The Pennsylvania State University

The Graduate School

College of the Liberal Arts

A PSYCHOLINGUISTIC STUDY OF NATIVE LANGUAGE CONSTRAINTS ON SPEAKING WORDS IN A SECOND LANGUAGE

A Thesis in

Psychology

by

Noriko Hoshino

© 2006 Noriko Hoshino

Submitted in Partial Fulfillment
of the Requirements
for the Degree of

Doctor of Philosophy

December 2006

The thesis of Noriko Hoshino was reviewed and approved* by the following:

Judith F. Kroll
Liberal Arts Research Professor of Psychology and Linguistics
Thesis Advisor
Chair of Committee

Paola E. Dussias
Assistant Professor of Spanish, Linguistics and Psychology

Richard A. Carlson
Professor of Psychology

Daniel J. Weiss
Assistant Professor of Psychology and Linguistics

Henry J. Gerfen Jr.
Associate Professor of Linguistics and Spanish Linguistics

Melvin M. Mark
Professor of Psychology
Interim Head of the Department of Psychology

*Signatures are on file in the Graduate School

ABSTRACT

Past research on bilingual production has been performed almost exclusively with bilinguals whose two languages share the same Roman alphabets. However, little research has examined the consequences of different script bilingualism on production. The primary goal of the present research was to determine whether language-specific differences, such as script, can modulate cross-language activation and the locus and manner of language selection in planning spoken words. To address this question, three experiments (simple picture naming, picture-word interference, and language switching) compared the performance of Japanese-English and Spanish-English bilinguals. In Experiment 1, bilinguals named cognate and noncognate pictures in each language. The results showed that both groups produced significant cognate facilitation in each language. The findings suggest that in the absence of the written lexical form, script differences do not function as a language cue to reduce cross-language activation. Furthermore, both languages appear to be activated to the level of the phonology. In Experiment 2, bilinguals named pictures in their L2 while ignoring visually presented distractor words in the L1. A critical finding in Experiment 2 was that both types of bilinguals showed phonological and translation facilitation, whereas only Spanish-English bilinguals demonstrated semantic interference and phono-translation facilitation. These results suggest that when the script is present in the task, different-script bilinguals are able to exploit perceptual information as a language cue to lexical access earlier than same script bilinguals. In Experiment 3, the bilinguals performed two language switching tasks, one with pictures and another with words. In each experiment they produced two names in L1 and two names in L2 in strict alternation. Although the two bilingual groups were similar in picture naming, Japanese-English bilinguals were slower in L2 than Spanish-English bilinguals in word naming, suggesting again that script differences create costs in mapping of orthography to phonology in L2. Taken together, the results of the three experiments suggest that although script differences cannot direct lexical access selectively, they allow the bilingual to select the language of production at an earlier point in speech planning when they are perceptually available. Implications for models of lexical access in bilingual production are discussed.

TABLE OF CONTENTS

LIST OF FIGURES ..... **xii**

LIST OF TABLES ..... **xvi**

ACKNOWLEDGEMENTS ..... **xx**

CHAPTER 1 BACKGROUND AND INTRODUCTION **1**

SPEECH PRODUCTION IN MONOLINGUALS 2
Models of Lexical Access in Monolingual Production *4*
Discrete Two-Stage Models 4
Interactive Models 7
Cascade Models 9
SPEECH PRODUCTION IN BILINGUALS 12
Models of Lexical Access in Bilingual Production *12*
Simple Picture Naming *17*
Picture-Word Interference *19*
Language Mixing/Switching *23*

CHAPTER 2 AN OVERVIEW OF THE EXPERIMENTS AND GENERAL METHOD **28**

IS SELECTIVE LEXICAL ACCESS POSSIBLE? 28
Cross-Linguistic Differences between English and Japanese *28*
The Role of Orthography in Production *30*
Language Cue Hypothesis *31*
GOALS AND HYPOTHESES OF PRESENT RESEARCH 32
GENERAL METHOD 36
Participants *36*
Experiment 1: Simple Picture Naming *37*
Experiment 2: Picture-Word Interference *40*
Experiment 3: Language Switching in Picture and Word Naming *41*
PROFICIENCY MEASURES 43
Language History Questionnaire *44*
Lexical Decision Task *44*
Materials 45
Procedure 45
Data Analyses 46
Verbal Fluency Task *46*
Materials 46

Procedure ... 47
Data Analyses ... 47
INDIVIDUAL DIFFERENCE MEASURES ... 48
Simon Task ... *48*
Materials ... 49
Procedure ... 49
Data Analyses ... 50
Operation Span Task ... *50*
Materials ... 51
Procedure ... 51
Data Analyses ... 52

CHAPTER 3 EXPERIMENT 1: SIMPLE PICTURE NAMING ... 53

METHOD ... 56
Participants ... *56*
Materials ... *57*
Procedure ... *61*
RESULTS AND DISCUSSION ... 63
Proficiency Measures ... *64*
Language History Questionnaire ... 64
Cross-Language Group Comparisons ... 66
Cross-Environment Group Comparisons ... 66
Lexical Decision in L2 English ... 67
Cross-Language Group Comparisons ... 69
Cross-Environment Group Comparisons ... 69
Individual Difference Measures ... *70*
Simon ... 70
Cross-Language Group Comparisons ... 71
Cross-Environment Group Comparisons ... 72
Operation Span ... 73
Cross-Language Group Comparisons ... 73
Cross-Environment Group Comparisons ... 74
Data Trimming for Simple Picture Naming ... *74*
L2 Simple Picture Naming ... *75*
Latencies ... 75
Accuracy ... 79
Comparison with Monolingual Controls in English ... *82*
L1 Simple Picture Naming ... *83*
Latencies ... 84
Accuracy ... 88
Comparison with Monolingual Controls in Spanish and Japanese ... *91*
Effect of L2 Picture Naming on L1 Picture Naming ... *94*
Contribution of External Linguistic Environment ... *96*
Spanish-English bilinguals ... 97

Latency ... 97
Accuracy ... 99
Japanese-English bilinguals ... 101
Latency ... 101
Accuracy ... 103
GENERAL DISCUSSION ... 104
Frequency Account ... 105
The Role of Orthography/Script in Speech Planning ... 107
Contribution of External Linguistic Environment ... 108
Type of Bilingualism ... 109

CHAPTER 4 EXPERIMENT 2: PICTURE-WORD INTERFERENCE ... 114

METHOD ... 118
Participants ... 118
Materials ... 118
Pictures ... 118
Distractors ... 121
Procedure ... 126
RESULTS AND DISCUSSION ... 128
Proficiency Measures ... 129
Language History Questionnaire ... 129
Lexical Decision in L2 English ... 132
Verbal Fluency in L1 Spanish/Japanese and in L2 English ... 133
Individual Difference Measures ... 134
Simon ... 134
Operation Span ... 136
Data Trimming for Picture-Word Interference Task ... 137
Picture-Word Interference Task with Kanji Items ... 138
Phonological Condition ... 139
Latencies ... 139
Accuracy ... 139
Semantic Condition ... 141
Latencies ... 141
Accuracy ... 141
Phono-Translation Condition ... 143
Latencies ... 143
Accuracy ... 143
Translation Condition ... 145
Latencies ... 145
Accuracy ... 145
Summary ... 147
Picture-Word Interference Task with Kana Items ... 148
Phonological Condition ... 148
Latencies ... 148

Accuracy 149
Semantic Condition 150
Latencies 150
Accuracy 151
Phono-Translation Condition 152
Latencies 152
Accuracy 152
Translation Condition 154
Latencies 154
Accuracy 155
Summary 155
Orthographic and Phonological Similarity 157
Kana for Spanish-English Bilinguals 159
Latencies 159
Accuracy 160
Kanji for Spanish-English bilinguals 161
Latencies 161
Accuracy 162
Kana for Japanese-English bilinguals 164
Latencies 164
Accuracy 165
Kanji for Japanese-English bilinguals 166
Latencies 166
Accuracy 167
Error Analyses 168
GENERAL DISCUSSION 172

CHAPTER 5 EXPERIMENT 3: LANGUAGE SWITCHING 180

METHOD 183
Participants 183
Materials 184
Procedure 187
RESULTS AND DISCUSSION 190
Proficiency Measures 191
Language history questionnaire 191
Lexical decision in L2 English 193
Verbal fluency in L1 Spanish/Japanese and in L2 English 194
Individual Difference Measures 196
Simon 196
Operation Span 198
Data Trimming for Picture Naming Task 199
Data Trimming for Word Naming Task 199
Picture Naming Overall 200

Latencies 200
Accuracy 201
Picture Naming with Kana Items *202*
Latencies 202
Accuracy 203
Picture Naming with Kanji Items *203*
Latencies 203
Accuracy 204
Word Naming Overall *205*
Latencies 205
Accuracy 206
Word Naming with Kana Items *207*
Latencies 207
Accuracy 209
Word Naming with Kanji Items *209*
Latencies 209
Accuracy 210
Picture Naming Error Analyses *211*
GENERAL DISCUSSION 214
Magnitude of Switch Costs *215*
Pattern of Switch Costs *216*
Cost to L1 .... *218*
L1 Inhibition *219*
Production vs. Comprehension *222*

CHAPTER 6 CROSS-EXPERIMENT COMPARISONS 224

CROSS-EXPERIMENT COMPARISONS OF CHARACTERISTICS OF BILINGUALS 224
REANALYSIS OF THE PICTURE-WORD INTERFERENCE DATA 231

CHAPTER 7 GENERAL DISCUSSION 233

SUMMARY OF FINDINGS 234
IMPLICATIONS FOR MODELS OF LEXICAL ACCESS IN BILINGUAL PRODUCTION 237
Flow of Activation *238*
Manner of Lexical Selection *240*
THE ROLE OF ORTHOGRAPHY AND SCRIPT IN PRODUCTION 246
ADDITIONAL CONSIDERATIONS 249
Weak Link vs. Competition Hypotheses *249*
Consequences of Different Script Bilingualism *250*
Linguistic consequences 251
Cognitive consequences 251
CONCLUSIONS AND FUTURE DIRECTIONS 253

REFERENCES **255**

APPENDIX A NORMING EXPERIMENTS **270**

EXPERIMENT A1: PHONOLOGICAL SIMILARITY RATINGS 270
Method *270*
Participants 270
Materials 271
Procedure 271
Results and Discussion *271*
EXPERIMENT A2: PHONOLOGICAL SIMILARITY RATINGS 272
Method *272*
Participants 272
Materials 273
Procedure 273
Results and Discussion *274*
EXPERIMENT A3: SEMANTIC RELATEDNESS RATINGS 275
Method *275*
Participants 275
Materials 275
Procedure 275
Results and Discussion *276*
EXPERIMENT A4: PHONOLOGICAL SIMILARITY RATINGS BY BILINGUALS 276
Method *276*
Participants 276
Materials 276
Procedure 277
Results and Discussion *277*

APPENDIX B ADDITIONAL ANALYSES ON LEXICAL DECISION DATA . **279**

EXPERIMENT 1 280
Latencies *280*
Accuracy *281*
EXPERIMENT 2 282
Latencies *283*
Accuracy *284*
EXPERIMENT 3 284
Latencies *285*
Accuracy *286*

APPENDIX C ADDITIONAL ANALYSES FOR EXPERIMENT 1 .... **288**

APPENDIX D PICTURE STIMULI USED IN EXPERIMENT 1 .... **290**

APPENDIX E PICTURE AND DISTRACTOR WORD STIMULI USED IN EXPERIMENT 2 296

APPENDIX F PICTURE AND WORD STIMULI USED IN EXPERIMENT 3 . 324

APPENDIX G LANGUAGE HISTORY QUESTIONNAIRE 336

APPENDIX H WORD AND NONWORD STIMULI USED IN LEXICAL DECISION TASK....... 342

APPENDIX I WORD AND EQUATION STIMULI USED IN OPERATION SPAN TASK....... 345

LIST OF FIGURES

Figure 1.1. A blueprint of the speaker (adapted from Levelt, 1989). 3

Figure 1.2. A network model of lexical access (adapted from Bock & Levelt, 1994). 5

Figure 1.3. An interactive model of lexical access (adapted from Dell et al., 1997).......... 7

Figure 1.4. A cascade model of lexical access (adapted from Levelt et al., 1991)............ 9

Figure 1.5. A model of selective lexical activation with language-specific selection (adapted from Poulisse & Bongaerts, 1994 and Hermans, 2000)............................ 14

Figure 1.6. A model of nonselective lexical activation with language-specific selection (adapted from Poulisse & Bongaerts, 1994 and Hermans, 2000)............................ 16

Figure 1.7. A model of nonselective lexical activation with language-nonspecific selection (adapted from Poulisse & Bongaerts, 1994 and Hermans, 2000)............. 16

Figure 3.1. An illustration of a trial in the simple picture naming task. 62

Figure 3.2. Mean L2 picture naming latencies for Spanish-English bilinguals as a function of cognate status and cognate type. 77

Figure 3.3. Mean L2 picture naming latencies for Japanese-English bilinguals as a function of cognate status and cognate type. 78

Figure 3.4. Mean L2 picture naming percent accuracy for Spanish-English bilinguals as a function of cognate status and cognate type. 80

Figure 3.5. Mean L2 picture naming percent accuracy for Japanese-English bilinguals as a function of cognate status and cognate type. 81

Figure 3.6. Mean L1 picture naming latencies for Spanish-English bilinguals as a function of cognate status and cognate type. 86

Figure 3.7. Mean L1 picture naming latencies for Japanese-English bilinguals as a function of cognate status and cognate type. 87

Figure 3.8. Mean L1 picture naming percent accuracy for Spanish-English bilinguals as a function of cognate status and cognate type. 90

Figure 3.9. Mean L1 picture naming percent accuracy for Japanese-English bilinguals as a function of cognate status and cognate type. 90

Figure 3.10. Mean L1 picture naming latencies as a function of language and group. 95

Figure 3.11. Mean naming latencies (ms) for Spanish-English bilinguals as a function of language, cognate status, and environment.. 98

Figure 3.12. Mean naming percent accuracy for Spanish-English bilinguals as a function of language, cognate status, and environment. 100

Figure 3.13. Mean naming latencies (ms) for Japanese-English bilinguals as a function of language, cognate status, and environment.. 102

Figure 3.14. Mean naming percent accuracy for Japanese-English bilinguals as a function of language, cognate status, and environment. 103

Figure 3.15. Mean naming latencies for Spanish-English bilinguals as a function of language, cognate status, and type of bilinguals.. 112

Figure 3.16. Mean naming accuracy for Spanish-English bilinguals as a function of language, cognate status, and type of bilinguals.. 112

Figure 4.1. A model of nonselective lexical activation with language-nonspecific selection (adapted from Poulisse & Bongaerts, 1994 and Hermans, 2000)........... 116

Figure 4.2. An illustration of a trial in the picture-word interference task. 128

Figure 4.3. Mean picture naming latencies for kanji pictures in the phonological condition as a function of relatedness and bilingual group... 140

Figure 4.4. Mean picture naming percent accuracy for kanji pictures in the phonological condition as a function of relatedness and bilingual group................................... 140

Figure 4.5. Mean picture naming latencies for kanji pictures in the semantic condition as a function of relatedness and bilingual group. 142

Figure 4.6. Mean picture naming latencies and percent accuracy for kanji pictures in the semantic condition as a function of relatedness and bilingual group. 142

Figure 4.7. Mean picture naming latencies for kanji pictures in the phono-translation condition as a function of relatedness and bilingual group................................... 144

Figure 4.8. Mean picture naming percent accuracy for kanji pictures in the phono-translation condition as a function of relatedness and bilingual group.................. 144

Figure 4.9. Mean picture naming latencies for kanji pictures in the translation condition as a function of relatedness and bilingual group.. 146

Figure 4.10. Mean picture naming percent accuracy for kanji pictures in the translation condition as a function of relatedness and bilingual group.................................... 146

Figure 4.11. Mean picture naming latencies for kana pictures in the phonological condition as a function of relatedness and bilingual group.................................... 149

Figure 4.12. Mean picture naming latencies and percent accuracy for kana pictures in the phonological condition as a function of relatedness and bilingual group.............. 150

Figure 4.13. Mean picture naming latencies for kana pictures in the semantic condition as a function of relatedness and bilingual group. 151

Figure 4.14. Mean picture naming percent accuracy for kana pictures in the semantic condition as a function of relatedness and bilingual group.................................... 152

Figure 4.15. Mean picture naming latencies for kana pictures in the phono-translation condition as a function of relatedness and bilingual group.................................... 153

Figure 4.16. Mean picture naming percent accuracy for kana pictures in the phono-translation condition as a function of relatedness and bilingual group.................. 153

Figure 4.17. Mean picture naming latencies for kana pictures in the translation condition as a function of relatedness and bilingual group.. 154

Figure 4.18. Mean picture naming percent accuracy for kana pictures in the translation condition as a function of relatedness and bilingual group.................................... 155

Figure 4.19. Mean picture naming latencies for Spanish-English bilinguals for kana pictures as a function of phonological relatedness and orthographic similarity..... 159

Figure 4.20. Mean picture naming percent accuracy for Spanish-English bilinguals for kana pictures as a function of phonological relatedness and orthographic similarity. 160

Figure 4.21. Mean picture naming latencies for Spanish-English bilinguals for kanji pictures as a function of phonological relatedness and orthographic similarity..... 162

Figure 4.22. Mean picture naming percent accuracy for Spanish-English bilinguals for kanji pictures as a function of phonological relatedness and orthographic similarity. 163

Figure 4.23. Mean picture naming latencies for Japanese-English bilinguals for kana pictures as a function of phonological relatedness and orthographic similarity..... 165

Figure 4.24. Mean picture naming percent accuracy for Japanese-English bilinguals for kana pictures as a function of phonological relatedness and orthographic similarity. 166

Figure 4.25. Mean picture naming latencies for Japanese-English bilinguals for kanji pictures as a function of phonological relatedness and orthographic similarity..... 167

Figure 4.26. Mean picture naming percent accuracy for Japanese-English bilinguals for kanji pictures as a function of phonological relatedness and orthographic similarity. 168

Figure 5.1. An illustration of picture naming switch and non-switch trials. 189

Figure 5.2. Mean overall picture naming latencies as a function of language, type of trial, and language group. 200

Figure 5.3. Mean kana picture naming latencies as a function of language, type of trial, and language group. 203

Figure 5.4. Mean kanji picture naming latencies as a function of language, type of trial, and language group. 204

Figure 5.5. Mean overall word naming latencies as a function of language, type of trial, and language group. 206

Figure 5.6. Mean kana word naming latencies as a function of language, type of trial, and language group. 208

Figure 5.7. Mean kanji word naming latencies as a function of language, type of trial, and language group. 210

Figure 7.1. A possible revised model of bilingual word production. 248

LIST OF TABLES

Table 1.1. Models of Lexical Access in Bilingual Production 13

Table 1.2. Time Course of Distractor Effects for Hermans et al. (1998) 20

Talbe 2.1. Overview of Experiments in Present Research.. 34

Table 3.1. Characteristics of Materials in English Used in Experiment 1 58

Table 3.2. Examples of Materials by Cognate Type and Cognate Status......................... 59

Table 3.3. Phonological Similarity Ratings for Cognates and Noncognates across English, Spanish, and Japanese 61

Table 3.4. Characteristics of Spanish-English and Japanese-English bilinguals in Experiment 1 by Language Group and External Linguistic Environment 65

Table 3.5. English Lexical Decision Results for Spanish-English and Japanese-English bilinguals in Experiment 1 by Language Group and External Linguistic Environment 68

Table 3.6. Simon Results for Spanish-English and Japanese-English bilinguals in Experiment 1 by Language Group and External Linguistic Environment 71

Table 3.7. Operation Span Results for Spanish-English and Japanese-English bilinguals in Experiment 1 by Language Group and External Linguistic Environment 73

Table 3.8. Mean Picture Naming Latencies (ms) for English Monolinguals by Cognate Status and Cognate Type 83

Table 3.9. Characteristics of Materials in Spanish and in Japanese Used in Experiment 1 92

Table 3.10. Mean Picture Naming Latencies (ms) for Spanish and Japanese Monolinguals by Cognate Status and Cognate Type 93

Table 3.11. Characteristics of Spanish-English Bilinguals in the L2 Environment by Proficiency and Dominance.. 110

Table 4.1. Examples of Type of Distractors in Experiment 2 for Spanish-English Bilinguals Naming the Picture “Envelope” 115

Table 4.2. Characteristics of Pictures and Picture Names in English Used in Experiment 2 120

Table 4.3. Examples of Distractors for Pictures "Envelope" and "Goat" by Distractor Type, Relatedness, Script, and Language 122

Table 4.4. Characteristics of Distractors in Spanish and in Japanese 123

Table 4.5. Similarity Ratings for Phonological, Phono-Translation, and Semantic Conditions and Their Unrelated Conditions. 125

Table 4.6. Characteristics of Spanish-English and Japanese-English bilinguals in Experiment 2 130

Table 4.7. Lexical Decision Results for Spanish-English and Japanese-English bilinguals in Experiment 2 132

Table 4.8. Verbal Fluency Results for Spanish-English and Japanese-English bilinguals in Experiment 2 134

Table 4.9. Simon Results for Spanish-English and Japanese-English bilinguals in Experiment 2 136

Table 4.10. Operation Span Results for Spanish-English and Japanese-English Bilinguals in Experiment 2 137

Table 4.11. Summary of the Picture-Word Interference Results for Kanji Blocks 147

Table 4.12. Summary of the Picture-Word Interference Results for Kana Blocks 157

Table 4.13. Examples of Phonologically Related Distractors by Orthographic Similarity and Language 158

Table 4.14. Distribution of Type of Errors by Language Group and by Script 171

Table 4.15. Phonological Similarity Ratings by English Monolinguals and Spanish-English Bilinguals 177

Table 5.1. Characteristics of Pictures and Picture Names Used in Experiment 3 185

Table 5.2. Characteristics of Spanish-English and Japanese-English bilinguals in Experiment 3 192

Table 5.3. Lexical Decision Results for Spanish-English and Japanese-English bilinguals in Experiment 3 194

Table 5.4. Verbal Fluency Results for Spanish-English and Japanese-English bilinguals in Experiment 3 195

Table 5.5. Simon Results for Spanish-English and Japanese-English bilinguals in Experiment 3 197

Table 5.6. Operation Span Results for Spanish-English and Japanese-English Bilinguals in Experiment 3 198

Table 5.7. Mean Picture Naming Percent Accuracy by Block, Language, Type of Trial, and Language Group 201

Table 5.8. Mean Word Naming Percent Accuracy by Block, Language, Type of trial, and Language Group 207

Table 5.9. Distribution of Type of Errors in Picture Naming 212

Table 6.1. Proficiency Measures for Spanish-English Bilinguals in Experiments 1, 2, and 3 226

Table 6.2. Proficiency Measures for Japanese-English Bilinguals in Experiments 1, 2, and 3 227

Table 6.3. Individual Difference Measures for Spanish-English Bilinguals in Experiments 1, 2, and 3 229

Table 6.4. Individual Difference Measures for Japanese-English Bilinguals in Experiments 1, 2, and 3 230

Table 7.1. Selectivity of Lexical Access in Bilingual Production 238

Table A.1. Phonological Similarity Ratings by Spanish-English and Japanese-English Bilinguals 277

Table B.1. Mean L2 Lexical Decision Latencies as a Function of Number of Meanings, Relatedness, and Language Group for Experiment 1 281

Table B.2. Mean L2 Lexical Decision Accuracy as a Function of Number of Meanings, Relatedness, and Language Group for Experiment 1 282

Table B.3. Mean L2 Lexical Decision Latencies as a Function of Number of Meanings, Relatedness, and Language Group for Experiment 2 283

Table B.4. Mean L2 Lexical Decision Accuracy as a Function of Number of Meanings, Relatedness, and Language Group for Experiment 2 284

Table B.5. Mean L2 Lexical Decision Latencies as a Function of Number of Meanings, Relatedness, and Language Group for Experiment 3 286

Table B.6. Mean L2 Lexical Decision Accuracy as a Function of Number of Meanings, Relatedness, and Language Group for Experiment 3 287

ACKNOWLEDGEMENTS

I would like to acknowledge that the portions of this research were funded by a National Science Foundation Dissertation Research Grant BCS-0518814, a teaching release dissertation award from the College of the Liberal Arts Research and Graduate Studies Office at the Pennsylvania State University, and the Eileen Wirtshafter and Herschel W. Leibowitz Graduate Scholarship from the Department of Psychology at the Pennsylvania State University.

I cannot express on these few pages of acknowledgements how grateful I am for all of the people who have supported and encouraged me through my years as a graduate student at Penn State. My time at Penn State could not have been as wonderful and valuable as it was without their support and encouragement. There were good and hard times, but they all turned into meaningful experiences.

First and foremost, I would like to thank my advisor, Judy Kroll for her boundless guidance, support, and encouragement through the years. I do not even know how to express my huge gratitude and appreciation for her. She is the best mentor anybody could ever imagine and I am very fortunate to have been working with her for the past five years. She has been my “academic mother” who trusts me and is always honest with me and who understands my personalities, trains me, and prepares me for my future career.

I would also like to thank the members of my committee. I thank Giuli Dussias for her enormous encouragement and support for the past five years. I have always enjoyed talking with her not only about academics but also about our personal lives. I thank Chip Gerfen for encouraging me and sharing his knowledge and skills as a phonologist. I now know that you like teasing me once in a while and that I should not take every single word from you seriously! I am thankful for Rich Carlson and Dan Weiss for sharing their perspectives as cognitive psychologists.

I would also like to express my gratitude to colleagues outside State College who let me collect data in Spain, Japan, California (San Diego and Pomona), and Pittsburgh. I thank Teresa Bajo for welcoming me to her lab and making my stay comfortable and smooth and Carmen Ruiz and Pedro Macizo for helping me recruit subjects and communicate with other people. Without their help, I could not have survived with my limited Spanish! I thank my former advisor from Tsuda, Hiroko Tajika, for letting me visit the College for the purpose of data collection, my friend from college, Nao Ohkubo, for reserving a room and putting up flyers, and my former professor and friend who has always been on my side, Mary Althaus for advertising my experiments in her classes. I thank Vic Ferreira and Tami Gollan for allowing me to visit their lab and giving me a place to run participants and access to their resources, and Rosa Montoya for helping me recruit participants, giving me a ride to school, and showing me around the city of San Diego. I thank Debby Burke for welcoming me to her lab and hosting me at her house, which made me feel at home. And I thank Natasha Tokowicz for welcoming me to her lab, hosting me, talking about our research, and setting up opportunities to meet with people, and Tamar Degoni, Susan Dunlap, Anat Prior and Yuki Yoshimura for hosting me and/or helping me recruit participants. I was so glad that you celebrated my birthday with me too.

Many thanks go to all the members of the Purple Lab. I am lucky to have such friendly and supportive former and current labmates: Kate Cheng, Sara Hasson, April

Jacobs, Jared Linck, Maya Misra, Tyler Phelps, Ana Schwartz, Bianca Sumutka, Gretchen Sunderman, and Tracy Cramer. They all have been very helpful in a variety of ways at different stages of this process. I have always felt that I have a community where I can feel comfortable and secure. I have enjoyed times with you not only in the lab but also outside the lab and even outside the country! I thank all the undergraduate research assistants, Dan Burke, James Burns, Kristin Dresner, Kay Holtzinger, Hiroko Kitajima, Matilda Navarro, Lindsey Neblock, Maria Peredes, Judith Pirela, Jack Sun, and Jessica Yoon, who helped me with this gigantic dissertation project. It would have been impossible without their hard work.

I would also like to thank our wonderful visitor to the lab, Janet Van Hell. When I visited Nijmegen, The Netherlands, two summers ago, Janet spent time discussing possible ideas for my dissertation. Two years later, she was sharing the office with me when I was trying to finish up my dissertation. Her presence in the same office definitely energized me and made my final stretch more comfortable.

To Susan Bobb who has become my best friend and labmate through the past three years. Thank you very much for being such a wonderful friend throughout the good and bad days. I enjoyed our time not only in State College, but also in Virginia, Japan, Spain, Canada, New York, and Maryland. You are the best friend one could ever dream of having in graduate school!

I am also thankful for my good friends from Penn State: Hanae Katayama, Eriko Kobayashi, Takoko Nomi, and Eva Suarez. It was always a good study break to cook together and have good meals!

To Beverly Adams who was my advisor from Randolph-Macon Woman's College and has been my friend and American mother since I met her in 1997 when I was at R-MWC as an exchange student. If I had not met her, I would not be doing psycholinguistic research now and would be an applied linguist rather than a cognitive psychologist. She is the one who attracted me to the field of cognitive psychology and psycholinguistics. If Judy is the one who raised me as a psycholinguist, Beverly is the one who gave birth to me as a psycholinguist!

Special thanks go out to my best friends from junior high and high school or college: Sachiko Isobe, Yurina (Maeda) Shimada, and Yoko Nomura. Even when I can be in Japan only for one week, they find time to get together and accept me as I am despite the fact that I have probably changed by living in a different culture for a long time.

Finally, but not last, I would like to thank my family who was willing to let me come to the United States and has encouraged and supported me with their love across the Pacific Ocean through this process. Even though we live in completely opposite time zones, my mother calls me every weekend. I always look forward to our phone conversations on weekends about our life in different worlds. They also welcome me home from the middle of nowhere Pennsylvania twice a year, which always motivates me to get work done before going home and allows me to recharge my batteries.

I could not have made this possible without all of these people! I am now leaving the "nest" of State College and will continue to thrive wherever I am.

「ぼくの前に道はない。ぼくのうしろに道はできる。」　高村　光太郎

"Even when there is no path ahead of me, there will be a path behind me."

By Kotaro Takamura

CHAPTER 1

BACKGROUND AND INTRODUCTION

Most people in the world are routinely exposed to more than one language in learning second or foreign languages in classrooms, communicating with speakers of other languages, and living in bilingual or multilingual communities. It is now accepted that bilingualism is a natural phenomenon with consequences for cognition that are potentially positive and enduring. Cognitive research on bilingualism not only provides insight into the nature of bilingualism but more generally about plasticity and constraints that characterize the relations between language and thought. A critical observation in recent experimental studies of bilingual performance is that both languages appear to be active regardless of the bilingual's intention to use one language only (e.g., Colomé, 2001; Dijkstra & Van Heuven, 2002; Kroll, Sumutka, & Schwartz, 2005). Despite the presence of cross-language activity, it is rare to see bilinguals speaking to others in the unintended language. How do bilinguals speak in one language alone when the other is also active? Much of the research on bilingual language comprehension and production has been performed with Dutch-English, Spanish-English, Spanish-Catalan, and French-English bilinguals. In each case, these bilinguals' two languages share the same script, making them more similar in appearance than different-script languages and potentially more ambiguous with respect to language status. Only a few studies have examined the consequences of a life experience of bilingualism with languages whose scripts differ. For obvious reasons, these studies have examined word recognition (e.g., Gollan, Forster, & Frost, 1997; Jiang, 1999; Kim & Davis, 2003) but not word production. However, although it might seem that differences in the written lexical form might not influence word production presenting the absence of the word itself, other recent research that we discuss below suggests that all lexical codes are active to some degree in both comprehension and production (e.g., Chéreau, Gaskell, & Dumay, in press; Damian & Bowers, 2003; Tan & Perfetti, 1999; Ziegler, Muneaux, & Grainger, 2003). The goal of the present study was to determine whether language-specific differences, such as script, can modulate the degree of cross-language activation and the locus of language selection during bilingual word production. A second goal was to assess the degree to which the nature of the linguistic environment (i.e., whether bilinguals find themselves in contexts that support one of their two languages more than the other), the level of language proficiency, and the availability of cognitive and attentional resources affects the ability to control the activation or inhibition of the unintended language.

Speech Production in Monolinguals

Speech production requires transforming an intention into sounds. According to Levelt's blueprint of the speaker (1989), the process of speech production is hypothesized to consist of four major components: the conceptualizer, the formulator, the articulator, and the speech-comprehension system (see Figure 1.1.). First, the conceptualizer creates preverbal messages reflecting a speaker's intention. The formulator is divided into two subcomponents: the grammatical encoder and the phonological encoder. The grammatical encoder retrieves lemmas (i.e., semantic and syntactic information such as gender that is associated with lexical entries but has not been phonologically or orthographically encoded) corresponding to the preverbal message from the lexicon and determines syntactic relations between words and phrases indicating the conceptual relations in the preverbal message. The phonological encoder generates a phonological form of the output from the grammatical encoder. Then the articulator executes the phonological form. Finally, the speech-comprehension system interprets both the phonological form of the message and the executed message by accessing forms and lemmas for each word and by monitoring speech within this general framework.

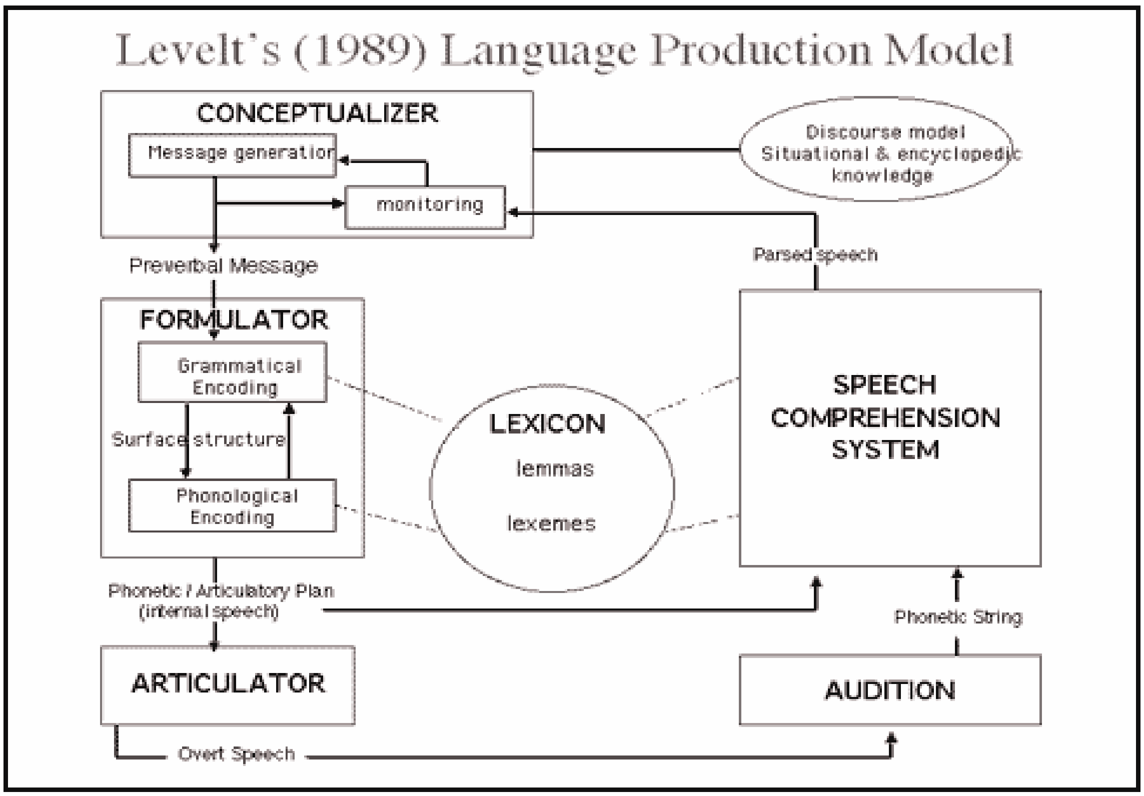


Figure 1.1. A blueprint of the speaker (adapted from Levelt, 1989).

Levelt's blueprint of the speaker characterizes the process of speech production in general. Given that the present research focuses on word production, the sections that follow review models of lexical access in speech production. Each of these models includes the component processes identified by Levelt as critical in speech planning but differs in the assumptions made about the sequencing of information flow and the interpretation. We describe each of the models and the empirical evidence that has been taken as support.

Models of Lexical Access in Monolingual Production

Discrete Two-Stage Models

Most models of word production involve three levels of representation: conceptual, lexical/lemma, and phonological levels. The conceptual level is where the speaker decides what concept she wants to convey. The lexical level includes lexical entries along with their syntactic properties. The phonological level represents the phonological code associated with lexical entries. When an individual speaks, she first conceives a concept, retrieves a lemma that corresponds to her concept from the lexicon, and then specifies the retrieved lexical entry phonologically. Although this process seems very simple, the actual process of speech production is more complicated, even in the case of producing a single word, because selecting the appropriate word is a competitive process (e.g., Bock & Levelt, 1994; Caramazza, 1997; Dell, 1986; Dell, Schwartz, Martin, Saffran, & Gagnon, 1997; Levelt, Roelofs, & Meyer, 1999; Peterson & Savoy, 1998 ; but see Finkbeiner & Caramazza, in press).

For example, when naming an object, the speaker first needs to conceive the meaning of the object to be named. As depicted in Figure 1.2., it is assumed that not only the semantic representation of the intended concept “SHEEP” but also those of semantically related concepts such as “WOOL,” “MILK,” “ANIMAL,” and “GOAT” are activated to some degree. The concept “GOAT” might be directly activated from the object that the speaker has seen, but it may also receive activation from the related concepts such as "MILK" and "ANIMAL."[1] The activation of the semantic representations in the conceptual system then spreads to the lexical system, activating proportionally the corresponding lexical nodes.[2] Thus, multiple lexical candidates are activated at the lexical level.

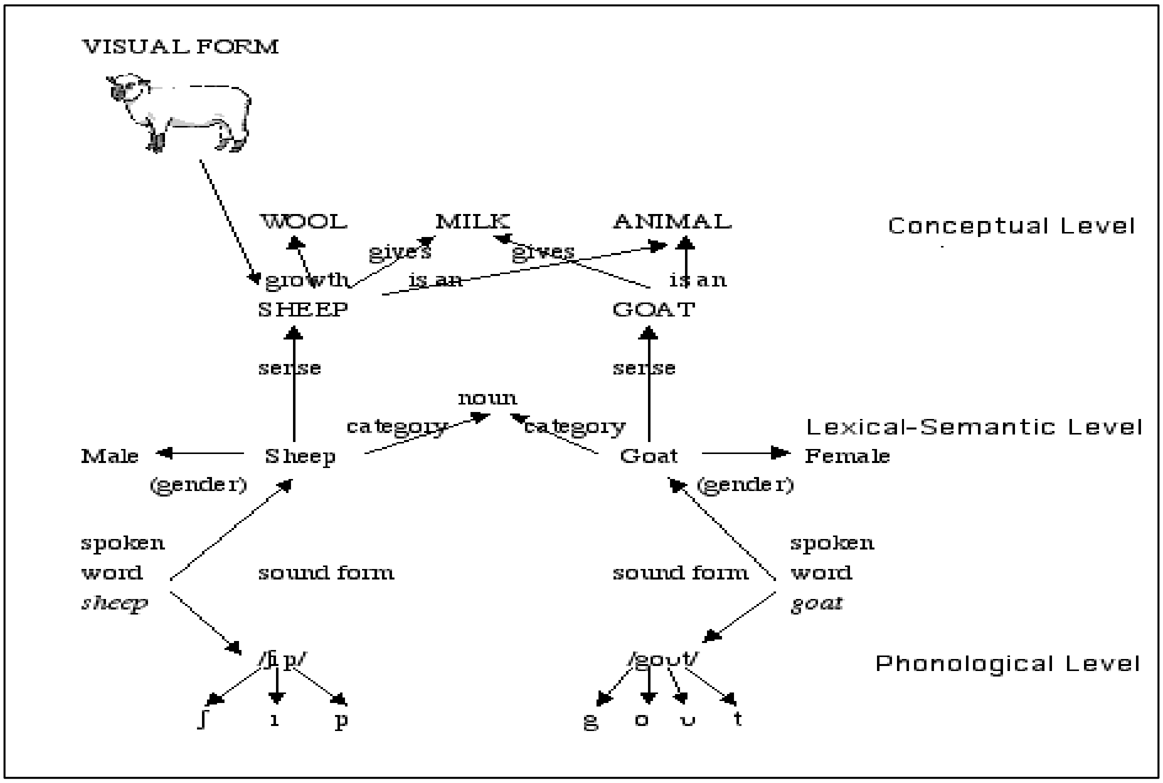


Figure 1.2. A network model of lexical access (adapted from Bock & Levelt, 1994).

[1] It is important to note that the arrows in this figure do not represent the flow of activation, but the relationship between nodes.

[2] La Heij (2005) has a different view on the flow of activation from the conceptual level to the lexical level. He assumes that a concept that has the highest activation is selected at the conceptual level and that the selected concept activates the corresponding lexical node and the activated lexical node.

Discrete two-stage models assume that the lexical node that has received the highest activation is selected. Once the lemma is selected, the selected lemma is phonologically encoded and its lexeme (i.e., a word form that includes phonological information) is activated (e.g., Levelt, 1989; Levelt et al., 1999; Levelt, Schriefers, Vorberg, Meyer, Pechmann, & Havinga, 1991). In other words, multiple lemmas can be activated and compete for selection, but lexical selection occurs at the lemma level and lexical competitors are not be specified phonologically.

Evidence for the discrete two-stage model comes from studies using the picture-word interference paradigm, a variant of the Stroop task (Stroop, 1935). In this task participants are asked to name a picture as quickly and accurately as possible while ignoring a visually or auditorily presented distractor word. The relation of the distractor word to the picture's name and timing of the presentation of the distractor relative to the picture is varied. The time course of distractor effects is used to map out the stages of production (i.e., the conceptual, lemma, and phonological levels) at which different types of information become available. If lexical/lemma selection takes place prior to phonological encoding and there is no interaction between semantic and phonological activation, semantic effects should be observed earlier in the speech planning, whereas phonological effects should be obtained later in the process. Schriefers, Meyer, and Levelt (1990) demonstrated that relative to unrelated distractors, semantically related distractors produced interference at short SOAs (-150 ms), whereas phonologically related distractors produced facilitation at longer SOAs (0 ms & 150 ms).[3] Semantic

[3] These SOA values differ funcitionally for experiments in which auditory vs. visual distractors have been used. Auditory distractors take longer to be processed than visual distractors. Furthermore, auditory distractors are presented for a certain duration, whereas

interference and phonological facilitation were not obtained in the same time course of processing. These results support the discrete two-stage model, such that there are two independent stages in which semantic and phonological processing occur sequentially.

Interactive Models

Other models of lexical access in speech production have challenged the notion of discreteness (e.g., Dell, 1986; Dell et al., 1997; Starreveld & La Heij, 1995, 1996). Contrary to discrete two-stage models, interactive models assume that activation between the lemma/lexical level and the phonological level is bi-directional and that multiple lemmas are phonologically encoded in parallel (See Figure 1.3.). In other words, once lemmas are activated, they start spreading activation to the phonological level to some degree. Thus, phonological specification starts before lexical selection.

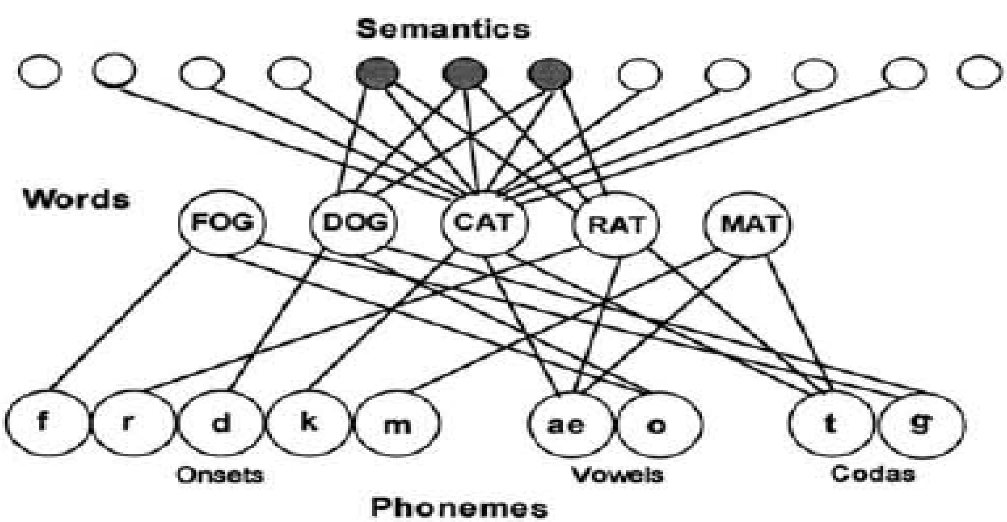


Figure 1.3. An interactive model of lexical access (adapted from Dell et al., 1997).

---

visual distractors remain on the computer screen until the participant responds. Therefore, the same SOA value functions differently, depending upon whether the distractor is presented auditorily or visually (see *Footnote 4* in this chapter for further discussions).

Empirical evidence for interactive models comes from observations of speech errors (e.g., Dell, 1986) and also picture-word interference experiments (e.g., Damian & Martin, 1999; Starreveld & La Heij, 1995, 1996). Starreveld and La Heij (1995, 1996) included distractor words that were both semantically and phonologically related to the name of the picture (e.g., "calf" for the picture of "cat") in addition to semantically related, phonologically related, and unrelated distractors. If processing at the lemma/lexical level and processing at the phonological level are two distinct stages and activation flows only from the lemma/lexical level to the phonological level, semantic interference and phonological facilitation should be additive. Starreveld and La Heij found that there was an interaction between semantic interference and phonological facilitation, such that semantic interference was reduced when the distractor word was both semantically and phonologically related. Furthermore, they observed semantic interference at short SOAs (-100 ms, 0 ms) and phonological facilitation at a wide range of SOAs (-200 ms to 100 ms).[4] These results suggest that competition at the lexical/lemma level is modulated by feedback from the phonological level, which is consistent with the interactive view of lexical access in speech production rather than the serial view.

[4] The different pattern of the results from Schriefers et al. (1990) can be attributed to the modality of the presentation of distractors. Damian and Martin(1999) found that when the duration of visual distractors was limited and similar to that of auditory distractors, phonological facilitation followed semantic interference. However, Damian and Martin obtained the interaction between semantic and phonological effects even in the auditory presentation, which supports the interactive view.

Cascade Models

Although the notion of discrete two stages in speech production needs to be abandoned to accommodate the findings with the interaction between semantic interference and phonological facilitation (e.g., Damian & Martin, 1999; Starreveld & La Heij, 1995, 1996), some research suggests that the flow of activation is unidirectional rather than bi-directional (e.g., Jescheniak & Schriefers, 1998; Peterson & Savoy, 1998). Similar to fully interactive models, cascade models posit that phonological specification starts prior to lexical selection, such that multiple lexical candidates are phonologically encoded in parallel (see Figure 1.4.). However, cascade models assume that activation feeds only forward and does not feed back from the phonological level to the lemma/lexical level.[5]

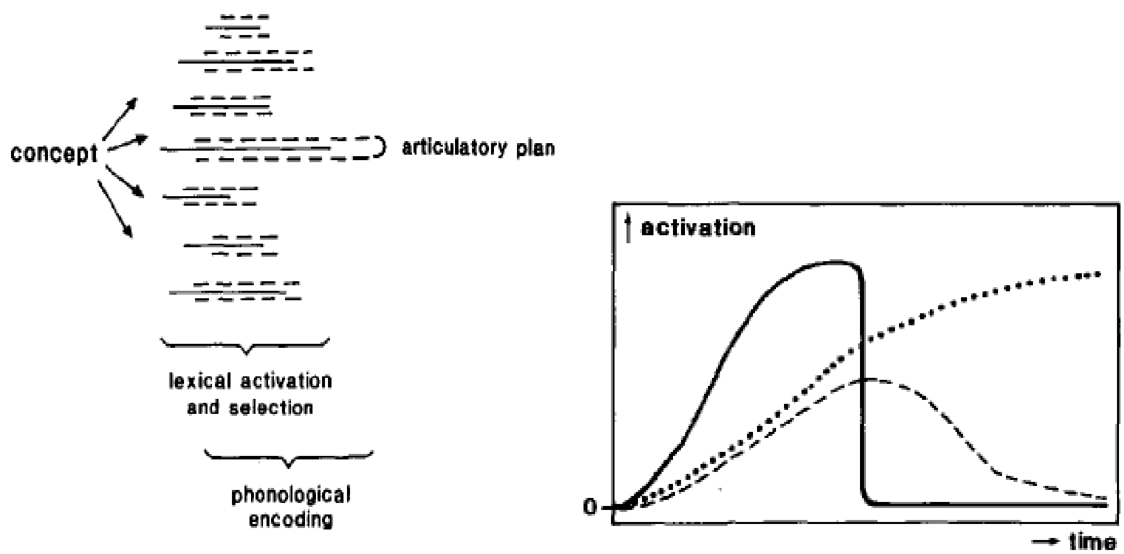


Figure 1.4. A cascade model of lexical access (adapted from Levelt et al., 1991).

[5] The solid, dotted, and dashed lines refer to the semantic activation of the target, the phonological activation of the target, and the phonological activation of the alternative candidate, respectively.

Support for a cascading flow of information in speech production was provided by a set of studies (Jescheniak & Schriefers, 1998; Peterson & Savoy, 1998) that exploited the fact the some pictures have close synonym names. Peterson and Savoy (1998) adapted the variant of the picture-word interference used by Levelt et al. (1991) so that some trials required picture naming and others required word naming. In this version of the task, on most trials, a question mark followed the offset of the picture presentation to indicate that participants should name the picture. However, on a smaller percentage of trials, the picture was followed by a word and the task was to name the word instead of the picture. These word naming trials, in which the relation between the word and picture name were manipulated, comprised the critical trials. The critical items were pictures that had two close synonym names (e.g., "couch," "sofa") and words that were phonologically related to the picture names (e.g., "soda," "count") or unrelated to the picture name (e.g., "tiger"). If both synonym names such as "couch" and "sofa" are active and phonologically encoded prior to the selection of the lexical item, then phonologically related words such as "count" and "soda" should be named faster relative to an unrelated probe such as "tiger." However, if the dominant name "couch" is selected prior to phonological encoding, then only the word that is phonologically related to couch (i.e., "count") should be named faster than the unrelated probe "tiger." Peterson and Savoy obtained phonological facilitation for both dominant and secondary names, a result that supports cascade models that predict that both dominant and secondary names are phonologically specified before the dominant name is selected. Furthermore, they found that words that were phonologically related to the dominant name produced facilitation both at early and late SOAs, whereas words that were phonologically related to the secondary name produced facilitation only at early SOAs. These results suggest that multiple lexical candidates are phonologically encoded prior to lexical selection, contrary to the predictions of discrete two-stage models.

Although the proponents of discrete two-stage models argued that it is rare that there are close synonyms for a given concept (e.g., Levelt et al., 1999), that argument would appear to apply to monolingual speakers within a single language only. For bilinguals, almost every concept has at least two lexical alternatives, the name in one language and its translation equivalent in the other language. If these lexical alternatives from two languages function as lexical competitors, then a cascaded model of speech planning may easily characterize activity within the bilingual lexicon. Unless bilinguals are somehow able to switch off one of their languages completely, an alternative that seems very unlikely from the evidence we later review, studies of speech planning in bilinguals will be critical for evaluating production models.

Other recent within-language research has shown that cascading activation feeds forward not only down to the phonological level but also from the phonological level to articulation when processing resources are limited (e.g., Goldrick & Blumstein, 2006; Kello, Plaut, & MacWhinney, 2000; but see Damian, 2003). Given that speaking in a second language (L2) imposes more demands on the bilingual's cognitive resources than speaking in the first language (L1) (e.g., Hasegawa, Carpenter, & Just, 2003; Hoshino, Dussias, & Kroll, in preparation-b; Michael & Gollan, 2005; Miyake & Friedman, 1998), it is possible that the flow of activation cascades to a deeper level of speech planning in the bilingual case than in the monolingual case, particularly when the less dominant language is spoken. In the following section, we review models of lexical access in bilingual word production and the evidence that has been taken to support them.

Speech Production in Bilinguals

When a bilingual speaks a word in each of her languages, is the process of lexical access in speech production similar to speech planning for a monolingual? Although it seems that bilinguals can use each of their languages without the influence of the other because we rarely see bilinguals speaking in the wrong language, past research suggests that lexical alternatives are active not only in the response language but also in the non-response language (e.g., Colomé, 2001; Costa & Caramazza, 1999; Costa, Caramazza, & Sebastián-Gallés, 2000; Costa, Colomé, Gómez, & Sebastián-Gallés, 2003; Costa, Miozzo, & Caramazza, 1999; Hermans, Bongaerts, De Bot, & Schreuder, 1998). Models of lexical access in bilingual production must therefore address the locus and manner of language selection if the intention to speak one language alone is not sufficient to restrict activation to that language.

Models of Lexical Access in Bilingual Production

Models of lexical access in bilingual production are generally categorized into two theoretical camps: selective/language-specific vs. nonselective/language-nonspecific.

As shown in Table 1.1., selectivity can be defined in terms of the flow of activation and the manner of lexical selection.[6]

Table 1.1.

Models of Lexical Access in Bilingual Production

Activation	Lexical Selection	Language Selection
Selective: No cross-language activation	Language-specific: Only candidates in the intended language are considered	Conceptual level
Nonselective: Cross-language activation	Language-specific: Only candidates in the intended language are considered	Conceptual level
	Language-nonspecific: Candidates in both languages are considered	Lemma level Phonological level Articulation

If lexical activation in bilingual word production is fundamentally selective, the intention to speak a word in one language is sufficient to activate only lemmas in the intended language and thus there is no cross-language activation and language selection occurs at the conceptual level. An illustrative selective model of bilingual word production adapted from Poulisse and Bongaerts (1994) and Hermans (2000) is shown in Figure 1.5. In this figure, the intention to speak a word in one language is represented at

[6] Some researchers use the terms selective/nonselective and language-specific/language-nonspecific interchangeably when considering the flow of activation and the manner of lexical selection (see Costa, 2005 for a review). In this dissertation, selective access refers to no parallel "activation", whereas nonselective access refers to parallel "activation." Language-specific selection means that only lexical candidates in the intended language are considered for "selection," whereas language-nonspecific selection means that lexical candidates in both the intended and the unintended languages are considered for "selection."

the conceptual level of encoding as a language cue. For example, when a Spanish-English bilingual intends to name the pictured object "cat" in her L2 English, the language cue is sufficient to selectively activate lemmas in the target language alone. Lexical access is functionally monolingual in this case.

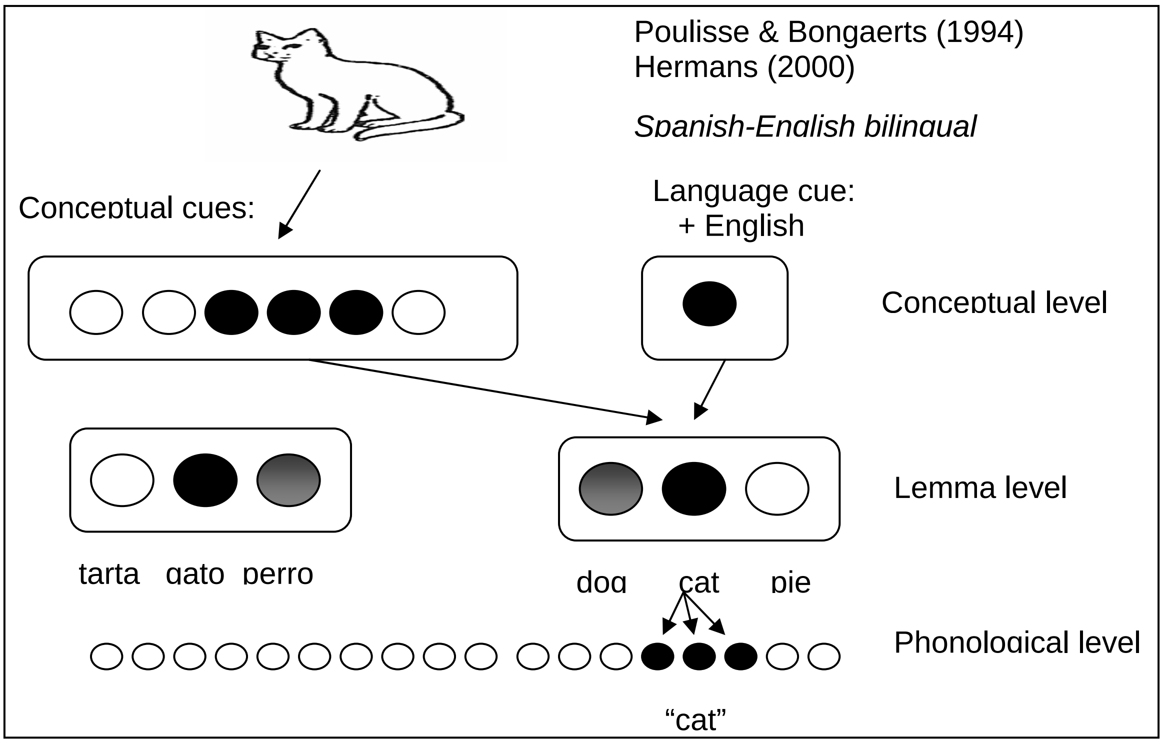


Figure 1.5. A model of selective lexical activation with language-specific selection (adapted from Poulisse & Bongaerts, 1994 and Hermans, 2000).

In contrast, if lexical activation in bilingual word production is fundamentally nonselective with respect to language, then the intention to speak a word in one language is insufficient to restrict activation to the intended language alone and lemmas from both languages are active. For example, when a Spanish-English bilingual intends to name the pictured object "cat" in English, not only English lemmas but also Spanish lemmas would be active.

Although past bilingual research concurs with the view of nonselective activation, particularly in L2 production,[7] there has been a debate over the manner of lexical selection.[8] The manner of lexical selection also falls into two theoretical camps: language-specific selection and language-nonspecific selection. The language-specific view posits that lexical alternatives are active in both languages but only those in the response language are considered for lexical selection (e.g., Costa et al., 1999). Thus, the activation of lexical candidates from the non-response language does not interfere lexical selection in the intended language (see Figure 1.6.).

On the other hand, the language-nonspecific view assumes that as shown in Figure 1.7., lexical nodes are active in the response and the non-response languages and lexical alternatives from both languages compete for selection (e.g., Hermans et al., 1998). Therefore, the activation of the lexical alternatives in the non-response language influences lexical selection in the response language and the lexical nodes in the non-response language need to be inhibited or those in the response language need to reach a higher level of activation.

---

[7] Evidence for selective activation is generally from production tasks exclusively in the bilingual's first language (L1) (e.g., Bloem & La Heij, 2003; Bloem, Van Den Boogaard, & La Heij, 2004; Kroll, Dijkstra, Janssen, & Schriefers, in preparation).

[8] Within a bilingual model, there can still be lexical competition across languages as well as competition within a language when lexical selection occurs. In this dissertation, it is assumed that the language of the lexical candidate has been selected prior to lexical selection (see Kroll, Bobb, & Wodniecka, 2006 for a further explanation).

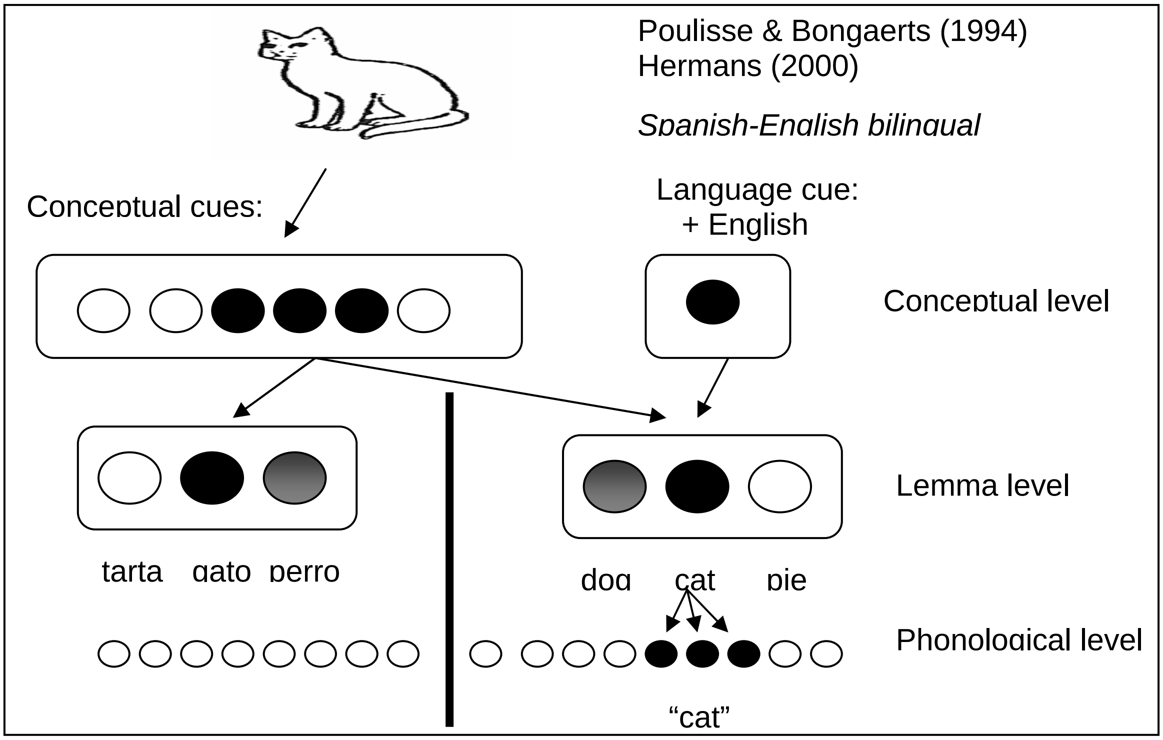


Figure 1.6. A model of nonselective lexical activation with language-specific selection (adapted from Poulisse & Bongaerts, 1994 and Hermans, 2000).

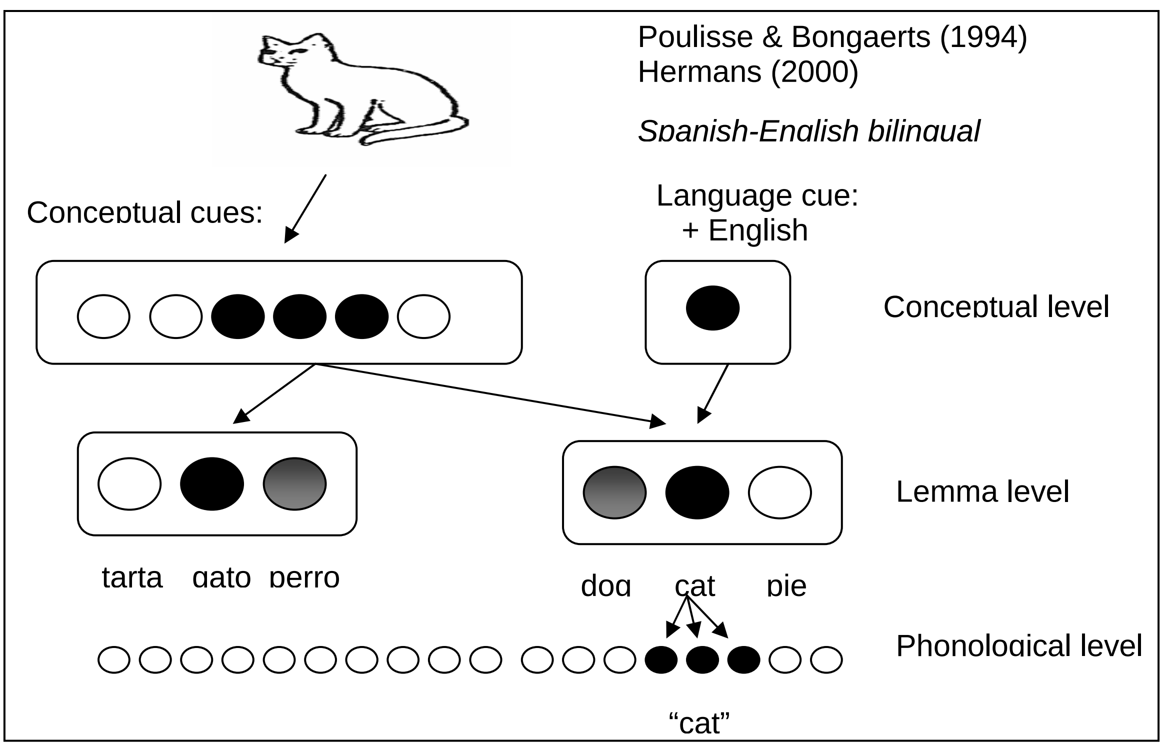


Figure 1.7. A model of nonselective lexical activation with language-nonspecific selection (adapted from Poulisse & Bongaerts, 1994 and Hermans, 2000).

Furthermore, there has been debate in the recent literature regarding the locus of language selection and the evidence that supports each alternative model. Some studies suggest that as illustrated in Figure 1.7., alternative candidates from both languages are active at the lemma level but only candidates from the intended language are encoded phonologically (e.g., Hermans et al., 1998). On this view, language selection occurs at the lemma level. Others demonstrate that alternative candidates from both languages are active all the way to the phonological level and language is selected at the phonological level (e.g., Colomé, 2001; Costa et al., 2000; Kroll et al., in preparation). A recent study (Jacobs, Gerfen, & Kroll, 2005) suggests that under circumstances in which the L2 is weak relative to L1 that lexical alternatives in both languages remain active through the execution of speech, i.e., beyond the onset of articulation.

The disagreement in the literature regarding the locus and manner of language and/or lexical selection results in part from the use of different experimental paradigms and comparisons of bilinguals who differ in their proficiency and dominance in the two languages. The section that follows in this chapter reviews seminal bilingual word production studies in different paradigms.

Simple Picture Naming

A number of studies on picture naming have shown that bilinguals are faster to name a picture when the picture's name is a cognate translation that has the same meaning and similar phonology across the bilingual's two languages (e.g., lion-león) than when the picture's name is a noncognate translation (e.g., leaf-hoja) (e.g., Costa et al., 2000; Kroll et al., in preparation). The logic of picture naming with cognates and noncognates is that if both languages are active regardless of the bilingual's intention to speak in one language, the level of activation is higher for a cognate than for noncognate because the shared phonological segments receive activation from both languages, whereas those of the noncognate receive activation from one language only. The presence of cognate facilitation suggests that the name of the picture in the nonresponse language is activated to the point where phonology is specified. Although these effects are typically larger in the L2, they have also been reported for L1 (Costa et al., 2000).

A further result that suggests that there is activation through the phonology is that bilinguals are slower to name a picture when the picture's name in the L2 (e.g., "leaf" in English) is a homophone in the L1 (e.g., "lief" in Dutch means "dear") relative to a matched control picture (Kroll et al., in preparation). Homophone interference indicates that the activation of the phonological codes of the L2 picture name feeds back not only to the corresponding lexical nodes in the L2 but also to lexical nodes in the L1, resulting in competition at the lexical/lemma level. This result itself is consistent only with a fully interactive model of speech planning in which activation can flow in both directions.

Taken together, the results of simple picture naming studies support models of nonselective activation and language-nonspecific selection. Moreover, the cognate picture naming data suggest that lexical alternatives in both languages are active to the phonological level and that the flow of activation is cascading. On the other hand, the homophone results demonstrate that both languages are active all the way to phonology and the activation between lexical/lemma and phonological levels is interactive.

Picture-Word Interference

Similar to within-language production studies, many bilingual production studies have also used the picture-word interference paradigm, in which bilinguals name a picture in one language while ignoring a visually or auditorily presented distractor word in the same or other language (e.g., Costa et al., 1999; Hermans et al., 1998). In these experiments, the relation between the distractor word and the picture's name is varied along with the timing of the distractor presentation relative to the picture, and the language of the distractor. Like the monolingual picture-word interference studies, the logic of the bilingual studies is to examine the time course of distractor effects as a way of identifying the activity of the nontarget language during each stage of production (i.e., at the conceptual, lemma, and phonological levels).

To illustrate, Hermans et al. (1998) asked Dutch-English bilinguals to name pictures in their L2 English while ignoring auditorily presented distractor words either in English or in Dutch. Like the previous monolingual studies, the distractors were either semantically or phonologically related to the picture's name or an unrelated control and were presented at variable SOAs relative to the presentation of the picture. Unlike the monolingual studies, Hermans et al. included a condition in which distractors were phonologically related to the translation of the picture's name. For example, if a Dutch-English bilingual was asked to name a picture of a mountain in English, the distractor might be the word "berm" in Dutch which sounds like the word "berg" which mean mountain in Dutch. As shown in Table 1.2., there was interference when the distractor word was semantically related to the picture's name and was presented early in speech planning, regardless of the language of the distractor word. In contrast, there was facilitation when the distractor words were phonologically related to the picture's name in the target language and were presented late in the production process. However, when the distractor word was phonologically related to the picture's name in the nontarget language (Dutch), there was interference rather than facilitation, which suggests that there was activation of the lexical node of the translation of the picture's name. The result suggests that the translation competes with the lexical node of the picture's name in the target language for selection. The time course of interference for these phono-Dutch distractors that resembled the translation equivalent was similar to that for semantically related distractors. The pattern of results suggests that not only lexical candidates in the intended language but also those in the other language are active at the lemma level but not specified at the phonological level.

Table 1.2.

Time Course of Distractor Effects for Hermans et al. (1998)

Distractor Language	Distractor Type	SOA -300	SOA -150	SOA 0	SOA 150
L2 English	Phonological (mouth)	19 ms*	24 ms*	31 ms*	64 ms*
	Phono-Dutch (bench)	-14 ms	-5 ms	-28 ms*	-5 ms
	Semantic (valley)	-44 ms*	-19 ms*	-31 ms*	10 ms
L1 Dutch	Phonological (mouw [sleeve])	-8 ms	-5 ms	-10 ms	35 ms*
	Phono-Dutch (berm [verge])	-30 ms*	-38 ms*	-35 ms*	-7 ms
	Semantic (dal [valley])	-17 ms	-37 ms*	-19 ms	-13 ms

Notes. Picture naming was always in the L2 English and the example of the distractors was for the picture of a mountain. The magnitude of the effect was a difference in picture naming latencies for unrelated control and for each type of distractor words. $*p < .05$

With regard to the manner of language selection, Hermans and his colleagues (1998) interpreted these findings as support for a language-nonspecific model of bilingual production. This model assumes that the intention to speak in one language is not sufficient to activate only lemmas in the intended language and therefore lexical candidates from both languages compete for selection. Selection is eventually possible because candidates in the intended language receive additional activation via language cues (De Bot & Schreuder, 1993) or because those in the unintended language are inhibited (Green, 1986, 1993).

Costa et al. (1999), performed a series of experiments quite similar to Hermans et al. (1998). However, they interpreted their results as evidence for language-specific selection. According to their view of language-specific selection, it is possible to have activation of candidates in the nonresponse language without assuming that all activated alternatives are candidates for selection. Like Hermans et al., Costa et al. also obtained semantic interference and phonological facilitation in the picture-word interference task regardless of the language of the distractor word. A critical finding that they use to argue for language-specific selection comes from the results for translation distractors (e.g., the Spanish distractor "mesa [table]" for the Catalan picture name "taula [table]"). If lexical candidates from both languages compete for selection, a distractor that is the translation itself should produce the most interference of all because the lexical node in the nonresponse language receives activation from two sources, the picture and the distractor word, and is highly activated as a competitor. In contrast, if lexical candidates are active in both languages but selection is restricted to the response language, then the translation distractor word should produce facilitation relative to the unrelated distractor word because only lexical alternatives in the response language are considered for selection and the translation distractor word activates not only the lexical node of the translation equivalent in the nonresponse language but also the lexical node in the response language through the conceptual representation of the distractor word. On this view, the selection mechanism does not consider the highly activated lexical node of the translation equivalent of the picture name as a possible response. Therefore, there should be no interference but facilitation. Costa et al. found that Catalan-Spanish bilinguals named pictures with a translation distractor word faster than with an unrelated distractor word and claimed that lexical selection is language-specific.

Although translation facilitation has been observed in other studies with different language pairs (e.g., Costa & Caramazza, 1999 for Spanish-English/English-Spanish bilinguals; Hermans, 2000 for Dutch-English bilinguals), Hermans (2004) argues that translation facilitation itself cannot be taken as evidence for either language-specific or language-nonspecific selection. Hermans demonstrated that picture naming latencies in the L2 English were faster when the translation of the L1 Dutch distractor word was phonologically related to the target picture name in L2 (e.g., "geld [money]" for naming the picture of a "monkey") and was a picture that had appeared in another trial during the experiment compared to a control condition. Together with translation facilitation found in previous research (Costa & Caramazza, 1999; Costa et al., 1999; Hermans, 2000), these results suggest that the translation distractor activates the phonological codes of the to-be-named picture, resulting in facilitation. Given the finding that the magnitude of facilitation is smaller for translation distractors in the nonresponse language than for identity distractors in the response language (Costa et al., 1999), Hermans (2004) points out that language-nonspecific theorists would argue that cross-language competition reduces the activation of the phonological codes of the to-be-named picture, whereas language-specific theorists would claim that the distractor word in the response language can activate the phonological codes of the to-be-named picture more. Therefore, Hermans argues that translation facilitation itself does not unequivocally support either type of the models.

Finally, despite the frequent use of the picture-word interference paradigm, it is important to note that there has been criticism task. Most critically for understanding bilingual production, because distractors in the nonresponse language engage bottom-up activation when they are heard as spoken words or read, it is unclear whether the observed cross-language activation results from processing engaged by speech planning (i.e., naming a picture), to the bottom-up activation of the distractor, or to an interaction between these two processes (see Costa, La Heij, & Navarrete, 2006 for similar concerns).

Language Mixing/Switching

Another paradigm that has been used to examine bilingual production is language mixing/switching in which bilinguals are cued to speak in one of their two languages in a mixed language sequence. Past research on language mixing/switching has shown that language mixing affects L1 and L2 differently (e.g., Kroll et al., in preparation; Meuter & Allport, 1999; Miller, 2001). Meuter and Allport (1999) asked unbalanced bilinguals to name Arabic numerals in their L1 and L2 based on color cues (e.g., if the background is yellow, name the number in L1 and if it is blue, name it in L2). A critical result was that there was a greater switch cost from L2 to L1 than from L1 to L2, which suggests that greater inhibition of L1 during L2 production than the reverse. In other words, the greater suppression of L1 when speaking L2 makes it harder to reactivate the L1 on the subsequent trial and produces an asymmetrical pattern of switch costs. This result is consistent with the models of nonselective activation and language-nonspecific selection such that lexical alternatives from both languages compete for selection.[9] A possible mechanism of lexical selection has been proposed within the Inhibitory Control model (Green, 1998). The model assumes that in the process of planning a spoken utterance, both L1 and L2 lemmas are activated and that lemma selection is dependent on which language is more active at a given time. A task schema is hypothesized to be responsible for controlling the level of activation of lemmas in the nonresponse language. When bilinguals intend to speak in one language, the task schema effectively suppresses the activation of lemmas in the unintended language. The model assumes that it is more difficult to suppress L1 than L2 because L1 is normally more active than L2. Crucially, inhibition is reactive rather than proactive in the sense that only once candidates are activated is there inhibition of the nontarget alternatives.

In a recent paper, Costa and Santesteban (2004) argued against an inhibitory account of language switching. In a series of language switching experiments using picture rather than number naming, they replicated the asymmetrical switch costs in L1 and L2 for unbalanced bilinguals, but not for balanced bilinguals. Balanced bilinguals produced a symmetrical pattern of switch costs. This finding itself can be understood as evidence for an inhibitory control mechanism in which the degree of inhibition is a

[9] Recently, Finkbeiner, Almeida, Janssen, and Caramazza (2006) have shown that the asymmetrical switch cost in unbalanced bilinguals is eliminated when stimuli are not bivalent, a result that potentially challenges the Inhibitory Control model.

function of the relative activation of the two languages. Because the balanced bilinguals are equally proficient in their L1 and L2, the amount of suppression that is necessary to speak in the intended language is similar for L1 and L2, which results in symmetrical switch costs. However, a critical result in their study was that balanced bilinguals also produced symmetrical switch costs when switching between L1 and L3, although L3 is not nearly as active as L1 or L2. If the amount of suppression were the account for the symmetrical switch cost to L1 and L2 in balanced bilinguals, then the balanced bilinguals should have shown an asymmetrical switch cost when they switched between L1 and L3. Based on these results, Costa and Santesteban claimed that balanced bilinguals who have attained high proficiency in two languages can apply a language-specific selection mechanism in which no inhibition is involved, not only to their highly proficient L1 and L2 but also to their less proficient language, L3

Similar to the weaknesses that have been identified in the picture-word interference paradigm, some may point out that language switching tasks also induce cross-language activation artificially by having bilinguals name numbers or pictures in two languages. In both switch and nonswitch trials, naming occurs in a mixed language context in which both languages are necessarily active. In fact, Grosjean (2001) raises concern about the language mode during the experiment and argues that the procedure and the stimuli force the participant to be in a bilingual mode (i.e., activating both of their languages), which results in the nonselective activation that has been reported in past bilingual research.

One way to compensate this weakness is to combine two paradigms. In combination with the simple picture naming and language mixing paradigms, Kroll et al.

(in preparation) showed that picture naming in L1 is slower when it is blocked by language of production than when it is mixed, whereas there is no difference in picture naming in L2 between blocked and mixed conditions. In other words, for the L2, there is little consequence of requiring both languages to be active, whereas there is a great cost on L1, suggesting that L1 is normally active when speaking L2. Critically, this pattern occurred for highly proficient Dutch-English bilinguals, which suggests that it is not simply a problem in producing L2 for learners.

In sum, there is converging evidence for nonselective activation although there is disagreement as to the manner of lexical selection and the locus of language/lexical selection. However, it is important to note that virtually all of the evidence we have reviewed regarding the nonselectivity of lexical access has come from bilinguals whose two languages share the same Roman alphabets. Shared script makes two languages more ambiguous and may itself contribute to the observed language nonselectivity. The main question in this dissertation was whether lexical access in production is also language nonselective for bilinguals whose languages differ in script. The present research examined the consequence of script differences for language selection and more generally evaluated the role of orthography in production by comparing the performance of Spanish-English bilinguals and that of Japanese-English bilinguals on a series of production tasks.

Chapter 2 first presents cross-linguistic differences between Japanese and English, followed by research on the role of orthography during production. The next chapter also further discusses the notion of "language cue" and presents the available empirical evidence although the research reviewed in this chapter suggests that the intention to speak a word in one language alone is not sufficient to activate only lexical alternatives in the intended language. Then, the general predictions and methods for the present research are introduced. The approach in the experiments to be reported followed the review presented in the present chapter: one study examined cognate facilitation in simple picture naming, a second study used the picture-word interference paradigm to compare same and different-script bilinguals, and a third study investigated language switching performance.

CHAPTER 2

AN OVERVIEW OF THE EXPERIMENTS AND GENERAL METHOD

The research reviewed in Chapter 1 converges on the conclusion that both languages are active during L2 word production. However, most of the evidence for cross-language activation during speech planning in the L2 comes from bilinguals whose two languages share the same Roman alphabets. Little research has examined the consequences of a life experience of bilingualism with languages whose scripts differ for word production. It is possible that different scripts modulate the cross-language activation that has been observed in previous studies of same script bilinguals. The first half of this chapter presents cross-linguistic differences between English and Japanese and the role of orthography in production and explains how these differences might modulate the presence of cross-language activation in spoken production. We then consider how this issue might be investigated in the production paradigms reviewed in Chapter 1.

Is Selective Lexical Access Possible?

Cross-Linguistic Differences between English and Japanese

English and Japanese differ in many respects. At the sentence level, one of the major differences is that English is a head-initial language, whereas Japanese is a head-final language. Parsing research has exploited the cross-linguistic difference in the head parameter to determine whether the parsing mechanism is universal (e.g., Kamide &

Mitchell, 1999). At the lexical level, the most noticeable difference between English and Japanese is in script. English uses an alphabetic script, whereas Japanese uses both logographic kanji and syllabic kana. Kanji and kana play different roles in written Japanese.[1] Kanji is often used to represent content words, whereas kana is used for both content words and grammatical elements such as inflectional endings of verbs, adjectives, and adverbs. A single kanji character can be phonologically ambiguous without context (e.g., 木 "tree" can be read as [ki], [bo.ku], or [mo.ku] in isolation. However, once the kanji木 is combined with the kanji 大 as in 大木 "big tree," it must be pronounced as [bo.ku].), whereas a single kana syllable is phonologically unambiguous (e.g., き has only one reading [ki].). On the other hand, kana words can be semantically ambiguous (e.g., あめ can be 雨 "rain" or 飴 "candy."), whereas kanji words are not (e.g., The kanji 雨 word has only the meaning of "rain."). These differences in characteristics between kanji and kana are reflected in the results of psycholinguistic research, such that phonology is specified earlier in kana than in kanji, whereas semantic access occurs earlier in kanji than in kana (e.g., Chen, Yamauchi, Tamaoka, & Vaid, in press; Ischebeck, 2004; Yamada, 1998). Therefore, kanji is considered as a lexical rather than sublexical script, whereas kana is considered as a sublexical script. In the present research, the distinctive lexical properties of Japanese are exploited to examine the role of script during lexical access in bilingual speech production.

[1] There are two types of kana in Japanese: hiragana and katakana. Hiragana is used for words with Japanese and Chinese origin, whereas katakana is used for loanwords from European languages. Although hiragana and katakana are different alphabets, the number of alphabets is the same and many of the alphabets are similar in shape.

The Role of Orthography in Production

Although it seems that script differences might not influence the process of speech planning because the word itself is not typically present, recent research suggests that all lexical codes are active to some degree in both comprehension and production regardless of the overt presence of the written lexical form. In word recognition, there is compelling evidence to suggest that orthography is active even when the written word is not present in a spoken word recognition task (e.g., Chéreau et al., in press; Donnenwerth-Nolan, Tanenhaus, & Seidenberg, 1981; Ziegler et al., 2003) and that phonology is active when words are presented in written form (e.g., Tan & Perfetti, 1999; Van Orden, 1987). According to the resonance model, all lexical codes (semantics, orthography, and phonology) are connected bi-directionally and modulate processing (Gottlob, Goldinger, Stone, & Van Orden, 1999). In word naming, for example, it takes longer to read homographs, words that have two distinctive phonological representations (e.g., /líd/ and /lɛ́d/ for "lead"), than their control words, suggesting that orthographic and phonological representations are connected bi-directionally and two phonological representations for a homograph compete against each other.

Likewise, recent within-language research suggests that orthography is active during speech production although orthography is not overtly present. Damian and Bowers (2003) demonstrated that production is facilitated in a form-preparation paradigm when a prime and the target are matched both on the initial phoneme and grapheme, but not on the phoneme or on the grapheme alone. This finding has recently been replicated with the picture-word interference paradigm (Osborne, Rastle, & Burke, 2004). Here, picture naming is facilitated only when the name of a target picture and a distractor word are both phonologically and orthographically similar. The important implication of these results is that phonological representations and orthographic representations are connected bi-directionally and that orthography modulates phonological processing during word production.

The present research examines the role of orthography in production by comparing the performance of bilinguals whose two languages share the same script (Spanish/English) with that of bilinguals whose two languages differ in script (Japanese/English). If phonological facilitation in word production depends on the presence of orthographic overlap, then bilinguals whose two languages do not share orthography or script should not reveal these effects.

Language Cue Hypothesis

The activation of non-overlapping orthographic codes across languages is one means by which cross-language phonological activation might be modulated. However, it is also possible that bilinguals' experience of using two languages with distinct properties enables them to use a set of cues that more generally establish language status earlier in processing. In terms of bilingual production models, the presence of structural differences across languages may serve as a language cue to direct lexical access, making the planning of an utterance analogous to monolingual production, or may function to more rapidly inhibit unintended alternatives and thereby facilitate language selection.

Evidence for the language cue hypothesis comes from a translation Stroop study (Miller & Kroll, 2002). The translation Stroop task is formally similar to picture-word interference but instead of a picture as the initiating event, a word is presented for translation. The task is to translate the word as quickly as possible while ignoring a distractor that is presented at some point before, during, or after the presentation of the word to be translated. When the distractor word appears in the language of production, there is semantic interference and form facilitation that is analogous to the results that have been reported for the picture-word task (La Heij et al., 1990). However, when the distractor word appears in the language of the target word to be translated, Miller and Kroll found that there was neither semantic interference nor form facilitation. They argued that in translation, unlike picture naming, there is a cue to language membership available in the target word that initiates the task. If the word appears in Spanish, the bilingual knows not to speak Spanish. Research on task switching suggests that explicit cues reduce switch costs (e.g., Miyake, Emerson, Padilla, & Ahn, 2004). If script differences function as explicit cues to language status and bilinguals can exploit that language-specific information, then the process of planning the spoken utterance becomes similar to a within-language process in which only candidates in the language to be produced compete for selection. Because English and Japanese differ in a number of critical respects, as described above, there may be stronger cues for language status than for English and Spanish.

Goals and Hypotheses of Present Research

The primary goal of the present research was to determine whether language-specific differences, such as script, can modulate cross-language activation, the locus of language selection, and the manner of language/lexical selection (the process of inhibitory control) during bilingual word production. To address this question, a series of production experiments compared the performance of Japanese-English bilinguals with that of Spanish-English bilinguals. Japanese and Spanish are orthographically dissimilar (non-Roman alphabets vs. Roman alphabets), but they are relatively similar in phonology (e.g., five vowels and CV is a dominant syllable structure). Therefore, we attempted to minimize the possibility that observed differences between Japanese-English and Spanish-English bilinguals reflect phonological differences between Japanese and Spanish. We also attempted to match the two bilingual groups as closely as possible on their proficiency in English to enable between-group comparisons.

Three experiments were conducted using the three main paradigms described in Chapter 1 to obtain converging evidence on the role of script in bilingual production: simple picture naming, picture-word interference, and language switching. The materials used were similar to those for which cross-language activation has been observed in past research. A critical manipulation in the present experiments is whether the written lexical form is perceptually present or absent (See Table 2.1.).

If different scripts function as a language cue to direct lexical access selectively, the strongest prediction is that Japanese-English bilinguals can switch off the unintended language and there will be no cross-language activation. This strong view posits that when two languages are orthographically dissimilar, bilinguals develop two separate production mechanisms which do not allow any cross-language activation. A weaker version of this hypothesis is that Japanese-English bilinguals will also show cross-language activation but can select the response language earlier than the same script bilinguals such as Spanish-English bilinguals. The weaker view assumes that bilinguals whose languages are orthographically dissimilar engage the same mechanisms for both languages but that orthographic dissimilarity prevents cross-language competition to some extent, resulting in early language selection.[2] According to this weaker version of the hypothesis, the presence of the script itself in the task may play an important role in modulating the degree of cross-language activation.

Table 2.1.

Overview of Experiments in Present Research

Exp	Task	Task language	Critical item	Script	Goal
Exp 1	Simple picture naming	L1 & L2 picture naming	Cognates & noncognates	Absent in task	To study cross-language activation and language selection
Exp 2	Picture-word interference	L2 picture naming with L1 distractors	Noncognates	Present in task	To study cross-language activation and language selection
Exp 3	Switching picture naming	L1 & L2 picture naming	Noncognates	Absent in task	To study inhibitory control
	Switching word naming	L1 & L2 word naming	Noncognates	Present in task	To study inhibitory control

A second goal of the current study was to assess the degree to which the nature of the linguistic environment (i.e., whether bilinguals find themselves in a context that supports one of their two languages more than the other or both equally), the level of language proficiency, and individual differences in cognitive resources and attentional

[2] Finkbeiner, Gollan, and Caramazza (2006) recently proposed a “selection by threshold” mechanism in which the lexical candidate that has received the highest activation is simply selected without competition and inhibition. Based on this model, it can be hypothesized that Japanese-English bilinguals can have a selective access to the target language because the high activation is achieved by the distinctive script.

control affect the ability to control the activation or inhibition of the unintended language. As mentioned briefly in Chapter 1, there has been a debate over the influence of language dominance and language proficiency on the manner of lexical selection. Costa and Santesteban (2004) suggested that both language specific and language nonspecific models of lexical selection may hold but for different types of bilinguals. Highly proficient bilinguals may have acquired the control mechanisms that allow them to select the intended language without active inhibition of the unintended language. In contrast, L2 learners and less proficient bilinguals may need to inhibit candidates in the unintended language that have been activated during speech planning. At this point, however, very little research has systematically investigated the consequence of the type of bilingualism and the context in which the two languages are used. A recent study of elderly bilinguals suggests that the experience that bilinguals have across their lifespan in learning to selectively ignore the irrelevant language may result in positive cognitive consequences for executive control (Bialystok, Craik, Klein, & Viswanathan, 2004). However, few studies have asked whether there is any consequence of the way in which bilingualism is manifest in bilinguals who receive distinct support from their environment for maintaining both languages actively relative to those who receive support for only one of their two languages in an environment that is strongly dominant in one language. A goal of the present work is to begin to investigate this issue by comparing the performance of Japanese-English and Spanish-English bilinguals who are immersed in an L2 environment in which English is the dominant language with the same type of bilinguals who have become relatively proficient in the L2 but are living in their L2 environment.

To examine these issues, a series of proficiency and individual difference measures was included in each of the three experiments and data were collected at three different locations—the L2 environment (United States) and the L1 environment (Spain and Japan). If the availability of the L1 in the external environment influences the degree of activation of L1 lexical competitors during L2 word production, bilinguals in an L1 dominant environment should be the most susceptible to cross-language competition from L1 to L2 and bilinguals in an L2 dominant environment should be the least susceptible. Alternatively, if the activation of cross-language candidates reflects a bilingual's level of proficiency rather than the immediate availability of the nontarget language in the environment, then bilinguals at comparable levels of proficiency should reveal similar cross-language interactions.[3]

In the remainder of this chapter, the participants, tasks, and materials, and the logic of each experiment are explained, followed by the description of proficiency and individual difference measures.

General Method

Participants

Bilingual participants fell into four critical groups, all of whom were non-native English speakers: (1) Spanish-English bilinguals living in the United States (L2

[3] There may be self-selection issues that complicate the comparison of bilingual groups living in the L1 vs. the L2 environment. In the present study, a set of cognitive tasks were included in addition to language processing tasks and measures of language proficiency that should make it possible, at least to a first approximation, to ensure that the groups compared across contexts are otherwise equivalent. These measures are explained at the end of this chapter.

environment); (2) Japanese-English bilinguals living in the United States (L2 environment); (3) Spanish-English bilinguals living in Spain (L1 environment); (4) Japanese-English bilinguals living in Japan (L1 environment).[4] The last two participant groups were included to address the question of whether the external linguistic environment modulates the activation and inhibition of the unintended language. Unfortunately, the bilinguals in the L1 environment were included only in Experiment 1 because the materials and program scripts for Experiments 2 and 3 had not been ready at the time of testing in Spain and in Japan. However, the data available allow for at least a preliminary test of the language context hypothesis.

In addition to bilingual participants who were non-native speakers of English, native English speakers who were functionally monolingual were recruited from the psychology department subject pool to serve as controls and for the purpose of norming.

Experiment 1: Simple Picture Naming

In the first experiment, the task was simple picture naming in which participants were asked to name each picture in their L2 English or in their L1 Spanish/Japanese. The language of picture naming was blocked and all bilinguals first named pictures in their L2 English and then in their L1 Spanish or Japanese. The critical materials were cognates, translation equivalents that are phonologically and orthographically similar in both English and Spanish (e.g., guitar-guitarra) and phonologically similar in both English and Japanese (e.g., guitar-ｷﾞﾀｰ [gi.ta.a]), and noncognate controls that were matched on lexical properties with the cognates. As reviewed in Chapter 1, a number of studies have shown

[4] In the present research the term "bilingual" is used liberally to refer to individuals who actively use two languages.

that there is facilitation for naming pictures whose names are cognate translations (e.g., Costa et al., 2000; Kroll et al., in preparation). These results suggest that the L1 name of the picture is activated to the level of the phonology when naming in L2. The logic of the simple picture naming experiment with cognate materials was to determine whether there is cognate facilitation even when two languages differ in scripts (i.e., when cognate status is based on shared phonology only) and to replicate the cognate facilitation effect when two languages share the same scripts. Although cross-script cognate facilitation has been observed in comprehension (e.g., Gollan et al., 1997; Kim & Davis, 2003), it has not been reported in production. If the name of the picture in the unintended language is activated at the phonological level even when L1 and L2 differ in script, then similar cross-language effects (faster latencies for cognates than for matched noncognate controls) should be observed for all bilinguals. However, to the extent that script differences modulate the cognate effect, then only Spanish-English but not Japanese-English bilinguals are expected to demonstrate the effect.

Another important aspect of the simple picture naming paradigm is that the written lexical form is not perceptually present. Recent within-language research suggests that the orthographic effect can be found during speech production only when orthography is perceptually present in the task (Alario, Perre, Castel, & Ziegler, in press; Roelofs, 2006). In the simple picture naming experiment, the distinct script of the bilingual's language may not modulate the degree of cross-language activation and the locus of language selection. Unlike the within-language research, however, it may be possible to observe an orthographic effect during production in the L2 because the speech planning in the L2 is slower than in the L1 and makes it more likely to reveal the effects of orthographic feedback if they are present (e.g., Kroll et al., 2006). Furthermore, the presence of script differences across languages may serve as a language cue to direct lexical access or may function to more rapidly inhibit unintended alternatives and thereby facilitate lexical selection (e.g., Miller & Kroll, 2002). If script functions as an explicit cue to language status and if bilinguals can exploit that information, then the process of speech planning becomes similar to the monolingual case for different script bilinguals even when the task itself does not contain the lexical written form.

As mentioned above, four groups of bilinguals participated in Experiment 1. The comparison of bilinguals in the L1 environment and those in the L2 environment allowed us to examine the contribution of the external linguistic environment to the activation and inhibition of the unintended language. Spanish-English bilinguals in the United States and those in Spain were matched on proficiency and individual difference measures, described below. Likewise, Japanese-English bilinguals in the United States and those in Japan were matched on proficiency and individual difference measures. If the availability of the L1 in the external environment influences the degree of activation of L1 lexical competitors, bilinguals in the L1 environment should be more susceptible to cross-language competition from L1 to L2 when naming pictures in the L2 and should be less susceptible to cross-language competition from L2 to L1 when naming pictures in the L1 than bilinguals in the L2 environment.

Experiment 2: Picture-Word Interference

Much of the research on bilingual word production has used a picture-word interference task to investigate processes that contribute to the planning of spoken utterances (e.g., Costa & Caramazza, 1999; Costa et al., 2003; Costa et al., 1999; Hermans et al., 1998). Experiment 2 used the picture-word interference paradigm in which participants were asked to name a picture of an object in their L2 while ignoring an L1 distractor word that was visually presented with the picture. In Experiment 2, pictures were all noncognates and the L1 distractor word was semantically or phonologically related to the picture's name in L2, the L1 translation equivalent, phonologically related to the L1 translation equivalent, or an unrelated control that was matched on lexical properties with the related distractor word. As reviewed earlier, past research has shown cross-language semantic interference, phonological facilitation, translation facilitation, and phono-translation interference (e.g., Hermans et al., 1998), suggesting that for at least a brief time during the planning of a spoken utterance in one language, candidates in the other language are also active.

However, virtually all of this past research has examined bilingual performance for bilinguals whose languages are orthographically similar. The hypothesis to be tested is that distractor words in a language whose script is different from the target language may provide a language cue to production that will inhibit the activation of cross-language competitors. Unlike simple picture naming in Experiment 1, the written lexical form in the unintended language of production was perceptually present during the picture-word interference task. If L1 distinctive script functions as a language cue to inhibit cross-language activation and to select a response language, the strongest prediction is that no semantic interference, phonological facilitation, translation facilitation, or phono-translation interference would be observed for Japanese-English bilinguals. This strong view posits that when two languages are orthographically dissimilar, bilinguals develop two separate production mechanisms which do not allow any cross-language activation. A weaker version of this hypothesis predicts that the magnitude of semantic interference, phonological facilitation, translation facilitation, and phono-translation interference would be smaller for Japanese-English bilinguals than for Spanish-English bilinguals and that language selection would occur earlier for Japanese-English bilinguals than for Spanish-English bilinguals because the degree of the activation of the unintended language Japanese is smaller due to the distinct orthography. The weaker view assumes that bilinguals whose languages are orthographically dissimilar engage the same mechanisms for both languages but that orthographic dissimilarity prevents cross-language competition to some extent, resulting in early language selection.

Experiment 3: Language Switching in Picture and Word Naming

Experiment 3 used a switching paradigm that allows us to examine the process of inhibitory control and its consequences on word production in the L1 and L2. The switching experiment examined picture and word naming when bilinguals were required to switch between their two languages. A set of pictures with noncognate names in English, Spanish, and Japanese was selected for picture naming and the same set of items was used for word naming as well. Pictures or words were displayed on a colored background that served as a cue to the language to be produced (e.g., name pictures on a blue background in L1 and on a red background in L2). The alternating runs paradigm

(Rogers & Monsell, 1995) was used with a predictable sequence of two trials in L1, two trials in L2, etc. To our knowledge, Experiment 3 is the first bilingual switching study that utilizes word naming as a primary task in addition to picture naming.

The Inhibitory Control model assumes that in the process of planning a spoken utterance, both L1 and L2 lemmas are activated and that lemma selection is dependent on which language is more active at a given time (Green, 1998). When bilinguals intend to speak in one language, the task schema effectively suppresses the activation of lemmas in the unintended language. The model assumes that it is more difficult to suppress L1 than L2 because L1 is normally more active than L2. Past research on language switching has shown that a greater switch cost is observed for L1 than for L2 if bilinguals are not balanced, suggesting that the suppression of L1 during L2 production requires more effort than the suppression of L2 during L1 production (e.g., Meuter & Allport, 1999). The greater suppression of L1 when speaking L2 makes it harder to reactivate the L1 on the subsequent trial and produces an asymmetrical pattern of switch costs.

If Japanese-English bilinguals can suppress cross-language activation more effectively than Spanish-English bilinguals, then the switch cost for L1 should be greater for Japanese-English bilinguals because of the greater suppression of the L1 than for Spanish-English bilinguals and that both groups would show an asymmetrical switch cost—a greater cost for L1 than for L2. An alternative prediction, however, is that Japanese-English bilinguals can use the language cue inherent in the script difference to reduce the switch cost and thus should show symmetrical switch costs. In fact, a recent study has shown that when the stimulus includes a strong and unambiguous cue (e.g., Arabic numerals vs. Chinese logographic numerals), switch costs are symmetrical

(Meuter & Tan, 2003). Another possibility is that Japanese-English bilinguals may show an asymmetrical switch cost for picture naming when a language cue (i.e., a color of the background) is ambiguous and a symmetrical switch cost when there is an unambiguous language cue (i.e., the written lexical form in a different script) as well as a color of the background. However, Spanish-English bilinguals would show an asymmetrical switch cost for both picture naming and word naming because there is no overt language cue available.

Taken together, these three experiments allowed us not only to determine whether the presence of cross-language activation, the locus of language selection, and the process of inhibitory control can be modulated by language-specific differences but also to test the assumption that orthography plays a role when the written lexical form is overtly present or absent in production tasks.

Proficiency Measures

It was critical to match two bilingual groups as closely as possible on the level of their L2 English proficiency in the proposed research to eliminate the possibility that differences between the two groups arise from their different levels of proficiency in English. There is little agreement in the literature about how this should be done, but in the present research we used three measures to develop a converging assessment of proficiency: (1) a language history questionnaire; (2) an on-line processing measure using a lexical decision task in English; (3) a measure of verbal fluency in L1 and in L2. The proficiency measures allowed us to not only compare across bilingual groups and experiments, but also to assess the role of proficiency within groups. Within-group effects would be of interest, especially for conditions in which group by effect interactions were predicted, to assess the developmental trajectory of the target phenomena. The language history questionnaire and the lexical decision task were included in all three experiments, whereas the verbal fluency task was included only in Experiments 2 and 3. Materials, procedure, and data analyses for each of the tasks are described below.

Language History Questionnaire

A questionnaire was designed to obtain information about participants' language learning experiences. It asked participants about their native and home languages, the amount and type of their language learning experiences, the length of living in target language cultures, daily use of L1 and L2, and self-rated proficiency for each of the four language skills of reading, writing, speaking, and listening in their L1 and L2. The self-rated proficiency measure was a 10-point scale with 1 being not proficient and 10 being very proficient. The language history questionnaire is provided in Appendix G.

Lexical Decision Task

A lexical decision task in English was used as an on-line proficiency measure. This task has been used in a number of past studies as a measure of L2 lexical proficiency (e.g., Hermans et al., 1998). Furthermore, some research has shown that a lexical decision task is a valid test to measure the size of vocabulary in L2 (Huibregtse, Admiraal, & Maera, 2002).

Materials

The materials for the lexical decision task were taken from an experiment performed by Azuma and Van Orden (1997) using 56 English words and 56 English pseudo-homophones. The words varied in number of meanings (few, many) and relatedness of word meanings (low, high). If a word had four or less meanings, Azuma and Van Orden classified it as *few*. If a word had six or more meanings, it was classified as many. For relatedness, words with relatedness scores < 3.0 from Azuma and Van Orden's norming study were classified as *low*, whereas words with relatedness scores > 3.5 were classified as *high*. In short, four types of words were included: 14 words with few meanings and low relatedness (e.g., *bank*), 14 words with few meanings and high relatedness (e.g., *card*), 14 words with many meanings and low relatedness (e.g., *sound*), and 14 words with many meanings and high relatedness (e.g., *cover*). All nonwords were pseudo-homophones, nonwords that sound like real words (e.g., panzy). Four pseudo-randomized lists were created to ensure that no more than three items from the same condition were presented in a row. The lists were counterbalanced across participants. The complete set of the materials is provided in Appendix H.

Procedure

Participants were seated in front of a computer monitor and a button box and received written instructions on the computer screen. They were informed that strings of letters would be presented one at a time on the computer screen. Their task was to decide whether each string of letters was a real English word or not. On each trial, a fixation sign (+) was presented for 500 ms at the center of the computer screen. When the fixation sign was replaced with a string of letters, participants were required to judge whether the string of letters was a real English word or not. If it was an English word, they pressed the “yes” button on the left; if it was not a real English word, they pressed the “no” button on the right. After they responded, a fixation sign appeared for 500 ms again and another string of letters was presented. Ten practice trials preceded the experimental session.

Data Analyses

After trimming RTs for correct responses that were less than 300 ms or greater than 3000 ms, RTs that were 2.5 standard deviations above or below the mean were identified as outliers separately for words and nonwords and excluded from the analyses. Then, the final mean accuracy and the RTs for correct responses were calculated for each condition.

Verbal Fluency Task

A verbal fluency task was included as another measure of language proficiency. Unlike the lexical decision task, the verbal fluency task can measure proficiency in each of their languages by having participants produce name of objects that belong to given categories in each of their languages.

Materials

Four animate categories (animals, body parts, fruits, and vegetables) and four inanimate categories (clothing, colors, furniture, and musical instruments) were adapted from Linck (2005). Two lists were constructed so that each bilingual participant received two animate and two inanimate categories in each of their languages. None of the categories was repeated across two languages and the L1 categories always preceded the L2 categories. The two lists were counterbalanced across participants and the order of categories was randomized within a language for each participant.

Procedure

Participants were seated in front of a computer monitor, a button box, a microphone, and a digital recorder, and first received written instructions on the computer screen. They were told that a series of category names would be presented in their L1 (Spanish/Japanese) one at a time on the computer screen. Their task was to name as many examples that belong to a presented category as possible in their L1 for 30 seconds. On each trial, a category name was presented in the L1 for two seconds, followed by a blank screen. At the end of the 30 seconds, the word "STOP" appeared at the center of the computer screen with a chime. When they were ready to go onto a next trial, they pressed a spacebar. After four trials in the L1, a short break was inserted and participants were told to do the same task in their L2 English for the next four trails. No practice trial was included in either of the languages.

Data Analyses

Recorded responses were transcribed and scored based on the following criteria developed by Linck (2005): (1) the response was scored as *correct* if it was an example of the presented category; (2) the response was scored as a *repetition* if the same example had already been given; (3) the response was scored as a *superordinate category* if it was a general example (e.g., shoes), followed by specific types of the general example (e.g., running shoes, walking shoes); (4) the response was scored as an *error* if the example did not belong to the given category. The total number of correct and superordinate category responses was counted for L1 and for L2 separately and divided by the number of categories that they performed.

Individual Difference Measures

In addition to the proficiency measures, two individual difference measures were included in all of the experiments in the present research to ensure that observed group differences reflect differences in the consequences of specific forms of bilingualism and the constraints of the native language, not in cognitive ability. Past research suggests that individual differences in cognitive resources influence the process of word production (e.g., Ferreira & Pashler, 2002). Because it is difficult to examine differences in cognitive resources separately from L2 proficiency in bilingual groups who speak different native languages (Japanese and Spanish), two language-independent individual difference measures were included in the present research: a measure of executive control (the Simon task) and a measure of processing resources (an operation span task).

Simon Task

The Simon task was included to assess the ability to suppress irrelevant information by requiring participants to attend to the color of the square and ignore its location. Bialystok et al. (2004, 2005) and Bialystok, Martin, and Viswanathan (2005) have shown that performance on the Simon task appears to be sensitive to the consequences of bilingualism, with elderly bilinguals outperforming age-matched monolingual controls. For present purposes, the task may be considered a language-neutral task that can be used to match bilingual groups on cognitive abilities.

Materials

Two colors of the square (28 x 28 pixels) were used—blue and red. These two squares were presented at three different locations during the task—2° right or left of a fixation sign on the center of the screen and the center of the screen. The task consisted of three experimental blocks where there were seven trials for each condition—2 (colors) x 3 (locations). Thus, there were 42 trials in each block and 126 trials in total. The order of trials was randomized.

Procedure

Participants received written instructions on the computer screen. They were told that a blue or red square was presented on the right side, the left side, or the center of a computer screen. They were asked to press the right button on a button box when they saw a red square and the left button when they saw a blue square, regardless of the location of the square. On each trial, a fixation sign appeared at the center of the screen for 350 ms, followed by a blank screen for 150 ms. A red or blue square was displayed either at the right, left, or center of the screen until participants responded or for 2000 ms. If their response was correct, another trial began immediately, preceded by a blank screen for 850 ms. If their response was incorrect, the word "ERROR" was presented at the center of the screen for 1500 ms, followed by a blank screen for 850 ms. Then another trial began. A practice block consisting of 24 trials (four trials for each condition) preceded three experimental blocks. RTs and accuracy for all trials were recorded.

Data Analyses

Trials whose responses were incorrect or whose responses were correct but RTs were over 1500 ms were considered as errors and excluded from both RT and accuracy analyses. Furthermore, the trials that immediately followed an incorrect response were also excluded from the RT analyses. The mean RT and accuracy was calculated for three conditions—congruent, incongruent, and neutral. Congruent trials were trials where the color and its location were matched (e.g., a blue square on the left), whereas incongruent trials were those where the color and its location were mismatched (e.g., a blue square on the right). Neutral trials were trials whose stimulus appeared at the center of the screen. The Simon effect was calculated by subtracting the mean RT for the congruent trials from the mean RT for the incongruent trial.

Operation Span Task

An operation span task was used to measure individual differences in cognitive resources. Performance on the operation span task appears to predict the efficiency of language processing as well as reading and speaking span measures but again minimizing the contribution of language-specific processing (Turner & Engle, 1989).

Materials

Sixty simple arithmetic equations (e.g., (4*2) – 2 = 2, (16/2) – 5 = 3) and 60 English words were taken from Tokowicz, Michael, and Kroll (2004). Half of arithmetic equations were incorrect and the other half correct. The complete set of the materials is in Appendix I.

Procedure

Participants received written instructions on the computer screen. They were asked to solve a series of simple arithmetic operations that appeared, one by one, on the screen, and to decide whether the presented equation was correct or not as quickly and accurately as possible while remembering a series of presented words.

Participants initiated each set by pressing a *yes* button (on the left) or a *no* button (on the right). A fixation sign (+) appeared immediately after the button press and remained at the center of the screen for 1000 ms. The fixation sign was then replaced by an equation, and participants were required to judge whether the equation was correct or not. If it was correct, they pressed the “yes” button; if it was not, they pressed the “no” button. After they responded or 3750 ms after the offset of the fixation sign, an English word was appeared for 1250 ms. Then, a fixation sign appeared again and another equation was presented. The equations and English words in this task were divided into sets of two to six pairs. After every series of three sets, the set size increased. At the end of each set, the word *RECALL* appeared, followed by a blank screen. At this point, participants were asked to use the keyboard to type all the English words in the set. The words did not have to be the order in which they saw, but they could not type the last word first. When they finished recalling as many of the words as they could, they pressed the ESC key to begin the next set. Two practice sets (one set with four pairs and another set with six pairs) preceded the experimental sets. RTs and accuracy for the equation judgment and typed responses for the recall part were recorded.

Data Analyses

The mean RTs for correct judgments were calculated separately for “yes” and “no” stimuli. RTs that were 2.5 standard deviations above or below the mean were identified as outliers and excluded from the analysis. We then counted the number of words that were recalled correctly among correct responses to the equation judgment. This number was used as an index of the participant’s operation span.

Together with these proficiency and individual difference measures, this dissertation research investigated the consequences of bilingualism with languages whose scripts differ on word production by conducting three experiments with different paradigms described above.

CHAPTER 3

EXPERIMENT 1: SIMPLE PICTURE NAMING

The primary goal of Experiment 1 is to determine to what extent the degree of cross-language activation and the locus of language selection during word production are modulated by orthographic characteristics of the L1 in a simple picture naming task. As mentioned in Chapter 1, past research on this task with bilingual speakers has shown that pictures whose names are cognates in the two languages are named more quickly than pictures whose names are noncognates (e.g., Costa et al., 2000; Kroll et al., in preparation). The facilitation for naming cognate pictures suggests that lexical candidates in the unintended language are activated to the level of phonology. However, the previous results are based on the performance of bilinguals whose two languages are orthographically similar (Spanish and Catalan in the study by Costa et al., 2000, and Dutch and English in the study by Kroll et al., in preparation). The main goal of the present experiment is to determine whether the conclusion that there is activation of the nontarget language all the way to the level of the phonology is restricted to bilinguals whose L1 and L2 are orthographically similar (i.e., share the same Roman alphabets). In other words, the purpose of Experiment 1 was to determine whether there is cognate facilitation even when two languages differ in scripts (i.e., when cognate status is based on shared phonology only) and to replicate the cognate facilitation effect when two languages share the same scripts (i.e., when cognate status is based on shared phonology and orthography).

As reviewed in previously, recent research suggests that all lexical codes are active to some degree even in production. Damian and Bowers (2003) demonstrated that production is facilitated in a form-preparation paradigm when primes and targets are matched on both initial phonemes and graphemes, but not on either one alone. Osborne et al. (2004) replicated this result in the picture-word interference task, showing that naming was facilitated only when the names of target pictures and distractor words were phonologically and orthographically similar. The implication is that lexical codes are connected bi-directionally such that orthography modulates phonological processing during word production. If orthography modulates phonological processing, then the cognate facilitation should be greatest for bilinguals whose two languages share the same scripts, but diminished or absent for bilinguals whose two languages differ in script.

However, it is important to note that unlike the previous studies with the form-preparation paradigm and the picture-word interference paradigm, the written lexical form is perceptually absent during production in the simple picture naming task that the present experiment used. Indeed, other recent studies indicate that the orthographic effect can be found during speech production only when orthography is perceptually present in the task (Alario et al., in press; Roelofs, 2006). Most relevant to the present study is the observation that the role of orthography on production has been evaluated only in L1. Although simple picture naming does not involve the explicit presentation of words and therefore orthography, the extended time course of planning in the L2 make it more likely to reveal the effects of orthographic feedback if they are present (e.g., Kroll et al., 2006).

Furthermore, the presence of script differences may serve as a language cue or may function to inhibit unintended alternatives and thereby facilitate lexical selection (e.g., Miller & Kroll, 2002). If script functions as an explicit cue to language status and if bilinguals can exploit that information, then the process of speech planning may become similar to the monolingual case.

In Experiment 1, the performance of two groups of bilinguals was compared. One group, Spanish-English bilinguals, has the same script in each of their languages. The other group, Japanese-English bilinguals, has different writing systems associated with each language. Although Japanese-English cognates are loanwords from English and are scripted in katakana and noncognate controls are Shino-Japanese words written in kanji or hiragana (sometimes preferred to be written in katakana as well), all of these scripts are different from English/Spanish scripts and were not presented in simple picture naming. If the name of the picture in the non-target language is activated at the phonological level even when L1 and L2 differ in script, then similar cross-language effects (i.e., faster latencies for cognates than for matched noncognate controls) should be observed for all bilinguals. However, to the extent that script differences serve as a language cue to direct lexical access selectively and/or modulate phonological processing, then only Spanish-English but not Japanese-English bilinguals are expected to demonstrate the cognate effect.

A second goal of Experiment 1 is to evaluate the contribution of the external linguistic environment in constraining cross-language activation. The logic here is to compare bilinguals who differ in the degree to which their L2 is supported by virtue of being immersed in an L2 environment (English spoken in the United States) or in an L1 environment (English spoken in Japan/Spain). Although a range of claims has been made about the factors that control the relative activation of the bilingual's two languages (e.g., Grosjean, 2001), there have been very few studies that have systemically investigated this issue (see Dijkstra, De Bruijn, Schriefers, & Ten Brinke, 2000, for an illustration in the realm of word recognition). Recent semantic priming studies have shown that the sensitivity to L2 semantics appears to depend on bilinguals' language experience in addition to proficiency (e.g., Kotz & Elston-Güttler, 2004; Silverberg & Samuel, 2004). If the availability of the L1 in the external environment influences the degree of activation of L1 lexical competitors, bilinguals in the L1 environment should be more susceptible to cross-language competition from L1 to L2 when naming pictures in the L2 and should be less susceptible to cross-language competition from L2 to L1 when naming pictures in the L1 than bilinguals in the L2 environment. Alternatively, if the activation of cross-language candidates reflects a bilingual's level of proficiency rather than the immediate availability of the nontarget language in the environment, then bilinguals at comparable levels of proficiency should reveal similar cross-language interactions.

Method

Participants

Forty-three Spanish-English bilinguals and 28 Japanese-English bilinguals participated in Experiment 1. Twenty-seven Spanish-English and 17 Japanese-English bilinguals were recruited from The Pennsylvania State University. Sixteen Spanish-English bilinguals were recruited from the University of Granada, Granada, Spain and 11 Japanese-English bilinguals were recruited from Tsuda College, Tokyo, Japan. Of these 27 Spanish-English and 17 Japanese-English bilinguals from The Pennsylvania State

University, one Spanish-English bilingual and one Japanese-English bilingual were excluded from all analyses due to technical difficulties caused by an audio recording setting. In the Spanish-English bilingual group in the United States, seven additional participants were removed because they were heritage speakers of Spanish and were English dominant. The remaining 35 Spanish-English bilinguals (United States: $n = 19$; Spain: $n = 16$) and 27 Japanese-English bilinguals (United States: $n = 16$; Japan: $n = 11$) were included in the data analyses.

Materials

Seventy-two black-and-white line drawings were sampled from Snodgrass and Vanderwart (1980) and Szekely et al. (2003, 2004). Half of the pictures had cognate names for one or both of the two bilinguals groups and the other half had noncognate names. Each cognate picture was matched as closely as possible with a noncognate picture on word length of the picture's name (number of characters and number of syllables), frequency, age of acquisition, name agreement, familiarity, imageability, visual complexity, which are variables that have been found to influence picture naming latencies in past research (e.g., Alario et al., 2004; Cuetos, Ellis, & Alvarez, 1999; Ellis & Morrison, 1998; Snodgrass & Yuditsky, 1996), word naming latencies, and phonological onset in English.[1] The characteristics of the pictures are summarized in Table 3.1.

[1] The International Picture Naming Project database did not include the data for one noncogate picture and the paired-sample comparisons for age of acquisition, name agreement, and visual complexity were conducted with 35 pairs of cognate and noncognate control. The MRC Psycholinguistic database did not have the familiarity data for five cognate items and six noncognate items, resulting in the paired-sample comparison with 27 pairs. Likewise, there were eight cognate items and seven

Table 3.1.

Characteristics of Materials in English Used in Experiment 1

Variable	Cognates	Noncognates	*p* value (t-test)
Number of characters	5.7	5.2	.057
Number of syllables	1.8	1.4	.014
Frequency (per million words)[a]	18.7	18.5	*ns*
Age of acquisition (1-3 point scale)[b]	2.2	2.0	*ns*
Name agreement (%)[b]	93.1	91.7	*ns*
Familiarity (100-700)[c]	531	529	*ns*
Imageability (100-700)[c]	597	598	*ns*
Visual complexity (KB)[b]	15225	16161	*ns*
Word naming latencies (ms)[d]	633	614	.096

Notes. [a]Kučera & Francis (1967). [b]Data from the International Picture Naming Project database (Szekely et al., 2003, 2004). [c]Data from the MRC Psycholinguistic database (Coltheart, 1981). [d]Data from the English Lexicon Project database (Balota et al., 2002).

As can be seen in Table 3.1., the cognate picture names were longer in length and word naming latencies than the noncognate picture names [$t(35) = 1.97$, $p = .057$ for the number of characters; $t(35) = 2.58$, $p < .05$ for the number of syllables; $t(35) = 1.71$, $p = .096$ for the word naming latencies]. However, it is important to remember that if bilinguals show a difference in picture naming latencies and accuracy, they should be faster and more accurate for cognates than for noncognates. If anything, the small

---

noncognate items missing in the imageability data set from the MRC Psycholinguistic database. Therefore, the comparison was conducted with 24 pairs.

differences in the lexical properties of the critical items would be predicted to work against finding cognate facilitation.

As illustrated in Table 3.2., the cognate pictures were categorized into three types: cognates in English, Spanish, and Japanese, cognates in English and Spanish, and cognates in English and Japanese. Although Japanese cognates are all loanwords from English, some of the Spanish cognates are also loanwords from English. It is important to note that Spanish cognates share both phonology and orthography, whereas Japanese cognates share only phonology. The complete set of the experimental materials is provided in the Appendix D.

Table 3.2.

Examples of Materials by Cognate Type and Cognate Status

	Cognate			Noncognate		
Cognate type	English	Spanish	Japanese	English	Spanish	Japanese
English, Spanish, & Japanese	**guitar**	**guitarra**	**ｷﾞﾀｰ (gi.ta.a)**	glasses	gafas	ﾒｶﾞﾈ (me.ga.ne)
English & Spanish	**camel**	**camello**	ﾗｸﾀﾞ (ra.ku.da)	clown	payaso	ﾋﾟｴﾛ (pi.e.ro)
English & Japanese	**shirt**	camisa	**ｼｬﾂ (sha.tsu)**	sheep	oveja	ﾋﾂｼﾞ (hi.tsu.ji)

Note. Cognates are bolded.

Four pseudo-randomized lists were created to ensure that no more than three items from the same condition, from the same semantic category, and with the same phonological onset or rhyme were presented in a row. The lists were counterbalanced across participants.

Furthermore, the phonological similarity of the materials was normed to ensure that observed cross-language differences in the present experiment, if any, are due to script but not to differences in phonological similarity. Eighteen English monolinguals who had not studied Spanish and 25 English monolinguals who had not studied Japanese were asked to rate sound pairs consisting of a Spanish word and its English translation or a Japanese word and its English translation respectively according to how similar two words sounded on a 7-point Likert scale with “1” being completely different and “7” being identical (see Appendix A1 for the details of the phonological similarity rating norming experiment). The mean ratings for each condition are summarized by sound pairs in Table 3.3. An important result in the norming experiment is that monolingual English speakers perceived the phonological similarity of cognates to be greater than noncognates for both language groups.

Table 3.3.

Phonological Similarity Ratings for Cognates and Noncognates across English, Spanish, and Japanese

	Spanish-English pairs		Japanese-English pairs	
Cognate type	Cognate	Noncognate	Cognate	Noncognate
English, Spanish, & Japanese	4.9 (1.0)	2.0 (0.8)*	4.9 (1.1)	1.3 (0.3)*
English & Spanish	3.5 (1.0)	1.7 (0.4)*	1.2 (0.2)	1.3 (0.2)
English & Japanese	1.4 (0.2)	1.3 (0.2)	4.3 (1.3)	1.3 (0.3)*

Note. Standard deviations are in parentheses. *Differences between cognate and noncognate control items were significant at $p < .001$

Procedure

Participants were tested individually in a quiet room. They were seated in front of a computer monitor, a button box, a microphone connected to the button box and a digital recorder. All participants were given the picture naming task in their L2 English, followed by the lexical decision task in English, the Simon task, the operation span task, and the language history questionnaire (see Chapter 2 for the materials, procedure, and data trimming/scoring regarding the proficiency and individual differences measures). At the end of the experiment, the participants were asked to perform the same picture naming task in their L1, Spanish or Japanese.

In the L2 picture naming task, participants first received written instructions in English on the computer screen. They were informed that a series of pictures would be presented one at a time on the computer screen. Their task was to name the pictured object in English as quickly and accurately as possible. At the beginning of each trial, a fixation sign (+) was presented at the center of the computer screen. At the press of a button, the fixation sign was replaced with a blank screen and 500 ms after the offset of the fixation sign, a picture was presented until the participants responded or for 5000 ms (see Figure 3.1.). Participants were required to name the pictured object in English. If they did not know the name of the object, they were asked to say "no." After they responded, a blank screen was presented for 200 ms and a fixation sign appeared again. Twenty practice trials preceded the experimental session. The pictures used in the practice trials were different from the experimental items. In the present experiment, participants were not taught the expected name of each picture in advance and none of the pictures was repeated.

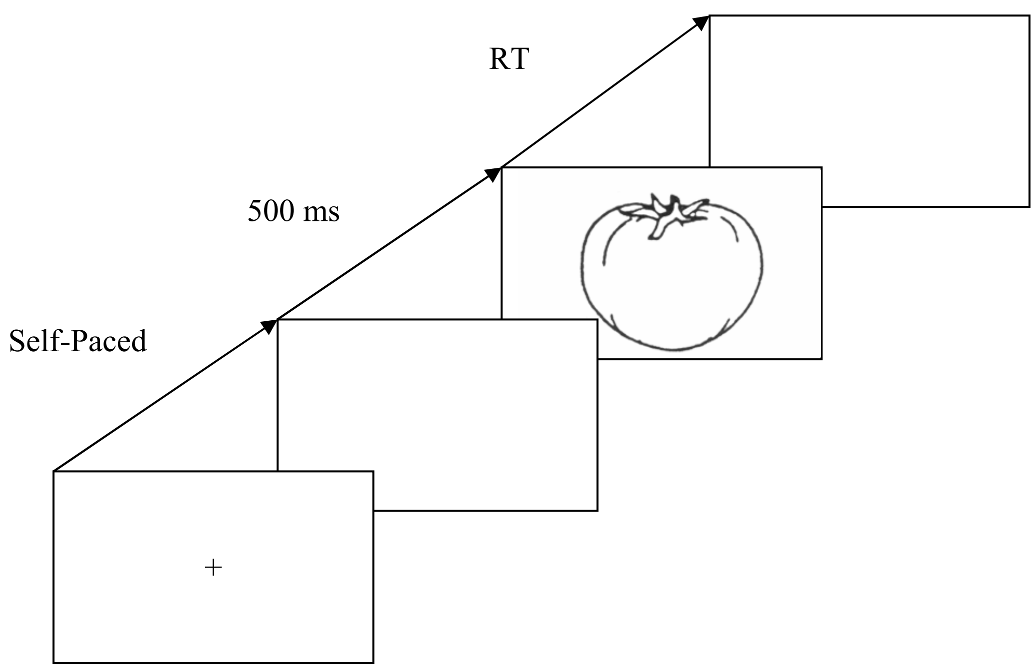


Figure 3.1. An illustration of a trial in the simple picture naming task.

The procedure for the L1 simple picture naming was identical to the L2 simple picture naming other than the requirement that the picture names be spoken in the participants' L1 Spanish or Japanese. If they did not know the name of the object, they were told to say "no" or "iie" in Spanish/Japanese respectively.

Results and Discussion

In the present experiment, the data were analyzed in a variety of ways. In the primary analyses, data from the simple picture naming task in the L2 English and in the L1 Spanish/Japanese were analyzed together for Spanish-English and Japanese-English bilinguals. Furthermore, monolingual control data in English, Spanish, and Japanese were obtained from recent cross-linguistic picture norms (Nishimoto, Miyawaki, Ueda, Une, & Takahashi, 2005; Szekely et al., 2003, 2004) and analyzed in order to make certain that the pattern of the data observed for the bilinguals was the reflection of bilingualism, not the properties of the materials. To examine the contribution of the external linguistic environment to cross-language activation, the same set of the picture naming data in the L2 and L1 was then reanalyzed for each bilingual group.

For statistical analyses, when the assumption of equal variances or the assumption of Sphericity is violated, the equal-variance-not-assumed or the Greenhouse-Geisser is used to adjust the degrees of freedom throughout the dissertation.

Prior to the main data analyses, data from the proficiency and individual difference measures are first analyzed to ensure that the Spanish-English bilinguals and the Japanese-English bilinguals and the Spanish-English and Japanese-English bilinguals in the L1 and in the L2 environments are as closely matched on the proficiency and cognitive ability as possible. Otherwise, the observed differences in the performance on the critical tasks might not reflect differences in the consequences of specific forms of bilingualism, the external linguistic environment, and the constraints of the native language but differences in proficiency or cognitive ability.

Proficiency Measures

Language History Questionnaire

Language history questionnaire data are summarized in Table 3.4. by language groups and external linguistic environments (US vs. Spain/Japan). All of the bilinguals who were included in the subsequent analyses spoke English as an L2 and were more proficient in the L1 than in the L2 English or equally proficient in both languages based on their self-assessed ratings for the L1 and L2.[2] Of these bilinguals, 10 Spanish-English bilinguals (five in the United States and five in Spain) and eight Japanese-English bilinguals (four in the United States and four in Japan) started learning English before the age of 10 years. However, even these bilinguals considered themselves to be L1 dominant.

[2] There was one Japanese-English bilingual who rated herself as more proficient in the L2 English than in the L1 Japanese on the measures of self-reported proficiency. However, she ranked Japanese as a more proficient language rather than English on another question in the language history questionnaire. Furthermore, the length of living in English speaking countries was only 54 months at the time of testing and she has spent the rest of her life in the L1 environment (Japan). Her language background was clearly different from that of the heritage speakers of Spanish who were excluded from the analyses and more similar to the bilinguals who were included in the analyses. Therefore, we did not exclude this Japanese-English bilingual from the analyses.

Table 3.4.

Characteristics of Spanish-English and Japanese-English bilinguals in Experiment 1 by Language Group and External Linguistic Environment

	Spanish-English			Japanese-English		
	US (n = 19)	Spain (n = 16)	Overall (N = 35)	US (n = 16)	Japan (n = 11)	Overall (N = 27)
Age (years)	26.7 (6.2)	23.2 (2.2)	25.1 (5.1)	28.2 (6.5)	24.6 (11.0)	26.6 (8.8)
L1 self-ratings (10 pt scale)						
Reading	9.7 (0.6)	8.6 (1.1)	9.2 (1.0)	9.2 (1.0)	7.9 (1.9)	8.7 (1.5)
Writing	9.5 (0.9)	8.2 (1.0)	8.9 (1.1)	8.8 (1.3)	8.0 (1.7)	8.5 (1.5)
Speaking	9.8 (0.5)	8.3 (1.1)	9.1 (1.1)	9.3 (1.0)	8.3 (2.0)	8.9 (1.5)
Listening	9.8 (0.5)	8.9 (1.1)	9.4 (0.9)	9.4 (1.1)	7.8 (2.3)	8.7 (1.8)
Mean	9.7 (0.5)	8.5 (0.9)	9.2 (0.9)	9.2 (0.9)	8.0 (1.8)	8.7 (1.4)
L2 self-ratings (10 pt scale)						
Reading	8.6 (1.0)	7.4 (1.1)	8.1 (1.2)	7.2 (1.9)	6.6 (1.2)	7.0 (1.7)
Writing	8.1 (1.2)	6.7 (1.2)	7.4 (1.4)	7.1 (2.1)	5.6 (1.3)	6.5 (1.9)
Speaking	8.2 (1.3)	7.1 (1.4)	7.7 (1.5)	6.7 (2.5)	5.4 (1.3)	6.2 (2.2)
Listening	8.3 (1.2)	7.1 (1.4)	7.8 (1.4)	6.9 (2.1)	5.4 (1.4)	6.3 (2.0)
Mean	8.3 (1.1)	7.1 (1.1)	7.7 (1.2)	7.0 (2.0)	5.8 (1.1)	6.3 (1.8)
Mean daily L1 usage (%)	37.9 (23.8)	80.0 (12.6)	57.1 (28.7)	24.7 (24.3)	90.0 (8.1)	51.3 (37.9)
Mean daily L2 usage (%)	59.0 (24.5)	25.1 (18.0)	43.5 (27.5)	69.1 (24.8)	13.6 (9.5)	46.5 (34.1)
L2 age of acquisition (years)	10.4 (4.0)	10.3 (1.9)	10.3 (3.2)	10.7 (3.6)	9.4 (4.5)	10.2 (4.0)
Months of L2 immersion	46.7 (28.3)	8.3 (4.2)	28.6 (28.3)	53.7 (38.5)	23.0 (37.1)	40.7 (40.2)

Note. Standard deviations are in parentheses.

Cross-Language Group Comparisons

Overall, the Spanish and Japanese groups were closely matched on age, L2 age of acquisition (AoA), L1 self-assessed ratings, mean daily L1 and L2 usage, and length of living in English speaking countries (months of L2 immersion). The only significant difference between the two groups was that the self-assessed ratings for L2 English were higher for the Spanish-English than for the Japanese-English bilinguals, $t(60) = 3.31$, $p < .01$, suggesting that the Spanish-English bilinguals perceived themselves to be more proficient in the L2 English than the Japanese-English bilinguals. Given the equivalent level of performance on the simple picture naming task in the L2 English described below (i.e., no main effect of language group for latencies and accuracy), the difference in the L2 ratings seem likely to reflect a cultural difference in the use of the self-assessment scale, replicating previous findings with Spanish-English and Japanese-English bilinguals (Hoshino, Dussias, Kroll, in preparation-a).

Cross-Environment Group Comparisons

As can be seen in Table 3.4., the bilinguals in the L2 environment (US) rated themselves as more proficient in the L1 and in the L2 than those in the L1 environment (Spain/Japan) for both language groups [$t(33) = 4.99$, $p < .001$ for Spanish-English in the L1; $t(33) = 3.43$, $p < .01$ for Spanish-English in the L2; $t(25) = 2.19$, $p < .05$ for Japanese-English in the L1; $t(25) = 1.82$, $p = .081$ for Japanese-English in the L2]. Interestingly, the difference in the self-assessed ratings between the L1 and L2 environments was greater for the L1 ratings than for the L2 ratings. It is not clear whether the bilinguals in the L2 environment were more proficient in the L2 than those in the L1 environment or whether they were evaluating their language skills relative to a different assumed standard. We return to consider the issue of proficiency across two linguistic environments later in this chapter.

In addition to the rating data, there were differences in the months of L2 immersion and mean L1 and L2 usage between the L1 and L2 linguistic environments for each bilingual group. The bilinguals in the L2 environment had a longer immersion experience [$t(32) = 5.36$, $p < .001$ for Spanish-English; $t(24) = 2.04$, $p = .053$ for Japanese-English][3], used the L2 more frequently [$t(33) = 4.59$, $p < .001$ for Spanish-English; $t(25) = 7.04$, $p < .001$ for Japanese-English], and used the L1 less frequently than those in the L1 environment [$t(33) = -6.35$, $p < .001$ for Spanish-English; $t(25) = -8.55$, $p < .001$ for Japanese-English], suggesting that the bilinguals in the L2 environment had been significantly more exposed to the L2 than those in the L1 environment. There was no difference in the L2 age of acquisition for either bilingual group [*t*s < 1] although the Spanish-English bilinguals in the L2 environment were slightly older than those in the L1 environment [$t(31) = 2.08$, $p < .05$].[4]

Lexical Decision in L2 English

A lexical decision task in the L2 English was included in the present experiment as an on-line measure of proficiency. The word and nonword materials (see Chapter 2) were taken from Azuma and Van Orden (1997). Although the number and relatedness of

---

[3] One Spanish-English bilingual in the L2 environment and one Japanese-English bilingual in the L2 environment did not answer the question on their L2 immersion experience.

[4] One Spanish-English bilingual in the L1 environment and another one in the L2 environment did not fill in their age on the language history questionnaire.

word meanings were manipulated in the original lexical decision study for which these materials were designed, here we report only the simple analyses on words and nonwords as a measure of L2 lexical proficiency. More detailed analyses on the effects of the number and relatedness of word meanings are reported in Appendix B1. The mean accuracy and RT for words and nonwords are shown by language groups and external linguistic environments (i.e., whether bilinguals are immersed in the L1 or L2 context) in Table 3.5. Because we report the cross-language group comparison and the cross-environmental comparisons for each bilingual group in the sections on critical picture naming data below, the lexical decision data were also analyzed by bilingual language groups and by linguistic context for each group.

Table 3.5.

English Lexical Decision Results for Spanish-English and Japanese-English bilinguals in Experiment 1 by Language Group and External Linguistic Environment

	Spanish-English			Japanese-English		
	US	Spain	Overall	US	Japan	Overall
Nonword RT (ms)	878	958	915	1007	1226	1096
	(220)	(303)	(260)	(324)	(462)	(393)
Word RT (ms)	676	726	699	761	786	772
	(104)	(160)	(133)	(190)	(247)	(211)
Nonword accuracy (%)	84.7	86.3	85.4	71.4	70.8	71.2
	(10.7)	(9.4)	(10.0)	(18.2)	(6.6)	(14.4)
Word accuracy (%)	95.4	93.1	94.3	92.5	94.8	93.5
	(1.7)	(4.3)	(3.3)	(5.1)	(3.0)	(4.5)

Note. Standard deviations are in parentheses.

Cross-Language Group Comparisons

An independent-group t-test was performed on latencies and accuracy for words and nonwords with language group (Spanish-English bilinguals vs. Japanese-English bilinguals) as an independent variable. The Spanish-English bilinguals were faster and more accurate for nonwords than the Japanese-English bilinguals [$t(42.81) = 2.07$, $p < .05$ for latencies; $t(60) = 4.59$, $p < .001$ for accuracy]. However, there was no difference in latencies or accuracy for words between these two bilingual groups [$t(41.44) = 1.57$, $p > .10$ for latencies; $t < 1$ for accuracy]. These results suggest that it is possible that the Spanish-English bilinguals were more proficient in the L2 English than the Japanese-English bilinguals in the present experiment. As reported earlier, however, the language history data were similar across these two bilingual groups and there was no main effect of language group in the critical L2 picture naming data. The difference in the performance on the nonword items in the lexical decision task may reflect a difference in proficiency in word recognition, but not in word production. We return to consider this point in Chapter 7. For the purpose of the analyses of the simple picture naming data, we assume that the groups of Spanish-English and Japanese-English bilinguals were matched as closely as possible on their L2 proficiency.

Cross-Environment Group Comparisons

An independent-group t-test was performed with external linguistic environment (L1 environment vs. L2 environment) as an independent variable for each bilingual group separately. For the Spanish-English bilinguals, the only difference between the L1 and the L2 environments was a trend found in the accuracy for words [$t(18.98) = 2.01$, p

= .06]. None of the other measures approached significance [$t(33) = 1.12$, $p > .10$ for word latencies; *t*s < 1 for nonword latencies and word accuracy]. The Spanish-English bilinguals in the L2 environment were slightly more accurate to recognize words than those in the L1 environment. For the Japanese-English bilinguals, there was no difference between the L1 and the L2 environments [$t(25) = 1.45$, $p > .10$ for nonword latencies; $t(25) = 1.33$, $p > .10$ for word accuracy; *t*s < 1 for word latencies and nonword accuracy]. In sum, both the Spanish-English and Japanese-English bilinguals performed similarly regardless of the linguistic environment although the Spanish-English bilinguals showed a slight difference in the accuracy for words.

In sum, although there were some differences across language/environment groups in proficiency measures, they were relatively small, which suggests that overall the groups were reasonably well matched for the purpose of the processing comparison that is the main focus of the present experiment.

Individual Difference Measures

Simon

The Simon task was included to assess the ability to ignore irrelevant information. Simon data are summarized by language group and linguistic environment in Table 3.6.

Table 3.6.

Simon Results for Spanish-English and Japanese-English bilinguals in Experiment 1 by Language Group and External Linguistic Environment

	Spanish-English			Japanese-English		
	US	Spain	Overall	US	Japan	Overall
Simon effect (ms)	47.5	26.2	37.8	32.7	28.0	30.8
	(24.2)	(31.8)	(29.5)	(31.9)	(14.5)	(25.9)
RT for neutral (ms)	442	453	447	398	415	405
	(58)	(73)	(65)	(52.6)	(64.9)	(57)
RT for congruent (ms)	425	444	434	391	403	396
	(55)	(75)	(65)	(52)	(78)	(63)
RT for incongruent (ms)	472	470	471	424	431	427
	(68)	(75)	(70)	(54)	(74)	(62)
Accuracy for neutral (%)	98.9	99.0	98.9	98.2	97.8	98.1
	(2.0)	(1.5)	(1.4)	(1.6)	(2.7)	(2.1)
Accuracy for congruent (%)	99.2	99.1	99.2	98.4	98.7	98.5
	(1.4)	(1.5)	(1.4)	(2.6)	(1.2)	(2.1)
Accuracy for incongruent (%)	97.5	97.0	97.3	96.3	96.3	96.3
	(2.9)	(2.9)	(2.9)	(3.4)	(3.1)	(3.2)

Note. Standard deviations are in parentheses.

Cross-Language Group Comparisons

A 3 (type of trials: neutral, congruent, and incongruent) x 2 (language group: Spanish-English and Japanese-English) mixed ANOVA was conducted on the RT and accuracy data. The analysis for the RT data revealed a main effect of language group [$F(1, 60) = 6.60$, $MSE = 11702.18$, $p < .05$] with faster RTs for the Japanese group than for the Spanish group and a main effect of type of trials [$F(2, 106) = 63.17$, $MSE = 332.06$, $p < .001$] such that congruent trials were faster than incongruent or neutral trials [ps < .001] and neutral trials were also faster than incongruent trials. However, there was no interaction between type of trials and language group [$F < 1$]. The analysis for the accuracy data also revealed a main effect of language group [$F(1, 60) = 5.68$, $MSE = 5.66$, $p < .05$] with lower accuracy for the Japanese group than for the Spanish group and a main effect of type of trials [$F(2, 104) = 14.41$, $MSE = 5.87$, $p < .001$] such that incongruent trials were less accurate than congruent or neutral trials [$ps < .001$]. Again, there was no interaction between language group and type of trials [$F < 1$]. These results suggest that the difference between the Japanese-English and the Spanish-English bilinguals appear to be due to a speed-accuracy trade-off. An important result of the Simon data is that the two bilingual groups were similar on the ability to suppress irrelevant information.

Cross-Environment Group Comparisons

A 3 (type of trials: neutral, congruent, and incongruent) x 2 (environment: L1 environment and L2 environment) mixed ANOVA was conducted on the RT and accuracy data for each bilingual group separately. For the Spanish group, the main effect of type of trials was significant both for the RT and accuracy data [$F(2, 66) = 38.25$, $MSE = 317.54$, $p < .001$; $F(2, 55) = 9.12$, $MSE = 4.96$, $p < .001$, respectively]. There was no main effect of environment either for RT or for accuracy [$F < 1$]. Most importantly, the interaction between type of trials and environment was marginally significant in the RT data but not in the accuracy data [$F(2, 66) = 3.13$, $MSE = 317.54$, $p = .05$; $F < 1$, respectively], indicating that the magnitude of a difference between congruent and incongruent trials (i.e., the Simon effect) was greater for the Spanish-English bilinguals in the L2 environment than for those in the L1 environment [$t(33) = 2.24$, $p < .05$]. On the other hand, the analyses for the Japanese-English bilinguals revealed only the main effect of type of trials [$F(2, 50) = 25.90$, $MSE = 242.03$, $p < .001$ for RT; $F(2, 50) = 5.30$, $MSE = 6.73$, $p < .01$ for accuracy] and no main effect of environment or the interaction [Fs < 1], which suggest that the two environmental groups were similar in the ability to ignore irrelevant information.

Operation Span

An operation span task was used to measure processing resources. Operation span data are summarized by language group and linguistic environment in Table 3.7.

Table 3.7.

Operation Span Results for Spanish-English and Japanese-English bilinguals in Experiment 1 by Language Group and External Linguistic Environment

	Spanish-English			Japanese-English		
	US	Spain	Overall	US	Japan	Overall
Operation span (1-60)	33.9	30.6	32.4	38.6	37.8	38.3
	(10.8)	(10.8)	(10.8)	(7.8)	(4.6)	(6.6)
RT on judgment (ms)	2450	2453	2451	2141	2290	2202
	(315)	(361)	(332)	(52.6)	(64.9)	(291)
Errors on judgment (1-60)	15.7	16.8	16.2	8.8	9.6	9.1
	(10.4)	(9.5)	(9.9)	(6.3)	(5.3)	(5.8)

Note. Standard deviations are in parentheses.

Cross-Language Group Comparisons

An independent-group t-test was performed on operation span, RTs on judgment, errors on judgment with language group (Spanish-English bilinguals vs. Japanese-English bilinguals) as an independent variable. The Japanese-English bilinguals recalled more words on the correct trials [$t(57.22) = 2.66$, $p < .05$], made a judgment on equations more quickly [$t(60) = 3.10$, $p < .01$], and made fewer errors on the judgment part [$t(56.58) = 3.52$, $p < .01$] than the Spanish-English bilinguals. These results suggest that the Japanese-English bilinguals appear to have greater processing resources than the Spanish-English bilinguals. However, we cannot rule out the possibility that this difference might be a reflection of a proficiency difference although we tried to minimize including the linguistic component in the task.

Cross-Environment Group Comparisons

Similarly, an independent-group t-test was performed on operation span, RTs on judgment, errors on judgment with external linguistic environment (L1 environment vs. L2 environment) as an independent variable for each bilingual group separately. There was no difference for either of the bilingual groups [$t(25) = 1.33$, $p > .10$ for RT in the Japanese group; all the other *t*s < 1].

Again, there were some small differences across groups in measures of cognitive resources. However, overall the groups were reasonably well matched for the purpose of the processing comparison that is the main focus of this experiment.

Data Trimming for Simple Picture Naming

Recorded picture naming responses were first transcribed and coded for accuracy. We adopted a liberal criterion for accuracy such that synonyms of the expected name of a given picture (e.g., bike for bicycle) were considered to be correct responses. Responses that deviated from the expected picture name and synonyms, responses that started with an article or hesitation, and "no" responses were scored as errors. Responses that the microphone did not detect were eliminated as technical errors. After trimming RTs for correct responses that were less than 300 ms or greater than 3000 ms, RTs that were 2.5 standard deviations above or below the mean were identified as outliers and excluded from the analyses. Finally, we calculated RTs and accuracy for correct responses again. Errors (18.3 %), outliers (4.6 %), and technical errors (2.2 %) for the L2 picture naming and errors (8.5 %), outliers (4.0 %), and technical errors (1.0 %) for the L1 picture naming were excluded from the following analyses.

L2 Simple Picture Naming

A 2 x 3 x 2 mixed analysis of variance (ANOVA) was conducted by participants ($F1$) and by items ($F2$) on naming latencies and accuracy, with cognate status (cognate/noncognate), cognate type (cognate in English, Spanish, and Japanese/cognate in English and Spanish/cognate in English and Japanese), and language group (Spanish-English bilingual/Japanese-English bilingual) as independent variables. In the participant analyses, cognate status and cognate type were within-participants variables and language group was a between-participants variable. In the item analyses, cognate status and cognate type were between-items variables, whereas language group was a within-items variable.

Latencies

The 2 (cognate status) x 3 (cognate type) x 2 (language group) mixed ANOVA revealed a significant main effect of cognate status both by participants and by items

[$F1(1, 60) = 42.76$, $MSE = 17794.8$, $p < .001$; $F2(1, 66) = 6.74$, $MSE = 49358.9$, $p < .05$]. The main effects of cognate type and language group did not emerge [$Fs < 1$]. The interaction between cognate status and cognate type approached significance by participants [$F1(2, 120) = 3.06$, $MSE = 14181.8$, $p = .05$], but not by items [$F2 < 1$]. The interaction between cognate type and language group was reliable by participants and by items [$F1(2, 120) = 7.02$, $MSE = 13995.2$, $p < .01$; $F2(2, 66) = 4.81$, $MSE = 9581.00$, $p < .05$]. There was no interaction between cognate status and language group [$Fs < 1$]. Most critically, the three-way interaction was significant both by participants and by items [$F1(2, 120) = 8.59$, $MSE = 14181.8$, $p < .001$; $F2(2, 66) = 5.28$, $MSE = 9581.0$, $p < .01$].

To further investigate the three-way interaction, a 2 (cognate status) x 3 (cognate type) repeated-measure ANOVA was performed for each language group. For the Spanish-English bilinguals, this analysis revealed a main effect of cognate status both by participants and by items [$F1(1, 34) = 39.12$, $MSE = 11977.6$, $p < .001$; $F2(1, 66) = 5.46$, $MSE = 30911.1$, $p < .05$] and a main effect of cognate type by participants [$F1(2, 68) = 3.83$, $MSE = 14214.5$, $p < .05$] but not by items [$F2 < 1$]. There was also an interaction between cognate status and cognate type by participants [$F1(2, 68) = 6.80$, $MSE = 13276.8$, $p < .01$; $F2 < 1$]. Follow-up paired-samples t-tests performed with a Bonferroni correction revealed that as can be seen in Figure 3.2., the Spanish-English bilinguals showed the cognate facilitation effect for cognates in English, Spanish, and Japanese [$t_1(34) = 4.87$, $p < .001$; $t_2(22) = 1.37$, $p > .10$] and for cognates in English and Spanish [$t_1(34) = 5.81$, $p < .001$; $t_2(22) = 2.93$, $p < .05$], but not for cognates in English and Japanese [$ts < 1$].

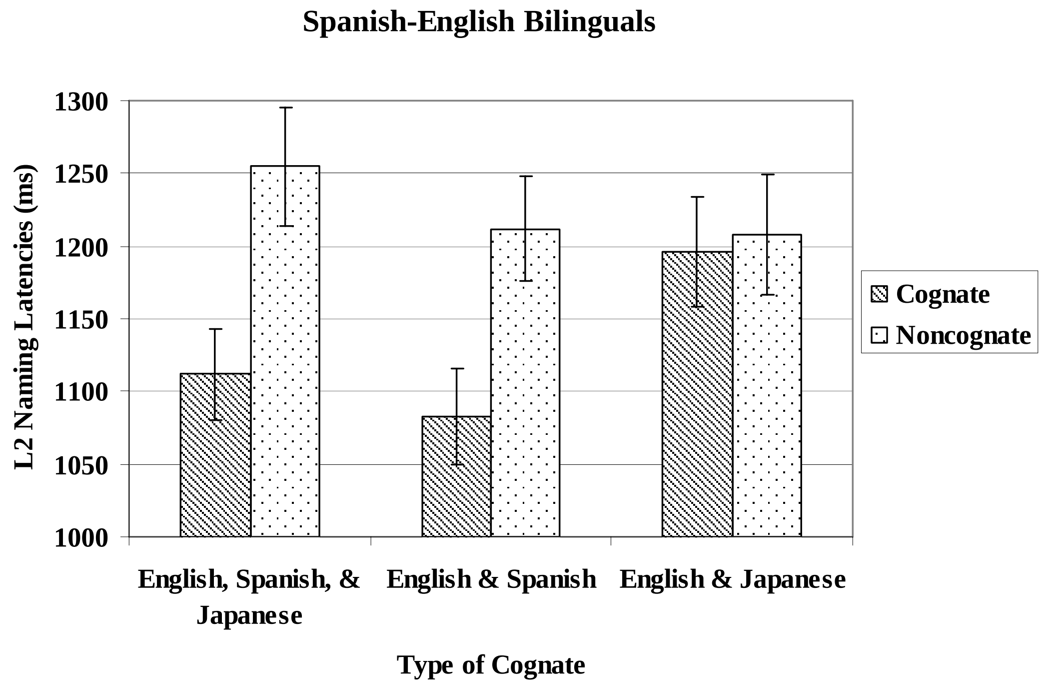


Figure 3.2. Mean L2 picture naming latencies for Spanish-English bilinguals as a function of cognate status and cognate type.

For the Japanese-English bilinguals, a 2 (cognate status) x 3 (cognate type) ANOVA revealed a main effect of cognate status both by participants and by items [$F1(1, 26) = 12.34$, $MSE = 25401.9$, $p < .01$; $F2(1, 66) = 5.85$, $MSE = 28028.8$, $p < .05$] and a main effect of cognate type by participants [$F1(2, 52) = 3.29$, $MSE = 13708.5$, $p < .05$] but not by items [$F2 < 1$]. There was also an interaction between cognate status and cognate type by participants [$F1(2, 52) = 5.00$, $MSE = 15365.2$, $p < .05$; $F2 < 1$]. Follow-up paired-samples t-tests performed with a Bonferroni correction revealed that as can be seen in Figure 3.3., the Japanese-English bilinguals showed the cognate facilitation effect for cognates in English, Spanish, and Japanese [$t_1(26) = 4.23$, $p < .001$; $t_2(22) = 1.75$, p

> .10] and for cognates in English and Japanese [$t_1(26) = 3.38$, $p < .01$; $t_2(22) = 2.12$, $p = .07$], but not for cognates in English and Spanish [*t*s <1].

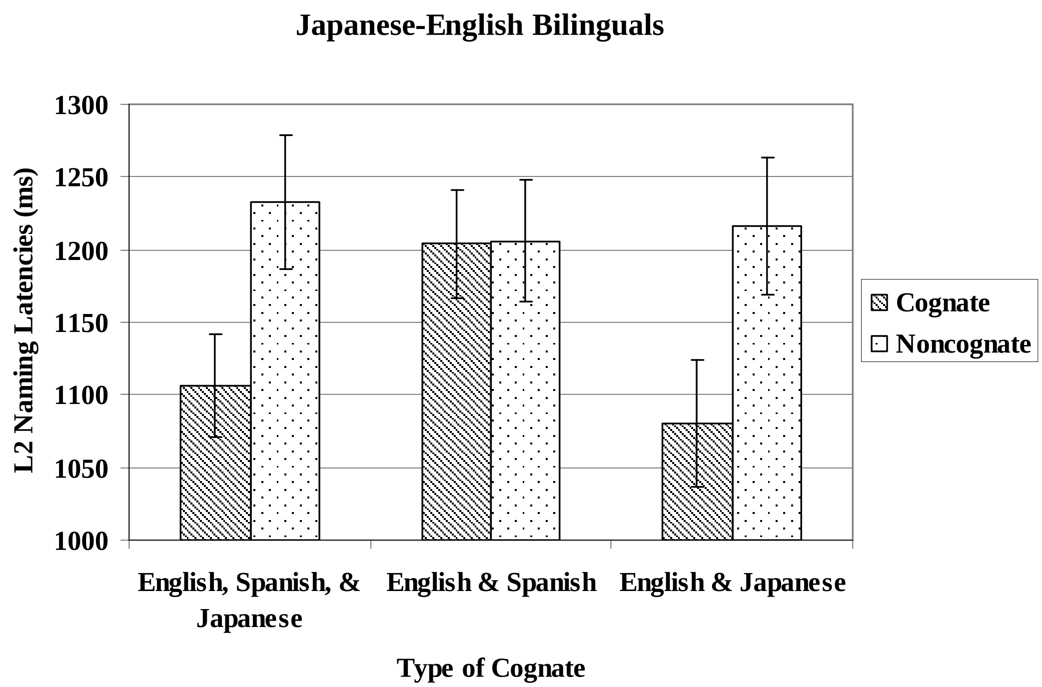


Figure 3.3. Mean L2 picture naming latencies for Japanese-English bilinguals as a function of cognate status and cognate type.

An important result in the L2 picture naming latency analyses is that not only Spanish-English bilinguals but also Japanese-English bilinguals were faster to name cognate pictures than non-cognate pictures, suggesting that even when the bilingual's two languages do not share script, there is activation of the phonology of the nontarget language (L1).

Accuracy

The 2 (cognate status) x 3 (cognate type) x 2 (language group) mixed ANOVA revealed a significant main effect of cognate status both by participants and by items [$F1(1, 60) = 89.36$, $MSE = 163.3$, $p < .001$; $F2(1, 66) = 9.33$, $MSE = 609.8$, $p < .01$] and a main effect of language group by items only [$F1 < 1$; $F2(1, 66) = 5.34$, $MSE = 71.0$, $p < .05$]. The main effects of cognate type did not emerge [$Fs < 1$]. The interaction between cognate status and cognate type was significant by participants [$F1(2, 120) = 9.22$, $MSE = 105.0$, $p < .001$], but not by items [$F2 < 1$]. The interaction between cognate type and language group was reliable by participants and by items [$F1(2, 120) = 19.86$, $MSE =$ 119.1.2, $p < .001$; $F2(2, 66) = 13.40$, $MSE = 71.0$, $p < .001$]. There was no interaction between cognate status and language group [$Fs < 1$]. More importantly, the three-way interaction was significant both by participants and by items [$F1(2, 120) = 17.13$, $MSE = 105.0$, $p < .001$; $F2(2, 66) = 10.22$, $MSE = 71.0$, $p < .001$].

To further investigate the three-way interaction for the accuracy data, as we did for the latency data, a 2 (cognate status) x 3 (cognate type) repeated-measure ANOVA was performed for each language group. For the Spanish-English bilinguals, this analysis revealed a main effect of cognate status both by participants and by items [$F1(1, 34) = 57.50$, $MSE = 132.9$, $p < .001$; $F2(1, 66) = 7.20$, $MSE = 365.8$, $p < .01$] and a main effect of cognate type by participants [$F1(2, 68) = 13.75$, $MSE = 125.4$, $p < .001$] but not by items [$F2(2, 66) = 1.67$, $MSE = 365.8$, $p > .10$]. The interaction between cognate status and cognate type was significant by participants [$F1(2, 68) = 20.58$, $MSE = 130.1$, $p < .001$] and marginally significant by items [$F2(2, 66) = 2.47$, $MSE = 365.8$, $p = .09$]. Follow-up paired-samples t-tests performed with a Bonferroni correction revealed that as can be seen in Figure 3.4., the Spanish-English bilinguals showed the cognate facilitation effect for cognates in English, Spanish, and Japanese [$t_1(34) = 5.30$, $p < .001$; $t_2(22) = 1.89$, $p > .10$] and for cognates in English and Spanish [$t_1(34) = 8.91$, $p < .001$; $t_2(15.65) = 3.95$, $p < .01$], but not for cognates in English and Japanese [*t*s <1].

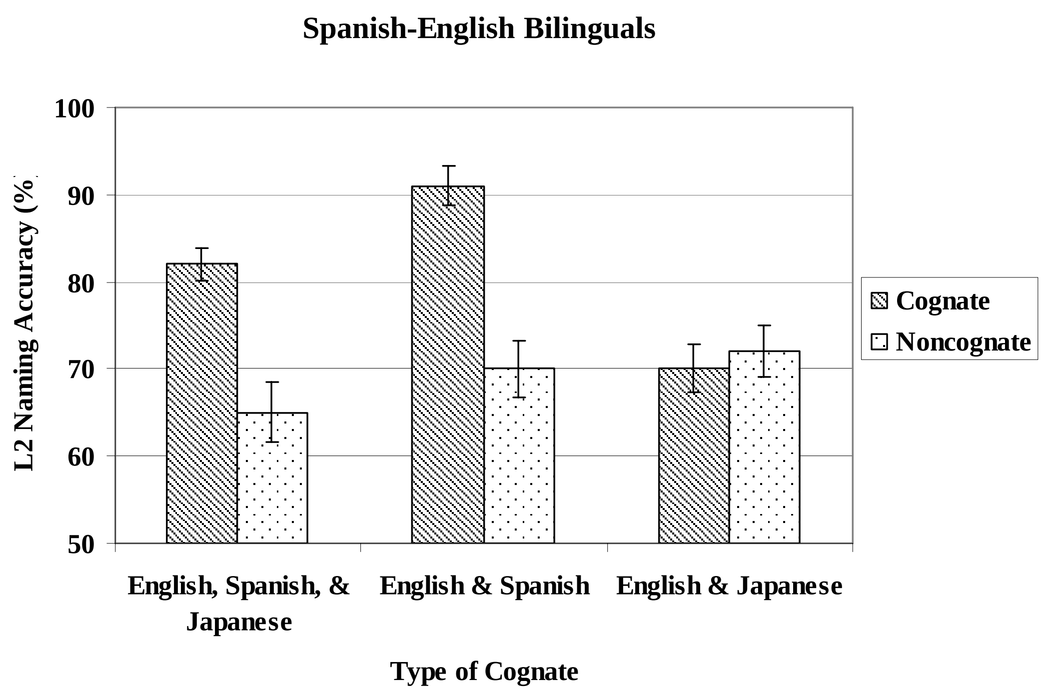


Figure 3.4. Mean L2 picture naming percent accuracy for Spanish-English bilinguals as a function of cognate status and cognate type.

For the Japanese-English bilinguals, a 2 (cognate status) x 3 (cognate type) ANOVA revealed a main effect of cognate status both by participants and by items [$F1(1, 26) = 34.75$, $MSE = 203.2$, $p < .001$; $F2(1, 66) = 9.72$, $MSE = 314.9$, $p < .01$] and a main effect of cognate type by participants [$F1(2, 52) = 7.41$, $MSE = 110.9$, $p < .01$] but not by items [$F2(2, 66) = 1.15$, $MSE = 314.9$, $p > .10$]. The interaction between cognate status and cognate type was significant by participants [$F1(2, 68) = 5.33$, $MSE = 72.3$, $p < .01$; $F2 < 1$]. Follow-up paired-samples t-tests performed with a Bonferroni correction revealed that as can be seen in Figure 3.5., the Japanese-English bilinguals showed a significant cognate facilitation effect for cognates in English, Spanish, and Japanese [$t_1(26) = 5.90$, $p < .001$; $t_2(22) = 2.23$, $p = .05$] and for cognates in English and Japanese [$t_1(26) = 5.02$, $p < .001$; $t_2(15.90) = 2.11$, $p = .08$] and a marginally significant cognate effect for cognates in English and Spanish as well [$t_1(26) = 2.53$, $p < .05$; $t_2 < 1$].

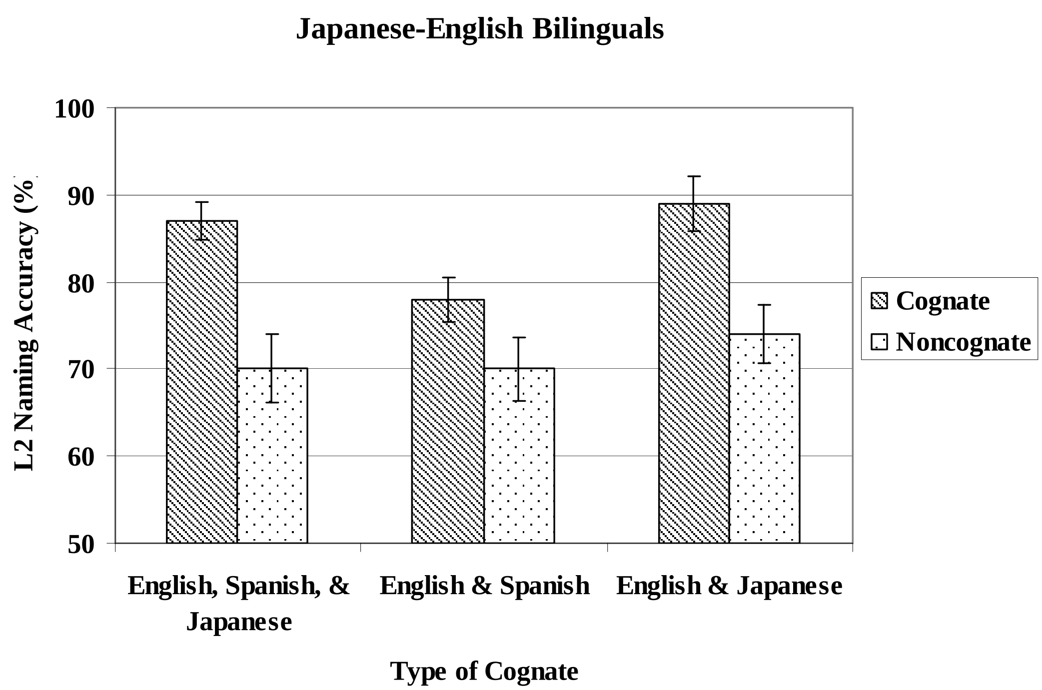


Figure 3.5. Mean L2 picture naming percent accuracy for Japanese-English bilinguals as a function of cognate status and cognate type.

Although the Japanese-English bilinguals showed a slight cognate facilitation effect even for the cognate in English and Spanish condition where the cognate pictures in this condition were supposed to be noncognates for the Japanese-English bilinguals, the overall pattern of the accuracy data was similar to that of the latency data. Both the Spanish-English and Japanese-English bilinguals were more accurate to name cognate pictures than noncognate pictures, suggesting that the phonology of both languages is active regardless of script differences.

Comparison with Monolingual Controls in English

The specificity of the pattern of cognate effects for the two bilingual groups suggests that the observed cognate facilitation is the reflection of bilingualism, not a property of the picture materials or their names. However, translations that are cognates across all three languages may potentially be special words. Although we attempted to match cognate and noncognate pictures as closely as possible on frequency, age of acquisition, name agreement, familiarity, imageability, visual complexity, word naming latencies, and phonological onset, it was not possible to control for all lexical properties that can potentially influence the process of picture naming. To further examine this issue, we sampled the performance of monolingual English speakers naming the same set of pictures from a recent picture norming study (Szekely et al., 2003, 2004). Although there was one noncognate control item that the picture naming corpus did not contain, the rest of the items were available in the corpus and the mean naming latencies are summarized in Table 3.8.

Table 3.8.

Mean Picture Naming Latencies (ms) for English Monolinguals by Cognate Status and Cognate Type

Cognate type	Cognates	Noncognate control
English, Spanish, & Japanese	971 (62.9)	964 (60.4)
English & Spanish	884 (38.8)	921 (54.5)
English & Japanese	909 (55.4)	971 (68.4)

Note. Standard errors are in parentheses.

A 2 (cognate status) x 3 (cognate type) ANOVA was performed on the sampled English picture naming latencies with both cognate status and cognate type as between-items variables. This analysis revealed no main effect or interaction [$F2$s < 1], suggesting that the cognate facilitation observed in the Spanish-English and Japanese-English bilinguals is the reflection of bilingualism, not the properties of the materials.

L1 Simple Picture Naming

As mentioned earlier, all participants performed the same simple picture naming task in the L1 (Spanish or Japanese) at the end of the experiment. The lexical decision task, the Simon task, the operational span task, and the language history questionnaire intervened between L2 picture naming and L1 picture naming. All the intervening tasks were conducted in the L2 English. Therefore, the L1 picture naming task was the first opportunity to use the L1 during the present experiment.

One Spanish-English bilingual in the L2 environment and one Japanese-English bilingual in the L2 environment were excluded from the analyses on the L1 simple picture naming due to the failure to record their responses. Again, a 2 x 3 x 2 mixed analysis of variance (ANOVA) was conducted by participants (*F*1) and by items (*F*2) on naming latencies and accuracy, with cognate status (cognate/noncognate), cognate type (cognate in English, Spanish, and Japanese/cognate in English and Spanish/cognate in English and Japanese), and language group (Spanish-English bilingual/Japanese-English bilingual) as independent variables. In the participant analyses, cognate status and cognate type were within-participants variables and language group was a between-participants variable. In the item analyses, cognate status and cognate type were between-items variables, whereas language group was a within-items variable.

Latencies

The 2 (cognate status) x 3 (cognate type) x 2 (language group) mixed ANOVA revealed a significant main effect of cognate status both by participants and by items [$F1(1, 58) = 38.57$, $MSE = 16640.9$, $p < .001$; $F2(1, 66) = 14.46$, $MSE = 24054.9$, $p < .001$]. The main effect of cognate type was reliable by participants [$F1(2, 116) = 3.96$, $MSE = 9097.3$, $p < .05$], but not by items [$F2 < 1$]. There was also a significant main effect of language group [$F1(1, 58) = 8.62$, $MSE = 137751.8$, $p < .01$; $F2(1, 66) = 53.80$, $MSE = 8704.5$, $p < .001$], with a faster naming latency for the Spanish-English bilinguals than for the Japanese-English bilinguals. There was no interaction between cognate status and language group or between cognate status and cognate type [$Fs < 1$]. The interaction between cognate type and language group was reliable [$F1(2, 116) = 6.02$, $MSE = 9097.3$,

$p < .01$; $F2(1, 66) = 3.96$, $MSE = 8704.5$, $p < .05$]. Most critically, the interaction between cognate type and language group was qualified by a significant three-way interaction [$F1(2, 116) = 9.14$, $MSE = 9433.3$, $p < .001$; $F2(2, 66) = 4.52$, $MSE = 8704.5$, $p < .05$].

To examine the three-way interaction, a 2 (cognate status) x 3 (cognate type) repeated-measure ANOVA was performed for each language group. For the Spanish-English bilinguals, this analysis revealed a main effect of cognate status both by participants and by items [$F1(1, 33) = 36.89$, $MSE = 9302.9$, $p < .001$; $F2(1, 66) = 11.89$, $MSE = 12860.6$, $p < .01$] and a main effect of cognate type by participants [$F1(2, 66) = 6.33$, $MSE = 7994.4$, $p < .01$] but not by items [$F2(2, 66) = 1.69$, $p < .10$]. There was also a significant interaction between cognate status and cognate type by participants [$F1(2, 66) = 6.88$, $MSE = 6027.8$, $p < .01$; $F2(2, 66) = 1.53$, $p > .10$]. Follow-up paired-samples t-tests performed with a Bonferroni correction revealed that the Spanish-English bilinguals showed the cognate facilitation effect not only for cognates in English, Spanish, and Japanese [$t_1(33) = 2.99$, $p < .01$; $t_2(22) = 1.53$, $p > .10$] and cognates in English and Spanish [$t_1(34) = 6.55$, $p < .001$; $t_2(14.55) = 3.69$, $p < .01$], but also for cognates in English and Japanese [$t_1(33) = 2.35$, $p < .05$; $t_2(22) = 1.00$, $p > .10$]. As can be seen in Figure 3.6., however, the magnitude of the cognate effect was smaller for the cognates in English and Japanese than for those in English and Spanish or for those in English, Spanish, and Japanese.

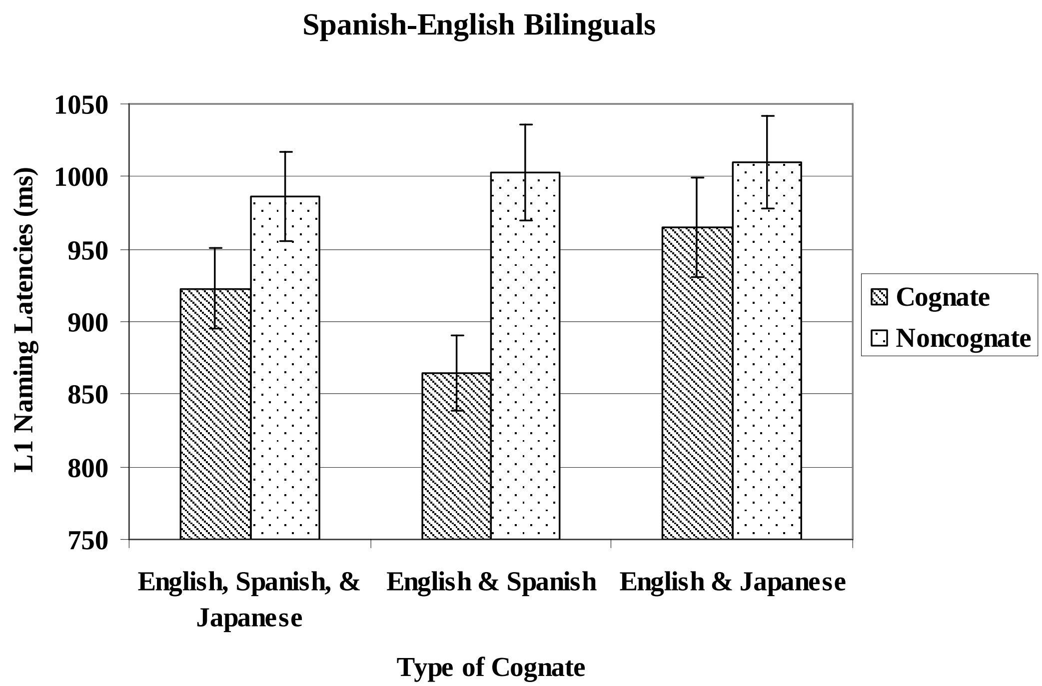


Figure 3.6. Mean L1 picture naming latencies for Spanish-English bilinguals as a function of cognate status and cognate type.

For the Japanese-English bilinguals, a 2 (cognate status) x 3 (cognate type) ANOVA revealed a main effect of cognate status both by participants and by items [$F1(1, 25) = 11.58$, $MSE = 26327.1$, $p < .01$; $F2(1, 66) = 9.87$, $MSE = 19898.9$, $p < .01$] and a main effect of cognate type by participants [$F1(2, 50) = 3.92$, $MSE = 10553.1$, $p < .05$] but not by items [$F2(1, 66) = 1.28$, $MSE = 19898.9$, $p > .10$]. There was also an interaction between cognate status and cognate type by participants [$F1(2, 50) = 3.23$, $MSE = 13928.5$, $p < .05$; $F2(1, 66) = 1.00$, $MSE = 19898.9$, $p > .10$]. Follow-up paired-samples t-tests performed with a Bonferroni correction revealed that as can be seen in Figure 3.7., the Japanese-English bilinguals showed the cognate facilitation effect for cognates in English, Spanish, and Japanese [$t_1(25) = 2.97$, $p < .01$; $t_2(22) = 2.13$, $p = .07$]

and for cognates in English and Japanese [$t_1(25) = 2.90$, $p < .05$; $t_2(22) = 2.66$, $p < .05$], but not for cognates in English and Spanish [*t*s <1].

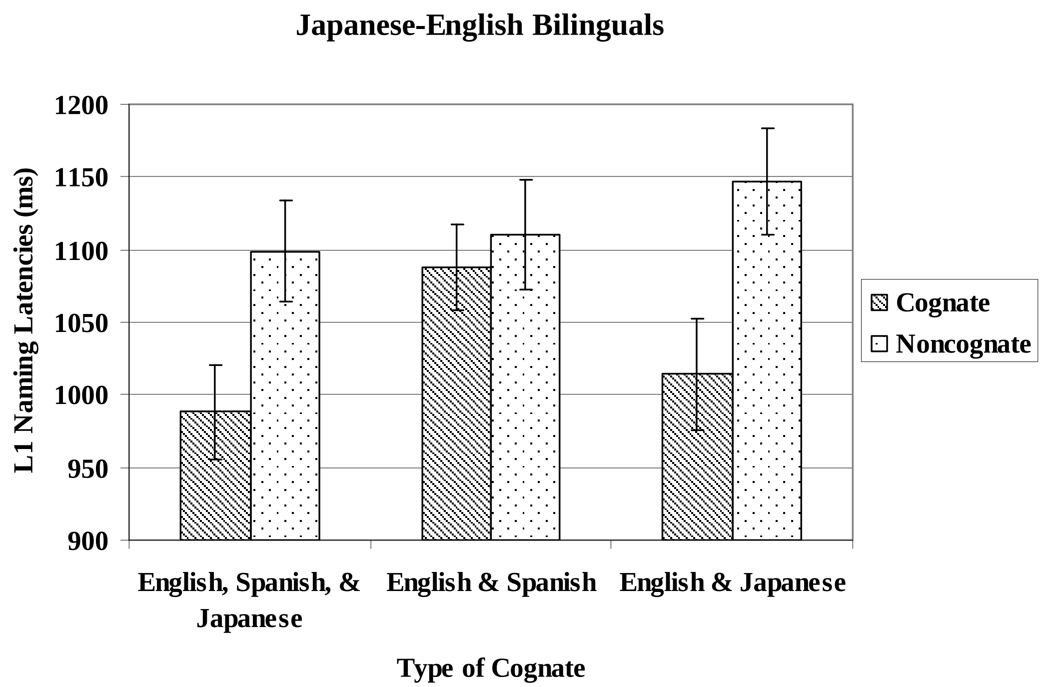


Figure 3.7. Mean L1 picture naming latencies for Japanese-English bilinguals as a function of cognate status and cognate type.

Overall, both the Spanish-English and Japanese-English bilinguals named cognate pictures faster than noncognate pictures even in their L1 Spanish or Japanese. This finding was somewhat surprising to the extent that past research showed small or no cognate facilitation in L1 (e.g., Costa et al., 2000; Kroll et al., in preparation). As mentioned above, we used the same set of pictures for L2 and L1 picture naming. The repetition of pictures from L2 naming to L1 naming may have contributed to the large cognate facilitation in L1. If cognate facilitation reflects a higher level of activation because of the shared phonological segments in two languages (Costa et al., 2000), naming cognate pictures in L2 will facilitate naming cognate pictures in L1 later. On the other hand, naming pictures in one language interferes naming the same pictures in the other language later (Wodniecka, Bobb, Kroll, & Green, 2005). In other words, naming noncognate pictures in English might have slowed down naming the same noncognate pictures in Spanish/Japanese. It is possible that the observed cognate facilitation in L1 may reflect the fact that cognate picture naming was facilitated and noncognate picture naming was interfered.

Furthermore, the Spanish-English bilinguals named pictures in their L1 faster than the Japanese-English bilinguals although there was no difference in the L2 picture naming latencies between these two bilinguals groups. One question then arises in asking whether the difference in the L1 naming latencies was due to the lexical properties of picture names in two different languages (Spanish and Japanese) or due to the nature of bilingualism. We address this issue in the section on *Monolingual Controls in Spanish and Japanese* after reporting the accuracy data for the L1 picture naming.

Accuracy

A 2 (cognate status) x 3 (cognate type) x 2 (language group) mixed ANOVA was also performed on the accuracy data for the L1 picture naming. Unlike the latency data, there was no main effect of language group for the accuracy data [Fs < 1]. The main effect of cognate status was significant by participants [$F1(1, 58) = 41.33$, $MSE = 76.8$, $p < .001$] and approached significance by items [$F2(1, 66) = 3.84$, $MSE = 334.6$, $p = .05$], with higher accuracy for cognates than for noncognates. There was also a significant interaction between cognate status and language group by subjects [$F1(1, 58) = 4.03$, $MSE = 76.8$, $p < .05$], but not by items [$F2(1, 66) = 1.65$, $MSE = 70.5$, $p > .10$]. Follow-up tests with a Bonferonni correction indicated that the cognate facilitation was larger for the Spanish-English bilinguals [$t(33) = 6.60$, $p < .001$] than for the Japanese-English bilinguals [$t(25) = 2.83$, $p < .01$]. The main effect of cognate type was reliable by subjects [$F1(2, 116) = 5.49$, $MSE = 89.4$, $p < .01$; $F2 < 1$]. However, this main effect was qualified by a significant interaction with language group by participants [$F1(2, 116) = 3.68$, $MSE = 89.4$, $p < .05$; $F2(2, 66) = 1.87$, $p > .10$]. Follow-up tests revealed that the main effect of cognate type was only marginally significant for the Spanish-English bilinguals by participants [$F1(2, 66) = 2.67$, $MSE = 82.6$, $p = .08$; $F2(2, 69) = 1.50$, $MSE = 209.7$, $p > .10$]. After Bonferroni correction, however, there was no significant difference across types for the Spanish-English bilinguals (See Figure 3.8.). In contrast, the main effect of cognate type was significant for the Japanese-English bilinguals [$F1(2, 50) = 15.44$, $MSE = 105.2$, $p < .001$; $F2 < 1$], such that as can be seen in Figure 3.9., they were less accurate for the condition of the cognates in English and Spanish than for the conditions of the cognates in English, Spanish, and Japanese [$t_1(25) = 4.17$, $p < .001$; $t_2 < 1$] or the cognates in English and Japanese [$t_1(25) = 4.03$, $p < .001$; $t_2 < 1$].

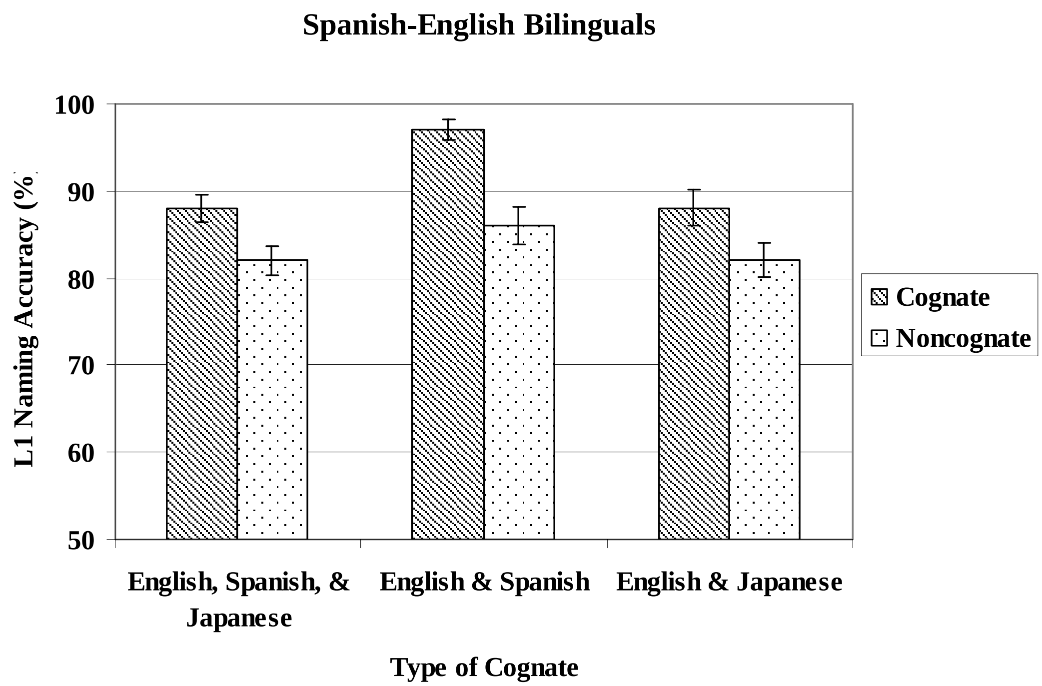


Figure 3.8. Mean L1 picture naming percent accuracy for Spanish-English bilinguals as a function of cognate status and cognate type.

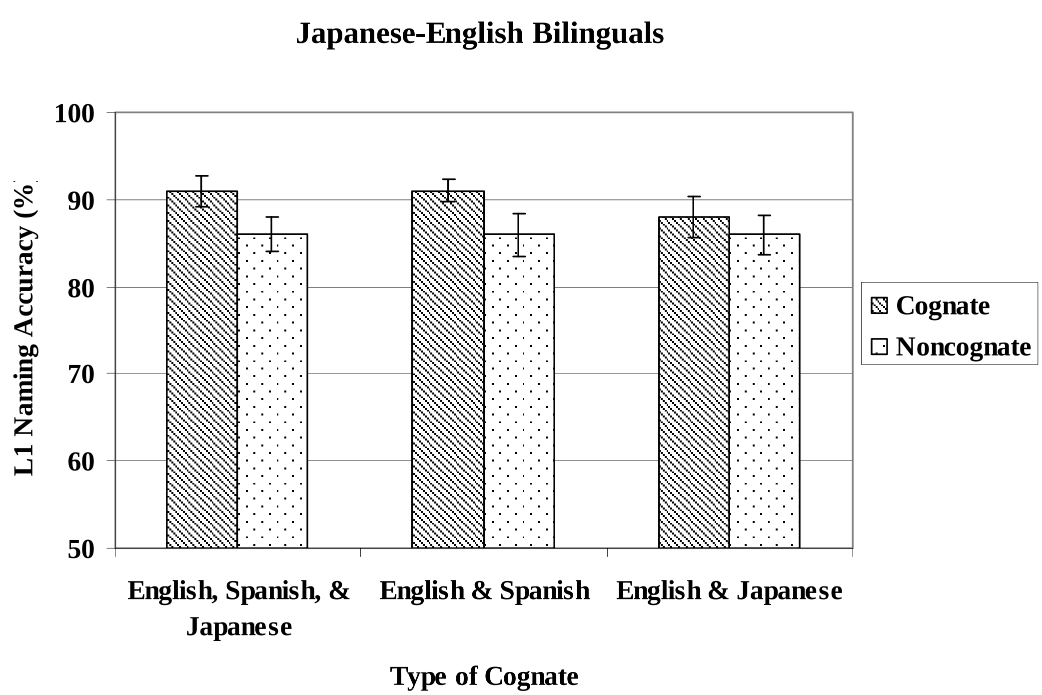


Figure 3.9. Mean L1 picture naming percent accuracy for Japanese-English bilinguals as a function of cognate status and cognate type.

The pattern of the accuracy data for the L1 simple picture naming raises a question of whether the cognate and noncognate items had different lexical properties, given that the cognate items were named more accurately than the noncognate items regardless of the type of the cognate and the language group. It is important to note that the materials were originally constructed based on the English lexical properties, not the Spanish and/or Japanese lexical properties. We examine this issue in the following section.

Comparison with Monolingual Controls in Spanish and Japanese

Prior to the analyses on the monolingual controls in Spanish and English, the lexical properties of the items in Spanish and in Japanese were examined. As mentioned earlier, the materials were originally constructed based on the English lexical properties because the critical task in the present experiment was English picture naming, not Spanish or Japanese picture naming. The post-hoc analyses on the Spanish and Japanese lexical properties are summarized in Table 3.9. As reported earlier for the lexical properties of the materials in English, the names of the cognate pictures were longer than those of the noncognate pictures both in Spanish and Japanese [$t(35) = 2.13$, $p < .05$ for the number of characters in Spanish; $t(35) = 2.47$, $p < .05$ for the number of morae in Japanese]. Once again, if the difference in length had affected the L1 picture naming latencies, then the bilinguals should have named noncognate pictures faster than cognate pictures, which was opposite to the data obtained in the present experiment.

Table 3.9.

Characteristics of Materials in Spanish and in Japanese Used in Experiment 1

	Spanish		Japanese	
Variable	Cognate	Noncognate	Cognate	Noncognate
Number of characters[a]	6.4	5.7*	N/A	N/A
Number of syllables/morae	2.7	2.6	3.4	2.8*
Log frequency[b]	0.91	1.10	3.06	3.02
Age of acquisition[c]	2.2	1.7	4.0	3.6
Name agreement (%)[c]	91.9	86.5	94.9	95.0
Familiarity[d]	5.8	6.0	4.9	4.9
Imageability[d]	6.2	6.1	N/A	N/A

Note. [a]The number of characters was not computed for the Japanese names of the pictures because some noncognate items were preferred to be written in kanji rather than in katakana or hiragana and the number of characters differed depending upon the script. [b]Baayen, Piepenbrock, & Gulikers (1996) for Spanish; Amano & Kondo (2000) for Japanese. [c]The Spanish data were from the International Picture Naming Project database and the 1-3 point scale was used (Szekely et al., 2003, 2004). The Japanese data were from Nishimoto et al. (2005). [d]For Spanish, the data were extracted from BuscaPalabras (Davis & Perea, 2005) and the rating scale was from 1 to 7. For Japanese, the data were extracted from Nishimoto et al. (2005).

For the analyses on the monolingual controls in Spanish and in Japanese, the performance of monolingual Spanish and Japanese speakers naming the same set of pictures was sampled from recent picture naming norms (Szekely et al., 2003, 2004 for Spanish; Nishimoto et al., 2005 for Japanese). The Spanish database did not include one noncognate control item and the Japanese norming database did not contain five cognate items and four noncognate controls. The mean naming latencies based on the available monolingual data are summarized in Table 3.10.

Table 3.10.

Mean Picture Naming Latencies (ms) for Spanish and Japanese Monolinguals by Cognate Status and Cognate Type

	Spanish		Japanese	
Cognate type	Cognate	Noncognate	Cognate	Noncognate
English, Spanish, & Japanese	1068 (79.4)	1069 (87.8)	1032 (82.9)	959 (66.3)
English & Spanish	928 (41.5)	971 (54.2)	933 (80.2)	1045 (82.1)
English & Japanese	959 (45.7)	1067 (75.4)	1017 (82.5)	1011 (71.7)

Note. Standard errors are in parentheses.

Similar to the analyses on the L1 picture naming latency data reported above, a 2 (cognate status) x 3 (cognate type) x 2 (language group) mixed ANOVA was conducted on the sampled item means with cognate status and cognate type as between-items variables and language group as a within-item variable. This analysis did not reveal any main effect or interaction [$F2(2, 56) = 1.12$, $MSE = 23160.1$, $p > .10$ for the interaction between cognate type and language group; $F2(2, 56) = 1.12$, $MSE = 23160.1$, $p > .10$ for the three-way interaction; $F2$s < 1 for others], suggesting that the cognate facilitation obtained for the bilingual groups was not due to the special lexical properties of the materials in Spanish or in Japanese. Although the Spanish-English bilinguals were faster to name pictures in the L1 than the Japanese-English bilinguals in the analysis on the L1 picture naming latency reported earlier, there was no difference in the naming latencies between the Spanish monolinguals and the Japanese monolinguals in this analysis. In other words, naming pictures in the L2 English and/or the participants' bilingualism might have affected the performance of naming pictures in the L1 differentially for the Spanish-English bilinguals and the Japanese-English bilinguals.

Effect of L2 Picture Naming on L1 Picture Naming

To further investigate the differential impact of L2 picture naming on L1 picture naming, the L1 picture naming data for the Spanish-English and Japanese-English bilinguals was compared to the L1 picture naming data from the Spanish and Japanese monolingual norms. A 2 (language: Spanish vs. Japanese) x 2 (group: bilingual vs. monolingual) repeated-measure ANOVA was performed on the item means. This analysis revealed no main effect of group [$F2 < 1$], but a significant main effect of language [$F2(1, 61) = 9.13$, $MSE = 18330.4$, $p < .01$] with faster naming latencies for Spanish than for Japanese. However, this main effect was qualified by a significant interaction between language and group [$F2(1, 61) = 13.94$, $MSE = 13284.8$, $p < .001$]. As shown in Figure 3.10., the Spanish-English bilinguals named pictures in their L1 slightly faster than the Spanish monolingual controls [$F2(1, 70) = 3.85$, $MSE = 16305.3$, $p = .06$], whereas the Japanese-English bilinguals named pictures in their L1 significantly more slowly than the Japanese monolingual controls [$F2(1, 62) = 7.19$, $MSE = 23633.1$, $p < .01$]. The pattern of the data for the Spanish speakers is analogous to the finding in the literature on between-language repetition priming where bilinguals name the picture faster in one language if they have previously named it in the other language before than if they have not previously named it (e.g., Francis, Augustini, & Saenz, 2003; Hernandez & Reyes, 2002). In other words, the faster naming latencies for the Spanish-English bilinguals than for the Spanish monolingual controls can be interpreted as a between-language repetition priming effect because the Spanish-English bilinguals named the same set of pictures in their L2 English before.

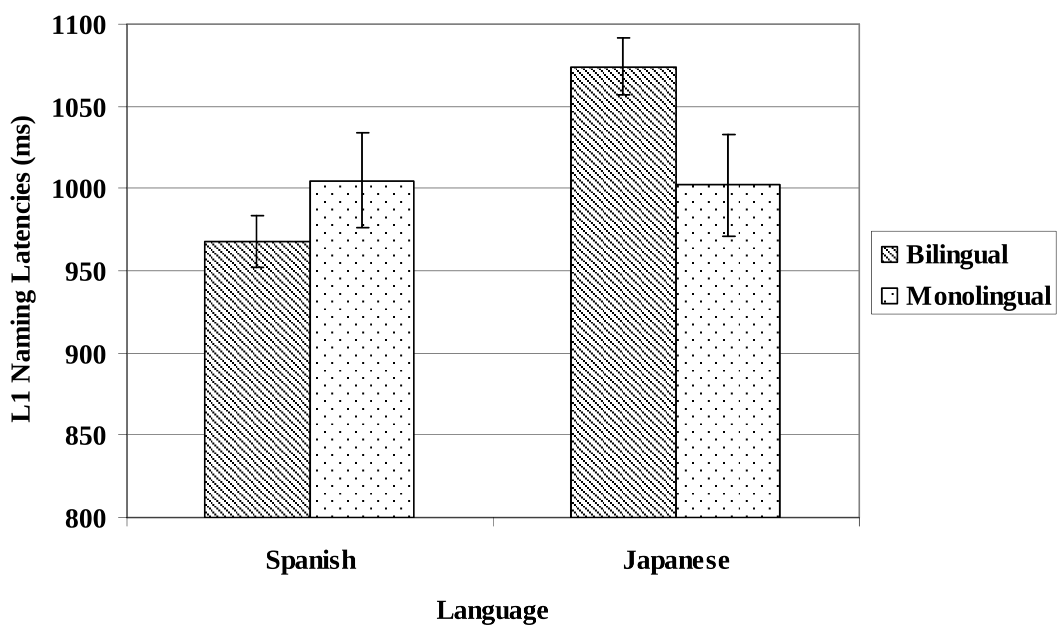


Figure 3.10. Mean L1 picture naming latencies as a function of language and group.

A question arises, however, in asking why the Japanese-English bilinguals showed the inhibitory effect rather than a facilitatory effect unlike the Spanish-English bilinguals. It might not be surprising that the Japanese-English bilinguals named pictures in their L1 Japanese more slowly than the Japanese monolingual controls, given the research demonstrating that bilinguals tend to name pictures in their L1 more slowly than monolinguals (e.g., Gollan, Montoya, Fennema-Notestine, & Morris, 2005). However, it is surprising to find the inhibitory effect only for the Japanese-English bilinguals, not for the Spanish-English bilinguals. One possibility is that the Japanese-English bilinguals might have been suppressing their L1 more strongly during the L2 picture naming and all the other tasks in the L2 English prior to the L1 picture naming than the Spanish-English bilinguals.

Although these analyses are only speculative because the monolingual control data were extracted from the cross-linguistic picture naming databases and were not obtained from a control experiment, it is still possible that the consequence of naming pictures in one language may be different depending upon the relationship between two languages (i.e., different scripts vs. same scripts). We further discuss this issue in the following section of the analyses on the contribution of the external linguistic environment.

Contribution of External Linguistic Environment

To evaluate the contribution of the external linguistic environment in constraining cross-language activation, we compared bilinguals who differed in the degree to which their L2 was supported—L2 environment (United States) vs. L1 environment (Spain/Japan). For the purpose of these analyses, only the functionally language-relevant cognate conditions and their noncognate controls were included.[5]

---

[5] In other words, the cognates in English and Japanese and their matched noncognate controls were excluded and the conditions of the cognates in English, Spanish, and Japanese and the cognates in English and Spanish and the conditions of their noncognate controls were collapsed for Spanish-English bilinguals. Likewise, the cognates in English and Spanish and their matched noncognate controls were excluded and the conditions of

A 2 (language: L1 vs. L2) x 2 (cognate status: cognate vs. noncognate) x 2 (environment: L1 environment vs. L2 environment) mixed ANOVA was performed with language and cognate status as within-participants variables and environment as a between-participants variable on the latency and accuracy data for Spanish-English and Japanese-English bilinguals separately. One Spanish-English bilingual and one Japanese-English bilingual were excluded from the following analyses due to the loss of the L1 picture naming data that were mentioned above.

Spanish-English bilinguals

Latency

The 2 (language) x 2 (cognate status) x 2 (environment) ANOVA revealed a main effect of language with faster latencies for the L1 than for the L2 [$F(1, 32) = 71.48$, $MSE = 24665.6$, $p < .001$] and a main effect of cognate status indicating that the Spanish-English bilinguals named cognate pictures faster than noncognate pictures [$F(1, 32) = 118.91$, $MSE = 3836.0$, $p < .001$]. There was no main effect of environment [$F(1, 32) = 1.18$, $MSE = 83728.8$, $p > .10$]. The interaction between language and cognate status was not reliable [$F(1, 32) = 2.06$, $MSE = 5036.0$, $p > .10$]. The interaction between language and environment approached significance [$F(1, 32) = 71.48$, $MSE = 24665.6$, $p < .001$], such that there was no difference in the L1 between the L1 and L2 environments [$t < 1$], whereas the Spanish-English bilinguals in the L2 environment were slightly faster to name pictures in the L2 English than those in the L1 environment. However, this

---

the cognates in English, Spanish, and Japanese and the cognates in English and Japanese and the conditions of their noncognate controls were collapsed for Japanese-English bilinguals.

difference was not reliable after Bonferroni correction [$t(32) = 1.64$, $p = .11$]. Most importantly, the three-way interaction was significant [$F(1, 24) = 5.58$, $MSE = 5036.0$, $p < .05$].

To further examine the three-way interaction, a 2 (language) x 2 (cognate) ANOVA was conducted for each linguistic environment separately. For the Spanish-English bilinguals in the L1 environment, the main effects of language and cognate status were significant [$F(1, 15) = 96.09$, $MSE = 13122.5$, $p < .001$; $F(1, 15) = 70.74$, $MSE = 2869.4$, $p < .001$, respectively]. The interaction between language and cognate status was also reliable [$F(1, 15) = 8.95$, $MSE = 3832.6$, $p < .01$, such that as can be seen in Figure 3.11., the Spanish-English bilinguals in the L1 environment showed a greater cognate facilitation in the L2 [$t(15) = 7.16$, $p < .001$] than in the L1 [$t(15) = 3.57$, $p < .01$].

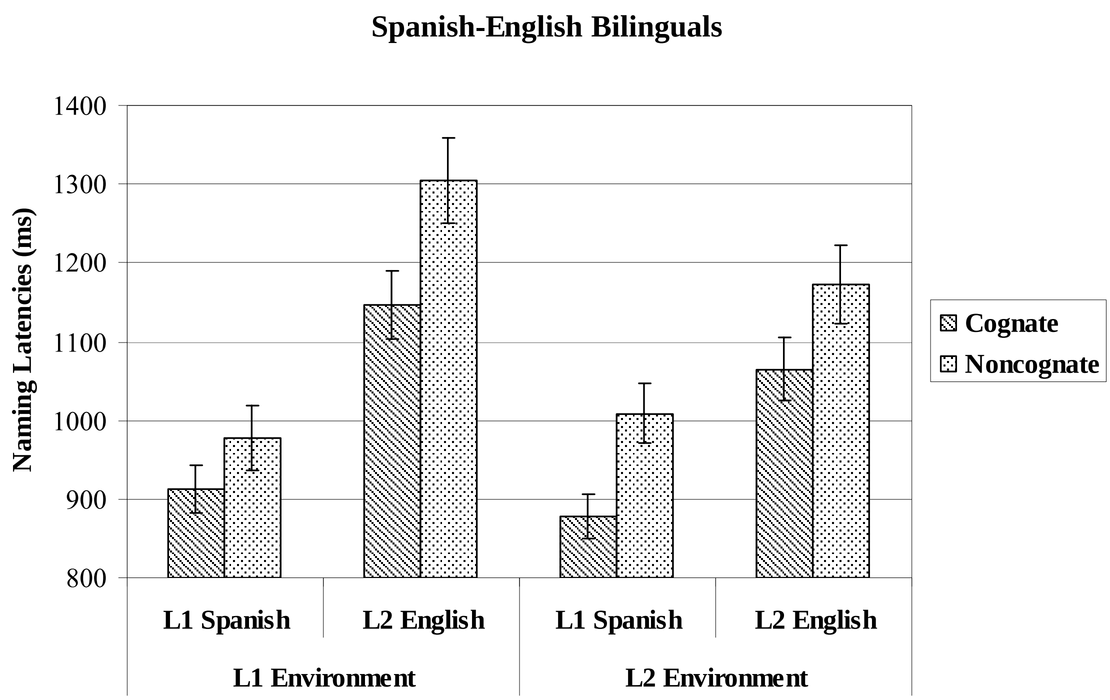


Figure 3.11. Mean naming latencies (ms) for Spanish-English bilinguals as a function of language, cognate status, and environment.

For the Spanish-English bilinguals in the L2 environment, there were significant main effects of language and cognate status [$F(1, 17) = 15.91$, $MSE = 34850.7$, $p < .01$; $F(1, 17) = 54.75$, $MSE = 4688.9$, $p < .001$, respectively]. Unlike the bilinguals in the L1 environment, there was no interaction between language and cognate status [$F < 1$] (See Figure 3.11.).

Accuracy

The 2 (language) x 2 (cognate status) x 2 (environment) mixed ANOVA was also performed on the accuracy data. The main effects of language and cognate status were significant [$F(1, 32) = 49.94$, $MSE = 96.5$, $p < .001$; $F(1, 32) = 108.08$, $MSE = 64.0$, $p < .001$, respectively], but the main effect of environment was not reliable [$F(1, 32) = 2.07$, $MSE = 182.1$, $p > .10$]. The interactions between language and environment and between language and cognate status were significant [$F(1, 32) = 21.89$, $MSE = 96.53$, $p < .001$; $F(1, 32) = 27.61$, $MSE = 38.80$, $p < .001$] and the interaction between cognate status and environment approached significance [$F(1, 32) = 3.09$, $MSE = 63.99$, $p = .088$]. More critically, the three-way interaction was significant [$F(1, 32) = 11.47$, $MSE = 38.80$, $p < .01$].

Again, a 2 (language) x 2 (cognate status) ANOVA was conducted for each environment as follow-up tests. Similar to the latency analyses, the Spanish-English bilinguals in the L1 environment showed the main effects of language and cognate status [$F(1, 15) = 44.22$, $MSE = 142.20$, $p < .001$; $F(1, 15) = 104.35$, $MSE = 42.79$, $p < .001$, respectively] and a significant interaction between language and cognate status [$F(1, 15) = 73.45$, $MSE = 18.63$, $p < .001$]. Specifically, as illustrated in Figure 3.12., the Spanish-

English bilinguals showed a greater cognate facilitation (i.e., higher accuracy for cognates than for noncognates) in the L2 [$t(15) = 13.05$, $p < .001$] than in the L1 [$t(15) = 3.87$, $p < .01$]. In contrast, the Spanish-English bilinguals in the L2 environment showed the main effects of language and cognate status with a higher accuracy for the L1 than for the L2 and a higher accuracy for cognates than for noncognates [$F(1, 17) = 5.20$, $MSE = 56.22$, $p < .05$; $F(1, 17) = 30.67$, $MSE = 82.69$, $p < .001$, respectively]. However, there was no significant interaction between language and cognate status [$F(1, 17) = 1.27$, $MSE = 56.60$, $p > .10$].

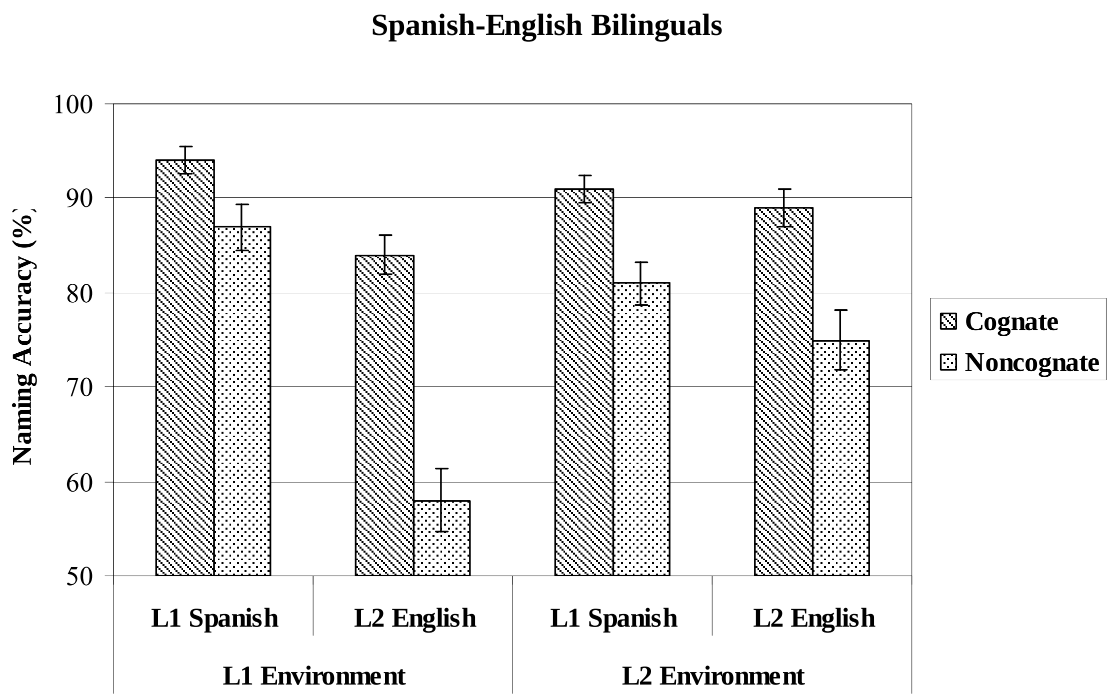


Figure 3.12. Mean naming percent accuracy for Spanish-English bilinguals as a function of language, cognate status, and environment.

In summary, the Spanish-English bilinguals in the L1 environment showed a larger cognate effect in the L2 than in the L1, whereas those in the L2 environment showed a similar size of cognate facilitation in the L1 and in the L2. The observed difference across the two environmental groups can be understood as a difference in proficiency in the L2. The word accuracy on the lexical decision task in English suggests that the Spanish-English bilinguals in the L2 environment were more proficient in the L2 English than those in the L1 environment. Although other aspects of the data from the lexical decision task did not show any difference between the L1 and the L2 environments, it is possible that the Spanish-English bilinguals in the L1 environment were less proficient than those in the L2 environment particularly because the critical task was picture naming and production is usually more difficult than comprehension. Furthermore, most of the bilinguals in the L1 environment were English majors who were exposed to written English on a daily basis but who had fewer opportunities to speak English. When a less proficient bilingual speaks in the L2, the phonology of the L1 may have a greater influence on the production than when a more proficient bilingual speaks in the L2 (e.g., see Costa et al., 2000).

Japanese-English bilinguals

The same set of analyses was conducted on the data from Japanese-English bilinguals.

Latency

The 2 (language) x 2 (cognate status) x 2 (environment) ANOVA revealed a main effect of language with faster latencies for the L1 than for the L2 [$F(1, 24) = 8.30$, MSE =

38583.6, $p < .01$] and a main effect of cognate status with faster latencies for cognates than for noncognates [$F(1, 24) = 25.67$, $MSE = 15889.8$, $p < .001$]. The main effect of environment was not significant [$F < 1$]. The interaction between language and environment was marginally significant [$F(1, 24) = 3.58$, $MSE = 38583.6$, $p = .07$], such that the Japanese-English bilinguals in the L1 environment named pictures faster in the L1 than in the L2 [$t(10) = 3.31$, $p < .01$], whereas the Japanese-English bilinguals in the L2 environment did not show such a difference [$t < 1$] (See Figure 3.13.). There was no other significant interaction [Fs < 1].

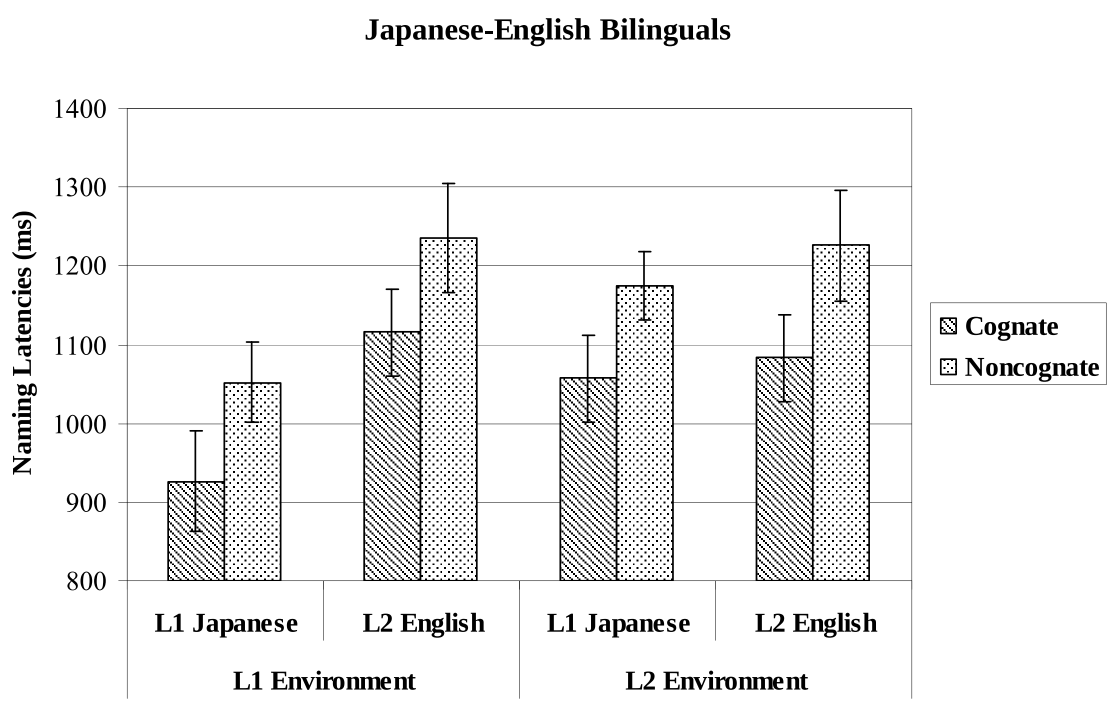


Figure 3.13. Mean naming latencies (ms) for Japanese-English bilinguals as a function of language, cognate status, and environment.

Accuracy

The 2 (language) x 2 (cognate status) x 2 (environment) mixed ANOVA revealed the main effects of language and cognate status [$F(1, 24) = 13.38$, $MSE = 130.9$, $p < .01$; $F(1, 32) = 30.80$, $MSE = 89.50$, $p < .001$, respectively]. However, these main effects were qualified by the significant interaction between language and cognate status [$F(1, 24) = 14.50$, $MSE = 68.0$, $p < .001$], such that there was a greater cognate facilitation for the L2 [$t(25) = 5.99$, $p < .001$] than for the L1 [$t(25) = 1.77$, $p = .09$] (See Figure 3.14.).

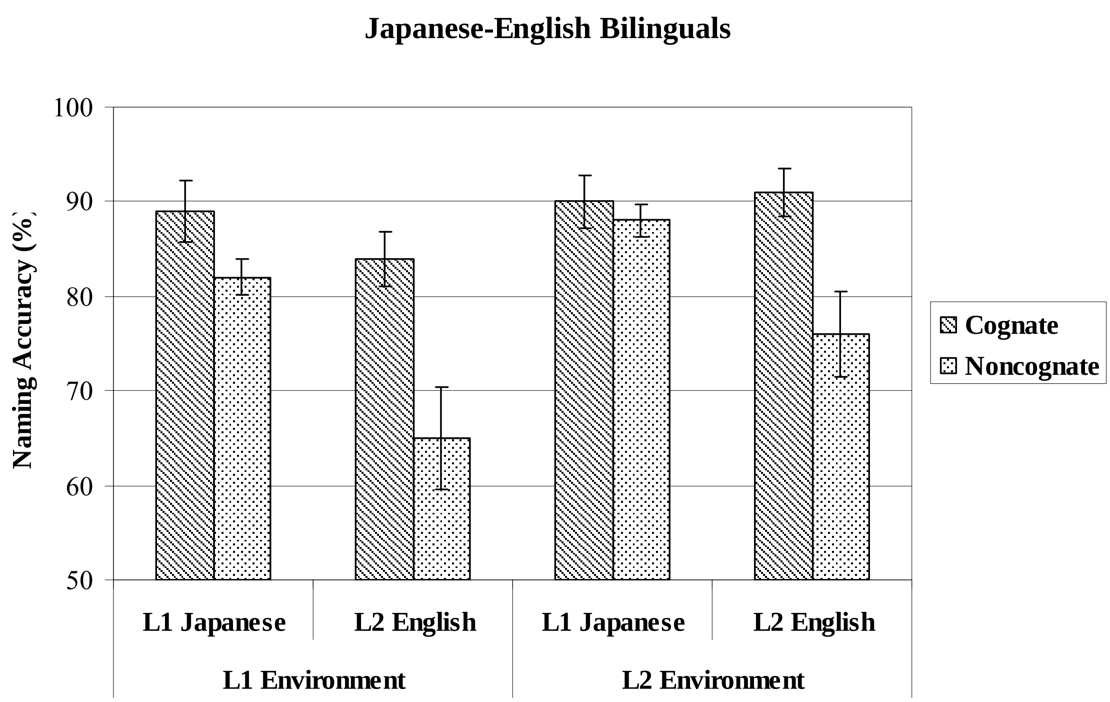


Figure 3.14. Mean naming percent accuracy for Japanese-English bilinguals as a function of language, cognate status, and environment.

The main effect of environment approached significance [$F(1, 24) = 3.89$, $MSE = 272.4$, $p = .06$], showing that L1 picture naming was more accurate than L2 picture naming. The factor "environment" did not interact with any other factors [$F(1, 24) = 1.69$, $MSE = 130.9$, $p > .10$ for the interaction with language; $F(1, 24) = 1.48$, $MSE = 89.5$, $p > .10$ for the interaction with cognate status; $F < 1$ for the three-way interaction].

In sum, unlike the Spanish-English bilinguals, the magnitude of the cognate facilitation was not modulated by language and external linguistic environment for the Japanese-English bilinguals. An important result in these analyses is that the Japanese-English bilinguals in the L2 environment named pictures in the L1 as slowly as in the L2, whereas those in the L1 environment named pictures in the L1 faster than in the L2. However, there was no difference in the L2 picture naming across the two environmental groups. These results suggest that the limited access to the L1 input in the environment imposes processing costs in the L1 rather than the use of two languages itself. Indeed, if we compare the mean L1 naming latencies for the Japanese-English bilinguals in the L1 environment (989 ms; see Figure 3.13.) with those for the Japanese monolinguals (1002 ms; see Figure 3.10.), there was no difference between the bilinguals and the monolinguals.[6] The inhibitory effect reported in Figure 3.10. appears to be due to the processing costs to the bilinguals in the L2 environment.

General Discussion

There were two main goals in the present experiment. The primary goal of the present experiment was to determine to what extent the degree of cross-language

---

[6] The mean value for the Japanese-English bilinguals in the L1 environment was the two thirds of the items that were selected for the analyses on the contribution of the external linguistic environment (see the beginning of the section of *Contribution of External Linguistic Environment*). The mean for the Japanese-English bilinguals in the L1 environment with all the items was 1002 ms.

activation and the locus of language selection are modulated by script differences in the context where the written lexical form is not presented perceptually. In the present experiment, both Spanish-English and Japanese-English bilinguals showed significant cognate facilitation in the L1 and in the L2. We replicated the results of Costa et al. (2000) for bilinguals whose two languages share the same Roman alphabets and extended the finding to bilinguals whose two languages differ in script. The monolingual control data sampled from the cross-linguistic picture naming databases did not show any of these cognate effects. These results suggest that even when the bilingual's two languages do not share script, there is activation of the phonology of the nontarget language. In the absence of the written lexical form, both languages are activated to the level of phonology and script differences do not serve as a language cue, which results in the language selection at the phonological level regardless of script differences in the bilingual's two languages.

Frequency Account

Cognate facilitation in bilingual production has been taken to suggest that lexical candidates in both languages are active to the level of phonology. When phonological segments are shared, facilitation occurs. An alternative account is that the cognate facilitation may be a unique frequency effect for bilinguals. Cognates share the meaning and phonology across the bilingual's two languages and the convergence of meaning and phonology may increase the functional frequency of cognates. There is indeed some evidence to support this conjecture. Dijkstra, Van Jaarsveld, and Ten Brinke (1998) conducted a series of lexical decision experiments with Dutch-English bilinguals. In a purely English lexical decision experiment where cognates, homographs, unambiguous English words, and English-like nonwords were included, the Dutch-English bilinguals showed cognate facilitation but no inhibition for interlingual homographs, false friends (e.g., “room” means “cream” in English). If the cognate effect were simply a reflection of cross-language activation, the Dutch-English bilinguals should have demonstrated the homograph inhibition as well as the cognate facilitation. It is possible that the differential effects for cognates and homographs in word recognition are due to differences in the time course of activation, but we cannot rule out the alternative that cognate facilitation is a frequency effect in disguise. Another piece of evidence for the possible frequency effect of cognates comes from the translation data in Kroll and Stewart (1994) showing that semantic category interference occurred only in the L1 to L2 translation, which is conceptually mediated. Although the cognates were translated faster than the noncognates, the semantic category interference effect was obtained in the L1 to L2 translation for both cognates and noncognates, suggesting that cognates are functionally more frequent than noncognates. If cognates were translated by activating the translation equivalent at a lexical level only, there should be no semantic category interference effect for cognates. It is important to note that the monolingual comparison does not speak to this issue because monolinguals would not be expected to show either activation of the other language alternative or increased frequency. Although evidence on the activity of L1 phonology during L2 production that does not rely on cognates (e.g., Colomé, 2001), makes it most parsimonious to assume that the results we have reported are due to activation that spreads across candidates within the two languages, further research will be required to rule out the frequency alternative.

The Role of Orthography/Script in Speech Planning

Whether or not the cognate facilitation reflects a functional frequency effect or learning effect, a question still arises in asking whether the presence of cognate facilitation for different-script bilinguals show that phonological processing in speech planning is not modulated by orthography. If both orthographic and phonological overlap were required,then only Spanish-English bilinguals whose two languages share the same script should have shown cognate facilitation. Finding similar effects for Japanese-English bilinguals might be interpreted as evidence against the role of orthography during speech planning. In line with recent research showing no orthographic effect in production (Alario et al., in press; Roelofs, 2006), phonological processing may be modulated by orthography only when the written lexical form is present. In the simple picture naming, no lexical form was presented in either of the bilinguals' languages. It is possible that the orthographic properties of the bilingual's L1 were not active in this context. As we will see in the next set of experiments, differences between the two bilingual groups begin to emerge when the script is present in the task.

However, it is also possible that script differences may not be identical to orthographic differences. According to bilingual word recognition models such as BIA+, semantics, lexical codes are activated in parallel across the two languages and interact with each other (Dijkstra & Van Heuven, 2002). The interaction between L1 and L2 orthography may be limited to the case in which two languages share the same scripts, such as English and Dutch. That interaction may impose processing benefits or costs depending on the task and mapping to the phonology, but may be absent when script differences prevent the modulation of orthographic interactions. We return to this issue in Chapter 7.

Contribution of External Linguistic Environment

The secondary goal of the present experiment was to evaluate the contribution of the external linguistic environment in constraining cross-language activation. The magnitude of cognate facilitation was an index of cross-language activation in the present experiment. The magnitude of cognate facilitation was modulated by language and external linguistic environment only for the Spanish-English bilinguals, not for the Japanese-English bilinguals. It is possible that the greater cognate facilitation in the L2 English for the Spanish-English bilinguals in the L1 environment was partly due to the level of their L2 proficiency. However, the greater cognate facilitation in the L1 Spanish for the Spanish-English bilinguals in the L2 environment indicates that the external linguistic environment modulates the degree of cross-language activation. Although the cognate effect was not modulated by language and external linguistic environment for the Japanese-English bilinguals, the environment affected processing costs in the L1 Japanese. The Japanese-English bilinguals in the L2 environment named pictures in the L1 more slowly than those in the L1 environment.

Although the pattern of the results differs across the two bilingual groups, both groups indicate that processing costs in the L1 are modulated by the external linguistic environment. Studies of language production show that under some circumstances, bilinguals are slower to name pictures in the L1 than monolinguals, suggesting that the use of two languages imposes processing costs (Gollan et al., 2005). However, at issue is whether the observed costs are a reflection of reduced availability of words in each language (the weak link hypothesis) or by the modulation of activity associated with the two languages as a function of potential competition between them (the competition hypothesis). The present results provide support for the competition hypothesis, given that the bilinguals in the L1 environment who had a similar level of L2 proficiency to those in the L2 environment showed smaller or no processing costs in the L1. We have to be cautious about the fact that the monolingual data were from a set of databases, not from matched control experiments, but as preliminary evidence, the results suggest that costs to the L1 reflect the environment in which the L2 is used. It is important to note that the bilinguals in the present experiment were individuals who had a reasonable level of education in the L1 in their native countries, whereas the bilinguals in Gollan et al. were heritage speakers who grew up in the United States and were educated predominantly in the L2 English.

Type of Bilingualism

To determine whether the processing cost to L1 differs depending upon the type of bilingualism, we went back to the data of the Spanish-English bilinguals who were L2 dominant (heritage speakers) and who had been excluded from the previous analyses to compare their performance with that of the L1 dominant Spanish-English bilinguals living in the L2 environment.[6] To match L2 dominant and L1 dominant Spanish-English bilinguals on the level of proficiency in the L2 English, L1 dominant Spanish-English bilinguals in the L2 environment were divided into two proficiency groups. The data from proficiency measures are summarized in Table 3.11.

Table 3.11.

Characteristics of Spanish-English Bilinguals in the L2 Environment by Proficiency and Dominance

	Less proficient L1 dominant (n = 9)	More proficient L1 dominant (n = 9)	Heritage speakers L2 dominant (n = 7)
Age (years)	25.5 (1.5)	26.8 (8.3)	21.7 (4.4)
L1 self-ratings (10-pt scale)	9.8 (0.4)*	9.6 (0.7)*	8.0 (0.4)
L2 self-ratings (10-pt scale)	7.7 (1.2)*	8.5 (0.8)	9.5 (0.7)
L2 age of acquisition (years)	11.7 (2.3)*	9.6 (5.2)*	3.3 (2.4)
Months of L2 immersion	52.0 (36.6)*	44.4 (20.8)*	240.4 (61.7)
Mean daily L1 usage (%)	36.1 (18.3)	35.0 (26.6)	14.3 (3.5)
Mean daily L2 usage (%)	57.2 (20.1)	65.0 (26.6)	82.1 (10.4)
Nonword RT (ms)	954 (235)	775 (168)	867 (204)
Word RT (ms)	730 (109)	621 (76)	658 (106)
Nonword accuracy (%)	77.0 (11.2)*	91.9 (2.2)	89.8 (5.6)
Word accuracy (%)	95.0 (0.9)	95.0 (1.7)	95.0 (1.7)
Simon effect (ms)	42.6 (20.7)	45.8 (20.8)	57.7 (36.0)
Operation span (1-60)	29.2 (10.6)*	40.2 (7.4)	45.0 (5.4)
RT on judgment (ms)	2622 (300)*	2318 (252)	2376 (254)
Error on judgment (1-60)	19.6 (12.1)*	11.0 (6.9)	7.3 (3.9)

Note. Standard deviations are in parentheses. * Differences between L2 dominant and another group were significant at $p < .05$.

As can be seen in Table 3.11., less proficient L1 dominant Spanish-English bilinguals were not as proficient in L2 English as more proficient L1 dominant Spanish-English bilinguals or L2 dominant Spanish-English bilinguals. On the other hand, L2 dominant Spanish-English bilinguals were not as proficient in L1 Spanish as less or more L1 dominant Spanish-English bilinguals. In other words, more proficient L1 dominant Spanish-English bilinguals had not only similar L2 English proficiency to L2 dominant Spanish-English bilinguals (heritage speakers) but also similar L1 Spanish proficiency to less proficient L1 dominant Spanish-English bilinguals.

Similar to the analyses for the contribution of external linguistic environment, the cognates in English and Japanese and their matched noncognate controls were excluded and the conditions of the cognates in English, Spanish, and Japanese and the cognates in English and Spanish and the conditions of their noncognate controls were collapsed. A 2 (language: L1/L2) x 2 (cognate status: cognate/noncognate) x 3 (type of bilinguals: less proficient L1 dominant/more proficient L1 dominant/L2 dominant) mixed ANOVA was performed with language and cognate status as within-participants variables and type of bilinguals as a between-participants variable on the latency and accuracy data. The results of these analyses are illustrated in Figure 3.15. for latency and Figure 3.16. for accuracy (see Appendix C for the statistical results).

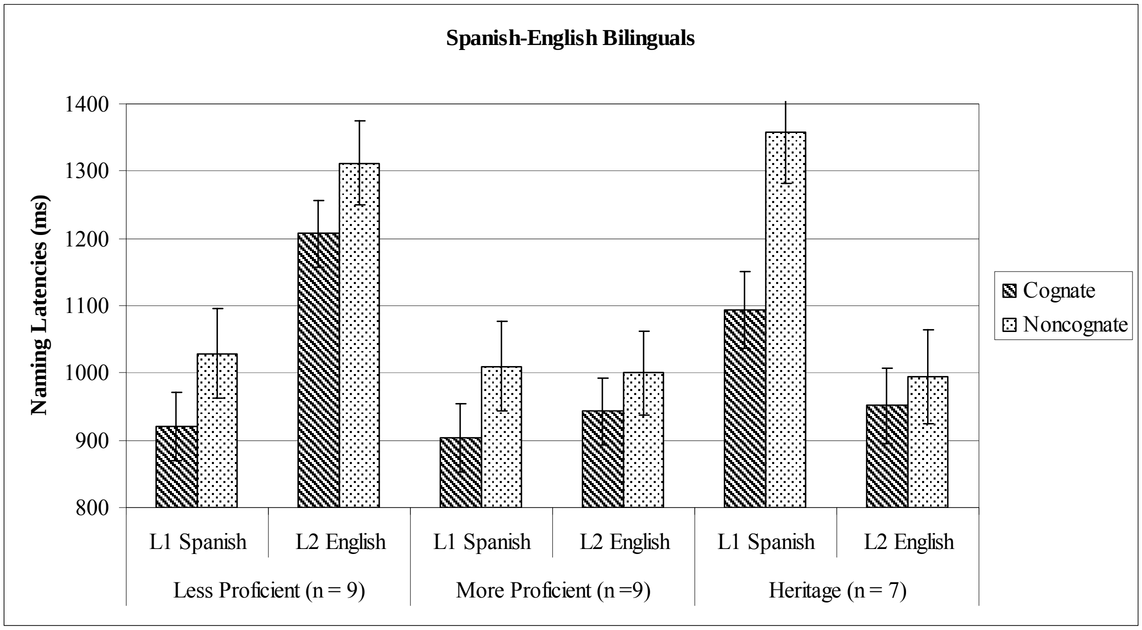


Figure 3.15. Mean naming latencies for Spanish-English bilinguals as a function of language, cognate status, and type of bilinguals.

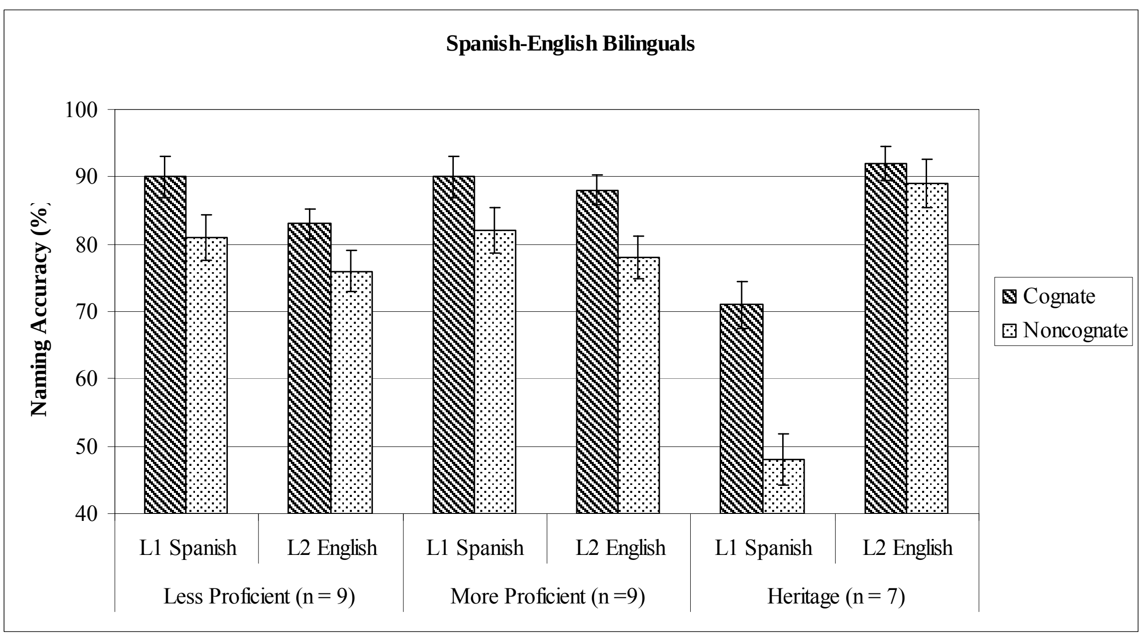


Figure 3.16. Mean naming accuracy for Spanish-English bilinguals as a function of language, cognate status, and type of bilinguals.

The most critical finding in these analyses is that although more proficient L1 dominant bilinguals were similar in the pattern of cognate effects to L2 dominant bilinguals, overall they performed similarly in their L1 Spanish to less proficient L1 dominant bilinguals but in their L2 English to L2 dominant heritage speakers. These results suggest that the experience of education in L1 appear to make a difference in processing costs to L1 when bilinguals are immersed in the L2 environment. In other words, the weak link hypothesis might be applied to L2 dominant heritage speakers, but not to highly proficient L1 dominant late bilinguals. However, the present experiment was not originally designed to examine the issue of processing costs in the L1. To further investigate the weak link hypothesis and the competition hypothesis, it is critical to conduct further research on the consequences of bilingualism on processing in the L1 with different types of bilinguals and matched monolingual controls.

In summary, the results of the simple picture naming experiment suggest that both languages are active to the level of phonology regardless of script differences and linguistic environments and that experience with different-script languages is not sufficient to limit activation during speech planning to the unintended language alone. In Chapter 4, a picture-word interference task was used to further investigate the degree of cross-language activation and the locus of language selection as a function of script. If the lack of the modulation of cross-language activation by script is due to the absence of the written lexical form in the task, then we should observe different patterns of results for Spanish-English and Japanese-English bilinguals in the picture-word interference experiment where bilinguals name pictures in the L2 English while ignoring distractor words that are presented with pictures.

CHAPTER 4

EXPERIMENT 2: PICTURE-WORD INTERFERENCE

The results of Experiment 1 suggest that script differences are not sufficient to serve as a language cue to direct lexical access selectively in simple picture naming in which the written lexical form is absent. However, recent within-language research has shown that there is an orthographic effect on production only when the written lexical form is overtly present in the task such as form-preparation, word naming, and picture-word interference tasks (e.g., Alario et al., in press; Damian & Bowers, 2003; Osborne et al., 2004; Roelofs, 2006). Therefore, the primary goal of Experiment 2 is to determine whether the degree of cross-language activation and the locus of language selection can be modulated by script when the task includes an overt written lexical form.

In Experiment 2, we used a picture-word interference paradigm in which bilinguals were asked to name noncognate pictures in their L2 English while ignoring visually presented distractors in their L1 Spanish or Japanese. The logic of the picture-word interference paradigm is to map out the time course over which different types of information become available as a spoken utterance is planned by manipulating the relation of the distractor word to the picture's name, the language in which the distractor occurs, and the point in time when it is presented relative to the picture. Like past bilingual studies that have used this paradigm (see Chapter 1), the present experiment included four types of distractor words in relation to the name of the target picture: semantically related, phonologically related, translation, and phono-translation (see Table 4.1.).

Table 4.1.

Examples of Type of Distractors in Experiment 2 for Spanish-English Bilinguals Naming the Picture "Envelope"

Type	Related	Unrelated	Predicted effect
Semantic	tarjeta (postcard)	alicates (pliers)	Interference
Phonological	enchufe (plug)	rodilla (knee)	Facilitation
Phono-translation	sobrino (nephew)	paloma (pigeon)	Interference
Translation	sobre (envelope)	hombre (man)	Facilitation

Note. English translations of the Spanish distractor words are in parentheses.

The main result in the past picture-word interference experiments is that when the distractor word is presented in the non-response language, semantic interference, phonological facilitation, phono-translation interference, and translation facilitation is observed (e.g., Costa & Caramazza, 1999; Costa et al., 2003; Costa et al., 1999; Hermans, 2000; Hermans et al., 1998). The assumption in most accounts of this pattern is that as illustrated in Figure 4.1., a target picture (e.g., ENVELOPE) activates conceptual representation of the picture and spreads the activation to its related lexical nodes in both response and non-response languages. At this early stage of speech planning, semantically related lexical nodes as well as the lexical node of the target picture are assumed to be active.

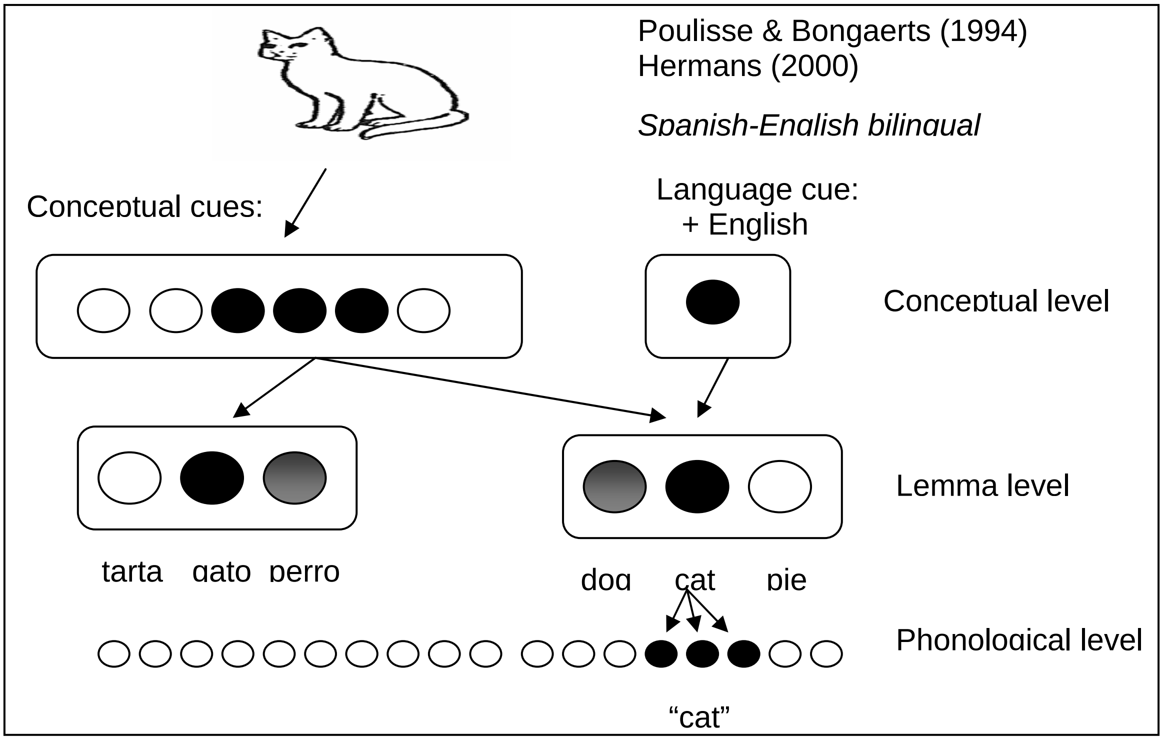


Figure 4.1. A model of nonselective lexical activation with language-nonspecific selection (adapted from Poulisse & Bongaerts, 1994 and Hermans, 2000).

If the distractor word is semantically related to the target picture (e.g., postcard), the semantically related lexical node of "tarjeta (postcard)" receives the activation not only from the picture but also from the distractor word, resulting in the competition between "tarjeta (postcard)" and "envelope" and longer naming latencies relative to the unrelated distractor. If the distractor word is phonologically related to the target picture (e.g., enchufe (plug)), the associated phonological segments of the target picture name ENVELOPE will receive higher activation due to the similar phonological segments /en/, which facilitates lexical selection at the phonological level or at the lemma level if the phonological activation feeds back to the lemma level. Likewise, if the distractor word is phonologically related to the translation of the target picture name (e.g., sobrino (nephew) to sobre (envelope)), the lexical node of the target picture in the non-response language “sobre (envelope” receives more activation and complete for selection between “sobre” and “envelope,” resulting in interference. Finally, the translation distractor “sobre (envelope)” is assumed to activate the conceptual representation of the target picture and spreads activation to its lexical nodes in both languages, which facilitates lexical selection at the lemma level without being a competitor. Overall, the results from bilingual picture-word interference experiments suggest that for at least a brief time during the planning of a spoken utterance in one language, candidates in the other language are also active.

However, virtually all of this past research has examined bilingual performance for bilinguals whose languages share the same Roman alphabets. The hypothesis to be tested in the present experiment is that distractor words in a language that is different in script from the target language will provide a language cue to production that will inhibit the activation of cross-language competitors. If the script difference for Japanese-English bilinguals provides a language cue and Japanese-English bilinguals can exploit that information, then picture naming performance is predicted to resemble the results reported by Miller and Kroll (2002) for translation, such that picture naming with related distractors will resemble picture naming with unrelated controls. For Spanish-English bilinguals, the results should replicate previously reported results for similar-script languages.

Method

Participants

Forty Spanish-English and 40 Japanese-English bilinguals participated in Experiment 2. Thirty Spanish-English and 18 Japanese-English bilinguals were recruited from The Pennsylvania State University. Two Spanish-English and 19 Japanese-English bilinguals were from University of California, San Diego and eight Spanish-English and four Japanese-English bilinguals were from Pomona College. Of these four Japanese-English bilinguals from Pomona College, one participant was excluded from all analyses due to a technical error in conducting the experiment. The remaining 40 Spanish-English and 40 Japanese-English bilinguals were included in the data analyses.

Materials

Pictures

Forty-eight black-and-white line drawings were drawn from Snodgrass and Vanderwart (1980) and Szekely et al. (2003, 2004) based on the following criteria: (1) all pictures had noncognate names in English, Spanish, and Japanese; (2) the phonological onset of the English name of pictures was restricted to phonology that was shared with Spanish and Japanese.[1] Pictures were divided into two sets according to the Japanese name of the selected pictures. In Japanese, some words can be written both in kanji and in

[1] For example, "frog" was not included according to the second criterion because the consonant cluster /fr/ was not possible in Japanese. Although these two criteria limited the number of items in the present experiment, it was critical to use these criteria to make the contribution of phonologically related distractors equal across two bilingual groups.

kana (hiragana and katakana), whereas others can be written only in kana (hiragana and katakana). Although some words can be written in either writing system, there are preferences for one rather than the other. Based on the frequency of each lexical form of the Japanese picture names, pictures were categorized as a kana picture or kanji picture. Thus, 16 kanji pictures and 16 kana pictures were included in the present experiment. The characteristics of pictures and picture names in English are summarized in Table 4.2.[2] As can be seen in Table 4.2., kanji pictures were more frequent and more familiar than kana pictures [$t(30) = 2.81$, $p < .01$; $t(28) = 2.89$, $p < .01$, respectively]. Furthermore, the distribution of semantic categories is slightly different between kanji and kana pictures. A major difference is in the proportion of animals relative to the total number of pictures; there were more animals in kana than in kanji. Although the distinction between kanji and kana applies only to Japanese, the same categorization of the materials was used for Spanish because the goal of the present study was to compare the performance of Japanese-English bilinguals with that of Spanish-English bilinguals.[3]

In addition to the experimental pictures, eight filler pictures were included in kanji and kanji lists. Kanji fillers were pictures whose Japanese names are typically written in kanji, whereas kana fillers were those whose Japanese names are typically written in kana. All of the fillers were noncognates in English, Spanish, and Japanese and none of the fillers were the same as the experimental pictures. Thus, each list had 16 experimental pictures and eight filler pictures.

---

[2] The International Picture Naming Project database did not have the data for kana item. The MRC Psycholinguistic database did not include the data for two kana items.

[3] Although the identification of pictures as being kana or kanji pictures for the Spanish-English bilinguals may appear to be an artificial distinction, the comparison of the two bilingual groups allows us to assess the consequence of the correlated lexical and semantic features of kana and kanji.

Table 4.2.

Characteristics of Pictures and Picture Names in English Used in Experiment 2

Variable	Kanji	Kana	*p* value (t-test)
Number of characters	4.4	4.7	*ns*
Number of syllables	1.3	1.3	*ns*
Frequency (per million words)[a]	77.1	20.5	.001
Age of acquisition (1-3 point scale)[b]	1.8	1.5	*ns*
Name agreement (%)[b]	97.3	95.5	*ns*
Familiarity (100-700)[c]	576	529	.007
Imageability (100-700)[c]	600	603	*ns*
Visual complexity (KB)[b]	13714	15488	*ns*
Word naming latencies (ms)[d]	605	597	*ns*
Semantic categories (# of items)[b]			
People	1	0	
Animals	3	7	
Body parts	2	0	
Vehicles	1	0	
Foods	0	2	
Things to wear	1	0	
Small artifacts	5	5	
Large artifacts	2	1	
Objects & phenomena in nature	1	0	

Notes. [a]Kučera & Francis (1967). [b]Data from the International Picture Naming Project database (Szekely et al., 2003, 2004). [c]Data from the MRC Psycholinguistic database (Coltheart, 1981). [d]Data from the English Lexicon Project database (Balota et al., 2002).

Distractors

For each of the pictures, four types of distractor words were selected in Spanish and in Japanese: phonologically related to the English picture name, semantically related to the English picture name, phonologically related to the Spanish/Japanese translation name of the English picture name (phono-translation), and Spanish/Japanese translation name of the English picture name (see Table 4.3. for examples). The following criteria were used to select each type of distractor: (1) the distractors that were phonologically related to the English picture name or to the Spanish/Japanese translation of the English picture name were not also semantically related to the target picture; (2) the semantically related distractors were largely from the same semantic categories and were not phonologically related to the English, Spanish, or Japanese name of the picture; (3) for Japanese distractors, kanji pictures were paired with words that were typically written in kanji, whereas kana pictures, with two exceptions, were paired with words that were typically written in kana; (4) the semantically related distractors were identical for Spanish and Japanese (i.e., the English translation of the semantically related distractors were the same). Each of these related distractors had an unrelated control that was matched as closely as possible on length (number of characters and syllables/morae) and frequency (see Table 4.4). It was impossible to match distractors on other lexical properties across distractor types.

Table 4.3.

Examples of Distractors for Pictures "Envelope" and "Goat" by Distractor Type, Relatedness, Script, and Language

Language	Script	Distractor Type	Related Distractor	Related Meaning	Unrelated Distractor	Unrelated Meaning
Spanish	Kanji	Phonological	enchufe	plug	rodilla	knee
	"envelope"	Semantic	tarjeta	postcard	alicates	pliers
		Phono-translation	sobrino	nephew	paloma	pigeon
		Translation	sobre	envelope	hombre	man
	Kana	Phonological	goma	rubber	lava	lava
	"goat"	Semantic	venado	deer	escoba	broom
		Phono-translation	cabeza	head	sangre	blood
		Translation	cabra	goat	lápiz	pencil
Japanese	Kanji	Phonological	煙突 e.n.to.tsu	chimney	大根 da.i.ko.n	radish
	"envelope"	Semantic	葉書 ha.ga.ki	postcard	毛虫 ke.mu.shi	caterpillar
		Phono-translation	風鈴 fu.u.ri.n	wind-bell	王冠 o.u.ka.n	crown
		Translation	封筒 fu.u.to.u	envelope	花火 ha.na.bi	firework
	Kana	Phonological	ゴム go.mu	rubber	バネ ba.ne	spring
	"goat"	Semantic	シカ shi.ka	deer	ノリ no.ri	seaweed
		Phono-translation	ヤジ ya.ji	jeering	ツル tsu.ru	crane
		Translation	ヤギ ya.gi	goat	タバコ ta.ba.ko	cigarette

Notes. The readings of Japanese distractors are provided below each item in the Hepburn transcription system for Japanese below.

Table 4.4.

Characteristics of Distractors in Spanish and in Japanese

			Related		Unrelated	
Language	Script	Distractor Type	Frequency	Length	Frequency	Length
Spanish	Kanji	Phonological	2.015	5.4 (2.3)	2.004	5.6 (2.4)
		Semantic	1.735	5.8 (2.4)	1.819	6.1 (2.6)
		Phono-translation	1.614	5.8 (2.6)	1.603	5.8 (2.6)
		Translation	2.061	5.2 (2.2)	2.065	5.3 (2.2)
	Kana	Phonological	1.397	5.6 (2.4)	1.407	5.6 (2.4)
		Semantic	1.295	6.1 (2.7)	1.311	5.8* (2.7)
		Phono-translation	1.539	6.0 (2.7)	1.563	5.9 (2.4)
		Translation	1.313	5.3 (2.5)	1.357**	5.3 (2.3)
Japanese	Kanji	Phonological	3.375	1.7 (2.7)	3.390	1.7 (2.7)
		Semantic	3.409	1.5 (2.7)	3.370	1.5 (2.7)
		Phono-translation	3.670	1.7 (2.7)	3.652	1.7 (2.7)
		Translation	3.642	1.3 (2.8)	3.639	1.3 (2.7)
	Kana	Phonological	3.086	2.8 (2.8)	3.058	3.0 (2.9)
		Semantic	2.883	3.0 (3.0)	2.884	3.1 (3.0)
		Phono-translation	2.419	2.8 (2.8)	2.475	2.8 (2.8)
		Translation	2.772	2.8 (2.6)	2.736	2.8 (2.7)

Notes. The number of characters is provided without parentheses and the number of syllables (Spanish) and morae (Japanese) is provided with parentheses. Spanish frequency was from Alameda and Cuetos (1995) and Japanese frequency was from Amano and Kondo (2000). *$p = .06$ ** $p = .08$

Similarly, each of the filler pictures also had a semantically related distractor and a semantically unrelated distractor that was matched on length and frequency. Again, kanji pictures had kanji distractors and kana pictures had kana distractors in Japanese. The complete set of the experimental and filler materials is provided in the Appendix E.

In the present experiment, each experimental picture was presented eight times but with different distractors so that none of the distractor words was repeated. Likewise, filler pictures were also repeated eight times. Unlike the experimental trials, however, semantically related and unrelated distractors for filler pictures were each presented four times.To avoid inducing potential switch costs between kanji and kana because kanji and kana belong to different writing systems (logographic and syllabary respectively), kanji and kana pictures were completely blocked and the order of the kanji and kana blocks was counterbalanced across participants for both Japanese-English and Spanish-English bilinguals. For the Spanish-English bilinguals there were no apparent differences in the distractors across blocks. Each kanji/kana list had eight blocks and each of the eight blocks included 16 experimental pictures and eight filler pictures. There were two items for each type of distractor and each of its unrelated controls per block for the experimental pictures and four items each for semantically related and unrelated distractors for the filler pictures. The order of blocks was also counterbalanced across participants.

An additional measure of phonological similarity of the distractors and picture names was obtained to ensure that observed cross-language differences in the present experiment, if any, are due to script but not to differences in phonological similarity. Fifteen English monolinguals who had not studied Spanish and 16 English monolinguals who had not studied Japanese were asked to rate pairs consisting of an English picture name and its phonologically related or unrelated Spanish/Japanese distractor word and pairs consisting of a Spanish/Japanese picture name and its phonologically related or unrelated Spanish/Japanese distractor word according to how similar two words sounded on a 7-point Likert scale with "1" being completely different and "7" being identical (see Appendix A2 for the details of the phonological similarity rating norming experiment). The mean ratings for each condition are summarized by sound pairs in Table 4.5.

Table 4.5.

Similarity Ratings for Phonological, Phono-Translation, and Semantic Conditions and Their Unrelated Conditions.

		Spanish		Japanese	
Script	Distractor type	Related	Unrelated	Related	Unrelated
Kanji	Phonological	3.6 (1.3)	1.2 (0.2)*	4.6 (1.3)	1.3 (0.2)*
	Phono-translation	4.0 (0.5)	1.4 (0.5)*	4.3 (0.7)	1.4 (0.3)*
	Semantic	4.7 (0.6)	1.9 (1.0)*	4.7 (0.6)	1.5 (0.6)*
Kana	Phonological	3.6 (1.5)	1.3 (0.3)*	4.0 (0.7)	1.3 (0.2)*
	Phono-translation	3.9 (0.7)	1.3 (0.3)*	4.4 (1.0)	1.5 (0.4)*
	Semantic	4.5 (1.1)	1.2 (0.4)*	4.5 (1.1)	1.5 (0.6)*

Note. Standard deviations are in parentheses. * Differences between related and unrelated conditions were significant at $p < .001$

A critical result in the morning experiment is that monolingual English speakers perceived the phonological similarity of related pairs to be greater than unrelated pairs for both language groups. Although the care was taken to ensure that phonological similarity would be similar across language groups, the English names of kanji pictures and their phonologically related Japanese distractors were rated as more similar than those of the English names of kanji pictures and their phonologically related Spanish distractors [$F2(1, 15) = 9.74$, $MSE = .975$, $p < .01$]. However, it is important to note that if this difference in phonological similarity of kanji items influences bilingual performance, then Japanese-English bilinguals should show a greater phonological facilitation than Spanish-English bilinguals.

In addition to phonological similarity of picture names and distractors, semantic relatedness was also normed using the translation equivalents of semantically related distractors for both bilingual groups. Fourteen English monolinguals were asked to rate word pairs consisting of the English name of a picture and the English translation of a semantically related/unrelated distractor word in Spanish or in Japanese according to how similar two words were in meaning on a 7-point Likert scale with "1" being completely different and "7" being identical (see Appendix A3 for the details of the semantic relatedness rating norming experiment). As shown in Table 4.5., semantically related items were rated more similarly than semantically unrelated items for all the conditions.

Procedure

Participants were tested individually in a quiet room. They were seated in front of a computer monitor, a button box, a microphone connected to the button box and a digital recorder. All participants were given the picture-word interference task, followed by the lexical decision task in their L2 English, the Simon task, the operational span task, the language history questionnaire, and the verbal fluency task (see Chapter 2 for the materials, procedure, and data/trimming/scoring for the proficiency and individual difference measures).

In the picture-word interference task, participants first received written instructions in English on the computer screen. They were informed that a series of pictures would be presented with an L1 (Spanish or Japanese depending upon their native language) distractor word one at a time on the computer screen. Their task was to name the pictured object in English while ignoring the L1 distractor word as quickly and accurately as possible. At the beginning of each trial, a fixation sign (+) was presented at the center of the computer screen. At the press of a button, the fixation sign was replaced with a blank screen and 500 ms after the offset of the fixation sign, a picture was presented. A distractor word was appeared in red at the center of the picture 25 ms after the onset of the presentation of the picture. The picture and the distractor word were presented until the participants responded or for 5000 ms. If they did not know the name of the object, they were asked to say "no." After they responded, a blank screen was presented for 500 ms and a fixation sign appeared again. (See Figure 4.2. for the illustration of a trial.) The 25 ms of delay was included to ensure that participants could first see the pictured object without covering.

Unlike most previous research using the picture-word interference paradigm, there was no picture familiarization phase in the present experiment. In other words, participants were not taught the expected name of each picture in advance. Eight practice trials were presented twice prior to the experimental trials for kanji and kana blocks. The pictures and distractors used in the practice trials were different from the experimental items.

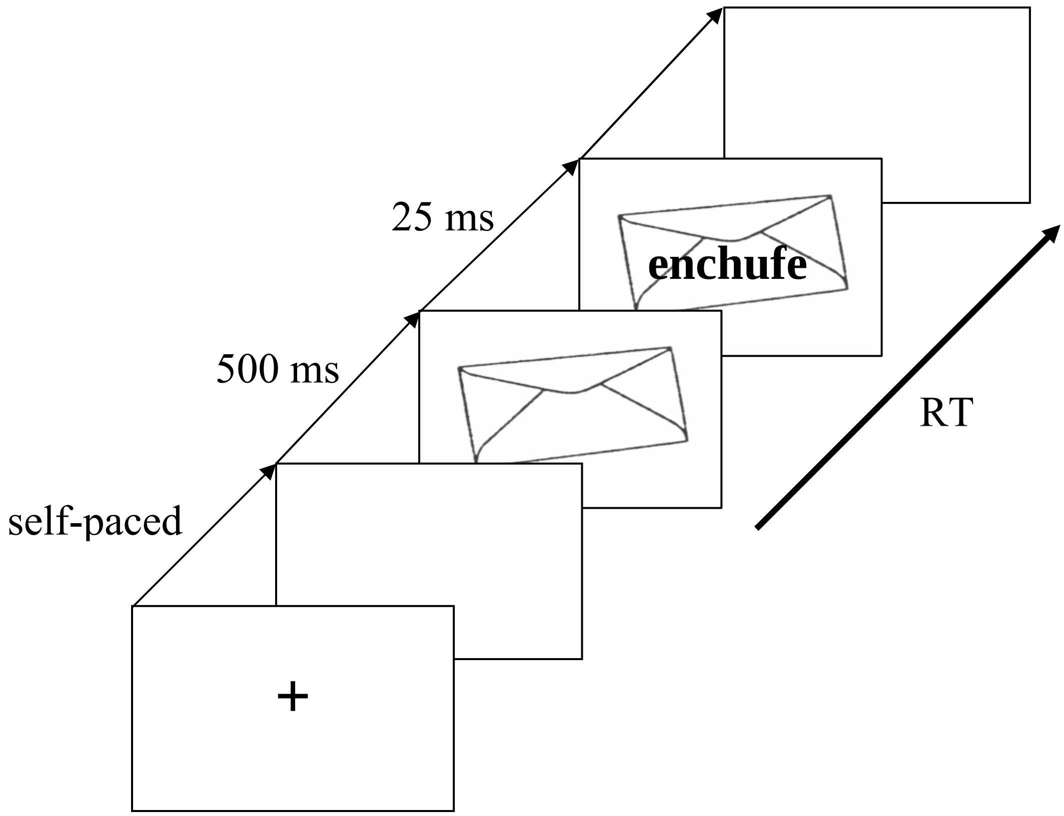


Figure 4.2. An illustration of a trial in the picture-word interference task.

Results and Discussion

In the present experiment, the kanji and kana data were analyzed separately. As mentioned above, kanji and kana scripts belong to different writing systems—logographic and syllabary respectively. To avoid introducing a potential switch cost within language for the Japanese-English bilinguals (from kanji to kana vice versa), we blocked the kanji and kana trials. Furthermore, the lexical properties of the kanji and kana items differ in frequency (and familiarity for pictures), resulting in significant differences in naming latencies and accuracy on the picture-word interference task. Therefore, the kanji and kana blocks were treated as separate tasks for all participants.

In this section of the chapter, overall analyses are reported, followed by a series of post-hoc analyses with different lexical properties. Prior to the main data analyses, data from the proficiency and individual difference measures are first analyzed to ensure that the Spanish-English bilinguals and the Japanese-English bilinguals are as closely matched on the proficiency and cognitive ability as possible. Otherwise, the observed differences in the performance on the critical tasks might not reflect differences in the consequences of specific forms of bilingualism and the constraints of the native language but differences in proficiency or cognitive ability.

Proficiency Measures

Language History Questionnaire

Language history questionnaire data are summarized in Table 4.6. for each bilingual group.

Table 4.6.

Characteristics of Spanish-English and Japanese-English bilinguals in Experiment 2

Variables	Spanish-English (n = 40)	Japanese-English (n = 40)	p-value t-test
Age (years)	25.2 (6.2)	28.2 (10.2)	*ns*
L1 self-ratings (10 pt scale)			
Reading	9.4 (1.0)	9.1 (1.1)	*ns*
Writing	8.7 (1.7)	8.7 (1.5)	*ns*
Speaking	9.6 (0.7)	9.3 (1.3)	*ns*
Listening	9.7 (0.6)	9.4 (1.1)	*ns*
Mean	9.4 (0.8)	9.1 (1.1)	*ns*
L2 self-ratings (10 pt scale)			
Reading	8.9 (1.1)	7.5 (1.7)	< .001
Writing	8.4 (1.5)	6.8 (1.9)	< .001
Speaking	8.3 (1.7)	6.9 (2.3)	< .01
Listening	8.7 (1.2)	7.1 (2.3)	< .001
Mean	8.6 (1.3)	7.1 (1.9)	< .001
Mean daily L1 usage (%)	46.7 (25.5)	38.5 (27.1)	*ns*
Mean daily L2 usage (%)	54.7 (24.1)	57.1 (26.2)	*ns*
L2 age of acquisition (years)	8.3 (4.6)	10.7 (3.7)	<. 05
Months of L2 immersion	95.3 (81.7)	78.8 (72.1)	*ns*

Note. Standard deviations are in parentheses.

Overall, the Spanish and Japanese groups were closely matched on age, L1 self-assessed ratings, mean daily L1 and L2 usage, and length of living in English speaking countries (months of L2 immersion). Similar to Experiment 1, the ratings of self-assessed proficiency in L2 were higher for Spanish-English bilinguals than for Japanese-English bilinguals [$t(78) = 4.17$, $p < .001$], suggesting that the Spanish-English bilinguals perceived themselves to be more proficient in the L2 English than the Japanese-English bilinguals. There was also a significant difference in the age of L2 acquisition between these two bilingual groups, such that Spanish-English bilinguals acquired the L2 English earlier than Japanese-English bilinguals [$t(74.26) = 2.56$, $p < .05$]. Given the equivalent level of performance on the other proficiency measures, reported below, the difference in the L2 ratings seem likely to reflect a cultural difference in the use of the self-assessment scale (e.g., Hoshino et al., in preparation-a).

It is also important to point out that most of the bilinguals who were included in the subsequent analyses spoke English as an L2 and were more proficient in the L1 Spanish/Japanese than in the L2 English or equally proficient in both languages based on their self-assessed ratings for the L1 and L2. Unlike Experiment 1, however, there were 12 Spanish-English bilinguals and four Japanese-English bilinguals who were more proficient in the L2 English than in the L1 Spanish/Japanese included in the analyses. In Chapter 7, we will address the question of whether the slightly different composition of bilinguals across experiments had an impact on the pattern of the results.

Lexical Decision in L2 English

A lexical decision task in the L2 English was included in the present experiment as an on-line measure of proficiency. As described in the general method in Chapter 2, the materials were taken from Azuma and Van Orden (1997). Although the number and relatedness of word meanings were manipulated in the original paper, we report only the simple analyses on words and nonwords here for the purpose of assessing lexical proficiency in English. More detailed analyses reported in Appendix B2. Mean values for the accuracy and RT for words and nonwords are shown by language groups and external linguistic environments (i.e., whether bilinguals are immersed in the L1 or L2 context) in Table 4.7.

Table 4.7.

Lexical Decision Results for Spanish-English and Japanese-English bilinguals in Experiment 2

Variables	Spanish-English (*n* = 40)	Japanese-English (*n* = 40)
Nonword RT (ms)	924 (257)	1015 (298)
Word RT (ms)	681 (112)	731 (175)
Nonword accuracy (%)	83.1 (11.3)	79.1 (10.8)
Word accuracy (%)	94.2 (3.7)	93.6 (3.0)

Note. Standard deviations are in parentheses.

There were no significant differences in RTs and accuracy for nonwords and words between Spanish-English and Japanese-English bilinguals [$t(78) = 1.47$, $p > .10$ for nonword RTs; $t(66.28) = 1.52$, $p > .10$ for word RTs; $t(78) = 1.61$, $p > .10$ for nonword accuracy; $t < 1$ for word accuracy], suggesting that the two bilingual groups were equally proficient in the L2 English although the Spanish-English bilinguals had rated themselves as more proficient in L2 than the Japanese-English bilinguals.

Verbal Fluency in L1 Spanish/Japanese and in L2 English

A verbal fluency task was also included in the present experiment as an independent measure of proficiency in L2 production. As noted earlier, category names were taken from Linck (2005) and participants were first asked to name as many examples that belong to a given category as possible in L1 for the first four categories and in L2 for the second four categories (see Chapter 2). As shown in Table 4.8., the Japanese-English bilinguals produced more examples in L1 than in L2 [$t(39) = 3.10$, $p < .01$], whereas the Spanish-English bilinguals did not show such a difference [$t(39) = 1.46$, $p > .10$].[4] However, there was no difference in both L1 and L2 between Spanish-English and Japanese-English bilinguals [*t*s < 1]. Although it appears that these bilinguals are balanced in their L1 and L2, it is important to note that the verbal fluency task was the last task in the experiment and that naming pictures in their L2 English eight times for the critical picture-word interference task might have inflated their verbal fluency in the L2 English. In other words, the bilinguals might not have been able to name as many

[4] The lack of difference in Spanish-English bilinguals between L1 and L2 was partly due to the number of L2 dominant bilinguals in the Spanish group. The Spanish group had 12 L2 dominant bilinguals, whereas the Japanese group had only four L2 dominant bilinguals based on their self-assessed proficiency in L1 and L2. Indeed, the L1 dominant Spanish-English bilinguals ($n = 28$) produced more examples in L1 ($M = 12.9$) than in L2 ($M = 10.9$) [$t(27) = 3.66$, $p < .01$].

examples in the L2 English during the verbal fluency task if they had not performed the picture-word interference task prior to the verbal fluency task.

Table 4.8.

Verbal Fluency Results for Spanish-English and Japanese-English bilinguals in Experiment 2

	Spanish-English (n = 40)	Japanese-English (n = 40)
Mean exemplars per category in L1	11.8 (2.9)	11.7 (1.7)
Mean exemplars per category in L2	11.0 (2.0)	10.8 (2.0)

Note. Standard deviations are in parentheses.

Overall, the results of the three proficiency measures suggest that Spanish-English bilinguals and Japanese-English bilinguals were closely matched on their L2 English proficiency.

Individual Difference Measures

Simon

The Simon task was included to assess the ability to ignore irrelevant information. Simon data are summarized by language group in Table 4.9. A 3 (type of trials: neutral, congruent, and incongruent) x 2 (language group: Spanish-English and Japanese-English) mixed ANOVA was conducted on the RT and accuracy data. The analysis for the RT data revealed a main effect of language group [$F(1, 78) = 18.14$, $MSE = 15733.58$, $p < .001$] and a main effect of type of trials [$F(2, 156) = 76.17$, $MSE = 401.91$, $p < .001$].

More importantly, the interaction between type of trials and language group was significant [$F(2, 156) = 4.57$, $MSE = 401.91$, $p < .05$]. To further examine the 3 (type of trials) x 2 (language group) interaction, three 2 (type of trials) x 2 (language group) ANOVA was conducted by taking out one level from type of trials. The 2 x 2 interaction was significant when congruent and incongruent trails were entered [$F(1, 78) = 8.12$, $MSE = 449.02$, $p < .01$], but not when neutral and congruent or neutral and incongruent trials were entered [$F(1, 78) = 2.01$, $MSE = 331.66$, $p > .10$; $F(1, 78) = 2.81$, $MSE = 425.07$, $p = .098$, respectively]. The significant 2 x 2 interaction indicates that the magnitude of the difference between Spanish-English and Japanese-English bilinguals was larger for incongruent trials [$F(1, 78) = 24.67$, $MSE = 5056.11$, $p < .001$] than for congruent trials [$F(1, 78) = 12.26$, $MSE = 5849.97$, $p < .01$]. For the accuracy data, the main effect of type of trials was significant [$F(2, 156) = 22.74$, $MSE = 7.74$, $p < .001$], indicating that incongruent trials were less accurate than congruent or neutral trials [$ps < .001$]. However, there was no main effect of language group or interaction between language group and type of trials [$F < 1$ for language group; $F(2, 156) = 1.68$, $MSE = 7.74$, $p > .10$ for the interaction]. These results suggest that the Japanese-English bilinguals appear to have a better inhibitory control.

Table 4.9.

Simon Results for Spanish-English and Japanese-English bilinguals in Experiment 2

Variables	Spanish-English (n = 40)	Japanese-English (n = 40)
Simon effect (ms)	48.6 (36.1)	29.5 (22.2)
RT for neutral (ms)	472 (93)	404 (51)
RT for congruent (ms)	450 (92)	390 (58)
RT for incongruent (ms)	499 (86)	420 (52)
Accuracy for neutral (%)	99.4 (1.4)	98.9 (1.9)
Accuracy for congruent (%)	99.2 (1.8)	98.5 (2.1)
Accuracy for incongruent (%)	96.4 (4.5)	97.0 (3.4)

Note. Standard deviations are in parentheses.

Operation Span

An operation span task was used to measure processing resources. As can be seen in Table 4.10., the Japanese-English bilinguals recalled more words on the correct trials [$t(68.14) = 2.65$, $p < .05$], made a judgment on equations more quickly [$t(78) = 5.56$, $p < .001$], and made fewer errors on the judgment part [$t(59.53) = 3.94$, $p < .001$] than the Spanish-English bilinguals. These results suggest that the Japanese-English bilinguals appear to have greater processing resources than the Spanish-English bilinguals.[5]

[5] However, we cannot rule out the possibility that this difference might reflect efficiency in solving simple arithmetic operation rather than the availability of language processing resources.

Table 4.10.

Operation Span Results for Spanish-English and Japanese-English Bilinguals in Experiment 2

Variables	Spanish-English (*n* = 40)	Japanese-English (*n* = 40)
Operation span (1-60)	33.4 (11.1)	39.0 (7.4)
RT on judgment (ms)	2514 (242)	2197 (266)
Errors on judgment (1-60)	14.8 (8.7)	8.6 (4.6)

Note. Standard deviations are in parentheses.

In sum, the Japanese-English bilinguals appear to have better inhibitory control and more cognitive resources than Spanish-English bilinguals. In the *General Discussion* of the present chapter, we will later reanalyze the critical data from the main picture-word interference task with the Simon and span measures as covariates to consider the implications of these differences.

Data Trimming for Picture-Word Interference Task

As mentioned earlier, kanji trials and kana trials were analyzed separately because kanji and kana belong to different writing systems. Although this script distinction applies only to Japanese-English bilinguals, the data from Spanish-English bilinguals were analyzed in the same manner to make the cross-language group comparisons comparable.

Recorded picture naming responses were first transcribed and coded for accuracy. Unlike Experiment 1, we accepted only the expected picture names as correct responses in order to maintain the phonological manipulation.[6] Responses that deviated from the expected picture name, responses that started with an article or hesitation, and “no” responses were scored as errors. Responses that the microphone did not detect were eliminated as technical errors. After trimming RTs for correct responses that were less than 200 ms for kanji trials and less than 300 ms for kana trials or greater than 3000 ms for both kanji and kana trials, RTs that were 3 standard deviations above or below the mean were identified as outliers and excluded from the analyses.[7] Finally, we calculated RTs and accuracy for correct responses again. Errors (5.6 %), outliers (1.9 %), and technical errors (0.0003 %) for kanji and errors (19.4 %), outliers (2.1 %), and technical errors (0.0005 %) for kana were excluded from the following analyses.

Picture-Word Interference Task with Kanji Items

A 2 x 2 analysis of variance (ANOVA) was conducted by participants (*F*1) and by items (*F*2) on picture naming latencies and accuracy for each type of distractor, with relatedness of distractors (related/unrelated) and language group (Spanish-English/Japanese-English) as independent variables. In the participant analyses, relatedness of distractors is a within-participants variable, whereas language group is a between-participants variable. In the item analyses, both relatedness of distractors and language group are within-items variables. As described earlier, the related distractor words and their unrelated controls were matched on length and frequency item by item.

---

[6] For example, if the participant names the picture of “chicken” as “rooster,” the phonologically related distractor “chico” for “chicken” will turn into an unrelated distractor. Thus, we did not accept synonyms as correct responses regardless of the type of distractors in the present experiment.

[7] Different cut-off scores were used for kanji and kana trials because the distribution of naming latencies for kanji trials was about 100 ms shifted left.

However, the related and unrelated distractors were not matched on length and frequency across conditions. It was impossible to match all the distractors on length and frequency across conditions. Therefore, the data analyses were conducted separately for each condition as well as for each script.

Phonological Condition

Latencies

A 2(relatedness) x 2(language group) mixed ANOVA revealed a main effect of relation both by participants and by items [$F1(1, 78) = 12.94$, $MSE = 2030.77$, $p < .01$; $F2(1, 15) = 6.45$, $MSE = 1440.21$, $p < .05$], with faster latencies in naming pictures with phonologically related distractor words than in naming pictures with phonologically unrelated distractor words (see Figure 4.3.). The main effect of language group approached significance by participants [$F1(1, 78) = 3.88$, $MSE = 35487.58$, $p = .05$] and emerged by items [$F2(1, 15) = 21.71$, $MSE = 2564.28$, $p < .001$], indicative of faster latencies for Japanese-English bilinguals than for Spanish-English bilinguals. However, there was no interaction between relatedness and language group [$F1(1, 78) = 1.69$, $MSE = 2030.77$, $p > .10$; $F2(1, 15) = 1.70$, $MSE = 1378.26$, $p > .10$].

Accuracy

The analysis did not reveal any main effect or interaction [$Fs < 1$] (See Figure 4.4.).

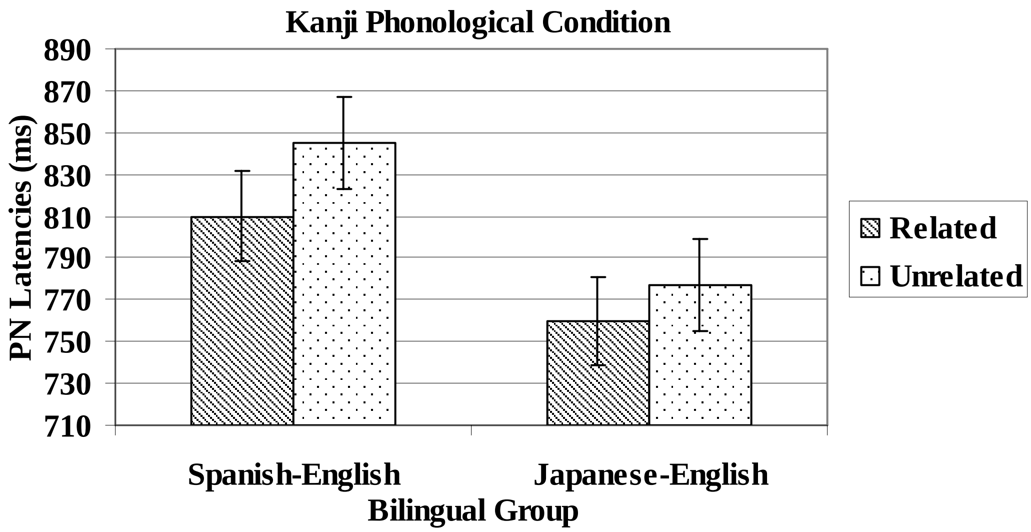


Figure 4.3. Mean picture naming latencies for kanji pictures in the phonological condition as a function of relatedness and bilingual group.

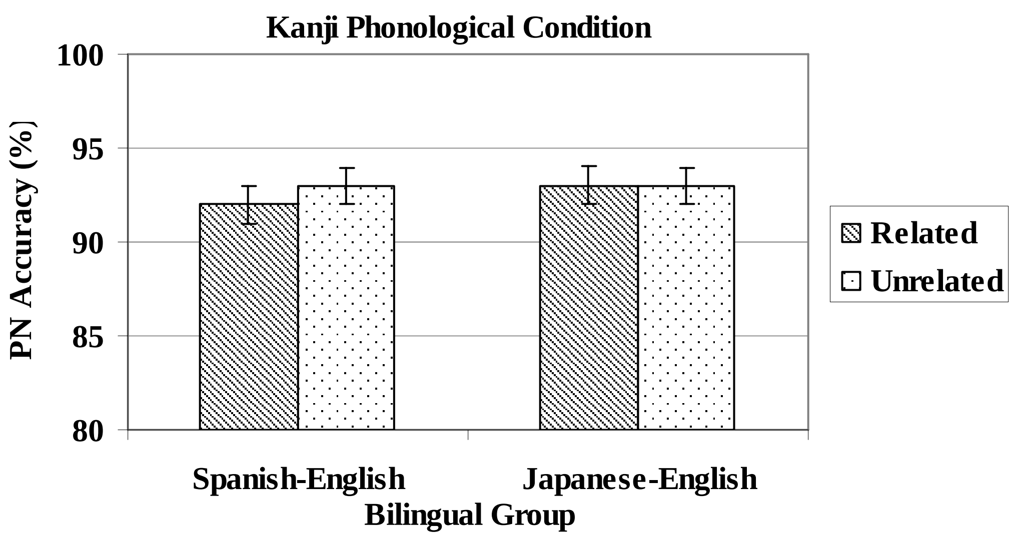


Figure 4.4. Mean picture naming percent accuracy for kanji pictures in the phonological condition as a function of relatedness and bilingual group.

Semantic Condition

Latencies

A 2(relatedness) x 2(language group) mixed ANOVA did not reveal a main effect of relatedness [*F*s < 1], but the main effect of language group was significant both by participants and by items [$F1(1, 78) = 5.26$, $MSE = 40689.09$, $p < .05$; $F2(1, 15) = 63.52$, $MSE = 1226.51$, $p < .001$], with faster latencies for Japanese-English bilinguals than for Spanish-English bilinguals. Most critically, the interaction between relatedness and language group was significant by participants and marginally significant by items [$F1(1, 78) = 5.70$, $MSE = 4072.46$, p < .05; $F2(1, 15) = 3.69$, $MSE = 2230.82$, $p = .07$], such that (see Figure 4.5.)Spanish-English bilinguals named pictures with semantically related distractors more slowly than those with semantically unrelated distractors [$F1(1, 39) = 4.04$, $MSE = 5743.85$, $p = .05$; $F2(1, 15) = 2.51$, $MSE = 4060.63$, $p > .10$], whereas Japanese-English bilinguals did not show such a difference [$F1(1, 39) = 1.67$, $MSE = 2401.66$, $p > .10$; $F2 < 1$].

Accuracy

The analysis revealed a main effect of relatedness [$F1(1, 78) = 7.76$, $MSE = 26.34$, $p < .01$; $F2(1, 15) = 10.05$, $MSE = 8.17$, $p < .01$], indicative of lower accuracy for semantically related distractors than for semantically unrelated distractors. The main effect of language group and the interaction between relatedness and language group were not significant [*F*s < 1 for language group; $F1(1, 78) = 1.11$, $MSE = 26.34$, $p > .10$; $F2(1, 15) = 1.68$, $MSE = 7.03$, $p > .10$] (see Figure 4.6.).

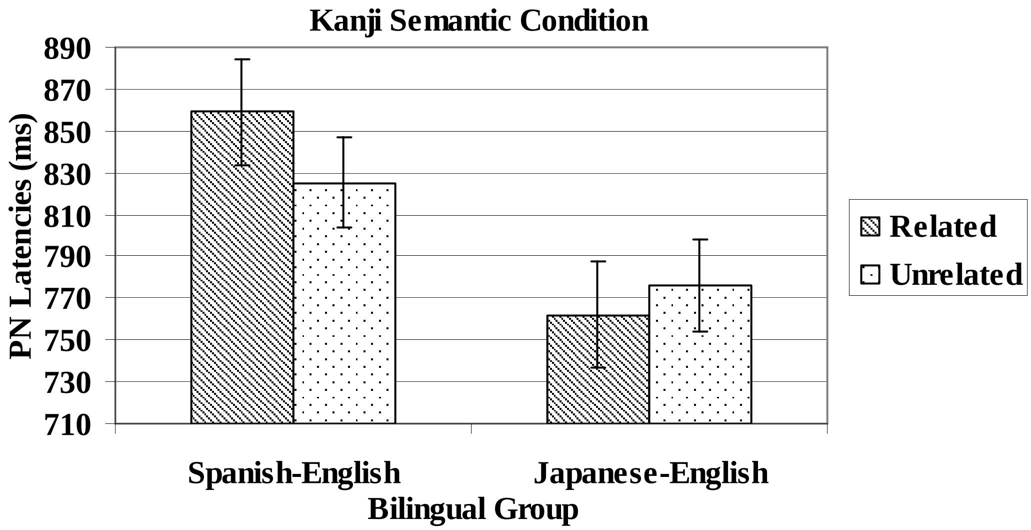


Figure 4.5. Mean picture naming latencies for kanji pictures in the semantic condition as a function of relatedness and bilingual group.

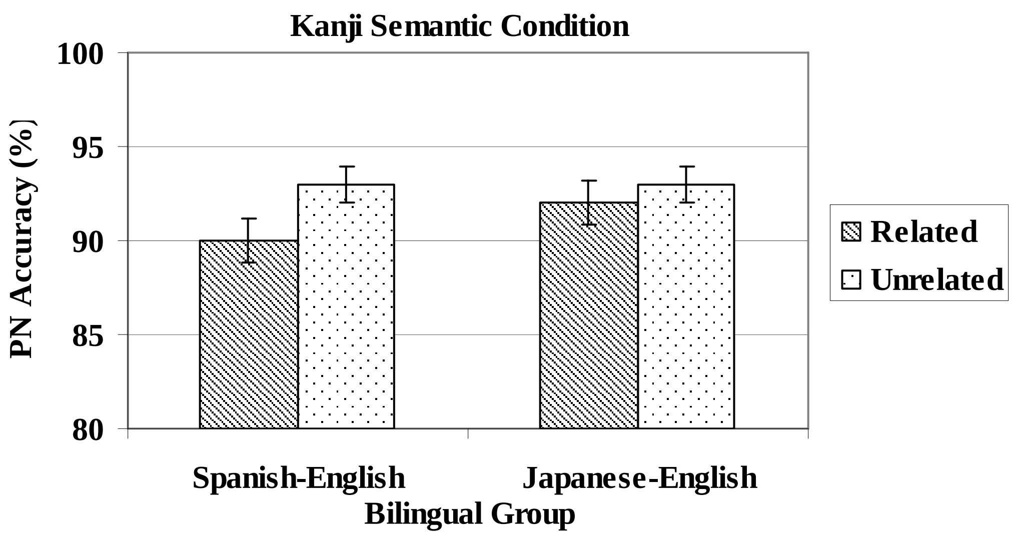


Figure 4.6. Mean picture naming latencies and percent accuracy for kanji pictures in the semantic condition as a function of relatedness and bilingual group.

Phono-Translation Condition

Latencies

The main effect of language group approached significance by participants and was significant by items [$F1(1, 78) = 2.94$, $MSE = 35983.52$, $p = .09$; $F2(1, 15) = 9.09$, $MSE = 3817.82$, $p < .01$], with faster latencies for Japanese-English bilinguals than for Spanish-English bilinguals. The main effect of relatedness was also significant both by subjects and by items [$F1(1, 78) = 5.35$, $MSE = 3233.73$, $p < .05$; $F2(1, 15) = 5.35$, $MSE = 1485.94$, $p < .05$], indicating that pictures with phonologically related distractors to the translation name of the picture were named faster than those with unrelated distractors. However, this main effect of relatedness was qualified by the interaction between relatedness and language group [$F1(1, 78) = 6.36$, $MSE = 3233.73$, $p < .05$; $F2(1, 15) = 7.99$, $MSE = 1008.93$, $p < .05$]. As illustrated in Figure 4.7., Spanish-English bilinguals named pictures with distractors that were phonologically related to the translation of the picture's name faster than those with unrelated distractors [$F1(1, 39) = 12.14$, $MSE = 3112.50$, $p < .01$; $F2(1, 15) = 18.85$, $MSE = 848.83$, $p < .01$], whereas Japanese-English bilinguals did not show such a difference [Fs < 1].

Accuracy

There was no main effect or interaction for accuracy [$F1(1, 78) = 2.45$, $MSE = 43.99$, $p > .10$; $F2(1, 15) = 1.31$, $MSE = 32.86$, $p > .10$; All the other Fs <1] (see Figure 4.8.).

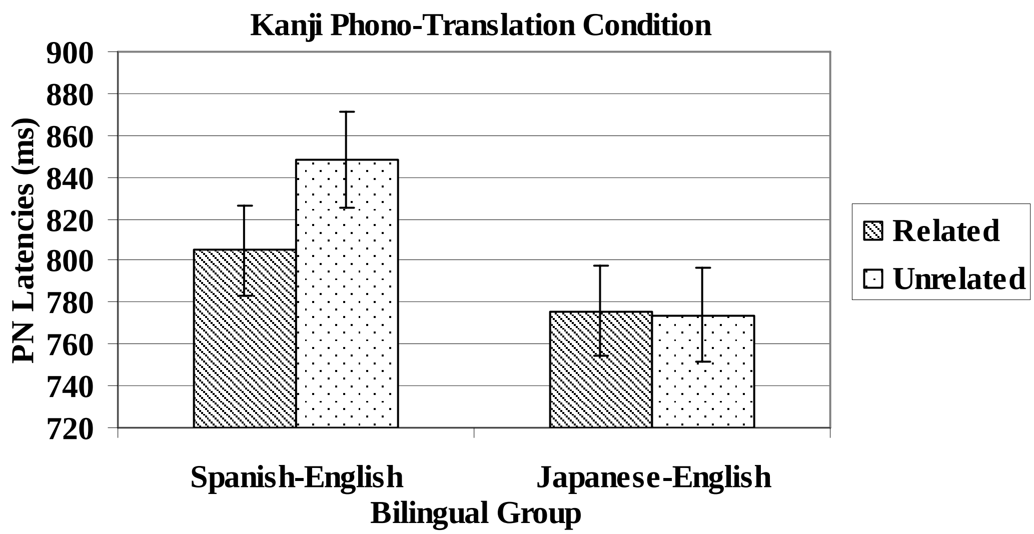


Figure 4.7. Mean picture naming latencies for kanji pictures in the phono-translation condition as a function of relatedness and bilingual group.

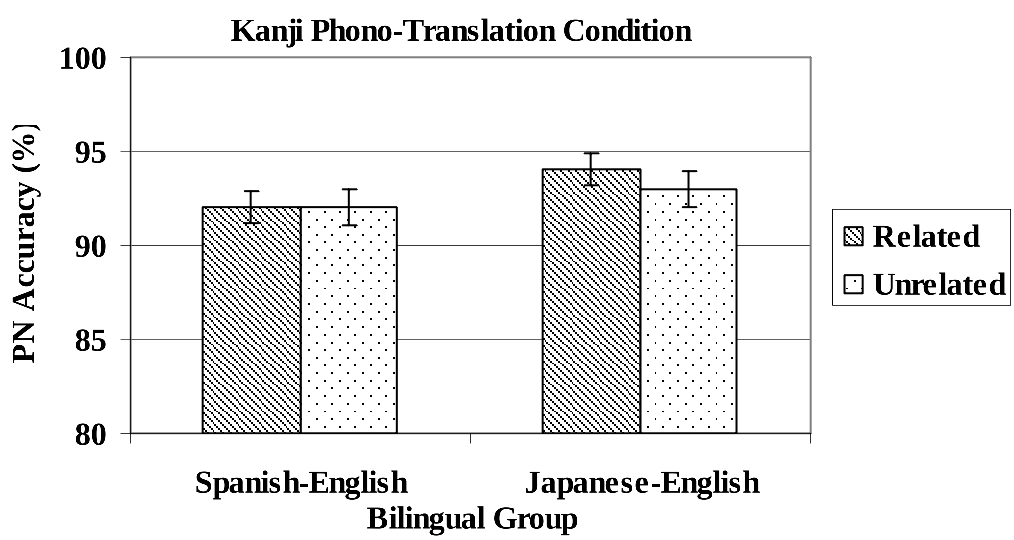


Figure 4.8. Mean picture naming percent accuracy for kanji pictures in the phono-translation condition as a function of relatedness and bilingual group.

Translation Condition

Latencies

The analysis revealed a main effect of relation both by participants and by items [*F*1(1, 78) = 9.90, *MSE* = 2427.01, $p < .01$; *F*2(1, 15) = 7.84, *MSE* = 1419.69, $p < .05$], replicating the translation facilitation effect that has been reported in previous studies (see Chapter 1) in naming pictures with their translation names relative to unrelated distractors (See Figure 4.9.). The main effect of language group approached significance by participants [*F*1(1, 78) = 3.79, *MSE* = 37326.33, $p = .06$] and emerged by items [*F*2(1, 15) = 24.20, *MSE* = 2458.71, $p < .001$], such that Japanese-English bilinguals named pictures faster than Spanish-English bilinguals. However, there was no interaction between relatedness and language group [*F*s < 1].

Accuracy

The main effect of relatedness was significant by participants [*F*1(1, 78) = 5.57, *MSE* = 19.33, $p < .05$] and marginally significant by items [*F*2(1, 15) = 3.52, *MSE* = 12.23, $p = .08$], with higher accuracy for pictures with translation names than for pictures with unrelated names. The main effect of language group and the interaction were not significant [Fs < 1] (see Figure 4.10.).

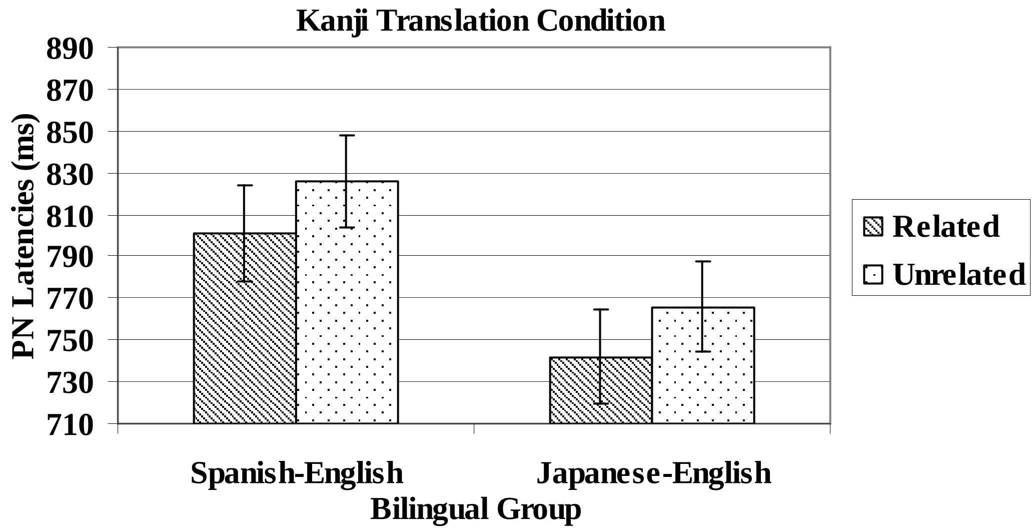


Figure 4.9. Mean picture naming latencies for kanji pictures in the translation condition as a function of relatedness and bilingual group.

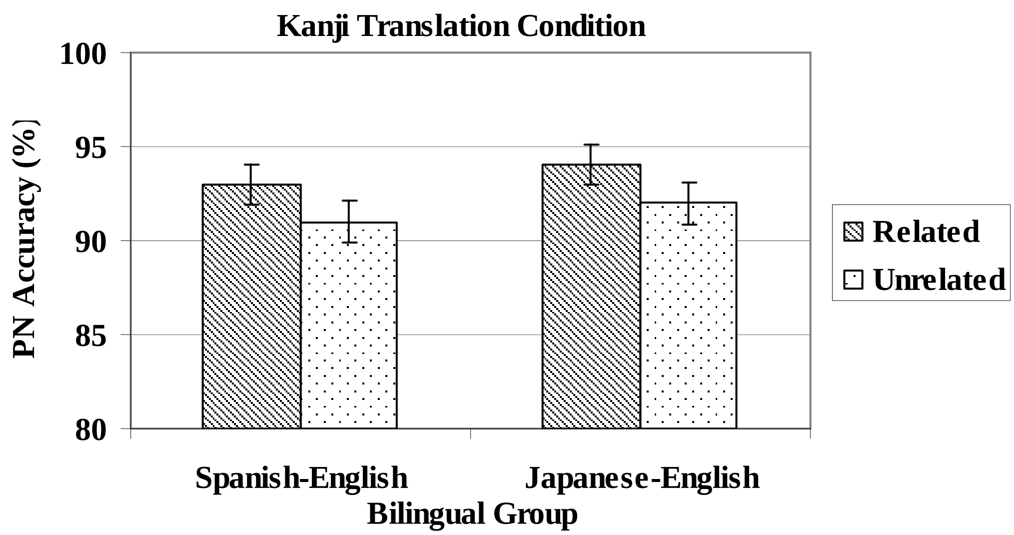


Figure 4.10. Mean picture naming percent accuracy for kanji pictures in the translation condition as a function of relatedness and bilingual group.

Summary

An important result in the analyses on the kanji trials is that as summarized in Table 4.11., both Spanish-English and Japanese-English bilinguals showed phonological and translation facilitation, whereas only Spanish-English bilinguals demonstrated semantic interference and phono-translation facilitation. These results suggest that the presence of script differences appears to serve as a language cue or to function to inhibit unintended alternatives. We discuss the implication of the differential pattern of the results for Spanish-English and Japanese-English bilinguals in the General Discussion of this chapter.

Table 4.11.

Summary of the Picture-Word Interference Results for Kanji Blocks

	Spanish-English bilinguals		Japanese-English bilinguals	
Type of distractor	Latencies	Accuracy	Latencies	Accuracy
Phonological	Facilitation	No effect	Facilitation	No effect
Semantic	Interference	Interference	No effect	Interference[8]
Phono-translation	Facilitation	No effect	No effect	No effect
Translation	Facilitation	Facilitation	Facilitation	Facilitation

[8] Because the main effect of relatedness was significant but there was no significant interaction between relatedness and language group, statistically it is appropriate to interpret that the Japanese-English bilinguals also showed semantic interference. However, if we ran simple main effect tests, only Spanish-English bilinguals showed the semantic interference [$F1(1, 39) = 7.15$, $MSE = 27.15$, $p < .05$; $F2\ (1, 15) = 3.82$, $MSE = 14.78$, $p = .07$], but Japanese-English bilinguals did not [$F1(1, 39) = 1.55$, $MSE = 25.53$, $p > .10$; $F2 < 1$].

One of the questions that arises is whether the faster naming latencies for Japanese-English bilinguals might have washed out the semantic and phono-translation effects. If that is the case, Japanese-English bilinguals should show semantic interference and phono-translation facilitation for kana items that are less frequent.

Picture-Word Interference Task with Kana Items

Again, a 2(relatedness) x 2(language group) ANOVA was performed by participants ($F1$) and by items ($F2$) on picture naming latencies and accuracy for each type of distractor. In the participant analyses, relatedness of distractors is a within-participants variable, whereas language group is a between-participants variable. In the item analyses, both relatedness of distractors and language group are within-items variables.

Phonological Condition

Latencies

The main effect of language group was not significant [$F1 < 1$; $F2(1, 15) = 1.63$, $MSE = 3070.84$, $p > .10$]. The main effect of relatedness was reliable both by subjects and by items [$F1(1, 78) = 19.02$, $MSE = 4337.97$, $p < .001$; $F2(1, 15) = 10.22$, $MSE = 3554.31$, $p < .01$], with faster naming latencies for pictures with phonologically related than unrelated distractors. However, this main effect of relatedness was qualified by the interaction between relatedness and language group [$F1(1, 78) = 9.62$, $MSE = 4337.97$, $p < .01$; $F2(1, 15) = 8.18$, $MSE = 3026.02$, $p < .05$]. As shown in Figure 4.11., Japanese-English bilinguals named pictures with phonologically related distractors faster than those with unrelated distractors [$F1(1, 39) = 21.24$, $MSE = 5687.71$, $p < .001$; $F2(1, 15) = 29.54$, $MSE = 2048.96$, $p < .001$], whereas Spanish-English bilinguals did not show such a difference [$F1(1, 39) = 1.15$, $MSE = 2988.23$, $p > .10$; $F2 < 1$].

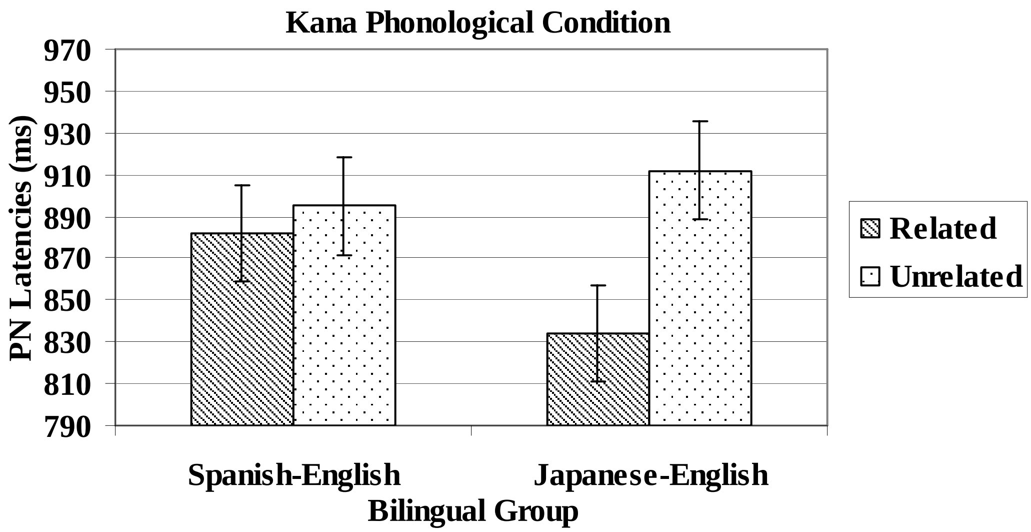


Figure 4.11. Mean picture naming latencies for kana pictures in the phonological condition as a function of relatedness and bilingual group.

Accuracy

The main effect of language group was marginally significant by participants, but not by items [$F1(1, 78) = 3.29$, $MSE = 284.18$, $p = .07$; $F2(1, 15) = 1.65$, $MSE = 229.41$, $p > .10$], indicative of higher accuracy for Japanese-English bilinguals than Spanish-English bilinguals (see Figure 4.12.). The main effect of relatedness approached significance both by participants and by items [$F1(1, 78) = 3.20$, $MSE = 30.14$, $p = .08$; $F2(1, 15) = 4.35$, $MSE = 9.21$, $p = .05$], such that pictures with phonologically related distractors were named more accurately than those with phonologically unrelated distractors. The interaction between language group and relatedness was not reliable [$F1 < 1$; $F2(1, 15) = 1.21$, $MSE = 7.22$, $p > .10$].

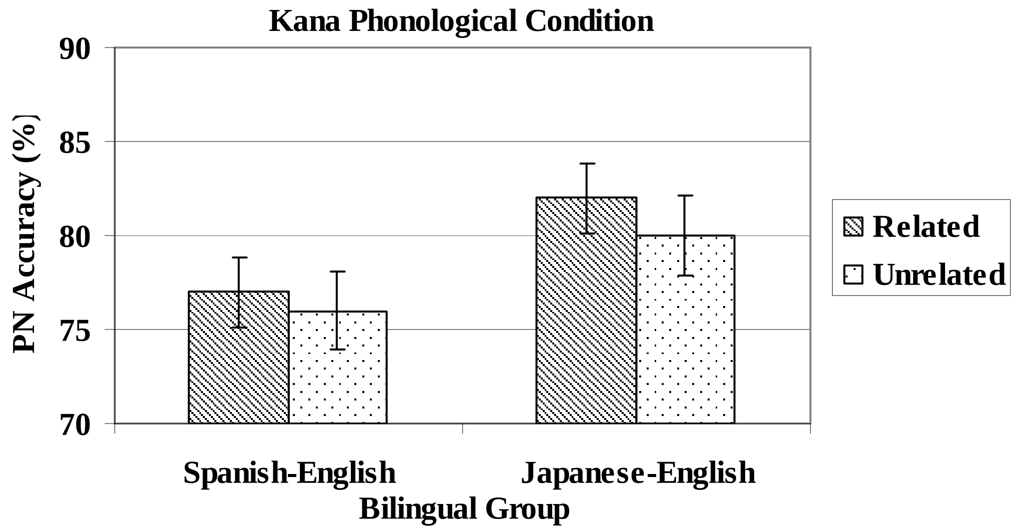


Figure 4.12. Mean picture naming latencies and percent accuracy for kana pictures in the phonological condition as a function of relatedness and bilingual group.

Semantic Condition

Latencies

The analysis revealed a significant main effect of language group by items [$F1 < 1$; $F2(1, 15) = 6.59$, $MSE = 2402.14$, $p < .05$], with faster naming latencies for Japanese-English bilinguals than for Spanish-English bilinguals (see Figure 4.13.). The main effect of relatedness was not significant [Fs < 1]. There was no interaction between language group and relatedness either [Fs < 1].

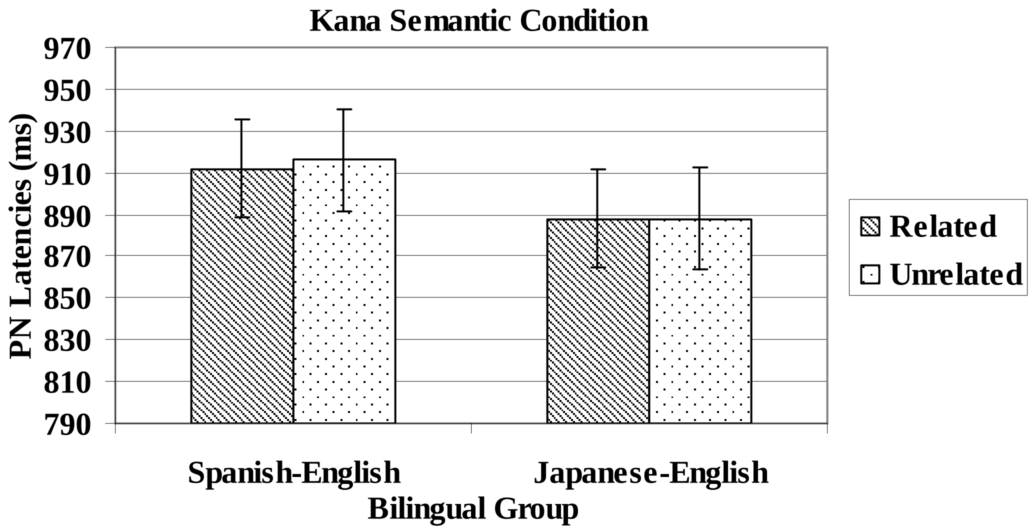


Figure 4.13. Mean picture naming latencies for kana pictures in the semantic condition as a function of relatedness and bilingual group.

Accuracy

The main effect of relatedness approached significance both by participants and by items [$F1(1, 78) = 2.94$, $MSE = 45.24$, $p = .09$; $F2(1, 15) = 3.53$, $MSE = 14.77$, $p = .08$], such that pictures with semantically related distractors were named less accurately than those with semantically unrelated distractors (see Figure 4.14.). There was no main effect of language group and the interaction between relatedness and language group [$F1(1, 78) = 1.77$, $MSE = 291.74$, $p > .10$, $F2(1, 15) = 1.06$, $MSE = 201.00$, $p > .10$ for language group; Fs < 1 for interaction].

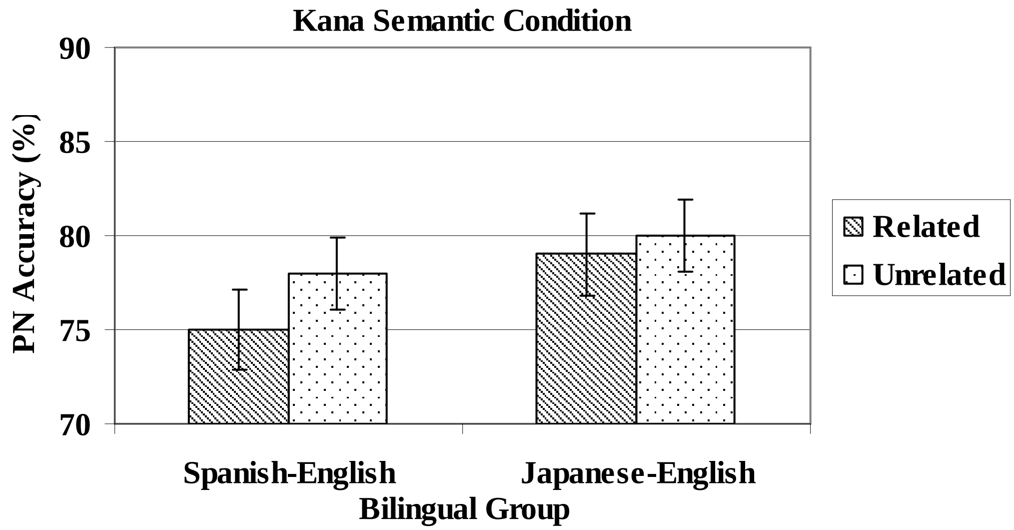


Figure 4.14. Mean picture naming percent accuracy for kana pictures in the semantic condition as a function of relatedness and bilingual group.

Phono-Translation Condition

Latencies

There was no main effect or interaction [*F*1 , *F*2(1, 15) = 1.62, *MSE* = 1546.06, *p* > .10 for relatedness; All the other *F*s < 1] (see Figure 4.15).

Accuracy

The main effect of language group was marginally significant by participants but not by items [*F*1(1, 78) = 3.97, *MSE* = 267.62, *p* = .05; *F*2(1, 15) = 1.98, *MSE* = 215.18, *p* > .10], with higher accuracy for the Japanese-English bilinguals than for the Spanish-English bilinguals (See Figure 4.16.). The main effect of relatedness and the interaction between language group and relatedness were not significant [*F*s < 1].

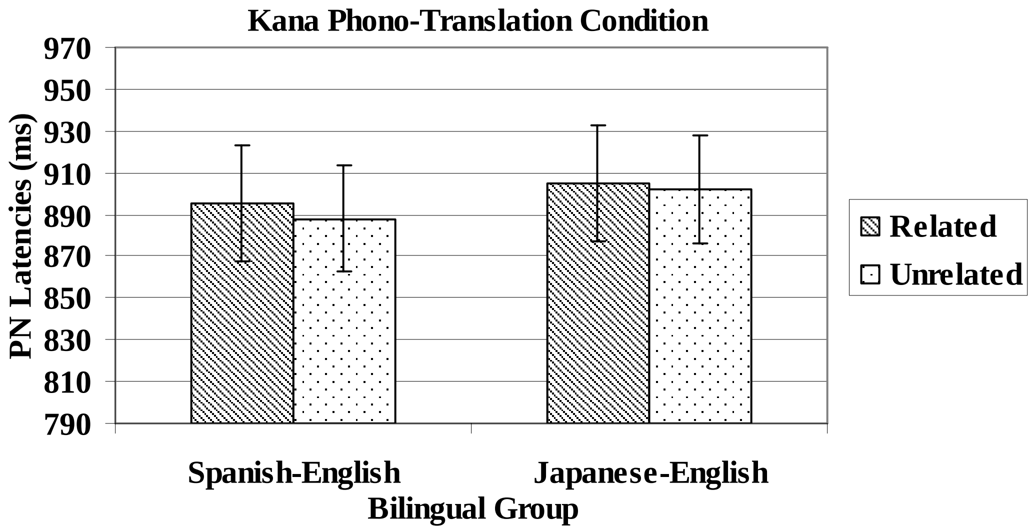


Figure 4.15. Mean picture naming latencies for kana pictures in the phono-translation condition as a function of relatedness and bilingual group.

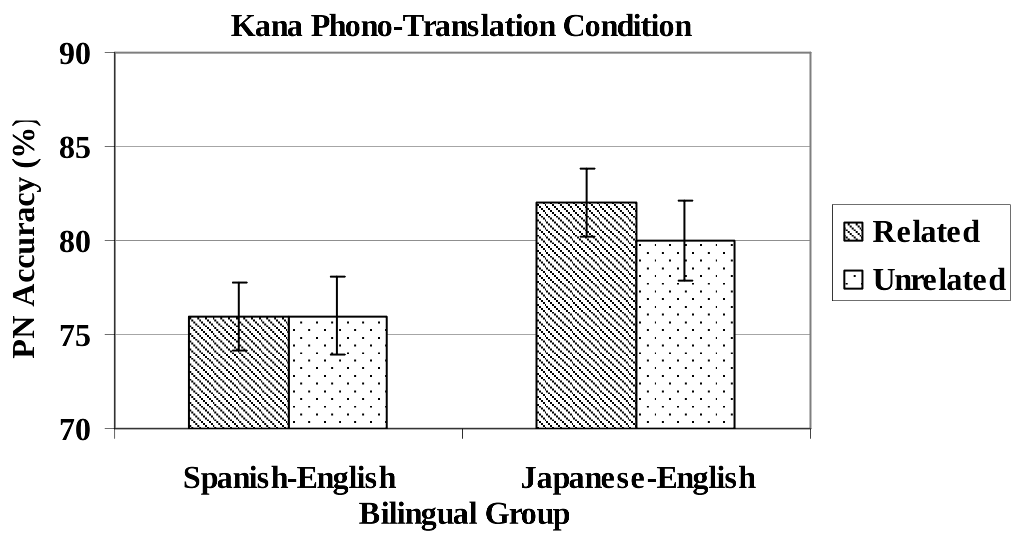


Figure 4.16. Mean picture naming percent accuracy for kana pictures in the phono-translation condition as a function of relatedness and bilingual group.

Translation Condition

Latencies

The main effect of relatedness was reliable by participants, but not by items [$F1(1. 78) = 8.38$, $MSE = 4299.04$, $p < .01$; $F2(1, 15) = 2.66$, $MSE = 3319.59$, $p > .10$], with faster naming latencies for pictures with their translation names than those with unrelated distractors (see Figure 4.17.). The main effect of language group was not significant either by participants or by items [$F1(1, 78) = 1.43$, $MSE = 44102.37$, $p > .10$, $F2(1, 15) = 3.03$, $MSE = 6516.50$, $p > .10$]. There was no significant interaction between relatedness and language group [Fs < 1].

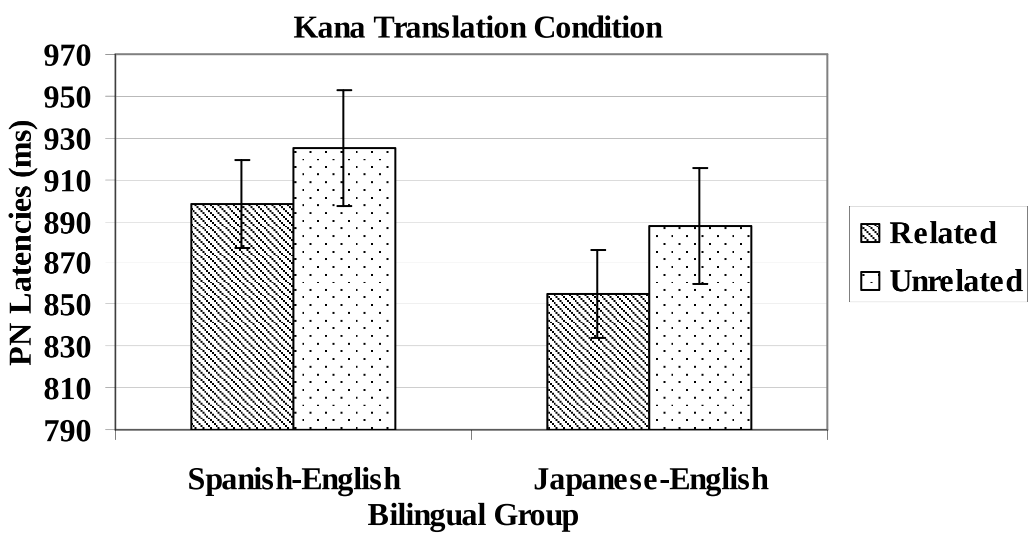


Figure 4.17. Mean picture naming latencies for kana pictures in the translation condition as a function of relatedness and bilingual group.

Accuracy

There was no main effect or interaction for accuracy either [$F1(1, 78) = 1.82$, $MSE = 288.25$, $p < .05$, $F2(1, 15) = 1.26$, $MSE = 169.62$, $p > .10$ for language group; All the other Fs < 1] (see Figure 4.18.).

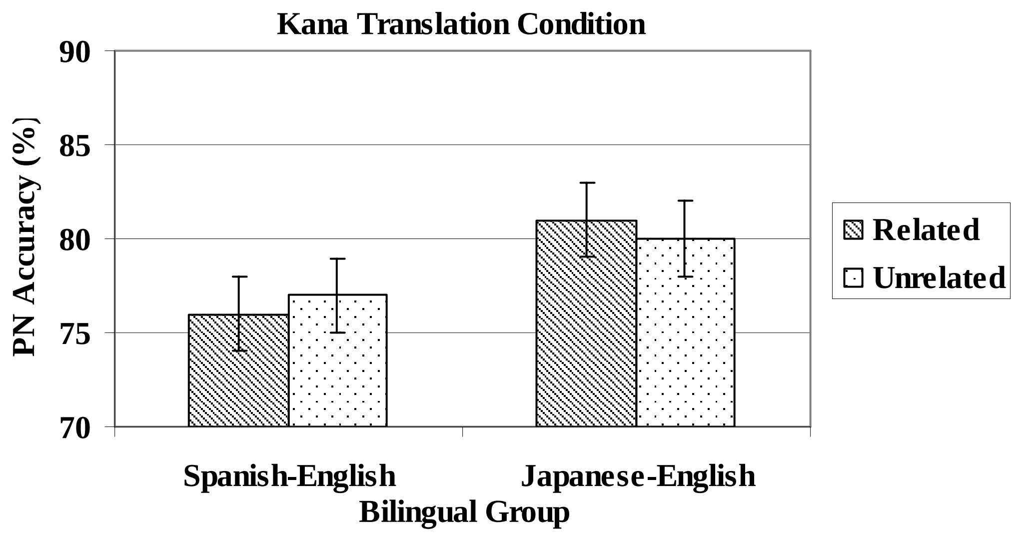


Figure 4.18. Mean picture naming percent accuracy for kana pictures in the translation condition as a function of relatedness and bilingual group.

Summary

Unlike kanji blocks, neither Spanish-English bilinguals nor Japanese-English bilinguals showed semantic interference or phono-translation facilitation in kana (see Table 4.11.). As shown in Table 4.5., there was no difference in relatedness and similarity ratings between kanji and kana for Spanish materials [ts < 1] except for semantically unrelated items [$t(18.86) = 2.41$, $p < .05$]. If anything, the difference in the relatedness ratings of semantically unrelated items between kanji and kana should have produced a larger effect of semantic interference for the Spanish-English bilinguals for the kana pictures. The ratings suggest that the absence of semantic interference and phono-translation facilitation for kana pictures for the Spanish-English bilinguals was not due to the relation of the picture and the distractor word. Alternatively, if the lack of semantic and phono-translation effect in kanji for Japanese-English was simply due to the speed of processing, these effects should have emerged for the kana pictures because they were named more slowly than the kanji pictures. One possibility for the lack of semantic and phono-translation effects in kana for Spanish-English bilinguals is that the absence of picture familiarization phase in the present experiment might have increased variability so that otherwise subtle effects of semantic and phono-translation relatedness may have disappeared. In other words, it is possible that in the present experiment participants may have named pictures more slowly in the first blocks than in the last few blocks regardless of the manipulation of distractors. In most of the previous picture-word interference studies, participants were trained on picture names prior to the experimental proper. Thus naming less familiar objects in the first few blocks would not have been more difficult than naming those objects in the last few blocks. Given that the kanji pictures were more frequent and familiar and were named more accurately, the absence of a familiarization procedure may have had an impact on the pattern of the results if pictures are less frequent and familiar and pictures are repeated during the experiment.

However, a question still remains as to why the Japanese-English bilinguals demonstrated large phonological facilitation, whereas Spanish-English bilinguals did not. As can be seen in Table 4.5., phonological similarity for kana items in Spanish was as great as for kanji items in Spanish [$t < 1$] and was not any smaller than for kana items in

Japanese [$t(15) = 1.18$, $p > .10$]. The absence of phonological facilitation naming kana pictures for the Spanish-English bilinguals may be due to the orthographic manipulation of the Spanish phonological distractors. To investigate this possibility, the data for phonologically related and unrelated conditions were reanalyzed in the following section.

Table 4.12.

Summary of the Picture-Word Interference Results for Kana Blocks

	Spanish-English bilinguals		Japanese-English bilinguals	
Type of distractor	Latencies	Accuracy	Latencies	Accuracy
Phonological	No effect	No effect	Facilitation	No effect
Semantic	No effect	No effect	No effect	No effect
Phono-translation	No effect	No effect	No effect	No effect
Translation	Facilitation	No effect	Facilitation	No effect

Orthographic and Phonological Similarity

As mentioned in Chapter 3, script differences may not be identical to orthographic differences. The reason why we obtained cognate facilitation for Japanese-English bilinguals whose two languages differ in script may be that there was no interaction between L1 and L2 “orthography.” To investigate this possibility, Experiment 2(the picture-word interference experiment) included an additional manipulation for the Spanish-English bilinguals, such that half of the experimental pictures had not only phonologically but also orthographically similar distractors in the related condition

(+O+P) and the other half had phonologically similar but orthographically dissimilar distractors in the related condition (-O+P) (see Table 4.13.). For Japanese-English bilinguals, all the pictures had phonologically similar but orthographically dissimilar phonologically related distractors (-O+P) because Japanese distractors always differ in script from English picture names. As described previously, each phonologically related distractor was paired with an unrelated control that was matched on frequency and length.

Table 4.13.

Examples of Phonologically Related Distractors by Orthographic Similarity and Language

Spanish-English		Japanese-English	
Orthographically Similar Phonologically Similar (+O+P)	GOAT goma (rubber)	Orthographically Dissimilar Phonologically Similar (-O+P)	GOAT ゴム [go.mu] (rubber)
Orthographically Dissimilar Phonologically Similar (-O+P)	BEAR vestido (dress)	Orthographically Dissimilar Phonologically Similar (-O+P)	BEAR ベルト [be.ru.to] (belt)

Note. Each of these distractors has an unrelated matched control. The English picture names are capitalized. The translations of the distractor words are in parentheses and the readings of the Japanese distractors are in brackets.

A 2(orthographic similarity: similar/dissimilar) x 2(relatedness: phonologically related/phonologically unrelated) ANOVA was conducted on naming latencies and accuracy for kana and kanji blocks separately for each language group. In the participant analyses, both orthographic similarity and relatedness were within-participants variables, whereas in the item analyses, orthographic similarity was a between-items variable and relatedness was a within-items variable.

Kana for Spanish-English Bilinguals

Latencies

The analysis revealed a main effect of orthographic similarity by participants [$F1(1, 39) = 4.37$, $MSE = 12733.29$, $p < .05$; $F2(1, 14) = 2.01$, $MSE = 7468.06$, $p > .10$], with faster naming latencies for orthographically dissimilar condition than orthographically similar condition. The main effect of relatedness was not significant [Fs < 1]. Most importantly, the interaction between orthographic similarity and relatedness was significant by participants [$F1(1, 39) = 4.78$, $MSE = 12036.30$, $p < .05$; $F2(1, 14) = 1.86$, $MSE = 4284.77$, $p > .10$]. As illustrated in Figure 4.19., Spanish-English bilinguals showed facilitation only when the phonologically related distractors were also orthographically similar [$F1(1, 39) = 4.51$, $MSE = 10909.22$, $p < .05$; $F2(1, 7) = 1.05$, $MSE = 6099.06$, $p > .10$], but not when the phonologically related distractors were orthographically dissimilar [$F1(1, 39) = 1.90$, $MSE = 7239.95$, $p > .10$; $F2 < 1$].

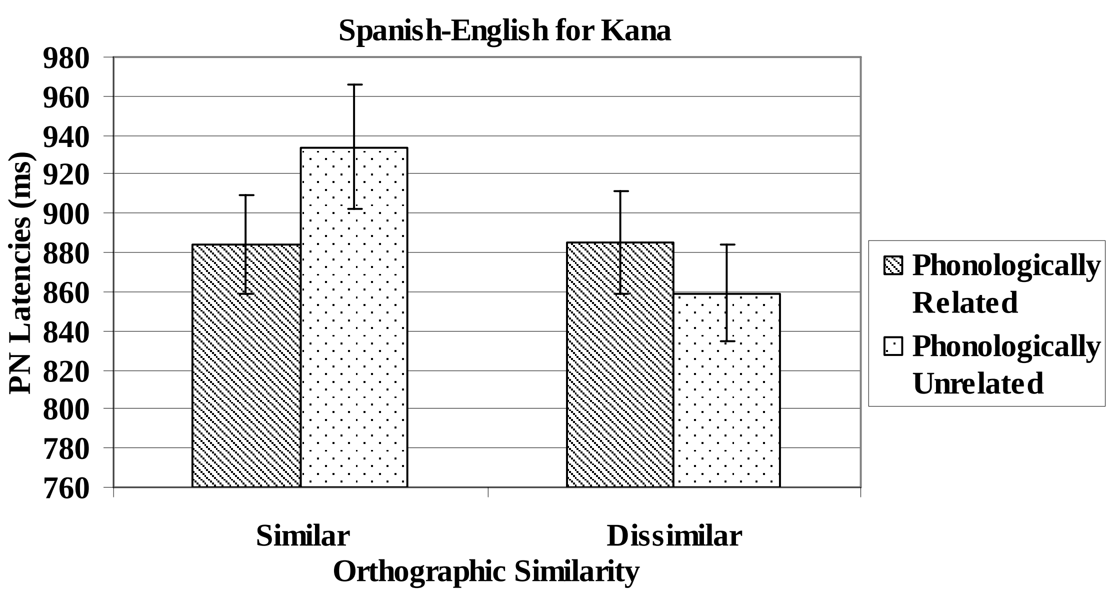


Figure 4.19. Mean picture naming latencies for Spanish-English bilinguals for kana pictures as a function of phonological relatedness and orthographic similarity.

Accuracy

The main effect of orthographic similarity was significant by participants but not by items [$F1(1, 39) = 8.13$, $MSE = 312.48$, $p < .01$; $F2 < 1$], such that Spanish-English bilinguals named pictures for the orthographically similar condition more accurately than those for the orthographically dissimilar condition. The main effect of relatedness was not reliable [$F1 < 1$; $F2(1, 14) = 1.08$, $MSE = 5.30$, $p > .10$]. The interaction between orthographic similarity and relatedness approached significance by participants and was significant by items [$F1(1, 39) = 3.38$, $MSE = 48.85$, $p = .07$; $F2(1, 14) = 6.63$, $MSE = 5.30$, $p < .05$], such that as can be seen in Figure 4.20., Spanish-English bilinguals were more accurate for naming pictures with orthographically and phonologically similar distractosr relative to pictures with unrelated controls [$F1(1, 39) = 2.93$, $MSE = 54.04$, $p = .095$; $F2(1, 7) = 7.96$, $MSE = 4.35$, $p < .05$] but did not show such facilitation in naming pictures with only phonologically similar distractors [$F1 < 1$; $F2(1, 7) = 1.00$, $MSE = 6.25$, $p > .10$].

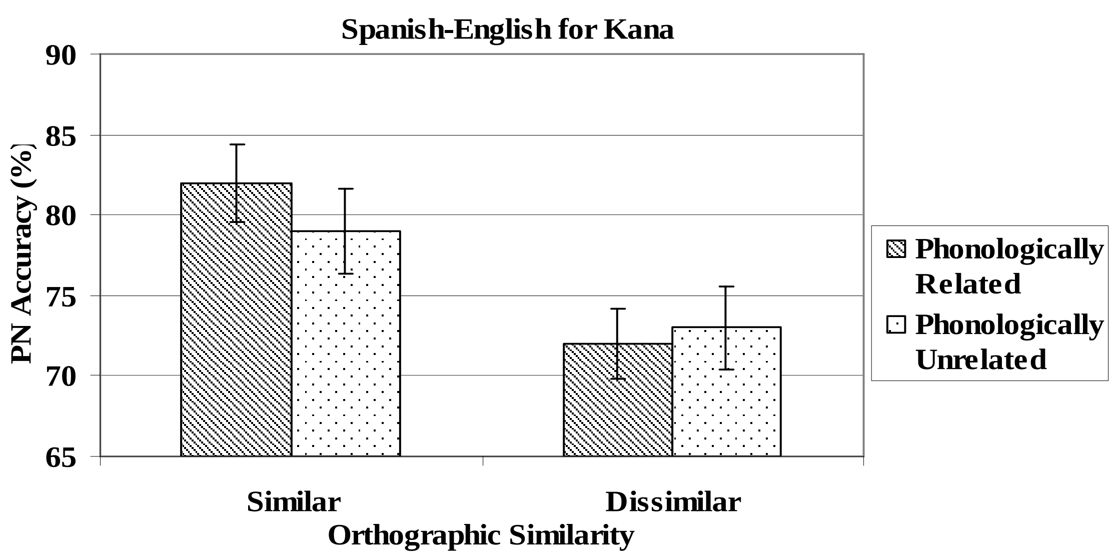


Figure 4.20. Mean picture naming percent accuracy for Spanish-English bilinguals for kana pictures as a function of phonological relatedness and orthographic similarity.

An important result of these analyses is that Spanish-English bilinguals demonstrated phonological facilitation only when the Spanish distractor word was orthographically as well as phonologically similar to the name of the picture in English. This result suggests that the lack of phonological facilitation in the overall analyses was due to the inclusion of orthographically dissimilar items. Contrary to the kana picture blocks, the Spanish-English bilinguals showed phonological facilitation for kanji trials even in the overall analyses. In the following section, we performed the same set of analyses to determine whether orthographic similarity would modulate phonological facilitation for the kanji pictures with higher frequency and familiarity.

Kanji for Spanish-English bilinguals

Latencies

A 2(orthographic similarity) x 2(relatedness) ANOVA revealed a main effect of relation both by participants and by items [$F1(1, 39) = 8.87$, $MSE = 6088.10$, $p < .01$; $F2(1, 14) = 7.16$, $MSE = 1462.64$, $p < .05$], with faster naming latencies for pictures with phonologically related distractors than for ones with phonologically unrelated distractors. The main effect of orthographic similarity was not significant either by participants or by items [$F1(1, 39) = 1.33$, $MSE = 5415.31$, $p > .10$; $F2 < 1$]. Most critically, the interaction between orthographic similarity and relatedness was significant by participants and approached significance by items [$F1(1, 39) = 4.83$, $MSE = 6150.08$, $p < .05$; $F2(1, 14) = 4.51$, $MSE = 1462.64$, $p = .05$]. As can be seen in Figure 4.21., Spanish-English bilinguals showed phonological facilitation when the distractor was not only phonologically but also orthographically similar to the name of the picture [$F1(1, 39) =$

12.61, *MSE* = 6494.02, $p < .01$; *F*2(1, 7) = 12.20, *MSE* = 1379.63, $p < .01$], but not when the distractor was only phonologically related to the name of the picture [*F*s < 1].

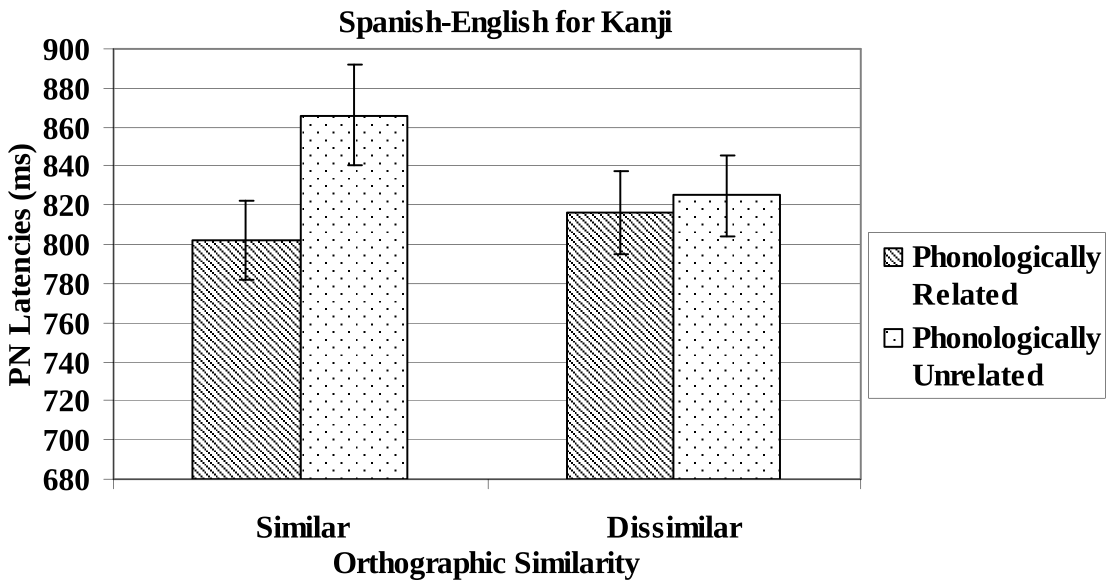


Figure 4.21. Mean picture naming latencies for Spanish-English bilinguals for kanji pictures as a function of phonological relatedness and orthographic similarity.

Accuracy

The main effect of orthographic similarity was significant by participants but not by items [*F*1(1, 39) = 14.54, *MSE* = 98.45, $p < .001$; *F*2(1, 14) = 1.77, *MSE* = 269.97, $p > .10$], with higher accuracy for pictures with orthographically dissimilar distractors than ones with orthographically similar distractors (See Figure 4.22.).

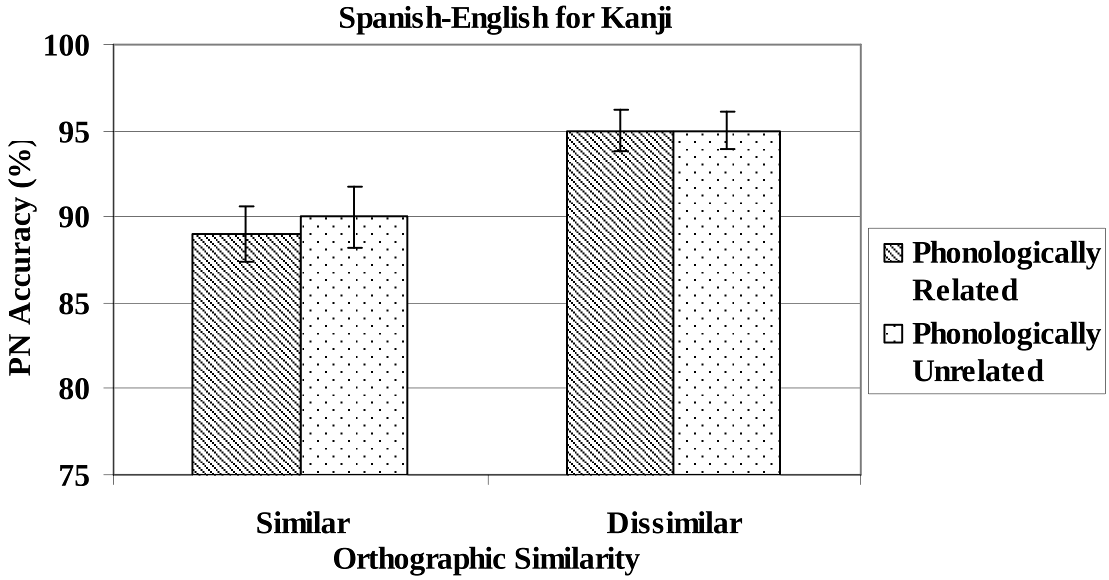


Figure 4.22. Mean picture naming percent accuracy for Spanish-English bilinguals for kanji pictures as a function of phonological relatedness and orthographic similarity.

Again, the difference in accuracy between pictures for the orthographically similar condition and those for the orthographically dissimilar condition was due to the experimental design. There were more low accuracy items for the orthographically similar condition than for the orthographically dissimilar condition. However, the critical finding in these analyses is that similar to the kana blocks, the Spanish-English bilinguals named pictures with a phonologically related distractor faster than those with a phonologically unrelated distractor, only when the Spanish distractor was both orthographically and phonologically similar to the name of the picture in English.

Although the results of the overall analyses for Japanese-English bilinguals and the results of the analyses on orthographic and phonological similarity for Spanish-English bilinguals suggest that script differences are not identical to orthographic differences, we reanalyzed the data for the phonological condition from the Japanese-English bilinguals as well.

Kana for Japanese-English bilinguals

Latencies

Although "orthographic similarity" is a dummy variable for Japanese-English bilinguals (i.e., orthographically dissimilar for all the pictures), the same 2(orthographic similarity) x 2(relatedness) ANOVA was performed. The main effect of relatedness was reliable both by participants and by items [$F1(1, 39) = 22.32$, $MSE = 11016.17$, $p < .001$; $F2(1, 14) = 28.11$, $MSE = 2153.40$, $p < .001$], with faster naming latencies for pictures with phonologically related distractors than those with phonologically unrelated distractors. The main effect of orthographic similarity was also significant both by participants and by items [$F1(1, 39) = 15.08$, $MSE = 13300.25$, $p < .001$; $F2(1, 14) = 5.24$, $MSE = 8140.21$, $p < .05$], such that pictures for the orthographically similar condition were named more slowly than those for the orthographically dissimilar condition. However, there was no interaction between relatedness and orthographic similarity [Fs < 1] (see Figure 4.23.).

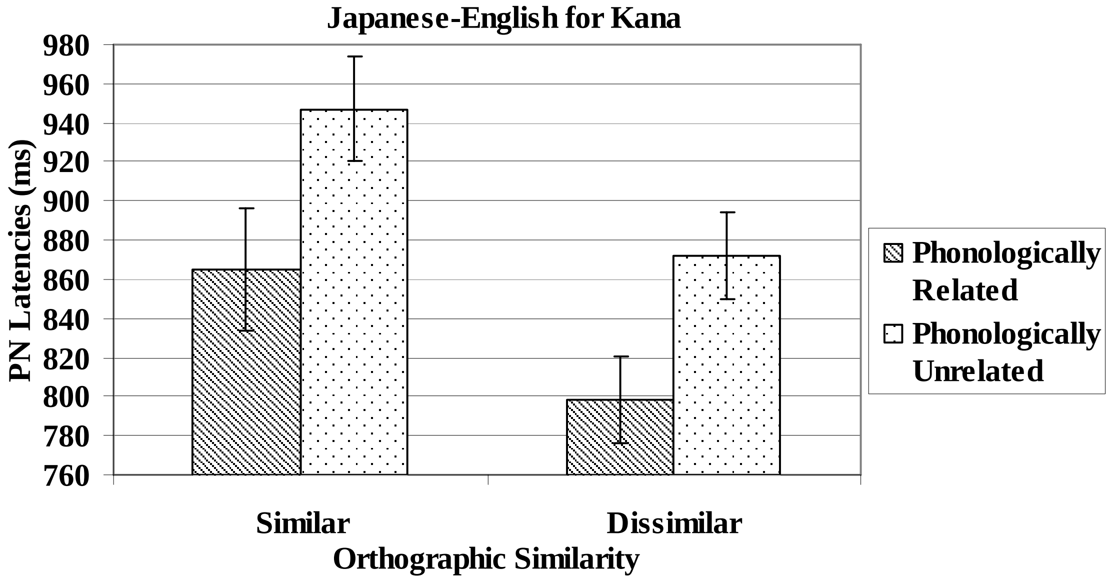


Figure 4.23. Mean picture naming latencies for Japanese-English bilinguals for kana pictures as a function of phonological relatedness and orthographic similarity.

Accuracy

The main effect of relatedness was marginally significant both by participants and by items [$F1(1, 39) = 3.97$, $MSE = 52.25$, $p = .05$; $F2(1, 14) = 4.46$, $MSE = 9.65$, $p = .05$], with higher accuracy for naming pictures with phonologically related distractors than naming pictures with phonologically unrelated distractors (see Figure 4.24.). The main effect of orthographic similarity was reliable by participants but not by items [$F1(1, 39) = 6.78$, $MSE = 101.70$, $p < .05$; $F2 < 1$], such that pictures for the orthographically similar condition were named more accurately than those for the orthographically dissimilar condition. There was no significant interaction between relatedness and orthographic similarity [$F\text{s} < 1$].

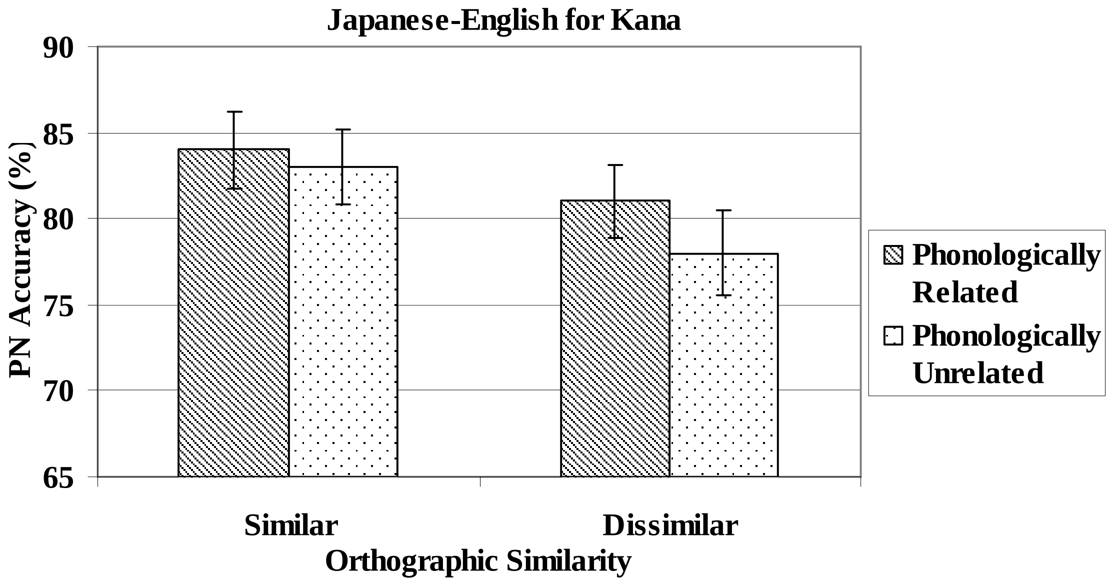


Figure 4.24. Mean picture naming percent accuracy for Japanese-English bilinguals for kana pictures as a function of phonological relatedness and orthographic similarity.

An important result of these analyses is that contrary to the Spanish-English bilinguals, the Japanese-English bilinguals did not show the interaction between orthographic similarity and relatedness. This result suggests that the interaction that was observed for the Spanish-English bilinguals was not due to the way of dividing pictures into orthographically similar and dissimilar conditions.

Kanji for Japanese-English bilinguals

Latencies

The 2(orthographic similarity) x 2(relatedness) ANOVA revealed a main effect of relatedness by participants [$F1(1, 39) = 4.86$, $MSE = 2222.35$, $p < .05$; $F2(1, 14) = 1.06$, $MSE = 1086.38$, $p > .10$], with faster naming latencies for pictures with phonologically related distractors than those with phonologically unrelated distractors. The main effect of orthographic similarity was significant by participants [*F*1(1, 39) = 6.17, *MSE* = 7175.60, *p* < .05; *F*2(1, 14) = 2.52, *MSE* = 4138.48, *p* > .10], such that pictures for the orthographically similar condition were named more slowly than those for the orthographically dissimilar condition. However, there was no interaction between relatedness and orthographic similarity [*F*s < 1] (see Figure 4.25.).

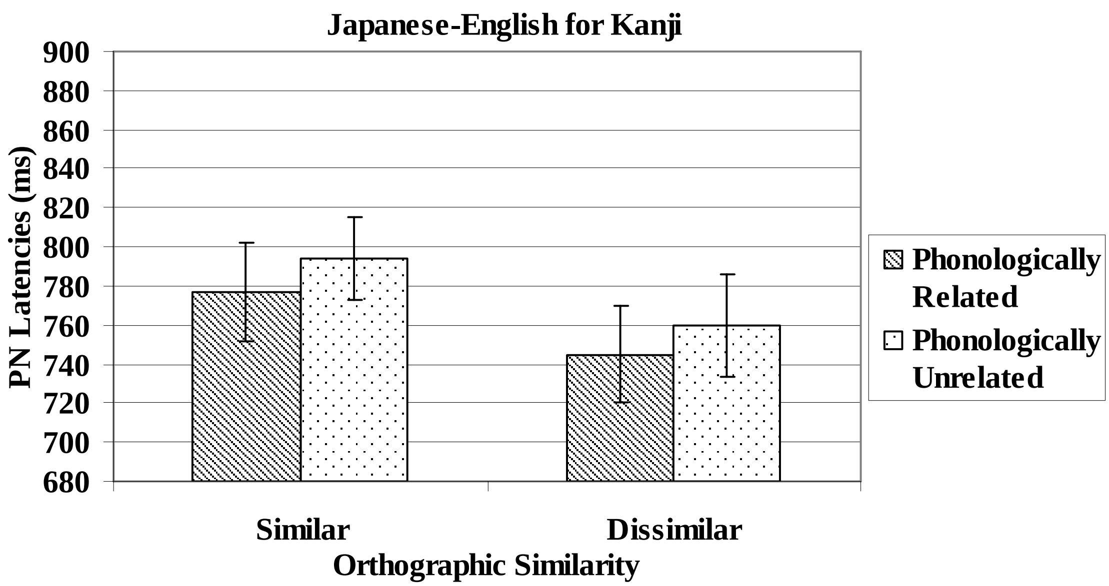


Figure 4.25. Mean picture naming latencies for Japanese-English bilinguals for kanji pictures as a function of phonological relatedness and orthographic similarity.

Accuracy

The main effect of relatedness was not reliable [*F*s < 1]. The main effect of orthographic similarity was significant by participants but not by items [*F*1(1, 39) = 30.49, *MSE* = 77.34, *p* < .001; *F*2(1, 14) = 1.77, *MSE* = 269.97, *p* > .10], such that pictures for the orthographically dissimilar condition were named more accurately than those for the orthographically similar condition (see Figure 4.26.). There was no significant interaction between relatedness and orthographic similarity [*F*s < 1].

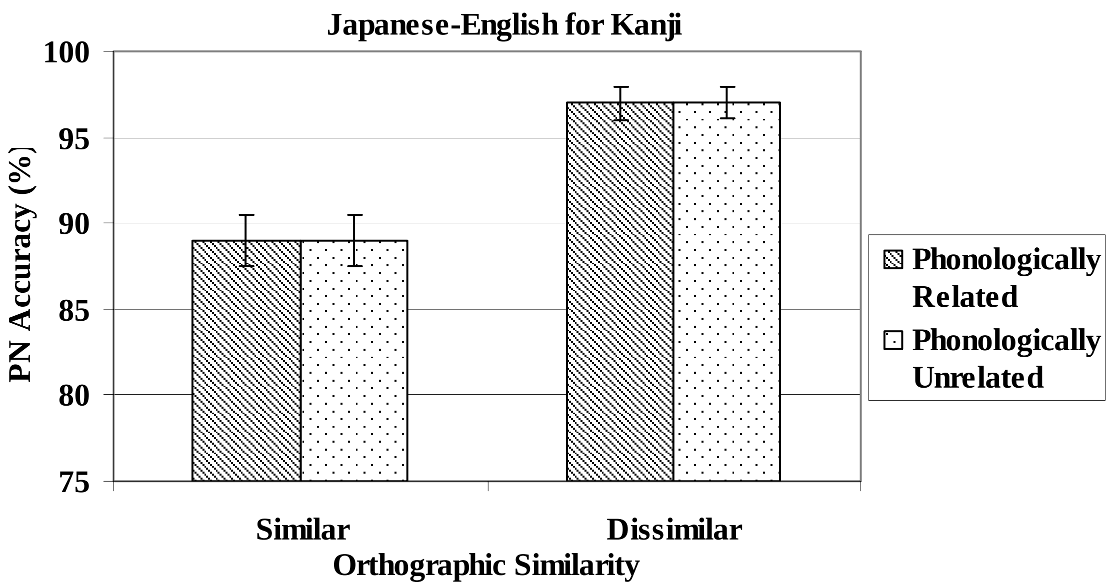


Figure 4.26. Mean picture naming percent accuracy for Japanese-English bilinguals for kanji pictures as a function of phonological relatedness and orthographic similarity.

Again, a critical finding is that the Japanese-English bilinguals did not show the interaction between orthographic similarity and relatedness although they were faster and more accurate to name pictures in the orthographically dissimilar condition. These results suggest that script and orthographic differences are not identical and that orthography modulates phonological processing, but script does not.

Error Analyses

The results of the overall analyses on the kanji data suggest that cross-language competition appears to be modulated by script when the task itself includes a written lexical form. In the final section of the Results and Discussion, we present the results of error analyses. Miller and Kroll (2002) demonstrated that bilinguals were more likely to name the distractor words instead of translating the target words when the distractor words were presented in the language of production (i.e., the language into which they were supposed to translate). When the distractors were in the language of input, bilinguals never made this error. This pattern of data suggested when the language of production could be selected early in translation, alternative lexical candidates from the non-response language are not considered for selection. If script functions as a language cue, then Spanish-English bilinguals should have been more likely to read the Spanish distractor words than Japanese-English bilinguals, given that the results from the overall analyses on the kanji data suggest that the Japanese-English bilinguals select the language of production earlier than the Spanish-English bilinguals.

To characterize the nature of errors that the bilinguals made, responses that were scored as other than *correct* or *technical errors* were divided into the following eight categories: (1) *outliers* were responses that were correct but trimmed from the data analyses because of short or long naming latencies; (2) *liberal correct* were responses that were synonyms of the expected name of the picture[9]; (3) *semantic errors* were responses that were incorrect but from the same semantic category; (4) *phonological errors* were responses that were incorrect but whose phonological onset was similar to the target picture name; (5) *language errors* were responses in the language of the distractors; (6) *translation errors* were responses in which the distractor was literally

[9] As mentioned earlier, only the exact name of the picture was accepted as a correct response in the present experiment because of the manipulation of the phonological distractors.

translated into the language of production although the distractor was not the translation equivalent of the target picture; (7) *disfluency errors* were response that started with a hesitation such as “um” although the participants named the picture object correctly; (8) *miscellaneous errors* were errors that did not fall into any of the described categories (e.g., “No”).

The distribution of types of errors is summarized by language group and by script in Table 4.14. Although Spanish-English bilinguals made slightly more language errors for both kanji and kana picture naming blocks than Japanese-English bilinguals, these differences were not statistically significant [$t(39.59) = 1.57$, $p > .10$ for kanji;$t(39.53) = 1.40$, $p > .10$ for kana]. Unlike Miller and Kroll (2002), pictures were repeated and the repetition might have reduced the possibility of making language errors. The only significant difference between Spanish-English and Japanese-English bilinguals was in the liberal correct category for kana [$t(68.36) = 3.69$, $p < .001$], such that the Spanish-English bilinguals used synonyms of the expected picture names more frequently than the Japanese-English bilinguals. This difference explains the lower accuracy on the kana trials for the Spanish-English bilinguals (76.35 %) than the Japanese-English bilinguals (80.66 %) [$t(78) = 1.69$, $p = .095$]. In other words, the slightly lower accuracy for Spanish-English bilinguals in the overall analyses on the kana data appears to result from the use of names that were not expected but that were synonyms of the expected name of the picture.

Table 4.14.

Distribution of Type of Errors by Language Group and by Script

Script	Error type	Spanish-English bilinguals	Japanese-English bilinguals
Kanji			
	Outliers	1.90 % (1.04)	1.97 % (1.02)
	Liberal correct	3.22 % (3.74)	2.54 % (2.92)
	Semantic errors	0.35 % (0.93)	0.37 % (0.50)
	Phonological errors	0.25 % (1.02)	0.20 % (1.00)
	Language errors	0.37 % (1.41)	0.02 % (0.12)
	Translation errors	0.04 % (0.17)	0.02 % (0.12)
	Disfluency errors	0.90 % (1.37)	0.68 % (1.20)
	Miscellaneous errors	0.96 % (1.97)	1.21 % (2.60)
Kana			
	Outliers	2.09 % (1.14)	2.05 % (1.07)
	Liberal correct*	5.90 % (5.22)	2.23 % (3.51)
	Semantic errors	3.26 % (3.96)	2.83 % (3.23)
	Phonological errors	0.63 % (1.52)	0.47 % (1.30)
	Language errors	0.35 % (1.50)	0.02 % (0.12)
	Translation errors	0.16 % (0.36)	0.12 % (0.28)
	Disfluency errors	1.33 % (1.97)	2.17 % (3.25)
	Miscellaneous errors	9.93 % (11.33)	9.45 % (10.81)

Note. Standard deviations are in parentheses. *The difference was at $p < .001$.

General Discussion

The goal of Experiment 2 was to determine whether the degree of cross-language activation and the locus of language selection can be modulated by script when the task includes an overt written lexical form. In the present experiment, Spanish-English and Japanese-English bilinguals named two sets of pictures in their L2 English while ignoring visually presented L1(Spanish/Japanese) distractor words. The distractor words were manipulated in relation to the picture in four ways: phonological, semantic, phono-translation, and translation. Although the pattern of the data was different for the kanji and kana picture naming blocks, it is clear that unlike the simple picture naming task in Experiment 1, Spanish-English and Japanese-English bilinguals performed differently on the picture-word interference task. Specifically, both groups showed phonological facilitation and translation facilitation, whereas only Spanish-English bilinguals demonstrated semantic interference and phono-translation facilitation. In other words, we replicated the results of previous bilingual PWI studies (e.g., Costa & Caramazza, 1999; Costa et al., 2003; Costa et al., 1999; Hermans, 2000; Hermans et al., 1998) for bilinguals whose two languages share the same Roman alphabets, but not completely for bilinguals whose two languages differ in script. These results suggest that the script is present in the task, different script bilinguals appear to exploit the perceptual information as a language cue to direct lexical access earlier, not selectively, than same script bilinguals.

The remaining question, however, is why Japanese-English bilinguals showed phonological and translation facilitation, but not semantic interference and phono-translation facilitation. One possible explanation for the presence of phonological facilitation in the absence of semantic interference is that the recognition of the L1 distractor word is so automatic that L1 phonology is activated immediately and influences speech planning in L2. However, by the time the semantics of the L1 distractor word becomes active, Japanese-English bilinguals exploit the perceptual information of distinctive scripts as a language cue and select the language of production, which makes the mechanism language-selective such that only lexical candidates from the target language (i.e., English) are competing for selection. It is important to note that two processes (word production and word reading) are involved in the picture-word interference task and the direction of activating lexical codes is different in production and reading. In word production, semantic codes are activated first, whereas in word reading orthographic and phonological codes are activated prior to semantic codes. Therefore, it is possible to assume that phonological information becomes available prior to semantic information in the picture-word interference task.

The presence of translation facilitation and the absence of phono-translation facilitation can also be explained by the time course of processing. The L1 translation distractor sends activation to the conceptual level as soon as the semantics are activated, which results in the higher level of activation of related conceptual nodes to the picture. This extra activation leads to facilitation. In contrast, when the L1 distractor word is phonologically related to the translation name of the picture (i.e., the picture name in L1), the L1 picture name will be activated via the activation of the L1 distractor that is phonologically related to the L1 picture name. In other words, the activation of phonology of the phono-translation distractor results in the activation of the translation name of the picture, which eventually sends extra activation to the conceptual nodes of the picture. Thus, when the distractor word is phono-translation, it takes longer for the conceptual nodes of the picture to receive activation from the distractor word than when it is translation. Similar to the case of the semantic distractor word, Japanese-English bilinguals may have selected the lexical candidate by the time when the conceptual nodes of the picture receive extra activation via the translation name of the picture from the phono-translation distractor. We argue that the distinctive script of the distractor word facilitates language and lexical selection.

A further possibility that we considered to explain the group differences is that the absence of semantic interference and phono-translation facilitation for the Japanese-English bilinguals might have been due to individual differences in the ability to ignore irrelevant information and in the availability of the amount of processing resources. As mentioned earlier, the Japanese-English bilinguals produced a smaller Simon effect and a larger operation span than the Spanish-English bilinguals (see Tables 4.8. and 4.9). To examine this possibility, we reanalyzed the semantic and phono-translation data from the kanji block by including the Simon effect and the operation span as covariates. Because there was multicollinearity between Simon effect and operation span [$r = -.32$, $p < .01$], the analysis was ran with each variable as a covariate separately. When the Simon effect was entered as a covariate, the language group difference remained for both semantic and phono-translation effects in kanji [$F(1, 77) = 4.17$, $MSE = 8194.45$, $p < .05$ for semantic; $F(1, 77) = 5.19$, $MSE = 6540.83$, $p < .05$ for phono-translation]. Likewise, the pattern of the results did not change when the operation span was entered as a covariate as well [$F(1, 77) = 4.97$, $MSE = 8248.10$, $p < .05$ for semantic; $F(1, 77) = 4.88$, $MSE = 6510.87$, $p < .05$ for phono-translation]. The results of these analyses suggest that the group differences that were observed in the picture-word interference task were not simply due to the individual differences in cognitive abilities between Spanish-English and Japanese-English bilinguals.

Another issue that requires discussion concerns the phono-translation effect. We need to understand why the phono-translation distractor words in the present study produced facilitation rather than interference. Hermans et al. (1998) found an effect of interference for phono-translation distractors for Dutch-English bilinguals. A critical difference between their study and the present study was the modality of the presentation of distractors. In Hermans et al., the distractor words were presented auditorily, whereas in the present study, they were presented visually. As Damian and Martin (1999) pointed out, the duration of the presentation of the auditory distractor word is limited, whereas that of the visual distractor word is unlimited. The unlimited presentation of the phono-translation distractor might have induced facilitation rather than interference. As shown in Table 1.2. in Chapter 1, the interference effect of phono-translation was obtained from SOA -300 ms to SOA 0 ms and no phono-translation effect was observed at SOA + 150 ms when picture naming was in L2 and the distractor word was presented auditorily in L1. In other words, the phono-translation effect was observed at an earlier stage of speech planning. The SOA used in the present study was + 25 ms and the distractor word stayed with the target picture on the computer screen until the participant responded. It was possible that the phono-translation distractor might have tapped into a later stage of speech planning (i.e., phonological processing), which resulted in facilitation rather than interference.

Finally, and perhaps most critically, the results of Experiment 2 suggest that orthography and script function differently. In the present experiment, half of phonologically related distractor words in Spanish were orthographically similar to the picture name in English as well, whereas the other half was orthographically dissimilar. The Spanish-English bilinguals showed phonological facilitation only when the Spanish distractor word was both phonologically and orthographically similar to the name of the picture in English (see Figures 4.19. and 4.21). We performed one final set of analyses to be sure that the observed result was not due to a difference in the degree of phonological similarity among the orthographically similar and dissimilar items. We recalculated the phonological similarity ratings generated by English monolinguals reported in Table 4.5. by taking orthographic similarity into consideration. The recalculated means are reported in Table 4.14. Although English monolinguals seem to have rated orthographically dissimilar related items less phonologically similar, the difference was not significant [$t(14) = 1.52$, $p > .10$ for kanji; $t < 1$ for kana].

However, some might argue that because English monolinguals do not know the spellings of these Spanish distractor words, the orthographic dissimilarity may not influence the phonological similarity ratings. To investigate this possibility, we gave the bilinguals the same phonological similarity rating task that the English monolinguals performed (see Appendix A2 & A4 for details) at the end of the experiment. As can be seen in Table 4.15., the Spanish-English bilinguals also perceived related items equally similar regardless of orthographic overlap [$t(14) = 1.59$, $p > .10$ for kanji; $t < 1$ for kana]. These results suggest that the lack of phonological facilitation for orthographically dissimilar items was not due to the degree of phonological similarity in the items and that the L1 orthography influences speech planning in L2. This finding is also consistent with bilingual research on reading where orthographic and phonological similarity in one language influences reading in the other language (Schwartz, Kroll, & Diaz, in press). Furthermore, as recent within-language research has shown (e.g., Alario et al., in press; Osborne et al., 2004; Roelofs, 2006), these data demonstrate that orthography is active even during production when the lexical form is present in the task.

Table 4.15.

Phonological Similarity Ratings by English Monolinguals and Spanish-English Bilinguals

		English monolinguals		Spanish-English bilinguals	
Script	Orthographic similarity	Related	Unrelated	Related	Unrelated
Kanji	Similar	4.1 (1.2)	1.2 (0.2)	4.7 (0.7)	1.3 (0.2)
	Dissimilar	3.2 (1.2)	1.2 (0.2)	4.1 (1.0)	1.3 (0.2)
Kana	Similar	3.7 (1.4)	1.4 (0.4)	4.1 (1.1)	1.2 (0.2)
	Dissimilar	3.5 (1.7)	1.2 (0.2)	4.1 (1.0)	1.2 (0.2)

Note. Standard deviations are in parentheses.

Given that the Japanese-English bilinguals showed phonological facilitation despite the fact that Japanese and English never share the same script, script does not constrain phonological processing in the other language. However, it is clear that the writing system (logographic kanji vs. syllabary kana) influences the ease of access to phonology. The magnitude of phonological facilitation in the Japanese-English bilinguals was greater for kana [$F(1, 39) = 21.24$, $MSE = 5687.71$, $p < .001$, $\eta^2 = .35$] than for kanji [$F(1, 39) = 4.99$, $MSE = 1073.14$, $p < .05$, $\eta^2 = .11$]. This difference in the magnitude of phonological facilitation was not due to the phonological similarity of the distractor words. As can be seen in Table 4.5., if anything, the English monolinguals perceived phonologically related distractors for the kana block slightly more similar than those for the kanji block (although this difference was not significant [$t(24.10) = 1.57$, $p = .13$]), which is in the opposite direction.[10] The greater magnitude of phonological facilitation for the kana block is indeed consistent with the research showing that phonology is accessed more easily in kana than in kanji (e.g., Chen et al., in press; Ischebeck, 2004; Yamada, 1998).

In summary, the results of the picture-word interference experiment suggest that when the script is present in the task, the degree of cross-language activation and the locus of language selection is modulated by script differences between bilingual's two languages and that script and orthography plays a different role in production. In Chapter 5, the language switching paradigm was used to investigate the process of inhibitory control and its consequences on word production in the L1 and L2. One task was picture naming in which the written lexical form was absent and the other task was word naming in which the written lexical form was overtly present. If the reduced cross-language activation and early language selection observed in the picture-word interference experiment was due to the fact that Japanese-English bilinguals can suppress cross-language activation more effectively than Spanish-English bilinguals, then the switch cost for L1 should be greater for Japanese-English bilinguals because of the greater suppression of the L1 than for Spanish-English bilinguals. An alternative prediction,

[10] The Japanese-English bilinguals were also asked to perform the phonological similarity rating task. They rated the phonologically related items for the kanji block and for the kana block equally similar [$M = 4.7$, $SD = 0.6$ for kanji; $M = 4.5$, $SD = 0.5$ for kana]. The complete set of the data is included in Appendix A4.

however, is that Japanese-English bilinguals can use the language cue inherent in the script difference to reduce switch costs.

CHAPTER 5

EXPERIMENT 3: LANGUAGE SWITCHING

The results of Experiments 1 and 2 indicate that the degree of cross-language activation is modulated by script differences when the written lexical form is present in the task, but not when it is absent. These results suggest that only when a distinctive script is perceptually available can bilinguals exploit language-specific information to select the language of production earlier in the process of speech planning. What processes are involved in language selection for Japanese-English bilinguals? Given that Japanese-English bilinguals demonstrated cognate facilitation in the simple picture naming experiment, we can assume that cross-language activation occurs. The results of Experiment 2 suggest that the selection mechanism itself is sensitive to language-specific information when it is unambiguously available in the task. In Experiment 3, the process of inhibitory control was examined in the context of the presence and absence of the written script by using a language switching paradigm. Experiment 3 included two critical tasks—picture naming and word naming—one without and one with the overt written lexical form.

The Inhibitory Control model (Green, 1998; and see Chapters 1 and 2) assumes that in the process of planning a spoken utterance, both L1 and L2 lemmas are activated and that lemma selection is dependent on which language is more active at a given time. When bilinguals intend to speak in one language, the task schema effectively suppresses the activation of lemmas in the unintended language. The model assumes that the amount of inhibition is proportional to the amount of the activation of those lemmas in the unintended language and that the magnitude of the switch cost reflects the amount of inhibition required to suppress the activation of the unintended language.

Past research on language switching has shown that a greater switch cost is observed for L1 than for L2 if bilinguals are not balanced, suggesting that the suppression of L1 during L2 production requires more effort than the suppression of L2 during L1 production (e.g., Meuter & Allport, 1999). The greater suppression of L1 when speaking L2 makes it harder to reactivate the L1 on the subsequent trial and produces an asymmetrical pattern of switch costs. On the other hand, some researchers argue that the switch cost is not a reflection of inhibition and that the pattern of switch costs determines whether the activation of the unintended language is suppressed or not (e.g., Costa & Santesteban, 2004). Costa and Santesteban demonstrated the asymmetrical pattern of switch costs for unbalanced bilinguals and a symmetrical pattern of switch costs for balanced bilinguals and claimed that balanced bilinguals can apply a language-specific selection mechanism in which no inhibition is involved. However, it is important to note that these balanced Spanish-Catalan bilinguals were always slower in their more proficient language in the language switching paradigm (i.e., L1 than L2 and L1 than even L3). In the language mixing/switching paradigm, both languages are required to be active, which usually induces a greater cost to L1 and little consequence for L2 (e.g., Kroll et al., in preparation; Miller, 2001). It is possible to interpret that the slower naming latencies in the more proficient language might be due to the inhibition of the more proficient language. Therefore, we discuss the results of the present experiment in terms of the magnitude of switch costs, the symmetric or asymmetric pattern of switch costs, and the cost to L1 at the end of this chapter.

The goal of Experiment 3 was to investigate the process of inhibitory control and its consequences on L1 and L2 word production in unbalanced same and different script bilinguals (Spanish-English and Japanese-English bilinguals). If Japanese-English bilinguals can suppress cross-language activation more effectively than Spanish-English bilinguals, then the switch cost for L1 should be greater for Japanese-English bilinguals because of the greater suppression of the L1 than for Spanish-English bilinguals. By the logic of the Costa and Santesteban (2004) study, both groups were predicted to show an asymmetrical switch cost—a greater cost for L1 than for L2--because both groups of bilinguals are unbalanced and L1 dominant. An alternative prediction, however, is that Japanese-English bilinguals can use the language cue inherent in the script difference to reduce language switch costs and thus may show symmetrical switch costs. In fact, a recent study has shown that when the stimulus includes a strong and unambiguous cue (e.g., Arabic numerals vs. Chinese logographic numerals), switch costs are symmetrical (Meuter & Tan, 2003). It is also possible that Japanese-English bilinguals will show an asymmetrical switch cost for picture naming when a language cue (i.e., a color of the background) is ambiguous and a symmetrical switch cost when there is an unambiguous language cue (i.e., the written lexical form in a different script) in addition to the color of the background. However, Spanish-English bilinguals should show an asymmetrical switch cost for both picture naming and word naming because there is no overt language cue available.

To our knowledge, the present experiment is the first bilingual switching study that has directly compared picture naming and word naming. Although we used picture naming and word naming as a vehicle for having the script perceptually absent or present, picture and word naming differ with respect to the event that initiates speech planning and the direction of activating lexical codes. Picture naming engages semantics to phonology to orthography, whereas word naming engages orthography to phonology to semantics. Therefore, the role of orthography is potentially fragile for picture naming, and the role of semantics is fragile for word naming because these processing components are last and are not necessarily required prior to a response. Indeed, a recent study has shown no semantic interference from priming in word naming, but in picture naming, suggesting that semantics is not activated during word naming (Vitkovitch, Cooper-Pye, & Leadbetter, 2006). If the nature of these two tasks influences the performance of Spanish-English and Japanese-English bilinguals, then we predict that the two bilingual groups would be similar in picture naming but Japanese-English bilinguals would be slower in L2 and show greater switch costs in word naming than Spanish-English bilinguals because word naming is initiated by the activation of orthography which differs from their L1.

Method

Participants

Twenty-six Spanish-English and 26 Japanese-English bilinguals participated in Experiment 3. Fourteen Spanish-English and 11 Japanese-English bilinguals were recruited from The Pennsylvania State University. Twelve Spanish-English and 15 Japanese-English bilinguals were from the University of Pittsburgh. Of these 26 Spanish-English and 26 Japanese-English bilinguals, five Spanish-English bilinguals and eight

Japanese-English bilinguals were excluded from the all data analyses due to poor performance on the picture naming task (less than 50 % correct one or more than one conditions). Two additional Spanish-English bilinguals were removed because according to the self-rated proficiency, they were L2 English dominant. The remaining 19 Spanish-English and 18 Japanese-English bilinguals were included in the data analyses.

Materials

For the picture naming task, 128 black-and-white line drawings whose names were noncognates in English, Spanish, and Japanese were drawn from Snodgrass and Vanderwart (1980) and Szekely et al. (2003, 2004). The pictures were divided into two sets according to the Japanese name of the selected pictures. As mentioned in Chapter 4, in Japanese, some words can be written both in kanji and in kana (hiragana and katakana), whereas others can be written only in kana. Although some words can be written in either writing system, there are preferences for one over the other. Based on the frequency of each lexical form of the Japanese picture names, pictures were categorized as a kana picture or kanji picture. Thus, one set has 64 kana pictures and the other has 64 kanji pictures. The characteristics of pictures and picture names are summarized in Table 5.1.[1] As in Experiment 2, it is important to remember that the distinction between kana and

[1] The International Picture Naming Project database did not have the data for five kana items and one kanji item in English and for nine kana items and five kanji items in Spanish. The MRC Psycholinguistic database did not include the familiarity data for 12 kana items and eight kanji items in English and the imageability data for 13 kana items and eight kanji items. The Busca Palabras did not include the familiarity data for 17 kana items and seven kanji items and the imageability data for 18 kana items and seven kanji items. Likewise, the Japanese picture naming norms did not have the data for seven kana items and five kanji items. The CELEX did not have frequency information for three kana items in English and for one kana item and one kanji item in Spanish.

kanji pictures is maintained for both groups of bilingual speakers because there are correlated features of kana and kanji that are likely to affect performance.

Table 5.1.

Characteristics of Pictures and Picture Names Used in Experiment 3

	English		Spanish		Japanese	
Variable	Kana	Kanji	Kana	Kanji	Kana	Kanji
Number of characters	5.28	4.81	5.98	5.66	2.97	1.45**
Number of syllables/morae	1.50	1.30	2.66	2.45	2.94	2.66
Log frequency[a]	1.03	1.51**	0.83	1.38**	2.77	3.45**
Age of acquisition[b]	2.08	1.86	1.85	1.78	3.47	3.30
Name agreement (%)[b]	94.0	94.8	90.0	91.6	87.6	87.6
Familiarity[c]	523	557**	5.75	6.02	5.93	6.16*
Imageability[c]	602	599	6.19	6.19	N/A	N/A
Visual complexity (KB)[d]	15712	16191	15712	16191	15712	16191
Picture naming latencies (ms)[b]	924	885	1005	958	991	974
Word naming latencies (ms)[e]	618	600**	N/A	N/A	N/A	N/A

Note. [a]Baayen, Piepenbrock, & Gulikers (1996) for English and Spanish; Amano & Kondo (2000) for Japanese. [b]The English and Spanish data were from the International Picture Naming Project database and the 1-3 point scale was used (Szekely et al., 2003, 2004). The Japanese data were from Nishimoto et al. (2005). [c]For English, the data were sampled form the MRC Psycholinguistic database and the scale was 100 to 700 (Coltheart, 1981). For Spanish, the data were extracted from the Busca Palabras (Davis & Perea, 2005) and the rating scale was from 1 to 7. For Japanese, the data were extracted from Nishimoto et al. (2005). [d]The values were extracted from the International Picture Naming Project database (Szekely et al., 2003, 2004). [e d]The data were from the English Lexicon Project database (Balota et al., 2002).

As can be seen in Table 5.1., kanji items were more frequent [$t(123) = 5.40$, $p < .001$ for English; $t(124) = 6.52$, $p < .001$ for Spanish; $t(126) = 7.47$, $p < .001$] and more familiar [$t(108) = 3.66$, $p < .001$ for English; $t(102) = 1.78$, $p = .08$ for Spanish; $t(126) = 2.38$, $p < .05$] than kana items. English word naming latencies were also faster for kanji items than for kana items [$t(126) = 2.77$, $p < .01$]. In Japanese, kanji items were shorter in terms of the number of characters because of the writing system. The kana and kanji items were blocked in the present experiment. Again, although the distinction between kanji and kana applies only to Japanese, the same categorization of the materials was used for Spanish because the goal of the present study was to compare the performance of Japanese-English bilinguals with that of Spanish-English bilinguals.

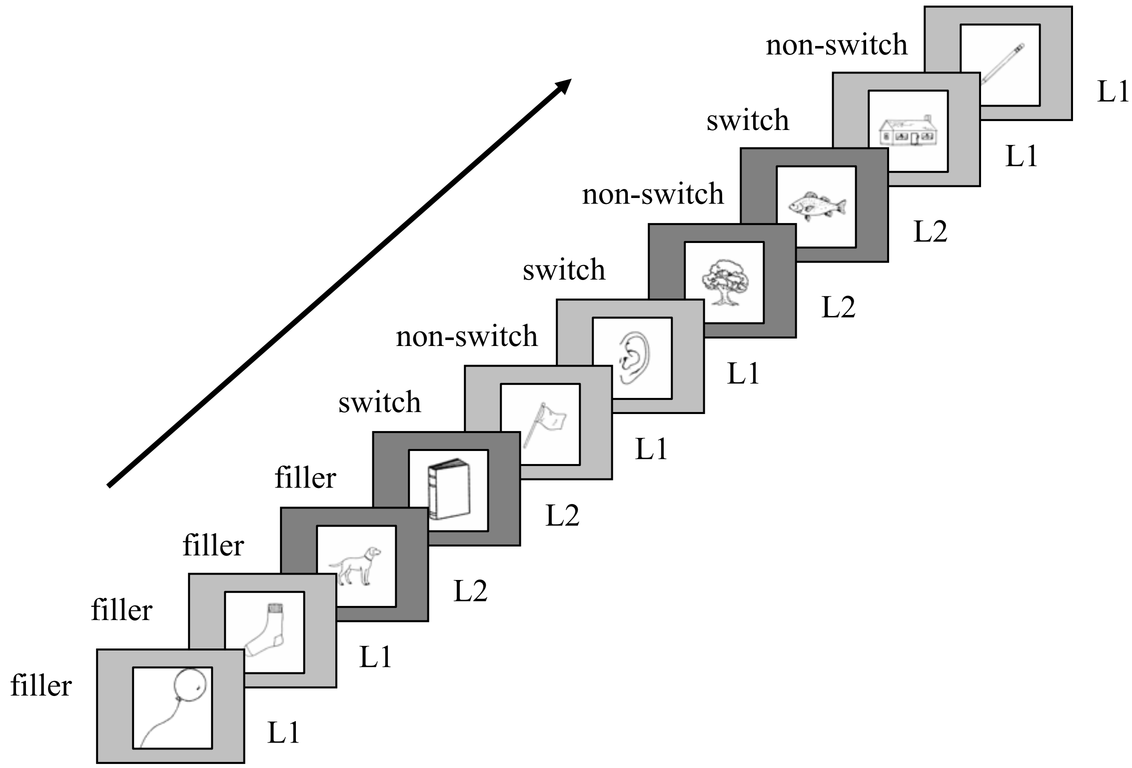
In the present experiment, the same items were used for word naming. However, none of the items was repeated across the two tasks for a given participant. Therefore, items in each set (kana and kanji) were divided into two subsets. Half participants saw Set 1 for picture naming and Set 2 for word naming, whereas the other half saw Set 2 for picture naming and Set 1 for word naming. Set 1 and Set 2 were closely matched on the lexical properties [$p > .10$ except for familiarity in Spanish for kana ($p = .08$) and number of syllables in English for kanji ($p = .097$)]. As described below, language of naming (L1 and L2) and type of trial (non-switch and switch) were manipulated in each of the tasks. Thus, the items of each set were further divided into four lists so that each condition (L1 switch, L1 non-switch, L2 switch, and L2 non-switch) had eight items. These lists were also matched on the lexical properties listed above [$p > .10$ except for familiarity in Spanish for one of the kana sets ($p = .049$) and imageability in Spanish for one of the kanji sets ($p = .021$)]. To counterbalance the assignment of the lists to the four experimental conditions, four versions of the experimental scripts were created for Set 1 and Set 2. Therefore, eight participants were necessary to cycle through all the versions.

Procedure

Participants were tested individually in a quiet room. They were seated in front of a computer monitor, a button box, a microphone connected to the button box and a digital recorder. All participants were given the picture naming and word naming tasks, followed by the lexical decision task in their L2 English, the Simon task, the operation span task, the language history questionnaire, and the verbal fluency task (see Chapter 2 for the materials, procedure, and data/trimming/scoring for the proficiency measures—the lexical decision task, the language history questionnaire, and the verbal fluency task—and for the individual difference measures—the Simon task and the operation span task). The order of the picture and word naming tasks was counterbalanced across participants. Furthermore, the order of the kana and kanji sets was also counterbalanced across participants. However, the picture naming task and the word naming task were blocked. For example, a given participant first performed the picture naming task with kana items and then the same task with kanji items, followed by the word naming task with kana items and the word naming task with kanji items.

In the picture naming task, participants first received written instructions in English on the computer screen. They were informed that a series of pictures would be presented one at a time on the computer screen. Their task was to name each picture in English if the background was red and in their L1 Spanish or Japanese if the background was blue. At the beginning of each trial, a fixation sign (+) was presented for 350 ms at the center of the computer screen. The fixation sign was then replaced with a blank screen and 50 ms after the offset of the fixation sign, a picture was presented. The picture remained on the computer screen until the participants responded. If they did not know the name of the object, they were asked to say “no” in English if the background was red and “no sé” in Spanish or “iie” in Japanese if the background was blue. After they responded, a blank screen was presented for 1500 ms and a fixation sign appeared again. As illustrated in Figure 5.1., in the present experiment we used the alternating runs paradigm in which the language of production changed every two trials such as L1, L1, L2, L2, L1, L1, L2, L2 (Rogers & Monsell, 1995). The experimental block started with L1 and the first four trials were fillers that were different from the critical experimental items. Therefore, the first critical trial was an L1 switch trial, followed by an L1 non-switch trial, an L2 switch trial, an L2 non-switch trial, and so on. The presentation of items was pseudo-randomized such that items were sampled from the sub-list that was assigned to a given condition.

Unlike most previous research using the language switching paradigm, there was no picture familiarization phase in the present experiment. In other words, participants were not taught the expected name of each picture in advance. Twelve practice trials were presented twice prior to the experimental trials for kanji and kana blocks. The pictures used in the practice trials were different from the experimental items.



<u>Figure 5.1.</u> An illustration of picture naming switch and non-switch trials.

The procedure for the word naming task was identical to the one for the picture naming task except for the color of the background. The L1 word and the L2 word were presented with a green background and a yellow background, respectively. Although the color of the background was redundant information in the word naming task, we used the identical procedure for the word naming task as well to allow us to compare the performance of bilinguals across the two language switching tasks—one with a script and one without a script. Furthermore, we chose to use different colors to cue language in each of the tasks to rule out a possible confound such that experience in the word naming task might benefit learning the mapping of color to language in the picture naming task.

The reverse would not have the same consequences because the color cue is required in the picture naming task but redundant in the word naming task.

Results and Discussion

Unlike Experiments 1 and 2, the two groups of bilingual participants differed in their language proficiency and language experience. In part, this problem arose because the sample included a larger number of lower proficiency L2 speakers than the previous experiments. To make the two groups comparable, we adopted the exclusion criteria described in the section on Participants: (1) participants whose accuracy for one or more conditions was less than 50 %; and (2) participants whose L2 self-ratings were higher than their L1 self-ratings—L2 dominant were excluded from the analyses. One of the consequences of this exclusion was that item analyses could not be performed in the present experiment. As mentioned in the *Method* section, none of the items was repeated in either of the picture naming and word naming tasks and across the two tasks. Thus, there were eight versions of the script and each version was equally assigned to the first 24 participants. However, the exclusion of seven Spanish-English and eight Japanese-English bilinguals resulted in the unequal distribution of versions of the script and made it hard to conduct the item analyses. Therefore, a 2 x 2 x 2 mixed analysis of variance (ANOVA) was conducted only by participants on picture naming and word naming latencies and accuracy, with language (L1/L2), type of trial (switch/non-switch), and language group (Spanish-English bilingual/Japanese-English bilingual) as independent variables. Language and type of trial were within-participants variables and language group was a between-participants variable.

Prior to the main data analyses, data from the proficiency measures and individual difference measures after excluding seven Spanish-English bilinguals and eight Japanese-English bilinguals are first summarized below to ensure that the two bilingual groups are as closely matched on the proficiency and the cognitive ability as possible. Then, the data trimming procedure for the picture naming and word naming is presented followed by the analyses on the picture naming and word naming data. The constraints within the present data set for Experiment 3 necessarily make the results more preliminary than those reported in the previous chapters.

Proficiency Measures

Language history questionnaire

Language history questionnaire data are summarized in Table 5.2. by language groups. All of the bilinguals who were included in the subsequent analyses spoke English as an L2 and were more proficient in the L1 than in the L2 English or equally proficient in both languages based on their self-assessed ratings for the L1 and L2. Of these bilinguals, nine Spanish-English bilinguals and two Japanese-English bilinguals started learning English before the age of 10 years. However, even these bilinguals considered themselves to be L1 dominant.

Table 5.2.

Characteristics of Spanish-English and Japanese-English bilinguals in Experiment 3

Variable	Spanish-English (*n* = 19)	Japanese-English (*n* = 18)	p-value t-test
Age (years)	31.1 (7.6)	28.6 (6.9)	*ns*
L1 self-ratings (10 pt scale)			
Reading	9.8 (0.4)	9.7 (0.6)	*ns*
Writing	9.6 (0.5)	9.0 (1.4)	= .07
Speaking	9.7 (0.7)	9.4 (1.0)	*ns*
Listening	10.0 (0.0)	9.6 (0.8)	< .05
Mean	9.8 (0.3)	9.4 (0.8)	= .09
L2 self-ratings (10 pt scale)			
Reading	8.6 (1.0)	7.4 (1.5)	< .01
Writing	8.0 (1.4)	6.7 (1.7)	< .05
Speaking	7.7 (1.6)	7.2 (1.9)	*ns*
Listening	8.1 (1.2)	6.9 (2.1)	= .06
Mean	8.1 (1.1)	7.0 (1.6)	< .05
Mean daily L1 usage (%)	47.1 (25.9)	30.8 (25.6)	*ns*
Mean daily L2 usage (%)	52.4 (25.9)	68.9 (25.4)	*ns*
L2 age of acquisition (years)	10.2 (6.0)	12.6 (3.4)	*ns*
Months of L2 immersion	43.1 (45.4)	65.4 (51.3)	*ns*

Note. Standard deviations are in parentheses.

Overall, the Spanish and Japanese groups were closely matched on age, L2 age of acquisition (AoA), L1 self-assessed ratings for reading and speaking, L2 self-assessed ratings for speaking, and length of living in English speaking countries (months of L2 immersion). However, the Spanish-English bilinguals were using their L1 slightly more and their L2 slightly less than the Japanese-English bilinguals. Similar to Experiments 1 and 2, these two groups differed in some of the self-assessed ratings (see Table 5.2.). Although the Spanish-English bilinguals tended to rate their language proficiency higher not only in the L2 but also in the L1 than the Japanese-English bilinguals, it is important to note that the Spanish-English and the Japanese-English bilinguals were matched on the self-assessed ratings for L1 speaking and L2 speaking.

Lexical decision in L2 English

A lexical decision task in the L2 English was included in the present experiment as an on-line measure of proficiency. As described in the general method in Chapter 2, the materials were taken from Azuma and Van Orden (1997). Although the number and relatedness of word meanings were manipulated in the original lexical decision task, we report only the simple analyses on words and nonwords in this chapter for the purpose of assessing lexical proficiency in the L2. More detailed analyses on the effects of the number and relatedness of word meanings are reported in Appendix B3. The mean values for the accuracy and RT for words and nonwords are shown by language groups in Table 5.3.

Despite our efforts to match the two bilingual groups on L2 proficiency, the Spanish-English bilinguals were faster and more accurate for nonwords than the

Japanese-English bilinguals [$t(26.62) = 3.38$, $p < .01$ for RTs; $t(35) = 2.08$, $p < .05$ for accuracy]. The two groups also differed in the RTs for words [$t(28.52) = 2.47$, $p < .05$], but not in the accuracy. These results suggest that the Spanish-English bilinguals were more proficient in reading L2 words than the Japanese-English bilinguals.

Table 5.3.

Lexical Decision Results for Spanish-English and Japanese-English bilinguals in Experiment 3

Variable	Spanish-English (n = 19)	Japanese-English (n = 18)
Nonword RT (ms)	852 (185)	1150 (327)
Word RT (ms)	670 (118)	796 (185)
Nonword accuracy (%)	84.1 (12.9)	76.1 (10.5)
Word accuracy (%)	95.0 (4.5)	93.1 (4.0)

Note. Standard deviations are in parentheses.

Verbal fluency in L1 Spanish/Japanese and in L2 English

A verbal fluency task was also included in the present experiment as an additional independent measure of proficiency. As noted earlier, category names were taken from Linck (2005) and participants were first asked to name as many examples that belong to a given category as possible in L1 for the first four categories and in L2 for the second four categories (see Chapter 2). As shown in Table 5.4., both groups produced more examples in L1 than in L2 [$t(18) = 5.74$, $p < .001$ for Spanish-English bilinguals; $t(15) = 4.07$, $p < .01$ for Japanese-English bilinguals]. Furthermore, the Spanish-English named more items both in L1 and in L2 than the Japanese-English bilinguals [$t(33) = 3.67$, $p < .01$ for L1; $t(35) = 2.22$, $p < .05$ for L2]. The results of the verbal fluency task suggest that both groups of bilinguals were L1 dominant and that the Spanish-English bilinguals were more verbally fluent in both languages.

Table 5.4.

Verbal Fluency Results for Spanish-English and Japanese-English bilinguals in Experiment 3

Variable	Spanish-English (n = 19)	Japanese-English (n = 18)
Mean exemplars per category in L1	14.7 (1.9)	12.3 (1.9)
Mean exemplars per category in L2	12.1 (2.6)	10.5 (1.8)

Note. Standard deviations are in parentheses.

Overall, the results of the three proficiency measures suggest that Spanish-English bilinguals were more proficient in the L2 English than the Japanese-English bilinguals although their language experiences were otherwise similar. It is clear that the Spanish-English bilinguals were more proficient in comprehension from the English lexical decision data. However, it is not clear to what extent the Spanish-English bilinguals were specifically more proficient in the L2 English than the Japanese-English bilinguals, given that they rated themselves as more proficient in most L1 and L2 language skills and were more fluent on the verbal fluency task in both languages. We return to the issue of proficiency in comprehension and production in the general discussion.

Individual Difference Measures

Simon

The Simon task was included to assess the ability to ignore irrelevant information. Simon data are summarized by language group in Table 5.5. A 3 (type of trial: neutral, congruent, and incongruent) x 2 (language group: Spanish-English and Japanese-English) mixed ANOVA was conducted on the RT and accuracy data. The analysis for the RT data revealed a main effect of type of trial [$F(2, 70) = 35.37$, $MSE = 292.67$, $p < .001$]. The main effect of language group was not reliable [$F(1, 35) = 2.28$, $MSE = 17115.92$, $p > .10$]. The interaction between type of trial and language group approached significance [$F(2, 70) = 2.29$, $MSE = 292.67$, $p = .11$]. To further examine the 3 (type of trial) x 2 (language group) interaction, three 2 (type of trial) x 2 (language group) ANOVA was conducted by taking out one level from type of trial. The 2 x 2 interaction was significant when congruent and incongruent trials were entered [$F(1, 35) = 5.50$, $MSE = 243.42$, $p < .05$], but not when neutral and congruent or neutral and incongruent trials were entered [$F(1, 35) = 1.69$, $MSE = 231.89$, $p > .10$; $F < 1$]. The significant 2 x 2 interaction indicates that Spanish-English bilinguals were slightly slower in incongruent trials than Japanese-English bilinguals [$F(1, 35) = 3.64$, $MSE = 5332.07$, $p = .07$], but there was no difference in congruent trials [$F(1, 35) = 1.36$, $MSE = 5643.07$, $p > .10$]. The 3 (type of trial) x 2 (language group) ANOVA on the accuracy data also revealed a main effect of type of trial was significant [$F(1.38, 48.28) = 12.68$, $MSE = 10.06$, $p < .001$]. The main effect of language group was not reliable [$F < 1$]. More critically, the interaction between type of trial and language group was significant [$F(1.38, 48.28) = 3.93$, $MSE = 10.06$, $p < .05$]. Again, three 2 (type of trial) x 2 (language group) were conducted as follow-up tests by excluding one of the levels from the variable type of trial. The 2 x 2 interaction was marginally significant or significant when neutral or congruent trials and incongruent trials were entered [$F(1, 35) = 3.37$, $MSE = 9.96$, $p = .08$; $F(1, 35) = 5.55$, $MSE = 8.51$, $p < .05$, respectively], but it was not significant when neutral and congruent trials were included. Specifically, Spanish-English bilinguals were less accurate for incongruent trials than for congruent or neutral trials [$F(1, 18) = 15.17$, $MSE = 12.05$, $p < .01$; $F(1, 18) = 11.61$, $MSE = 12.35$, $p < .01$, respectively], whereas Japanese-English bilinguals were equally accurate regardless of type of trial [$F(1, 17) = 2.68$, $MSE = 4.75$, $p > .10$; $F(1, 17) = 1.72$, $MSE = 7.42$, $p > .10$]. These results suggest that the Japanese-English bilinguals appear to have a better inhibitory control.

Table 5.5.

Simon Results for Spanish-English and Japanese-English bilinguals in Experiment 3

Variable	Spanish-English ($n = 19$)	Japanese-English ($n = 18$)
Simon effect (ms)	41.4 (21.3)	24.4 (22.8)
RT for neutral (ms)	439 (107)	401 (40)
RT for congruent (ms)	423 (97)	394 (38)
RT for incongruent (ms)	464 (90)	419 (47)
Accuracy for neutral (%)	98.9 (2.4)	98.2 (1.8)
Accuracy for congruent (%)	99.4 (1.6)	98.3 (2.1)
Accuracy for incongruent (%)	95.0 (4.9)	97.1 (3.4)

Note. Standard deviations are in parentheses.

Operation Span

An operation span task was used to measure processing resources. Unlike Experiments 1 and 2, there was no group difference in operation span, RTs, or errors [$t(35) = 1.43$, $p > .10$ for RTs; other *t*s < 1] (see Table 5.6.). These results suggest that the groups of Spanish-English bilinguals and Japanese-English bilinguals were closely matched on processing resources in the present experiment.

Table 5.6.

Operation Span Results for Spanish-English and Japanese-English Bilinguals in Experiment 3

Variable	Spanish-English (*n* = 19)	Japanese-English (*n* = 18)
Operation span (1-60)	36.9 (12.2)	36.9 (9.1)
RT on judgment (ms)	2318 (261)	2192 (272)
Errors on judgment (1-60)	12.3 (10.2)	10.0 (6.5)

Note. Standard deviations are in parentheses.

In sum, the data from the individual difference measures indicate that the Japanese-English bilinguals appear to have a better inhibitory control than the Spanish-English bilinguals but similar processing resources to the Spanish-English bilinguals. We consider the implications of the difference in the Simon effect in the *General Discussion* of the present chapter.

Data Trimming for Picture Naming Task

Recorded picture naming responses were first transcribed and coded for accuracy. We adopted a liberal criterion for accuracy in the present experiment. Responses that were synonyms of the expected name of a given picture (e.g., bike for bicycle) were considered to be correct since participants had not been familiarized with the expected name of each picture in advance in the present experiment. Responses that deviated from the expected picture name and synonyms, responses that started with an article or hesitation, and “no” responses were scored as errors. Responses that the microphone did not detect were eliminated as technical errors. After trimming RTs for correct responses that were less than 300 ms or greater than 3000 ms, RTs that were 2.5 standard deviations above or below the mean were identified as outliers separately for L1 and L2 in each of the blocks (kana and kanji) and excluded from the analyses. Finally, we calculated RTs and accuracy for correct responses again. Errors (13.9 %), outliers (4.1 %), and technical errors (0.4 %) for the kana block and errors (11.9 %), outliers (2.6 %), and technical errors (0.2 %) for the kanji block were excluded from the following analyses.

Data Trimming for Word Naming Task

Recorded word naming responses were also transcribed and coded for accuracy. Responses that were mispronounced, responses that started with hesitation, and “no” responses were scored as errors. Responses that the microphone did not detect were eliminated as technical errors. Similar to the picture naming data, after trimming RTs for correct responses that were less than 200 ms or greater than 2000 ms, RTs that were 2.5 standard deviations above or below the mean were identified as outliers separately for L1 and L2 in each of the blocks (kana and kanji) and excluded from the analyses. Finally, we calculated RTs and accuracy for correct responses again. Errors (2.8 %) and outliers (1.9 %) for the kana block and errors (2.8 %) and outliers (2.0 %) for the kanji block were excluded from the following analyses.

Picture Naming Overall

Latencies

A 2 (language) x 2 (type of trial) x 2 (language group) ANOVA revealed a main effect of type of trial [$F(1, 35) = 12.35$, $MSE = 15518.84$, $p < .01$], indicating that as illustrated in Figure 5.2., non-switch trials were faster than switch trials. There was no other main effect or interaction [$F(1, 35) = 1.17$, $MSE = 15518.84$, $p > .10$ for the interaction between type of trial and language group; $F(1, 35) = 1.15$, $MSE = 8675.44$, $p > .10$ for the three-way interaction; all the other Fs < 1].

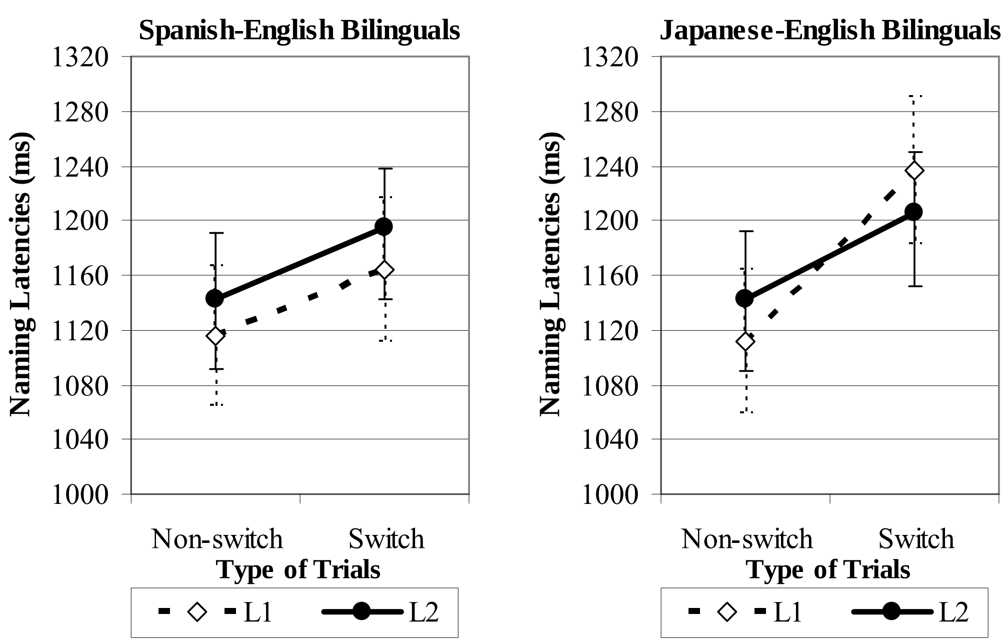


Figure 5.2. Mean overall picture naming latencies as a function of language, type of trial, and language group.

Accuracy

The main effect of language was significant [$F(1, 35) = 8.80$, $MSE = 123.38$, $p < .01$], with higher accuracy for L1 than for L2 (see Table 5.7.). No other main effect or interaction was significant [$F(1, 35) = 1.21$, $MSE = 61.66$, $p > .10$ for the interaction between type of trial and language group; $F(1, 35) = 2.63$, $MSE = 64.07$, $p > .10$ for the three-way interaction; all the other Fs < 1].

Table 5.7.

Mean Picture Naming Percent Accuracy by Block, Language, Type of Trial, and Language Group

Block	Condition	Spanish-English bilinguals	Japanese-English bilinguals
Overall	L1 non-switch	87.5 (2.1)	86.5 (2.2)
	L1 switch	85.7 (2.1)	86.1 (2.2)
	L2 non-switch	78.3 (2.8)	84.5 (2.9)
	L2 switch	81.1 (2.6)	80.2 (2.6)
Kana	L1 non-switch	88.2 (2.9)	87.5 (3.0)
	L1 switch	82.0 (2.9)	86.8 (3.0)
	L2 non-switch	77.0 (3.6)	82.2 (3.7)
	L2 switch	77.0 (3.8)	75.7 (3.9)
Kanji	L1 non-switch	86.8 (2.7)	85.4 (2.8)
	L1 switch	89.5 (2.5)	85.4 (2.6)
	L2 non-switch	79.6 (3.1)	86.8 (3.2)
	L2 switch	85.3 (2.7)	84.7 (2.7)

Note. Standard errors are in parentheses.

Picture Naming with Kana Items

Latencies

A 2 (language) x 2 (type of trial) x 2 (language group) ANOVA was conducted on the picture naming latency data for kana items. The main effect of type of trial was significant [$F(1, 35) = 8.05$, $MSE = 31434.50$, $p < .01$], such that as shown in Figure 5.3., naming latencies were faster for non-switch trials than for switch trials. The main effect of language or language group was not reliable [$F(1, 35) = 2.16$, $MSE = 4324.90$, $p > .10$ for language; $F < 1$ for language group]. There was no significant interaction [$F(1, 35) = 1.08$, $MSE = 31434.50$, $p > .10$ for the interaction between type of trial and language group; $F(1, 35) = 1.55$, $MSE = 19146.38$, $p > .10$ for the interaction between language and type of trial; $F(1, 35) = 1.40$, $MSE = 19146.38$, $p > .10$ for the three-way interaction; $F < 1$ for the interaction between type of trial and language group].

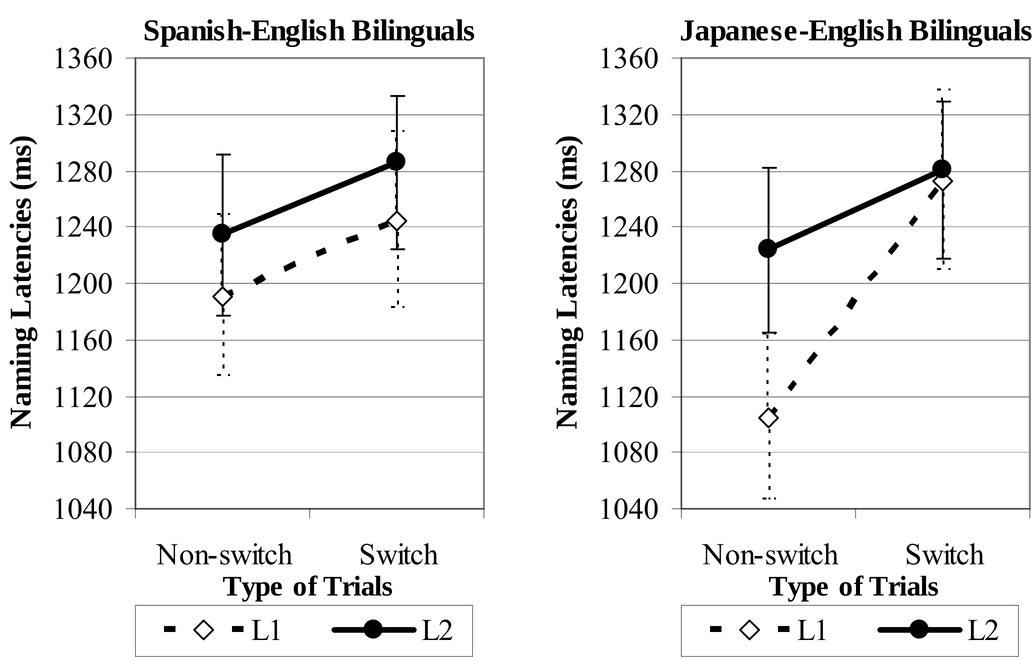


Figure 5.3. Mean kana picture naming latencies as a function of language, type of trial, and language group.

Accuracy

The main effect of language was significant [$F(1, 35) = 8.20$, $MSE = 299.36$, $p < .01$], with higher accuracy for L1 than for L2 (see Table 5.7.). The main effect of type of trial approached significance [$F(1, 35) = 2.81$, $MSE = 147.25$, $p = .10$], indicating that the bilinguals were more accurate for non-switch trials than for switch trials. The main effect of language group was not reliable [$F < 1$]. There was no significant interaction [$F(1, 35) = 2.65$, $MSE = 125.54$, $p > .10$ for the three-way interaction; *F*s < 1 for other interactions].

Picture Naming with Kanji Items

Latencies

Again, a 2 (language) x 2 (type of trial) x 2 (language group) ANOVA was conducted. There was a significant main effect of type of trial [$F(1, 35) = 12.19$, $MSE = 11873.80$, $p < .01$], indicating that as can be seen in Figure 5.4., non-switch trials were faster than switch trials. The main effects of language and language group were not reliable [$F(1, 35) = 1.27$, $MSE = 17930.68$, $p > .10$ for language; $F < 1$ for language group]. The interaction between language and language group approached significance [$F(1, 35) = 3.32$, $MSE = 17930.68$, $p = .08$], such that the Japanese-English bilinguals were faster in L2 than in L1 [$F(1, 17) = 3.57$, $MSE = 10629.85$, $p = .08$], whereas the Spanish-English bilinguals did not show such a difference [$F < 1$]. The other interactions were not significant [*Fs* < 1].

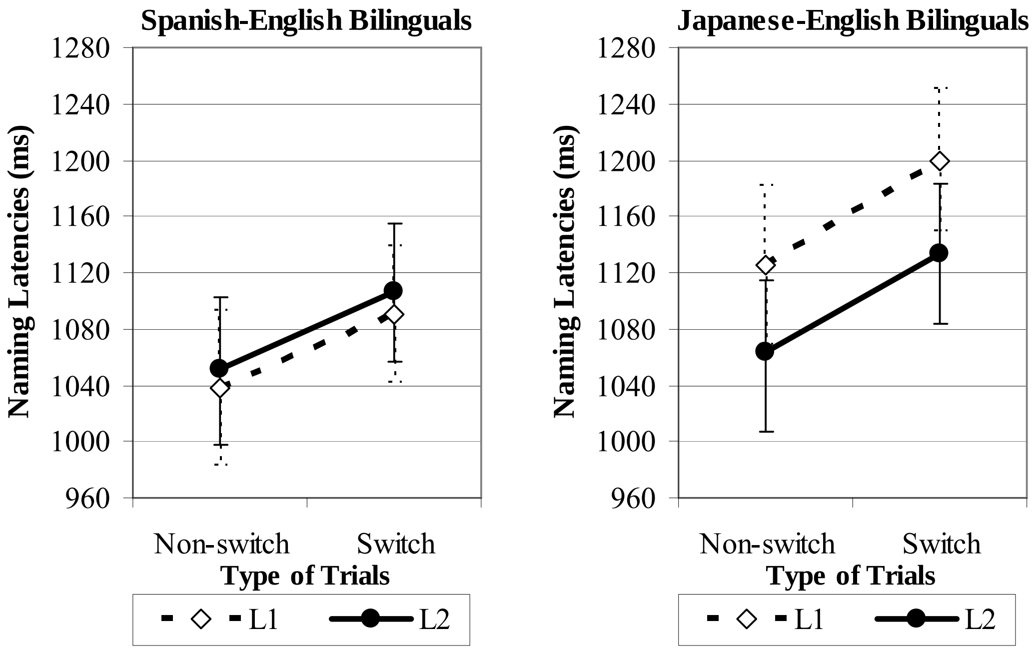


Figure 5.4. Mean kanji picture naming latencies as a function of language, type of trial, and language group.

Accuracy

There was no main effect or interaction (see Table 5.7.) [$F(1, 35) = 2.11$, $MSE = 125.02$, $p > .10$ for language; $F(1, 35) = 2.69$, $MSE = 125.02$, $p > .10$ for the interaction between language and language group; $F(1, 35) = 2.41$, $MSE = 104.52$, $p > .10$ for the interaction between type of trial and language group; all the other *F*s < 1].

In sum, the Spanish-English and Japanese-English bilinguals performed similarly in L2 picture naming regardless of type of blocks, whereas the two groups differed in L1 picture naming. Although the three-way interaction was not significant, the switch cost for the Spanish-English bilinguals was symmetrical, whereas the switch cost for the Japanese-English bilinguals tended to be asymmetrical in the kana block (see Figure 5.3.). In the kanji block, both groups showed a symmetrical switch cost, but the Spanish-

English bilinguals were equally fast both in L1 and in L2, whereas the Japanese-English bilinguals were faster in L2 than in L1 (see Figure 5.4.). These results suggest that these two bilingual groups were similar in L2 proficiency (at least in production) but that mixing two languages has a different impact on their performance in the L1.

Word Naming Overall

Latencies

A 2 (language) x 2 (type of trial) x 2 (language group) ANOVA was conducted. The main effect of type of trial was significant [$F(1, 35) = 19.41$, $MSE = 370.16$, $p < .001$], indicating that non-switch trials were faster than switch trials. The main effect of language was also significant [$F(1, 35) = 17.19$, $MSE = 6805.19$, $p < .001$], with faster latencies for L1 than for L2. There was a significant main effect of language group [$F(1, 35) = 6.59$, $MSE = 34700.88$, $p < .05$], with faster latencies for Spanish-English bilinguals than Japanese-English bilinguals. More importantly, the interaction between language and language group was marginally significant [$F(1, 35) = 3.53$, $MSE = 6805.19$, $p = .07$], such that as can be seen in Figure 5.5., the Spanish-English bilinguals were faster than the Japanese-English bilinguals for L2 [$F(1, 35) = 8.94$, $MSE = 11207.82$, $p < .01$] but these two groups did not differ in L1 [$F(1, 35) = 2.74$, $MSE = 9545.22$, $p > .10$]. There was no other interaction [Fs < 1].

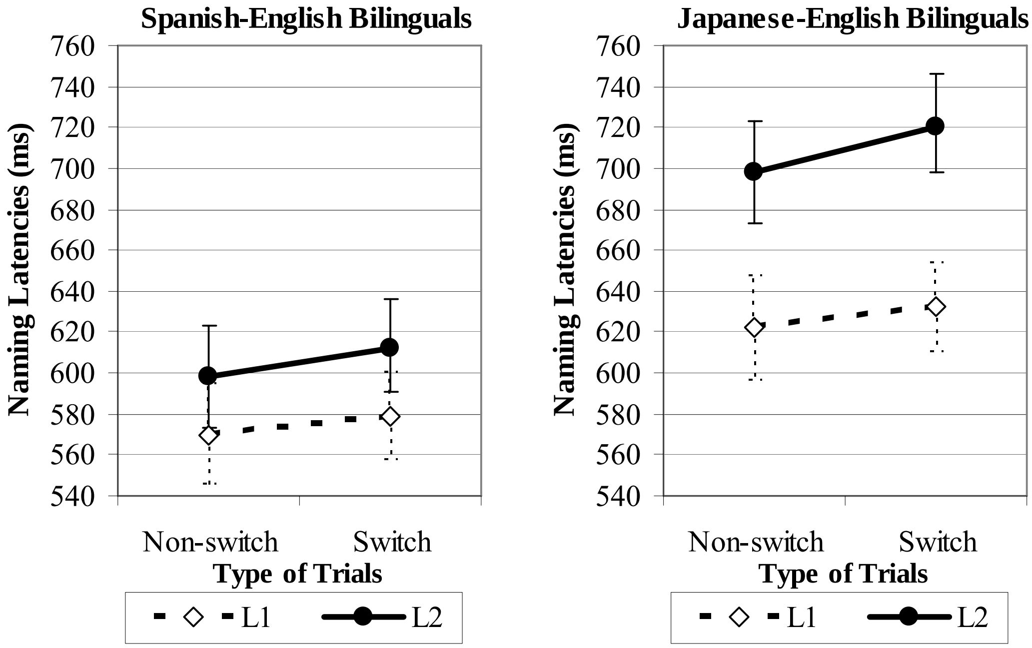


Figure 5.5. Mean overall word naming latencies as a function of language, type of trial, and language group.

Accuracy

The analysis revealed a main effect of language [$F(1, 35) = 6.60$, $MSE = 31.57$, $p < .05$], with higher accuracy for L1 than for L2 (see Table 5.8.). No other main effect or interaction was significant [$F(1, 35) = 2.53$, $MSE = 17.89$, $p > .10$ for the interaction between type of trial and language group; all the other *F*s < 1].

Table 5.8.

Mean Word Naming Percent Accuracy by Block, Language, Type of trial, and Language Group

Block	Condition	Spanish-English bilinguals	Japanese-English bilinguals
Overall	L1 non-switch	96.4 (0.9)	96.2 (1.0)
	L1 switch	97.0 (1.0)	95.8 (1.1)
	L2 non-switch	93.8 (1.3)	95.1 (1.3)
	L2 switch	94.7 (1.4)	92.7 (1.4)
Kana	L1 non-switch	98.0 (1.4)	95.8 (2.1)
	L1 switch	95.4 (1.7)	98.6 (1.7)
	L2 non-switch	93.4 (1.7)	96.5 (1.8)
	L2 switch	94.1 (2.5)	90.3 (2.5)
Kanji	L1 non-switch	94.7 (1.6)	96.5 (1.6)
	L1 switch	98.7 (1.4)	93.1 (1.4)
	L2 non-switch	94.1 (2.1)	93.8 (2.2)
	L2 switch	95.4 (1.9)	95.1 (1.9)

Note. Standard errors are in parentheses.

Word Naming with Kana Items

Latencies

The 2 (language) x 2 (type of trial) x 2 (language group) ANOVA revealed a main effect of type of trial [$F(1, 35) = 7.13$, $MSE = 678.46$, $p < .05$], with faster naming latencies for non-switch trials than for switch trials. There was a significant main effect of language [$F(1, 35) = 58.62$, $MSE = 5265.15$, $p < .001$], indicating that L1 was faster than L2. The main effect of language group was also reliable [$F(1, 35) = 5.19$, $MSE = 29510.08$, $p < .05$], with faster latencies for Spanish-English bilinguals than for Japanese-English bilinguals. Most importantly, the interaction between language and language group was significant [$F(1, 35) = 19.53$, $MSE = 5265.15$, $p < .001$], such that as illustrated in Figure 5.6., the Spanish-English bilinguals were faster than the Japanese-English bilinguals for L2 trials [$F(1, 35) = 11.52$, $MSE = 11000.01$, $p < .01$], but there was no such a difference for L1 trials [$F < 1$].

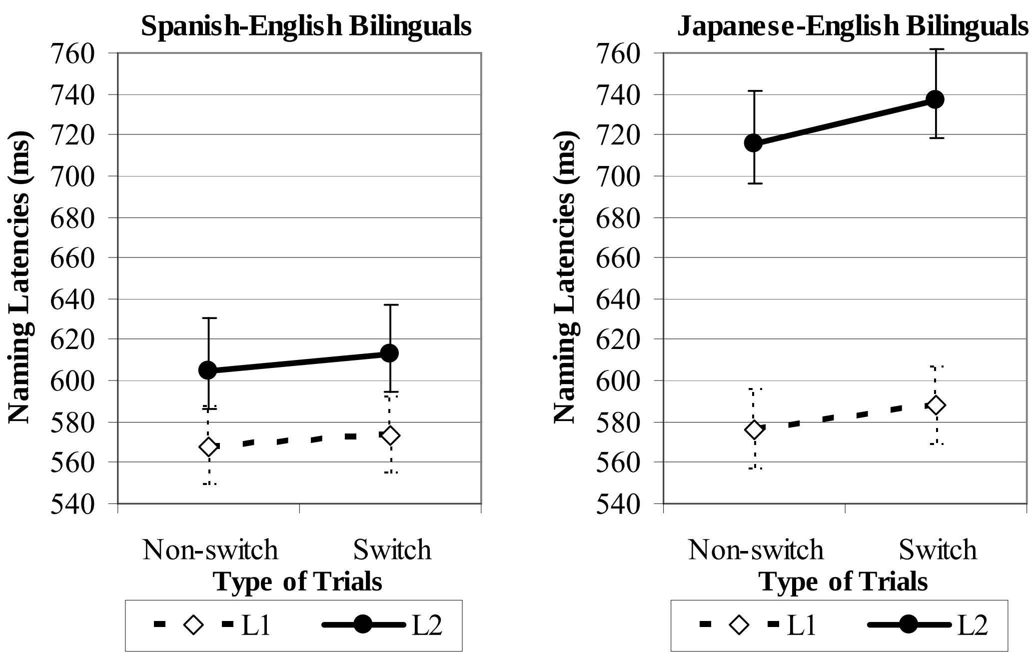


Figure 5.6. Mean kana word naming latencies as a function of language, type of trial, and language group.

Accuracy

The main effect of language was reliable [$F(1, 35) = 6.68$, $MSE = 6.68$, $p < .05$], indicating that L1 trials were more accurate than L2 trials (see Table 5.8.). The main effects of type of trial and language group were not significant [$F(1, 35) = 1.06$, $MSE = 64.89$, $p > .10$ for type of trial; $F < 1$ for language group]. There was no two-way interaction [$F(1, 35) = 1.04$, $MSE = 72.87$, $p > .10$ for the interaction between language and type of trial; *F*s < 1 for the other two-way interactions]. The three-way interaction was significant [$F(1, 35) = 4.81$, $MSE = 72.87$, $p < .05$]. As can be seen in Table 5.6., the Japanese-English bilinguals showed an asymmetrical switch cost [$F(1, 17) = 7.39$, $MSE = 49.66$, $p < .05$], such that they were more accurate for non-switch trials than for switch trials in L2 [$F(1, 17) = 5.28$, $MSE = 66.64$, $p < .05$], whereas they were equally accurate for both types of trials in L1 [$F(1, 17) = 1.66$, $MSE = 41.87$, $p > .10$]. However, the Spanish-English bilinguals did not show any switch cost in either language [$F < 1$].

Word Naming with Kanji Items

Latencies

The 2 (language) x 2 (type of trial) x 2 (language group) ANOVA revealed a main effect of type of trial [$F(1, 35) = 9.05$, $MSE = 1178.92$, $p < .01$], with faster naming latencies for non-switch trials than for switch trials. The main effect of language group was also reliable [$F(1, 35) = 6.67$, $MSE = 47095.66$, $p < .05$], indicative of faster naming latencies for Spanish-English bilinguals than for Japanese-English bilinguals (see Figure 5.7.). There was no other main effect or interaction [$F(1, 35) = 1.52$, $MSE = 10507.10$, $p > .10$ for language; all the other *F*s < 1].

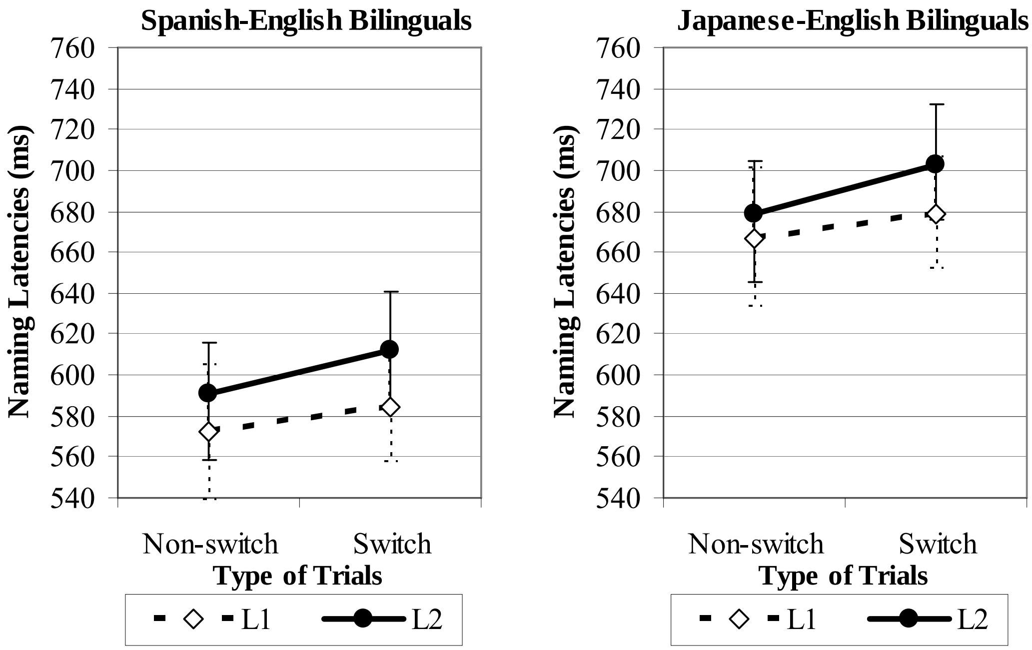


Figure 5.7. Mean kanji word naming latencies as a function of language, type of trial, and language group.

Accuracy

There was no significant main effect [*F*s < 1]. The interaction between switch and language group approached significance [$F(1, 35) = 3.59$, $MSE = 34.74$, $p = .07$], such that as illustrated in Table 5.8., the Spanish-English bilinguals were more accurate for switch trials than for non-switch trials although the difference was not statistically significant [$F(1, 18) = 2.21$, $MSE = 9.42$, $p > .10$], whereas the Japanese- English bilinguals did not reveal such a difference [$F < 1$]. No other interaction was reliable [$F(1, 35) = 1.83$, $MSE = 1.83$, $p > .10$ for the three-way interaction; all the other *F*s < 1].

To summarize the word naming data, both bilingual groups showed a symmetrical switch cost. In the kana block, the Spanish-English bilinguals were much faster in L2 word naming than the Japanese-English bilinguals, whereas these two groups were similar in L1 word naming (see Figure 5.6.). In the kanji block, however, the Spanish-English bilinguals were faster in both languages than the Japanese-English bilinguals (see Figure 5.7.). An important result of these analyses is that unlike picture naming, the two bilingual groups greatly differ in L2 word naming. Together with the picture naming data, these results suggest that the task demands differentially affect the L1 and L2 performance in the same script bilinguals and in the different script bilinguals.

Picture Naming Error Analyses

The analyses of picture naming data suggest that the Spanish-English and Japanese-English bilinguals are similar in L2 picture naming, whereas they differ in L1 picture naming. To further investigate the differential cost of language mixing on L1 naming, error analyses were conducted. Similar to the error analyses in Chapter 4, responses that were scored as other than *correct* or *technical errors* were divided into the following categories: (1) *outliers* were responses that were correct but trimmed from the data analyses because of short or long naming latencies; (2) *semantic errors* were responses that were incorrect but from the same semantic category; (3) *phonological errors* were responses that were incorrect but whose phonological onset was similar to the target picture name; (4) *language errors* were responses in the wrong language; (5) *disfluency errors* were response that started with a hesitation such as “um” although the participants named the picture object correctly; (6) *miscellaneous errors* were errors that did not fall into any of the described categories (e.g., “No”).

The distribution of types of errors in the picture naming task is summarized by language group and by block in Table 5.9.

Table 5.9.

Distribution of Type of Errors in Picture Naming

		Spanish-English		Japanese-English	
Block	Error type	L1	L2	L1	L2
Overall					
	Outliers	2.8 % (3.6)	3.3 % (3.1)	4.7 % (4.6)	4.2 % (4.1)
	Semantic errors	3.1 % (2.9)	4.9 % (4.7)	1.7 % (2.2)	3.6 % (3.4)
	Phonological errors	0.0 % (0.0)	0.5 % (1.2)	0.0 % (0.0)	0.7 % (1.3)
	Language errors	4.1 % (3.6)	2.8 % (3.6)	4.9 % (6.5)	2.4 % (2.3)
	Disfluency errors	0.5 % (1.2)	0.3 % (1.0)	0.9 % (1.4)	0.3 % (1.0)
	Miscellaneous errors	2.8 % (2.6)	8.1 % (8.4)	2.3 % (2.9)	6.0 % (6.1)
Kana					
	Outliers	3.0 % (4.8)	3.6 % (5.6)	5.2 % (3.9)	5.7 % (6.9)
	Semantic errors	3.0 % (3.2)	5.9 % (6.4)	1.4 % (2.7)	2.1 % (3.7)
	Phonological errors	0.0 % (0.0)	0.7 % (2.0)	0.0 % (0.0)	1.0 % (2.4)
	Language errors	3.6 % (5.2)	2.0 % (4.7)	4.2 % (6.5)	3.1 % (4.4)
	Disfluency errors	0.7 % (2.0)	0.0 % (0.0)	0.3 % (1.5)	0.0 % (0.0)
	Miscellaneous errors	4.7 % (4.2)	10.2 % (10.7)	1.8 % (3.7)	8.6 % (10.0)
Kanji					
	Outliers	2.6 % (4.3)	3.0 % (3.9)	2.8 % (3.8)	2.8 % (3.9)
	Semantic errors	3.3 % (4.4)	3.9 % (6.3)	2.1 % (3.0)	5.2 % (5.4)
	Phonological errors	0.0 % (0.0)	0.3 % (1.4)	0.0 % (0.0)	0.3 % (1.5)
	Language errors	4.6 % (4.6)	3.6 % (4.3)	5.6 % (7.7)	1.7 % (2.9)
	Disfluency errors	0.3 % (1.4)	0.7 % (2.0)	1.4 % (2.7)	0.7 % (2.0)
	Miscellaneous errors	1.0 % (2.3)	5.9 % (7.1)	2.8 % (4.4)	3.5 % (4.4)

Note. Standard deviations are in parentheses. *The difference was at $p < .001$.

Two sets of analyses were performed: between-language group comparisons for each language (independent group t-tests) and between-language comparisons for each language group (paired sample t-tests). In the between-language group comparisons, only two significant differences were found between Spanish-English and Japanese-English bilinguals: semantic errors and miscellaneous errors in L1 for kana. As can be seen in Table 5.7., Spanish-English bilinguals made more semantic and miscellaneous errors in L1 for the kana block [$t(35) = 2.21$, $p < .05$; $t(35) = 2.21$, $p < .05$, respectively]. The between-language comparisons showed a somewhat different pattern of the distribution of errors in L1 and in L2 for each bilingual group. As shown in Table 5.7., both Spanish-English and Japanese-English bilinguals made more miscellaneous errors such as "No" in L2 than in L1 overall [$t(18) = 2.40$, $p < .05$ for Spanish-English; $t(17) = 2.44$, $p < .05$ for Japanese-English], indicating that they were L1 dominant. Specifically, Spanish-English bilinguals showed this difference both in kana and in kanji [$t(18) = 1.87$, $p = .08$; $t(18) = 2.81$, $p < .05$, respectively], whereas Japanese-English bilinguals demonstrated it only in kana [$t(17) = 2.46$, $p < .05$]. Furthermore, Spanish-English bilinguals produced slightly more semantic errors in L1 than in L2 in the kana block [$t(18) = 1.84$, $p = .08$], whereas Japanese-English bilinguals made more semantic errors in L1 than in L2 in the kanji block [$t(17) = 2.30$, $p < .05$], which results in a significant difference in the rate of semantic errors overall [$t(17) = 2.44$, $p < .05$]. Most importantly, the Japanese-English bilinguals spoke in the wrong language marginally more frequently when they were supposed to name kanji pictures in L1 than in L2 [$t(17) = 1.83$, $p = .09$]. In contrast, the Spanish-English bilinguals did not show such a difference [$t < 1$]. The higher error rate in L1 only for the Japanese group suggests that the Japanese-English bilinguals were suppressing L1 more strongly than the Spanish-English bilinguals in the kanji block, which is consistent with the latency data for the kanji block (see Figure 5.4.). It is important to remember that all of these bilinguals were L1 dominant (see Tables 5.2. and 5.4.) and that the higher language error rate for L1 than for L2 is not a reflection of L1 attrition, but the cost of language mixing on L1.

General Discussion

The goal of Experiment 3 was to determine whether the process of inhibitory control can be modulated by script differences when the written lexical form is present and absent in the task. In the present experiment, Spanish-English and Japanese-English bilinguals performed the language switching in picture naming and in word naming where noncognate items were presented with a predictable sequence of two trials in L1, two trials in L2, etc. The picture naming and word naming tasks revealed a different pattern of the results for these two bilingual groups. In picture naming, the two bilingual groups were identical in L2 regardless of the type of blocks (kana/kanji), whereas in L1 they tended to differ in the magnitude of switch cost and in speed, depending on the type of blocks. Specifically, in the kana block, the Japanese-English bilinguals tended to show a greater switch cost in L1 than the Spanish-English bilinguals although this difference was not statistically significant. In the kanji block, the Japanese-English bilinguals were slower in L1 than the Spanish-English bilinguals. In word naming, however, the two bilingual groups were similar in L1 in the kana block but the Spanish-English bilinguals were faster in L2 than the Japanese-English bilinguals. On the other hand, in the kanji block, the Spanish-English bilinguals were faster both in L1 and in L2 than the Japanese-

English bilinguals. In the rest of this chapter, the results of the present experiment are first considered with respect to the magnitude of switch costs, and the pattern of switch costs (asymmetry vs. symmetry), and the cost to L1 and then the implications of the results are discussed.

Magnitude of Switch Costs

As explained earlier, the Inhibitory Control model (Green, 1998) posits that the activation of lemmas in the unintended language is inhibited retroactively when lemmas from both languages are activated and that the amount of inhibition is proportional to the amount of the activation of those lemmas in the unintended language. It has been assumed in the literature on language switching that the magnitude of the switch cost reflects the amount of inhibition required to suppress the activation of the unintended language in the sense that the inhibition of the unintended language makes it hard to reactivate the suppressed lemmas on the subsequent trial (e.g., Meuter & Allport, 1999). In the present experiment, both Spanish-English and Japanese-English bilinguals revealed the switch cost in each of their languages both in picture naming and in word naming. However, there was no difference in the magnitude of switch costs depending upon language or language group (but see the discussion in the next section).

Interestingly, although the magnitude of switch costs was greater for picture naming (72 ms) than for word naming (15 ms) [$F(1, 35) = 7.66$, $MSE = 8136.98$, $p < .01$], their effect size was larger for word naming [$\eta^2 = .36$] than for picture naming [$\eta^2 = .26$], which is somewhat a surprising finding because some task switching literature suggests that when cues are explicit/familiar, switch costs are reduced (e.g., Miyake et al., 2004).

If the ambiguity of the language cue influences the magnitude of switch costs, then the effect size should have been larger for picture naming than for word naming.

Pattern of Switch Costs

Past research on language switching has indicated that unbalanced bilinguals produce a greater switch cost from L2 to L1 than from L1 to L2 (e.g., Meuter & Allport, 1999; Costa & Santesteban, 2004), whereas balanced bilinguals show a symmetrical pattern of switch costs in L1 and L2 (e.g., Costa & Santesteban, 2004). It has been assumed that the asymmetrical switch cost is a reflection of inhibition such that L1 is more active than L2 in unbalanced bilinguals and the greater suppression of L1 when speaking L2 makes it harder to reactivate the L1 on the subsequent trial (e.g., Meuter & Allport, 1999). Although it is apparent from the proficiency measures that the Spanish-English and Japanese-English bilinguals in the present experiment were unbalanced bilinguals, these bilinguals also showed the symmetrical switch costs in L1 and L2. The balanced bilinguals in Costa and Santesteban's study (2004) were not only highly proficient in two languages but also acquired both languages earlier in their life. In fact, Costa and Santesteban pointed out that not only high proficiency in two languages but also early acquisition might have resulted in the symmetrical switch cost in L1 and L2/L3.[2] The results of the present experiment are not consistent with the explanation on age of acquisition because as can be seen in Table 5.2., the late bilinguals produced symmetrical switch costs. In terms of L2 proficiency, it is possible that the unbalanced

[2] As reviewed in Chapter 1, the highly proficient Spanish-Catalan bilinguals in Costa and Santesteban's study produced a symmetrical pattern of switch costs in L1 and L3, suggesting that inhibition is unnecessary even for their less proficient language.

bilinguals in the present experiment were more proficient in their L2 than the unbalanced bilinguals in the previous studies (e.g., Costa & Santesteban, 2004; Finkbeiner, Almeida et al., 2006; Meuter & Allport, 1998). If this is the case, then the pattern of switch costs may be determined whether the bilingual speaks at least two languages whose proficiency is reasonably high even though they are not balanced.

Although the pattern of switch costs obtained in the present experiment was statistically symmetrical for both bilingual groups on both picture naming and word naming, there was a trend for an asymmetrical pattern of switch costs for Japanese-English bilinguals in naming kana pictures. The Japanese-English bilinguals were similar in L2 to the Spanish-English bilinguals in the kana block (see Figure 5.3.), but they appear to show a greater switch cost in L1 than the Spanish-English bilinguals. As pointed out in the section of individual difference measures, the Japanese-English bilinguals have a better inhibitory control (see Table 5.5). The individual differences in inhibitory control might have reduced the difference across the two bilingual groups. To examine this possibility, the naming latencies on kana pictures were reanalyzed with the magnitude of the Simon effect as a covariate. The reanalysis indicated that the Japanese-English bilinguals showed a greater switch cost in L1 (185 ms) than the Spanish-English bilinguals (38 ms) [$F(1, 34) = 4.27$, $MSE = 39971.78$, $p < .05$]. In other words, the Japanese-English bilinguals tended to show the asymmetrical pattern of switch costs in L1 and L2 in the kana picture naming.

Cost to L1

Past research shows that when both languages are required to be active in a task, there is little consequence for L2 but great cost to L1, such that L1 naming slows down (e.g., Costa & Santesteban, 2004; Kroll et al., in preparation; Miller, 2001). The results of the present experiment show a greater cost to L1 for Japanese-English bilinguals than for Spanish-English bilinguals. Specifically, in the kanji block of picture naming, the Japanese-English bilinguals tended to be slower and make more language errors in L1 than in L2, whereas the Spanish-English bilinguals were equally fast and made about the same number of language errors in each of their languages (see Figure 5.4.). Although the Spanish-English bilinguals did not show the L2 advantage over the L1 in picture naming as the Japanese-English bilinguals did, it does not necessarily mean that there is no consequence of language mixing/switching for L1 in Spanish-English bilinguals. Despite the fact that the bilinguals included in the data analyses in the present experiment were all L1 dominant, they were not any faster in L1 than in L2 except for the kana block of word naming where items were less frequent. The similar naming latencies for L1 and L2 may be a reflection of the cost to L1. Because the design of the present experiment did not have blocked naming (i.e., naming only in one language without mixing), these observations on the cost to L1 are necessarily tentative, but it appears that L1 naming is affected by L2 naming more for Japanese-English bilinguals than for Spanish-English bilinguals, a finding that is consistent with the results of L1 simple picture naming from Experiment 1. We further discuss the greater cost to L1 in Japanese-English bilinguals than in Spanish-English bilinguals in Chapter 7.

L1 Inhibition

Past research on language switching suggests that unbalanced bilinguals rely on the mechanism of language non-specific selection in which lexical alternatives from both languages are considered for selection and inhibition is used for language selection, whereas balanced bilinguals use the mechanism of language-specific selection in which lexical alternatives from both languages are active but only the alternatives from the target language are considered for selection and inhibition is not necessary (e.g., Costa & Santesteban, 2004; Meuter & Allport, 1998). This argument has been made primarily based on the pattern of switch costs (asymmetrical vs. symmetrical).

However, the results of the present experiment raise a question of whether the symmetrical pattern of switch costs reflects no inhibition involved in speech planning. In the present experiment, despite the fact that the Spanish-English and Japanese-English bilinguals were closely matched on proficiency measures at least in speaking skills, the Japanese-English bilinguals showed the asymmetrical pattern of switch costs in L1 and L2 in the kana picture naming, but the Spanish-English bilinguals did not (after the individual differences in the Simon effect were co-varied out). Some may argue that the Japanese-English bilinguals were less proficient in the L2 than the Spanish-English bilinguals, but the two bilingual groups were almost identical in L2 picture naming, suggesting that the differential pattern of the results was not due to L2 proficiency. Furthermore, the same group of Japanese-English bilinguals showed the symmetrical pattern of switch costs in L1 and L2 in the kanji picture naming. Again, the Japanese-English bilinguals were similar in L2 to the Spanish-English bilinguals, but only the Japanese-English bilinguals showed slower naming latencies in L1 than in L2. These results suggest that the mechanism of lexical selection cannot be determined simply by the pattern of switch costs.

However, the question still remains as to why the Japanese-English bilinguals demonstrated a different pattern of switch costs in the kana and kanji picture naming. It is important to remember that the Japanese-English bilinguals were similar to the Spanish-English bilinguals in L2 regardless of the kana or kanji blocks and that the difference was in L1 in the kanji block (1163 ms for Japanese-English bilinguals vs. 1064 ms for Spanish-English bilinguals). As shown in Table 5.1., picture naming latencies in Japanese and in Spanish from the monolingual norming database were not different from one another (974 ms for Japanese vs. 958 ms for Spanish). One possibility is that the kanji script was activated during picture naming, which might have slowed down naming the kanji picture. It is clear from the word naming data that the kanji words were read more slowly than the kana words in the word naming task in spite of the higher frequency and familiarity for the kanji items than for the kana items. Although the picture naming itself did not include the overt written form, it is possible that the Japanese-English bilinguals who performed the word naming task first followed by the picture naming task might have activated the written lexical form of the L1 picture name and contributed to the greater cost to L1 in the kanji picture naming. To test this possibility, the kanji picture naming data from the Japanese-English bilinguals were reanalyzed by including the order of tasks as a between-participants variable. The 2 (language) x 2 (type of trial) x 2 (order of tasks) mixed ANOVA revealed a marginally significant interaction between order of tasks and type of trial [$F(1, 16) = 3.06$, $MSE = 13881.34$, $p = .099$], such that the Japanese-English bilinguals who performed the picture naming followed by the word naming showed a significant switch cost (121 ms) [$F(1, 8) = 9.98$, $MSE = 6618.03$, $p < .05$], whereas those who performed the picture naming after the word naming did not show a switch cost (24 ms) [$F < 1$]. However, the main effect of order of tasks, the interaction between order of tasks and language, or the three-way interaction was not significant [$F < 1$]. These results suggest that the slower naming latencies for L1 than for L2 in the kanji block were not due to the order of tasks and that it is less likely that the activation of the written lexical form incurred the cost to naming pictures in L1.[3] Therefore, it may be more reasonable to assume that the slower naming latencies in L1 than in L2 in the kanji block was due to the suppression of the L1. The lack of the L2 advantage over the L1 in the kana block might be due to the lexical properties of the items. The kana items were less frequent and familiar than the kanji items so that the Japanese-English bilinguals might not have demonstrated slower naming latencies in L1 than in L2. However, we can interpret the asymmetrical pattern of switch costs in L1 and L2 in the kana block as one form of manifestation of the suppression of the L1. In other words, the picture naming data from the Japanese-English bilinguals suggest that the application of L1 inhibition can be reflected by more than one form—the asymmetrical switch cost and the cost to L1.

---

[3] As mentioned in the section of procedure, we chose the different colors of mapping for the picture naming and word naming tasks to rule out a possible confound such that the prior performance of the word naming task might benefit learning the color mapping of two languages in the picture naming task, but not the other way around because the color of the background was not necessary to perform the word naming task. The results of this analysis suggest that despite the use of two different sets of colors of mapping, the Japanese-English bilinguals who performed the word naming first appear to have shown a practice effect for language switching. Interestingly, the interaction between order of tasks and type of trials was not significant for the Spanish-English bilinguals [$F < 1$], suggesting that the presence of the interaction between order of tasks and type of trials for the Japanese-English bilinguals might be due to script differences.

Production vs. Comprehension

The pattern of the word naming data was different from that of the picture naming data in two respects. The Spanish-English and the Japanese-English bilinguals were similar in naming L1 in the kana block, but not in the kanji block. This difference is probably due to the nature of the kanji script. Research on Japanese word recognition has shown that it takes longer to recognize the kanji form than the kana form of the same lexical item even when the kana form is less familiar than the kanji form (e.g., Havelka & Tomita, 2006). Kana is a syllabary script and the letter-sound correspondence is one-to-one, whereas kanji is a logographic script and the letter-sound correspondence is more opaque. Therefore, it usually takes longer to read kanji words than kana words even when relevant lexical properties are controlled for.

A further result of note is that the Japanese-English bilinguals were slower in L2 on the word naming task than the Spanish-English bilinguals although their L2 performance on the picture naming task was similar to that of the Spanish-English bilinguals. This is because the direction of the activation of lexical codes is different in word naming from picture naming. When the task requires the bilingual to activate orthography and to map it to phonology in L2, script differences between L1 and L2 incur costs. However, when the event is initiated by semantics (i.e., picture naming), distinctive scripts do not impose greater costs on the last processing component, orthography. The difference in L2 word naming also suggests that the Japanese-English bilinguals had a similar L2 proficiency in speaking to the Spanish-English bilinguals but were not as proficient in L2 reading as the Spanish-English bilinguals, which is consistent with the difference in RTs and accuracy observed in one of the proficiency measures, the lexical decision task in English. These Japanese-English bilinguals were not learners and highly proficient in the L2 English. It appears that the script difference between L1 and L2 has a greater impact on reading than on speaking. We further discuss the issue of comprehension vs. production in Chapter 7.

In summary, the results of Experiment 3 suggest that the Japanese-English bilinguals suppress their L1 more strongly than the Spanish-English bilinguals and that the script difference between L1 and L2 influences reading and speaking differently. The relatively small sample size following the elimination of participants who were not adequately proficient in the L2 makes it difficult to draw this conclusion with confidence, but the trends in the present experiment provide important preliminary data for investigating the consequences of cross-language script differences.

CHAPTER 6

CROSS-EXPERIMENT COMPARISONS

The results of the three experiments suggest that bilingual performance depends upon whether the script is present in the task and whether the task requires that L1 be used. Before discussing the implications of these results in the final chapter, we compare the data from a set of the proficiency and individual measures across the three experiments to ensure that the observed differences across experiments are due to the nature of the tasks and the materials, not due to the characteristics of the different participants in each of the experiments. It is important to make a cross-experiment comparison on characteristics of bilinguals because the present research was designed as between-subjects and because data were collected at different locations for each experiment.

Cross-Experiment Comparisons of Characteristics of Bilinguals

In this comparison, only the participants who were tested in the L2 environment were included because no participants were tested in the L1 environment in Experiments 2 and 3. Data from the proficiency measures (the language history questionnaire, the lexical decision task, and the verbal fluency task) are summarized by experiments for Spanish-English bilinguals in Table 6.1. The Spanish-English bilinguals in Experiment 2 were different in age, L1 mean self-ratings, months of L2 immersion, and verbal fluency in L1 from those in Experiment 3 and different in months of L2 immersion from those in

Experiment 1. As shown in Table 6.1., the Spanish-English bilinguals in Experiment 2 were younger [$p < .01$], rated their L1 as less proficient [$p = .06$], lived longer in the English speaking countries [$p < .05$], and were less fluent both in L1 and in L2 on the verbal fluency task [$p < .05$ for L1 and $p = .07$ for L2] than those in Experiment 3 and lived longer in the English speaking countries [$p < .05$] than those in Experiment 1. These differences between the Spanish-English bilinguals in Experiment 2 and those in Experiments 1 and 3 may be due to the inclusion of L2 dominant bilinguals in Experiment 2. Therefore, we compared the proficiency measures across the three experiments again without the 12 L2 dominant Spanish-English bilinguals in Experiment 2. As a result, all of the differences obtained in the earlier comparisons disappeared. We report the reanalysis of the data from the picture-word interference experiment without the L2 dominant Spanish-English bilinguals in the following section.

Data from the same proficiency measures for the Japanese-English bilinguals who were tested in the L2 environment are summarized by experiments in Table 6.2. Although four L2 dominant Japanese-English bilinguals were included in Experiment 2, the Japanese-English bilinguals were closely matched across the three experiments and there was no significant difference in any of the proficiency measures.

Table 6.1.

Proficiency Measures for Spanish-English Bilinguals in Experiments 1, 2, and 3

Dependent measures	Exp 1 (*n* = 19)	Exp 2 (*n* = 40)	Exp 3 (*n* =19)	*p*
Age (years)	26.7 (6.2)	25.2 (6.2)	31.1 (7.6)	< .01
L1 mean self-ratings (1-10)	9.7 (0.5)	9.4 (0.8)	9.8 (0.3)	< .05
L2 mean self-ratings (1-10)	8.3 (1.0)	8.6 (1.3)	8.1 (1.1)	*ns*
Mean daily L1 usage (%)	37.9 (23.8)	46.7 (25.5)	47.1 (25.9)	*ns*
Mean daily L2 usage (%)	59.0 (24.5)	54.7 (24.1)	52.4 (25.9)	*ns*
L2 age of acquisition (years)	10.4 (4.0)	8.3 (4.6)	10.2 (6.0)	*ns*
Months of L2 immersion	46.7 (28.3)	95.3 (81.7)	43.1 (45.4)	< .01
Lexical decision				
Nonword RT (ms)	878 (220)	924 (257)	852 (185)	*ns*
Word RT (ms)	676 (104)	681 (112)	670 (118)	*ns*
Nonword accuracy (%)	84.7 (10.7)	83.1 (11.3)	84.1 (12.9)	*ns*
Word accuracy (%)	95.4 (1.7)	94.2 (3.7)	95.0 (4.5)	*ns*
Verbal fluency				
Mean exemplars per category in L1	N/A	11.8 (2.9)	14.7 (1.9)	< .01
Mean exemplars per category in L2	N/A	11.0 (2.0)	12.1 (2.6)	= .07

Note. Standard deviations are in parentheses.

Table 6.2.

Proficiency Measures for Japanese-English Bilinguals in Experiments 1, 2, and 3

Dependent measures	Exp 1 (*n* = 14)	Exp 2 (*n* = 40)	Exp 3 (*n* =18)	*p*
Age (years)	28.2 (6.5)	28.3 (10.2)	28.6 (6.9)	*ns*
L1 mean self-ratings (1-10)	9.2 (0.9)	9.1 (1.1)	9.4 (0.8)	*ns*
L2 mean self-ratings (1-10)	7.0 (2.0)	7.1 (1.9)	7.0 (1.6)	*ns*
Mean daily L1 usage (%)	24.7 (24.3)	38.5 (27.1)	30.8 (25.6)	*ns*
Mean daily L2 usage (%)	69.1 (24.8)	57.1 (26.2)	68.9 (25.4)	*ns*
L2 age of acquisition (years)	10.7 (3.6)	10.7 (3.7)	12.6 (3.4)	*ns*
Months of L2 immersion	53.7 (38.5)	78.8 (72.1)	65.4 (51.3)	*ns*
Lexical decision				
Nonword RT (ms)	1007 (324)	1015 (298)	1150 (327)	*ns*
Word RT (ms)	761 (190)	731 (175)	796 (185)	*ns*
Nonword accuracy (%)	71.4 (18.2)	79.1 (10.8)	76.1 (10.4)	*ns*
Word accuracy (%)	92.5 (5.1)	93.6 (3.0)	93.1 (4.0)	*ns*
Verbal fluency				
Mean exemplars per category in L1	N/A	11.7 (1.7)	12.3 (1.9)	*ns*
Mean exemplars per category in L2	N/A	10.8 (2.0)	10.5 (1.8)	*ns*

Note. Standard deviations are in parentheses.

Likewise, the data from the individual difference measures (the Simon task and the operation span task) were compared across experiments for each bilingual group. These data are summarized in Table 6.3. for Spanish-English bilinguals and in Table 6.4. for Japanese-English bilinguals. The only difference observed in this comparison was in the RT on the equation judgment in the operation span task for the Spanish-English bilinguals. Specifically, the Spanish-English bilinguals in Experiment 2 were slower in deciding whether the equation was correct or incorrect than those in Experiment 3 [$p < .05$], but they did not differ from those in Experiment 1 [$p > .10$]. However, given that the Spanish-English bilinguals in Experiment 2 were similar to those in Experiments 1 and 3 in the operation span, which we used an index of the measure of cognitive resources, we do not take this difference into consideration for the discussion in the final chapter.

Table 6.3.

Individual Difference Measures for Spanish-English Bilinguals in Experiments 1, 2, and 3

Dependent measures	Exp 1 (*n* = 19)	Exp 2 (*n* = 40)	Exp 3 (*n* =19)	*p*
Simon task				
Simon effect (ms)	47.5 (24.2)	48.6 (36.1)	41.4 (21.3)	*ns*
RT for neutral (ms)	442 (58)	472 (93)	439 (107)	*ns*
RT for congruent (ms)	425 (55)	450 (92)	423 (97)	*ns*
RT for incongruent (ms)	472 (68)	499 (86)	464 (90)	*ns*
Accuracy for neutral (%)	98.9 (2.0)	99.4 (1.4)	98.9 (2.4)	*ns*
Accuracy for congruent (%)	99.2 (1.4)	99.2 (1.8)	99.4 (1.6)	*ns*
Accuracy for incongruent (%)	97.5 (2.9)	96.4 (4.5)	95.0 (4.9)	*ns*
Operation span task				
Operation span (1-60)	33.9 (10.8)	33.4 (11.1)	36.9 (12.2)	*ns*
RT on judgment (ms)	2450 (315)	2514 (242)	2318 (261)	$< .05$
Errors on judgment (1-60)	15.7 (10.4)	14.8 (8.7)	12.3 (10.2)	*ns*

Note. Standard deviations are in parentheses.

Table 6.4.

Individual Difference Measures for Japanese-English Bilinguals in Experiments 1, 2, and 3

Dependent measures	Exp 1 (*n* = 14)	Exp 2 (*n* = 40)	Exp 3 (*n* =18)	*p*
Simon task				
Simon effect (ms)	32.7 (31.9)	29.5 (22.2)	24.4 (22.8)	*ns*
RT for neutral (ms)	398 (52.6)	404 (51)	401 (40)	*ns*
RT for congruent (ms)	391 (52)	390 (58)	394 (38)	*ns*
RT for incongruent (ms)	424 (54)	420 (52)	419 (47)	*ns*
Accuracy for neutral (%)	98.2 (1.6)	98.9 (1.9)	98.2 (1.8)	*ns*
Accuracy for congruent (%)	98.4 (2.6)	98.5 (2.1)	98.3 (2.1)	*ns*
Accuracy for incongruent (%)	96.3 (3.4)	97.0 (3.4)	97.1 (3.4)	*ns*
Operation span task				
Operation span (1-60)	38.6 (7.8)	39.0 (7.4)	36.9 (9.1)	*ns*
RT on judgment (ms)	2141 (52.6)	2197 (266)	2192 (272)	*ns*
Errors on judgment (1-60)	8.8 (6.3)	8.6 (4.6)	10.0 (6.5)	*ns*

Note. Standard deviations are in parentheses.

Reanalysis of the Picture-Word Interference Data

The cross-experiment comparison has shown that the group of Spanish-English bilinguals in Experiment 2 was slightly different in the language proficiency and experience from those in Experiments 1 and 3 due to the inclusion of 12 L2 dominant Spanish-English bilinguals in Experiment 2. To ensure that we still obtain the same pattern of the results without these L2 dominant bilinguals, we reanalyzed the picture-word interference data on the semantic and phono-translation conditions in the kanji block, where we found differences between the Spanish-English and the Japanese-English bilinguals, without L2 dominant bilinguals.[1] A 2 (relation) x 2 (language group) mixed ANOVA was performed on the data from the semantic condition and the phono-translation condition in the kanji block separately. Similar to the original analysis in Chapter 4, the reanalysis revealed the interaction between relation and language group for both the semantic and phono-translation conditions [$F1(1, 62) = 5.15$, $MSE = 2823.80$, $p < .05$; $F1(1, 62) = 9.56$, $MSE = 3052.59$, $p < .01$, respectively], such that the Spanish-English bilinguals showed the semantic interference and the phono-translation facilitation [$F1(1, 27) = 4.20$, $MSE = 3117.64$, $p = .05$ for semantic; $F1(1, 27) = 11.05$, $MSE = 3320.78$, $p < .01$ for phono-translation], whereas the Japanese-English bilinguals did not demonstrate either of the effects [$F1(1, 35) = 1.06$, $MSE = 2597.12$, $p > .10$ for semantic; $F1 < 1$ for phono-translation]. These results indicate that the cross-language group difference observed in the original analyses on the picture-word interference data was

[1] The group of Japanese-English bilinguals in Experiment 2 had similar characteristics to the Japanese-English bilinguals in Experiments 1 and 3 despite the fact that four L2 dominant bilinguals were included in Experiment 2. However, the four L2 dominant Japanese-English bilinguals were also excluded from the reanalysis to apply the same criterion “L1 dominant” to both bilingual groups.

independent of the slight differences in language proficiency and backgrounds between the Spanish-English bilinguals in Experiment 2 and those in Experiments 1 and 3.

Unlike the original overall analysis, however, the main effect of language group was not significant [$F1(1, 62) = 2.61$, $MSE = 40385.53$, $p > .10$ for semantic; $F1 < 1$ for phono-translation], suggesting that the slower naming latencies for the Spanish-English bilinguals, which the original analysis in Chapter 4 showed, were due to the inclusion of the L2 dominant Spanish-English bilinguals. In other words, the L2 dominant Spanish-English bilinguals appear to have slowed down in naming pictures in their more proficient language L2 English when the distractor words were presented visually in their less proficient language L1 Spanish. We return to this issue of type of bilinguals in the section on the Weak Link vs. Competition Hypotheses in Chapter 7.

In sum, the comparisons of characteristics of bilinguals across experiments and the reanalysis of the picture-word interference data suggest that the participants in the three experiments in the present research had reasonably similar characteristics and the differential pattern of the results for each experiment was due to the demands of the task rather than the characteristics of participants.

CHAPTER 7

GENERAL DISCUSSION

Past research on bilingual production has been performed almost exclusively with bilinguals whose two languages share the same Roman alphabets such as Dutch-English, Spanish-English, Spanish-Catalan, and French-English. Little research has examined the consequences of different script bilingualism on production. Although it might seem that differences in the written lexical form might not influence the process of speech planning, recent research suggests that all lexical codes are active to some degree in both comprehension and production (e.g., Damian & Bowers, 2003; Tan & Perfetti, 1999; Ziegler et al., 2003). The primary goal of the present research was to determine whether language-specific differences, such as script, can modulate cross-language activation, the locus of language selection, and the manner of language/lexical selection during bilingual word production. To address this question, three production experiments (simple picture naming, picture-word interference, and language switching) compared the performance of Japanese-English bilinguals with that of Spanish-English bilinguals. A second goal of the present study was to assess the degree to which the nature of the linguistic environment (i.e., whether bilinguals find themselves in contexts that support one of their two languages more than the other), the level of language proficiency, and the availability of cognitive and attentional resources affects the ability to control the activation or inhibition of the unintended language. In this chapter, we first summarize the major findings of each of the experiments. We then consider the implications of the results for the models of lexical access in bilingual production reviewed in Chapter 1. Finally, we discuss a set of issues surrounding the interpretation of the effects of different-language scripts for activating lexical codes and for bilingualism more generally.

Summary of Findings

In Experiment 1, Spanish-English and Japanese-English bilinguals completed a simple picture naming task in L2, followed by in L1. The critical materials were pictures whose names were cognates or noncognate controls matched on lexical properties with the cognates. In Spanish and English, cognates can be similar both orthographically and phonologically. In Japanese and English, they can only be similar phonologically. The results showed that both bilingual groups produced significant cognate facilitation in the L2 and also in the L1. We replicated the results of Costa et al. (2000) for bilinguals whose two languages share the same Roman alphabets and extended the finding to bilinguals whose two languages differ in script. These results suggest that even when the bilingual's two languages do not share script, there is activation of the phonology of the nontarget language. In the absence of the written lexical form, both languages appeared to be activated to the level of phonology and script differences did not function as a language cue to reduce cross-language activation for the Japanese-English bilinguals.

In Experiment 2, a picture-word interference task was used to determine whether the degree of cross-language activation and the locus of language selection can be modulated by script when the task includes an overt written lexical form. In this experiment, Spanish-English and Japanese-English bilinguals named pictures in their L2 while ignoring visually presented distractor words in the L1. The distractor words were related to the picture's name in four ways: phonologically, semantically, phonologically through the translation, and as the translation equivalent itself. The pictures in this experiment were also divided into two sets according to whether the preferred Japanese name of the pictures is typically written in kana or kanji. The kanji pictures were paired with kanji distractors and the kana pictures with kana distractors for the Japanese bilingual group. Picture naming was blocked by script (kanji vs. kana). Although the distinction between kanji and kana applies only to Japanese, the same categorization of the materials was used for Spanish because there are correlated lexical properties of kana and kanji pictures (e.g., word frequency and age of acquisition) that are likely to affect performance more generally. Unlike Experiment 1, Spanish-English and Japanese-English bilinguals performed differently on the picture-word interference task in the presence of the written lexical form. Although there were some differences for the kana and kanji pictures that are likely attributable to frequency and/or familiarity, both bilingual groups showed phonological facilitation and translation facilitation, whereas only Spanish-English bilinguals demonstrated semantic interference and phono-translation facilitation. In other words, we replicated the results of previous bilingual picture-word interference studies (e.g., Costa & Caramazza, 1999; Costa et al., 2003; Costa et al., 1999; Hermans, 2000; Hermans et al., 1998) for bilinguals whose two languages share the same Roman alphabets, but not for bilinguals whose two languages differ in script. These results suggest that when the script is present in the task, different script bilinguals appear to exploit the perceptual information as a language cue to direct lexical access earlier than same script bilinguals.

In the final experiment, the language switching paradigm was used to investigate the process of inhibitory control and its consequences on word production in the L1 and

L2. In one task, bilinguals named pictures in which the written lexical form was absent and in the other task, they named words in which the written lexical form was overtly present. In both tasks, they were required to switch languages in alternation, every two trials. The picture naming task resembled the conditions of Experiment 1 but the pictures were not cognates and the mixed language conditions required that both languages be active. The word naming task resembled the conditions of Experiment 2 in that the script was perceptually present but unlike Experiment 2, in which the lexical form was a distractor to be ignored, in Experiment 3 attention to the lexical form was required because the word was named aloud. Like Experiment 2, the pictures in the language switching experiment were divided into two sets based on the properties of Japanese—kanji and kana. The picture naming and word naming tasks revealed a different pattern of the results for these two bilingual groups. In picture naming, the two bilingual groups were identical in L2 regardless of the type of blocks (kana/kanji), whereas in L1 they tended to differ in the magnitude of switch cost and in speed, depending on the type of blocks. Specifically, in the kana block, the Japanese-English bilinguals tended to show a greater switch cost in L1 than the Spanish-English bilinguals although this difference was not statistically significant. In the kanji block, the Japanese-English bilinguals were slower in L1 than the Spanish-English bilinguals. In word naming, however, the two bilingual groups were similar in L1 in the kana block but the Spanish-English bilinguals were faster in L2 than the Japanese-English bilinguals. On the other hand, in the kanji block, the Spanish-English bilinguals were faster both in L1 and in L2 than the Japanese-English bilinguals. These results suggest that the Japanese-English bilinguals suppress their L1 more strongly than the Spanish-English bilinguals and that the script difference between L1 and L2 influences reading and speaking differently.

In sum, we investigated the degree of cross-language activation, the locus and manner of language/lexical selection during word production with three different experimental paradigms by comparing the performance of Spanish-English bilinguals with that of Japanese-English bilinguals. These two bilinguals groups performed similarly when the script (a language cue) was absent in the task but differently when the script was present. The results of these experiments also suggest that even when same and different script bilinguals performed similarly in one language, the cost to the other language and the manner of language/lexical selection differed.

Implications for Models of Lexical Access in Bilingual Production

Models of lexical access in bilingual production are generally categorized into two theoretical camps: selective/language-specific vs. nonselective/language-nonspecific. Selectivity can be defined in terms of the flow of activation and the manner of lexical selection (see Table 7.1.).

Table 7.1.

Selectivity of Lexical Access in Bilingual Production

Activation	Lexical Selection
Selective: No cross-language activation	Language-specific: Only candidates in the intended language are considered
Nonselective: Cross-language activation	Language-specific: Only candidates in the intended language are considered
	Language-nonspecific: Candidates in both languages are considered

Flow of Activation

As to the flow of activation, past research examining the performance of bilinguals whose two languages share the same Roman alphabets concurs with the view of nonselective activation when production is in L2 or both in L1 and L2, which is the case for all the experiments in the present research. If lexical activation in bilingual word production is fundamentally selective, the intention to speak a word in one language should be sufficient to activate only lemmas in the intended language and thus there is no cross-language activation and language selection occurs at the conceptual level. In the present context, if different scripts functioned as a language cue to direct lexical access selectively, Japanese-English bilinguals should have been able to switch off the unintended language and there should have been no cross-language activation (the strong version of selective activation hypothesis). Another possibility is that although different scripts may not be sufficient to serve as a language cue that allows Japanese-English bilinguals to activate only the lemmas in the intended language, they may have reduced cross-language activation to allow earlier language selection (the weak version of selective or nonselective activation hypothesis). The alternative is that different scripts neither reduce cross-language activation nor allow early language selection (fully nonselective activation hypothesis).

What do the present results suggest? First, both Spanish-English and Japanese-English bilinguals showed cognate facilitation in the simple picture naming experiment (Experiment 1), a result that allows us to reject the strong version of the selective activation hypothesis. Second, in the picture-word interference experiment (Experiment 2), both bilingual groups showed phonological and translation facilitation, but only Spanish-English bilinguals demonstrated semantic interference and phono-translation facilitation, which also rejects the fully nonselective activation hypothesis. In the *General Discussion* of Chapter 4, we interpreted the presence of phonological facilitation but the absence of semantic interference and the presence of translation facilitation but the absence of phono-translation facilitation as early language selection. In Experiment 2, the bilinguals always named pictures in L2 while ignoring visually presented L1 distractors. Reading in L1 is skilled and automatic so that L1 phonology is activated as soon as bilinguals see the word, resulting in phonological facilitation. Unlike Spanish-English bilinguals, Japanese-English bilinguals appear to exploit the salient perceptual cue (script difference) to direct their attention to the target lexicon and to select the language of production before the semantic codes of the distractor word are activated. Therefore, the activation of semantics in L1 does not interfere lexical selection in L2. Likewise, lexical selection may have completed by the time when the phono-translation distractor spreads activation to the lexical node of the translation name of the picture. These results suggest that when the script itself is present in the task, the degree of cross-language activation is modulated and language selection occurs early, which supports the weak version of selective or nonselective activation hypothesis.

A question, then, arises in asking whether the language production mechanism in different script bilinguals is fundamentally selective or nonselective. Given the fact that there was cross-language activation all the way to the phonological level in the simple picture naming task, it would seem most parsimonious to assume that as previous research with the same script bilinguals has shown, the bilinguals whose two languages differ in script also engage the same mechanism for both languages but that when different scripts are perceptually available, that information can be exploited to minimize cross-language competition and thereby effectively select the language to speak more quickly.

Manner of Lexical Selection

Contrary to the evidence on the flow of activation, there is disagreement concerning the manner of lexical selection: language-specific vs. language-nonspecific. The language-specific view assumes that only lexical alternatives in the response language are considered for lexical selection (e.g., Costa et al., 1999). Therefore, even if there is cross-language activation, the activation of lexical candidates from the non-response language does not interfere lexical selection in the intended language. In contrast, the language-nonspecific view posits that all the activated lexical alternatives from both languages compete for selection (e.g., Hermans et al., 1998). Thus, the activation of the lexical alternatives in the non-response language influences lexical selection in the response language and the lexical nodes in the non-response language need to be inhibited or those in the response language need to reach a higher level of activation.

Unlike the flow of activation, one aspect of the data has been taken as evidence for the language-specific and another aspect for the language-nonspecific selection in past research with the picture-word interference paradigm. For example, Costa et al. (1999) argued that if lexical candidates are active in both languages but selection is restricted to the response language, then the translation distractor word should produce facilitation relative to the unrelated distractor word because only lexical alternatives in the response language are considered for selection and the translation distractor word activates not only the lexical node of the translation equivalent in the non-response language but also the lexical node in the response language through the conceptual representation of the distractor word. On the other hand, Hermans et al. (1998) demonstrated that when the distractor word was phonologically related to the picture's name in the non-response language, there was interference rather than facilitation. This result supports the language-nonspecific view such that there is activation of the lexical node of the translation of the picture's name and that the lexical node in the non-response language competes for selection.

In the present picture-word interference experiment (Experiment 2), the bilinguals named a picture in their L2 English while ignoring a visually presented distractor that was semantically or phonologically related to the picture's name in L2, the L1 translation equivalent, phonologically related to the L1 translation equivalent, or an unrelated control that was matched on lexical properties with the related distractor word. The Spanish-English bilinguals showed phonological, phono-translation, and translation facilitation and semantic interference, whereas the Japanese-English bilinguals revealed only phonological and translation facilitation. The pattern of the results for the Spanish-English bilinguals can support either the language-specific or the language-nonspecific selection. The semantic interference effect can be interpreted as the indication of cross-language competition, such that the semantically related distractor word in the non-response language and the name of the picture in the response language compete for selection. On the other hand, the phono-translation effect may be taken as evidence for language-specific selection. It is assumed that the phono-translation distractor, the distractor word that is phonologically related to the translation name of the picture, activates the translation equivalent of the picture name (i.e., the picture name in the non-response language) at the lemma level. Unlike Hermans et al. (1998), however, the phono-translation distractor induced facilitation rather than interference in the present experiment, suggesting that the picture name in the response language and the one in the non-response language are unlikely to be competing for selection (and see Costa, 2005 and Finkbeiner, Gollan et al., 2006).

In contrast, the pattern of the results for the Japanese-English bilinguals is more consistent with the language-specific selection view. Although phonological facilitation can be considered as cross-language activation at the phonological level, this interpretation is unlikely because there was no semantic interference in the present experiment. If the activation of the L1 phonology originated from the spreading activation from the conceptual and lexical levels, then the semantically related distractor word should have activated its lexical node and competed with the lexical nodes in the response language for selection. The observed phonological facilitation is probably due to the bottom-up activation of the L1 distractor word. The only other effect obtained for the Japanese-English bilinguals was translation facilitation. Although translation facilitation itself cannot be taken as evidence for either language-specific or language–nonspecific selection (Hermans 2004), the translation facilitation effects suggests that the name of the picture in the non-response language is active. Given the absence of semantic interference, however, it is less likely that the lexical candidates in the non-response language compete for selection in the case of Japanese-English bilinguals. If the phonological and translation facilitation is the indication of cross-language activation, then the selection mechanism is language-nonspecific for Japanese-English bilinguals.

The manner of selection has also been discussed in the language switching literature. The pattern of switch costs has been used to determine whether the selection mechanism is language-specific or language-nonspecific (e.g., Costa & Santesteban, 2004; Meuter & Allport, 1999). It has been assumed that the asymmetrical pattern of switch costs involves inhibition for lexical selection, whereas the symmetrical pattern of switch costs does not. The logic behind this distinction is that it is more difficult to suppress L1 than L2 because L1 is normally more active than L2. The greater suppression of L1 when speaking L2 then makes it harder to reactivate the L1 on the subsequent trial and produces an asymmetrical pattern of switch costs. According to this logic, the results of the language switching experiment (Experiment 3) in the present research suggest that the selection mechanism for both Spanish-English and Japanese-English bilinguals is language-specific (although there was a trend for the asymmetrical pattern of switch costs in the kana block of picture naming for the Japanese-English bilinguals). However, this does not necessarily mean that no inhibition was involved in the language switching tasks in the present research. It is clear that both the Spanish-English and the Japanese-English bilinguals in Experiment 3 were L1 dominant from the proficiency measures and from their performance on the word naming task (i.e., faster word naming latencies for L1 than for L2).[1] Nonetheless, these bilinguals were as slow to name pictures in L1 as in L2 under the mixed language conditions of the switching experiment. The Japanese-English bilinguals were even slower to name pictures in L1 than in L2 in the kanji block. These results suggest that their L1 was inhibited, regardless of the absence of an asymmetrical pattern, a result that is more consistent with selection following competition, the non-specific alternative.

Furthermore, the comparison between picture naming and word naming demonstrates that both bilingual groups showed the symmetrical pattern of switch costs regardless of whether the stimuli were bivalent (i.e., L1 and L2 names for a given object in picture naming) and univalent (i.e., one reading for a given string of letters/characters in word naming). Recently, Finkbeiner, Almeida et al. (2006) have shown that L2 learners produced asymmetrical switch costs when stimuli were bivalent, but they demonstrated no switch cost when stimuli were univalent. Based on past research on task switching showing no switch cost for univalent stimuli (e.g., Spector & Biederman, 1976; Allport, Styles, & Hsieh, 1994), Finkbeiner, Almeida et al. argue that the absence of switch costs for univalent stimuli in their language switching experiments reflects no inhibition involved in language switching. However, the word naming results of

---

[1] Reading words out loud is more automatized than naming pictures. Therefore, it is reasonable to assume that the language dominance becomes apparent in word naming.

Experiment 3 indicate that there were switch costs even in word naming in which stimuli were univalent. If the source of switch costs were simply due to reading two different scripts (e.g., Shafiullah & Monsell, 1999), then there should not have been switch costs for Spanish-English bilinguals because both of their languages use the same Roman alphabets. Although the present data on word naming cannot resolve the issue of whether inhibition is involved or not, the results suggest that the switch costs incurred in word naming result from the processes in involved in reading words in two languages.

In summary, the results of the present research suggest that for bilinguals whose two languages differ in script, there is nonselectivity with respect to the flow of information but that the presence of script cues can effectively direct attention to create language specificity. When different script bilinguals direct their attention to the target language early enough in the process of planning a spoken utterance, they may effectively cut off the flow of activation to the nontarget language. However, the results of the present research cannot determine whether Japanese-English bilinguals selectively attend to the target language or suppress the nontarget language earlier in the process of speech planning than Spanish-English bilinguals. In future research, it is important to systematically investigate the manner of selection for same and different script bilinguals.

One alternative that needs to be considered before concluding this section is a threshold model (Finkbeiner, Gollan, & Caramazza, 2006), which assumes that lexical alternatives in the nontarget language are further away from the selection criteria (threshold) and thus are rejected more easily than alternatives in the response language. The threshold model posits that the bilingual’s intention to speak in one language over the other activates the target language more strongly than the nontarget language and lexical candidates in the target language will reach the threshold for selection. The absence of semantic and phono-transalation effects for Japanese-English bilinguals in Experiment 2 could also be explained by the threshold account, such that the distinctive script does not meet a selection criterion and lexical alternatives in the nonresponse language will be rejected rapidly.

The Role of Orthography and Script in Production

In Chapter 2, we reviewed recent within-language research that has shown that orthography is active during production when the task includes the overt lexical form and that orthography modulates phonological processing during word production (e.g., Alario et al., in press; Damian & Bowers, 2003; Osborne et al., 2004; Roelofs, 2006). In line with these studies, the results of Experiments 1 and 2 suggest that script differences modulate cross-language activation during production when the written lexical form is perceptually available in one language. The distinctive script appears to serve as a language cue to selectively activate the lemmas in the target language or to selectively direct attention to the lemmas in the target language alone.

Furthermore, the present results suggest that orthography and script play different roles in production such that phonological processing is modulated by orthography, but not by script. Specifically, the Spanish-English bilinguals showed phonological facilitation in L2 only when the L1 phonologically related distractor words were also orthographically similar, but not when they were orthographically dissimilar. This finding is consistent with resonance models of word recognition that assume that all lexical codes (semantics, orthography, and phonology) are connected bi-directionally and modulate processing (Gottlob et al., 1999). The presence of different mappings between orthography to phonology in the two languages have been shown to affect reading performance (Schwartz et al., in press). The results of Experiment 2 for the Spanish-English bilinguals suggest that they also affect production. In contrast, the Japanese-English bilinguals showed phonological facilitation regardless of the fact that L1 and L2 never overlapped in script.

The question, then, arises in asking where the orthographic/script layer might be included in models of bilingual word production. The models described in Chapter 1 do not include orthography or script. Figure 7.1. shows a possible revised model of bilingual word production that incorporates the semantic-orthographic-phonological relations that have been proposed in models of bilingual word recognition (e.g., Dijkstra & Van Heuven, 2002).

An orthographic layer is now represented between the lemma and the phonological levels. Lemma, phonological, and orthographic representations are connected bi-directionally, which allows interactive activation among the three layers. This version of the model illustrates the case in which two languages share the same script. In this model, cross-language activation occurs at all three levels—lemma, orthographic, and phonological levels. A critical point is that not only phonology but also orthography is shared across two languages. Thus, when the mapping of orthography to phonology is mismatched, phonological activation is limited.[2]

[2] The present results did not show that when the orthography was mismatched across two languages, phonological activation was inhibited by mismatched orthography. Instead, the activation from orthography to phonology seemed limited.

In contrast, when two languages differ in script, there is no connection between L1 and L2 at the orthographic level, resulting in no modulation of phonological processing. Phonological activation is independent of script. In other words, phonological activation in one language will not be influenced by orthographic activation in the other language.

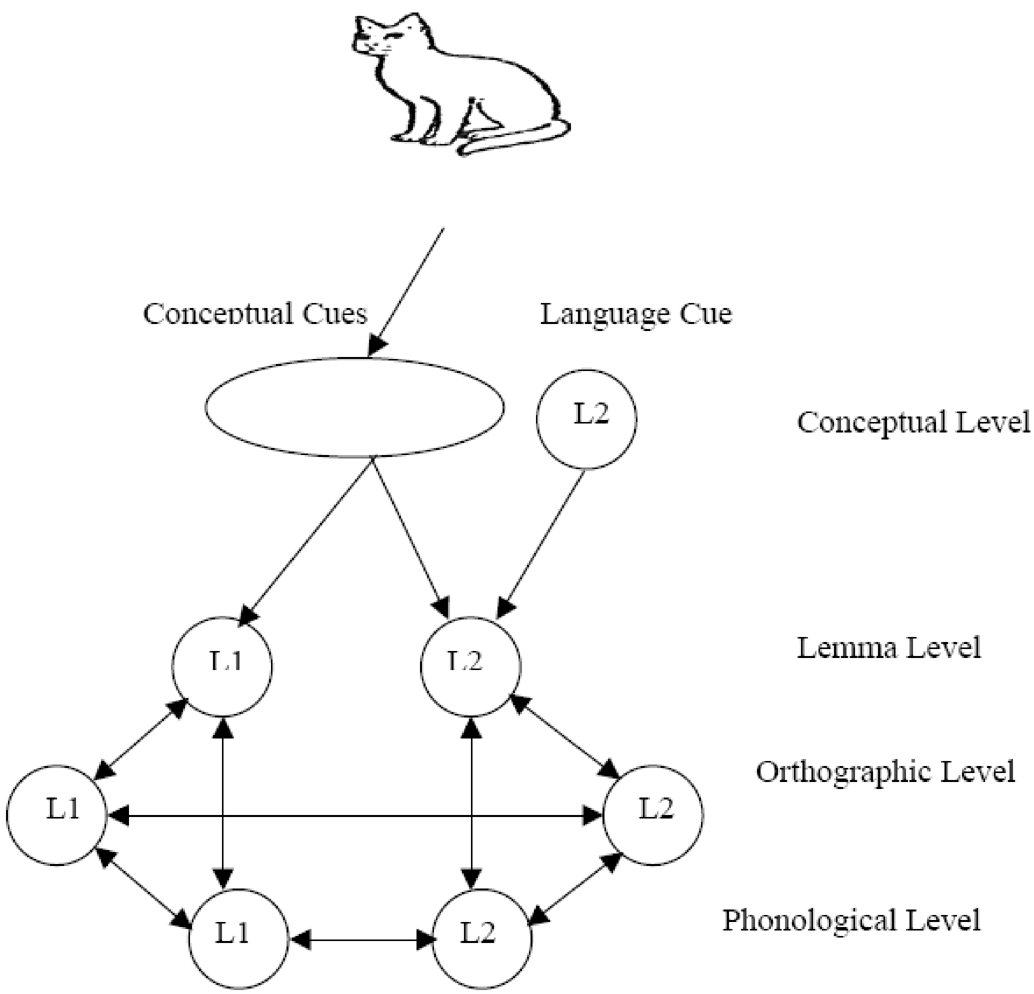


Figure 7.1. A possible revised model of bilingual word production.

Additional Considerations

Before concluding, we return to a set of issues raised earlier in the dissertation concerning the effects of the type of bilingualism and the consequences of different script bilingualism.

Weak Link vs. Competition Hypotheses

Some bilingual research reports bilingual disadvantages in language processing, assuming that processing costs to L1 reflects reduced availability of words in each language—the weak link hypothesis (e.g., Gollan & Acenas, 2004; Gollan, Montoya, & Werner, 2002; Gollan et al., 2006). According to the weak link hypothesis, bilinguals use each of their languages less frequently than monolingual counterparts so that connections among representations are weaker and the weak connections result in slower processing. The alternative competition hypothesis posits that processing costs to L1 are associated with the competition of lexical alternatives across two languages (Green, 1998; Wodniecka et al, 2005).

As we briefly discussed in Chapter 3, the research supporting the weak link hypothesis has been conducted primarily with L2 dominant early bilinguals who grew up in the United States and were educated predominantly in the L2 English. These bilinguals tend not to have the same lexical knowledge that monolinguals or even L1 dominant late bilinguals have, but their L2 is also not as proficient as the L1 of their monolingual counterparts. The majority of bilinguals tested in the present research were individuals who received at least primary and secondary education in L1 and who were highly proficient in L2 but still L1 dominant. When possible, the data from L2 dominant bilinguals were analyzed separately or excluded from the analyses. The results of post-hoc analyses in the simple picture naming experiment (Experiment 1) showed that highly proficient L1 dominant Spanish-English bilinguals performed similarly in their L1 Spanish to less proficient L1 dominant Spanish-English bilinguals. However, they were similar in their L2 English to L2 dominant Spanish-English bilinguals, who were similar to the bilinguals tested in past research (e.g., Gollan et al., 2006).

Furthermore, the reanalysis of the picture-word interference data presented above indicate that L2 dominant Spanish-English bilinguals were slow to name pictures even in their more proficient language, English, when their weak language was presented as a distractor word. These results suggest that the experience of education in L1 appear to make a difference in processing costs to L1 when bilinguals are immersed in the L2 environment. In other words, the weak link hypothesis appears to characterize L2 dominant early bilinguals, but not highly proficient L1 dominant late bilinguals.

Consequences of Different Script Bilingualism

Most bilingual research has been conducted with bilinguals whose two languages share the same Roman alphabets and little research has examined the consequences of a life experience of bilingualism with languages whose scripts differ. In the present research, the performance of Spanish-English bilinguals (the same script bilinguals) and that of Japanese-English bilinguals (different script bilinguals) was systematically compared on three different language production tasks and on a variety of proficiency measures and individual difference measures.

Linguistic consequences

As discussed earlier, the results of the present research suggest that the interaction between L1 and L2 orthography is limited to the case in which two languages share the same scripts, such as English and Spanish. This interaction incurs processing costs when mapping to phonology is inconsistent but imposes processing benefits when mapping to phonology is consistent. In contrast, the absence of the interaction between L1 and L2 orthography for the case in which two languages differ in script provides does not hurt phonological processing, but creates costs to mapping of orthography to phonology in L2 because the recognition of L2 script/orthography is less automatic for different script bilinguals than for the same script bilinguals. The disadvantage of different script bilingualism was reflected in the slower L2 word naming latencies in Experiment 3 and slower latencies and lower accuracy on the lexical decision task (although the differences were not statistically significant in many cases). The results of the present research suggest that even if different script bilinguals are equally proficient in speaking to the same script bilinguals, they are less likely to be as proficient in L2 reading as the same script bilinguals. An interesting question is whether this is a fixed difference that is imposed by the different structure of the L1 or whether with even higher proficiency, different script bilinguals eventually attain the same levels of L2 reading as same script bilinguals.

Cognitive consequences

Bilinguals have been shown to have better inhibitory control and more cognitive resources than monolingual controls (e.g., Bialystok, 2001; Bialystok et al., 2004; Kroll, Michael, Tokowicz, & Dufour, 2002). Only few studies have examined cognitive consequences of different script bilingualism (e.g., Bialystok, 1997; Bialystok, Shenfiled, & Codd, 2000). However, these studies primarily focused on bilingual children's understanding of concepts of print, not on adult bilinguals who acquired the L2 late.

The present research included the Simon task and the operation span task to match two bilingual groups on inhibitory control and cognitive resources. We reanalyzed the critical data when the two bilingual groups were not matched on these cognitive measures and demonstrated that the differential pattern of the results for the picture-word interference and language switching experiments was not due to differences in cognitive abilities. To the extent that speech production is initiated by the speaker's intention (top-down processing), it is surprising that there was no effect of individual differences in cognitive abilities on picture naming. However, the present research is not the first study showing little impact of individual differences in cognitive abilities on picture naming. Christoffels, De Groot, and Kroll (2006) also demonstrated that interpreters and language teachers whose L2 proficiency was similar did not differ in the performance of picture naming although the interpreters outperformed the teachers on working memory tasks. These findings suggest that the performance of picture naming is less constrained by cognitive abilities.

A further result of note is that, interestingly, the Japanese-English bilinguals showed a smaller Simon effect and a larger operation span than the Spanish-English bilinguals in the present research. A recent study on the Simon task suggests that the effects of bilingualism and the effects of playing video games need to be distinguished (Bialystok, 2006). Bialystok showed that video game players were faster not only on the incongruent condition but also on the congruent and neutral conditions, whereas bilinguals demonstrated an advantage specifically on the incongruent condition. Although the Japanese-English bilinguals were faster on the all the conditions than the Spanish-English bilinguals, the difference between these two bilingual groups tended to be larger for the incongruent condition, suggesting that a life experience of bilingualism with languages whose scripts differ appears to have a positive impact on inhibitory control.

Conclusions and Future Directions

The three experiments reported here indicate that the degree of cross-language activation, the locus of language selection, and the manner of lexical selection can be modulated by script differences depending upon the presence of the written lexical form and task demands. Both same and different script bilinguals showed cross-language activation all the way to phonology in a simple picture naming task in which the overt written script was absent (Experiment 1). In a picture-word interference task in which the written lexical form was overtly present, however, the degree of cross-language activation was reduced and performance appeared to be more language selective for the different script bilinguals than for the same script bilinguals (Experiment 2). A language switching experiment (Experiment 3) showed that processing costs to the L1 were greater for the different script bilinguals. Based on the pattern of these results, we have argued that the flow of activation and the manner of selection in the mechanism of language production are fundamentally nonselective and language-nonspecific. Language-specific differences such as script can serve as a language cue to allow the bilingual to direct lexical access selectively or to resolve cross-language competition early when those cues are perceptually available. The bilingualism with different script languages facilitates processing when orthography/script needs to be ignored. However, when the mapping of orthography to phonology is required such as in word naming, different script bilingualism incurs processing costs.

Although it was not feasible to manipulate SOA values in Experiment 2, it is critical to examine the time course of language/lexical selection as a function of type of bilingualism (same script vs. different script) in the future research, using methodologies that are sensitive to the time course of planning such as Event Related Potentials (ERPs). The investigation of the time course of selection will allow us to evaluate the manner of selection for different type of bilingualism. It is also important to investigate the relationship between production and comprehension. The present research suggests that an equal level of L2 proficiency in one skill does not necessarily predict L2 proficiency in another skill. Although it appears that script differences impose costs to the mapping of orthography to phonology in L2, but not to speaking, even for highly proficient bilinguals, the investigation of the relationship between production and comprehension will provide critical information, for models of how the bilingual's two languages interact with one another and for models of language processing more generally.

References

Alameda, J. R., & Cuetos, F. (1995). *Diccionario de frecuencias de las unidas de castellano*. Oviedo: Servicio de Publicaciones de la Universidad de Oviedo.

Alario, F. –X., Ferrand, L., Laganaro, M., New, B., Frauenfelder, U. H., & Segui, J. (2004). Predictors of Picture naming speed. *Behavior Research Methods, Instruments, and Computers, 36,* 140-155.

Alario, F. –X., Perre, L., Castel, C., & Ziegler, J. C. (in press). The role of orthography in speech production revisited. *Cognition.*

Allport, A., Styles, E. A., & Hsieh, S. (1994). Shifting intentional set: Exploring the dynamic control of tasks. In C. Umilta & M. Moscovitch (Eds.), *Attention and performance XV: Conscious and nonconscious information processing* (pp. 421-452). Hillsdale, NJ: Erlbaum.

Amano, S., & Kondo, T. (2000). *Nihongo no goi tokusei. [Lexical properties of Japanese]*. Tokyo: Sanseido.

Azuma, T., & Van Orden, G. C. (1997). Why safe is better than fast: The relatedness of a word's meanings affects lexical decision times. *Journal of Memory and Language, 36*, 484-504.

Baayen, R. H., Piepenbrock, R., & Gulikers, L. (1995). *The Celex Lexical Database.* Philadelphia, PA: Linguistic Data Consortium, University of Pennsylvania.

Balota, D. A., Cortese, M. J., Hutchison, K. A., Neely, J. H., Nelson, D., Simpson, G. B., & Treiman, R. (2002). *The English Lexicon Project: A web-based repository of descriptive and behavioral measures for 40,481 English words and nonwords.*

Bialystok, E. (1997). Effects of bilingualism and biliteracy on children's emerging concepts of print. *Developmental Psychology, 33,* 429-440.

Bialystok, E. (2001). *Bilingualism in development: Language, literacy, and cognition*. New York, NY: Cambridge University Press.

Bialystok, E. (2006). Effect of bilingualism and computer video game. *Canadian Journal of Experimental Psychology, 60,* 68-79.

Bialystok, E., Craik, F. I. M., Grandy, C., Chau, W., Ishii, R., Gunji, A., & Pantev, C. (2005). Effect of bilingualism on cognitive control in the Simon task: Evidence from MEG. *NeuroImage, 24,* 40-49.

Bialystok, E., Craik, F. I. M., Klein, R., & Viswanathan, M. (2004). Bilingualism, aging, and cognitive control: Evidence from the Simon Task. *Psychology and Aging, 19*, 290-303.

Bialysotk, E., Martin, & Viswanathan. (2005). Bilingualism across the lifespan: The rise and fall of inhibitory control. *International Journal of Bilingualism, 9,* 103-119.

Bialystok, E., Shenfield, T., & Codd, J. (2000). Languages, scripts, and the environment: factors in developing concepts of print. *Developmental Psychology, 36,* 66-76.

Bloem, I., & La Heij, W. (2003). Semantic facilitation and semantic interference in word translation: Implications for models of lexical access in language production. *Journal of Memory and Language*, *48*, 468-488.

Bloem, I., Van Der Boogaard, S., & La Heij, W. (2004). Sematnic facilitation and semantic interference in language production: Further evidence for the conceptual selection model of lexical access. *Journal of Memory and Language, 51,* 307-323.

Bock, K., & Levelt, W. (1994). Language production: Grammatical encoding. In M. A. Gernsbacher (Ed.), *Handbook of psycholinguistics* (pp. 945-984). San Diego, CA: Academic Press, Inc.

Caramazza, A. (1997). How many levels of processing are there in lexical access? *Cognitive Neuropsychology, 14,* 177-208.

Chen, H. -C., Yamauchi, T., Tamaoka, K., Vaid, J. (in press). Homophonic and semantic priming of Japanese kanji words: A time course study. *Psychonomic Bulletin and Review.*

Chéreau, C., Gaskell, M. G., & Dumay, N. (in press). Reading spoken words: Orthographic effects in auditory priming. *Cognition.*

Christoffels, I. K., De Groot, A. M. B., & Kroll, J. F. (2006). Memory and language skills in simultaneous interpreters: The role of expertise and language proficiency. *Journal of Memory and Language, 54,* 324-345.

Colomé, A. (2001). Lexical activation in bilinguals' speech production: Language-specific or language-independent? *Journal of Memory and Language, 45*, 721-736.

Coltheart, M. (1981). The MRC Psycholinguistic Database. *Quarterly Journal of Experimental Psychology, 33A,* 497-505.

Costa, A. (2005). Lexical access in bilingual production. In J. F. Kroll & A. M. B. De Groot (Eds.), *Handbook of bilingualism: Psycholinguistic approaches* (pp. 308-325). New York: Oxford University Press.

Costa, A., & Caramazza, A. (1999). Is lexical selection in bilingual speech production language-specific? Further evidence from Spanish-English and English-Spanish bilinguals. *Bilingualism: Language and Cognition, 2*, 231-244.

Costa, A., Caramazza, A., & Sebastián-Gallés, N. (2000). The cognate facilitation effect: Implications for models of lexical access. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 26*, 1283-1296.

Costa, A., Colomé, A., & Gómez, O., & Sebastián-Gallés, N. (2003). Another look at cross-language competition in bilingual speech production: Lexical and phonological factors. *Bilingualism: Language and Cognition, 6,* 167-179.

Costa, A., La Heij, W., & Navarrete, E. (2006). The dynamics of bilingual lexical access. *Bilingualism: Language and Cognition, 9,* 137-151.

Costa, A., Miozzo, M., & Caramazza, A. (1999). Lexical selection in bilinguals: Do words in the bilingual's two lexicons compete for selection? *Journal of Memory and Language, 41*, 365-397.

Costa, A., & Santesteban, M. (2004). Lexical access in bilingual speech production: Evidence from language switching in highly proficient bilinguals and L2 learners. *Journal of Memory and Language, 50*, 491-511.

Cuetos, F., Ellis, A. W., & Alvarez, B. (1999). Naming times for the Snodgrass and Vanderwart pictures in Spanish. *Behavior Research Methods, Instruments and Computers, 31*, 650-658.

Damian, M. F. (2003). Articulatory duration in single-word speech production. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 29*, 416-431.

Damian, M. F., & Bowers, J. S. (2003). Effects of orthography on speech production in a form-preparation paradigm. *Journal of Memory and Language, 49*, 119-132.

Damian, M. F., & Martin, R. C. (1999). Semantic and phonological codes interact in single word production. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 25*, 345-361.

Davis, C. J., & Perea, M. (2005). BuscaPalabras: A program for deriving orthographic and phonological neighborhood statistics and other psycholinguistic indices in Spanish. *Behavior Research Methods, Instruments, and Computers, 35,* 665-671.

De Bot, K. , & Schreuder, R. (1993). Word production and the bilingual lexicon. In R. Schreuder & B. Weltens (Eds.), *The bilingual lexicon* (pp. 191-214). Amsterdam/Philadelphia: John Benjamins.

Dell, G. S. (1986). A spreading-activation theory of retrieval in sentence production. *Psychological Review, 93*, 283-321.

Dell, G. S., Schwartz, M. F., Martin, N., Saffran E. M., & Gagnon, D. A. (1997). Lexical access in aphasic and nonaphasic speakers. *Psychological Review, 104,* 801-838.

Dijkstra, A., De Bruijn, E., Schriefers, H., & Ten Brinke, S. (2000). More on interlingual homograph recognition: Language intermixing versus explicitness of instruction. *Bilingualism: Language and Cognition, 3*, 69-78.

Dijkstra, A., & Van Heuven. (2002). The architecture of the bilingual word recognition system: From identification to decision. *Bilingualism: Language and Cognition, 5*, 175-197.

Dijkstra, A., Van Jaarsveld, H., & Ten Brinke, S. (1998). Interlingual homograph recognition: Effects of task demands and language intermixing. *Bilingualism: Language and Cognition, 1,* 51-66.

Donnenwerth-Nolan, S., Tanenhaus, M. K., & Seidenberg, M. S. (1981). Multiple code activation in word recognition: Evidence from rhyme monitoring. *Journal of experimental psychology: Human learning and memory, 7*, 170-180.

Ellis, A. W., & Morrison, C. M. (1998). Real age-of-acquisition effects in lexical retrieval. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 24,* 515-523.

Ferreira, V. S., & Pashler, H. (2002). Central bottleneck influences on processing stages of word production. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 28*, 1187-1199.

Finkbeiner, M., Almeida, J., Janssen, N., & Caramazza, A. (2006). Asymmetrical costs of language switching: Is this evidence of language suppression? *Journal of Experimental Psychology: Learning, Memory, and Cognition, 32,* 1075-1089.

Finkbeiner, M., Gollan, T. H., & Caramazza, A. (2006). Lexical access in bilingual speakers: What's the (hard) problem? *Bilingualism: Language and Cognition, 9,* 153-166.

Francis, W. S., Augustini, B. K., & Saenz, S. P. (2003). Repetition priming in picture naming and translation depends on shared processes and their difficulty. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 29, 1283-1297.*

Goldrick, M., & Blumstein, S. E. (2006). Cascading activation from phonological planning to articulatory processes: Evidence from tongue twisters. *Language and Cognitive Processes, 21,* 649-683.

Gollan, T.H. & Acenas, L.A. (2004). What is a TOT?: Cognate and translation effects on tip-of-the-tongue states in Spanish-English and Tagalog-English bilinguals. *Journal of Experimental Psychology: Learning, Memory, & Cognition,* 30, 246-269.

Gollan, T. H., Forster, K. I., & Frost, R. (1997). Translation priming with different scripts: Masked priming with cognates and noncognates in Hebrew-English bilinguals. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 23*, 1122-1139.

Gollan, T. H., Montoya, R. I., Fennema-Notestine, C., & Morris, S. K. (2005). Bilingualism affects picture naming but not picture classification. *Memory and Cognition, 33*, 1220-1234.

Gollan, T. H., Montoya, R. I., & Werner, G. A. (2002). Semantic and letter fluency in Spanish-English bilinguals. *Neuropsychology, 16,* 562-576.

Gottlob, L. R., Goldinger, S. D., Stone, G. O., & Van Orden, G. C., (1999). Reading homographs: Orthographic, phonologic, and semantic dynamics. *Journal of Experimental Psychology: Human Perception and Performance, 25*, 561-574.

Green, D. W. (1986). Control, activation and resource. *Brain and Language, 27,* 210-223.

Green, D. W. (1993). Towards a model of L2 comprehension and production. In R. Schreuder & B. Weltens (Eds.), *The bilingual lexicon* (pp. 249-277). Amsterdam/Philadelphia: John Benjamins.

Green, D. W. (1998). Mental control of the bilingual lexico-semantic system. *Bilingualism: Language and Cognition, 1*, 67-81.

Grosjean, F. (2001). The bilingual's language modes. In J. L. Nicol (Ed.), *One Mind, two languages: Bilingual language processing* (p. 49-71). Cambridge, MA: Blackwell Publishers.

Hasegawa, M., Carpenter, P. A., & Just, M. A. (2003). An fMRI study of bilingual sentence comprehenstion and workload. *NuroImage, 15,* 647-660.

Havelka, J., & Tomita, I. (2006). Age of acquisition in naming Japanese words. *Visual Cognition, 13,* 981-991.

Hermans, D. (2000). *Word production in a foreign language.* Unpublished doctoral dissertation, University of Nijmegen, Nijmegen, The Netherlands.

Hermans, D. (2004). Between-language identity effects in picture-word interference tasks: A challenge for language-nonspecific or language-specific models of lexical access? *International Journal of Bilingualism, 8,* 115-125.

Hermans, D., Bongaerts, T., De Bot, K., & Schreuder, R. (1998). Producing words in a foreign language: Can speakers prevent interference from their first language? *Bilingualism: Language and Cognition, 1*, 213-229.

Hernandez, A. E., & Reyes, I. (2002). Within- and between-language priming differ: Evidence from repetition of pictures in Spanish-English bilinguals. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 28,* 726-734.

Hoshino, N., Dussias, P. E., & Kroll, J. F. (in preparation-a). *Producing subject-verb agreement: Does L1 syntax influence L2 performance?*

Hoshino, N., Dussias, P. E., & Kroll, J. F. (in preparation-b). *The role of conceptual resources in guiding the production of subject-verb agreement.*

Huibregtse, I., Admiraal, W., & Meara, P. (2002). Scores on a yes-no vocabulary test: Correction for guessing and response style. *Language Testing, 19,* 227-245.

Ischebeck, A. K. (2004). *Processing phonographic and morphographic script: Similarities and differences.* Unpublished doctoral dissertation, University of Nijmegen, Nijmegen, The Netherlands.

Jacobs, A., Gerfen, C., & Kroll, J. F. (2005, March). *Planning and producing speech in L2: The activation of L1 affects production in L2*. Poster presented at the Fifth International Symposium on Bilingualism, Barcelona, Spain.

Jescheniak, J. D., & Schriefers, H. J. (1998). Serial versus cascaded processing in lexical access in language production: Further evidence from the coactivation of near-synonyms. *Journal of Experimental Psychology: Learning, Memory and Cognition, 24*, 1256-1274.

Jiang, N. (1999). Testing processing explanations for the asymmetry in masked cross-language priming. *Bilingualism: Language and Cognition, 2*, 59-75.

Kamide, Y., & Mitchell, D. C. (1999). Incremental pre-head attachment in Japanese parsing. *Language and Cognitive Processes, 14*, 631-662.

Kello, C. T., Plaut, D. C., & MacWhinney, B. (2000). The task-dependence of staged and cascaded processing: An empirical and computational study of Stroop interference in speech production. *Journal of Experimental Psychology: General, 129*, 340-360.

Kim, J., & Davis, C. (2003). Task effects in masked cross-script translation and phonological priming. *Journal of Memory and Language, 49*, 484-499.

Kotz, S. A., & Elston-Güttler, K. (2004). The role of proficiency on processing categorical and associative information in the L2 as revealed by reaction times and event-related brain potentials. *Journal of Neurolinguistics, 17*, 215-235.

Kroll, J. F., Bobb, S., & Wodniekca, Z. (2006). Language selectivity is the exception, not the rule: Arguments against a fixed locus of language selection in bilingual speech. *Bilingualism: Language and Cognition, 9,* 119-135.

Kroll, J. F., Dijkstra, A., Janssen, N., & Schriefers, H. (in preparation). *Selecting the language in which to speak: Cued-picture naming experiments on lexical access in bilingual production.* Unpublished manuscript, Pennsylvania State University, University Park, PA.

Kroll, J. F., Michael, E., Tokowicz, N., & Dufour, R. (2002). The development of lexical fluency in a second language. *Second Language Research, 18,* 137-171.

Kroll, J. F., & Stewart, E. (1994). Category interference in translation and picture naming: Evidence for asymmetric connections between bilingual memory representations. *Journal of Memory and Language, 33,* 149-174.

Kroll, J. F., Sumutka, B. M., & Schwartz, A. I. (2005). A cognitive view of the bilingual lexicon: Reading and speaking words in two languages. *International Journal of Bilingualism, 9,* 27-48.

Kučera, H., & Francis, W. N. (1967). *Computational analysis of present day American English.* Providence, RI: Brown University Press.

La Heij, W. (2005). Selection processes in monolingual and bilingual lexical access. In J. F. Kroll & A. M. B. De Groot (Eds), *Handbook of bilingualism: Psycholinguistic approaches* (pp. 289-307). New York: Oxford University Press.

La Heij, W., De Bruyn, E., Elens, E., Hartsuiker, R., & et al. (1990). Orthographic facilitation and categorical interference in a word-translation variant of the Stroop task. *Canadian Journal of Psychology, 44*, 76-83.

Levelt, W. J. M. (1989). *Speaking: Form intention to articulation*. Cambridge, MA: MIT Press.

Levelt, W. J. M., Roelofs, A., & Meyer, A. (1999). A theory of lexical access in speech production. *Behavioral and Brain Sciences, 22,* 1-75.

Levelt, W. J. M., Schriefers, H., Vorberg, D., Meyer, A. S., Pechnaatm, T., & Havinga, J. (1991). The time course of lexical access in speech production: A study of picture naming. *Psychological Review, 98,* 122-142.

Linck, J. (2005). *Language and cognitive processing in a study abroad context.* Unpublished master's thesis, Pennsylvania State University, University Park, PA.

Meuter, R. F. I., & Allport, A. (1999). Bilingual language switching in naming: Asymmetrical costs of language selection. *Journal of Memory and Language, 40*, 25-40.

Meuter, R. F. I., & Tan, C. (2003, April). *A comparative study of the role of language-specificity and language mode*. Paper presented at the 4th International Symposium on Bilingualism, Tempe, AZ.

Michael, E., & Gollan. T. H. (2005). Being and becoming bilingual: Individual differences and consequences for language production. In J. F. Kroll & A. M. B.

De Groot (Eds.), *Handbook of Bilingualism: Psycholinguistic Approaches* (pp. 389-407). New York: Oxford University Press.

Miller, N. A. (2001). *Language and lexical selection in Dutch/English bilinguals.* Unpublished doctoral dissertation, Pennsylvania State University, University Park, PA.

Miller, N. A., & Kroll, J. F. (2002). Stroop effects in bilingual translation. *Memory and Cognition, 30*, 614-628.

Miyake, A., Emerson, M. J., Padilla, F., & Ahn, J. (2004). Inner speech as a retrieval aid for task goals: The effect of cue type and articulatory suppression in the random task cuing paradigm. *Acta Psychologica, 115,* 123-142.

Miyake, A., & Friedman, N. P. (1998). Individual differences in second language proficiency: Working memory as language aptitude. In A. F. Healy & L. E. Bourne (Eds.), *Foreign language learning: Psycholinguistic studies on training and relation* (pp. 339-364). Mahwah, NJ: Lawrence Erlbaum Associates Publishers.

Nishimoto, T., Miyawaki, K., Ueda, T., Une, Y., & Takahashi, M. (2005). Japanese normative set of 359 pictures. *Behavior Research Methods, Instruments, and Computers, 37,* 398-416.

Osborne, G., Rastle, K., & Burke, D. (2004, November). *Phonological and orthographic effects on picture naming.* Poster presented at the 45th Annual Meeting of Psychonomic Society, Minneapolis, MN.

Peterson, R. R. & Savoy, P. (1998). Lexical selection and phonological encoding during language production: Evidence for cascaded processing. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 24*, 539-557.

Poulisse, N., & Bongaerts, T. (1994). Title first language use in second language production. *Applied Linguistics, 15*, 36-57.

Roelofs, A. (2006). The influence of spelling on phonological encoding in word reading, object naming, and word generation. *Psychonomic Bulletin and Review, 13,* 33-37.

Rogers, R. D., & Monsell, S. (1995). Costs of a predictable switch between simple cognitive tasks. *Journal of Experimental Psychology: General, 124*, 207-231.

Schriefers, H, Meyer, A.S., & Levelt, W. J. M. (1990). Exploring the time course of lexical access in language production: Picture-word interference studies. *Journal of Memory and Language, 29*, 86-102.

Schwartz, A. I., Kroll, J. F., & Diaz, M. (in press). Reading words in Spanish and English: Mapping orthography to phonology in two languages. *Language and Cognitive Processes.*

Shafiullah, M., & Monsell, S. (1999). The cost of switching between kanji and kana while reading Japanese. *Language and cognitive processes, 14,* 567-607.

Silverberg, S., & Samuel, A. G. (2004). The effects of age of acquisition and fluency on processing second language words: Translation or direct conceptual access? *Journal of Memory and Language, 51,* 381-398.

Snodgrass, J. G., & Vanderwart, M. (1980). A standardized set of 260 pictures: Norms for name agreement, image agreement, familiarity, and visual complexity. *Journal of Experimental Psychology: Human Learning and Memory, 6*, 174-215.

Snodgrass, J. G., & Yuditsky, T. (1996). Naming times for the Snodgrass and Vanderwart Pictures. *Behavior Research Methods, Instruments, and Computers, 28,* 516-536.

Spector, A., & Biederman, I. (1976). Mental set and mental shift revisited. *American Journal of Psychology, 89,* 669-679.

Starreveld, P. A., & La Heij, W. (1995). Semantic interference, orthographic facilitation and their interaction in naming tasks. *Journal of Experimental Psychology: Learning, Memory and Cognition, 21*, 685-698.

Starreveld, P. A., & La Heij, W. (1996). Time-course analysis of semantic and orthographic context effects in picture naming. *Journal of Experimental Psychology: Learning, Memory and Cognition, 22*, 896-918.

Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology, 18,* 643-662.

Székely, A., D'Amico, S., Devescovi, A., Federmeier, K., Herron, D., Iyer, G., et al. (2003). Timed picture naming: Extended norms and validation against previous studies. *Behavior Research Methods, Instruments, & Computers, 35,* 621-633.

Szekely, A., Jacobsen, T., D'Amico, S., Devescovi, A., Andonova, E., Herron, D., et al. (2004). A new on-line resource for psycholinguistic studies. *Journal of Memory and Language, 51,* 247-250.

Tan, L. H., & Perfetti, C. A. (1999). Phonological and associative inhibition in the early stages of English word identification: Evidence from backward masking. *Journal of Experimental Psychology: Human Learning and Memory, 25*, 59-69.

Tokowicz, N., Michael, E., & Kroll, J. F. (2004). The role of study-abroad experience and working-memory capacity in the types of errors made during translation. *Bilingualism: Language and Cognition, 7,* 255-272.

Turner, M. L., & Engle, R. W. (1989). Is working memory capacity task dependent? *Journal of Memory and Language, 28*, 127-154.

Van Orden, B. C. (1987). A ROWS is a ROSE: Spelling, sound and reading. *Memory and Cognition, 15*, 181-198.

Vitkocitch, M., Cooper-Pye, E., & Leadbetter, A. G. (2006). Semantic priming over unrelated trials: Evidence for different effects in word and picture naming. *Memory and Cognition, 34,* 715-725.

Wodniecka, Z., Bobb, S. C., Kroll, J. F., & Green, D. W. (2005, September). *Is the first language inhibited when speaking the second language? Evidence from a competitor priming paradigm*. Paper presented at the European Society for Cognitive Psychology, Leiden, The Netherlands.

Yamada, J. (1998). The time course of semantic and phonological access in naming kanji and kana words. *Reading and Writing, 10*, 425-437.

Ziegler, J. C., Muneaux, M., & Grainger, J. (2003). Neighborhood effects in auditory word recognition: Phonological competition and orthographic facilitation. *Journal of Memory and Language, 48*, 779-793.

APPENDIX A

Norming Experiments

To determine whether different scripts modulate the degree of cross-language activation and the manner and locus of selection, we compared the performance of Spanish-English bilinguals with that of Japanese-English bilinguals. To ensure that observed cross-language differences are due to script but not to differences in properties of materials in each language, we normed the phonological similarity of the materials for Experiments 1 and 2 and the semantic relatedness of the materials for Experiment 2.

Experiment A1: Phonological Similarity Ratings

The goal of the phonological similarity rating task was to determine how similar the English picture name was to its translation equivalent in Spanish/Japanese phonologically.

Method

Participants

Eighteen English monolinguals who had not studied Spanish and 25 English monolinguals who had not studied Japanese from The Pennsylvania State University participated in Experiment A1.

Materials

The names of 36 cognate and 36 noncognate pictures were recorded in the native language by the female native speakers of English, Spanish, and Japanese. The sound file of each picture name in Spanish or in Japanese was combined with that of its English equivalent. Therefore, each stimulus set consisted of 72 sound pairs. A pseudo-randomized list was created to ensure that no more than three items from the same condition were presented in a row.

Procedure

Participants were first given a brief language history questionnaire asking about native language, home languages, and foreign language learning. Based on their foreign language learning experience, we assigned the Spanish-English stimulus set to participants who had not studied Spanish before and the Japanese-English stimulus set to those who had not studied Japanese before. Once participants were assigned one of the stimulus sets, they received written and oral instructions. They were asked to click on each file of sound pairs and to rate sound pairs consisting of a Spanish word and its English translation or a Japanese word and its English translation respectively according to how similar two words sounded on a 7-point Likert scale with “1” being completely different and “7” being identical.

Results and Discussion

The mean rating for each sound pair was calculated and analyzed by condition. As shown in Table 3.3., monolingual English speakers perceived the phonological similarity of cognates to be greater than noncognates for the Spanish-English pairs [$t(11) = 9.07$, $p < .001$ for English, Spanish, and Japanese; $t(11) = 5.54$, $p < .001$ for English and Spanish; $t < 1$ for English and Japanese] and for the Japanese-English pairs [$t(11) = 10.61$, $p < .001$ for English, Spanish, and Japanese; $t < 1$ for English and Spanish; $t(11) = 8.12$, $p < .001$ for English and Japanese]. Furthermore, the similarity ratings for cognates in English, Spanish, and Japanese did not differ between the Spanish-English and the Japanese-English pairs [$t < 1$]. These results suggest that the phonological similarity was similar for each language pairs.

Experiment A2: Phonological Similarity Ratings

The goal of the phonological similarity rating task was to determine how similar the English picture name and its phonologically related or unrelated Spanish/Japanese distractor word were and how similar the Spanish/ Japanese picture name and its phonologically related or unrelated Spanish/Japanese distracotr word were.

Method

Participants

Fifteen English monolinguals who had not studied Spanish and 16 English monolinguals who had not studied Japanese from The Pennsylvania State University participated in Experiment A2.

Materials

The English names of 16 kanji and 16 kana pictures were recorded by a female native speaker of English. Likewise, 16 phonologically related distractors and their 16 unrelated controls and 16 phono-translation distractors and their unrelated controls were recorded in the native language by the female native speakers of Spanish and Japanese. The sound file of each distractor word in Spanish or in Japanese was combined with that of the target English picture name or the target Spanish/Japanese picture name. A set of English-Spanish/Japanese sound pairs and a set of Spanish-Spanish or Japanese-Japanese sound pairs were created. Each stimulus set consisted of 64 sound pairs. A pseudo-randomized list was created to ensure that no more than three items from the same condition were presented in a row.

Procedure

Participants were first given a brief language history questionnaire asking about native language, home languages, and foreign language learning. Based on their foreign language learning experience, we assigned the English-Spanish and Spanish-Spanish stimulus sets to participants who had not studied Spanish before and the English-Japanese and Japanese-Japanese stimulus sets to those who had not studied Japanese before. Once participants were assigned these stimulus sets, they received written and oral instructions. They were asked to click on each file of sound pairs and to rate sound pairs consisting of an English word and a Spanish/Japanese word or a Spanish/Japanese word and another Spanish/Japanese word according to how similar two words sounded on a 7-point Likert scale with "1" being completely different and "7" being identical. All the participants first received the English-Spanish or English-Japanese stimulus set, followed by the Spanish-Spanish or Japanese-Japanese stimulus set.

Results and Discussion

The mean rating for each sound pair was calculated and analyzed by script and condition. As shown in Table 4.5., monolingual English speakers perceived the phonological similarity of related pairs to be greater than unrelated pairs for kanji [$t(15) = 7.61$, $p < .001$ for English-Spanish pairs; $t(15) = 11.25$, $p < .001$ for English-Japanese pairs; $t(15) = 17.68$, $p < .001$ for Spanish-Spanish pairs; $t(15) = 14.31$, $p < .001$ for Japanese-Japanese pairs] and for kana [$t(15) = 6.12$, $p < .001$ for English-Spanish pairs; $t(15) = 13.30$, $p < .001$ for English-Japanese pairs; $t(15) = 14.27$, $p < .001$ for Spanish-Spanish pairs; $t(15) = 9.49$, $p < .001$ for Japanese-Japanese pairs].

Although the care was taken to ensure that phonological similarity would be similar across language groups, the English names of kanji pictures and their phonologically related Japanese distractors were rated as more similar than those of the English names of kanji pictures and their phonologically related Spanish distractors [$F2(1, 15) = 9.74$, $MSE = .975$, $p < .01$]. However, it is important to note that if this difference in phonological similarity of kanji items influences bilingual performance, then Japanese-English bilinguals should show a greater phonological facilitation than Spanish-English bilinguals.

Experiment A3: Semantic Relatedness Ratings

The goal of the semantic relatedness rating task was to determine how similar the picture name and its semantically related or unrelated distractor word were in meanings.

Method

Participants

Fourteen English monolinguals from The Pennsylvania State University participated in Experiment A3.

Materials

The semantically related and unrelated distractor words in Spanish and Japanese were first translated into English and then paired with their target picture. Because we used the same semantically related distractor words for both Spanish-English and Japanese-English bilingual groups, the total number of word pairs was 96. A pseudo-randomized list was created to ensure that no more than three items from the same condition were presented in a row.

Procedure

Participants first received written and oral instructions. They were asked to rate word pairs consisting of the English name of the picture and the English translation of a semantically related/unrelated distractor word in Spanish or in Japanese according to how similar two words were in meaning on a 7-point Likert scale with “1” being completely different and “7” being identical.

Results and Discussion

The mean rating for each sound pair was calculated and analyzed by script and condition. As shown in Table 4.5., semantically related items were rated as more similar than semantically unrelated items for kanji [$t(15) = 8.84$, $p < .001$ for Spanish; $t(15) = 15.64$, $p < .001$ for Japanese] and for kana [$t(15) = 10.07$, $p < .001$ for Spanish; $t(15) = 10.19$, $p < .001$ for Japanese].

Experiment A4: Phonological Similarity Ratings by Bilinguals

To determine whether bilinguals also perceived the phonological similarity of items similarly to the monolinguals in Experiment A2, the same phonological similarity rating task was given to the bilinguals who participated in Experiment 2.

Method

Participants

Thirty-nine Spanish-English bilinguals and 40 Japanese-English bilinguals from Experiment 2 completed the phonological similarity rating task.

Materials

The materials were identical to Experiment A2.

Procedure

The phonological similarity rating task was given to the participants at the end of Experiment 2. The Spanish-English bilinguals performed the English-Spanish and Spanish-Spanish sets, whereas the Japanese-English bilinguals performed the English-Japanese and Japanese-Japanese sets. The procedure for the rating task was identical to Experiment A2.

Results and Discussion

The mean rating for each sound pair was calculated and analyzed by script and condition (see Table A.1.).

Table A.1.

Phonological Similarity Ratings by Spanish-English and Japanese-English Bilinguals

		Spanish-English bilinguals		Japanese-English bilinguals	
Script	Type of Distractor	Related	Unrelated	Related	Unrelated
Kanji	Phonological	4.4 (0.9)	1.3 (0.2)	4.7 (0.6)	1.4 (0.1)
	Phono-translation	5.0 (0.4)	1.4 (0.5)	5.2 (0.4)	1.3 (0.1)
Kana	Phonological	4.1 (1.0)	1.2 (0.2)	4.5 (0.5)	1.4 (0.1)
	Phono-translation	5.0 (0.4)	1.4 (0.3)	5.1 (0.5)	1.4 (0.3)

Note. Standard deviations are in parentheses.

Both Spanish-English and Japanese-English bilinguals perceived the phonological similarity of related pairs to be greater than unrelated pairs for kanji [$t(15) = 13.46$, $p < .001$ for English-Spanish pairs; $t(15) = 22.60$, $p < .001$ for English-Japanese pairs; $t(15) = 20.29$, $p < .001$ for Spanish-Spanish pairs; $t(15) = 40.62$, $p < .001$ for Japanese-Japanese pairs] and for kana [$t(15) = 11.79$, $p < .001$ for English-Spanish pairs; $t(15) = 22.62$, $p < .001$ for English-Japanese pairs; $t(15) = 30.99$, $p < .001$ for Spanish-Spanish pairs; $t(15) = 24.18$, $p < .001$ for Japanese-Japanese pairs].

APPENDIX B

ADDITIONAL ANALYSES ON LEXICAL DECISION DATA

A lexical decision task in English was included in all the experiments as an on-line proficiency measure. As we described in Chapter 2, the materials for the lexical decision task were taken from an experiment performed by Azuma and Van Orden (1997) using 56 English words and 56 English pseudo-homophones. The words varied in number of meanings (few, many) and relatedness of word meanings (low, high). If a word had four or less meanings, Azuma and Van Orden classified it as *few*. If a word had six or more meanings, it was classified as many. For relatedness, words with relatedness scores < 3.0 from Azuma and Van Orden's norming study were classified as *low*, whereas words with relatedness scores > 3.5 were classified as *high*. In short, four types of words were included: 14 words with few meanings and low relatedness (e.g., *bank*), 14 words with few meanings and high relatedness (e.g., *card*), 14 words with many meanings and low relatedness (e.g., *sound*), and 14 words with many meanings and high relatedness (e.g., *cover*). All nonwords were pseudo-homophones, nonwords that sound like real words (e.g., panzy). Although we did not analyze the word data including number of meanings and relatedness of word meanings as independent variables because the lexical decision task was not a main task in the present study, we report the complete statistical analyses on the word data from each of the three experiments below.

Experiment 1

A 2 x 2 x 2 mixed analysis of variance (ANOVA) was conducted on latencies and accuracy for words, with meanings (few/many) and relatedness (low/high) as within-participants variables and language group (Spanish-English bilingual/Japanese-English bilingual) as a between-participants variable.

Latencies

The analysis revealed a main effect of meaning [$F(1, 60) = 8.63$, $MSE = 3145.37$, $p < .01$] with faster latencies for words with few meanings than for words with many meanings and a main effect of relatedness [$F(1, 60) = 12.89$, $MSE = 3504.73$, $p < .01$] indicating that the bilinguals recognized the word faster when the meanings of the word were highly related than when they were less related. More importantly, the interaction between meaning and relatedness was significant [$F(1, 60) = 7.28$, $MSE = 2453.92$, $p < .01$], such that as shown in Table B.1., the relatedness mattered only when the word had many meanings [$F(1, 61) = 14.80$, $MSE = 3608.07$, $p < .001$], but not when the word had few meanings [$F(1, 61) = 1.50$, $MSE = 2521.45$, $p > .10$]. Although the main effect of language group was not significant [$F(1, 60) = 2.77$, $MSE = 117035.28$, $p > .10$] or interacted with meaning or relatedness [$F(1, 60) = 1.73$, $MSE = 3145.37$, $p > .10$ for meaning; $F < 1$ for relatedness], the three-way interaction was reliable [$F(1, 60) = 5.35$, $MSE = 2453.92$, $p < .05$]. To further examine the three-way interaction, a 2 (meaning) x 2 (relatedness) ANOVA was conducted for each language group. The analysis for Spanish-English bilinguals revealed a main effect of meaning [$F(1, 34) = 17.99$, $MSE = 1815.26$, $p < .001$] and a main effect of relatedness [$F(1, 34) = 6.62$, $MSE = 2095.81$, $p < .05$], but no interaction between meaning and relatedness [$F < 1$]. In other words, Spanish-English bilinguals were faster for highly related items regardless of number of meanings. In contrast, the analysis for Japanese-English bilinguals revealed a main effect of relatedness [$F(1, 26) = 6.02$, $MSE = 5347.16$, $p < .05$] but no main effect of meaning [$F < 1$]. Critically, the interaction between meaning and relatedness was significant [$F(1, 26) = 7.88$, $MSE = 3460.54$, $p < .01$], such that Japanese-English bilinguals were faster for highly related items than for less related items only when the items had more meanings [$F(1, 26) = 11.22$, $MSE = 5293.64$, $p < .01$], but not when the items had fewer meanings [$F < 1$].

Table B.1.

Mean L2 Lexical Decision Latencies as a Function of Number of Meanings, Relatedness, and Language Group for Experiment 1

	Few meanings		Many meanings	
Language group	High	Low	High	Low
Spanish-English	675 (129)	692 (127)	703 (138)	725 (156)
Japanese-English	765 (206)	767 (220)	744 (195)	811 (156)

Note. Standard deviations are in parentheses.

Accuracy

The main effect of meaning was significant [$F(1, 60) = 12.78$, $MSE = 38.76$, $p < .01$], showing that the bilinguals were more accurate for words with few meanings than for words with many meanings. The main effect of relatedness or language group was not reliable [*F*s < 1]. However, the interaction between relatedness and language group was significant [$F(1, 60) = 4.43$, $MSE = 33.22$, $p < .05$], such that as illustrated in Table B.2., Spanish-English bilinguals were more accurate than Japanese-English bilinguals when the meanings of the word were less related [$F(1, 60) = 5.00$, $MSE = 18.13$, $p < .05$], but they did not differ when the meanings of the word were highly related [$F < 1$]. All the other interactions were not significant [$F(1, 60) = 2.01$, $MSE = 38.76$, $p > .10$ for the interaction between meaning and language group; $F(1, 60) = 75.76$, $MSE = 1.61$, $p > .10$ for the interaction between meaning and relatedness; $F < 1$ for the three-way interaction].

Table B.2.

Mean L2 Lexical Decision Accuracy as a Function of Number of Meanings, Relatedness, and Language Group for Experiment 1

	Few meanings		Many meanings	
Language group	High	Low	High	Low
Spanish-English	95.5 (5.5)	97.1 (4.3)	92.0 (7.9)	92.7 (6.1)
Japanese-English	94.4 (6.7)	94.2 (6.3)	94.4 (6.7)	90.7 (7.7)

Note. Standard deviations are in parentheses.

Experiment 2

A 2 x 2 x 2 mixed analysis of variance (ANOVA) was conducted on latencies and accuracy for words, with meanings (few/many) and relatedness (low/high) as within-participants variables and language group (Spanish-English bilingual/Japanese-English bilingual) as a between-participants variable.

Latencies

The analysis revealed a main effect of relatedness [$F(1, 78) = 7.34$, $MSE = 3148.57$, $p < .01$], indicating that the bilinguals recognized the word faster when the meanings of the word were highly related than when they were less related. More importantly, the main effect of relatedness was qualified by the significant interaction between meaning [$F(1, 78) = 5.44$, $MSE = 2518.74$, $p < .05$]. As shown in Table B.3., the relatedness mattered only when the word had many meanings [$F(1, 79) = 11.91$, $MSE = 3037.02$, $p < .01$], but not when the word had few meanings [$F < 1$]. There was no other main effect or interaction [$F(1, 78) = 1.87$, $MSE = 5474.00$, $p > .10$ for meaning; $F(1, 78) = 2.31$, $MSE = 86589.08$, $p > .10$ for language group; $F(1, 78) = 1.86$, $MSE = 3148.57$, $p > .10$ for the interaction between relatedness and language group; all the other Fs < 1].

Table B.3.

Mean L2 Lexical Decision Latencies as a Function of Number of Meanings, Relatedness, and Language Group for Experiment 2

	Few meanings		Many meanings	
Language group	High	Low	High	Low
Spanish-English	675 (123)	675 (122)	678 (115)	694 (130)
Japanese-English	721 (188)	729 (189)	714 (168)	758 (190)

Note. Standard deviations are in parentheses.

Accuracy

The main effect of relatedness was significant [$F(1, 78) = 4.97$, $MSE = 39.28$, $p < .05$] with higher accuracy for high related items than for less related items. The main effect of meaning also approached significance [$F(1, 78) = 3.09$, $MSE = 49.54$, $p = .08$], showing that the bilinguals were more accurate for words with few meanings than for words with many meanings (see Table B.4.). However, the main effect of language group was not reliable [$F < 1$]. There was no significant interaction [$F(1, 78) = 1.00$, $MSE = 45.93$, $p > .10$ for the three-way interaction; *F*s < 1 for all the other interactions].

Table B.4.

Mean L2 Lexical Decision Accuracy as a Function of Number of Meanings, Relatedness, and Language Group for Experiment 2

	Few meanings		Many meanings	
Language group	High	Low	High	Low
Spanish-English	96.3 (5.8)	94.1 (5.6)	93.2 (6.0)	93.2 (7.9)
Japanese-English	94.8 (7.0)	93.2 (6.5)	94.5 (6.6)	92.0 (7.8)

Note. Standard deviations are in parentheses.

Experiment 3

A 2 x 2 x 2 mixed analysis of variance (ANOVA) was conducted on latencies and accuracy for words, with meanings (few/many) and relatedness (low/high) as within-participants variables and language group (Spanish-English bilingual/Japanese-English bilingual) as a between-participants variable.

Latencies

The analysis revealed a main effect of meaning [$F(1, 35) = 5.94$, $MSE = 3782.05$, $p < .05$] with faster latencies for words with few meanings than for words with many meanings and a main effect of language group [$F(1, 35) = 6.25$, $MSE = 94629.83$, $p < .05$] indicating that Spanish-English bilinguals were faster than Japanese-English bilinguals. The main effect of relatedness or any two-way interaction was not reliable [*F*s < 1]. More importantly, the three-way interaction was significant [$F(1, 35) = 4.50$, $MSE = 4902.71$, $p < .05$]. To further examine the three-way interaction, a 2 (meaning) x 2 (relatedness) ANOVA was conducted for each language group. The analysis for Spanish-English bilinguals revealed no main effect [$F(1, 18) = 2.05$, $MSE = 3463.29$, $p > .10$ for meaning; $F < 1$ for relatedness] but a marginally significant interaction between meaning and relatedness [$F(1, 18) = 4.16$, $MSE = 978.30$, $p = .06$]. Specifically, as can be seen in Table B.5., Spanish-English bilinguals were faster for words with few meanings than for words with many meanings only when the meanings were highly related [$F(1, 18) = 3.82$, $MSE = 2869.59$, $p = .07$], but not when the meanings were less related [$F < 1$]. In contrast, the analysis for Japanese-English bilinguals revealed only a marginally significant main effect of meaning [$F(1, 17) = 3.94$, $MSE = 4119.57$, $p = .06$]. In other words, Japanese-English bilinguals were faster for words with few meanings than for words with many meanings regardless the relatedness of the meanings.

Table B.5.

Mean L2 Lexical Decision Latencies as a Function of Number of Meanings, Relatedness, and Language Group for Experiment 3

	Few meanings		Many meanings	
Language group	High	Low	High	Low
Spanish-English	649 (94)	670 (126)	683 (134)	675 (144)
Japanese-English	793 (208)	770 (165)	788 (174)	834 (229)

Note. Standard deviations are in parentheses.

Accuracy

The analysis revealed only the interaction between meaning and language group [$F(1, 35) = 6.19$, $MSE = 46.08$, $p < .05$], such that as shown in Table B.6., Spanish-English bilinguals were more accurate than Japanese-English bilinguals for words with few meanings [$F(1, 35) = 10.38$, $MSE = 20.01$, $p < .01$], but they did not differ for words with many meanings [$F < 1$].

Table B.6.

Mean L2 Lexical Decision Accuracy as a Function of Number of Meanings, Relatedness, and Language Group for Experiment 3

	Few meanings		Many meanings	
Language group	High	Low	High	Low
Spanish-English	96.2 (6.9)	97.4 (5.4)	93.6 (6.7)	92.9 (8.9)
Japanese-English	94.0 (6.6)	90.1 (7.8)	94.8 (6.4)	93.3 (8.3)

Note. Standard deviations are in parentheses.

APPENDIX C

ADDITIONAL ANALYSES FOR EXPERIMENT 1

A 2 (language: L1/L2) x 2 (cognate status: cognate/noncognate) x 3 (type of bilinguals: less proficient L1 dominant/more proficient L1 dominant/L2 dominant) mixed ANOVA was performed with language and cognate status as within-participants variables and type of bilinguals as a between-participants variable on the latency and accuracy data. The analysis on the latency data revealed a significant main effect of cognate status [$F(1, 22) = 51.43$, $MSE = 8197.72$, $p < .001$] and a marginally significant main effect of type of bilinguals [$F(2, 22) = 2.74$, $MSE = 91748.98$, $p = .09$] but no main effect of language [$F(1, 22) = 1.68$, $MSE = 16076. 15$, $p > .10$]. The interaction between language and cognate status was reliable [$F(1, 22) = 6.28$, $MSE = 7706.54$, $p < .05$], but the interaction between type of bilinguals and cognate status was not reliable [$F < 1$]. Importantly, the interaction between language and type of bilinguals was significant [$F(2, 22) = 39.81$, $MSE = 16076. 15$, $p < .001$], such that as illustrated in Figure 3.15., L2 dominant bilinguals were faster in L2 than in L1 [$t(6) = 4.68$, $p < .01$], whereas less proficient L1 dominant bilinguals were faster in L1 than in L2 [$t(8) = 8.35$, $p < .001$]. However, there was no difference between L1 and L2 for more proficient L1 dominant bilinguals [$t < 1$]. The three-way interaction was also significant [$F(2, 22) = 4.06$, $MSE = 7706.54$, $p < .05$]. Follow-up tests with Bonferroni corrections demonstrate that less proficient L1 dominant bilinguals showed significant cognate facilitation both in L1 and in L2 [$t(8) = 4.70$, $p < .01$ for L1; $t(8) = 5.42$, $p < .01$ for L2], whereas more proficient L1 dominant bilinguals and L2 dominant bilinguals showed cognate facilitation only in L1 [$t(8) = 3.45$, $p < .05$ for more proficient L1 dominant bilinguals in L1; $t(6) = 2.94$, $p = .08$

for L2 dominant bilinguals in L1; $t(8) = 2.16$, $p > .10$ for more proficient L1 dominant bilinguals in L2; $t(6) = 1.92$, $p > .10$ for L2 dominant bilinguals in L2].

The 2 (language) x 2 (cognate status) x 3 (type of bilinguals) mixed ANOVA on the accuracy data revealed the main effects of language, cognate status, and type of bilinguals [$F(1, 22) = 19.47$, $MSE = 73.00$, $p < .001$; $F(1, 22) = 48.27$, $MSE = 76.99$, $p < .001$; $F(2, 22) = 5.02$, $MSE = 169.49$, $p < .05$, respectively]. There was no interaction between cognate status and type of bilinguals or between language and cognate status [$F < 1$; $F(1, 22) = 2.55$, $MSE = 49.31$, $p > .10$, respectively]. Critically, the interaction between language and type of bilinguals was significant [$F(2, 22) = 42.44$, $MSE = 73.00$, $p < .001$]. As can be seen in Figure 3.16., L2 dominant bilinguals were less accurate in L1 than in L2 [$t(6) = 7.47$, $p < .001$], whereas either group of L1 dominant bilinguals did not show such a difference [$t(8) = 2.10$, $p > .10$ for less proficient L1 dominant bilinguals; $t(8) = 1.02$, $p > .10$ for more proficient L1 dominant bilinguals]. The three-way interaction was also significant [$F(2, 22) = 8.68$, $MSE = 49.31$, $p < .01$]. A series of follow-up tests with Bonferroni corrections indicate that more proficient L1 dominant bilinguals showed cognate facilitation both in L1 and in L2 [$t(8) = 4.97$, $p < .01$ for L1; $t(8) = 4.17$, $p < .01$ for L2], whereas L2 dominant bilinguals showed the cognate effect only in L1 [$t(6) = 4.92$, $p < .01$ for L1; $t(6) = 1.66$, $p > .10$ for L2]. Less proficient L1 dominant bilinguals did not show cognate facilitation in either language [$t(8) = 2.04$, $p > .10$ for L1; $t(8) = 2.26$, $p > .10$ for L2].

APPENDIX D

PICTURE STIMULI USED IN EXPERIMENT 1

Cognate in English, Spanish, & Japanese						Noncognate control					
English	Spanish	P	O	Japanese	P	English	Spanish	P	O	Japanese	P
asparagus	espárrago	4.82	139	アスパラガス a.su.pa.ra.ga.su	4.35	airplane	avión	3.06	347	飛行機 hi.ko.u.ki	1.00
flute	flauta	3.94	566	フルート fu.ru.u.to	2.54	fly	mosca	1.41	30	ハエ ha.e	1.88
guitar	guitarra	5.06	750	ギター gi.ta.a	4.88	glasses	gafas	3.82	636	眼鏡 me.ga.ne	1.27
kangaroo	kanguro	4.18	774	カンガルー ka.n.ga.ru.u	5.73	kettle	tetera	2.06	250	やかん ya.ka.n	1.31
lemon	limón	5.82	560	レモン re.mo.n	6	ladder	escalera	2.24	123	はしご ha.shi.go	1.04
lion	león	3	550	ライオン ra.i.o.n	4.92	leaf	hoja	1.35	75	葉 ha	1.08
piano	piano	6.29	1000	ピアノ pi.a.no	6.46	pig	cerdo	1.53	30	豚 bu.ta	1.77
robot	robot	4.59	1120	ロボット ro.bo.t.to	4.58	raccoon	mapache	1.76	164	タヌキ ta.nu.ki	1.35

Cognate in English, Spanish, & Japanese						Noncognate control					
English	Spanish	P	O	Japanese	P	English	Spanish	P	O	Japanese	P
sandwich	sandwích	6.12	813	サンドイッチ sa.n.do.i.t.chi	3.85	scissors	tijeras	2.29	237	はさみ ha.sa.mi	1.15
skis	esquís	5.82	253	スキー su.ki.i	6.19	snail	caracol	1.41	232	カタツムリ ka.ta.tsu.mu.ri	1.08
tomato	tomate	4.59	837	トマト to.ma.to	4.62	tail	cola	1.65	100	しっぽ shi.p.po	1.12
violin	violín	4.71	850	バイオリン ba.i.o.ri.n	5.27	vase	jarrón	1.35	53	壺 tsu.bo	1.15

Notes. P refers to the mean phonological similarity ratings from the norming experiment with English monolinguals (See Appendix A1 for details). O refers to orthographic/graphemic similarity computed with the algorithm described by Van Orden (1987). Japanese picture names are written in a preferred script based on frequency (Amano & Kondo, 2000) and their readings given here follow the Hepburn transcription system.

Cognate in English & Spanish only						Noncognate control					
English	Spanish	P	O	Japanese	P	English	Spanish	P	O	Japanese	P
beard	barba	2.65	480	ひげ hi.ge	1.23	balloon	globo	1.82	202	風船 fu.u.se.n	1.31
bicycle	bicicleta	3.71	596	自転車 ji.te.n.sha	1.08	bride	novia	1.29	70	花嫁 ha.na.yo.me	1.19
camel	camello	3.24	722	ラクダ ra.ku.da	1.19	clock	reloj	1.59	190	時計 to.ke.i	1.62
castle	castillo	3.24	593	城 shi.ro	1.46	clown	payaso	1.59	60	ピエロ pi.e.ro	1.12
crown	corona	3.65	530	王冠 o.u.ka.n	1.50	comb	peine	1.47	40	クシ ku.shi	1.84
elephant	elefante	5.94	570	象 zo.u	1	envelope	sobre	1.47	257	封筒 fu.u.to.u	1.23
giraffe	girafa	1.53	119	キリン ki.ri.n	1.12	goat	cabra	2.24	62	ヤギ ya.gi	1.12
mountain	montaña	4.29	580	山 ya.ma	1.46	moon	luna	2.59	75	月 tsu.ki	1.46
nose	naríz	2.24	332	鼻 ha.na	1.19	nail	clavo	2.06	84	クギ ku.gi	1.08
pear	pera	2.65	620	なし na.shi	1.23	pillow	almohada	1.29	80	枕 ma.ku.ra	1.04

English	Spanish	P	O	Japanese	P	English	Spanish	P	O	Japanese	P
soldier	soldado	4.53	591	兵士 he.i.shi	1.27	squirrel	ardilla	1.35	84	リス ri.su	1.08
turtle	tortuga	2.76	528	カメ ka.me	1.23	tear	lágrima	1.24	47	涙 na.mi.da	1.04

Notes. P refers to the mean phonological similarity ratings from the norming experiment with English monolinguals (See Appendix A1 for details). O refers to orthographic/graphemic similarity computed with the algorithm described by Van Orden (1987). Japanese picture names are written in a preferred script based on frequency (Amano & Kondo, 2000) and their readings given here follow the Hepburn transcription system.

Cognate in English & Japanese only						Noncognate control					
English	Spanish	P	O	Japanese	P	English	Spanish	P	O	Japanese	P
belt	cinturón	1.18	42	ベルト be.ru.to	2.35	bee	abeja	1.41	230	ハチ ha.chi	1.15
brush	cepillo	1.29	36	ブラシ bu.ra.shi	2.96	bone	hueso	1.24	84	骨 ho.ne	1.77
cake	pastel	1.24	73	ケーキ ke.e.ki	4.15	cow	vaca	1.41	66	牛 u.shi	1.00
cookie	galleta	1.88	58	クッキー ku.k.ki.i	5.96	crab	cangrejo	1.29	345	かに ka.ni	1.73
fork	tenedor	1.18	47	フォーク fo.o.ku	4.23	finger	dedo	1.82	53	指 yu.bi	1.00
heart	corazón	1.53	119	ハート ha.a.to	3.54	hammer	martillo	1.18	138	カナヅチ ka.na.zu.chi	1.00
helmet	casco	1.41	42	ヘルメット he.ru.me.t.to	2.96	horse	caballo	1.29	36	馬 u.ma	1.31
necklace	collar	1.29	152	ネックレス ne.k.ku.re.su	4.77	needle	aguja	1.24	42	針 ha.ri	1.31
rocket	cohete	1.35	300	ロケット ro.ke.t.to	4.65	rabbit	conejo	1.41	50	ウサギ u.sa.gi	1.12
shirt	camisa	1.35	78	シャツ sha.tsu	5.27	sheep	borrego	1.35	69	羊 hi.tsu.ji	1.54

English	Spanish	P	O	Japanese	P	English	Spanish	P	O	Japanese	P
skirt	falda	1.76	50	スカート su.ka.a.to	3.65	snake	víbora	1.06	60	蛇 he.bi	1.12
spoon	cuchara	1.71	36	スプーン su.pu.u.n	6.62	spider	araña	1.35	60	くも ku.mo	1.04

Notes. P refers to the mean phonological similarity ratings from the norming experiment with English monolinguals (See Appendix A1 for details). O refers to orthographic/graphemic similarity computed with the algorithm described by Van Orden (1987). Japanese picture names are written in a preferred script based on frequency (Amano & Kondo, 2000) and their readings given here follow the Hepburn transcription system.

APPENDIX E

PICTURE AND DISTRACTOR WORD STIMULI USED IN EXPERIMENT 2

Kana: Translation Condition (Spanish)

Picture	Related				Unrelated			
	Distractor	Meaning	Length	Frequency	Distractor	Meaning	Length	Frequency
chair	silla	chair	5 (2)	2.124	copa	wineglass	4 (2)	2.097
comb	peine	comb	5 (2)	1.322	tirón	wrench	5 (2)	1.431
corn	maíz	corn	4 (2)	1.462	tapa	lid	4 (2)	1.477
duck	pato	duck	4 (2)	1.041	bota	boot	4 (2)	1.000
goat	cabra	goat	5 (2)	1.342	lápiz	pencil	5 (2)	1.322
mouse	ratón	mouse	5 (2)	1.556	dardo	dart	5 (2)	1.556
nail	clavo	nail	5 (2)	1.255	farol	lantern	5 (2)	1.255
pumpkin	calabaza	pumpkin	8 (4)	0.845	avestruz	ostrich	8 (3)	0.954
basket	canasta	basket	7 (3)	0.699	silbato	whistle	7 (3)	0.845
bear	oso	bear	3 (2)	1.672	nube	cloud	4 (2)	1.708
bee	abeja	bee	5 (3)	0.903	hongo	mushroom	5 (2)	0.845
butterfly	mariposa	butterfly	8 (4)	1.204	cenicero	ashtray	8 (4)	1.301
kettle	tetera	kettle	6 (3)	0.699	suéter	sweater	6 (3)	0.845
key	llave	key	5 (2)	1.949	avión	airplane	5 (2)	1.914
kite	cometa	kite	6 (3)	1.556	bolsa	bag	5 (2)	1.826
owl	búho	owl	4 (2)	1.380	lazo	bow	4 (2)	1.342

Kana: Translation Condition (Japanese)

Picture	Related				Unrelated			
	Distractor	Meaning	Length	Frequency	Distractor	Meaning	Length	Frequency
chair	イス i.su	chair	2 (2)	3.077	トラ to.ra	tiger	2 (2)	3.002
comb	クシ ku.shi	comb	2 (2)	1.869	ノブ no.bu	doorknob	2 (2)	1.968
corn	トウモロコシ to.u.mo.ro.ko.shi	corn	6 (6)	3.143	ドライバー do.ra.i.ba.a.	screwdriver	5 (5)	3.256
duck	アヒル a.hi.ru	duck	3 (3)	2.459	セロリ se.ro.ri	celery	3 (3)	2.461
goat	ヤギ ya.gi	goat	2 (2)	2.618	タバコ ta.ba.ko	cigarette	3 (3)	2.643
mouse	ネズミ ne.zu.mi	mouse	3 (3)	3.240	カップ ka.p.pu	cup	3 (2)	3.187
nail	クギ ku.gi	nail	2 (2)	3.200	サル sa.ru	monkey	2 (2)	3.157
pumpkin	カボチャ ka.bo.cha	pumpkin	4 (3)	2.849	ウナギ u.na.gi	eel	3 (3)	2.870
basket	カゴ ka.go	basket	2 (2)	2.473	ヒョウ hyo.u	leopard	3 (2)	2.228
bear	クマ ku.ma	bear	2 (2)	3.001	ピン pi.n	pin	2 (2)	3.104
bee	ハチ ha.chi	bee	2 (2)	2.925	ナス na.su	eggplant	2 (2)	2.950

Picture	Related				Unrelated			
	Distractor	Meaning	Length	Frequency	Distractor	Meaning	Length	Frequency
butterfly	チョウ cho.u	butterfly	3 (2)	2.837	ナシ na.shi	pear	2 (2)	2.618
kettle	ヤカン ya.ka.n	kettle	3 (3)	1.633	イカリ i.ka.ri	anchor	3 (3)	1.591
key	カギ ka.gi	key	2 (2)	3.786	ベッド be.d.do	bed	3 (2)	3.660
kite	タコ ta.ko	kite	2 (2)	2.831	ヘビ he.bi	snake	2 (2)	2.727
owl	フクロウ fu.ku.ro.u	owl	4 (4)	2.417	ドングリ do.n.gu.ri	acorn	4 (4)	2.358

Kana: Semantic Condition (Spanish)

Picture	Related					Unrelated				
	Distractor	Meaning	Length	Frequency	Rating	Distractor	Meaning	Length	Frequency	Rating
chair	mesa	table	4 (2)	2.672	5.07	boca	mouth	4 (2)	2.603	1.07
comb	cepillo	brush	7 (3)	1.230	6.07	tortuga	turtle	7 (3)	1.279	1.07
corn	pimiento	pepper	8 (3)	0.845	3.07	langosta	lobster	8 (3)	0.903	2.36
duck	pingüino	penguin	8 (3)	0.845	4.57	columpio	swing	8 (3)	0.845	1.36
goat	venado	deer	6 (3)	0.954	4.21	escoba	broom	6 (3)	1.000	1.00
mouse	conejo	rabbit	6 (3)	0.301	4.57	salero	saltshaker	6 (3)	0.301	1.00
nail	tornillo	screw	8 (3)	0.778	6.14	plátano	banana	7 (3)	0.845	1.00
pumpkin	cebolla	onion	7 (3)	1.556	3.93	molino	windmill	6 (3)	1.568	1.07
basket	maleta	suitcase	6 (3)	1.681	3.29	oreja	ear	5 (3)	1.845	1.00
bear	lobo	wolf	4 (2)	1.681	4.57	taza	cup	4 (2)	1.672	1.00
bee	araña	spider	5 (3)	1.279	4.43	cerco	fence	5 (2)	1.230	1.21
butterfly	hormiga	ant	7 (3)	0.954	4.29	granero	barn	7 (3)	0.954	1.64
kettle	olla	pan	4 (2)	1.079	4.86	foca	seal	4 (2)	1.041	1.14
key	puerta	door	6 (2)	2.914	5.07	agua	water	4 (2)	2.900	1.00
kite	trompo	top	6 (2)	0.477	2.00	sandía	watermelon	6 (3)	0.477	1.43
owl	águila	eagle	6 (3)	1.477	5.93	muñeca	doll	6 (3)	1.519	1.21

Kana: Semantic Condition (Japanese)

Picture	Related					Unrelated				
	Distractor	Meaning	Length	Frequency	Rating	Distractor	Meaning	Length	Frequency	Rating
chair	テーブル te.e.bu.ru	table	4 (4)	3.481	5.07	ロケット ro.ke.t.to	rocket	4 (3)	3.570	1.29
comb	ブラシ bu.ra.shi	brush	3 (3)	2.587	6.07	メロン me.ro.n	melon	3 (3)	2.562	1.00
corn	ピーマン pi.i.ma.n	pepper	4 (4)	2.790	3.07	ブラウス bu.ra.u.su	blouse	4 (4)	2.754	1.00
duck	ペンギン pe.n.gi.n	penguin	4 (4)	2.879	4.57	ジャケット ja.ke.t.to	jacket	5 (3)	2.864	1.14
goat	シカ shi.ka	deer	2 (2)	2.894	4.21	ノリ no.ri	seaweed	2 (2)	2.927	1.86
mouse	ウサギ u.sa.gi	rabbit	3 (3)	3.137	4.57	ズボン zu.bo.n	pants	3 (3)	3.171	1.07
nail	ビス bi.su	screw	2 (2)	1.602	6.14	タル ta.ru	barrel	2 (2)	1.724	2.00
pumpkin	タマネギ ta.ma.ne.gi	onion	4 (4)	3.172	3.93	ネクタイ ne.ku.ta.i	tie	4 (4)	3.208	1.00
basket	スーツケース su.u.tsu.ke.e.su	suitcase	6 (6)	2.471	3.29	パイナップル pa.i.na.p.pu.ru	pineapple	6 (5)	2.350	1.36
bear	オオカミ o.o.ka.mi	wolf	4 (4)	2.768	4.57	スイカ su.i.ka	watermelon	3 (3)	2.759	1.14
bee	クモ ku.mo	spider	2 (2)	2.521	4.43	ユリ yu.ri	lily	2 (2)	2.394	2.79

Picture	Related					Unrelated				
	Distractor	Meaning	Length	Frequency	Rating	Distractor	Meaning	Length	Frequency	Rating
butterfly	アリ a.ri	ant	2 (2)	3.010	4.29	カニ ka.ni	crab	2 (2)	3.069	2.71
kettle	ナベ na.be	pan	2 (2)	3.586	4.86	サケ sa.ke	salmon	2 (2)	3.404	1.64
key	ドア do.a	door	2 (2)	3.659	5.07	ワイン wa.i.n	wine	3 (3)	3.608	1.07
kite	コマ ko.ma	top	2 (2)	3.079	2.00	バラ ba.ra	rose	2 (2)	3.233	1.14
owl	ワシ wa.shi	eagle	2 (2)	2.483	5.93	ノミ no.mi	chisel	2 (2)	2.539	1.36

Kana: Phonological Condition (Spanish)

Picture	Related					Unrelated				
	Distractor	Meaning	Length	Frequency	Rating	Distractor	Meaning	Length	Frequency	Rating
chair	chelo	cello	5 (2)	1.00	4.56	ancla	anchor	5 (2)	1.146	1.50
comb	comida	food	6 (3)	2.130	4.50	bosque	forest	6 (2)	2.130	1.50
corn	córnea	cornea	6 (3)	0.477	5.31	formón	chisel	6 (2)	0.301	2.19
duck	dama	lady	4 (2)	2.117	1.06	humo	smoke	4 (2)	2.117	1.06
goat	goma	rubber	4 (2)	1.415	3.88	lava	lava	4 (2)	1.380	1.06
mouse	martillo	hammer	8 (3)	1.204	2.94	lechuga	lettuce	7 (3)	1.114	1.00
nail	nervio	nerve	6 (2)	1.079	4.81	gemelo	twin	6 (3)	0.845	1.44
pumpkin	pantalón	pants	8 (3)	1.792	2.44	chaqueta	jacket	8 (3)	1.839	1.03
basket	vaso	glass	4 (2)	2.079	2.19	flor	flower	4 (1)	2.076	1.00
bear	vestido	dress	7 (3)	2.230	1.25	edificio	building	8 (4)	2.152	1.56
bee	vino	wine	4 (2)	2.556	4.50	cabo	end	4 (2)	2.574	1.13
butterfly	vatio	watt	5 (2)	0.301	1.06	dedal	thimble	5 (2)	0.301	1.50
kettle	queso	cheese	5 (2)	1.398	4.44	aguja	needle	5 (3)	1.505	1.06
key	quijada	jaw	7 (3)	0.699	4.63	ballena	whale	7 (3)	0.954	1.13
kite	caimán	alligator	6 (2)	0.699	4.13	gorila	gorilla	6 (3)	0.903	1.00
owl	aula	classroom	4 (2)	1.176	5.56	nuez	nut	4 (1)	1.176	1.06

Kana: Phonological Condition (Japanese)

Picture	Related					Unrelated				
	Distractor	Meaning	Length	Frequency	Rating	Distractor	Meaning	Length	Frequency	Rating
chair	チェロ che.ro	cello	3 (2)	2.935	4.73	トンボ to.m.bo	dragonfly	3 (3)	2.926	1.07
comb	コウモリ ko.u.mo.ri	bat	4 (4)	2.253	4.93	ザリガニ za.ri.ga.ni	lobster	4 (4)	2.083	1.33
corn	コート ko.o.to	coat	3 (3)	3.341	3.27	ヨット yo.t.to	yacht	3 (2)	3.322	1.47
duck	ダイヤ da.i.ya	timetable	3 (3)	3.389	2.33	テント te.n.to	tent	3 (3)	3.435	1.33
goat	ゴム go.mu	rubber	2 (2)	3.246	3.27	バネ ba.ne	spring	2 (2)	3.120	1.47
mouse	マウンド ma.u.n.do	mound	4 (4)	3.327	3.80	スイッチ su.i.t.chi	switch	4 (3)	3.266	1.87
nail	ネタ ne.ta	material	2 (2)	3.020	3.73	ズレ zu.re	difference	2 (2)	3.045	1.27
pumpkin	パン pa.n	bread	2 (2)	3.485	3.80	フン fu.n	excrement	2 (2)	3.418	1.27
basket	バス ba.su	bus	2 (2)	4.072	4.33	ラジオ ra.ji.o	radio	3 (3)	3.939	1.47
bear	ベルト be.ru.to	belt	3 (3)	2.956	4.47	コップ ko.p.pu	glass	3 (2)	2.959	1.13
bee	ビール bi.i.ru	beer	3 (3)	3.803	4.87	カメラ ka.me.ra	camera	3 (3)	3.905	1.33

Picture	Related					Unrelated				
	Distractor	Meaning	Length	Frequency	Rating	Distractor	Meaning	Length	Frequency	Rating
butterfly	バター ba.ta.a	butter	3 (3)	3.042	3.87	キュウリ kyu.u.ri	cucumber	4 (3)	3.093	1.20
kettle	ケチ ke.chi	miser	2 (2)	2.547	3.47	ウニ u.ni	sea urchin	2 (2)	2.618	1.47
key	キノコ ki.no.ko	mushroom	3 (3)	2.943	4.20	レモン re.mo.n	lemon	3 (3)	2.927	1.20
kite	カイコ ka.i.ko	silkworm	3 (3)	2.114	5.13	ダチョウ da.cho.u	ostrich	4 (3)	1.996	1.40
owl	アウト a.u.to	out	3 (3)	2.895	4.20	リボン ri.bo.n	bow	3 (3)	2.882	1.27

Kana: Phono-Translation Condition (Spanish)

Picture	Related					Unrelated				
	Distractor	Meaning	Length	Frequency	Rating	Distractor	Meaning	Length	Frequency	Rating
chair	sierra	saw	6 (2)	1.724	4.50	pájaro	bird	6 (3)	1.799	1.00
comb	pelícano	pelican	8 (4)	0.301	2.69	leopardo	leopard	8 (4)	0.477	1.19
corn	manga	sleeve	5 (2)	1.544	3.44	gallo	rooster	5 (2)	1.531	1.25
duck	palo	stick	4 (2)	1.716	3.69	mapa	map	4 (2)	1.708	1.50
goat	cabeza	head	6 (3)	2.922	3.13	sangre	blood	6 (3)	2.636	1.06
mouse	raqueta	racket	7 (3)	0.699	3.94	champú	shampoo	6 (2)	0.699	1.00
nail	clase	class	5 (2)	2.607	3.19	suelo	floor	5 (2)	2.638	1.31
pumpkin	calamar	squid	7 (3)	0.301	4.06	galleta	cookie	7 (3)	0.699	2.13
basket	canario	canary	7 (3)	1.839	4.25	regla	ruler	5 (2)	1.857	1.00
bear	ostra	oyster	5 (2)	0.699	4.94	pulga	flea	5 (2)	0.699	1.50
bee	abertura	opening	8 (4)	1.146	3.56	carnaval	carnival	8 (3)	1.146	1.19
butterfly	marino	sailor	6 (3)	1.633	3.50	corona	crown	6 (3)	1.633	1.38
kettle	techo	ceiling	5 (2)	2.041	4.13	reina	queen	5 (2)	2.033	2.00
key	llama	flame	5 (2)	2.425	4.88	plaza	square	5 (2)	2.033	1.13
kite	comedia	comedy	7 (3)	1.908	5.13	humedad	humidity	7 (3)	1.908	1.44
owl	bufanda	scarf	7 (3)	1.114	3.63	plancha	iron	7 (2)	1.114	1.19

Kana: Phono-Translation Condition (Japanese)

Picture	Related					Unrelated				
	Distractor	Meaning	Length	Frequency	Rating	Distractor	Meaning	Length	Frequency	Rating
chair	イカ i.ka	squid	2 (2)	2.989	4.20	ケーキ ke.e.ki	cake	3 (3)	2.975	1.53
comb	クリ ku.ri	chestnut	2 (2)	2.560	4.73	ワニ wa.ni	alligator	2 (2)	2.609	2.07
corn	トースター to.o.su.ta.a	toaster	5 (5)	1.756	3.33	ドンブリ do.m.bu.ri	bowl	4 (4)	1.724	2.40
duck	アピール a.pi.i.ru	appeal	4 (4)	3.772	3.73	トンネル to.n.ne.ru	tunnel	4 (4)	3.741	2.13
goat	ヤジ ya.ji	jeering	2 (2)	2.786	4.93	ツル tsu.ru	crane	2 (2)	2.824	1.07
mouse	ネギ ne.gi	leek	2 (2)	3.213	3.20	エビ e.bi	shrimp	2 (2)	3.206	1.87
nail	クッキー ku.k.ki.i	cookie	4 (3)	2.526	5.27	ヒマワリ hi.ma.wa.ri	sunflower	4 (4)	2.515	1.07
pumpkin	カブト ka.bu.to	helmet	3 (3)	2.140	4.53	ハシゴ ha.shi.go	ladder	3 (3)	2.188	1.20
basket	カメ ka.me	turtle	2 (2)	2.602	3.53	ハエ ha.e	fly	2 (2)	2.642	1.13
bear	クイ ku.i	post	2 (2)	2.134	3.73	ネガ ne.ga	negative	2 (2)	2.423	2.07
bee	ハス ha.su	lotus	2 (2)	2.375	4.13	サイ sa.i	rhino	2 (2)	2.215	1.27

Picture	Related					Unrelated				
	Distractor	Meaning	Length	Frequency	Rating	Distractor	Meaning	Length	Frequency	Rating
butterfly	チョッキ cho.k.ki	vest	4 (2)	1.863	4.60	モップ mo.p.pu	mop	3 (2)	1.903	1.27
kettle	ヤカラ ya.ka.ra	clan	3 (3)	0.602	4.87	クサリ ku.sa.ri	chain	3 (3)	1.204	1.27
key	カキ ka.ki	oyster	2 (2)	2.964	6.13	ハト ha.to	pigeon	2 (2)	2.879	1.40
kite	タオル ta.o.ru	towel	3 (3)	3.042	3.13	バナナ ba.na.na	banana	3 (3)	3.102	1.07
owl	フクロ fu.ku.ro	sack	3 (3)	1.380	6.40	スパナ su.pa.na	wrench	3 (3)	1.447	1.27

Kanji: Translation Condition (Spanish)

Picture	Related				Unrelated			
	Distractor	Meaning	Length	Frequency	Distractor	Meaning	Length	Frequency
car	coche	car	5 (2)	2.480	pelo	hair	4 (2)	2.486
chicken	pollo	chicken	5 (2)	1.477	blusa	blouse	5 (2)	1.505
cow	vaca	cow	4 (2)	1.398	gorra	cap	5 (2)	1.431
desk	escritorio	desk	10 (4)	1.462	bicicleta	bicycle	9 (4)	1.477
dog	perro	dog	5 (2)	2.352	carta	letter	5 (2)	2.358
envelope	sobre	envelope	5 (2)	3.614	hombre	man	6 (2)	3.294
mirror	espejo	mirror	6 (3)	2.318	labios	lips	6 (2)	2.509
sock	calcetín	sock	8 (3)	0.845	acordeón	accordion	8 (4)	0.954
balloon	globo	balloon	5 (2)	1.462	casco	helmet	5 (2)	1.462
bell	campana	bell	7 (3)	1.544	chaleco	vest	7 (3)	1.556
book	libro	book	5 (2)	2.758	calle	street	5 (2)	2.780
bone	hueso	bone	5 (2)	1.653	cañón	cannon	5 (2)	1.653
box	caja	box	4 (2)	2.083	dedo	finger	4 (2)	2.121
eye	ojo	eye	3 (2)	2.286	pan	bread	3 (1)	2.143
king	rey	king	3 (1)	2.491	piel	skin	4 (1)	2.515
sun	sol	sun	3 (1)	2.762	cara	face	4 (2)	2.800

Kanji: Translation Condition (Japanese)

Picture	Related				Unrelated			
	Distractor	Meaning	Length	Frequency	Distractor	Meaning	Length	Frequency
car	車 ku.ru.ma	car	1 (3)	4.740	額 hi.ta.i	forehead	1 (3)	4.730
chicken	鶏 ni.wa.to.ri	chicken	1 (4)	3.136	唇 ku.chi.bi.ru	lips	1 (4)	2.926
cow	牛 u.shi	cow	1 (2)	3.661	腹 ha.ra	belly	1 (2)	3.749
desk	机 tsu.ku.e	desk	1 (3)	3.611	涙 na.mi.da	tear	1 (3)	3.856
dog	犬 i.nu	dog	1 (2)	3.624	髪 ka.mi	hair	1 (2)	3.516
envelope	封筒 fu.u.to.u	envelope	2 (4)	3.268	花火 ha.na.bi	fireworks	2 (3)	3.244
mirror	鏡 ka.ga.mi	mirror	1 (3)	3.314	桜 sa.ku.ra	cherry blossom	1 (3)	3.505
sock	靴下 ku.tsu.shi.ta	sock	2 (4)	2.810	戦艦 se.n.ka.n	battleship	2 (4)	2.766
balloon	風船 fu.u.se.n	balloon	2 (4)	2.906	親指 o.ya.yu.bi	thumb	2 (4)	2.897
bell	鐘 ka.ne	bell	1 (2)	3.088	舌 shi.ta	tongue	1 (2)	3.061
book	本 ho.n	book	1 (2)	4.496	家 i.e	house	1 (2)	4.516

Picture	Related				Unrelated			
	Distractor	Meaning	Length	Frequency	Distractor	Meaning	Length	Frequency
bone	骨 ho.ne	bone	1 (2)	3.800	雪 yu.ki	snow	1 (2)	3.944
box	箱 ha.ko	box	1 (2)	3.771	馬 u.ma	horse	1 (2)	3.656
eye	目 me	eye	1 (1)	4.706	地 chi	ground	1 (1)	4.522
king	王 o.u	king	1 (2)	3.620	口 ku.chi	mouth	1 (2)	3.529
sun	太陽 ta.i.yo.u	sun	2 (4)	3.722	警官 ke.i.ka.n	policeman	2 (4)	3.808

Kanji: Semantic Condition (Spanish)

Picture	Related					Unrelated				
	Distractor	Meaning	Length	Frequency	Rating	Distractor	Meaning	Length	Frequency	Rating
car	tren	train	4 (1)	2.045	5.29	árbol	tree	5 (2)	2.045	1.50
chicken	cisne	swan	5 (2)	1.041	4.07	limón	lemon	5 (2)	1.079	3.14
cow	cerdo	pig	5 (2)	1.544	5.14	dientes	teeth	7 (2)	2.274	2.00
desk	estante	shelf	7 (3)	0.903	4.07	cuchara	spoon	7 (3)	0.903	1.29
dog	gato	cat	4 (2)	2.149	5.07	baño	bath	4 (2)	2.149	1.93
envelope	tarjeta	postcard	7 (3)	1.362	4.64	rodilla	knee	7 (3)	1.342	1.07
mirror	ventana	window	7 (3)	2.513	4.79	corazón	heart	7 (3)	2.580	1.21
sock	guante	glove	6 (2)	1.398	5.14	mosca	fly	5 (2)	1.505	1.57
balloon	pelota	ball	6 (3)	1.653	4.00	caballo	horse	7 (3)	2.274	1.00
bell	iglesia	church	7 (3)	2.340	4.14	teléfono	telephone	8 (4)	2.272	4.29
book	revista	magazine	7 (3)	1.991	5.79	montaña	mountain	7 (3)	1.851	1.00
bone	músculo	muscle	7 (3)	1.279	5.00	caracol	snail	7 (3)	1.362	1.07
box	lata	can	4 (2)	1.380	3.93	pera	pear	4 (2)	1.322	1.07
eye	nariz	nose	5 (2)	2.152	4.86	reloj	watch	5 (2)	2.155	3.21
king	soldado	soldier	7 (3)	1.806	4.00	bandera	flag	7 (3)	1.813	2.71
sun	luna	moon	4 (2)	2.204	5.36	radio	radio	5 (2)	2.179	1.57

Kanji: Semantic Condition (Japanese)

Picture	Related					Unrelated				
	Distractor	Meaning	Length	Frequency	Rating	Distractor	Meaning	Length	Frequency	Rating
car	電車 de.n.sha	train	2 (3)	3.939	5.29	児童 ji.do.u	pupil	2 (3)	3.972	1.29
chicken	白鳥 ha.ku.cho.u	swan	2 (4)	2.709	4.07	大砲 ta.i.ho.u	cannon	2 (4)	2.708	1.29
cow	豚 bu.ta	pig	1 (2)	3.156	5.14	松 ma.tsu	pine	1 (2)	3.164	1.36
desk	棚 ta.na	shelf	1 (2)	3.185	4.07	琴 ko.to	harp	1 (2)	3.097	1.43
dog	猫 ne.ko	cat	1 (2)	3.444	5.07	城 shi.ro	castle	1 (2)	3.317	1.14
envelope	葉書 ha.ga.ki	postcard	2 (3)	1.613	4.64	毛虫 ke.mu.shi	caterpillar	2 (3)	1.875	1.07
mirror	窓 ma.do	window	1 (2)	3.787	4.79	脳 no.u	brain	1 (2)	3.939	1.71
sock	手袋 te.bu.ku.ro	glove	2 (4)	2.915	5.14	天使 te.n.shi	angel	2 (3)	2.860	1.07
balloon	球 ta.ma	ball	1 (2)	3.864	4.00	影 ka.ge	shadow	1 (2)	3.832	1.64
bell	教会 kyo.u.ka.i	church	2 (4)	3.772	4.14	人形 ni.n.gyo.u	doll	2 (4)	3.528	1.36
book	雑誌 za.s.shi	magazine	2 (2)	4.162	5.79	投手 to.u.shu	pitcher	2 (3)	4.147	1.07

Picture	Related					Unrelated				
	Distractor	Meaning	Length	Frequency	Rating	Distractor	Meaning	Length	Frequency	Rating
bone	筋肉 ki.n.ni.ku	muscle	2 (4)	3.309	5.00	鉛筆 e.m.pi.tsu	pencil	2 (4)	3.100	1.57
box	缶 ka.n	can	1 (2)	3.685	3.93	糸 i.to	thread	1 (2)	3.409	1.86
eye	鼻 ha.na	nose	1 (2)	3.312	4.86	皿 sa.ra	plate	1 (2)	3.269	1.86
king	兵士 he.i.shi	soldier	2 (3)	3.498	4.00	時計 to.ke.i	clock	2 (3)	3.466	1.00
sun	月 tsu.ki	moon	1 (2)	4.193	5.36	花 ha.na	flower	1 (2)	4.238	3.71

Kanji: Phonological Condition (Spanish)

Picture	Related					Unrelated				
	Distractor	Meaning	Length	Frequency	Rating	Distractor	Meaning	Length	Frequency	Rating
car	casa	house	4 (2)	3.249	2.69	mundo	world	5 (2)	3.249	1.00
chicken	chico	boy	5 (2)	2.241	5.44	jardín	garden	6 (2)	2.272	1.13
cow	causa	cause	5 (2)	2.418	4.94	autor	author	5 (2)	2.428	1.50
desk	descanso	rest	8 (3)	1.806	3.19	frontera	border	8 (3)	1.799	1.00
dog	doctor	doctor	6 (2)	2.167	3.25	botella	bottle	7 (3)	2.064	1.19
envelope	enchufe	plug	7 (3)	0.602	2.94	alicates	pliers	8 (4)	0.477	1.50
mirror	mira	sight	4 (2)	2.473	4.56	río	river	3 (2)	2.470	1.50
sock	saco	sack	4 (2)	1.792	5.81	piano	piano	5 (2)	1.792	1.00
balloon	valle	valley	5 (2)	2.017	1.88	isla	island	4 (2)	2.049	1.50
bell	vela	candle	4 (2)	1.740	2.81	león	lion	4 (2)	1.748	1.06
book	vuelta	turn	6 (2)	2.407	3.00	cocina	kitchen	6 (3)	2.354	1.38
bone	voto	vote	4 (2)	1.491	2.50	lana	wool	4 (2)	2.354	1.00
box	valor	value	5 (2)	2.456	1.88	seguro	insurance	6 (3)	2.505	1.13
eye	aire	air	4 (2)	2.761	5.19	paso	step	4 (2)	2.762	1.13
king	quinta	estate	6 (2)	1.580	4.19	pulgar	thumb	6 (2)	1.431	1.06
sun	zahahoria	carrot	9 (4)	1.041	4.06	trompeta	trumpet	8 (3)	1.000	1.06

Kanji: Phonological Condition (Japanese)

Picture	Related					Unrelated				
	Distractor	Meaning	Length	Frequency	Rating	Distractor	Meaning	Length	Frequency	Rating
car	蚊 ka	mosquito	1 (1)	2.713	5.60	酢 su	vinegar	1 (1)	2.826	1.40
chicken	地球 chi.kyu.u	earth	2 (3)	4.425	4.60	舞台 bu.ta.i	stage	2 (3)	4.415	1.47
cow	顔 ka.o	face	1 (2)	4.483	6.33	水 mi.zu	water	1 (2)	4.465	1.07
desk	出口 de.gu.chi	exit	2 (3)	3.314	2.40	指輪 yu.bi.wa	ring	2 (3)	3.032	1.13
dog	道具 do.u.gu	tool	2 (3)	3.573	5.53	戦車 se.n.sha	tank	2 (3)	3.544	1.33
envelope	煙突 e.n.to.tsu	chimney	2 (4)	2.792	3.87	大根 da.i.ko.n	radish	2 (4)	2.969	1.13
mirror	未来 mi.ra.i	future	2 (3)	3.827	4.20	神社 ji.n.ja	shrine	2 (3)	3.837	1.27
sock	作家 sa.k.ka	novelist	2 (2)	4.300	5.13	教師 kyo.u.shi	teacher	2 (3)	4.294	1.60
balloon	罰 ba.tsu	punishment	1 (2)	2.792	2.93	滝 ta.ki	waterfall	1 (2)	2.879	1.07
bell	別荘 be.s.so.u	cottage	2 (3)	3.398	2.53	真実 shi.n.ji.tsu	truth	2 (4)	3.444	1.00
book	部下 bu.ka	subordinate	2 (2)	3.492	5.20	屋根 ya.ne	roof	2 (2)	3.642	1.07

Picture	Related					Unrelated				
	Distractor	Meaning	Length	Frequency	Rating	Distractor	Meaning	Length	Frequency	Rating
bone	盆地 bo.n.chi	basin	2 (3)	2.356	4.20	定規 jo.u.gi	ruler	2 (3)	2.324	1.20
box	幕府 ba.ku.fu	shogunate	2 (3)	2.811	3.80	気質 ki.shi.tsu	temper	2 (3)	2.829	1.20
eye	愛 a.i	love	1 (2)	3.807	6.20	空 so.ra	sky	1 (2)	3.870	1.47
king	金庫 ki.n.ko	safe	2 (3)	3.283	4.87	辞書 ji.sho	dictionary	2 (2)	3.229	1.47
sun	酸 sa.n	acid	1 (2)	2.635	6.20	沼 nu.ma	swamp	1 (2)	2.640	1.33

Kanji: Phono-Translation Condition (Spanish)

Picture	Related					Unrelated				
	Distractor	Meaning	Length	Frequency	Rating	Distractor	Meaning	Length	Frequency	Rating
car	colegio	school	7 (3)	2.228	3.06	hermana	sister	7 (3)	2.342	1.06
chicken	pozo	well	4 (2)	1.690	4.00	arco	arch	4 (2)	1.653	1.19
cow	vaho	breath	4 (2)	1.362	3.44	hoyo	hole	4 (2)	1.362	1.13
desk	escalera	stairs	8 (4)	2.117	4.50	bolsillo	pocket	8 (3)	2.057	1.06
dog	percha	hanger	6 (2)	1.146	4.69	payaso	clown	6 (3)	1.079	1.75
envelope	sobrino	nephew	7 (3)	1.415	5.00	paloma	pigeon	6 (3)	1.505	1.25
mirror	espada	sword	6 (3)	1.663	4.69	anillo	ring	6 (3)	1.613	1.81
sock	calendario	calendar	10 (4)	1.230	3.44	escarabajo	beetle	10 (5)	0.845	1.13
balloon	gloria	glory	6 (2)	2.076	3.81	cuento	tale	6 (2)	2.064	1.75
bell	camisa	shirt	6 (3)	2.086	3.81	piedra	stone	6 (2)	2.250	1.44
book	lirio	iris	5 (2)	1.000	4.19	chapa	lock	5 (2)	1.000	1.06
bone	huevo	egg	5 (2)	1.740	3.81	ducha	shower	5 (2)	1.633	1.19
box	cama	bed	4 (2)	2.616	4.06	dinero	money	6 (3)	2.601	1.06
eye	ojal	buttonhole	4 (2)	0.845	4.56	piña	pineapple	4 (2)	0.845	1.00
king	repollo	cabbage	7 (3)	0.778	4.25	barril	barrel	6 (2)	0.903	2.75
sun	sofa	couch	4 (2)	1.833	3.63	hilo	thread	4 (2)	1.903	1.19

Kanji: Phono-Translation Condition (Japanese)

Picture	Related					Unrelated				
	Distractor	Meaning	Length	Frequency	Rating	Distractor	Meaning	Length	Frequency	Rating
car	雲 ku.mo	cloud	1 (2)	3.590	3.67	旗 ha.ta	flag	1 (2)	3.473	1.27
chicken	庭 ni.wa	garden	1 (2)	3.633	4.33	板 i.ta	board	1 (2)	3.736	1.40
cow	海 u.mi	sea	1 (2)	4.180	4.40	山 ya.ma	mountain	1 (2)	4.060	1.13
desk	津波 tsu.na.mi	tsunami	2 (3)	3.217	2.33	汽船 ki.se.n	steamship	2 (3)	3.142	1.60
dog	意図 i.to	intention	2 (2)	3.828	4.13	文字 mo.ji	character	2 (2)	3.843	1.40
envelope	風鈴 fu.u.ri.n	wind-bell	2 (4)	2.155	4.53	王冠 o.u.ka.n	crown	2 (4)	2.107	1.67
mirror	科学 ka.ga.ku	science	2 (3)	4.042	4.60	料理 ryo.u.ri	cooking	2 (3)	4.047	1.40
sock	苦痛 ku.tsu.u	pain	2 (3)	3.369	4.13	切手 ki.t.te	stamp	2 (2)	3.343	2.07
balloon	夫婦 fu.u.fu	couple	2 (3)	4.144	3.87	手紙 te.ga.mi	letter	2 (3)	4.151	1.67
bell	加熱 ka.ne.tsu	heating	2 (3)	3.609	4.80	倉庫 so.u.ko	warehouse	2 (3)	3.607	1.13
book	保護 ho.go	protection	2 (2)	4.500	4.20	維持 i.ji	maintenance	2 (2)	4.496	1.00

Picture	Related					Unrelated				
	Distractor	Meaning	Length	Frequency	Rating	Distractor	Meaning	Length	Frequency	Rating
bone	保険 ho.ke.n	insurance	2 (3)	4.171	3.87	市長 shi.cho.u	mayor	2 (3)	4.188	1.33
box	墓 ha.ka	grave	1 (2)	3.679	5.20	敵 te.ki	enemy	1 (2)	3.652	1.47
eye	綿 me.n	cotton	1 (2)	2.993	5.33	菊 ki.ku	mum	1 (2)	2.998	1.47
king	応募 o.u.bo	application	2 (3)	3.951	4.87	秘密 hi.mi.tsu	secret	2 (3)	3.947	1.00
sun	体重 ta.i.ju.u	weight	2 (4)	3.648	4.60	教訓 kyo.u.ku.n	lesson	2 (4)	3.641	1.27

Kana: Filler (Spanish)

Picture	Related					Unrelated				
	Distractor	Meaning	Length	Frequency	Rating	Distractor	Meaning	Length	Frequency	Rating
apple	naranja	orange	7 (3)	1.380	4.86	cartera	wallet	7 (3)	1.613	1.07
donkey	camello	camel	7 (3)	1.568	5.07	tomate	tomato	6 (3)	1.079	1.43
fox	mapache	raccoon	7 (3)	1.114	5.00	sándwich	sandwich	8 (2)	0.000	1.00
frog	lagarto	lizard	7 (3)	1.041	4.79	jarrón	vase	6 (2)	1.000	1.14
grapes	durazno	peach	8 (3)	1.255	5.86	tostador	toaster	8 (3)	0.000	1.64
scissors	cuchillo	knife	8 (3)	1.000	5.57	cinturón	belt	8 (3)	1.672	1.21
squirrel	panda	panda	5 (2)	1.653	3.14	trineo	sled	6 (3)	0.000	1.00
strawberry	cereza	cherry	6 (3)	0.954	5.86	jirafa	giraffe	6 (3)	0.477	1.07

Kana: Filler (Japanese)

Picture	Related					Unrelated				
	Distractor	Meaning	Length	Frequency	Rating	Distractor	Meaning	Length	Frequency	Rating
apple	ミカン mi.ka.n	orange	3 (3)	3.156	4.86	ギター gi.ta.a	guitar	3 (3)	3.120	1.00
donkey	ラクダ ra.ku.da	camel	3 (3)	2.660	5.07	タンス ta.n.su	dresser	3 (3)	2.673	1.00
fox	タヌキ ta.nu.ki	raccoon	3 (3)	2.747	5.00	ドレス do.re.su	dress	3 (3)	2.769	1.00
frog	トカゲ to.ka.ge	lizard	3 (3)	2.535	4.79	サイロ sa.i.ro	barn	3 (3)	2.386	1.64
grapes	モモ mo.mo	peach	2 (2)	2.670	5.86	コイ ko.i	carp	2 (2)	2.667	1.93
scissors	ナイフ na.i.fu	knife	3 (3)	3.439	5.57	ベンチ be.n.chi	bench	3 (3)	3.468	1.07
squirrel	パンダ pa.n.da	panda	3 (3)	2.981	3.14	キャベツ kya.be.tsu	cabbage	4 (3)	3.076	1.36
strawberry	サクランボ sa.ku.ra.n.bo	cherry	5 (5)	2.521	5.86	チューリップ chu.u.ri.p.pu	tulip	6 (4)	2.622	2.71

Kanji: Filler (Spanish)

Picture	Related					Unrelated				
	Distractor	Meaning	Length	Frequency	Rating	Distractor	Meaning	Length	Frequency	Rating
arm	hombro	shoulder	6 (2)	2.283	5.50	cadena	chain	6 (3)	2.083	1.86
drum	flauta	flute	6 (2)	1.362	4.93	estufa	stove	6 (3)	1.000	1.29
gun	bomba	bomb	5 (2)	0.477	5.14	pipa	pipe	4 (2)	1.591	2.71
hand	pie	foot	3 (1)	3.041	4.86	oro	gold	3 (2)	2.286	2.07
hat	zapato	shoe	6 (3)	1.949	3.93	camión	truck	6 (2)	1.415	2.43
leaf	rama	branch	4 (2)	1.857	5.36	botón	button	5 (2)	1.708	1.21
pillow	manta	blanket	5 (2)	1.519	5.14	carro	wagon	5 (2)	1.690	1.14
sheep	elefante	elephant	8 (4)	1.041	4.00	tenedor	fork	7 (3)	1.114	1.36

Kanji: Filler (Japanese)

Picture	Related					Unrelated				
	Distractor	Meaning	Length	Frequency	Rating	Distractor	Meaning	Length	Frequency	Rating
arm	肩 ka.ta	shoulder	1 (2)	3.875	5.50	波 na.mi	wave	1 (2)	3.857	3.71
drum	笛 fu.e	flute	1 (2)	2.995	4.93	芝 shi.ba	grass	1 (2)	3.142	1.00
gun	爆弾 ba.ku.da.n	bomb	2 (4)	3.786	5.14	携帯 ke.i.ta.i	cell phone	2 (4)	3.810	1.79
hand	足 a.shi	foot	1 (2)	4.299	4.86	壁 ka.be	wall	1 (2)	4.165	1.21
hat	靴 ku.tsu	shoe	1 (2)	3.603	3.93	門 mo.n	gate	1 (2)	3.660	1.07
leaf	枝 e.da	branch	1 (2)	3.325	5.36	瓶 bi.n	bottle	1 (2)	3.266	1.00
pillow	毛布 mo.u.fu	blanket	2 (3)	3.099	5.14	豆腐 to.u.fu	tofu	2 (3)	3.184	1.00
sheep	象 zo.u	elephant	1 (2)	3.015	4.00	豆 ma.me	bean	1 (2)	3.005	1.43

APPENDIX F

PICTURE AND WORD STIMULI USED IN EXPERIMENT 3

Kana

English			Spanish			Japanese			List
Name	Length	Frequency	Name	Length	Frequency	Name	Length	Frequency	
ant	3 (1)	3.010	hormiga	7 (3)	0.570	アリ a.ri	2 (2)	3.010	kana 2A
apple	5 (2)	3.407	manzana	7 (3)	1.080	リンゴ ri.n.go	3 (3)	3.407	kana 1D
axe	3 (1)	2.607	hacha	5 (2)	0.860	おの o.no	2 (2)	2.607	kana 2B
bat	3 (1)	2.253	murciélago	10 (4)	0.610	コウモリ ko.u.mo.ri	4 (4)	2.253	kana 2A
bear	4 (1)	3.001	oso	3 (2)	1.090	クマ ku.ma	2 (2)	3.001	kana 2C
bee	3 (1)	2.925	abeja	5 (3)	0.660	ハチ ha.chi	2 (2)	2.925	kana 2B
bread	5 (1)	3.485	pan	3 (1)	1.750	パン pa.n	2 (2)	3.485	kana 2C

English			Spanish			Japanese			List
Name	Length	Frequency	Name	Length	Frequency	Name	Length	Frequency	
broom	5 (1)	2.520	escoba	6 (3)	0.590	ほうき ho.u.ki	3 (3)	2.520	kana 1B
butterfly	9 (3)	2.837	mariposa	8 (4)	0.860	チョウ cho.u	3 (2)	2.837	kana 1A
candle	6 (2)	2.720	vela	4 (2)	1.200	ろうそく ro.u.so.ku	4 (4)	2.720	kana 2D
cane	4 (1)	1.030	bastón	6 (2)	1.110	ツエ tsu.e	2 (2)	1.934	kana 2D
carrot	6 (2)	0.550	zanahoria	9 (4)	0.520	ニンジン ni.n.ji.n	4 (4)	3.222	kana 1A
chain	5 (1)	1.530	cadena	6 (3)	1.770	クサリ ku.sa.ri	3 (3)	1.204	kana 2A
chair	5 (1)	2.020	silla	5 (2)	1.690	いす i.su	2 (2)	3.503	kana 1B
cherry	6 (2)	0.840	cereza	6 (3)	0.280	サクランボ sa.ku.ra.n.bo	5 (5)	2.521	kana 2B
chicken	7 (2)	1.500	gallina	7 (3)	1.150	ニワトリ ni.wa.to.ri	4 (4)	2.901	kana 2D
clown	5 (1)	0.630	payaso	6 (3)	0.710	ピエロ pi.e.ro	3 (3)	2.223	kana 2C
comb	4 (1)	0.830	peine	5 (2)	0.780	くし ku.shi	2 (2)	3.166	kana 1C
corn	4 (1)	1.410	maíz	4 (2)	1.070	トウモロコシ to.u.mo.ro.ko.shi	6 (6)	3.143	kana 2B
crab	4 (1)	0.810	cangrejo	8 (3)	0.390	カニ ka.ni	2 (2)	3.069	kana 1C

English			Spanish			Japanese			List
Name	Length	Frequency	Name	Length	Frequency	Name	Length	Frequency	
deer	4 (1)	1.100	venado	6 (3)	0.520	シカ shi.ka	2 (2)	2.894	kana 1C
donkey	6 (2)	1.000	burro	5 (2)	1.170	ロバ ro.ba	2 (2)	2.509	kana 1A
dragonfly	9 (3)	0.290	libélula	8 (4)	0.320	トンボ to.n.bo	3 (3)	2.926	kana 2C
duck	4 (1)	1.080	pato	4 (2)	0.770	アヒル a.hi.ru	3 (3)	2.459	kana 1B
egg	3 (1)	1.580	huevo	5 (2)	1.330	タマゴ ta.ma.go	3 (3)	2.389	kana 1A
fence	5 (1)	1.370	cerco	5 (2)	1.080	さく sa.ku	2 (2)	3.190	kana 2B
fly	3 (1)	1.720	mosca	5 (2)	1.070	ハエ ha.e	2 (2)	2.642	kana 1B
fox	3 (1)	1.170	zorro	5 (2)	0.770	キツネ ki.tsu.ne	3 (3)	2.725	kana 2C
frog	4 (1)	0.730	rana	4 (2)	0.860	カエル ka.e.ru	3 (3)	2.900	kana 1D
glass	5 (1)	2.100	vaso	4 (2)	1.580	コップ ko.p.pu	3 (2)	2.959	kana 1D
glasses	7 (2)	1.720	lentes	6 (2)	0.950	メガネ me.ga.ne	3 (3)	2.825	kana 2C
goat	4 (1)	1.100	cabra	5 (2)	1.090	ヤギ ya.gi	2 (2)	2.618	kana 2D
grapes	6 (1)	0.950	uvas	4 (2)		ブドウ bu.do.u	3 (3)	3.084	kana 2D

English			Spanish			Japanese			List
Name	Length	Frequency	Name	Length	Frequency	Name	Length	Frequency	
gun	3 (1)	1.810	pistola	7 (3)	1.440	ピストル pi.su.to.ru	4 (4)	2.851	kana 1A
hammer	6 (2)	1.130	martillo	8 (3)	0.800	カナヅチ ka.na.zu.chi	4 (4)	1.580	kana 1C
kettle	6 (2)	1.080	tetera	6 (3)	0.320	やかん ya.ka.n	3 (3)	2.364	kana 2B
kite	4 (1)	0.600	cometa	6 (3)	0.930	たこ ta.ko	2 (2)	3.953	kana 1B
ladder	6 (2)	1.160	escalera	8 (4)	1.590	はしご ha.shi.go	3 (3)	2.645	kana 1A
mouse	5 (1)	0.960	ratón	5 (2)	0.930	ネズミ ne.zu.mi	3 (3)	3.240	kana 1B
mushroom	8 (2)	0.780	seta	4 (2)	0.130	キノコ ki.no.ko	3 (3)	2.943	kana 2A
nail	4 (1)	1.110	clavo	5 (2)	0.800	クギ ku.gi	2 (2)	3.200	kana 2D
octopus	7 (3)	0.390	pulpo	5 (2)	0.420	タコ ta.ko	2 (2)	2.831	kana 2C
onion	5 (2)	1.020	cebolla	7 (3)	1.020	タマネギ ta.ma.ne.gi	4 (4)	3.164	kana 1B
owl	3 (1)	0.600	búho	4 (2)	0.740	フクロウ fu.ku.ro.u	4 (4)	2.417	kana 1A
pepper	6 (2)	0.890	pimiento	8 (3)	0.420	ピーマン pi.i.ma.n	4 (4)	2.790	kana 2C
pumpkin	7 (2)	0.430	calabaza	8 (4)	0.540	カボチャ ka.bo.cha	4 (3)	2.849	kana 1C

English			Spanish			Japanese			List
Name	Length	Frequency	Name	Length	Frequency	Name	Length	Frequency	
rabbit	6 (2)	1.070	conejo	6 (3)	0.880	ウサギ u.sa.gi	3 (3)	3.137	kana 2B
raccoon	7 (2)		mapache	7 (3)	0.130	タヌキ ta.nu.ki	3 (3)	2.747	kana 1D
saw	3 (1)		serrucho	8 (3)	0.320	ノコギリ no.ko.gi.ri	4 (4)	2.369	kana 1D
scarf	5 (1)	0.950	bufanda	7 (3)	0.710	マフラー ma.fu.ra.a	4 (4)	2.548	kana 1A
scissors	8 (2)	0.730	tijeras	7 (3)	0.770	はさみ ha.sa.mi	3 (3)	2.995	kana 2A
shark	5 (1)	1.170	tiburón	7 (3)	0.570	サメ sa.me	2 (2)	2.550	kana 1D
shrimp	6 (1)	0.370	gamba	5 (2)	0.130	エビ e.bi	2 (2)	3.206	kana 2A
snail	5 (1)	0.550	caracol	7 (3)	0.800	カタツムリ ka.ta.tsu.mu.ri	5 (5)	2.196	kana 1C
snake	5 (1)	1.190	serpiente	9 (3)	1.090	ヘビ he.bi	2 (2)	2.727	kana 2B
spider	6 (2)	0.710	araña	5 (3)	0.900	クモ ku.mo	2 (2)	2.521	kana 2D
squirrel	8 (2)	0.660	ardilla	7 (3)	0.960	リス ri.su	2 (2)	2.350	kana 2A
strawberry	10 (3)	0.580	fresa	5 (2)	0.590	イチゴ i.chi.go	3 (3)	2.744	kana 1B
sunflower	9 (3)	0.330	girasol	7 (3)	0.280	ひまわり hi.ma.wa.ri	4 (4)	2.763	kana 1D

English			Spanish			Japanese			List
Name	Length	Frequency	Name	Length	Frequency	Name	Length	Frequency	
tail	4 (1)	1.520	cola	4 (2)	1.580	しっぽ shi.p.po	3 (3)	2.707	kana 1C
watermelon	10 (4)		sandía	6 (3)	0.320	スイカ su.i.ka	3 (3)	2.759	kana 1C
whale	5 (1)	0.860	ballena	7 (3)	0.610	クジラ ku.ji.ra	3 (3)	3.135	kana 2D
wig	3 (1)	0.890	peluca	6 (3)	0.500	かつら ka.tsu.ra	3 (3)	2.644	kana 2A
worm	4 (1)	0.920	gusano	6 (3)	0.720	ミミズ mi.mi.zu	3 (3)	2.303	kana 1D

Kanji

English			Spanish			Japanese			List
Name	Length	Frequency	Name	Length	Frequency	Name	Length	Frequency	
airplane	8 (2)	0.710	avión	5 (3)	1.710	飛行機 hi.ko.u.ki	3 (4)	3.775	kanji 2B
arm	3 (1)	2.030	brazo	5 (2)	1.860	腕 u.de	1 (2)	3.753	kanji 1B
arrow	5 (2)	0.960	flecha	6 (2)	0.740	矢 ya	1 (1)	2.886	kanji 1C
ashtray	7 (2)	0.800	cenicero	8 (4)	0.870	灰皿 ha.i.za.ra	2 (4)	2.562	kanji 2D
balloon	7 (2)	0.630	globo	5 (2)	1.050	風船 fu.u.se.n	2 (4)	2.906	kanji 1A
bone	4 (1)	1.450	hueso	5 (2)	1.210	骨 ho.ne	1 (2)	3.800	kanji 1D
book	4 (1)	2.440	libro	5 (2)	2.290	本 ho.n	1 (2)	4.496	kanji 1D
bookshelf	9 (1)	0.210	estante	7 (3)	0.540	本棚 ho.n.da.na	2 (4)	2.611	kanji 2B
box	3 (1)	1.900	caja	4 (2)	1.660	箱 ha.ko	1 (2)	3.771	kanji 2B
bridge	6 (1)	1.790	puente	6 (2)	1.560	橋 ha.shi	1 (2)	3.599	kanji 2B

English			Spanish			Japanese			List
Name	Length	Frequency	Name	Length	Frequency	Name	Length	Frequency	
car	3 (1)	2.440	coche	5 (2)	2.090	車 ku.ru.ma	1 (3)	4.740	kanji 1B
cat	3 (1)	1.630	gato	4 (2)	1.590	猫 ne.ko	1 (2)	3.444	kanji 1B
church	6 (1)	2.200	iglesia	7 (3)	2.040	教会 kyo.u.ka.i	2 (4)	3.772	kanji 1B
clock	5 (1)	1.560	reloj	5 (2)	1.710	時計 to.ke.i	2 (3)	3.466	kanji 1C
cow	3 (1)	1.370	vaca	4 (2)	1.080	牛 u.shi	1 (2)	3.661	kanji 2B
desk	4 (1)	1.920	escritorio	10 (4)	1.030	机 tsu.ku.e	1 (3)	3.611	kanji 1B
dog	3 (1)	1.860	perro	5 (2)	1.790	犬 i.nu	1 (2)	3.624	kanji 2C
doll	4 (1)	1.270	muñeca	6 (3)	1.190	人形 ni.n.gyo.u	2 (4)	3.528	kanji 2A
drum	4 (1)	0.990	tambor	6 (2)	0.890	太鼓 ta.i.ko	2 (3)	3.141	kanji 2D
ear	3 (1)	1.630	oreja	5 (3)	1.360	耳 mi.mi	1 (2)	4.021	kanji 1C
envelope	8 (3)	1.300	sobre	5 (2)		封筒 fu.u.to.u	2 (4)	3.268	kanji 2D
eye	3 (1)	2.110	ojo	3 (2)	1.860	目 me	1 (1)	4.706	kanji 2A
fan	3 (1)	1.100	ventilador	10 (4)	0.570	扇風機 se.n.pu.u.ki	3 (5)	2.601	kanji 1B

English			Spanish			Japanese			List
Name	Length	Frequency	Name	Length	Frequency	Name	Length	Frequency	
finger	6 (2)	1.700	dedo	4 (2)	1.720	指 yu.bi	1 (2)	3.504	kanji 2B
fish	4 (1)	2.240	pez	3 (1)	1.220	魚 sa.ka.na	1 (3)	3.858	kanji 1A
flag	4 (1)	1.320	bandera	7 (3)	1.550	旗 ha.ta	1 (2)	3.473	kanji 1C
glove	5 (1)	0.750	guante	6 (2)	0.970	手袋 te.bu.ku.ro	2 (4)	2.915	kanji 1A
hair	4 (1)	2.280	pelo	4 (2)	2.010	髪 ka.mi	1 (2)	3.516	kanji 2C
hand	4 (1)	2.660	mano	4 (2)	2.590	手 te	1 (1)	4.705	kanji 1A
hat	3 (1)	1.730	sombrero	8 (3)	1.500	帽子 bo.u.shi	2 (3)	3.254	kanji 2A
horse	5 (1)	1.930	caballo	7 (3)	1.810	馬 u.ma	1 (2)	3.656	kanji 1C
house	5 (1)	2.750	casa	4 (2)	2.800	家 i.e	1 (2)	4.516	kanji 2D
key	3 (1)	1.860	llave	5 (2)	1.380	鍵 ka.gi	1 (2)	2.589	kanji 2A
king	4 (1)	1.960	rey	3 (1)	2.130	王 o.u	1 (2)	3.620	kanji 2A
leaf	4 (1)	1.220	hoja	4 (2)	1.430	葉 ha	1 (1)	3.630	kanji 2C
leg	3 (1)	1.810	pierna	6 (2)	1.410	足 a.shi	1 (2)	4.299	kanji 2D

English			Spanish			Japanese			List
Name	Length	Frequency	Name	Length	Frequency	Name	Length	Frequency	
lighthouse	10 (2)	0.560	faro	4 (2)	0.710	灯台 to.u.da.i	2 (4)	2.719	kanji 1D
magnet	6 (2)	0.550	imán	4 (2)	0.780	磁石 ji.sha.ku	2 (3)	2.810	kanji 1A
mirror	6 (2)	1.620	espejo	6 (3)	1.820	鏡 ka.ga.mi	1 (3)	3.314	kanji 2B
moon	4 (1)	1.730	luna	4 (2)	1.730	月 tsu.ki	1 (2)	4.193	kanji 1B
needle	6 (2)	1.060	aguja	5 (3)	1.000	針 ha.ri	1 (2)	3.377	kanji 1A
nurse	5 (1)	1.530	enfermera	9 (4)	1.160	看護婦 ka.n.go.fu	3 (4)	3.913	kanji 1D
pencil	6 (2)	1.220	lápiz	5 (2)	0.900	鉛筆 e.n.pi.tsu	2 (4)	3.100	kanji 1B
pig	3 (1)	1.280	cerdo	5 (2)	1.170	豚 bu.ta	1 (2)	3.156	kanji 2D
pillow	6 (2)	1.170	almohada	8 (4)	1.030	枕 ma.ku.ra	1 (3)	2.444	kanji 2C
rain	4 (1)	1.860	lluvia	6 (2)	1.780	雨 a.me	1 (2)	4.088	kanji 2D
ring	4 (1)	1.830	anillo	6 (3)	1.200	指輪 yu.bi.wa	2 (3)	3.032	kanji 1C
road	4 (1)	2.330	carretera	9 (4)	1.640	道路 do.u.ro	2 (3)	4.286	kanji 1C
roof	4 (1)	1.680	techo	5 (2)	1.610	屋根 ya.ne	2 (2)	3.642	kanji 1A

English			Spanish			Japanese			List
Name	Length	Frequency	Name	Length	Frequency	Name	Length	Frequency	
sheep	5 (1)	1.610	oveja	5 (3)	0.880	羊 hi.tsu.ji	1 (3)	3.087	kanji 1D
shell	5 (1)	1.470	concha	6 (2)	0.960	貝 ka.i	1 (2)	3.131	kanji 2A
shoe	4 (1)	1.190	zapato	6 (3)	1.150	靴 ku.tsu	1 (2)	3.603	kanji 1D
sock	4 (1)	0.600	calcetín	8 (3)	0.390	靴下 ku.tsu.shi.ta	2 (4)	2.810	kanji 2C
stairs	6 (1)	1.670	escalera	8 (4)	1.590	階段 ka.i.da.n	2 (4)	3.566	kanji 2A
sun	3 (1)	2.190	sol	3 (1)	2.270	太陽 ta.i.yo.u	2 (4)	3.722	kanji 2B
swan	4 (1)	0.810	cisne	5 (2)	0.620	白鳥 ha.ku.cho.u	2 (4)	2.709	kanji 1C
tree	4 (1)	1.860	árbol	5 (2)	1.560	木 ki	1 (1)	4.063	kanji 1A
umbrella	8 (3)	1.090	paraguas	8 (3)	1.130	傘 ka.sa	1 (2)	3.232	kanji 2D
vase	4 (1)	0.700	jarrón	6 (2)	0.690	壺 tsu.bo	1 (2)	2.741	kanji 1D
wheel	5 (1)	1.480	rueda	5 (2)	1.380	車輪 sha.ri.n	2 (3)	2.976	kanji 1D
whistle	7 (2)	1.030	silbato	7 (3)	0.420	笛 fu.e	1 (2)	2.995	kanji 2C
windmill	8 (2)	0.880	molino	6 (3)	0.980	風車 fu.u.sha	2 (3)	2.539	kanji 2A

English			Spanish			Japanese			List
Name	Length	Frequency	Name	Length	Frequency	Name	Length	Frequency	
window	6 (2)	2.130	ventana	7 (3)	1.980	窓 ma.do	1 (2)	3.787	kanji 2C
witch	5 (1)	1.220	bruja	5 (2)	1.020	魔女 ma.jo	2 (2)	2.515	kanji 2C

APPENDIX G

LANGUAGE HISTORY QUESTIONNAIRE

Participant # _____ **Date ____________**

Language History Questionnaire

This questionnaire is designed to give us a better understanding of your experience with other languages. We ask that you be as accurate and thorough as possible when answering the following questions.

Sex: M / F **Age: ______** **Native country: _____________**

Where do you currently live? City: ____________ Country: _________________

1.) Do you have any known visual or hearing problems (corrected or uncorrected)?

- ❑ No
- ❑ Yes [Please explain] ____

2.) What is your first language (i.e., **language first spoken**)? If more than one, please briefly describe the situations in which each language was used.

____

____

3.) What languages were spoken in your home while you were a child and by whom?

____

____

____

4.) If you have ever lived in or visited (**for more than one month**) a country where languages other than your native language were spoken, please indicate below the name of the country, the number of months you visited, and which languages you spoke while in the country. Please indicate if you were spoken to in a language other than your first language, even if you never actually spoke that language.

Country visited	Date (year)	# Months there	Language(s) used

How long have you lived in English speaking countries in total? _____year(s) _____month(s)

5.) List below, from most fluent to least fluent, all of the languages you know. Also specify the age at which you began to learn the language and the context in which you learned it. For example, "English, birth, home," "English, age 13, school and study abroad," or "English, age 7, living abroad and school." Include all languages to which you have been exposed (spoken), although you may never have had formal training in them and may not be able to read, speak, or write them.

Please remember to list your native language.

Language	Age	Learning Situation

6.) Are you currently enrolled in any language courses or any courses instructed in a second language?

- ❑ No
- ❑ Yes **If YES, in which language(s) and what?**

Language	Content

7.) Please rate your **native language** reading proficiency on a ten-point scale.

1	2	3	4	5	6	7	8	9	10
not literate									very literate

8.) Please rate your **native language** writing proficiency on a ten-point scale.

1	2	3	4	5	6	7	8	9	10
not literate									very literate

9.) Please rate your **native language** conversational fluency on a ten-point scale.

1	2	3	4	5	6	7	8	9	10
not fluent									very fluent

10.) Please rate your **native language** speech comprehension ability on a ten-point scale.

1	2	3	4	5	6	7	8	9	10
unable to understand conversation									perfectly able to understand conversation

11.) What languages **other than native language** do you <u>speak</u> fluently?

12.) What languages **other than native language** do you <u>read</u> fluently?

13.) What languages **other than native language** do you <u>write</u> fluently?

14.) What languages **other than native language** do you <u>understand</u> when spoken?

15.) Please rate your **English** <u>reading</u> proficiency on a ten-point scale.

1	2	3	4	5	6	7	8	9	10
not literate									very literate

16.) Please rate your **English** <u>writing</u> proficiency on a ten-point scale.

1	2	3	4	5	6	7	8	9	10
not literate									very literate

17.) Please rate your **English** <u>conversational fluency</u> on a ten-point scale.

1	2	3	4	5	6	7	8	9	10
not fluent									very fluent

18.) Please rate your **English** <u>speech comprehension ability</u> on a ten-point scale.

1	2	3	4	5	6	7	8	9	10
unable to understand conversation									perfectly able to understand conversation

19.) How would you rate your second language **learning** skills, not your second language skills?

worse than average | average | better than average

20.) When learning a second language, which of the following do you find easier or harder to learn? Please rate the following on a ten-point scale. (1= hardest, 10 = easiest)

Pronunciation: ______ Reading: ______

Grammar: ______ Writing: ______

Vocabulary: ______ Speaking: ______

Sayings/Expressions: ______ Listening: ______

21.) What percentage of the time do you spend using your **native language**—reading, writing, speaking, and listening (when you are awake)? ____%

22.) What percentage of the time do you spend using **English**—reading, writing, speaking and listening (when you are awake)? ____%

23.) How often do you read **in your native language**? (1 = not at all, 10 = always)

1	2	3	4	5	6	7	8	9	10
not at all		rarely		sometimes			often		always

24.) How often do you read **in English**? (1 = not at all, 10 = always)

1	2	3	4	5	6	7	8	9	10
not at all		rarely		sometimes			often		always

25.) How often do you write **in your native language**? (1 = not at all, 10 = always)

1	2	3	4	5	6	7	8	9	10
not at all		rarely		sometimes			often		always

26.) How often do you write **in English**? (1 = not at all, 10 = always)

1	2	3	4	5	6	7	8	9	10
not at all		rarely		sometimes			often		always

27.) How often do you speak **in your native language**? (1 = not at all, 10 = always)

1	2	3	4	5	6	7	8	9	10
not at all		rarely		sometimes			often		always

28.) How often do you speak **in English**? (1 = not at all, 10 = always)

1	2	3	4	5	6	7	8	9	10
not at all		rarely		sometimes			often		always

29.) How often do you watch TV programs/movies or listen to lectures/radio/conversations **in your native language**? (1 = not at all, 10 = always)

1	2	3	4	5	6	7	8	9	10
not at all		rarely		sometimes			often		always

30.) How often do you watch TV programs/movies or listen to lectures/radio/conversations **in English**? (1 = not at all, 10 = always)

1	2	3	4	5	6	7	8	9	10
not at all		rarely		sometimes			often		always

31.) Is there anything else about your language background that you would like to comment on? Please feel free to make comments about things that were not covered on this questionnaire.

APPENDIX H

WORD AND NONWORD STIMULI USED IN LEXICAL DECISION TASK

Item	Word	Meaning	Relatedness	Letter	Frequency	Neighbor	NOM	R
rare	word	few	low	4	41	17	3	2.92
mine	word	few	low	4	59	27	4	2.98
watch	word	few	low	5	81	9	4	1.95
firm	word	few	low	4	109	5	4	1.84
fast	word	few	low	4	78	13	3	2.48
rich	word	few	low	4	74	5	4	2.63
dull	word	few	high	4	27	15	4	4.21
ship	word	few	high	4	83	11	2	4.21
dust	word	few	high	4	70	12	3	4.26
drink	word	few	high	5	82	5	3	5.04
slip	word	many	low	4	19	11	8	2.72
stick	word	many	low	5	39	6	8	2.68
ring	word	many	low	4	47	13	9	2.84
scale	word	many	low	5	60	7	9	2.79
check	word	many	low	5	88	4	9	2.08
pitch	word	many	low	5	22	9	7	2.45
cross	word	many	low	5	55	6	6	2.09
blank	word	many	high	5	14	7	6	3.81
smoke	word	many	high	5	41	4	8	3.81
clean	word	many	high	5	70	3	7	5.20
file	word	many	high	4	81	16	8	3.71
share	word	many	high	5	98	16	6	4.51
dump	word	many	high	4	4	9	6	3.94
bill	word	many	high	4	143	17	6	3.52
pound	word	few	low	5	28	7	4	1.54
chest	word	few	low	5	53	4	2	2.11
trip	word	few	low	4	81	8	4	2.00
date	word	few	low	4	103	21	4	2.22
hide	word	few	low	4	22	13	2	1.64
park	word	few	low	4	94	15	2	1.76
ball	word	few	low	4	110	20	4	1.57
bomb	word	few	high	4	36	4	4	4.32
story	word	few	high	5	153	4	3	3.63
card	word	few	high	4	26	14	3	3.55
shop	word	few	high	4	63	12	3	3.96
rule	word	few	high	4	73	9	3	3.71

Item	Word	Meaning	Relatedness	Letter	Frequency	Neighbor	NOM	R
land	word	few	high	4	217	15	4	3.67
strip	word	many	low	5	30	4	7	2.15
cast	word	many	low	4	45	19	8	2.12
draw	word	many	low	4	56	6	10	1.32
sharp	word	many	low	5	72	5	7	2.89
stock	word	many	low	5	147	6	7	2.24
plot	word	many	low	4	37	8	6	2.93
club	word	many	low	4	145	2	6	1.90
lock	word	many	high	4	23	16	6	4.16
bound	word	many	high	5	42	7	9	3.68
round	word	many	high	5	81	7	13	3.51
cover	word	many	high	5	88	13	10	4.09
fine	word	many	high	4	161	23	9	3.53
chip	word	many	high	4	17	11	6	3.83
floor	word	many	high	5	158	3	6	3.58
limit	word	few	high	5	48	0	3	5.84
safe	word	few	high	4	58	8	3	5.79
charm	word	few	high	5	26	3	4	3.56
coat	word	few	high	4	43	8	4	4.83
tire	word	few	low	4	22	11	3	1.06
beaf	nonword							
korn	nonword							
durt	nonword							
doar	nonword							
feer	nonword							
frum	nonword							
heet	nonword							
jeap	nonword							
jirk	nonword							
lyne	nonword							
lyke	nonword							
neet	nonword							
roze	nonword							
scid	nonword							
scin	nonword							
soop	nonword							
tyme	nonword							
dreem	nonword							
furst	nonword							
grean	nonword							
leesh	nonword							
skalp	nonword							
shurt	nonword							
theef	nonword							

Item	Word	Meaning	Relatedness	Letter	Frequency	Neighbor	NOM	R
surve	nonword							
skore	nonword							
errur	nonword							
aftur	nonword							
elboe	nonword							
sneek	nonword							
nurve	nonword							
wheet	nonword							
burth	nonword							
treet	nonword							
swerl	nonword							
sheap	nonword							
speer	nonword							
majic	nonword							
muzic	nonword							
wheal	nonword							
berch	nonword							
proze	nonword							
speek	nonword							
urbin	nonword							
phaze	nonword							
leest	nonword							
durby	nonword							
panzy	nonword							
sheat	nonword							
leef	nonword							
teem	nonword							
hert	nonword							
ferm	nonword							
amuze	nonword							
skar	nonword							
bernt	nonword							

Note. The “R” and “NOM” refers to the number of meanings and relatedness ratings from Azuma and Van Orden (1997).

APPENDIX I

WORD AND EQUATION STIMULI USED IN OPERATION SPAN TASK

Equation	Correct Response	Word
(18 / 3) - 4 = 2	yes	hotel
(4 * 1) + 2 = 2	no	author
(16 * 1) - 9 = 7	yes	poem
(10 / 1) - 2 = 3	no	mouth
(7 * 2) - 6 = 8	yes	piano
(9 / 3) - 1 = 6	no	tree
(20 / 2) - 9 = 1	yes	foot
(8 / 8) + 6 = 3	no	rain
(14 * 1) - 8 = 6	yes	group
(14 / 7) + 2 = 4	yes	clock
(6 * 1) + 2 = 3	no	dust
(2 * 2) + 5 = 9	yes	island
(10 / 5) + 1 = 3	yes	dinner
(5 * 2) - 5 = 9	no	bottle
(10 / 5) + 3 = 9	no	hill
(12 / 2) - 4 = 2	yes	lake
(12 / 2) - 5 = 6	no	king
(6 * 2) - 8 = 9	no	girl
(5 * 2) - 7 = 3	yes	bank
(10 / 1) - 1 = 9	yes	moon
(20 / 5) + 5 = 5	no	sign
(6 * 1) + 1 = 7	yes	guide
(18 * 1) - 9 = 4	no	bridge
(12 / 6) + 3 = 1	no	chain
(15 * 1) - 7 = 2	no	knife
(20 / 4) - 3 = 2	yes	world
(3 * 1) + 1 = 4	yes	pipe
(14 / 2) - 1 = 6	yes	leaf
(5 * 3) - 9 = 2	no	site
(14 / 7) + 1 = 9	no	train
(3 * 3) - 6 = 8	no	band
(3 * 2) + 3 = 9	yes	plan
(15 / 3) - 1 = 9	no	rifle
(7 / 7) + 1 = 2	yes	nail
(8 * 2) - 9 = 3	no	black
(18 / 9) + 5 = 3	no	paper
(4 * 1) + 3 = 7	yes	lion
(18 / 2) - 6 = 8	no	radio

Equation	Correct Response	Word
(5 * 1) + 3 = 8	yes	finger
(16 / 2) - 5 = 3	yes	street
(2 * 4) + 1 = 9	yes	team
(2 * 4) - 2 = 2	no	hand
(4 * 2) - 2 = 2	no	boat
(4 * 1) + 1 = 5	yes	face
(9 / 3) + 2 = 5	yes	valley
(3 * 2) + 1 = 3	no	wine
(7 / 7) + 5 = 2	no	pear
(8 / 2) - 2 = 2	yes	line
(16 * 1) - 8 = 8	yes	wall
(7 * 2) - 9 = 9	no	floor
(9 / 3) - 2 = 1	yes	tooth
(6 * 2) - 3 = 9	yes	rock
(15 / 3) - 4 = 1	yes	cloud
(20 / 4) + 3 = 3	no	month
(12 / 4) + 4 = 7	yes	beach
(16 / 8) + 4 = 1	no	oven
(9 * 2) - 9 = 5	no	rule
(2 * 3) + 2 = 4	no	flower
(15 / 5) + 2 = 9	no	skirt
(8 * 1) + 1 = 9	yes	coast

Vita
Noriko Hoshino

Education

2006 Ph.D. in Psychology with an Option in Applied Linguistics, The Pennsylvania State University
2003 Master of Science in Psychology, The Pennsylvania State University
2001 Certificate of Major in Psychology, Randolph-Macon Woman's College
1999 Bachelor of Arts in English, Tsuda College

Research Support

2005-2006 National Science Foundation Dissertation Research Grant (with Judith F. Kroll). BCS-0518814: *A psycholinguistic study of native language constraints on speaking words in a second language* ($11,960)
2005 Dissertation Support Grant, College of the Liberal Arts Research and Graduate Studies Office, The Pennsylvania State University (release time)
2005 Eileen Wirtshafter and Herschel W. Leibowitz Graduate Scholarship, Department of Psychology, Pennsylvania State University

Selected Publications

Hoshino, N., & Kroll, J. F. (under review). Cognate effects in picture naming: Does cross-language activation survive a change of script?

Hoshino, N., Dussias, P. E., & Kroll, J. F. (in preparation). Producing subject-verb agreement: Does L1 syntax influence L2 performance?

Hoshino, N., Dussias, P. E., & Kroll, J. F. (in preparation). *The role of conceptual resources in guiding the production of subject-verb agreement in bilingual and monolingual speakers.*

Selected Presentations and Invited Colloquia

Hoshino, N., & Kroll, J. F. (2006, October). *The role of script in bilingual word production.* Paper presented at the Fifth International Conference on the Mental Lexicon, Montreal, Canada.

Hoshino, N., & Kroll, J. F. (2005, November). *Cross-language activation of phonology in bilingual production.* Poster presented at the annual meeting of the Psychonomic Society, Toronto, Canada.

Hoshino, N. (2005, October). *Language production in bilinguals: Does cross-language similarity matter?* Invited research talk given at the Center for Language Research, University of California, San Diego, La Jolla, CA.

Hoshino, N., & Kroll, J. F. (2005, March). *Cognate effects in picture naming: Does cross-language activation survive a change of script?* Paper presented at the 5th meeting of the International Symposium on Bilingualism, Barcelona, Spain.

Hoshino, N. (2004, June). *Production of subject-verb agreement in monolingual and bilingual speakers*. Invited research talk given at the Netherlands Institute for Cognition and Information, University of Nijmegen, Nijmegen, The Netherlands.

Hoshino, N., Dussias, P. E., & Kroll, J. F. (2003, May). *Production of subject-verb agreement in second language learners and proficient bilinguals.* Paper presented at the 4th meeting of the International Symposium of Bilingualism, Tempe, AZ.

Hoshino, N., Dussias, P. E., & Kroll, J. F. (2002, November). *Production of subject-verb agreement in monolingual and bilingual speakers.* Poster presented at the annual meeting of the Psychonomic Society, Kansas City, MO.

Selected Awards/Honors

2006 Fellowship, John Merck Fund Summer Institute on the Biology of Developmental Disabilities at Princeton University
2005 Travel Grant, College of the Liberal Arts Research and Graduate Studies Office, The Pennsylvania State University
2001 Departmental Honors, Randolph-Macon Woman's College
1999 Taizo Ishizaka Award, Graduation Honors, Tsuda College