puerto Rican Spanish speakers. For example, the word este ‘this, east’ is pronounced as [este] in Mexico but as either [ehte] or [ete] in Puerto Rico. In eleven of the fifteen of the words containing syllable-final /s/, the /s/ is lexical, as in este ‘this, east’. In the remaining four words, the /s/ is grammatical, functioning as the plural marker, as in gatos ‘cats’.

4.2.2 Filler Words

In addition to the three groups of test words, there is also a group of filler words in the stimulus set. The words in this group were chosen because they do not exhibit variation in word-final /n/, coda /s/, or coda /ɾ/. They were intended to be non-variable forms, or nearly non-variable forms. For instance, oso ‘bear’ was chosen because it is
pronounced as [oso] in both Mexico and Puerto Rico. Another such non-variable word that was used as a filler is obra ‘play, work’, which is pronounced as [oβra] in both Mexican and Puerto Rican Spanish. While the phonetic quality of all of the sounds in the filler words may not be exactly identical in these two dialects, they are more similar than the three phonological variables being studied. For instance, the difference in vowel quality in Mexican and Puerto Rican Spanish is less salient than the differences in the three variables being studied, if it is salient at all. This group of filler words, like all fillers, was used to distract the participants from the task at hand. Therefore, the filler words did not contain the variables being studied (/n/, /s/, /r/).

4.2.3 Nonwords

In Experiment 2, the stimulus set not only included the three test groups and the filler group described above, but also a group of nonwords. The nonwords were used only in the second experiment because that task was a lexical decision task. In that session, the participants were asked to listen to a word and determine whether it was a word that existed in Spanish or not. Therefore, nonwords were a necessary component of the stimulus set in order for the task to be completed.

There were 32 nonwords in the stimulus set. The nonwords were constructed from 32 real words in Spanish. These real words were divided into four sets of eight words. In the first set of words, the onset consonant in the penultimate syllable was changed to a consonant that resulted in a nonword in Spanish. An example of a change in the penultimate onset consonant is the nonword sindo, which was originally lindo ‘cute’. In this example, the onset [l] was changed to [s]. The second set of nonwords was constructed by changing the vowel in the penultimate syllable. The nonword dido
originated from *dedo* ‘finger’, in which the penultimate vowel was changed from [e] to [i]. In the third set, the nonwords were created by changing the onset of the last syllable, as in the nonword *cuanes*. This nonword was created from *cuales* ‘which (pl.)’ by changing the onset [l] to [n]. The final set of nonwords was produced by changing the vowel of the last syllable. Thus, the word *queso* ‘cheese’ converted into the nonword *quesa* by changing the final vowel from [o] to [a].

### 4.2.4 Production of Stimuli

The stimuli that were used in the experiments were produced by ten native Spanish speakers. Five participants were native Spanish speakers from Puerto Rico who were studying at the Ohio State University. The other five participants were native Spanish speakers from Mexico who were studying at the Ohio State University. All of the participants were born and raised in either Mexico or Puerto Rico and had been in Ohio for less than four years. They all reported Spanish as their native language and English as their second (non-dominant) language. The participants were paid $10 for their participation in a 20 minute production session. The participants were recruited by an advertisement distributed by email and by word of mouth (i.e. from contacts in the community).

The participants completed a questionnaire to ensure that they were in fact first language speakers of Spanish from either Mexico or Puerto Rico. The questionnaire also looked at how much out of country experience they had, particularly in areas of Latin America. The ten participants had very little, if any, travel experience in other Spanish-speaking countries, and had little contact here in Ohio with speakers outside of their
dialect. In order to elicit natural sounding, yet controlled, stimuli, the participants were given a list of words and were asked to read the list three times. The words were randomized so as not to draw attention to the variants in question (i.e. /n/, /ɾ/, /s/). The test words were kept separate from the nonwords so as not to confuse the participants in this production task. The recording took place in an anechoic chamber at the Ohio State University’s Department of Linguistics Phonetics Lab. The microphone was directly connected to the computer, and the program that was used to record the stimuli was Praat (www.praat.org).

Two of the five speakers from Puerto Rico had a difficult time producing the form that I was trying to elicit. In particular, they found it difficult to lateralize all of the syllable-final rhotics in such a formal environment (i.e. recording). In order to encourage lateralization in these cases, I made a CD with the words that had been produced by a trained phonetician, who is also a native speaker of Puerto Rican Spanish. That speaker produced the words with the variants that I was looking for, and was therefore a wonderful model for the other speakers. The two speakers who were having problems with lateralization were then able to listen to the words on the CD and repeat them. The words were played on a portable CD player inside the anechoic chamber. Headphones were not used in order to create a more natural listening setting for the speaker. This way, the speakers were producing the variants that I was seeking, while at the same time producing natural speech.

Once all ten speakers had produced the words in the stimulus set, I spliced them into individual tokens. The tokens had no silence before or after the word. There were three tokens of each stimulus word for each of the ten speakers. The second token of each
word was used, unless there was a mispronunciation or an intonation contour that was
unnatural. In those cases, either the first or the third token was used. Because there were
ten different speakers producing the stimuli, I equalized the amplitude of the tokens
across speakers. In order to do this I used a Praat script that went through the sound files
and scaled the amplitude so that all of the tokens had the same peak amplitude. This was
important because I did not want the participants in the experiments to focus on the
amplitude of a given speaker, rather than on the variables being tested.

After the tokens for the stimulus set where chosen, the stimulus list was made. In
order to make a stimulus set that was randomized, the names of each of the tokens in the
stimulus set were entered into an Excel worksheet. There were five sets of stimuli for the
first experiment and the second experiment. This was to ensure that each participant in
the study heard all of the speakers and the dialects the same amount of times. Once the
sets were organized, they were randomized with the help of the function Random() in
Excel. This function assigns a random number between zero and one to each cell. Then,
using the sort function, the cells were sorted in descending order, and the words were
randomized. Therefore the participants did not hear the same speakers or words
containing the same variable in a consecutively. In other words, the stimuli were constant
within a given participant group (i.e. every fifth participant had the same stimulus set),
but randomized across the participants and within stimulus sets.

4.3 Participants

Thirty three participants took part in the experiment. Thirteen (8 females and 5
males) of the participants were native Spanish speakers from Puerto Rico who studied or
worked at the Universidad de Puerto Rico – Río Piedras. The remaining twenty
participants (9 males and 11 females) were native Spanish speakers from Morelos, Mexico who taught at the Comunidad Educativa de Cemanáhuac, or who were relatives or friends of teachers at Cemanahuac. The data from one of the twenty participants from Mexico was not used. It should be noted that the desired number of participants was twenty from each region. However, due to the unpredictable occurrence of Hurricane Frances while in Puerto Rico, only thirteen participants from Puerto Rico took part in the study. All of the participants reported normal hearing and no history of speech or hearing trouble. The participants were paid $10 (or $100 pesos) for their participation in a 30-45 minute session. The participants were recruited by an advertisement posted at each of the respective schools and by word of mouth (i.e. from other participants).

The participant groups were intended to be as homogenous as possible. There was, however, some variation within and across the groups which was unavoidable. For the Puerto Rican participants, the average age for both males and females was approximately 25. For the Mexican participants, however, the females were about ten years older than the males, with an average female age of about 38, and an average male age of about 28. Figure 4.4 illustrates the mean age of the participants by dialect and gender.
The researcher attempted to control for the travel history of the participants, with the desired participant having little exposure outside of their own region. Overall, the Mexican participants had more exposure outside of their region than the Puerto Rican participants, with an average of 58 days and 45 days, respectively. Figure 4.5 illustrates the travel history of all the participants by gender and dialect.
However, the high average for the Mexican participants is due to one participant who spend almost one year living in the United States. If his data are removed, the Mexicans average only 20 days abroad, with the Puerto Ricans more than twice that. Figure 4.6 illustrates the travel history of the participants, except for the participant mentioned above.
Figure 4.6. Revised travel history by dialect and gender.

Figure 4.7 illustrates the Mexican participants’ age, sex, main residence locations, travel history, and friends’ origins, while Figure 4.8 illustrates the same information for the Puerto Rican participants. The origins of their friends were used to help determine how much dialect contact each participant has. The residential history of the participants is shown on maps in Appendix C.
<table>
<thead>
<tr>
<th>Part. #</th>
<th>Age</th>
<th>Sex</th>
<th>Residence (years)</th>
<th>Travel (days)</th>
<th>Friends’ Origins</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>28</td>
<td>M</td>
<td>Chihuahua (6), Queretaro (3), Potosí (2), Cuernavaca (17)</td>
<td>Nicaragua (10)</td>
<td>---</td>
</tr>
<tr>
<td>2</td>
<td>24</td>
<td>F</td>
<td>Cuernavaca (24)</td>
<td>Spain (25)</td>
<td>Argentina</td>
</tr>
<tr>
<td>3</td>
<td>31</td>
<td>F</td>
<td>Cuernavaca (22), Zacatepec (9)</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>4</td>
<td>27</td>
<td>M</td>
<td>Los Cabos (1), Cuernavaca (26)</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>5</td>
<td>30</td>
<td>F</td>
<td>D.F. (2), Cuernavaca (28)</td>
<td>Cuba (15)</td>
<td>Spain</td>
</tr>
<tr>
<td>6</td>
<td>58</td>
<td>F</td>
<td>Cuernavaca (58)</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>7</td>
<td>36</td>
<td>M</td>
<td>Guadalajara (2), Cuernavaca (34)</td>
<td>---</td>
<td>U.S.</td>
</tr>
<tr>
<td>8</td>
<td>57</td>
<td>M</td>
<td>Cuernavaca (57)</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>9</td>
<td>45</td>
<td>F</td>
<td>Cuernavaca (40), Guerrero (5)</td>
<td>---</td>
<td>Cuba, Chile, Colombia</td>
</tr>
<tr>
<td>10</td>
<td>31</td>
<td>F</td>
<td>D.F. (9), Cuernavaca (21), Puebla (1)</td>
<td>Panama (10), Spain (50)</td>
<td>Chile, Uruguay, Panama</td>
</tr>
<tr>
<td>11</td>
<td>47</td>
<td>F</td>
<td>Cuernavaca (47)</td>
<td>---</td>
<td>Guatemala</td>
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<tr>
<td>12</td>
<td>55</td>
<td>M</td>
<td>Cuernavaca (50), Michoacan (5)</td>
<td>U.S. (5)</td>
<td>Argentina, El Salvador, Guatemala</td>
</tr>
<tr>
<td>13</td>
<td>43</td>
<td>F</td>
<td>Michoacan (4), Cuernavaca (39)</td>
<td>U.S. (50)</td>
<td>U.S.</td>
</tr>
<tr>
<td>14</td>
<td>32</td>
<td>F</td>
<td>D.F. (17), Cuernavaca (15)</td>
<td>---</td>
<td>Colombia, U.S.</td>
</tr>
<tr>
<td>15</td>
<td>25</td>
<td>M</td>
<td>D.F. (18), West Virginia (1), Cuernavaca (5)</td>
<td>Spain (100)</td>
<td>Costa Rica, Spain, Argentina</td>
</tr>
<tr>
<td>16</td>
<td>21</td>
<td>F</td>
<td>D.F. (10), Xalapa (9), Cuernavaca (2)</td>
<td>---</td>
<td>Colombia</td>
</tr>
<tr>
<td>17</td>
<td>24</td>
<td>M</td>
<td>D.F. (8), Cuernavaca (16)</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>18</td>
<td>18</td>
<td>M</td>
<td>Cuernavaca (17)</td>
<td>U.S. (300)</td>
<td>U.S.</td>
</tr>
<tr>
<td>19</td>
<td>46</td>
<td>M</td>
<td>D.F. (5), Cuernavaca (41)</td>
<td>Cuba (10), Panama (5), Venezuela (5)</td>
<td>Colombia</td>
</tr>
<tr>
<td>20</td>
<td>65</td>
<td>F</td>
<td>Cuernavaca (65)</td>
<td>U.S. (50), Guatemala (21)</td>
<td>U.S.</td>
</tr>
</tbody>
</table>

Figure 4.7. Mexican participant background information.
<table>
<thead>
<tr>
<th>Part. #</th>
<th>Age</th>
<th>Sex</th>
<th>Residence (years)</th>
<th>Travel (days)</th>
<th>Friends' origins</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>23</td>
<td>F</td>
<td>Juncos (21), San Juan (2)</td>
<td>Mexico (7), Spain (50)</td>
<td>Mexico, Spain, Colombia, Bolivia</td>
</tr>
<tr>
<td>3</td>
<td>27</td>
<td>F</td>
<td>San Juan (27)</td>
<td>Colombia (14), Argentina (14), Uruguay (5), CR (21), Mexico (5)</td>
<td>Mexico, Argentina, Colombia</td>
</tr>
<tr>
<td>4</td>
<td>28</td>
<td>M</td>
<td>Manati (17), Chicago (1), Aguacilla (2), San Juan (2)</td>
<td>DR (30)</td>
<td>---</td>
</tr>
<tr>
<td>5</td>
<td>30</td>
<td>F</td>
<td>Arecibo (17), Río Piedras (11), Colorado (2)</td>
<td>Spain (14), Brazil (30)</td>
<td>---</td>
</tr>
<tr>
<td>6</td>
<td>25</td>
<td>M</td>
<td>Utuado (5), Mayagüez (18), Río Piedras (2)</td>
<td>Florida (60), DR (7)</td>
<td>---</td>
</tr>
<tr>
<td>7</td>
<td>24</td>
<td>F</td>
<td>Río Piedras (23), D.C. (1)</td>
<td>DR (7), Perú (14)</td>
<td>Cuba</td>
</tr>
<tr>
<td>8</td>
<td>24</td>
<td>F</td>
<td>San Juan (24)</td>
<td>Cuba (7), CR (21), Spain (100), Venezuela (7)</td>
<td>Spain, Argentina</td>
</tr>
<tr>
<td>9</td>
<td>36</td>
<td>M</td>
<td>San Juan (34), Illinois (2)</td>
<td>Spain (30), Cuba (7), CR (50), DR (7)</td>
<td>Spain, Cuba, DR</td>
</tr>
<tr>
<td>10</td>
<td>22</td>
<td>F</td>
<td>Ponce (2), San Juan (20)</td>
<td>DR (10)</td>
<td>Venezuela</td>
</tr>
<tr>
<td>11</td>
<td>21</td>
<td>M</td>
<td>Bayamón (21)</td>
<td>Florida (30)</td>
<td>Nicaragua</td>
</tr>
<tr>
<td>12</td>
<td>18</td>
<td>M</td>
<td>Canovanas (18)</td>
<td>DR (8)</td>
<td>Argentina, Mexico</td>
</tr>
<tr>
<td>13</td>
<td>21</td>
<td>M</td>
<td>Canovanas (21)</td>
<td>Mexico (14)</td>
<td>---</td>
</tr>
</tbody>
</table>

Figure 4.8. Puerto Rican participant background information.

4.4 Procedure

There were three tasks in the experiment: a naming task, a lexical decision task, and an identification task. The participants took part in all three of these tasks, in the
order listed above. For all of the participants and for all of the tasks, a Dell Inspiron 1000 laptop computer and a 5-button Serial Response Box were used to conduct the experiment. The experiment was run using E-Prime software. All of the participants used a head-mounted microphone headset for all of the tasks. After completing these tasks, the participants completed a one page, double-sided post-experiment questionnaire. The instructions used in the experiments are given in Appendix G, while the post-experiment questionnaire is given in Appendix B.

4.4.1 Naming Task

The first task, a naming task, investigates whether a speaker’s native dialect affects their naming or repetition time of words from both their dialect and another dialect. For instance, given a native Spanish speaker from Mexico and input in the form a of a word spoken by a speaker of Puerto Rican Spanish and a speaker of Mexican Spanish, will the listener be able to repeat the word from their own dialect faster than that of the other dialect? Does your language experience within a dialect affect how you perceive speech? If so, does that affect your ability to repeat words from both within and outside of your native dialect? These issues, among others, were the focus of the current experiment, a naming task.

In this task, two independent variables were manipulated. The first variable is the dialect of the speaker who is producing the stimulus token. As mentioned earlier, the stimuli were produced by five female speakers of Mexican Spanish and five female speakers of Puerto Rican Spanish. The second variable is the phonological variant found in the test words in the stimulus set. The three phonological variants being manipulated are the realization of syllable-final /s/, the realization of word-final /n/, and the realization
of syllable-final /r/. This variable is directly related to the first variable in that the realization of these variants is correlated with the native dialect of the speaker.

In the naming task, participants were instructed that they would hear a word in Spanish, and that they were to repeat or name that word as quickly and accurately as possible. They were to repeat the word as loudly as possible into the head-mounted microphone that was attached to their headphones. They were told that after each repetition, their response time (in milliseconds) would appear on the screen, and their goal was to keep the reaction times as low as possible (i.e. respond as quickly as possible), while maintaining accuracy.

After the spoken instructions from the researcher and after reading the instructions on the computer screen, they completed five practice trials in which they named filler words (i.e. non-variable words). During the practice block, the participants were given the opportunity to ask questions or ask for clarification. The researcher also used this time to adjust the microphone position and sensitivity. Once the participants and the researcher felt comfortable with the task, they were reminded of the instructions and then were able to start the test block, which consisted of 76 trials.

The participants in Puerto Rico were seated at a rectangular table with the researcher, in a reading room on the second floor of the main library at the University of Puerto Rico. The participants in Mexico were seated at a circular table with the researcher, in a private classroom at the Cemanahuac Educational Community. The researcher sat at the table with the participants to monitor progress and to be able to answer any questions or problems that arose during the experiment. The participants were able to partially control the presentation rate. Participants were told to press the #1 button
on the SRS box in order to continue with the experiment between test blocks. The participants were tested individually, and this task took participants fifteen minutes on average.

4.4.2 Lexical Decision Task

The lexical decision task investigates whether a speaker’s native dialect affects their ability to determine whether a word produced by a speaker from their dialect and another dialect is a word or a nonword in Spanish. For instance, given a native Spanish speaker from Mexico and input in the form of a word spoken by a speaker of Puerto Rican Spanish and a speaker of Mexican Spanish, will the listener be able to determine more quickly whether the word they heard is a real word or not when it is produced by someone in their own dialect, or someone from another dialect? Does your language experience within a dialect affect how you perceive speech? If so, does that affect your ability to access your lexicon to determine whether the word you heard was in fact a word in your language or not? These issues, among others, were the focus of the current task, a lexical decision task.

In the lexical decision task, participants were instructed that they would hear a word, and that they were to determine whether what they heard was a real word or a nonword in Spanish. If the word existed in Spanish, they were told to press button #1 on the button box. If the word did not exist in Spanish, they were told to press button #2 on the button box. They were to press the button as quickly as possible after having heard the stimuli. They were told that after each response, their response time (in milliseconds) would appear on the screen, and their goal was to keep the reaction times as low as
possible (i.e. respond as quickly as possible), while maintaining accuracy in their responses.

After the spoken instructions from the researcher and after reading the instructions on the computer screen, they completed five practice trials in which they determined whether five words existed in Spanish or not. All five words used in the practice trial were non-variable pronunciations of real words in Spanish (i.e. gato ‘cat’, oso ‘bear’, etc.) During the practice block, the participants were given the opportunity to ask questions or ask for clarification. Once the participants and the researcher felt comfortable with the task, they were reminded of the instructions and then were able to start the test block, which consisted of 100 trials.

4.4.3 Identification Task

The final task that was conducted was an identification task, in which the participants were asked to determine whether the word they heard was produced by a speaker of their dialect or another dialect. The task was designed in order to determine whether the participants in the study could perceive dialectal differences among the talkers in the experiment. If they were not able to hear the difference between a speaker from their own dialect and a speaker from another dialect, then the results from the previous two tasks would not be considered because for that participant, the variables being used were not salient dialectal cues. This task was also used to determine the prominent phonological variables that distinguish Mexican and Puerto Rican Spanish.

In the identification task, participants were instructed that they would hear a word, and that they were to determine whether that word was produced by a speaker of their dialect or another dialect. If the word was produced by a speaker of their own dialect,
they were told to press button #1 on the button box. If the word was produced by a
speaker of another dialect, they were told to press button #2 on the button box. They were
told to take their time responding, as their reaction time was not being calculated, only
their actual response.

For this task, there was no practice block, only a test block, which consisted of 24
of the real words from the stimulus set. One half of the words were produced by speakers
of Mexican Spanish, and the other half were produced by speakers of Puerto Rican
Spanish. One-third of the set of 24 words used in this task contained the phonological
variable /n/, another third the variable /s/, and the remaining third the variable /r/. Thus,
half of the words containing /n/ were produced by Mexican Spanish speakers, and the
other half by Puerto Rican Spanish speakers, etc.

4.4.4 Post-Experiment Questionnaire

The final task in which the listeners participated was a post-experiment
questionnaire. A copy of the questionnaire, in both English and Spanish, can be found in
Appendix B. The goal of the questionnaire was to determine the amount of dialect
exposure they had, and also the amount of time they had lived outside of their region. The
questionnaire was also used to determine extra-linguistic factors such as age, education
background, and travel experience. The purpose of the final portion of the questionnaire
was to tap into their insights regarding the purpose of the experiment, as well as to find
any problems with the tasks that they participated in.
CHAPTER 5

RESULTS

5.1 Introduction

This chapter presents the results of the study described in the previous chapter. The remainder of Section 5.1 provides background information on transformations used in the statistical analyses of the data (d’ transformation in 5.1.1, rationalized arcsine transformation in 5.1.2, z-score transformation in 5.1.3). Section 5.2 details the naming task data, while in Section 5.3 the results of the lexical decision task are presented (as reaction time data in 5.3.1, and correct responses in 5.3.2). Section 5.4 details the dialect identification task data, and in Section 5.5 the results of the familiarity judgment questionnaire are presented. Section 5.6 presents a summary of the results for all three tasks.

5.1.1 d’ transformation

The accuracy data from the lexical decision task are presented as proportion correct. Because the participants were asked to push the first button when they heard a real word and the second button when they heard a nonword, their results fall into four groups: hits, misses, false alarms, and correct rejections. For this experiment, a hit is when the participant hears a real word and responds that they heard a real word, by
pushing the first button. A miss is when the participant heard a real word but responded that it was a nonword. If the participant responded that they heard a real word when actually the stimulus was a nonword, that response is a false alarm. Finally, when a participant hears a nonword and reports that they heard a nonword, then that response is a correct rejection.

Many times, participants are biased to push word, and therefore end up with a lot of hits. They also, however, would have a lot of false alarms as they are biased to push word regardless of the stimuli. So, a participant that has a large number of hits is not necessarily performing well at the task, but rather is biased to push the correct answer. To ensure that participants in this experiment that seemed to be doing well at the task were actually doing well, their hits and false alarms were compared. To do this, a mean $d'$ value was calculated for each participant (cf. Macmillan and Creelman 1991). In order to calculate $d'$, the formula in (1) was used.

\[
d' = z(\text{hits}) - z(\text{false alarms})
\]
Where $z(\text{false alarms}) = -p(\text{false alarms})$

In this formula, the values of $z$ and $p$ are taken from the table in Macmillan and Creelman (1991: 318), which was, in turn, taken from Pearson (1931).

5.1.2 Rationalized arcsine transformation

The accuracy data from the dialect identification task are in the form of proportion (or percentage) correct. Most of the results were either very near 1.0 or very near 0.0. To make them more suitable for statistical analysis, a rationalized arcsine
transformation was performed. A traditional arcsine transformation was not used for this data because with a traditional transform, the transformed values fall in a range that has little intuitive relationship to the untransformed proportions. With a rationalized arcsine transform, however, the result is values that are numerically close to the original percentage values while retaining the statistical properties of the arcsine transformation (cf. Studebaker 1985).

In order to obtain the rationalized arcsine transform of the accuracy data from the lexical decision and dialect identification tasks, the formula in (2) was used.

\[
T = \arcsin \left( \sqrt{\frac{X}{N+1}} \right) + \arcsin \left( \sqrt{\frac{X+1}{N+1}} \right)
\]

In this formula, \(X\) is the number of samples observed to be correct and \(N\) is the total number of cases.

\subsection{5.1.3 z score transformation}

The data from the familiarity judgments (described in Section 5.5) have values ranging from 0 to approximately 18. These values are in inches, as the participants were asked to rate their familiarity of the stimuli by drawing a line that represented their level of familiarity with that word. Therefore, very familiar words have lines that are much longer than words that are rare. Each participant had their own way of determining how long the lines would be, and the maximum length of the lines. So, in order to be able to compare the responses across participants, their responses were transformed into z scores.
A z score for a given item represents how far and in what direction that value deviates from its distribution’s mean. The mean for that item will be zero, with a standard deviation of one. The overall distribution will still be maintained, with values above the mean having a positive z score, and values below the mean having a negative z score. Thus, the mean for each participant was calculated, along with the standard deviation for that participant’s responses. The z score for each judgment was then calculated using the formula in (3).

\[
(3) \quad z = \frac{\text{value} - \text{mean}}{\text{standard deviation}}
\]

For the familiarity judgments (measured in inches), the z scores were calculated in Excel, where the data were organized in a spreadsheet with each column representing a word and each row representing a participant. The average and standard deviation across a row for a given speaker were calculated using the AVERAGE and STDEV formulas in Excel. Then, the average for a speaker was subtracted from the familiarity judgment value (in inches) in each cell for that speaker, and then divided by the standard deviation for that speaker. This was done for all speakers for all words.

5.2 Naming Task

This task is a type of reaction time experiment, where the participants are not asked to choose between two responses, or to choose when to respond. Instead, they are told to respond (by repeating) to every stimulus item. Both mean and median reaction time values were computed from the results using E-Prime’s E-Data program. We
decided to use the median reaction time values rather than the mean reaction time values because the standard deviations of the mean reaction time values were typically greater than 10%. The median reaction time results for the naming task for each speaker dialect and listener dialect, averaged across the responses of all of the participants, are as follows: Mexican speaker = 1113 ms; Puerto Rican speaker = 1131 ms; Mexican listener = 1113 ms; Puerto Rican listener = 1128 ms. The median reaction time results for the naming task for speaker dialect by listener dialect are given in the following chart (Figure 5.1). These results will be analyzed statistically in the following sections.

<table>
<thead>
<tr>
<th></th>
<th>Mexican Speaker</th>
<th>Puerto Rican Speaker</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mexican Listener</strong></td>
<td>1101.50 ms</td>
<td>1119.00 ms</td>
</tr>
<tr>
<td><strong>Puerto Rican Listener</strong></td>
<td>1122.00 ms</td>
<td>1147.00 ms</td>
</tr>
</tbody>
</table>

Figure 5.1. Median reaction time results by speaker and listener dialect, presented in ms.

5.2.1 Phonological variable

Using SPSS software, we conducted a repeated-measures analysis of variance (ANOVA) on the reaction time data, with the two factors “phonological variable” (word-final /n/, syllable-final /r/, and syllable-final /s/) and “speaker dialect” (Mexican or Puerto Rican). One significant main effect was found from the results. There was a significant main effect of phonological variable \[F (2, 2) = 37.387; \ p < .05\]. The stimuli containing a syllable-final /r/ resulted in the shortest reaction times, while the stimuli containing
syllable-final /s/ resulted in the longest reaction times. This main effect is presented in Figure 5.2.

Figure 5.2. Main effect for phonological variable.

### 5.2.2 Phonological variable and listener gender

We also found several significant interactions. The first significant interaction is between phonological variable and listener gender [F (2, 2) = 54.40; p < .05]. The male listeners responded more quickly than the female listeners did to stimuli containing syllable-final /r/ and syllable-final /s/, while the female listeners responded more quickly than the male listeners did to stimuli containing word-final /n/. Figure 5.3 illustrates the significant interaction between listener gender and phonological variable. There was no overall significant effect for listener gender, although the females tended to respond more slowly than the males did. This is illustrated in Appendix D.
5.2.3 Speaker dialect and phonological variable

The second significant interaction that we found is between speaker dialect and phonological variable [F (2, 2) = 19.124; p = .05]. The participants responded more quickly to Mexican input than to Puerto Rican input containing the variables word-final /n/ and syllable-final /r/. The participants responded more quickly to Puerto Rican input than to Mexican input containing the variable syllable-final /s/. This significant interaction is illustrated in Figure 5.4.
5.2.4 Speaker dialect, listener dialect, and phonological variable

Another significant interaction that we found was between speaker dialect, listener dialect, and phonological variable \( F(2, 2) = 22.936; p < .05 \). The Puerto Rican listeners responded more quickly to Mexican input containing the word-final /n/ than they did to Puerto Rican input containing word-final /n/. The Mexican listeners responded as quickly to Mexican input as they did to Puerto Rican input containing word-final /n/. This interaction for the phonological variable /n/ is shown in Figure 5.5.

Figure 5.4. Significant interaction between speaker dialect and phonological variable.
Figure 5.5. Significant interaction between speaker dialect, listener dialect, and phonological variable, shown here for phonological variable /n/.

For input containing coda /r/, the Puerto Rican listeners responded much more quickly to input produced by Puerto Ricans than did to input produced by Mexican speakers. The Mexican listeners responded slighter more quickly to input produced by Mexican speakers than to input produced by Puerto Rican speakers. This interaction is shown in Figure 5.6.
Overall, both groups of listeners responded much more quickly to input containing coda /s/ produced by Puerto Ricans than they did to the same input produced by Mexican speakers. This interaction is shown in Figure 5.7.
Figure 5.7. Significant interaction between speaker dialect, listener dialect, and phonological variable, shown here for phonological variable /s/.

5.2.5 Speaker dialect, phonological variable, and listener gender

The fourth significant interaction for the naming task data is between speaker dialect, phonological variable, and listener gender \( F (2, 2) = 148.70; p < .01 \). The female participants were much faster than the males at responding to stimuli containing word-final /n/, regardless of speaker dialect. However, the males responded more slowly to input containing word-final /n/ produced by Puerto Rican speakers than to input containing word-final /n/ produced by Mexican speakers. This interaction for stimuli containing word-final /n/ is shown in Figure 5.8.
Almost the opposite is true for stimuli containing coda /ɾ/. The males, regardless of the dialect of the speakers, were faster than females at responding to stimuli containing coda /ɾ/. The females, on the other hand, were much slower at responding to stimuli containing coda /ɾ/ that were produced by Puerto Rican speakers than that same stimuli produced by Mexican speakers. This is shown in Figure 5.9.
Figure 5.9. Significant interaction between speaker dialect, listener gender, and phonological variable, shown here for phonological variable /r/.

For stimuli containing coda /s/, both males and females responded more quickly to input produced by Puerto Rican speakers than to input produced by Mexican speakers. Overall, the males responded more quickly than the females did to the stimuli containing coda /s/. This interaction between speaker dialect, listener gender, and phonological variable is shown in Figure 5.10.
Figure 5.10. Significant interaction between speaker dialect, listener gender, and phonological variable, shown here for phonological variable /s/.

5.2.6 Summary of naming results

The results from the naming task show that overall, listeners were slower to respond to stimuli containing coda /s/ than to stimuli containing word-final /n/ and coda /r/. Female listeners were slower at responding to stimuli containing coda /s/ and coda /r/ than the male listeners were, but were faster than males at responding to stimuli containing word-final /n/. Puerto Rican listeners responded more quickly to input containing word-final /n/ when it was produced by Mexican speakers than when it was produced by Puerto Rican speakers. However, when they heard stimulus items containing coda /r/, they responded more quickly to their own dialect than to the Mexican dialect. Also, overall both males and females responded more quickly to input containing coda /s/ when it was produced by Puerto Rican speakers than when it was produced by Mexican speakers. The female participants, however, responded more slowly to input containing
coda /r/ when it was produced by Puerto Ricans compared to that same input produced by Mexicans. These results will be discussed and modeled in Chapter 6.

5.3 Lexical decision task

This task is a choice reaction time experiment that requires participants to choose between two possible responses as quickly as possible. Therefore, in the lexical decision task, both the reaction time and the response were recorded for each participant. The reaction time data represent a measure of perceptual processing difficulty, while the accuracy responses are meant to determine whether the variation in the input affects the perceptual processing of stored exemplars in the lexicon. The results of both the reaction time and accuracy data will be discussed below.

5.3.1 Reaction time data

In this task, unlike in the naming task, it is assumed that listeners must listen to all of each stimulus word before being able to initiate the response of word or not a word in Spanish. Because the reaction time is measured at the onset of the stimulus word, rather than the offset of that word, the reaction time data in this task were adjusted for input duration. There is some variation in word duration across speakers, which indicates slightly varying speaking rates, as can be seen in the following figure, where the average word duration for all words for each speaker is given. The speakers with the two fastest speaking rates are circled in the figure.
In order to account for this variability in word duration across speakers, the duration of each stimulus item was subtracted from the reaction time to that word, resulting in a reaction time that takes duration variability into account, where the reaction time is from the word offset. The median reaction time results for the lexical decision task for each speaker dialect and listener dialect, averaged across the responses of all of the participants, are as follows: Mexican speaker = 268.9 ms; Puerto Rican speaker = 270.1 ms; Mexican listener = 266.5 ms; Puerto Rican listener = 274.1 ms. The average median reaction time results for the naming task for speaker dialect by listener dialect are given in Figure 5.12.

Figure 5.11. Average word duration (ms) by speaker.
As can be seen in the preceding figure, there was a tendency for the Mexican listeners to respond more quickly to input produced by Mexican speakers, as compared to input produced by Puerto Rican speakers. The opposite was true for the Puerto Rican listeners; they responded more quickly to input produced by Puerto Rican speakers than they did to input produced by Mexican speakers.

In order to determine whether there was an effect for phonological variable on the reaction time of the listeners, a repeated measures analysis of variance was conducted using SPSS software (version 12.0). We found a significant main effect for phonological variable \( F = (2, 2) = 36.64; p < 0.05 \). The stimulus items containing coda /s/ resulted in slower reaction times compared to those items containing word-final /n/ and coda /ɾ/. Overall, those items containing coda /ɾ/ resulted in the fastest reaction times. This effect of phonological variable is shown below in Figure 5.13.

<table>
<thead>
<tr>
<th></th>
<th>Mexican Speaker</th>
<th>Puerto Rican Speaker</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mexican Listener</td>
<td>251.697</td>
<td>281.284</td>
</tr>
<tr>
<td>Puerto Rican Listener</td>
<td>295.546</td>
<td>252.481</td>
</tr>
</tbody>
</table>

Figure 5.12. Average median reaction time by speaker and listener dialect.
There was no significant effect for listener age or listener gender. The analysis of variance showed that there were no significant interactions between any of the factors, although there were some trends that can be found between some of the factors. These trends are displayed in Appendix E.

5.3.2 Accuracy Data

Mean responses by speaker dialect for word and nonword stimuli for the lexical decision task, representing proportion correct, are given for each listener in the following figures. The first figure (5.14) has the responses for the Puerto Rican listeners, while the second figure (5.15) has the responses for the Mexican listeners. In both figures, the white columns contain the mean accuracy scores while the shaded boxes contain the d’ values for those scores (see Section 5.1.1). The final row in each figure contains the average values for all listeners.
<table>
<thead>
<tr>
<th>Part.</th>
<th>mean</th>
<th>d'</th>
<th>mean</th>
<th>d'</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>0.89</td>
<td>0.75</td>
<td>0.86</td>
<td>2.32</td>
</tr>
<tr>
<td>101</td>
<td>0.91</td>
<td>1.46</td>
<td>0.83</td>
<td>1.72</td>
</tr>
<tr>
<td>102</td>
<td>0.83</td>
<td>1.03</td>
<td>1.00</td>
<td>2.00</td>
</tr>
<tr>
<td>103</td>
<td>0.97</td>
<td>1.49</td>
<td>0.79</td>
<td>1.80</td>
</tr>
<tr>
<td>104</td>
<td>0.78</td>
<td>0.50</td>
<td>0.86</td>
<td>2.32</td>
</tr>
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<td>105</td>
<td>0.89</td>
<td>0.75</td>
<td>0.92</td>
<td>2.84</td>
</tr>
<tr>
<td>106</td>
<td>0.89</td>
<td>1.46</td>
<td>0.67</td>
<td>0.89</td>
</tr>
<tr>
<td>107</td>
<td>0.83</td>
<td>1.33</td>
<td>0.94</td>
<td>3.20</td>
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<tr>
<td>108</td>
<td>0.94</td>
<td>0.87</td>
<td>0.79</td>
<td>1.80</td>
</tr>
<tr>
<td>109</td>
<td>0.92</td>
<td>0.81</td>
<td>0.91</td>
<td>2.35</td>
</tr>
<tr>
<td>110</td>
<td>0.89</td>
<td>0.75</td>
<td>0.92</td>
<td>2.77</td>
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<td>111</td>
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<td>0.78</td>
<td>1.59</td>
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<tr>
<td>112</td>
<td>0.69</td>
<td>1.02</td>
<td>0.80</td>
<td>1.15</td>
</tr>
<tr>
<td>AVG</td>
<td>0.86</td>
<td>0.98</td>
<td>0.85</td>
<td>2.06</td>
</tr>
</tbody>
</table>

Figure 5.14. Mean accuracy and d’ responses by speaker dialect for the PR listeners.
<table>
<thead>
<tr>
<th>Part.</th>
<th>Mexican Speaker mean</th>
<th>d'</th>
<th>Puerto Rican Speaker mean</th>
<th>d'</th>
</tr>
</thead>
<tbody>
<tr>
<td>200</td>
<td>0.86</td>
<td>1.40</td>
<td>0.89</td>
<td>2.41</td>
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<tr>
<td>201</td>
<td>0.86</td>
<td>0.69</td>
<td>0.67</td>
<td>0.84</td>
</tr>
<tr>
<td>202</td>
<td>0.83</td>
<td>0.62</td>
<td>0.89</td>
<td>2.52</td>
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<tr>
<td>203</td>
<td>0.85</td>
<td>0.99</td>
<td>0.92</td>
<td>2.77</td>
</tr>
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<td>204</td>
<td>0.92</td>
<td>0.81</td>
<td>0.89</td>
<td>2.35</td>
</tr>
<tr>
<td>205</td>
<td>0.86</td>
<td>1.40</td>
<td>0.92</td>
<td>2.84</td>
</tr>
<tr>
<td>206</td>
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<td>1.40</td>
<td>0.83</td>
<td>2.23</td>
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<tr>
<td>208</td>
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<td>0.78</td>
<td>0.79</td>
<td>1.65</td>
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<tr>
<td>209</td>
<td>0.94</td>
<td>1.49</td>
<td>0.89</td>
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<td>210</td>
<td>0.83</td>
<td>0.62</td>
<td>0.91</td>
<td>1.88</td>
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<td>0.69</td>
<td>0.78</td>
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<td>0.72</td>
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</tr>
<tr>
<td>AVG</td>
<td>0.87</td>
<td>0.98</td>
<td>0.85</td>
<td>1.96</td>
</tr>
</tbody>
</table>

Figure 5.15. Mean accuracy and d’ responses by speaker dialect for the Mexican listeners.

From the mean data presented in these figures we can see that the Puerto Rican and Mexican listeners seemed to do equally well at this task, regardless of the dialect of the speaker. However, when we take into account the number of times they pushed ‘word’ when it was actually not a word, we can see that there is a difference in response
accuracy depending on the dialect of the speaker. This is shown in the difference in the average $d'$ values for listener and speaker groups. Both Puerto Rican and Mexican listeners tended to respond ‘word’ to Mexican stimuli, as can be seen by the low $d'$ value for Mexican speakers. The reverse is true for Puerto Rican stimuli, as evidenced by the higher $d'$ value for Puerto Rican speakers.

To determine if this difference was significant, we used SPSS software (version 12.0) to conduct a repeated-measures analysis of variance (ANOVA) on the accuracy data, with the factor “speaker dialect” (Mexican or Puerto Rican). These results contain the responses to both the words and the nonwords. One significant main effect was found from the results. There was a significant main effect of speaker dialect [$F (1, 3) = 14.813; p < 0.05$]. Regardless of the dialect of the listener, the participants were most accurate overall at responding to input produced by Puerto Rican speakers. This effect is shown below, and will be discussed in the following section.

![Figure 5.16. Overall accuracy by speaker dialect for words and nonwords.](image-url)
The results are presented as d’ scores in order to eliminate any bias in response. However, when we look at the number of hits (correct responses to words) and the number of false alarms (incorrect responses to words) individually, we see that both Mexican and Puerto Rican listeners responded correctly to words more often when those words were produced by Mexican speakers. Both Mexican and Puerto Rican listeners had an overall bias to push ‘word’ when they heard nonwords produced by Mexican speakers as compared to nonword stimuli produced by Puerto Rican speakers. These differences are shown below, with the average proportion of hits in Figure 5.17, and the average proportion of false alarms in Figure 5.18.

![Figure 5.17. Proportion of hits for speaker dialect by listener dialect.](chart.png)
Interestingly, there were no significant effects for phonological variable, listener age, listener dialect, or listener gender. The listeners responded with the same degree of accuracy regardless of whether the stimulus word contained a word-final /n/, a coda /t/, or a coda /s/. The age and gender of the listeners did not affect their accuracy at the lexical decision task, nor did their native dialect. Figures illustrating these results are in Appendix E.

5.3.3 Summary of lexical decision results

The reaction time results from the lexical decision task show that the stimulus items containing coda /s/ were most difficult to process perceptually for listeners overall, while the items containing word-final /n/ were the least difficult to process perceptually for listeners in general. There was also a trend, although not significant, for Mexican listeners to respond more quickly to words produced by Mexican speakers than to words
produced by Puerto Rican speakers, and for Puerto Rican listeners to respond more quickly to words produced by Puerto Rican speakers than to those produced by Mexican speakers.

The accuracy results for this task show that all listeners were more accurate at responding to words produced by Mexican speakers than to words produced by Puerto Rican speakers. However, when false alarms (incorrect responses to nonwords) were taken into consideration, the listeners responded more accurately overall to Puerto Rican speakers. This is because when the listeners heard a word produced by a Mexican speaker, they were more likely to respond that it was a word, even when it actually was not. This bias to respond to Mexican stimuli as words, and therefore to respond incorrectly when the stimulus items were nonwords, is reflected in the d’ scores.

5.4 Identification task

Mean responses (proportion correct) by speaker dialect and phonological variable for the identification task are given for each listener in the following figures. Figure 5.19 contains the mean responses for the Puerto Rican listeners, while Figure 5.20 contains the mean responses for the Mexican listeners. In both figures, the white columns contain the mean accuracy scores as proportion correct, while the shaded columns contain the rationalized arcsine transformed values for the mean accuracy scores. For an explanation of the rationalized arcsine transform, see Section 5.1.2. Also, the final row in each figure contains the average for all speakers for that speaker dialect and phonological variable.
Figure 5.19. Mean accuracy responses by speaker dialect and phonological variable for the Puerto Rican listeners.
As can be seen from the data presented in the figures above, overall the Puerto Rican listeners were more accurate when responding to Puerto Rican input. The Mexican listeners were more accurate when responding to Mexican input, regardless of phonological variable. These results will be analyzed in the following sections.
5.4.1 Phonological variable

Using SPSS software (version 12.0), we conducted a repeated-measures analysis of variance (ANOVA) on the accuracy data, with the two factors “phonological variable” (word-final /n/, coda /r/, and coda /s/) and “speaker dialect” (Mexican or Puerto Rican). One significant main effect was found from the results. There was a significant main effect of phonological variable [F (2, 28) = 3.528; p = 0.0]. Regardless of speaker and listener dialect, the participants were most accurate at identifying a speaker’s dialect when the stimuli contained a coda /s/. They were least accurate at identifying a speaker’s dialect when the stimuli contained a coda /r/. This main effect of phonological variable tells us what variables are most salient across dialects, and will be discussed in more detail later. The main effect for phonological variable is shown in Figure 5.21.

![Figure 5.21. Main effect for phonological variable.](image-url)
5.4.2 Speaker and listener dialects

Several significant interactions were also found. The first significant interaction that we found was an interaction between speaker dialect and listener dialect \([F (1, 29) = 32.049; p = 0.0]\). The Mexican listeners were nearly 90% accurate at identifying their own dialect, but only about 57% accurate at identifying Puerto Rican input as not being Mexican. The Puerto Rican listeners were almost 70% accurate at identifying their own dialect, but only about 32% accurate at identifying Mexican input as being not Puerto Rican. This difference in accuracy among Mexican and Puerto Rican listeners can be explained by their amount of exposure to the variable input in the stimuli, and will be discussed in a later section. This interaction between speaker and listener dialect is shown in Figure 5.22 below.

Figure 5.22. Significant interaction between listener dialect and speaker dialect for proportion correct.
5.4.3 Listener dialect and phonological variable

The second significant interaction that we found for the dialect identification task was an interaction between listener dialect and phonological variable [F (2, 28) = 15.426; p = 0.0]. For input containing the phonological variable word-final /n/, there was no real difference for the Mexican and Puerto Rican listeners. However, for input containing coda /r/, the Mexican listeners were considerably more accurate than the Puerto Rican listeners. The Puerto Rican listeners identified some of the stimuli produced by Mexicans as being produced by Puerto Ricans, and vice-versa. The same is true to a lesser extent for stimuli containing coda /s/. The Mexican listeners were over 80% accurate at identifying their own dialect when the stimuli contained coda /s/, while the Puerto Ricans were only about 50% accurate. The reason for this difference will be discussed in a later section, and can be attributed to the amount of experience with variable input in the two dialects. The interaction between listener dialect and variable is shown below.

![Graph showing the significant interaction for phonological variable by listener dialect.](image)

Figure 5.23. Significant interaction for phonological variable by listener dialect.
5.4.4 Speaker dialect and phonological variable

The final significant interaction for the dialect identification results is the interaction between speaker dialect and phonological variable \[F (2, 28) = 13.320; p = 0.0\]. When the listeners heard stimuli containing word-final /n/, they were slightly more accurate at identifying the dialect of the speaker when the speaker was Mexican. When the stimuli contained coda /r/, the listeners were more accurate at identifying the speaker dialect when the speaker was Mexican. However, when the stimuli contained coda /s/, the listeners were more accurate at identifying the dialect when the speaker was Puerto Rican, with an accuracy rate of almost 80%, compared to 55% for the same stimuli produced by Mexican speakers. This interaction is shown in Figure 5.24 below.

Figure 5.24. Significant interaction for phonological variable by speaker dialect for proportion correct.
5.4.5 Summary of identification results

The identification results show that overall, listeners were most accurate at identifying the dialect of the speaker when the stimulus item contained a coda /s/, and least accurate when the item contained a coda /ɾ/. For the Puerto Rican listeners, they were most accurate at identifying the native dialect of the speaker when the input contained a word-final /n/, while the Mexican listeners were most accurate when the input contained a coda /s/. For the Mexican listeners, the aspirated or deleted coda /s/ was a clear marker that the speaker was not a speaker of their dialect of Spanish. However, the Puerto Rican speakers had more difficulty with that variable, and with coda /ɾ/, since they both have variable realizations in Puerto Rican Spanish (i.e. they can also be produced as they are in Mexican Spanish). Overall, the Puerto Rican participants were more accurate at identifying their own dialect than at identifying Mexican Spanish, and the reverse was true for the Mexican participants. These results will be discussed in more detail in Chapter 6.

5.5 Familiarity judgment questionnaire

In order to determine if the words in the stimulus set were all familiar words in Spanish, eleven native speakers of Spanish were asked to complete a familiarity judgment questionnaire. These eleven participants did not participate in the previous experiments. They were from several countries, including Spain, Puerto Rico, Peru, and Mexico. In traditional familiarity judgment studies, participants are asked to rate the familiarity of a word using a numerical scale. However, the use of numbers creates bias
in the responses, where most participants tend to use the same numbers repeatedly, and typically do not use the entire range of numbers given to them in the scale.

In order to avoid this bias, a magnitude estimation test was used (cf. Bard et al. 1996). The magnitude estimation test is a technique that was originally used in psychophysics, but is gaining popularity in linguistics. This test allows participants to make fine-grained judgments, and has been found to be sensitive to a number of linguistic phenomena, including grammaticality (cf. Keller and Alexopolou 2001). For this study, participants were given a list containing the stimuli from the experiments described earlier. They were instructed to draw a line to indicate their familiarity with the word. The longer the line, the more familiar the word is, while the shorter the line, the more unfamiliar the word is. They were told that there is no maximum or minimum length for the lines. The lines were then measured in inches using a ruler.

In order to standardize the results, a z score transformation was performed using Excel (see Section 5.1.3). The results for each participant are given in Appendix F. The results for all of the speakers are shown in Figure 5.25 below. The words are numbered for identification, and in the cases of the outliers the words are labeled. See Appendix F for the list containing the rated familiarity data and the words.
The results for all participants show that for the most part, all of the words are of equal familiarity. However, four words are less familiar than the rest of the words. Those words are tanza ‘fishing line’, vero ‘skin from a European Pine Marten (animal)’, pellón ‘part of a saddle’, and lustra ‘polish’. The first two, tanza and vero, are filler words that are non-variable in these dialects. The remaining words, pellón and lustra, are test words that were used in the experiments. Since these two words could be unknown to some of the participants, their reaction time and accuracy results were compared to the results of the other test words.

The accuracy results for the lexical decision task show that there was an effect for level of familiarity on whether the participants responded that they heard a word or a
nonword. The least familiar words out of the test word set, *pellón* and *lustra*, were the real words judged to be nonwords by the most participants. To see if this is dependent on the dialect of the listener, the dialect and accuracy results were compared. The result of this comparison is given in Figure 5.26 below.

![Figure 5.26. Lexical decision accuracy by listener dialect.](image)

As can be seen in the figure above, both Mexican and Puerto Rican participants judged *pellón* to be a nonword more than any other real word. Following *pellón* is the word *lustra*, which was judged to be a nonword more than most other real words by Puerto Rican speakers. Interestingly, the Mexican participants did not have a difficult
time with this word, even though it was judged to be unfamiliar by the majority of participants in the familiarity judgment questionnaire.

5.6 Summary

The findings presented in this chapter suggest that there is a connection between a speaker’s native dialect and speech perception. There is also reason to believe that not all sounds should be treated equally within a speaker’s sound system. Both Mexican and Puerto Rican listeners had a difficult time (i.e. longer reaction times) with words containing syllable-final /s/. Also, there is evidence that suggests that the gender of a listener interacts with the speaker’s dialect and the phonological variable that the stimulus item contains. These findings will be discussed and modeled in Chapter 6.
CHAPTER 6

DISCUSSION

6.1 Introduction

The research described in this dissertation examined the perception and perceptual processing of two dialects of American Spanish using three experimental methodologies: speeded naming, lexical decision, and identification. The participants’ performance on the speeded naming task suggests that a listener’s native dialect and their amount of exposure to other dialects have an effect on their ability to perceive variable input, and that the phonological variables that vary across dialects affect listeners at different rates.

The listeners’ performance on the lexical decision task also suggests that not all phonological variables should be considered as equal factors in the perception of variable input, as the listeners responded most slowly to stimulus items containing coda /s/ and most quickly to those items containing coda /r/ for both the naming and lexical decision tasks. This finding suggests that there was a delay in the processing of items containing coda /s/ for Mexican listeners because they are not accustomed to variation in the production of coda /s/. The Puerto Rican listeners most likely had delayed processing for items containing coda /s/ precisely because of the amount of variation available in the
pronunciation of coda /s/ in Puerto Rican Spanish. Processing input that is variable, such as items containing coda /s/, will delay processing because listeners will get activation in the lexicon’s phonological grammar of all three variants of this variable, among other items. This will be discussed in more detail in the following sections.

The results from the lexical decision task also suggest that both Mexican and Puerto Rican Spanish listeners were more likely to respond positively (i.e. ‘word’) when the input was Mexican, but that overall they were most accurate at responding to Puerto Rican input. The bias to respond ‘word’ to both words and nonwords produced by Mexican speakers suggests that both groups of listeners consider Mexican Spanish to be more word-like than Puerto Rican Spanish, perhaps due to the variation in the input or stereotypes that speakers have toward ‘consonant-weakening’ dialects. It has been shown that listeners’ stereotypes affect their processing of input (cf. Strand 1999, 2000).

The listeners’ performance on the identification task showed marked differences for the two groups of listeners. The Mexican listeners were very good at identifying their own dialect (almost 90% accurate), while the Puerto Rican listeners were not quite as good at identifying their own dialect (almost 70% accurate). The results suggest that the Puerto Rican listeners were labeling the Mexican input as being Puerto Rican, which is expected since they are exposed to Mexican and Mexican-like Spanish on a daily basis (e.g. television, radio, formal addresses) and because Mexican-like Spanish is spoken in Puerto Rico by Puerto Ricans, though not typically in colloquial speech. Mexican-like Spanish refers to Spanish that is consonant preserving. In other words, Puerto Ricans are accustomed to variable pronunciation of syllable-final /s/, where the sibilant is retained in formal situations. They are also accustomed to syllable-final /r/ that is not lateralized, as
this variant is also used in certain styles of Puerto Rican Spanish. Orthography, which very closely reflects the Mexican pronunciation of the phonological variables discussed here, is also a possible reinforcement for both the Mexican and Puerto Rican participants. This experience with variable input will be discussed further in the upcoming section on exemplar-based models of speech perception.

The results from the identification task mirror those found for the other two tasks in that the pattern of phonological variables is identical in all three tasks. In this task, the dialect of the speakers producing words containing coda /s/ was most accurately identified, while those words containing coda /ɾ/ resulted in the lowest accuracy scores for the identification of the speaker’s dialect. This is also expected because lateralization of coda /ɾ/ is a variable phenomenon in Puerto Rican Spanish, so Puerto Rican listeners are accustomed to hearing both realizations of coda /ɾ/ (i.e. [ɾ] and [l]). In all dialects of Spanish, both laterals and rhotics are found syllable-finally, so the lateralized pronunciation of syllable-final /ɾ/ is not a new sound or sound pattern for the Mexican Spanish speakers. Also, it follows that words containing coda /s/ would have the highest accuracy level, as the variable realizations of coda /s/ in Puerto Rico are not found in this dialect of Mexican Spanish. In other words, speakers of this dialect of Mexican Spanish are not accustomed to hearing speech containing aspirated or deleted /s/, whereas the speakers of this dialect of Puerto Rican Spanish are accustomed to variation in the realization of /s/. The saliency of this variable as a dialect marker for both groups of participants will be discussed and modeled in Section 6.3.

As mentioned above, in all three tasks phonological variable had a significant effect on the listeners’ performance. There were also interactions between speaker dialect
and listener dialect for the naming task and the identification task. The gender of the
listener interacted with both phonological variable and speaker dialect for the naming
task, as did the listener’s age. These significant interactions, taken together with the
results presented above, have implications for sociolinguistics and dialectology, and
phonology. The findings also have implications for modeling perceptual processing and
production, and will be discussed with relation to Exemplar Theory in the following
sections.

6.2 Theoretical implications

6.2.1 Implications for dialectology and sociolinguistics

The findings of the current studies have implications for dialectology, particularly
the findings related to the effect of phonological variable and the interactions between
phonological variable and extralinguistic factors. One issue for or goal of dialectologists
has always been the classification of dialects. While there has been an abundance of
research done on dialectal characteristics of Spanish, both in Latin America and in Spain,
there is still the need for a classification system for these dialects. Many researchers,
starting with Henríquez Ureña in 1921, have attempted to define dialect boundaries in
Latin America and in Spain. These systems have been based on geographical, historical,
phonetic/phonological, and lexical features, but not one has been able to adequately
classify the dialects of Spanish. The saliency of a given feature or set of features was
generally not taken into account. In the cases where it was taken into account, the
saliency level was generally based on non-perceptual tests, such as classification tasks or
attitudinal studies (cf. Clopper 2004).
However, the results presented in this dissertation from both the naming task and the lexical decision task are alike in suggesting that input containing coda /s/ is more difficult to process than input containing coda /t/ and word-final /n/. The stimuli items containing syllable-final /s/ resulted in the slowest reaction times in the naming task and the lexical decision task. These findings, paired with the results of the identification task, suggest that the realization of syllable-final /s/ should be given more weight than the realization of word-final /n/ and syllable-final /t/ when classifying dialects of Spanish. In the identification task, the participants were much more accurate at labeling the dialect of the speakers when the stimulus item contained a coda /s/ than when it contained a word-final /n/ or coda /t/. These results suggest that syllable-final /s/ contains a great deal of information that is used by listeners to classify and identify speakers by dialect. Dialectologists can use results such as these to help determine the most salient dialect features for a given listener and speaker group. The findings of speech perception studies can be very useful in identifying and classifying dialects, as suggested by Thomas (2002) and as discussed above.

Within the fields of sociolinguistics and variation studies, gender has been found to interact with dialect in a number of ways (cf. Labov 1990). In general, women tend to be more advanced in terms of exhibiting phonological change than men do. Thus, women’s speech tends to exhibit some variables more than men’s speech, particularly when these variables are undergoing phonological change. Also, women traditionally avoid stigmatized forms, so that those variables that are considered to be stigmatized within a given dialect will occur more often in men’s speech than in women’s. This is the case for lateralization of coda /t/ in Puerto Rican Spanish, where it has been found that
women use the non-stigmatized form [ɾ] more often than men do (cf. Figueroa and Hislope 1999).

While most research thus far has focused on the relationship between production and gender, the findings of the speeded naming task seem to show that there is also a link between perception and gender. The female participants responded more slowly to input containing coda /ɾ/ and coda /s/ than did the male participants. The females responded more quickly than the males to input containing word-final /n/. Following Figueroa and Hislope’s (1999) findings on Puerto Rican Spanish speakers, females produce fewer stigmatized forms than males do, so it could be that they have more problems perceiving these stigmatized forms than males do, since males have more experience with them (in production). In terms of Exemplar Theory, the stigmatized forms (lateralized coda /ɾ/ and aspirated or deleted coda /s/) have a lower activation level for females than for males, which would cause a perceptual processing delay for the females, but not for the males. The females responded more quickly than the males to the form that is not stigmatized in their dialect (word-final velar nasals).

The results of the present study also support the notion that native dialect or dialect familiarity affects speech perception. Clopper (2004) found that listeners were more attuned to features in their native dialect than they were to features in other dialects. In the present identification study, listeners were much more accurate at determining the dialect of the speaker when responding to input produced by a speaker of their own dialect. Listeners were more accurate at determining when a speaker belongs to their own dialect group than they were at determining when a speaker does not belong to their dialect group. This is most likely due to the fact that some of the variables could be found
in both dialects, and those speakers did not get enough cues from the input to determine that the speaker was not from the same dialect as the listener. If the stimulus items were phrases rather than single words, the listeners would have been more accurate at this task, since there would be more cues available (such as intonation).

6.2.2 Implications for phonology

Research on the perception and processing of variable input also has implications for the field of theoretical linguistics, including phonology. Phonologists have typically assumed a one-to-one mapping between abstract phonological forms in the lexicon and phonetic outputs in production. However, the research reported in this dissertation suggests that phonological variation (both within and across dialects) is a property of speech perception and production, and that phonological systems must be able to account for these aspects of human language.

Traditional phonology accounts are typically not able to take this variation into account. Those accounts generally require that all variable information be stripped away from the input, leaving allophony as the only form of variation. If this were the case, we would not expect to find a difference in perceptual processing time for input produced by Mexican speakers and input produced by Puerto Rican speakers, as the underlying forms for both sets of input would be the same regardless of the speaker dialect. We would also not expect to find a difference in perceptual processing time or accuracy across phonological variables, as they each have an ‘underlying’ form that is being accessed in processing. In traditional phonology accounts, such as Optimality Theory (OT), variation is accounted for by a reordering of constraints in the lexicon. These constraints impose
restrictions on how the underlying form, or input, can be realized in a given language or dialect. Accounts such as OT do not allow for interactions between extra-linguistic factors and linguistic factors in the selection and production of speech. The findings presented in this dissertation do include effects for phonological variable, as well as interactions between speaker and listener dialects. Thus, we will need to turn to a different type of account in order to explain the results of these studies.

The model that will be used to account for the current findings is Exemplar Theory, a type of usage-based model (cf. Johnson 1997, Bybee 2001, Beckman et al. in press). Exemplar models are well suited to account for experience-based phenomena. Originally, proponents of exemplar-based models argued that there was no need for underlying or abstract speech segments (cf. Goldinger 1998). However, research over the last decade has shown that there is a need for both abstract units and stimulus-specific exemplars in a model of speech perception and production. Luce and Lyons (1998) provide evidence for both abstract and specific units at the lexical level, based on results of their priming experiments. Berent, Marcus, Shimron, & Gafos (2002) argue that both abstract and specific units must exist at the phonological level, since speakers are able to generalize to novel stimuli, stimuli which fall outside of their range of linguistic experience. For instance, native speakers of a language are able to judge the acceptability of nonwords in their native language, based on the sound patterns and sound generalizations that they have at both the abstract and specific (exemplar) levels.

Another proponent of a model that contains both abstract and exemplar-specific representations is Pierrehumbert (2001, 2002, 2003). She argues for the need for an abstract level in order to account for notions such as systematic phonological processes
that occur in human languages such as phonotactic regularities and allophonic variation. She proposes an exemplar level to account for lexical frequency effects and phonological shifts. Her model has three levels: a lexical level, a phonological level, and a phonetic level. A version of her model, which was revised to account for dialectal variation, was proposed by Clopper (2004). Clopper’s model includes talker representations, dialect representations, and social representations. Clopper’s model is given in Figure 2.5 in Chapter 2. Her model will be compared and contrasted with the model presented in Section 6.3 below.

However, there seems to be some confusion in the literature as to what the abstractions are. It is unclear whether they are generalizations over the stored exemplars that serve to illustrate the patterns found in a language, or are even more abstract units, such as phonemes. These issues will be discussed in the following section, where a revised model of speech perception and production, based on Beckman et al.’s (in press) model is described and presented.

6.3 Exemplar Theory revisited

As described in more detail in Chapter 2, Exemplar Theory allows for detailed acoustic and talker-specific information to be stored in the lexicon and later accessed in production. Thus, there is a direct connection between perception and production, as they are linked in the lexicon. For instance, given the input [ehta], for the Spanish word *esta* ‘this’, the talker and any information previously stored about that talker (i.e. voices and stereotypes) will be activated, as will the word <esta> in the lexicon and the string [ehta] in the phonology. Because [ehta] is a variable pronunciation of the word <esta>, other pronunciations of that word that the listener has stored will also be activated in the
listener’s phonology when that word is activated, such as [esta] and [eta]. Then, when the listener becomes the speaker and utters the word <esta>, he will have these three realizations or exemplars to choose from for the target of their own utterance. The phonology, thus, stores generalizations or patterns over exemplars, which are stored in the lexicon. Their choice will depend on several issues that are both linguistic and extralinguistic, such as who he is talking to (i.e. the listener) and their rate of speech. This perception (red solid line) and production (blue dotted line) loop is shown below in a simplified diagram.

The linguistic information is on the left side of the diagram, while the extralinguistic information is on the right side of the diagram.
In the above figure, the input [esta] for esta ‘this’ activates the talker, the voice category for friend, the talker information for educated and Mexico, as well as the word esta in the lexicon. This input also activates [es.t…, [eh.t…, and [e.t… in the phonology category, as the word esta was activated. Note that [es.t… received the strongest activation, as illustrated by the very thick line. However, when the talker produces the word esta, all three realizations are activated in the phonology, although [eh.t… receives the greatest activation because the talker is speaking with her mother, who is Puerto Rican. We know from sociolinguistic research that talkers use speech as a way of
marking social identity, so this talker uses the more “Puerto Rican” pronunciation when speaking with her mother in order to show closeness and identity.

Figure 6.1 is visibly similar to that proposed by Beckman et al. (in press). In the above figure, there are separate, one-way arrowed lines between categories, which were used to differentiate the perception and production processes. However, to more accurately depict the perception and production loop, the lines would have two-way arrows, where the activation of Puerto Rico would not only activate [eh.t...] but in turn the activation of [eh.t...] would also strengthen the activation of Puerto Rico. This strength of activation is not included in the Beckman et al. (in press) diagram, which is shown in Figure 2.2 in Section 2.1.

The varying activation levels are a crucial aspect of Exemplar Theory, as evidenced by the findings of this dissertation. The results of the identification experiment suggest that listeners find coda /s/ to be a stronger dialect marker than word-final /n/ and coda /ɾ/. Therefore, the activation between Puerto Rico and [eh.t...] would be stronger than the activation between both Puerto Rico and [pol.k...] and Puerto Rico and ...ŋ]. This follows intuitively based on the fact that coda [l] is a sound found in all dialects of Spanish (i.e. pulga ‘flea’), so this sound (voiced alveolar lateral) in that phonological context (i.e. coda) is not as strong a distinguishing marker for dialect as aspiration or deletion of coda /s/ is. The same is true for word-final /n/. Velar nasals occur in all dialects word-finally before other velars due to the process of nasal assimilation. Thus, word-final velar nasals are not as defining a marker for dialect as compared to the realization of coda /s/.
Based on the findings of the identification experiment, *Puerto Rico* would have the strongest activation of [eh.t..., followed by ...ŋ], and then [pol.k.... This again is a simplification, as *Puerto Rico* would also activate the other possible realizations of *esta*, such as [es.t... and [e.t.... The degree of activation for these realizations would depend on such factors as education, gender, and age. In the case of *esta*, [es.t... may be activated by *formal speech*, *educated*, and *older*, while [e.ta... may be activated by *informal speech*, *young*, and *male*. Because of the complex interactions between the various layers or categories of the lexicon, it was necessary to modify Beckman et al.’s diagram. A revised model of Exemplar Theory that is designed to illustrate the activation of and interaction between the stereotype category and the phonological grammar category for the word *costa* ‘coast’ is shown below in Figure 6.2, where the stereotype category is intended to contain such extralinguistic factors as education level, gender, age, and socioeconomic status. It is not intended to contain stereotypes that speakers have toward other speakers, although these may be included solely based on their realization in the speaker’s lexicon.
Figure 6.2. Model of Exemplar Theory for *costa* ‘coast’.

Figure 6.2 is a partial model of exemplar theory, where the interactions between stereotypes and phonological grammar are shown. For simplicity, not all interactions, realizations, or stereotypes are provided in the diagram. The thickness of the lines illustrates the level of interaction between two items, and thus the degree of activation of a given item, where the thick lines represent high levels of interaction and activation, and the thin lines represent low levels of interaction and activation. Because retention of coda /s/ is considered to be a marker of Mexican Spanish, as well as educated Puerto Rican Spanish, there is a high level of interaction between these stereotypes and [/kos.t...] in the phonological grammar. Uneducated speech can be correlated with the realization of coda /s/ as an aspirated segment or a deleted segment, so there is a high level of interaction between those realizations and the stereotype *uneducated*. However, because educated
Speakers also aspirate and delete coda /s/ in certain social contexts, there is an interaction between these realizations and educated, but note that the interaction is not as strong because aspiration and deletion of coda /s/ are not typical markers of educated speech. Finally, aspiration of coda /s/ has a stronger correlation with Puerto Rican Spanish than retention of coda /s/, so the interaction between aspiration and Puerto Rican Spanish is stronger than that for retention of coda /s/. Variability for stereotypes are accounted for in that each listener has specific activations and activation weights between the stereotype category and the other categories.

Once a word is activated by the input, that word in turn activates other items that are associated with that word. For instance, if Ana, a young female from Puerto Rico, utters the word *arte* ‘art’, that word is activated in the lexicon. The lexicon is assumed to be a collection of exemplars, or exemplar-cloud, where all of the items in that cloud are related in some lexical way. A string of input is compared to the exemplars stored in the lexicon. If the input is very similar to an item already stored, then it will be stored as part of that exemplar cloud. If it is fairly different, then it will be stored in its own exemplar space in the lexicon. Linguists working on the computational implementation of exemplar models have proposed formulas to compare the similarity of input to existing exemplars. The activation of the lexical item *arte* then activates representations in the phonological grammar, such as *...r.te* and *...l.te*. It also activates the semantic notion of {arte}. Because the listener has other exemplars of *arte* stored in the lexicon, those voices and stereotypes are also activated. This is illustrated below, in Figure 6.3.

In the model described and illustrated above, both …r.te] and …l.te] are activated in the phonological grammar. The latter is activated because of the input, while the former is activated because of a prior experience, or exemplar, of the word arte. It was produced by a Mexican Spanish speaker, and therefore was realized with a flap rather than a lateral. Both realizations are possible outputs, or pronunciations of arte for the listener. The realization that the listener chooses will be dependant on factors such as who he is talking to, the formality of the speech event, and their education level.

The category ‘semantics’ is included in this model of Exemplar Theory as a way of accounting for lexical differences across dialects. In other words, if a Puerto Rican hears the word pastel, that input will activate the notion of a plantain and meat dish. It will not activate ‘cake’ because in Puerto Rican Spanish, pastel is not used for ‘cake’.
However, if a Mexican Spanish speaker hears the word *pastel*, the notion of ‘cake’ will be activated, and ‘plantain and meat dish’ will not be activated. This is shown in the following figure, where the solid lines represent the activation by a Puerto Rican listener, and the dotted lines represent the activation by a Mexican listener. Note that only the categories for semantics, lexicon, and stereotypes were activated in this partial simulation.

![Model of Exemplar Theory for semantic activation of pastel.](image)

**6.4 Uses of exemplar-based models**

Exemplar-based models are not only used to model the perception of variable input, but also other aspects of language such as (first and second) language acquisition and language change. Recent studies on the acquisition of gender in a second language
(cf. Spinner and Juffs 2005) report findings that are easily modeled within an exemplar-based approach, where a speaker’s experience with gender in their L1 affects their use of gender in their L2. In their longitudinal study of the acquisition of German by one native speaker of Turkish and one native speaker of Italian, Spinner and Juffs (2005) found a native language effect for the assignment of gender in L2 German. These findings suggest that gender, language, and semantics are all connected and accessed during the processing and production of gender in L2 German.

Exemplar-based modeling is also useful in capturing processes of analogy. Native English speakers use phonetic similarity to determine the past tense forms of novel words (cf. Prasada and Pinker 1993, Baker 2005). Prasada and Pinker’s findings show that given a novel verb that sounds similar to a real verb, speakers will use the past tense form of the real verb to form the past tense of the novel verb. For instance, given the novel verb spling, speakers tend to give splung as the past tense form, based on the analogy with the real word spring. This process of analogy is easily modeled within an exemplar-based model of perception and production. Input of novel stimuli result in the activation of phonetically-similar exemplars in the lexicon. The activation of those exemplars, along with the notion of PAST, will result in the statistically most probable form for the past tense of that novel word. Researchers are currently working on a computational simulation of the past tense of novel words using an exemplar-based model (cf. Baker 2005). Baker (2005) simulated Prasada and Pinker’s study using Johnson’s XMOD (Johnson 1997). He found that XMOD’s simulation produced nearly identical results to the participants’ results in Prasada and Pinker’s study. This provides evidence for information rich representations of speech, such as in an exemplar-based model.
Eddington (2004) also posits the need for exemplar-based models to account for the prediction of nominal forms of verbs in Spanish. He uses Skousen’s Analogue Modeling (AM) of Language (1989, 1992, 1995) to model the nominalization of Spanish verbs using analogy. In this model, three properties are used in the selection of an analog: proximity, gang effect, and heterogeneity. Proximity refers to the similarity of the example to the given context. Gang effect refers to whether an example is surrounded by other examples with the same behavior. Heterogeneity serves to block the selection of an example as the analog if there are intervening examples with different behavior. He provides a simulation of how AM would predict the nominal form of the verb tentar ‘to tempt’, based on analogy with other verbs. After using the three properties described above, three verbs remain as possible analogs for tentar: representar ‘to represent’, adoptar ‘to adopt’, and excitar ‘to excite’. AM then calculates the predicted probability or extent of similarity of these three verbs with tentar. From this calculation, AM correctly predicts that the nominal form of tentar is tentación, based on an analogy with representar and excitar.

6.5 Future work and directions

While a lot of research has been done on speech perception and perceptual processing in general, very little has been conducted on cross-dialectal processing or on Spanish. In that sense, the current research will hopefully start a trend in which more linguists working on Spanish will begin to do speech perception research in which perception and processing are studied, both within one dialect of Spanish and cross-dialectally. Doing research on languages other than English will allow researchers in the
field to get a better understanding of what a model of speech perception and production should look like. A rough diagram of such a model was presented above. However, more research needs to be done to see which categories and levels are needed in a model, and how these categories interact.

An example of how more research will aid in understanding the system of perception and processing has to do with the interactions between stereotypes and voices, and stereotypes and the phonological grammar. Research was done on English where stereotypical and non-stereotypical voices were paired with stereotypical and non-stereotypical faces (cf. Strand 2000). Perception experiments in Spanish that look at stereotypes such as education level, age, and socioeconomic status could help elucidate the interactions between these factors and voices, lexical items, and phonological patterns. For instance, a matched-guise test could be used to determine the effects of education stereotypes on the perception of speech sounds and sound patterns. In other words, is perceptual processing delayed when a listener hears a voice that would stereotypically be considered to be an uneducated speaker but sees a picture of an educated person (e.g. a doctor)?

Also, following the findings of the current study, it would be interesting to be able to continue with the study of perceptual processing of variable input. I would like to run an experiment that looked at the interaction between familiarity of lexical forms and dialect stereotypicality. Speakers of two or more dialects would complete a familiarity judgment questionnaire, similar to the one described in Chapter 5, in which they rated their familiarity with words that are typically considered to be dialectal. The most familiar and least familiar words from each dialect would then be recorded by speakers of
both dialects. A perception study would be run using those stimuli. For instance, the Puerto Rican word for trash can, *zafacón*, would be produced by both a Spaniard and a Puerto Rican. The Spaniard would produce the word as [θafakon] while the Puerto Rican would produce the word as [safakoŋ]. The words would be played to both Spanish and Puerto Rican listeners in a naming task. Their reaction times would be recorded. This type of study would help shed light on the interaction of native dialect and lexical items.

Finally, it would be wonderful to be able to run the three experiments described in the dissertation on speakers of other dialects of Spanish, and on participants with varying degrees of dialect contact. The idea is that the more experience a listener has with the patterns found in their non-native dialect, the more easily they will perceive and process those sounds (i.e. shorter reaction times). So, it would be ideal to find native speakers from Mexico that have significant experience with Puerto Rican Spanish, and vice-versa for native speakers from Puerto Rico.

### 6.6 Conclusion

The experiments described in this dissertation provide new findings for the study of the perceptual processing of variable input in general, and for dialect variation in Spanish. First, a speeded naming task was used to measure the effects of variable input on speech perception in Mexican and Puerto Rican Spanish. There were several significant findings, including an effect for phonological variable and an interaction between phonological variable and speaker dialect. Second, a lexical decision task was used to measure the effects of variable input on the perceptual processing of words in Spanish. There was an overall response bias for the listeners for ‘word’ for the Mexican
input. There was again a significant effect for phonological variable. Third, a dialect identification task was used to measure the perceptual similarity of the two dialects being studied. There were many significant findings from this task, including an interaction between speaker dialect and listener dialect.

Perhaps the most significant finding from the three perception experiments is that the phonological variables patterned in the same way regardless of the experimental task. For both the naming and lexical decision tasks, the participants responded most slowly to stimuli containing syllable-final /s/, and in the dialect identification task, they were most accurate at identifying the dialect of the speaker when she produced a word containing this phonological variable. Thus, the realization of syllable-final /s/ seems to be a distinguishing marker of these two dialects of Spanish.

Finally, the findings of the three experiments were discussed in terms of several broader theoretical issues in linguistics, in particular the role of perception in sociolinguistics, the role of variation in speech perception and spoken language processing, and the plausibility of an exemplar-based model of phonological systems. A revised model of Exemplar Theory was presented, and some of the findings were illustrated within this model. This study is an example of the growing laboratory phonology movement within the field of Hispanic Linguistics. There is currently an annual conference devoted to this very field, and this research will surely add to the discipline.
APPENDIX A

STIMULUS SET
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Figure A.1. Test words containing syllable-final /n/ by dialect
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Figure A.2. Test words containing syllable-final /r/ by dialect
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Figure A.3. Test words containing syllable-final /s/ by dialect
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Figure A.4. Filler stimuli by dialect
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Figure A.5. Nonwords by dialect
Figure A.5 (continued)

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<td></td>
</tr>
<tr>
<td>sindo</td>
<td></td>
<td></td>
</tr>
<tr>
<td>telo</td>
<td></td>
<td></td>
</tr>
<tr>
<td>tima</td>
<td></td>
<td></td>
</tr>
<tr>
<td>vano</td>
<td></td>
<td></td>
</tr>
<tr>
<td>veda</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure A.5. Nonwords by dialect
APPENDIX B

POST-EXPERIMENT QUESTIONNAIRE
Encuesta

1. ¿Qué lenguas habla usted? En una escala de 1 a 7, favor de indicar su nivel de hablar cada lengua; donde 1 denota un nivel muy bajo y 7 denota que usted es hablante nativo.

<table>
<thead>
<tr>
<th>Lengua</th>
<th>bajo</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>alto</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
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<td>7</td>
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<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
</tbody>
</table>

2. ¿Qué lengua(s) habla usted con su familia? ____________________________________________

3. Favor de indicar las ciudades y países en que usted ha vivido, y también su edad cuando vivía en cada lugar.

<table>
<thead>
<tr>
<th>Ciudad, País</th>
<th>¿Cuántos años tenía usted?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ejemplo: Puebla, México</td>
<td>17-22 años</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4. ¿Ha visitado a otro país hispanohablante? ¿Cuál y por cuánto tiempo?

<table>
<thead>
<tr>
<th>país</th>
<th>duración</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
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<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
5. ¿Tiene amigos o parientes que viven en otro país hispanohablante? ¿Cuál país?

6. ¿Cuántos años tiene usted?

7. En su opinión, ¿de dónde son los hablantes de este estudio?

8. En su opinión, ¿de qué trataba el estudio?

9. ¿Había una palabra o hablante muy fácil o difícil de entender? ¿Cuál?

10. ¿Cuál parte del estudio fue más fácil? ¿Por qué?

11. ¿Cuáles son las diferencias entre el español de su país y el español del resto del mundo?

Muchas gracias por participar en el estudio.

Figure B.1. Post-experiment questionnaire in Spanish.
1. What languages do you speak? In a scale from 1 to 7, please indicate your proficiency for each language; where 1 denotes a low proficiency and 7 denotes that you are a native speaker.

<table>
<thead>
<tr>
<th>Language</th>
<th>low</th>
<th>medium</th>
<th>high</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. What language(s) do you speak with your family? __________________________

3. Please indicate the cities and countries where you have lived, and your age while living in each location.

<table>
<thead>
<tr>
<th>City, Country</th>
<th>How old were you?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example: Puebla, México</td>
<td>17-22 years old</td>
</tr>
</tbody>
</table>

4. Have you visited another Spanish-speaking country? Which, and for how long?

<table>
<thead>
<tr>
<th>Country</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
5. Do you have friends or relatives that live in another Spanish-speaking country? Which country?

__________________________________________________________________

6. How old are you? _______

7. In your opinion, where are the speakers in this study from?

8. In your opinion, what was the study about?

9. Was there a word or speaker that was difficult to understand? Which

10. What was the easiest part of the study? Why?

11. What are the differences between your dialect of Spanish and other dialects of Spanish?

Thank you for participating in the study.

Figure B.2. Post-experiment questionnaire in English.
APPENDIX C

LANGUAGE BACKGROUND OF PARTICIPANTS
Figure C.1. Mexico 1 (male, 28)

Figure C.2. Mexico 2 (female, 24)
Figure C.3. Mexico 3 (female, 31)

Figure C.4. Mexico (male, 27)
Figure C.5. Mexico 5 (female, 30)

Figure C.6. Mexico 6 (female, 58)
Figure C.9. Mexico 9 (female, 45)

Figure C.10. Mexico 10 (female, 31)
Figure C.11. Mexico 11 (female, 47)

Figure C.12. Mexico 12 (male, 55)
Figure C.13. Mexico 13 (female, 43)

Figure C.14. Mexico 14 (female, 32)
Figure C.15. Mexico 15 (male, 25)

Figure C.16. Mexico 16 (female, 21)
Figure C.17. Mexico 17 (male, 24)

Figure C.18. Mexico 18 (male, 18)
Figure C.19. Mexico 19 (male, 46)

Figure C.20. Mexico 20 (female, 65)
Figure C.21. Puerto Rico 1 (male, 29)

Figure C.22. Puerto Rico 2 (female, 23)

Figure C.23. Puerto Rico 3 (female, 27)
Figure C.24. Puerto Rico 4 (male, 28)

Figure C.25. Puerto Rico 5 (female, 30)

Figure C.26. Puerto Rico 6 (male, 25)
Figure C.27. Puerto Rico 7 (female, 24)

Figure C.28. Puerto Rico 8 (female, 24)

Figure C.29. Puerto Rico 9 (male, 36)
Figure C.30. Puerto Rico 10 (female, 22)

Figure C.31. Puerto Rico 11 (male, 21)

Figure C.32. Puerto Rico 12 (male, 18)
Figure C.33. Puerto Rico 13 (male, 21)
APPENDIX D

NAMING TASK RESULTS
Figure D.1. Reaction time results for naming task by listener gender.

Figure D.2. Reaction time results for naming task by listener age.
Figure D.3. Reaction time results by listener dialect by listener gender.

Figure D.4. Reaction time results for speaker dialect by listener gender.
Figure D.5. Reaction time results for listener dialect by phonological variable.

Figure D.6. Reaction time results for listener age by phonological variable.
APPENDIX E

LEXICAL DECISION TASK RESULTS
Figure E.1. Average median reaction time (ms) by listener age.

Figure E.2. Average median reaction time (ms) by listener gender.
Figure E.3. Average median reaction time (ms) by listener dialect.

Figure E.4. Average median reaction time (ms) by speaker dialect.
Figure E.5. Mean (arcsine transformed) accuracy results by listener age.

Figure E.6. Mean (arcsine transformed) accuracy results by listener dialect.
Figure E.7. Mean (arcsine transformed) accuracy results by listener gender.

Figure E.8. Mean (arcsine transformed) accuracy results by phonological variable.
APPENDIX F

FAMILIARITY JUDGMENT RESULTS
<table>
<thead>
<tr>
<th></th>
<th></th>
<th>23</th>
<th></th>
<th>45</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>pata</td>
<td>chisme</td>
<td>46</td>
<td>puerto</td>
</tr>
<tr>
<td>2</td>
<td>tanza</td>
<td>moco</td>
<td>47</td>
<td>casas</td>
</tr>
<tr>
<td>3</td>
<td>árbol</td>
<td>corte</td>
<td>47</td>
<td>tinto</td>
</tr>
<tr>
<td>4</td>
<td>bastón</td>
<td>pellón</td>
<td>48</td>
<td>césped</td>
</tr>
<tr>
<td>5</td>
<td>barcos</td>
<td>rasgar</td>
<td>49</td>
<td>circo</td>
</tr>
<tr>
<td>6</td>
<td>vero</td>
<td>pala</td>
<td>50</td>
<td>huerto</td>
</tr>
<tr>
<td>7</td>
<td>porque</td>
<td>martes</td>
<td>51</td>
<td>nación</td>
</tr>
<tr>
<td>8</td>
<td>poner</td>
<td>buzón</td>
<td>52</td>
<td>seso</td>
</tr>
<tr>
<td>9</td>
<td>papas</td>
<td>atún</td>
<td>53</td>
<td>trigo</td>
</tr>
<tr>
<td>10</td>
<td>oso</td>
<td>lustra</td>
<td>54</td>
<td>tapa</td>
</tr>
<tr>
<td>11</td>
<td>saco</td>
<td>cerdo</td>
<td>55</td>
<td>piso</td>
</tr>
<tr>
<td>12</td>
<td>astro</td>
<td>años</td>
<td>56</td>
<td>cantan</td>
</tr>
<tr>
<td>13</td>
<td>pardo</td>
<td>gorrión</td>
<td>57</td>
<td>color</td>
</tr>
<tr>
<td>14</td>
<td>camión</td>
<td>parque</td>
<td>58</td>
<td>bailan</td>
</tr>
<tr>
<td>15</td>
<td>trama</td>
<td>andén</td>
<td>59</td>
<td>tostar</td>
</tr>
<tr>
<td>16</td>
<td>mono</td>
<td>obra</td>
<td>60</td>
<td>este</td>
</tr>
<tr>
<td>17</td>
<td>betún</td>
<td>canción</td>
<td>61</td>
<td>gatos</td>
</tr>
<tr>
<td>18</td>
<td>muro</td>
<td>sueco</td>
<td>62</td>
<td>para</td>
</tr>
<tr>
<td>19</td>
<td>pista</td>
<td>irán</td>
<td>63</td>
<td>hierba</td>
</tr>
<tr>
<td>20</td>
<td>cantar</td>
<td>turno</td>
<td>64</td>
<td>premio</td>
</tr>
<tr>
<td>21</td>
<td>beso</td>
<td>actor</td>
<td>65</td>
<td>arte</td>
</tr>
<tr>
<td>22</td>
<td>sueldo</td>
<td>botín</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure F.1. Stimulus set for familiarity judgment study.
Figure F.2. Standardized familiarity judgments by word for all participants.

Figure F.3. Standardized familiarity judgments by word for participant 1.
Figure F.4. Standardized familiarity judgments by word for participant 2.

Figure F.5. Standardized familiarity judgments by word for participant 3.
Figure F.6. Standardized familiarity judgments by word for participant 4.

Figure F.7. Standardized familiarity judgments by word for participant 5.
Figure F.8. Standardized familiarity judgments by word for participant 6.

Figure F.9. Standardized familiarity judgments by word for participant 7.
Figure F.10. Standardized familiarity judgments by word for participant 8.

Figure F.11. Standardized familiarity judgments by word for participant 9.
Figure F.12. Standardized familiarity judgments by word for participant 10.

Figure F.13. Standardized familiarity judgments by word for participant 11.
APPENDIX G

EXPERIMENT INSTRUCTIONS
Bienvenidos al estudio.
Usted va a oír una palabra. Repítala, en voz alta, tan rápido como sea posible.
Marque el número 1 para empezar la práctica.

Figure G.1. Naming task preliminary instructions in Spanish.

Welcome to the study.
You will hear a word. Repeat it, out loud, as quickly as possible.
Push 1 to start the practice session.

Figure G.2. Naming task preliminary instructions in English.

¿Tiene preguntas?
Si no, marque el número 1 para seguir con el estudio.

Figure G.3. Naming task post-practice continuation prompt in Spanish.

Do you have questions?
If not, push 1 to continue with the study.

Figure G.4. Naming task post-practice continuation prompt in English.
Usted ha terminado la primera parte del estudio.
En la segunda parte, usted va a oír una palabra. 
Si la palabra es una palabra que existe en el español, marque el número 1.
Si la palabra no existe en el español, marque el número 2.
Trate de hacerlo tan rápido como posible.
Marque el número 1 para empezar.

Figure G.5. Lexical decision task instructions in Spanish.

You have finished the first part of the study.
En the second part, you will hear a word.
If the word is a word that exists in Spanish, push 1.
If the word does not exist in Spanish, push 2.
Try to do this as quickly as possible.

Push 1 to start.

Figure G.6. Lexical decision task instructions in English.

En la última parte del estudio, tiene que decidir si la hablante es de su región o no.
Por ejemplo, si usted es de Chile y la hablante también suena como hablante del español chileno, hay que marcar número 1.
Si suena como hablante de otro dialecto, marcar número 2.

1 = mismo dialecto

2 = dialecto distinto

Figure G.7. Dialect identification task instructions in Spanish.
En the last part of the study, you have to decide whether the speaker is from your region.

For example, if you are from Chile and the speaker also sounds like she is from Chile, you would push 1.
If she sounds like someone from another dialect, you would push 2.

1 = same dialect
2 = different dialect

Figure G.8. Dialect identification task instructions in English.

Usted ha terminado.
Por favor digale al investigador que ha terminado.
Muchas gracias por su participación.

Figure G.9. Experiment termination in Spanish.

You have finished.
Please tell the researcher that you have finished.
Thank you very much for your participation.

Figure G.10. Experiment termination in English.
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