NORTHWESTERN UNIVERSITY

Linguistic and Cognitive Mechanisms in Foreign Vocabulary Acquisition

A DISSERTATION

SUBMITTED TO THE GRADUATE SCHOOL

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS

for a degree

DOCTOR OF PHILOSOPHY

Field of Communication Sciences and Disorders

By

Margarita Kaushanskaya

EVANSTON, ILLINOIS

June 2007

ABSTRACT

Linguistic and Cognitive Mechanisms in Foreign Vocabulary Acquisition

Margarita Kaushanskaya

The general goal of this dissertation research was to examine linguistic and cognitive mechanisms in foreign vocabulary learning within theoretical frameworks of working memory and connectionist word processing models.

In *Study 1*, the effect of bimodal (auditory-and-visual) vs. unimodal (auditory-only) presentation on foreign word learning was examined at different levels of cross-linguistic overlap. Monolingual English-speaking adults were randomly assigned to one of four foreign-language conditions, where the overlap in phonological and orthographic properties between the foreign language and English was manipulated orthogonally. Results revealed that bimodal learning improved retention of foreign words that matched English in both phonology and orthography, but hindered retention of foreign words that mismatched English in phonology, orthography, or both. Findings suggest that bimodal exposure and cross-linguistic similarity interact to influence foreign word learning.

In *Study 2*, the effects of two different types of language-learning experience on foreign vocabulary acquisition were examined. Foreign-word learning performance was compared across monolingual English speakers, English-Spanish bilinguals, and English-Mandarin bilinguals. Compared to monolinguals, both groups of bilinguals were more accurate at retrieving newly-learned foreign words, suggesting that bilingualism is generally advantageous for further language learning. However, within each bilingual group, different patterns of performance were observed. Findings suggest that language-learning experience can modify subsequent language-learning processes, and that a particular bilingual experience influences subsequent language-

learning in specific and consistent ways. Exploratory follow-up analyses also suggest that the bilingual advantage for foreign word learning is mediated by age-of-acquisition and proficiency in the second language.

Together, the two studies contribute to cognitive models of language processing and working memory, and suggest that long-term knowledge associated with native-language letter-to-phoneme mappings influences foreign word learning, and that the language-learning process can be modulated by linguistic experience. The dissertation findings also offer practical suggestion for structuring ESL curriculum, and for planning speech-and-language treatment with bilingual clients, and can be used as guidelines for choosing the preferred teaching modality during early stages of L2 acquisition, for determining the age for L2 exposure to maximize the bilingual advantage, and for selecting the cognitive skills to target in speech-language treatment with L2 learners.

ACKNOWLEDGMENTS

This work was supported in part by NSF grant BCS0617455 and by Joseph Levin Foundation Scholarship to Margarita Kaushanskaya and by NSF grant BCS0418495 and NICHD grant 1R03HD046952-01A1 to Viorica Marian. It would not exist without the generous and unconditional support from Dr. Viorica Marian, and without the encouragement from my committee members, Dr. James Booth, Dr. Doris Johnson, and Dr. Karla McGregor. I would especially like to thank Henrike Blumenfeld for being a willing intellectual-combat partner during the last six years, and throughout the duration of this research. This work would not be possible without the people who contributed to it during all of its stages – Matthew Fitzgerald, who lent his voice to stimulus recordings; Bronwyn Woods, who helped with data collection; Tina Yao, Swapna Musunuru, Kylee Williamson, and Erica Meeks, who helped with data coding; Nicole Stanziale, who assisted with stimulus selection; and all members of the *Bilingualism and Psycholinguistics Laboratory*, who provided helpful comments and suggestions on this work.

To my parents.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I. LINGUISTIC AND COGNITIVE MECHANISMS IN FOREIGN VOCABULARY ACQUISITION

1.1 Theoretical and Clinical Need for Research on Second Language Acquisition

Knowing a second language is becoming the norm in the world of today. In the United States, many schools require students to take foreign language courses, and virtually all colleges and universities have a foreign language requirement (e.g., Huber, 1992). At the same time, the population of English-learners in the United States is also increasing, with more people emigrating from countries around the world into the United States. According to US Census data, among 262.4 million people aged 5 and over, 47.0 million (18%) spoke a language other than English at home in 2000, and these numbers are steadily increasing. Given the global trend towards multilingualism, understanding of mechanisms underlying language learning, and formulation of efficient and successful second language learning strategies is becoming increasingly necessary. The need for research on second language learning becomes especially clear in light of US Census data showing that while the number of non-English speakers in the United States is growing, the proportion of people who speak English “less than very well” is also increasing. In fact, the population of English speakers who rate themselves as “less than very proficient” has grown from 4.8% in 1980, to 6.1% in 1990, and to 8.1% in 2000. Research shows that low language proficiency carries social, cultural, occupational, and financial consequences. For instance, low English proficiency was found to affect high school dropout rates (McMillan, Kaufman, & Klein, 1997), as well as various clinical outcomes, including increased length of hospitalization (John-Baptiste et al., 2004). Yet, mechanisms underlying foreign language learning remain unclear and under-studied, and bilingual populations continue to be under-served in areas of education, special education, and speech-language pathology.

The goal of this dissertation research is to examine cognitive and linguistic mechanisms underlying foreign vocabulary acquisition in adults within the theoretical frameworks of working memory and connectionist word processing models.

1.2 Dissertation Overview: Objectives, Hypotheses, and Predictions

It is the goal of this dissertation research to examine linguistic and cognitive mechanisms underlying foreign vocabulary acquisition by testing the influence of native-language knowledge on working memory function during foreign vocabulary learning in monolingual and bilingual adults. This work is based on the idea that the overlap between the foreign language and the native language makes it more likely that learning of the foreign language will rely on knowledge of the native language. Therefore, influence of native-language knowledge on foreign word learning was examined by manipulating the degree of cross-linguistic overlap between the native language (English) and the artificially-constructed foreign language. The cross-linguistic overlap between the native and the foreign language was manipulated along the phonological and the orthographic dimension in an orthogonal manner.

Specific objectives of this dissertation research were three-fold:

<u>Objective 1:</u> The first objective of the present research was to examine the effects of cross-linguistic similarity on foreign vocabulary learning (Study 1).

<u>Objective 2:</u> The second objective of the present research was to examine the interaction between cross-linguistic similarity and learning modality on foreign vocabulary learning (Study 1).

<u>Objective 3:</u> The third objective of the present research was to examine the effect of language-learning experience on foreign vocabulary acquisition (Study 2).

Study 1 was designed to examine the effects of cross-linguistic similarity (both phonological *and* orthographic, phonological-only, orthographic-only, or neither phonological *nor* orthographic) on foreign vocabulary acquisition. Study 1 also tested the interaction between cross-linguistic similarity and modality of learning (unimodal, i.e., auditory-only vs. bimodal, i.e., auditory-and-visual) during foreign vocabulary learning. Monolingual speakers of English learned foreign vocabulary items that were based on four different alphabet versions, where phonological similarity and orthographic similarity to English were manipulated orthogonally. Monolingual speakers of English across the four conditions learned half of the foreign vocabulary items in auditory-only modality, and half - in auditory-and-visual modality. It was hypothesized that cross-linguistic mismatch in orthography-to-phonology mappings would impact foreign vocabulary learning. It was also hypothesized that presence of orthographic information at encoding (auditory-and-visual modality) would interact with cross-linguistic similarity in letter-to-phoneme mappings across the foreign and the native languages.

Study 2 was designed to examine the effect of foreign-language experience on foreign vocabulary acquisition. Monolingual speakers of English were compared to bilingual speakers of *English* and *Spanish* and to bilingual speakers of *English* and *Mandarin.* All participants learned foreign vocabulary items that contained non-English sounds, but maintained English letters (*-P+O Condition*). Spanish and Mandarin were chosen as languages of interest due to their different degrees of similarity to English and to the artificially-constructed foreign vocabulary. Spanish, like the artificially-constructed foreign vocabulary, uses a sound inventory that is different from English, but maintains the Roman alphabet. Thus, bilingual speakers of English and Spanish have experienced cross-linguistic mismatch in letter-to-phoneme mappings similar to the cross-linguistic mismatch that exists between English and -P+O foreign vocabulary items.

Mandarin, unlike the artificially-constructed foreign vocabulary, does not rely on the alphabet in order to express its sound inventory, but uses logographic symbols, instead. Thus, bilingual speakers of English and Mandarin have experienced a cross-linguistic mismatch in phonological and writing systems, but have *not* experienced a cross-linguistic mismatch in letter-to-phoneme mappings. It was hypothesized that bilingual speakers would outperform monolingual speakers of English on their ability to learn foreign vocabulary items. It was also hypothesized that different groups of bilingual speakers would demonstrate distinct learning profiles, due to differences in their linguistic backgrounds.

1.3 Theoretical and Clinical/Educational Implications of L2 Acquisition R esearch

Research described in this dissertation can widely inform memory models and language learning theories by testing the interaction between cross-linguistic similarity and learning modality, on the one hand, and by examining the influence of language-learning experience on foreign vocabulary acquisition, on the other hand. Study 1 findings can help uncover linguistic mechanisms underlying learning benefits associated with similarity between the foreign and the native languages. Previous work suggests that learning a second language when it is similar to the native language is less subject to critical period phenomena (De Keyser, 2000). This benefit, as well as the general vocabulary-learning benefit associated with cross-linguistic similarity (e.g., Ellis & Beaton, 1993; Gathercole, Willis, Emslie, & Baddeley; 1991; Papagno & Vallar, 1992; Service & Craik, 1993) is attributed to the involvement of long-term memory in the learning process. When the foreign language matches the native language, foreign-language information can be integrated into the existing memory system with greater ease. However, it remains unknown what specific linguistic characteristics make foreign language learning easier or more difficult. In this research, the overlap between orthographic and phonological properties of the foreign and the native linguistic systems was manipulated orthogonally, making it possible to uncover the graded effects of cross-linguistic mismatch on foreign vocabulary learning. Similarly, previous work consistently demonstrates that bimodal exposure to a linguistic stimulus (e.g., both auditory and visual) benefits language processing (e.g., Dijkstra, Fraunfelder, & Schreuder, 1993). However, the effect of bimodal exposure on word learning at different levels of cross-linguistic overlap has not yet been examined. Therefore, the current study may uncover specific learning conditions under which bimodal exposure may facilitate or hinder language learning.

Study 2 can reveal cognitive bases of foreign language acquisition through comparing foreign-vocabulary learning in monolingual and bilingual speakers. Previous research suggests that a person's ability to acquire foreign vocabulary depends on a number of cognitive factors, including phonological memory span and native-language vocabulary skills. By comparing bilingual and monolingual speakers, this project may suggest that language-learning experience can modify subsequent language-learning processes through modulation of one (or multiple) cognitive skills. A finding that different groups of bilinguals acquire novel foreign words in different ways would suggest that a particular language-learning experience influences subsequent language-learning in specific and discernable ways. Results of Study 2 may be used as bases for future studies that manipulate cognitive abilities of bilingual and monolingual participants in an effort to pinpoint specific cognitive skills that can be impacted by linguistic experience. Practically speaking, finding that language-learning experience can facilitate subsequent acquisition of foreign languages informs educational policy, since it indicates that exposure to a foreign language results in direct and measurable benefits to the learner.

In general, this research may broadly impact clinical and education practices of professionals working with second-language learners and bilingual populations. Results of this dissertation research may be suggestive of preferred learning modalities for early foreign vocabulary acquisition, thereby impacting practices of ESL and foreign-language instruction, as well as of language and speech remediation. For instance, a finding that exposing a novice adult learner to both the written and the auditory shape of a foreign word can weaken learning in some learning situations can be used in the classroom. Specifically, it may be prudent to expose early language learners to new foreign vocabulary in the auditory modality first, and introduce the visual modality only after a certain criterion point has been reached. By exposing participants to four different versions of foreign vocabulary, this research functions as a starting point for formulation of specific early-word-learning strategies in different populations of second-language learners. This dissertation research is intended to be the first step towards a research program focusing on mechanisms of second language acquisition in unimpaired and impaired populations along the developmental continuum.

1.4 Dissertation Outline

The dissertation is structured as follows:

In Chapter 2, the background for Study 1 is introduced. The roles of working memory and long-term knowledge in foreign vocabulary learning are presented first, followed by a discussion of bi-directional connections between letters and sounds established in the native language. Then, hypotheses regarding effects of cross-linguistic similarity in letter-to-phoneme mappings and of learning modality (auditory-only vs. auditory-and-visual) on foreign vocabulary learning are offered.

In Chapter 3, the methodology for Study 1 is presented. Methodological details and data analyses that allowed for testing the effects of native-language knowledge on foreign vocabulary learning are described.

In Chapter 4, the results for Study 1 are presented, followed by a discussion of findings.

In Chapter 5, the background for Study 2 is presented. First, literature suggesting differences between bilinguals and monolinguals in cognitive functioning and literature documenting bilingual advantage for foreign vocabulary acquisition is discussed. Second, hypotheses regarding the role of different language-learning experiences in foreign vocabulary acquisition are offered.

In Chapter 6, Study 2 is presented. Methodology that allowed for testing the effects of two different language-learning histories on foreign vocabulary acquisition is discussed, followed by results, and a discussion of the Study 2 findings.

In Chapter 7, bilingual data are analyzed further to examine (1) age-of-acquisition effects in development of bilingual advantage and (2) the role of second language proficiency in mediating the bilingual advantage for foreign vocabulary acquisition. These preliminary findings are interpreted in light of previous critical-period and bilingual-advantage literature. Future research directions stemming from these initial analyses are outlined.

In Chapter 8, the impact of underlying cognitive skills on foreign vocabulary learning is examined in monolingual and bilingual speakers. Previous studies establishing the roles of vocabulary knowledge and short-term phonological memory in foreign vocabulary acquisition are briefly discussed, and current findings are presented and interpreted with regards to previous studies.

In Chapter 9, monolinguals' ability to map foreign phonological information from the auditory onto the written modality at different levels of cross-linguistic overlap is examined. First, participants' recognition of auditorily-learned foreign is tested in the written modality vs. the auditory modality. Second, the role of native-language vocabulary knowledge and of the phonological short-term memory in participants' ability to map phonological information across modalities is tested. Findings are interpreted within the context of reading-acquisition literature, and are taken to suggest the mechanisms by which adults acquire literacy in a second language.

In Chapter 10, the findings are discussed in the context of previous research on foreign vocabulary acquisition, working memory, and language processing in monolingual and bilingual speakers, and the impact of the findings on current theories of working memory, language processing, and bilingualism is presented. Finally, future avenues of research building on this dissertation work are outlined.

CHAPTER II.

EFFECTS OF CROSS-LINGUISTIC SIMILARITY AND LEARNING MODALITY ON FOREIGN VOCABULARY ACQUISITION

The objective of this dissertation research is to examine the interactions between working memory (associated with acquisition of the foreign language) and long-term memory (associated with knowledge of the native language) in foreign vocabulary learning. The goal of this chapter is to present the theoretical framework for this research. This framework is formed by (1) the Working Memory model (Baddeley, 1986), which postulates a dedicated memory system for encoding novel verbal information, and by (2) the Connectionist model of language processing (Seidenberg & McClelland, 1981), which postulates interactive activation of phonology, orthography, and semantics during word recognition. The current work proposes that foreign word learning in adults can best be examined through the interaction of the two models. This research examines whether bi-directional connections between letters and phonemes established in the native language (Connectionist Model) influence encoding of novel phonological wordforms (Working Memory Model). The likelihood of cross-talk between native-language letter-to-phoneme mappings and working memory logically follows from one of the operating principles of the Working Memory model. Namely, the Working Memory model postulates that long-term memory can influence working memory function.

Chapter 2 is structured as follows: First, the Working Memory model is introduced and the role of working memory in foreign vocabulary learning is described. Second, interactions between long-term memory and working memory are discussed, and the influence of native-language phonology on working memory function is described. Third, the link between phonology and orthography in the native system is substantiated using the Connectionist framework, and a case is made for considering the role of native-language letter-to-phoneme mappings in working memory function. Fourth, the literature on bimodal (auditory and visual) processing is reviewed, and hypotheses regarding the impact of bimodal learning on foreign vocabulary acquisition at different levels of cross-linguistic overlap are proposed.

2.1 Role of Working Memory in Foreign Vocabulary Learning

Memory research suggests that novel environmental input (linguistic as well as non-linguistic) is stored temporarily in a dedicated memory system for a brief period of time. This dedicated memory system has been termed working memory (Baddeley, 1986; Vallar & Baddeley, 1984). The working memory model postulates three distinct memory components that function together to create novel memory traces during learning. The first component is the phonological (or articulatory) loop. The phonological loop is responsible for retention of verbal material, both auditory and written. It consists of two sub-components – the phonological storage, which maintains novel phonological forms for a brief period of time, and the rehearsal mechanism, which refreshes information contained in the phonological store, preventing its decay over time. The second component is the visuospatial sketchpad. The visuospatial sketchpad is responsible for retention of visuospatial material, e.g., shapes and objects. The third component is the central executive module. The executive module controls the attentional resources to the phonological loop and the visuospatial sketchpad.

Foreign vocabulary acquisition involves establishing stable phonological representations of new items in long-term memory. Within Baddeley's working memory model, learning novel verbal information depends on the function of both the phonological loop and the central executive. The function of the phonological loop involves (1) storage of novel phonological forms in short-term memory, and (2) transportation of short-term memory traces into a long-term memory store through rehearsal. The phonological loop is responsible for the retention of novel verbal material, both auditory and visual. In fact, the phonological loop has been termed the "language learning" device (Baddeley, Gathercole, & Papagno, 1998), and it is seen as a dedicated memory system responsible for learning unfamiliar verbal information. The function of the central executive involves allocation of sufficient resources to the phonological loop during learning. The importance of resource allocation to working memory function is supported by research showing that when the phonological loop is made to function under dual-task conditions (i.e., presenting two verbal tasks at once), short-term retention of verbal information is impaired (e.g., Baddeley, 2002; Saito, 1998).

The role of a dedicated memory system in language learning has been substantiated by a number of studies (e.g., Baddeley, Gathercole, & Papagno, 1998; Gathercole & Baddeley, 1989; Gathercole & Baddeley, 1990, but see Jones, Hughes, & Macken, 2006; Romani et al., 2005 for alternative views). For instance, the ability to form novel foreign phonological representations has been linked with phonological memory capacity, i.e., the ability to repeat non-words; conversely, non-linguistic skills, such as non-verbal IQ, have not been linked with the ability to form novel phonological representations (Gathercole & Baddeley, 1989). Research focusing on the role of phonological memory in foreign word learning consistently demonstrates that higher scores on various phonological measures (e.g., non-word repetition, phoneme manipulation, etc.) are associated with increased retention of foreign vocabulary. For instance, Service (1992) found that repetition accuracy for English pseudowords was a good predictor of learning English vocabulary by Finnish primary school students. Similarly, Gathercole and Baddeley (1989) demonstrated that children's short-term memory span (as measured by ability to repeat non-words) was highly predictive of their vocabulary size one year later. It appears that Baddeley's Working Memory model can account for a number of findings in foreign language acquisition research, such as the link between foreign language learning and phonological memory capacity (e.g., Gathercole and Baddeley, 1989; Service, 1992). In addition, the Working Memory model can account for the connection between the ease of foreign language acquisition and cross-linguistic phonological similarity (e.g., Gathercole and Baddeley, 1990; Papagno, Valentine, & Baddeley, 1991; De Jong, Seveke, & Van Veen, 2000; Masoura & Gathercole, 1999). It does so by postulating that native-language knowledge can influence the function of the working memory through the *episodic buffer*.

Baddeley and colleagues have modified the working memory model to include the episodic buffer (Baddeley, 2000; 2001) in order to accommodate findings of interaction between working memory and long-term memory. For instance, working memory function was found to be influenced by long-term lexical (e.g., Majerus et al., 2004) and semantic knowledge (e.g., Hanten & Martin, 2001; Martin & Saffran, 1999; Duyck, Szmalec, Kemps, & Vandierendonck, 2003). The episodic buffer functions as an integration module, where old information, stored as part of long-term knowledge, is integrated with new information obtained via the phonological loop (or the visuospatial sketchpad). In this way, the episodic buffer creates a direct link between long-term knowledge and the phonological loop.

2.2 Long-Term Memory Effects in Learning

Learning of novel verbal information does not depend only on the function of working memory; it is also influenced by long-term memory. Effects of long-term memory on learning are supported by studies demonstrating that lexical and semantic characteristics associated with the native language can influence working memory function (e.g., Hanten & Martin, 2001; Martin & Saffran, 1999; Duyck, Szmalec, Kemps, & Vandierendonck, 2003). For instance, Martin and Saffran (1999) demonstrated that aphasic patients' ability to remember words was affected by the words' imageability and frequency – lexical characteristics stored in long-term memory. Similarly, Duyck et al. (2003) found that "overloading" working memory interfered with learning of non-words but not with learning of concrete words, suggesting that concreteness status (a long-term memory variable) influences working memory function. Similar influences rooted in long-term phonological knowledge have also been shown to affect working-memory function (e.g., Gathercole and Baddeley, 1990; Papagno, Valentine, & Baddeley, 1991; De Jong, Seveke, & Van Veen, 2000; Masoura & Gathercole, 1999).

A review of working memory literature suggests that phonological short-term memory is especially important for learning foreign words when foreign vocabulary contains sounds that are perceptually different from the native sounds. For instance, Gathercole and Baddeley (1990) found that children with poor non-word repetition skills were slower at learning phonologically unfamiliar names for toys, but not at learning familiar names for them. Similarly, Papagno, Valentine, and Baddeley (1991) demonstrated that articulatory suppression (i.e., repeating a single phrase aloud while trying to learn) disrupted memorization of foreign words to a greater degree than memorization of native words in Italian speakers. Moreover, De Jong, Seveke, and Van Veen (2000) found that phonological sensitivity (i.e., the ability to detect and manipulate sound units in words) contributed to learning of novel words with unfamiliar phonological structure, but not to learning of familiar names. Similarly, Masoura and Gathercole (1999) showed that non-word repetition scores predicted knowledge of foreign, but not of native vocabulary. Together, studies of phonological skills' contribution to vocabulary learning converge in demonstrating that phonological similarity between the foreign and the native languages is an important contributor to successful learning. This is because similar phonological structures across the native and the foreign language allow the learner to rely on long-term phonological knowledge (lexical and sublexical) to support working memory function during learning.

Cross-linguistic similarity has appeared as an important variable in second language acquisition, extending the critical period for second-language acquisition (i.e., the notion that acquisition of a second language is made more difficult after a certain age, De Keyeser, 2000), as well as influencing the metacognitive advantage associated with knowing two languages (i.e., the notion that knowledge of two languages yields earlier understanding of the symbolic nature of language, Bialystok, 2003). The role of cross-linguistic phonological similarity in foreign vocabulary learning is supported by studies that explicitly examine the effect of similarity between the foreign and the native phonological systems on foreign vocabulary acquisition. A number of studies that explored the role of cross-linguistic similarities in the second language acquisition process show that participants find it easier to acquire vocabulary items in a foreign language when phonology of the foreign language is similar to that of the native language (e.g., Rogers, 1969; Gathercole, Willis, Emslie, & Baddeley; 1991; Service; 1992; Service & Craik, 1993; Papagno & Vallar, 1992). For instance, Ellis and Beaton (1993) demonstrated that the degree to which the foreign word conformed to the phonotactic patterns of the native language correlated highly with its "learnability." Similarly, Willis, Emslie, and Baddeley (1991) found that non-words that were structured in accordance with native-language phonotactic rules were more accurately repeated than non-words that were not consistent with the native phonotactic system.

Together, memory span studies and foreign-language learning studies suggest that learning foreign vocabulary that is phonologically-similar to the native vocabulary is supported by long-term memory. When the foreign phonological inventory is similar to the phonological inventory of the native language, a learner can rely on the established phonemic categories associated with the native language to process and integrate foreign-language information. Logically, orthographic overlap across the native and the foreign language should facilitate foreign vocabulary acquisition, as well. However, the role of orthographic similarity across languages has received little attention in the learning literature. The only study that examined the role of orthographic overlap in foreign vocabulary acquisition showed that orthographic overlap does facilitate foreign vocabulary learning, but to a lesser extent than phonological overlap (Ellis & Beaton, 1993). However, examining orthographic and phonological similarity effects on foreign vocabulary learning separately from each other may be misleading, because orthographic and phonological processing components are strongly linked by bi-directional connections (e.g., Coltheart, et. al., 2001; Seidenberg & McClelland, 1989; Van Orden & Goldinger, 1994; Van Orden, Pennington, & Stone, 1990). Within the context of connectionist models of word recognition (auditory and written), both phonological and orthographic elements influence word processing.

2.3 Interactions between Phonology and Orthography in Word Processing

For adults, word processing involves both orthographic and phonological elements. For experienced language users, understanding a word involves a highly interactive process, with phonological information influencing written word processing and orthographic information influencing auditory word processing (e.g., Van Orden & Goldinger, 1994; Van Orden, Pennington, & Stone, 1990). Theoretical and computational models of visual word recognition postulate a phonological processing component (e.g., Coltheart, et. al., 2001; Seidenberg & McClelland, 1989), where letters activate their corresponding sounds. The connectionist word-reading model (Seidenberg & McClelland, 1989), also known as the "triangle" model, proposes that reading a word involves interactive activations of orthography, phonology, and meaning (semantics) – the three components that form the end-points of the triangle. Moreover, unlike other models of reading (e.g., the dual-route model proposed by Coltheart), the connectionist reading model suggests that activation of both orthographic and phonological codes occurs for any given word, independent of its frequency, regularity, or familiarity. Within this framework, reading a letter string (meaningful or not) necessarily involves both orthographic and phonological processing. The first indication of phonological involvement in reading came from studies showing that words with regular letter-to-phoneme mappings (like MINT) are read faster than words with irregular letter-to-phoneme mappings (like PINT) (e.g., Baron & Strawson, 1976). More recent evidence for activation of phonological information during word reading comes from studies of cross-modal priming. Participants in cross-modal priming studies are consistently faster at accomplishing an *auditory* stem completion task after exposure to *written* primes (e.g., Berry, Banbury, & Henry, 1997; McClelland & Pring, 1991; Lovemann, van Hoff, & Gale, 2002). The facilitation of performance on the auditory task through exposure to the word's written form is thought to be due to the activation of phonological information during written word processing.

As an extension of the connectionist reading model, where letters activate their corresponding phonemes, some accounts of auditory speech perception incorporate an orthographic component. (The role of orthography in speech *production* is less clear, however; see Damian and Bowers (2003); Roelofs (2006); Alario, Perre, Castel, and Ziegler (2006) for inconsistent findings). In auditory tasks, orthographic information pertaining to the auditory signal appears to play a role in word recognition. For instance, in a phoneme detection task, the speed of phoneme detection is influenced by the number of different orthographic representation for that phoneme (e.g., Frauenfelder, Segui, & Dijkstra, 1990; Dijkstra, Roelofs, & Fiews, 1995). Further, auditory rhyme-judgments, which should be based on purely phonological similarities, are influenced by orthographic similarity between words (e.g., Seidenberg & Tannenhaus, 1979). Similarly, orthographic neighborhood size (the number of words that differ from a target word by just one letter) has been found to influence auditory word recognition (e.g., Ziegler, Muneaux, & Grainger, 2003). Additional evidence for orthographic involvement in auditory processing comes from studies of auditory lexical decision (e.g., Ziegler & Ferrand, 1998) and auditory priming (e.g., Chereau, Caskell, & Dumay, 2006; Jakimik, Cole, & Rudnicky, 1985; Slowiaczek, Soltano, Wieting, & Bishop, 2003). These studies consistently find stronger facilitation effects for targets or prime-target pairs that share both phonology and orthography, than for targets or prime-target pairs that share only phonology or only orthography. Along the same lines, some studies of cross-modal priming find that participants are faster at completing a written stem-completion task after studying auditory words (e.g., Lovemann, van Hoff, & Gale, 2002), reiterating the presence of bi-directional connections between phonology and orthography in the language system.

As a result of bi-directional connections between letters and phonemes, studies of bimodal (auditory-and-visual) processing consistently find that simultaneous presentation of orthographic information during an auditory task impacts recognition of auditory information (e.g., Dijkstra, Schreuder, & Frauenfelder, 1989; Dijkstra, Frauenfelder, & Schreuder, 1993; Frost, Repp, & Katz, 1988; Massaro, Cohen, & Thompson, 1990; Erdener & Burnham, 2005; Bird & Williams, 2002).

2. 4 Modality Effects in Word Processing

Studies of auditory and visual word processing suggest that phonological information influences visual word recognition, and orthographic information influences auditory word recognition (e.g., Van Orden & Goldinger, 1994; Van Orden, Pennington, & Stone, 1990). It is not surprising, then, that simultaneous presentation of visual and auditory information has been found to influence word processing. Studies of bimodal (auditory-and-visual) processing converge in suggesting that perception of information in the auditory modality is influenced by simultaneous presentation of this information in the visual modality. For instance, in a sound detection task, participants were significantly faster at detecting a target sound when it was accompanied by a congruent letter (e.g., sound /a/ - letter A) than when it was accompanied by a baseline symbol (e.g., sound /a/ - symbol *) or by an incongruent letter (e.g., sound /a/ - letter E) (e.g., Dijkstra, Schreuder, & Frauenfelder, 1989; Dijkstra, Frauenfelder, & Schreuder, 1993). Similarly, participants were significantly faster at detecting a word obscured by noise when this word was accompanied by matching print than when it was accompanied by non-matching print (e.g., Frost, Repp, & Katz, 1988), and were better at recognizing auditory input when it was accompanied by the written form than when it was accompanied by presentation of the speaker's face (e.g., Massaro, Cohen, & Thompson, 1990). Presence of orthographic information was also found to improve non-native accent recognition and foreign word repetition performance (e.g., Erdener & Burnham, 2005). Further, in a priming study using novel non-words (e.g., Bird & Williams, 2002), both native and non-native speakers of English showed better recognition of non-words that were studied bimodally than of non-words that were studied in the auditory-only or the visual-only modality. Bird and Williams (2002) demonstrated that wordforms studied bimodally were recognized better at a later stage of the study, even when they were tested in the auditory-only modality.

Together, studies of bimodal effects indicate that processing of phonological information associated with the auditory input can be influenced by simultaneous presentation of the same information in the written modality. When auditory and visual information are presented simultaneously, phonological information activated via the written input is integrated with phonological information associated with the auditory input. Behavioral findings of visual-auditory integration in bimodal processing are complemented by recent findings in the neuroimaging literature. Van Atteveldt, Formisano, Goebel, and Blomert (2004) demonstrated that responses to speech sounds in a modality-specific region of the auditory cortex were modified by simultaneous presentation of letters. While congruent combinations of letters and sounds elicited a stronger response than speech sounds alone, incongruent combinations of letters and sounds resulted in a weaker response than speech sounds alone. These findings indicate a neurocognitive mechanism that binds phonological information obtained simultaneously via letters and sounds, thereby facilitating auditory processing when the two converge, or inhibiting it when the two diverge. In other words, when phonological information from the two sources converges, the retained phonological representation is strengthened.

However, when phonological information from the two inputs diverges, the retained phonological representation is weakened.

2.5 Study 1: Examining the Effects of Native-Language Letter-to-Phoneme Mappings on Foreign Vocabulary acquisition

The hypotheses for Study 1 were formulated by integrating the findings from the working memory domain and from the connectionist domain. Working memory work suggests that long-term knowledge can influence working memory function during foreign word learning. Connectionist work suggests that bimodal (auditory-and-visual) learning can impact processing of phonological information associated with newly-learned foreign words. Because the presence of orthographic information modulates auditory processing, and can influence the retained phonological information, it is likely that bimodal presentation can also influence retention of phonological information during language learning.

Since long-term knowledge and working memory interact, it may be possible for letter-to-phoneme mappings in the native language (and the extent to which native- and foreign-language letter-to-phoneme mappings overlap) to influence the encoding of novel foreign wordforms. Moreover, cross-linguistic overlap in letter-to-phoneme mappings is likely to interact with presentation modality (auditory-only vs. auditory-and-visual) during foreign word learning. Specifically, bimodal presentation of foreign words can increase the salience of cross-linguistic match or mismatch in letter-to-phoneme mappings. For example, when a foreign language differs from the native language in orthography, but not in phonology (+P-O), presenting foreign words in the auditory-only modality conceals the cross-linguistic mismatch in orthography. However, presenting +P-O foreign words in the auditory-and-visual modality makes the cross-linguistic orthographic mismatch noticeable to the learner. Similarly, when a foreign language differs from the native language in phonology, but not in orthography (-P+O), presenting foreign words in the auditory-only modality conceals the cross-linguistic mismatch in letter-to-phoneme mappings. However, presenting -P+O words bimodally makes the cross-linguistic mismatch in letter-to-phoneme mappings overt and noticeable. Therefore, the objective of Study 1 was to test whether presentation modality interacts with cross-linguistic mismatch in orthography-to-phonology mappings during foreign vocabulary learning.

Since the ultimate goal when acquiring foreign-language vocabulary is to learn the words' meanings, Study 1 focused on acquisition of the *meanings* of foreign words, and not their phonological and orthographic properties. In this, Study 1 relied primarily on the connectionist models of word processing (e.g., Seidenberg & McClelland, 1989), which postulate that phonology and orthography of a given word are interactively activated in the processing of the word's *meaning*. Thus, in accordance with the connectionist framework, cross-linguistic overlap in the sub-lexical (phonological and orthographic) properties was predicted to have an effect on the encoding of the semantics associated with novel words.

Encoding of semantic information associated with novel verbal input has remained relatively unstudied within the working-memory framework (e.g., Baddeley, 1986; but see Cowan 1995; 1999 for an alternative conceptualization of working memory, where semantic codes play an active role in the learning process). The vast majority of studies that used Baddeley's working-memory framework to examine novel vocabulary acquisition have focused on acquisition of the shape of the novel word, i.e., its word-form, and not on the meaning of the novel word (e.g., Gathercole, 1995; Gathercole, Frankish, Pickering, & Peaker, 1999; Willis, Emslie, & Baddeley, 1991, but see Speciale, Ellis, & Bywater, 1994). However, while

Baddeley's Working Memory model (1986) does not incorporate a component that is dedicated to encoding of novel semantic information, working-memory function appears to be sensitive to lexico-semantic effects (e.g., Majerus & Van der Linden, 2003). For instance, performance on short-term memory tasks is better for words than for non-words (e.g., Hulme, Maughan, & Brown, 1991), for high-frequency words than for low-frequency words (e.g., Roodenrys, Hulme, Albah, & Ellis, 1994), for concrete words than for abstract words (e.g., Walker & Hulme, 1999), and for high-imageability words than for low-imageability words (e.g., Majerus & Van der Linden, 2003). In this, the effects of long-term semantic knowledge (e.g., concreteness and imageability) on working-memory function are comparable to the effects of long-term phonological knowledge (e.g., native-language phonotactics). In the current study, however, the involvement of long-term semantic knowledge in the foreign-vocabulary-acquisition process was not under investigation, and all English translations referred to high-frequency, concrete, and highly-imageable objects. Instead, the study tested whether cross-linguistic overlap in sub-lexical properties (phonology and orthography) would influence retention of the words' meanings.

CHAPTER III.

STUDY 1: EXPERIMENTAL TESTING OF CROSS-LINGUISTIC SIMILARITY AND LEARNING MODALITY EFFECTS IN FOREIGN WORD LEARNING - METHODS

Together, memory-span studies and foreign-language learning studies suggest that learning foreign vocabulary similar to the native vocabulary is supported by long-term memory knowledge. This is because similar phonological and orthographic structures across the native and the foreign language allow the learner to rely on long-term knowledge, in addition to the working memory system, to support learning. The objective of Study 1 was to examine the effects of long-term knowledge of letter-to-phoneme mappings associated with the native language on foreign word learning. This research was based on (1) what is known about phonological loop function, and on (2) what is known about letter-to-phoneme connections in long-term memory. First, the phonological loop within the working memory model is responsible for retention of verbal information received via auditory *and* written input. Second, orthographic information and phonological information pertaining to the same linguistic input share bi-directional connections. Given these two factors, the presence of orthographic information at encoding, in addition to phonological information, was hypothesized to affect foreign vocabulary learning. It was predicted that bimodal presentation would impact the function of the phonological loop to different degrees depending on the degree of overlap between the native and the foreign orthographic and phonological systems.

Cross-linguistic similarity was manipulated by creating four artificial phonemic and alphabetic inventories that shared different degrees of overlap with English. Use of artificial phonemic/alphabetic inventories allowed for stringent control of phonological and orthographic characteristics of foreign vocabulary items. Phonemic/alphabetic inventories across the four foreign-language versions consisted of 8 sounds and 8 letters, of which 4 were vowels and 4 were consonants. An artificial language based on 8 sounds (4 vowels and 4 consonants) has been shown to be suitable for examining short-term memory effects in learning (e.g., Majerus et al., 2004). Four versions of artificial vocabulary items were constructed to:

1) Match both the phonological system and the orthographic systems of English (+P+O),

2) Mismatch the phonological, but match the orthographic system of English (-P+O),

3) Match the phonological, but mismatch the orthographic system of English (+P-O), and

4) Mismatch both the phonological and the orthographic systems of English (-P-O).

English-speaking monolingual adults were assigned to one of four groups, with participants in each group learning a different version of the foreign vocabulary using the Paired-Associated Learning (PAL) paradigm where a novel word is paired with its native language translation. This paradigm has been frequently employed to teach foreign vocabulary in second language classrooms, and in laboratory studies of second language acquisition. Participants in each of the four groups learned half of the novel vocabulary items in the auditory-only modality, and another half – in both the auditory and the visual (auditory-and-visual) modality. Retention of novel vocabulary items was tested in the auditory-only modality so that differences in performance during testing could be attributed to modality at encoding (auditory-only vs. auditory-and-visual).

Two general hypotheses regarding the effects of orthographic information at encoding on foreign vocabulary learning were considered. One hypothesis was based on the interaction between long-term memory and working memory in foreign word learning. It could be hypothesized that presence of orthographic information at encoding would interfere with learning *only* when long-term knowledge of orthography-to-phonology mappings associated with the native language conflicted with foreign language input. Specifically, orthographic information at encoding would only impact learning under two conditions: (1) when orthographic information activated phonological information that conflicted with phonological information processed via the auditory input, or (2) when phonological information processed via the auditory input activated orthographic information that conflicted with presented orthographic information. For instance, during bimodal learning in the -P+O condition, presence of native-language orthography would activate phonological information associated with the native language. This *native-language* phonological information activated by the written input will mismatch the *non-native* phonological information received via the auditory input. The two mismatched phonological representations would compete, and this competition would result in inhibition effects during learning. Thus, when the foreign language shares native-language orthography, but mismatches the native language in phonology (-P+O), bimodal presentation would result in inferior learning, compared to unimodal (auditory-only) presentation.

Conversely, presence of orthographic information at encoding would not disrupt vocabulary learning when long-term knowledge of orthography-to-phonology mappings associated with the native language did not conflict with foreign-language input. In a non-conflicting situation, orthographic information at encoding would not evoke any conflicting phonological information that would compete with phonological information received via auditory input. In fact, consistent with literature showing benefits to bimodal presentation for detection, recognition, and repetition of an auditory stimulus (e.g., Frost, Repp, & Katz, 1988; Dijkstra, Schreuder, & Frauenfelder, 1989; Erdener & Burnham, 2005), it could be expected that bimodal presentation at encoding would facilitate retention of foreign words (compared to unimodal presentation), when foreign orthography-to-phonology mappings matched native orthography-to-phonology mappings (i.e., in the +P+O condition).

An *alternative* hypothesis was based on the function of the phonological loop, which processes both auditory and written input. It could be hypothesized that learning auditory foreign words in the presence of orthographic information would be akin to "dual-task" conditions, known to disrupt working-memory function. That is, the central executive would have to allocate resources to processing of both the auditory and the written input, thereby degrading the overall learning capability. This hypothesis yielded a prediction that presence of orthographic information at encoding would negatively impact foreign vocabulary learning in all circumstances, independent of similarity between foreign- and native-language orthography-to-phonology mappings.

3.1 Summary of Study 1 Objectives and Hypotheses

In sum, Study 1 tested the following hypothesis:

If cross-linguistic mismatch in orthography-to-phonology mappings interacts with learning modality, foreign words where foreign and native orthographic/phonological parameters mismatch will be learned better in the auditory-only learning condition (where no orthographic information for the foreign word is presented), than in the auditory-and-visual condition (where the orthographic information and phonological information for the foreign word are presented together). Alternatively, foreign words for which foreign and native orthographic and phonological parameters match will be learned equally well in the auditory-only condition and in the auditory-and-visual condition.

If cross-linguistic mismatch in orthography-to-phonology mappings does not interact with learning modality, and the effect of written information on foreign word learning is conditioned by the ability of the central executive to distribute attentional resources along two sources of input, then foreign words will be learned better in the auditory-only learning condition across all levels of cross-linguistic match and mismatch.

3.2 Method

3.2.1 Design

Study 1 followed a 4-way mixed design with three within-subjects independent variables, and one between-subjects independent variable. The first within-subjects independent variable was modality of learning (auditory-only vs. auditory-and-visual). The second within-subjects independent variable was testing method (production vs. recognition). The third within-subjects independent variable was testing session (immediate vs. delayed). The between-subjects independent variable was group (+P+O, -P+O, +P-O, and -P-O). Dependent variables intended to capture the success of vocabulary learning included both accuracy and reaction time measures. During *production* testing, accuracy of naming (defined as proportion accuracy in producing the appropriate English translation) and efficiency of naming (defined as length of time between the offset of the foreign word and the offset of the English translation pronounced by the participant) were measured. During *recognition* testing, accuracy of recognition (defined as proportion accuracy in selecting the appropriate response out of 5 offered), and efficiency of recognition (defined as the reaction time for selection of the correct translation) were measured.

3.2.2 Participants

One-hundred and one native speakers of English were recruited for Study 1. Only participants who rated their proficiency in a language other than English lower than 3 on a scale from 1 (minimal knowledge) to 5 (highly proficient) were recruited. However, post-testing

Table 1

Participant Data (Mean, SE)

	+P+O	-P+O	+P-O	-P-O	*F* and *p* values
N	24	24	24	24	
Age (years-months)	22-0 (1-4)	23-02 (1-5)	22-6 (1-4)	22-9 (1-4)	F (3, 88) = 0.10, p = 0.10
Years of Education	15.67 (0.47)	16.14 (0.49)	15.39 (0.48)	15.35 (0.48)	F (3, 88) = 0.54, p = 0.65
PPVT-III (Percentile)	84.71 (2.64)	86.91 (2.76)	84.48 (2.69)	85.83 (2.69)	F (3, 88) = 0.17, p = 0.92
EVT (Percentile)	86.71 (3.09)	92.18 (3.23)	85.30 (3.16)	91.56 (3.16)	F (3, 88) = 1.18, p = 0.32
CTOPP non-word repetition (Percentile)	30.04 (3.83)	27.36 (4.08)	29.17 (3.99)	21.77 (3.92)	F (3, 88) = 0.91, p = 0.44

interviews revealed that five participants misunderstood the criteria for study participation, and were highly proficient speakers of languages other than English. As a result, these participants were dropped from the study, and their data were not analyzed. The remaining ninety-six monolingual speakers of English (*Mean Age* = 23 years 11 months, *SD* = 0.83 years) were randomly assigned to one of four groups (see participant data for each group in Table 1). Groups did not differ in age, education level, gender distribution, and performance on standardized measures of short-term phonological memory (non-word repetition sub-test of the *Comprehensive Test Of Phonological Processing*, Wagner, Torgesen, & Rashotte, 1999) and of vocabulary knowledge (the *Peabody Picture Vocabulary Test – Third Edition*, Dunn & Dunn, 1997, and the *Expressive Vocabulary Test*, Williams, 1997).

3.2.3 Materials

Four versions of artificial foreign vocabulary items were constructed. Four English phonemes and four corresponding English letters, two vowels (/ʌ/-A and /ɛ/-E) and two consonants (/f/-F and /n/-N) were shared across the four vocabulary versions in order to ease the vocabulary-learning process. Four other phonemes, two vowels (/i/ and /u/) and two consonants (/t/ and /g/) were manipulated across the four vocabulary versions, so that in versions +P+O and +P-O they remained English, but in versions -P+O and -P-O they were replaced with non-English phonemes.

The non-English phonemes were selected to be perceptually different from all existing English phonemes and yet to be pronounceable by native speakers of English. In order to rule out confounds associated with articulating difficulties, the selected non-English phonemes shared place of articulation with the English phonemes. The non-English phonemes in the stimuli for -P conditions were taken from languages other than English (French, Russian, Urdu, and Hebrew).

The vowels /i/ and /u/ were replaced by non-English vowels /ɨ/ and /y/, respectively, while the consonants /t/ and /g/ were replaced by non-English consonants /ʈ/ and /x/, respectively.

Further, four English letters were manipulated across vocabulary versions, so that they remained English for versions +P+O and -P+O, but were replaced with non-English symbols for versions +P-O and -P-O. The non-English letters used to spell foreign words in -O conditions were selected based on their similarities (in terms of number of elements) to the English letters they replaced. Thus, letters I and U were replaced by symbols "˧" and "ᑫ", respectively, while letters T and G were replaced by symbols "<" and "ძ", respectively. Thus, for instance, letter T and the corresponding non-English symbol "<" both consist of two crossing strokes. The non-English letter symbols were drawn from rare languages (Bassa, Albanian, N'Ko), in order to rule out familiarity effects. None of the participants reported familiarity with these letters.

Forty-eight monosyllabic and disyllabic non-words corresponding to both English phonology and English orthography were constructed. All non-words were recorded by a native-English-speaking male audiologist, who was extensively trained on the non-words' pronunciation prior to the recording session. Each non-word was paired with its English "translation." All 48 English translations referred to concrete, highly imageable objects with frequent English names. The 48 translation pairs were split into two lists of 24 (list A and list B, see Tables 2 and 3 for lists of foreign word-English translation pairs used in the two lists across the four conditions). The two lists of non-words were matched for length, syllabic structure, and phonotactic probability (calculated according to Vitevitch & Luce, 2004), including sum of phoneme frequencies (*M1* = 1.14, *SE* = 0.06; *M2* = 1.14, *SE* = 0.05), and sum of biphone frequencies (*M1* = 1.00, *SE* = 0.003, *M2* = 1.00, *SE* = 0.004). The two lists of non-words were also matched on orthographic characteristics (calculated according to Duyck, Desmet, Verbeke,

Table 2

Non-Word and English word Pairings (List A)

Non-Word (Orthographic Shape) +O conditions	Non-Word (IPA) for +P conditions	Non-Word (Orthographic Shape) -O conditions	Non-Word (IPA) for -P conditions	English Word
TUF	/tuf/	∠ᑫF	/ʈyf/	CUBE
GEF	/gef/	ძEF	/xef/	HOCKEY
IGUF	/iguf/	ꟶძᑫF	/ɨxyf/	BOSS
EGUN	/egun/	EძᑫN	/exyn/	LAWN
ETUG	/etug/	E∠ᑫძ	/eʈyx/	INSECT
UTAF	/utʌf/	ᑫ∠AF	/yʈʌf/	CIGAR
EFIT	/efit/	EFꟶ∠	/efɨʈ/	OCEAN
ITUN	/itun/	ꟶ∠ᑫN	/ɨʈyn/	LAWYER
UNEF	/unef/	ᑫNEF	/ynef/	LEG
TUGI	/tugi/	∠ᑫძꟶ	/ʈyxɨ/	RAIN
FIGA	/figʌ/	FꟶძA	/fɨxʌ/	SUNBURN
FUNA	/funʌ/	FᑫNA	/fynʌ/	BUCKET
GITU	/gitu/	ძꟶ∠ᑫ	/xɨʈy/	HAMMER
FITU	/fitu/	Fꟶ∠ᑫ	/f ɨʈy/	CEMENT
FETI	/feti/	FE∠ꟶ	/feʈɨ/	CHICKEN
GAFUN	/gʌfun/	ძAFᑫN	/xʌfyn/	SIGN
NIGAF	/nigʌf/	NꟶძAF	/nɨxʌf/	ENVELOPE

GITUF	/gituf/	ʖꟸ∠ꟼF	/xɨʈyf/	MOUTH
TAFUN	/tʌfun/	∠AFꟼN	/ʈʌfyn/	MORNING
NAFIT	/nʌfit/	NAFꟸ∠	/nʌfɨʈ/	BOOK
NEFAG	/nefʌg/	NEFAʖ	/nefʌx/	BEACH
FUTIN	/futin/	Fꟼ∠ꟸN	/fyʈɨn/	STORM
FANET	/fʌnet/	FANE∠	/fʌneʈ/	ROSE
NUTIG	/nitug/	Nꟼ∠ꟸʖ	/nyʈɨx/	FLAME

& Brysbaert, 2004), including number of orthographic neighbors (*M1* = 1.04, *SE* = 1.99, *M2* = 1.04, *SE* = 2.14), and bigram frequency (*M1* = 4951.92, *SE* = 2925.51; *M2* = 4967.08, *SE* = 2945.73). The two lists of English words were matched for length (*M1* = 4.53 letters, *SE* = 0.52; *M2* = 4.53 letters, *SE* = 0.52), frequency of use (*M1* = 47.79, *SE* = 56.24; *M2* = 51, *SE* = 63.98), concreteness (*M1* = 578.38, *SE* = 35.71; *M2* = 587.21, *SE* = 33.70), imageability (*M1* = 593.58, *SE* = 30.15; *M2* = 597.08, *SE* = 20.06), and familiarity (*M1* = 547.50, *SE* = 35.84; *M2* = 560.67, *SE* = 32.81) ratings. Frequency ratings (Frances & Kucera, 1982), as well as concreteness, imageability, and familiarity ratings (Gilhooly & Logie, 1980; Paivio, Yuille, & Madigan, 1968; Toglia & Battig, 1978) for English words were obtained using the MRC Psycholinguistic Database. None of the non-words were similar to their English translations in either phonology or orthography. The two lists of non-words in the -P and -O conditions were counterbalanced for the number of non-English phonemes and letters. Detailed information for each non-word and English word is included in Appendices 1 (p. 199) and 2 (p. 203).

Table 3

Non-Word and English word Pairings (List B)

Non-Word (Orthographic Shape) +O conditions	Non-Word (IPA) for +P conditions	Non-Word (Orthographic Shape) -O conditions	Non-Word (IPA) for -P conditions	English Word
GAF	/gʌf/	ᑯAF	/xʌf/	PLUM
NAF	/nʌf/	NAF	/nʌf/	ZIPPER
UFAG	/ufʌg/	ᑫFAᑯ	/yfʌx/	CAPE
AGUT	/ʌgut/	Aᑯᑫ∠	/ʌxyʈ/	ROPE
EFUN	/efun/	EFᑫN	/efyn/	SUNSET
ITUG	/itug/	Ⴗ∠ᑫᑯ	/ɨʈyx/	ELBOW
AGET	/ʌget/	AᑯE∠	/ʌxeʈ/	SUGAR
ATUF	/ʌtuf/	A∠ᑫF	/ʌʈyf/	LIQUOR
IGAN	/igʌn/	ႷᑯAN	/ɨʈyx/	SKY
FAGU	/fʌgu/	FAᑯᑫ	/fʌxy/	SONG
NAFI	/nʌfi/	NAFႷ	/nʌfɨ/	LAUNDRY
GUTA	/gutʌ/	ᑯᑫ∠A	/xyʈʌ/	ROCKET
FUTA	/futʌ	Fᑫ∠A	/fyʈʌ/	LOCKER
NEGI	/negi/	NEᑯႷ	/nexɨ/	INFANT
GENA	/genʌ/	ᑯENA	/xenʌ	STOMACH
GIFET	/gifet/	ᑯႷFE∠	/xɨfeʈ/	PARK
TAGUF	/tʌguf/	∠AᑯᑫF	/ʈʌxyf/	MAGAZINE

NAGUT	/nʌgut/	NA¿ꟼ∠	/nʌxyʈ/	TEETH
NEGIF	/negif/	NE¿ꟸF	/nexɨf/	COLLEGE
TAGUN	/tʌgun/	∠A¿ꟼN	/ʈʌxyf/	ROAD
NITUG	/nitug/	Nꟸ∠ꟼ¿	/nɨʈyx/	COAST
GATEN	/gʌten/	¿A∠EN	/xʌʈen/	CLOUD
FITAN	/fitʌn/	Fꟸ∠AN	/fɨʈʌn/	SHIP
FIGEN	/figen/	Fꟸ¿EN	/fɨxen/	STEAM

Standardized tests of short-term phonological memory and of native-language vocabulary knowledge were administered to each participant. Previous research has shown that higher scores on phonological memory tests are associated with better retention of foreign vocabulary (e.g., Gathercole and Baddeley, 1989; Service, 1992). Similarly, more extensive vocabulary knowledge in the native language has been linked to improved foreign-language acquisition (De Keyeser, 2002; Masoura and Gathercole, 1999). In order to ensure that the four groups did not differ in phonological short-term memory and vocabulary knowledge, all participants were administered tests that measured these abilities. Phonological short-term memory was measured using a standardized test that required participants to repeat non-words of increasing length and difficulty (*Comprehensive Test Of Phonological Processing*, Wagner, Torgesen, & Rashotte, 1999). Native-language vocabulary knowledge was measured using two standardized tests, the *Peabody Picture Vocabulary Test* – IIIrd Edition (Dunn & Dunn, 1997) that measured receptive vocabulary, and the *Expressive Vocabulary Test* (Williams, 1997) that measured expressive vocabulary.

3.2.4 Procedure

Alphabet learning. At the beginning of the experimental session, each participant was taught the sounds and the corresponding letters of the foreign language. Each letter appeared on the computer screen, and the corresponding sound was played twice over the headphones. The participant was instructed to repeat the sound out loud three times. After all letters and sounds had been presented, the participant was asked to match each sound to the appropriate letter, and to pronounce each sound when presented with a letter. All participants were 100% accurate in producing the correct sounds for the letters at the end of the alphabet-learning sequence.

Vocabulary learning. Each participant completed both the auditory-only learning phase and the auditory-and-visual learning phase. The order of learning phases was counterbalanced across participants, so that half of the participants learned foreign vocabulary in the auditory-only modality first, while half of the participants learned foreign vocabulary in the auditory-and-visual modality first. List presentation was also counterbalanced across participants, so that half of the participants learned list A in the auditory-only modality, and learned list B in the auditory-and-visual modality, while half of the participants learned list B in the auditory-only modality, and learned list A in the auditory-and-visual modality. In the *auditory-only* phase, participants heard the novel word pronounced twice over the headphones, and saw its written English translation on the right side of the computer screen. The participants were instructed to repeat the novel word and its English translation out loud three times. Each pair was presented twice during the learning phase. In the *auditory-and-visual* phase, participants heard the novel foreign word pronounced twice via headphones, while the written form of the foreign word was shown on the left side of the computer screen, and the English translation was shown on the right side of the computer screen. The participants were instructed to repeat the novel word and its English translation out loud three times. Each pair was presented twice during the learning phase. Learning during both auditory-only and auditory-and-visual phases was self-paced.

Immediate vocabulary testing. After each learning phase, the participant's memory for presented items was tested using both production and recognition tasks. Production testing always preceded recognition testing in order to eliminate priming effects (since the correct English translation was one of the alternatives in recognition testing). During production, participants heard the foreign word and pronounced its English translation into a microphone. During recognition, participants heard foreign words over headphones and chose the correct English translations from five alternatives listed on the computer screen as fast as possible. Of the five alternatives, one answer was correct, two answers were translations of foreign words from the same list, one answer was an English word that was semantically related to the correct answer, and one answer was an unrelated English word not previously presented.

Delayed vocabulary testing. One week after the initial learning session, participants returned to the laboratory, and were tested on long-term retention of the learned vocabulary. Participants completed both the production and the recognition tasks for words learned bimodally and unimodally.

Standardized assessment of short-term memory and vocabulary knowledge. After delayed testing, participants were administered standardized assessment measures of vocabulary knowledge and phonological short-term memory.

3.2.5 Analyses

Accuracy and Reaction Time data were analyzed using 2 x 2 x 2 x 4 Analyses of Variance, with learning modality (auditory-only vs. auditory-and-visual), testing method (production vs. recognition), and testing session (immediate vs. delayed) as within-subjects variables, and group (+P+O, -P+O, +P-O, and -P-O) as a between-subjects variable. Overall results for the accuracy and reaction time data are presented first. Then, significant interactions are followed-up with 1) between-group comparisons and 2) within-group comparisons. Both by-subjects (F_1) and by-item (F_2) analyses are reported.

CHAPTER IV.

STUDY 1: EXPERIMENTAL TESTING OF CROSS-LINGUISTIC SIMILARITY AND LEARNING MODALITY EFFECTS IN FOREIGN WORD LEARNING – RESULTS AND DISCUSSION

4.1 Results

4.1.1 Overall Comparisons

For *accuracy*, a 2 x 2 x 2 x 4 Analysis of Variance revealed a main effect of testing method, F_1 (1, 79)[1] = 2086.70, $p < 0.0001$, *partial* $\eta^2 = 0.96$, F_2 (1, 92) = 1553.02, $p < 0.0001$, *partial* $\eta^2 = 0.94$, with participants generating more accurate responses during recognition (M = 0.67, SE = 0.02) than during production (M = 0.25, SE = 0.02), and a main effect of testing session, F_1 (1, 79) = 184.30, $p < 0.0001$, *partial* $\eta^2 = 0.70$, F_2 (1, 92) = 715.06, $p < 0.0001$, *partial* $\eta^2 = 0.89$, with participants generating more accurate responses during immediate testing (M = 0.53, SE = 0.02) than during delayed testing (M = 0.39, SE = 0.02). In addition, a main effect of group was observed, F_1 (3, 79) = 3.33, $p < 0.05$, *partial* $\eta^2 = 0.11$, F_2 (3, 92) = 9.18, $p <$ 0.0001, *partial* $\eta^2 = 0.23$, with participants in the +P+O condition (M = 0.51, SE = 0.03) producing more accurate responses than participants in the -P+O condition (M = 0.40, SE = 0.03) or participants in the -P-O condition (M = 0.42, SE = 0.03). Similarly, participants in the +P-O condition (M = 0.51, SE = 0.03) produced more accurate responses than participants in the -P+O condition (all p values < 0.05, least significance post-hoc tests). A significant four-way interaction between modality, method of testing, testing session, and group was revealed, F_1 (3,

[1] The degrees of freedom in the overall accuracy comparisons reflect the fact that not all participants completed delayed testing (four participants dropped out of the study after completing only the immediate testing session), and that recording equipment malfunctioned for some participants in some conditions (production data for 9 participants were not recorded due to microphone malfunction). As a result, production accuracy data for 83 participants (22 in the +P+O condition, 20 in the -P+O condition, 22 in the +P-O condition, and 19 in the -P-O condition) were analyzed in the overall Analysis of Variance.

79) = 2.60, $p < 0.05$, *partial* $\eta^2 = 0.10$, F_2 (3, 92) = 3.84, $p < 0.05$, *partial* $\eta^2 = 0.11$, and was further examined in follow-up analyses.

For *reaction times*, a similar 2 x 2 x 2 x 4 Analysis of Variance revealed a main effect of testing method, F_1 (1, 64)[2] = 153.29, $p < 0.0001$, *partial* $\eta^2 = 0.71$, F_2 (1, 76) = 239.04, $p < 0.0001$, *partial* $\eta^2 = 0.76$, with participants retrieving words faster during recognition testing (*M* = 3408.86, *SE* = 111.59) than during production testing (*M* = 5503.32, *SE* = 196.73). In addition, significant two-way interactions were observed between modality and testing session, F_1 (1, 64) = 4.33, $p < 0.05$, *partial* $\eta^2 = 0.06$, F_2 (1, 76) = 10.24, $p < 0.01$, *partial* $\eta^2 = 0.12$, and between testing method and testing session, F_1 (1, 64) = 7.09, $p < 0.05$, *partial* $\eta^2 = 0.10$, F_2 = N.S., $p = 0.13$. Planned follow-up analyses corresponding to post-hoc analyses conducted for accuracy rates were performed. Follow-up comparisons revealed that, at all levels of cross-linguistic similarity, production latencies did not differ significantly across learning modality (*p* values > 0.1). This was likely due to large variability in the data (*SE* in the -P-O condition was 1824.63 msec). Therefore, only post-hoc analyses for production accuracy (but not for production reaction times) are reported in between-group and within-group comparisons below.

4.1.2 Between-Group Comparisons

Between-group comparisons are presented in Table 4 (immediate testing) and Table 5 (delayed testing). Univariate Analyses of Variance with group (+P+O; -P+O; +P-O; -P-O) as a between-subjects independent variable revealed significant differences among groups for foreign words learned in the *auditory-and-visual* modality. Accuracy rates differed across groups during

[2] The degrees of freedom in the overall RT comparisons reflect the fact that when a participant did not produce any correct answers in one of the conditions, the RT data for that condition were absent. The resulting number of missing cells reduced the overall number of RT data points to 68 (19 participants in the +P+O condition, 13 participants in the -P+O condition, 22 participants in the +P-O condition, and 14 participants in the -P-O condition).

Table 4

Between-Group Comparisons for Immediate Testing of Foreign Words Learned in the Auditory-and-Visual Modality

A. Production – Accuracy				
Group	Mean (SE)	Comparison to:		
		+P+O	-P+O	+P-O
+P+O	0.44 (0.05)	---	---	---
-P+O	0.23 (0.04)	*t* (44) = 3.33**	---	---
+P-O	0.40 (0.04)	*t* (44) = 0.53	*t* (44) = 3.13**	---
-P-O	0.25 (0.04)	*t* (42) = 2.87**	*t* (42) = 0.44	*t* (42) = 2.64*
B. Production - Reaction Times				
		+P+O	-P+O	+P-O
+P+O	5769.05 (561.67)	---	---	---
-P+O	5818.81 (563.35)	*t* (43) = 0.06	---	---
+P-O	5196.87 (356.06)	*t* (44) = 0.86	*t* (43) = 0.94	---
-P-O	7432.75 (1736.0)	*t* (41) = 0.97	*t* (40) = 0.92	*t* (41) = 1.35
C. Recognition – Accuracy				
		+P+O	-P+O	+P-O
+P+O	0.79 (0.04)	---	---	---
-P+O	0.61 (0.04)	*t* (46) = 3.57**	---	---
+P-O	0.78 (0.03)	*t* (41) = 0.14	*t* (46) = 3.56**	---
-P-O	0.69 (0.04)	*t* (46) = 1.89	*t* (46) = 1.52	*t* (46) = 1.82
D. Recognition - Reaction Times				
		+P+O	-P+O	+P-O
+P+O	3134.43 (127.13)	---	---	---
-P+O	3798.28 (277.45)	*t* (46) = 2.18*	---	---
+P-O	3540.74 (192.32)	*t* (46) = 1.76	*t* (46) = 0.76	---
-P-O	3574.64 (227.99)	*t* (46) = 1.69	*t* (46) = 0.62	*t* (46) = 0.11

Note. Significance of comparisons (p) is marked by asterisks next to the t values. Significance at $p < 0.01$ is marked by two asterisks **; significance at $p < 0.05$ is marked by one asterisk *.

Table 5

Between-Group Comparisons for Delayed Testing of Foreign Words Learned in the Auditory-and-Visual Modality

Group	Mean (SE)	Comparison to:		
A. Production – Accuracy				
		+P+O	-P+O	+P-O
+P+O	0.19 (0.03)	---	---	---
-P+O	0.12 (0.03)	*t* (41) = 1.77	---	---
+P-O	0.23 (0.03)	*t* (42) = 1.04	*t* (41) = 2.73**	---
-P-O	0.13 (0.02)	*t* (41) = 1.65	*t* (40) = 0.31	*t* (41) = 2.70**
B. Production - Reaction Times				
		+P+O	-P+O	+P-O
+P+O	5052.47 (294.74)	---	---	---
-P+O	5192.38 (615.70)	*t* (34) = 0.22	---	---
+P-O	4779.42 (338.22)	*t* (41) = 0.61	*t* (35) = 0.63	---
-P-O	5156.84 (510.81)	*t* (40) = 0.18	*t* (34) = 0.05	*t* (41) = 0.62
C. Recognition – Accuracy				
		+P+O	-P+O	+P-O
+P+O	0.63 (0.04)	---	---	---
-P+O	0.58 (0.04)	*t* (44) = 0.86	---	---
+P-O	0.65 (0.04)	*t* (45) = 0.40	*t* (43) = 1.31	---
-P-O	0.57 (0.04)	*t* (45) = 1.01	*t* (43) = 0.13	*t* (44) = 1.48
D. Recognition - Reaction Times				
		+P+O	-P+O	+P-O
+P+O	3334.68 (186.79)	---	---	---
-P+O	3503.49 (254.05)	*t* (44) = 0.54	---	---
+P-O	3681.14 (243.58)	*t* (45) = 1.14	*t* (43) = 0.51	---
-P-O	3438.13 (221.27)	*t* (45) = 0.36	*t* (43) = 0.20	*t* (44) = 0.74

Note. Significance of comparisons (*p*) is marked by asterisks next to the *t* values. Significance at $p < 0.01$ is marked by two asterisks **; significance at $p < 0.05$ is marked by one asterisk *.

immediate production testing, F_1 (3, 86) = 6.17, $p < 0.01$, *partial* $\eta^2 = 0.18$, F_2 (3, 92) = 15.60, $p < 0.01$, *partial* $\eta^2 = 0.34$, during *immediate recognition testing*, (F_1 (3, 92) = 5.72, $p < 0.01$, *partial* $\eta^2 = 0.16$, F_2 (3, 92) = 15.13, $p < 0.01$, *partial* $\eta^2 = 0.33$, and during *delayed production testing*, F_1 (3, 82) = 3.76, $p < 0.05$, *partial* $\eta^2 = 0.12$, F_2 (3, 92) = 4.70, $p < 0.01$, *partial* $\eta^2 = 0.13$. Reaction times differed across groups during *immediate recognition testing* only, F_2 (3, 92) = 4.07, $p < 0.01$, *partial* $\eta^2 = 0.12$. Mean accuracy rates and reaction times for each condition, together with corresponding statistical comparisons (independent *t* tests) are provided in Tables 4 (immediate testing) and 5 (delayed testing), and show that *bimodally-presented* foreign words were learned better when foreign phonology matched English phonology (i.e., +P+O condition and +P-O condition) than when it mismatched English phonology (i.e., -P+O condition and -P-O condition). For *unimodally-presented* foreign words, accuracy rates and reaction times were similar across all four groups and across immediate and delayed testing (all *p* values > 0.05).

4.1.3 Within-Group Comparisons

Figures 1 and 2 show *immediate testing* data and suggest that bimodal learning improved retention of foreign words that matched English in both phonology and orthography (+P+O), but hindered retention of foreign words that mismatched English in phonology (-P+O), orthography (+P-O), or both (-P-O). Specific one-way post-hoc comparisons within each condition, across learning modality (auditory-only vs. auditory-and-visual) and testing method (production vs. recognition) are provided below. Immediate testing data are presented first, followed by delayed testing data; production data are presented first, followed by recognition data; accuracy data are presented first, followed by reaction time data.

+P+O condition. Accuracy analyses revealed different patterns of results for production and recognition testing. During production testing, participants were more accurate for foreign

words learned in the auditory-and-visual modality (M = 0.44, SE = 0.05) than in the auditory-only modality (M = 0.36, SE = 0.05), F_1 (1, 22) = 5.42, $p < 0.05$, *partial* $\eta^2 = 0.20$, F_2 (1, 23) = 10.01, $p < 0.01$, *partial* $\eta^2 = 0.30$. However, during recognition testing, participants showed comparable accuracy rates across the two modalities, F_1 (1, 23) = 0.55, $p = 0.47$, *partial* η^2 = 0.02, F_2 (1, 23) = 1.05, $p = 0.32$, *partial* $\eta^2 = 0.04$. *Reaction time* analyses revealed no significant effects of learning modality during recognition testing, F_1 (1, 23) = 1.04, $p = 0.32$, *partial* η^2 = 0.04, F_2 (1, 23) = 0.05, $p = 0.83$, *partial* $\eta^2 = 0.002$. In sum, participants in the +P+O condition were more accurate at retrieving items learned in the auditory-and-visual modality than items learned in the auditory-only modality.

-P+O condition. Accuracy analyses revealed similar patterns of results for production and recognition testing. Participants were more accurate at producing English translations for foreign items learned in the auditory-only modality (M = 0.27, SE = 0.04) than in the auditory-and-visual modality (M = 0.22, SE = 0.04), F_1 (1, 21) = 4.21, $p < 0.05$, *partial* $\eta^2 = 0.17$, F_2 (1, 23) = 5.05, $p < 0.05$, *partial* $\eta^2 = 0.18$. Similarly, participants were more accurate at recognizing English translations of foreign items learned in the auditory-only modality (M = 0.70, SE = 0.04) than in the auditory-and-visual modality (M = 0.61, SE = 0.04), F_1 (1, 23) = 6.64, $p < 0.05$, *partial* $\eta^2 = 0.22$, F_2 (1, 23) = 13.17, $p < 0.01$, *partial* $\eta^2 = 0.36$. *Reaction time* analyses revealed that participants responded faster to foreign words learned in the auditory-only modality (M = 3347.96, SE = 251.19) than in the auditory-and-visual modality (M = 3798.29, SE = 277.45), F_1 (1, 23) = 4.50, $p < 0.05$, *partial* $\eta^2 = 0.16$, F_2 (1, 23) = 12.40, $p < 0.01$, *partial* $\eta^2 = 0.35$. In sum, participants in the -P+O condition were hindered by bimodal presentation during learning, and

performed better on items learned in the auditory-only modality than on items learned in the auditory-and-visual modality.

+P-O Condition. Accuracy analyses revealed comparable rates across the two learning modalities for both production, F_1 (1, 22) = 0.004, $p = 0.95$, *partial* $\eta^2 = 0.001$, F_2 (1, 23) = 0.01, $p = 0.93$, *partial* $\eta^2 = 0.0001$, and recognition, F_1 (1, 23) = 0.19, $p = 0.66$, *partial* $\eta^2 = 0.008$, F_2 (1, 23) = 0.57, $p = 0.46$, *partial* $\eta^2 = 0.02$. *Reaction time* analyses revealed that participants responded faster to foreign words learned in the auditory-only modality (*M* = 3121.90, *SE* = 159.93) than in the auditory-and-visual modality (*M* = 3540.74, *SE* = 192.32), F_1 (1, 23) = 8.51, $p < 0.01$, *partial* $\eta^2 = 0.27$, F_2 (1, 23) = 16.64, $p < 0.001$, *partial* $\eta^2 = 0.42$. In sum, reaction time data (but not accuracy data) suggest that participants in the +P-O condition were hindered by bimodal presentation during learning, and performed better on items learned in the auditory-only modality than on items learned in the auditory-and-visual modality.

-P-O Condition. Accuracy analyses revealed marginally better performance for items learned in the auditory-only modality (*M* = 0.30, *SE* = 0.03) than in the auditory-and-visual modality (*M* = 0.25, *SE* = 0.03) in by-item analyses, F_2 (1, 23) = 4.25, $p = 0.051$, *partial* $\eta^2 = 0.16$, but not in by-subject analyses, F_1 (1, 20) = 2.00, $p = 0.17$, *partial* $\eta^2 = 0.09$. Comparable accuracy rates across the two learning modalities were observed for recognition, F_1 (1, 23) = 0.56, $p = 0.46$, *partial* $\eta^2 = 0.02$, F_2 (1, 23) = 1.35, $p = 0.26$, *partial* $\eta^2 = 0.06$. *Reaction time* analyses revealed that participants responded faster to foreign words learned in the auditory-only modality (*M* = 3012.50, *SE* = 132.26) than in the auditory-and-visual modality (*M* = 3574.64, *SE* = 227.99), F_1 (1, 23) = 14.10, $p < 0.01$, *partial* $\eta^2 = 0.38$, F_2 (1, 23) = 13.51, $p < 0.01$, *partial* $\eta^2 = 0.37$. In sum, participants in the -P-O condition were hindered by bimodal presentation during

Figure 1. Within-group differences in <u>accuracy</u> of retrieving English translations immediately after foreign-word learning. Performance for the +P+O group is shown in panel A; -P+O group is shown in panel B; +P-O group is shown in panel C; -P-O group is shown in panel D.

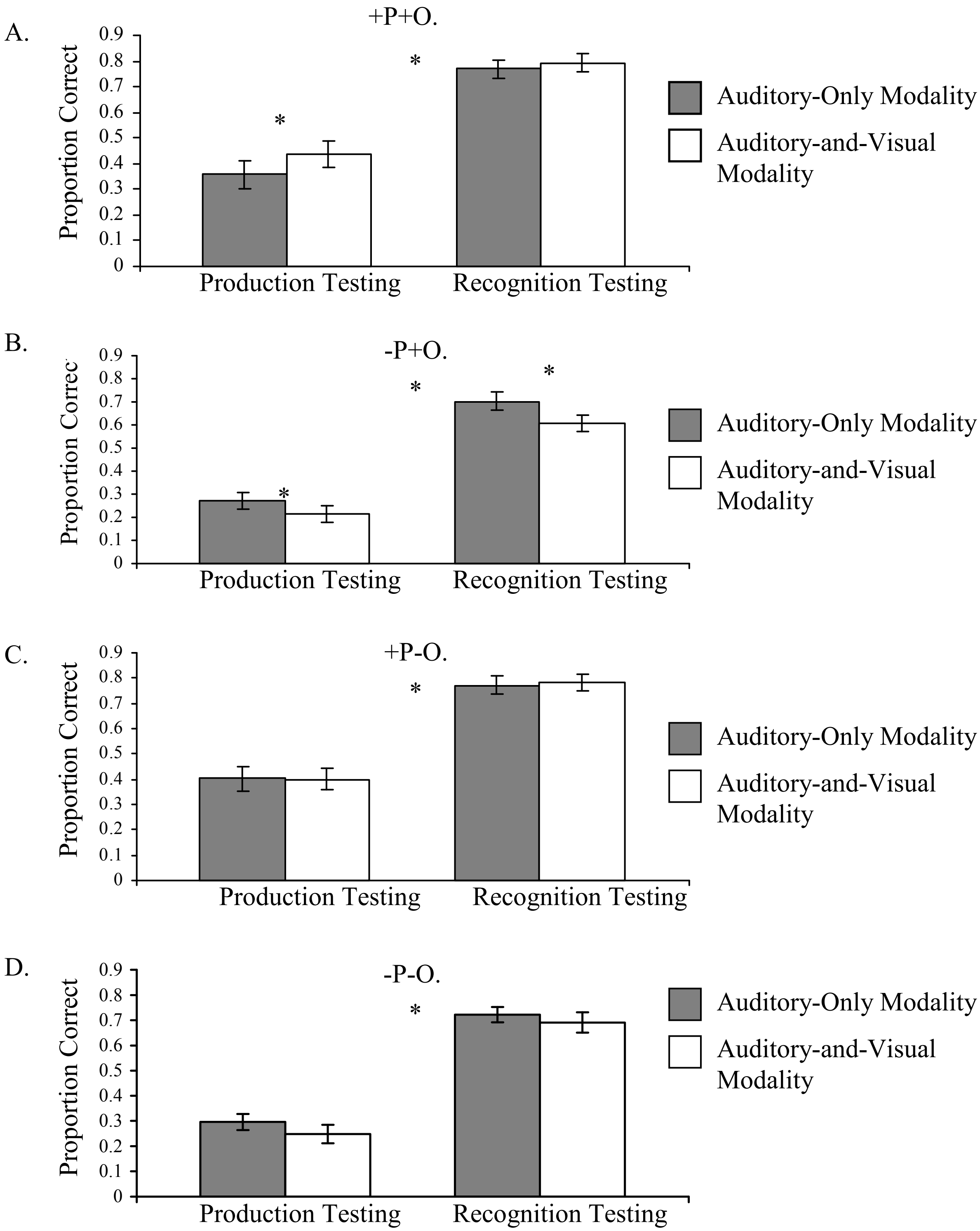
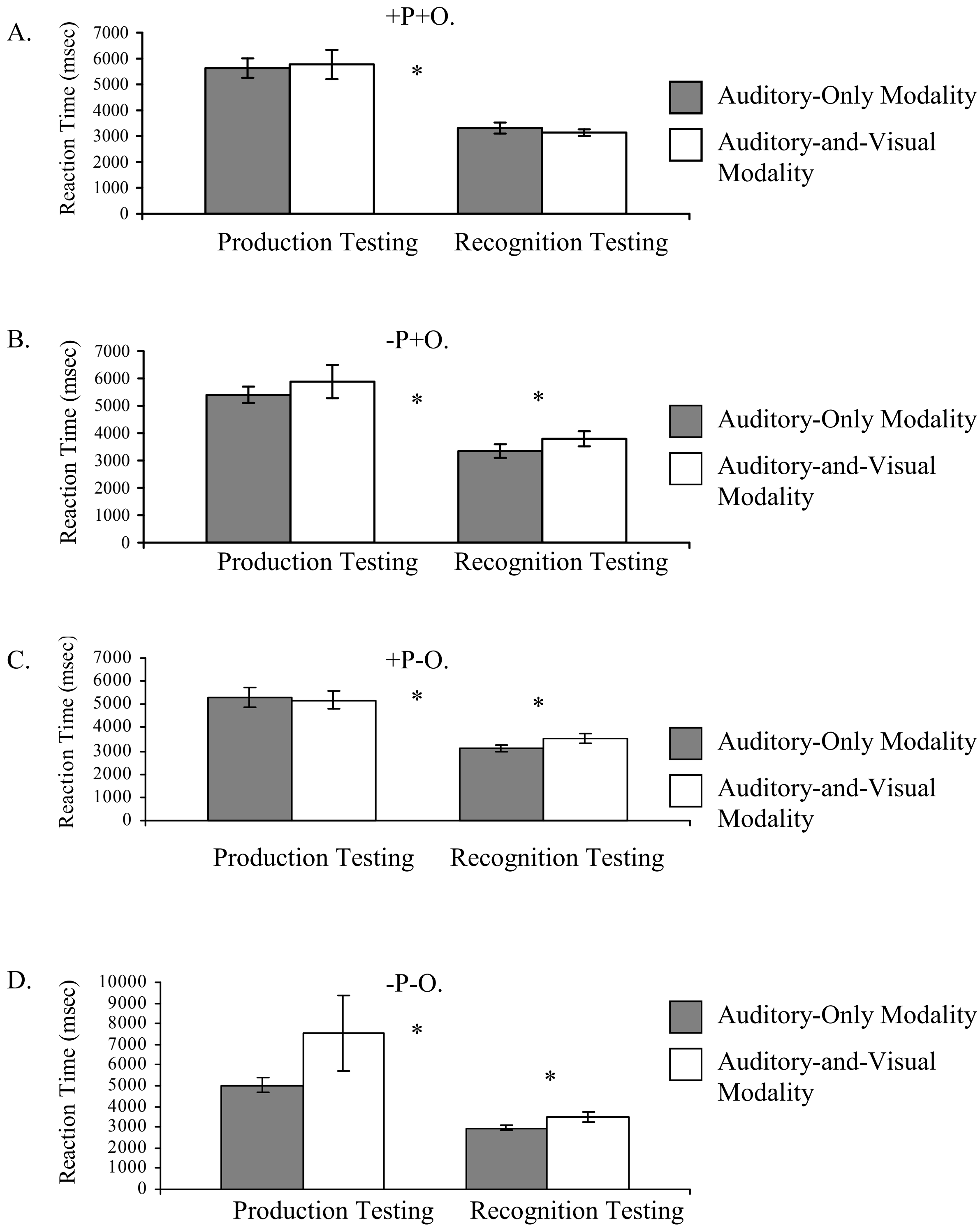


Figure 2. Within-group differences in reaction times for correctly-retrieved English translations immediately after foreign word learning. Performance for the +P+O group is shown in panel A; -P+O group is shown in panel B; +P-O group is shown in panel C; -P-O group is shown in panel D.



learning, and performed better on items learned in the auditory-only modality than on items learned in the auditory-and-visual modality, especially for reaction time data.

Delayed Testing. For the *+P+O* and *-P-O conditions*, post-hoc analyses revealed similar accuracy rates and reaction times for foreign words learned in the two modalities, during both production and recognition, all *p* values > 0.1. For the *-P+O condition*, post-hoc analyses revealed that participants were faster at recognizing correct English translations of foreign words learned in the auditory-only modality ($M = 3187.81$, $SE = 221.33$) than in the auditory-and-visual modality ($M = 3503.49$, $SE = 254.05$), F_1 (1, 21) = 5.89, $p < 0.05$, *partial* $\eta^2 = 0.22$, F_2 (1, 23) = 4.25, $p < 0.05$, *partial* $\eta^2 = 0.16$. For the *+P-O Condition,* post-hoc analyses revealed that participants were more accurate at producing English translations for foreign words learned in the auditory-and-visual modality ($M = 0.23$, $SE = 0.03$) than in the auditory-only modality ($M = 0.15$, $SE = 0.02$), F_1 (1, 21) = 12.39, $p < 0.01$, *partial* $\eta^2 = 0.37$, F_2 (1, 23) = 14.56, $p < 0.01$, *partial* $\eta^2 = 0.39$. No other main effects or interactions were observed, all *p* values > 0.1. These findings suggest that the bimodal hindrance effect observed in the -P+O condition during immediate testing persisted long-term and that bimodal learning benefited participants in the +P-O condition one week after the initial learning.

4.2 Study 1 Discussion

The objective of Study 1 was to compare the effects of bimodal (auditory-and-visual) and unimodal (auditory-only) learning on foreign word retention at different levels of cross-linguistic overlap. Results revealed that learning modality influenced foreign word retention both short-term (immediately after learning), and long-term (after a one-week delay). *Immediate testing* revealed that bimodal presentation improved retention of foreign words (compared to unimodal presentation) when foreign letter-to-phoneme mappings matched English. That is, participants in the +P+O condition were more accurate at producing English translations for foreign words learned in the auditory-and-visual modality compared to foreign words learned in the auditory-only modality. Conversely, bimodal presentation hindered immediate retention of foreign words (compared to unimodal presentation) when foreign letter-to-phoneme mappings mismatched English. That is, participants in the -P+O, +P-O and -P-O conditions were less accurate and/or slower at producing and recognizing English translations of foreign words learned in the auditory-and-visual modality compared to foreign words learned in the auditory-only modality. *Delayed testing* revealed that modality effects on learning abated over time, with differences in performance between foreign words learned bimodally vs. unimodally attenuating after a one-week delay.

These findings substantiate the hypothesis that effects of learning modality and cross-linguistic similarity interact during foreign vocabulary acquisition, and suggest that foreign-word learning is influenced by letter-to-phoneme mappings in the native language. Knowledge of native-language letter-to-phoneme mappings can facilitate or hinder foreign-word learning, depending on whether the foreign language mismatches the native language, and depending on whether this mismatch is covert (auditory-only modality) or overt (auditory-and-visual modality). This interplay between learning modality and cross-linguistic similarity can be attributed to the impact of long-term memory (of letter-to-phoneme mappings) on working-memory function. Thus, the present research converges with recent evidence for interaction between working memory and long-term memory (e.g., Duyck, Szmalec, Kemps, & Vandierendonck, 2003; Hanten & Martin, 2001; Majerus et al., 2004; Martin & Saffran, 1999), and extends it to long-term knowledge of letter-to-phoneme mappings. Specifically, the present study suggests that native-language knowledge of letter-to-phoneme mappings influences encoding of novel phonological wordforms.

Even more importantly, the present study indicates that cross-linguistic similarity in sub-lexical properties can facilitate acquisition of *meanings* associated with the foreign words. This is especially worthy of note because while the effect of cross-linguistic similarity can impact the encoding of novel wordforms directly (i.e., through reliance on long-term phonological knowledge during learning), the effect of cross-linguistic similarity on the encoding of meanings must be indirect. The working-memory mechanism at the root of this phenomenon may be the central executive. For instance, it is possible that reliance on long-term knowledge of letter-to-phoneme mappings during learning may make the phonological loop function more efficiently, requiring a smaller degree of attentional resources. These resources, then, may be channeled by the central executive into acquisition of the words' meanings. Conversely, in the case where the foreign language mismatches the native language in letter-to-phoneme mappings, the phonological loop may consume all the available resources to encode the shape of the novel word, and relatively little recourses remain for allocation to the encoding of the words' meanings.

4.2.1 Interactions between Long-Term Knowledge and Working Memory

As discussed in the introduction to Study 1, when processing native-language words, orthographic information is activated during auditory word processing and phonological information is activated during visual word processing. The bi-directionality of letter-to-phoneme connections in long-term memory (e.g., Dijkstra, Roelofs, & Fews, 1995; Seidenberg & McClelland, 1989; Seidenberg & Tannenhaus, 1979; Ziegler & Ferrand, 1998) was reflected in the current findings of modality influences on foreign-word learning. Specifically, presence of orthographic information during learning was found to influence the retained phonological representation. When participants were required to retrieve a phonological representation of a newly-learned foreign word based on the auditory input only, their ability to do so was influenced by whether this phonological representation was learned purely auditorily or whether it was learned from both the auditory and the visual inputs. The impact of learning modality on foreign-word retention was observed not only in the accuracy data, but also in the reaction time data.

Theoretically, bimodal presentation at encoding could impact both the strength of representation and the efficiency of access associated with the foreign word. For instance, it is possible that the *representation* of new phonological information is strengthened by convergent phonological input from the written and the auditory channels, and is weakened by non-convergent phonological input from the two modalities. It is also possible that convergent phonological input from the written and the auditory modalities facilitates *access* to the phonological representation, while non-convergent phonological input delays it. It may be that both the accuracy and the speed of performance during testing reflect the strength with which newly-learned foreign words are represented in memory. Thus, stronger representations may give rise to more accurate performance during testing (since participants are better able to map the foreign word presented at testing with the foreign word stored in memory). Stronger representations may also give rise to faster performance during testing (since participants are faster at matching the foreign word presented at testing with the foreign word stored in memory). However, reaction time data in the current study were analyzed only for foreign words retrieved correctly, and accuracy and reaction time findings diverged in a number of analyses. For instance, in the +P+O condition, bimodal learning facilitated accuracy, but not efficiency, of foreign-word retrieval. Conversely, in the +P-O condition, bimodal learning hindered efficiency, but not accuracy, of foreign-word retrieval. This discrepancy in accuracy and reaction time data may indicate that distinct working-memory mechanisms are responsible for accurate vs. speedy retrieval of foreign words during testing.

Accuracy of retrieval was improved by bimodal learning when native-language and foreign-language letter-to-phoneme mappings matched, and was hindered by bimodal learning when foreign-language phonemes mismatched those of the native language. These findings suggest that bimodal learning can either strengthen or weaken the strength of phonological representation. However, speed of access to the phonological representation was consistently weakened by bimodal learning. Specifically, efficiency of retrieval was hindered by bimodal learning in all mismatch conditions (phonology, orthography, or both), and led to slower retrieval times during testing. In the cross-linguistic match condition (+P+O), where bimodal learning might have been expected to result in faster access during retrieval, only accuracy, but not efficiency of access was facilitated. It is possible that bimodal learning imposes certain demands on the working-memory system that consistently result in less efficient access to the newly-formed phonological representations. If so, cross-linguistic match in letter-to-phoneme mappings may have offset this weakening effect, but did not reverse it, resulting in a lack of reaction-time differences between learning modalities in the cross-linguistic +P+O match condition.

4.2.2 Interpreting Modality Effects Within Working Memory Framework

According to Baddeley's working memory model (1986), learning novel verbal information depends on the function of both the phonological loop and the central executive. The phonological loop stores novel phonological forms in short-term memory, and transports short-term memory traces into a long-term memory store through rehearsal. The central executive allocates sufficient resources to the phonological loop during learning. The importance of resource allocation to working memory function is substantiated by research showing that when the phonological loop functions under dual-task conditions (for example, when two verbal tasks are presented simultaneously), short-term retention of verbal information is impaired (e.g., Baddeley, 2002; Larsen & Baddeley, 2003). The inhibition effects of bimodal presentation observed in the current study for the mismatch conditions may, therefore, be similar to "dual-task" effects in working memory. Assuming that the resources of the working memory system are finite, the central executive would have to allocate its resources to processing both the auditory and the written inputs, which may result in diminished overall learning capability. This mechanism is especially useful as an explanation for findings in the -P-O condition, where foreign phonemes and letters mismatch those of English. It could be argued that in the -P-O condition, auditory and written inputs do not activate incongruent phonological or orthographic representations, since both mismatch the native language. Therefore, bimodal learning should not hinder foreign-word retention. However, results indicate that bimodal learning in the -P-O condition did delay retrieval times for the foreign words during testing. Drawing a parallel between bimodal learning and dual-task performance provides a parsimonious explanation for these inhibition effects, since working memory is assumed to be working less efficiently during bimodal learning at all levels of cross-linguistic mismatch.

Thus, it appears that the mechanism underlying modality effects in foreign-word learning relies on both the long-term knowledge of orthography and phonology in the native language and on the function of the central executive within working memory. The finding that bimodal presentation in all cross-linguistic mismatch situations hindered learning is consistent with the central executive function of working memory. The finding that bimodal presentation in the match situation was beneficial to learning suggests that when phonological information from two inputs converges, the central executive may function effectively even under "dual-task" conditions. It remains to be seen whether modality effects during foreign word learning are equally attributable to 1) bottom-up processes associated with perceiving cross-linguistically matching or mismatching information and to 2) top-down processes associated with the ability of the central executive to distribute attention resources during bimodal learning. It is possible that the top-down and the bottom-up processes are differentially involved depending on the degree of cross-linguistic overlap. Specifically, when both phonology and orthography overlap across languages, the bottom-up facilitation processes may override the top-down inhibition processes. Alternatively, when both phonology and orthography mismatch across languages, the inhibitory top-down executive processes may override the bottom-up processes. Whatever the exact contributions of cross-linguistic overlap and central executive, it is likely that both facilitation and inhibition effects associated with bimodal learning can be accounted for by the same cognitive mechanism. This cognitive mechanism may rely on auditory-specific brain regions that are more active when auditory and written inputs converge, and less active when auditory and written inputs diverge (e.g., Van Atteveldt, Formisano, Goebel, & Blomert, 2004). In the present study, encoding of phonological information obtained via auditory input was strengthened by convergent written input, and was weakened by divergent written input.

4.2.3 Effects of Cross-linguistic Similarity on Foreign Word Learning

In the current study, two cross-linguistic overlap conditions shared native-language phonology and two conditions contained non-native phonemes. Comparing phonological-match and phonological-mismatch conditions revealed that participants found it easier to learn foreign vocabulary items where native language phonology was maintained. This finding is consistent with previous research, where learners performed better on foreign vocabulary items that shared native-language phonology than on items that contained non-native sounds or non-native phonotactics (e.g., Rogers, 1969; Gathercole, Willis, Emslie, & Baddeley; 1991; Service; 1992; Service & Craik, 1993; Papagno & Vallar, 1992). A new finding revealed by the present research is that learning modality mediates the benefits associated with cross-linguistic phonological match, as well as the detriments associated with cross-linguistic phonological mismatch. For instance, the phonological-match advantage, while present for unimodally-learned words, was more pronounced for bimodally-learned words. Similarly, the phonological-mismatch disadvantage manifested strongly for bimodally-learned words, and was less prominent for unimodally-learned words. These findings suggest that facilitation effects associated with cross-linguistic phonological match, and inhibition effects associated with cross-linguistic phonological mismatch, are magnified by bimodal presentation during learning.

Between-group comparisons also revealed that mismatched phonology (+P+O vs. -P+O) had a stronger effect on foreign word learning than mismatched orthography (+P+O vs. +P-O). Participants in the mismatched-orthography condition were just as accurate and fast as participants in the matched-orthography condition when choosing an English translation for the foreign word. This suggests that speakers are more sensitive to cross-linguistic differences in phonology than in orthography. Further, mismatched phonology (alone) had a stronger effect on foreign word learning than mismatched phonology *and* orthography (together). This suggests that a mismatch along only one linguistic parameter (phonology) impacts learning to a greater extent than mismatch along both linguistic parameters (phonology and orthography). These findings are consistent with previous findings in the bilingual production literature (Schwartz, Kroll, & Diaz, in press), with one exception. Specifically, in the current study, participants learning foreign words that mismatched English in orthography, but matched it in phonology, performed as well as participants learning foreign words that matched English in both phonology and orthography. In contrast, Schwartz et al. found that fluent Spanish-English bilinguals were significantly slower at producing Spanish words that shared only one linguistic parameter with English (i.e., only phonology or only orthography) than at producing Spanish words that shared both or neither parameter with English. The difference between learning data obtained here and bilingual production data obtained by Schwartz et al. (in press) is likely due to unstable and non-automatic phoneme-to-letter mappings that characterize the linguistic system of novice learners in the present study. It is likely that cross-linguistic orthographic mismatch influences auditory word processing only when the foreign language becomes highly-proficient, and letter-to-phoneme mappings stabilize into permanent, automatic connections in the long-term memory system. Cross-linguistic phonological mismatch, on the other hand, appears to influence both bilingual word production and early foreign word learning.

4.2.4 Long-Term Impact of Learning Modality on Foreign Word Learning

The impact of cross-linguistic phonological mismatch on foreign word learning was observed not only during immediate testing, but also during delayed testing. Specifically, during delayed testing, participants in the phonological-mismatch condition (-P+O) were slower at retrieving English translations of foreign words learned in the auditory-and-visual modality than of words learned in the auditory-only modality. The long-term persistence of inhibition effects associated with bimodal learning in the phonological-mismatch condition indicates that modality differences at encoding influenced long-term retention of foreign words, especially the efficiency of their retrieval. Long-term effects of modality on foreign word learning were also observed in the orthographic-mismatch condition (+P-O). However, unlike participants in the phonological-mismatch condition, participants in the orthographic-mismatch condition demonstrated long-term bimodal facilitation. Specifically, they made fewer errors for items learned in the auditory-and-visual modality than for items learned in the auditory-only modality. It is possible that the positive impact of unfamiliar orthography on long-term retention in the +P-O condition is due to the fact that unfamiliar letter symbols were processed as purely visual cues during learning. Previous research suggests that non-canonical presentation of material facilitates learning (e.g., Kroll, Michael, & Sankaranarayanan, 1998). Specifically, Kroll et al. (1998) demonstrated that participants were better at remembering foreign words when these were associated with pictures that were turned upside-down, than with pictures that were presented in their canonical orientation. In this sense, presence of novel orthographic symbols during learning in the +P-O condition may have served as a non-canonical visual cue that improved retention. These findings are somewhat difficult to reconcile with the results obtained for the +P-O condition during immediate testing, where bimodal learning was found to hinder, not facilitate, foreign vocabulary acquisition. However, the hindrance effect during immediate testing was observed only in the RT data, not in the accuracy data. If accuracy and RT effects are rooted in distinct working-memory mechanisms, it is not difficult to imagine that they would dissociate not only during immediate testing, but also during delayed testing. The hindrance effect associated with retrieval times disappeared during delayed testing, while the null effect associated with the accuracy measure evolved into an advantage during delayed testing. However, the mechanism by which bimodal learning in the +P-O condition exerted a positive effect on retrieval a week after learning had taken place is unclear. It is possible that facilitation associated with unfamiliar visual input requires a consolidation period to take effect. In the same vein, it is possible that forgetting of bimodally-learned words is better-insulated than forgetting of unimodally-learned words, yielding what seem to be facilitation effects during delayed testing. Whatever the exact mechanisms, long-term inhibition and facilitation effects observed in this study suggest that bimodal learning may lead to long-term disadvantages, as well as to long-term advantages in foreign vocabulary acquisition, depending on the type of cross-linguistic overlap.

4.2.5 Interaction between Learning Modality and Testing Method

The impact of bimodal learning on foreign-word retention was found to vary with testing method. For production testing, bimodal presentation impacted accuracy of retrieval to a greater extent than efficiency of retrieval. However, for recognition testing, bimodal presentation impacted efficiency of retrieval to a greater extent than accuracy of retrieval. It is likely that these distinct performance patterns reflect differences in demand characteristics for the two tasks. Specifically, successful production performance requires strong association links between newly-learned words and their English translations. Because only the foreign word is presented during production testing, the link to its English translation has to be re-created on-line. However, successful recognition performance may not rely on the strength of the foreign word-English translation link as much, since it does not have to be re-created at the time of testing, but only recognized.

Consistent with this difference between production and recognition tasks, learning studies consistently find that performance on production measures lags behind performance on recognition measures (Ellis & Beaton, 1993 b; De Groot & Keijzer, 2000). In the current study, accessing English translations proved exceedingly difficult for participants during production testing compared to recognition testing. Therefore, it is likely that lack of reaction time differences in the production data is due to overall longer retrieval times across both learning modalities, and to the high variability within and across participants in production speed. During recognition testing, however, performance accuracy was high across the two learning modalities. Therefore, the impact of learning modality during recognition testing was mostly efficiency-based, with participants showing longer retrieval times (but not lower accuracy rates) for bimodally-learned items. These findings of delayed, but not less accurate performance during recognition testing are consistent with previous findings in the bimodal literature. Specifically, Frost, Repp, and Katz (1988) demonstrated that simultaneous presentation of print and the auditory signal in noise influenced speed of speech detection to a greater extent than accuracy.

4.2.6 Future Directions

While the finding that modality interacts with cross-linguistic similarity during foreign word learning is clearly applicable to clinical and educational practices, additional research is necessary before the effect of bimodal exposure on foreign word leaning can be confirmed. For instance, future research will need to examine the effects of modality on foreign word learning in more ecologically-valid settings that approximate real language-learning scenarios, where learning is a result of long-term repeated exposure to novel linguistic information. Future studies may also examine foreign word learning within a more constrained learning paradigm. In research presented here, the foreign word learning procedure was self-paced, so as to approximate a natural word-learning process. It is possible that modality effects observed in the current study would change if time limits on learning were imposed. Further, future studies may examine foreign word learning within a more complex linguistic repertoire. Foreign vocabulary in the current study was based on a system of 8 sounds. While the system of 8 sounds allowed for control of phonemic and orthographic characteristics of the stimuli, and proved sufficient to create variability between vocabulary items, such a system is smaller than phonological inventories of natural languages. Finally, more drastic manipulations of cross-linguistic mismatch within a larger and more complex phonemic system may be helpful in examining the graded effects of cross-linguistic mismatch along the phonological and orthographic parameters on foreign-word learning.

Further, results observed in the +P-O condition may be interpreted to suggest that the articulatory loop processes not only phonological information (associated with auditory and written input), but also orthographic information (associated with written and auditory input). Before such a conclusion can be made, however, future work needs to examine whether unfamiliar orthographic information is processed as “orthography” or if it is processed similarly to non-linguistic visual-spatial input. In order to obtain “dual-task” effects in working memory, the two tasks have to involve the same component (either the phonological loop or the visual-spatial sketchpad). If the two tasks involve two different components of the working memory, performance does not suffer. Therefore, future studies must compare foreign word learning in the +P-O condition in the presence of unfamiliar orthography vs. unfamiliar visual input that is not explicitly linguistic. If similar results were obtained for novel orthographic vs. novel non-linguistic visual input, it would suggest that novel orthography is processed along a different route than familiar orthographic information. However, if the two (novel orthography vs. novel visual input) were found to differ, it would indicate that the articulatory loop processes not only phonological, but also the orthographic information, and would suggest that a long-standing assumption about working memory needs to be updated. This assumption strongly holds that working memory operates on the phonological (and according to some accounts, articulatory) code. If future research reveals orthographic effects in working memory, it would suggest that the rehearsal mechanism, which has been assumed to function on phonological code alone, may also involve an orthographic component. Thus, the working memory model would need to be revised by incorporating the role of orthographic codes in storage and rehearsal of novel verbal information.

4.2.7 Conclusion

In sum, Study 1 suggests that learning modality interacts with cross-linguistic similarity in foreign vocabulary acquisition. Presence of orthographic information at encoding benefits foreign-word learning when foreign letter-to-phoneme mappings match those in the native language. Conversely, presence of orthographic information at encoding impacts foreign-word learning negatively when foreign- and native-language letter-to-phoneme mappings mismatch. Moreover, results suggest that phonological mismatch across the two languages impacts foreign vocabulary learning to a greater extent than orthographic mismatch. These data indicate an interaction between working memory and long-term knowledge of letter-to-phoneme mappings in the native-language. Together, these findings substantiate the involvement of long-term memory in working-memory function.

The finding that bimodal learning can inhibit or facilitate retention of foreign words depending on level of cross-linguistic overlap may impact the field of second-language acquisition and foreign-language instruction, and inform such educational practices as multimodal teaching (e.g., Blachowicz & Fisher, 2001), and within- and between-language subtitling (e.g., Danan, 1992; Vanderplank, 1993). It is generally assumed that learning is facilitated by exposing students to the same material in multiple modalities and by using written sub-titles when teaching auditory comprehension in the foreign language. Current research suggests that bimodal exposure may not be facilitative to *early* foreign vocabulary learning across the board. Instead, exposure to the word's written form together with its auditory form may benefit learning when orthography-to-phonology mappings match across the native and the foreign languages, and may hinder learning when orthography-to-phonology mappings conflict across languages.

CHAPTER V.

ROLE OF LANGUAGE-LEARNING EXPERIENCE IN FOREIGN VOCABULARY ACQUISITION

Results of Study 1 suggest that learning foreign words where phonological content is different from that of the native language, but where orthographic structure of the native language is maintained is difficult for monolingual English speakers. When +P+O and -P+O groups were compared to each other, participants who learned vocabulary items in -P+O condition demonstrated poorer accuracy and longer reaction times during testing than participants in the +P+O condition. This difference was especially pronounced for vocabulary items learned in the auditory-and-visual modality, where both the written and the auditory form of the foreign word were presented during encoding. It appears that the long-term knowledge of letter-to-phoneme mappings associated with the native language interfered with encoding of novel phonological forms associated with the foreign language. The objective of Study 2 was to examine whether language-learning experience improves foreign vocabulary learning performance. In addition, Study 2 aimed to examine whether language-learning experience is generally facilitative for vocabulary learning, or whether a particular kind of language-learning experience accords a specific advantage for vocabulary learning in yet a third language.

5.1 Evidence for Bilingual Advantage in Cognitive Processing.

Recent work examining interactions between linguistic experience and cognition has suggested that bilingualism can positively influence some aspects of cognitive processing (e.g., Bialystok, 1999; Bialystok, 2006; Bialystok, Craik, & Ryan, 2006; Bialystok, Klein, Craik, &

Viswanathan, 2004; Bialystok & Martin, 2004; Bialystok & Shapero, 2005; Kormi-Nouri, Moniri, & Nilsson, 2003). Bialystok et al. localize the positive impact of bilingualism on cognitive processing to bilinguals' superior executive function, or more specifically, to superior inhibitory mechanisms. Superior inhibitory mechanisms allow bilinguals to exert greater cognitive control over processing than monolinguals. This inhibitory-control bilingual advantage is proposed to be a result of parallel processing, where two languages are activated in parallel in response to single-language input. Due to a constant stream of information that activates both languages in parallel, bilinguals habitually must suppress one language in order to select another.

The inhibitory-control advantage is proposed to underlie bilingual performance patterns on a number of cognitive tasks, including the card-sorting task[3] (e.g., Bialystok & Martin, 2004) the antisaccade task[4] (e.g., Bialystok, Craik, & Ryan, 2006), the ambiguous-figure reversing task[5] (e.g., Bialystok & Shapero, 2005), and the Simon task[6] (e.g., Bialystok, 2006; Bialystok, Craik, Klein, & Viswanathan, 2004). However, other benefits to bilingualism revealed by the literature do not yield themselves to inhibitory-control explanations. For instance, bilingual children were found to outperform monolingual children on metalinguistic tasks requiring conscious use of form-based, rather than content-based, grammatical expression (Galambos & Goldin-Meadow, 1990). Bilingual children were also found to outperform monolingual children on a number of literacy-related measures, including an onset-rime awareness task (Buck & Genesee, 1995), a phoneme segmentation task (Bialystok, Majumder, & Martin, 2003), and

[3] The dimensional change card sort task requires children to sort a set of cards by one dimension (e.g., by shape) and then to resort the same set of cards by a different dimension (e.g., by color).
[4] In an antisaccade task, the viewer fixates a central location, a stimulus is flashed to one side of the fixation, and the viewer must not look at the location of the stimulus, but rather to make an antisaccadic movement in the opposite direction.
[5] The ambiguous-figure reversing task requires the child to alternate between two interpretations of an ambiguous figure (e.g., old lady-young lady).
[6] The Simon task is based on stimulus-response compatibility, and assesses the extent to which the association to irrelevant spatial information affects participants' response to task-relevant non-spatial information.

phoneme counting and non-word decoding tasks (Bialystok, Luk, & Kwan, 2005). These findings suggest that the underlying mechanism of bilingual advantage may be localized to metalinguistic awareness of language in general, and of print in particular. Notably, while the inhibitory-control advantage has been obtained with various bilingual groups characterized by various L1 histories (e.g., Tamil, Cantonese, French, Korean, Hebrew, etc.), the literacy advantage has only been obtained with specific bilingual groups (English-Spanish, English-French, and English-Hebrew, but not English-Cantonese). It appears that this literacy advantage is only revealed in bilingual groups whose languages share the same print-to-sound conversion principle (e.g., alphabetic systems of English and Hebrew) and/or the same writing system (e.g., the Roman alphabet of English and Spanish). Conversely, bilingual groups whose languages do not share the same print-to-sound conversion system (English and Cantonese) do not show an advantage over monolinguals on literacy-related tasks. In that sense, the bilingual advantage can be conceptualized both in terms of language-general benefits (that are shared by all bilinguals) and in terms of language-specific benefits (that accrue only as a result of using a specific combination of two languages). The goal of the present study was to examine differences between bilingual and monolingual participants, and to test bilingual-general vs. bilingual-specific advantage hypotheses in the area of foreign vocabulary learning.

5.2 Differences between Bilingual and Monolingual Foreign Vocabulary Acquisition

Perhaps the most convincing evidence for a bilingual advantage in cognitive functioning comes from a small number of studies examining foreign language learning in bilingual and multilingual adults. These studies consistently demonstrate a robust difference between monolingual and bilingual foreign-word-learning performance, with bilinguals consistently outperforming monolinguals (e.g., Papagno & Vallar, 1995; Van Hell & Mahn, 1997). For instance, Van Hell and Mahn (1997) showed that experienced language learners outperformed novice language learners in both the number of retained foreign words, and in the speed of their retrieval. This bilingual advantage was present independent of the learning method, although bilingual speakers appeared to benefit from the rote rehearsal method (repeating the foreign word out-loud) more than from the key-word method (associating the foreign word with a similar-sounding key-word in the native language). Similar to the Van Hell and Mahn (1997) findings, Papagno and Vallar (1995) found that bilinguals performed better on tests of phonological short-term memory (both the digit span and the non-word repetition) and on a foreign-word learning task than monolinguals. Although the Papagno and Vallar (1995) study had a number of methodological shortcomings, including a limited sample size (10 multillinguals), a limited number of stimuli (8 foreign-native word pairs), and a lack of control over participants' language history (multilingual participants spoke 3 or more different languages), its findings are highly suggestive of bilingual advantage in foreign vocabulary acquisition. A comparable bilingual advantage was reported by Kroll, Michael, Tokowicz, and Dufour (2002), who found that English-Spanish and English-French bilinguals outperformed monolinguals on a reading span task – a task that involves verbal working memory.

Both Van Hell and Mahn (1997) and Papagno and Vallar (1995) provide similar explanations for the bilingual advantage in foreign word learning. Van Hell and Mahn (1997) suggest that experienced language learners possess superior rehearsal abilities, attained through extensive experience with vocabulary learning procedures. Papagno and Vallar (1995) propose that experienced learners' better performance stems from their superior phonological skills. Both explanations therefore localize the benefit for foreign word learning associated with bilingualism to the phonological loop of the working memory – a component which functions to store and rehearse new verbal input. However, this conclusion may be premature, since the logic that underlies it is somewhat circular: A bilingual's superior performance on a verbal memory task is ascribed to their superior verbal memory. As Kroll et al. (2002) point out, bilingual advantage on working memory tasks may stem from self-selection bias, with high-ability individuals capable of achieving high proficiency levels in a second language, and becoming fully bilingual. One way to start answering questions about mechanisms driving bilingual advantage is to examine whether the benefits of previous language-learning experience are common to all bilinguals, or whether specific experience yields a particular and discernable advantage. If it were demonstrated that all bilinguals show the same consistent advantage on a cognitive task, it would suggest that linguistic experience modifies the same underlying mechanism, regardless of the specifics of the experience. If, on the other hand, bilinguals with different language histories were demonstrated to perform differently on the same cognitive task, it would suggest that the degree of modulation, and/or the locus of modulation for the underlying cognitive mechanisms reflect the specifics of the linguistic experience.

Currently, it remains uncertain whether bilingual advantage in foreign vocabulary learning is general, and common to all bilinguals, or specific, and depends on the combination of the two languages known to a bilingual. This uncertainty stems in part from the fact that the few studies that examined foreign word learning in bilinguals focused on combinations of languages that shared alphabets. For instance, Van Hell and Mahn (1997) compared monolingual speakers of Dutch to bilingual speakers of Dutch and English, German, or French (languages that share an alphabet with Dutch). Therefore, these studies cannot tease apart contributions of specific linguistic experience from contributions of bilingualism, in general, to bilinguals' foreign vocabulary learning.

Both bilingual-general and bilingual-specific accounts of bilingual advantage in foreign vocabulary acquisition are possible. A general advantage would rely on modulation of the same cognitive mechanisms by any language-learning experience. A specific advantage would be contingent on the similarity between the second language and the to-be-acquired language, and their joined difference from the native language. Such a specific advantage is consistent with Lotto and De Groot's (1998) remark that when experienced foreign language learners start to learn vocabulary in yet another language, learning should be most successful if the new vocabulary is associated with the corresponding L1 (native language) items. In other words, if the new language is more similar to L1, learning will be more efficient than if the new language is less similar to L1.

In sum, the advantage experienced by bilingual speakers when learning a new language might stem from a general skill common to all bilinguals (bilingual general-advantage hypothesis), or from experience with a specific combination of two languages (bilingual specific-advantage hypothesis). When thus conceptualized, the dichotomy between bilingual-general and bilingual-specific hypotheses echoes the distinction revealed by Bialystok et al. studies (i.e., a global bilingual advantage on executive-control tasks and a language-specific bilingual advantage on phonological awareness and literacy tasks). If the process of foreign word learning is considered within the context of the working memory model (Baddeley, 1986), then foreign word learning is related to both the literacy-driven linguistic task, and to the non-linguistic control-driven task. Specifically, foreign word learning depends on both the function of the phonological loop (responsible for the linguistic component) and on the function of the central executive (responsible for allocation of cognitive resources that are not tied specifically to language). Thus, bilingualism may indeed impact a general cognitive mechanism (central executive) and/or a linguistic mechanism (the phonological loop).

CHAPTER VI.

STUDY 2: EXPERIMENTAL TESTING OF THE BILINGUAL ADVANTAGE IN FOREIGN VOCABULARY ACQUISITION

In order to test the bilingual-general vs. bilingual-specific advantage hypotheses, Study 2 compared foreign-word learning performance of monolingual English speakers (yielded by Study 1) to that of two bilingual groups: English-Spanish bilinguals and English-Mandarin bilinguals. Both bilingual groups consisted of native speakers of English, who acquired either Spanish or Mandarin as a second language. Participants learned artificially-constructed foreign words and their English translations via Paired-Associated Learning. Foreign words constructed for the -P+O condition in Study 1 were used in Study 2. These words were constructed to match English in orthography, but mismatch English in phonology. Therefore, learning these -P+O words simulated learning of Germanic or Romance foreign languages by native speakers of English. Participants learned half of the words via both listening and reading (auditory-and-visual modality), and half of the words via listening only (auditory-only modality). Retention of novel vocabulary items was tested in the auditory-only modality, so that differences in performance during testing could be attributed to modality at encoding (auditory-only vs. auditory-and-visual). It was hypothesized that different bilingual experiences would result in different bilingual advantages, and that the two bilingual groups would outperform the monolingual group in distinct ways. It was also hypothesized that presentation modality (bimodal vs. unimodal) would interact with language-learning experience.

6.1 Specific Hypotheses and Predictions for Study 2

Prediction 1. In accordance with previous literature suggesting a bilingual advantage for foreign word learning, it was predicted that both English-Spanish and English-Mandarin bilinguals would outperform monolingual speakers of English on the foreign-word learning. However, patterns of performance for the two bilingual groups were also expected to differ, and to reflect specific language-learning histories.

Prediction 2. For the English-Spanish bilingual group, it was predicted that presence of orthographic information at encoding would not hinder bilinguals' foreign-word learning performance. During acquisition of Spanish, English-Spanish bilinguals have acquired a linguistic system that mismatches English in phonology, but matches it in orthography. Specifically, Spanish and English share the Roman alphabet; however, some letters in Spanish encode phonemes that are different from those encoded by the same letters in English. For example, the letter J exists in both alphabets; however, it represents the phoneme /ʤ/ in English, but the phoneme /h/ in Spanish. The mismatch between English and Spanish is similar to the mismatch between English letter-to-phoneme mappings and letter-to-phoneme mappings that characterize the artificial foreign vocabulary items. Therefore, speakers of English who have acquired Spanish have experienced the same cross-linguistic mismatch as the one that characterizes English and the -P+O foreign vocabulary items. It was hypothesized that experience with learning a language where letter-to-phoneme mappings mismatch those of English would enable English-Spanish bilinguals to process -P+O foreign vocabulary items more efficiently. Therefore, it was predicted that English-Spanish bilinguals would not experience interference from orthographic information at encoding, and would perform similarly on foreign vocabulary items learned in auditory-only and auditory-and-visual modalities.

Prediction 3. Learning Mandarin does not involve mapping familiar orthography onto new phonology (the way learning Spanish does). Mandarin is not based on an alphabetic system, but on a logographic system, and learning Mandarin does not require that native English speakers learn new mappings between letters and sounds. Therefore, different predictions were made for the English-Mandarin bilingual group than for the English-Spanish bilingual group. If only the experience of learning a specific L2 (e.g., an L2 that shares letter-to-phoneme mappings with L3) facilitates further word learning in bilinguals, then English-Mandarin bilinguals should not show a vocabulary-learning advantage, and should perform similarly to monolingual speakers of English. Conversely, if general language-learning experience, independent of linguistic characteristics, facilitates further word learning in bilinguals, then English-Mandarin bilinguals should show an advantage, and should perform better than monolingual speakers of English. Because learning Mandarin does not involve mapping familiar phonemes onto new letters, the experience of learning Mandarin should not impact participants' ability to integrate unfamiliar phonological with familiar orthographic information. Therefore, the pattern of performance for English-Mandarin bilinguals should resemble that of monolingual speakers of English. Specifically, English-Mandarin bilinguals should be more successful at learning foreign words in the auditory-only modality than in the auditory-and-visual modality.

6.2 Method

6.2.1 Design

The study followed a 4-way mixed design with three within-subjects independent variables, and one between-subjects independent variable. The first within-subjects independent variable was modality of learning (auditory-only vs. auditory-and-visual). The second within-subjects independent variable was testing method (production vs. recognition). The third within-subjects independent variable was testing session (immediate vs. delayed). The between-subjects independent variable was group (English monolingual, English-Spanish bilinguals, and English-Mandarin bilinguals). Dependent variables intended to capture the success of vocabulary learning included both accuracy and reaction time measures. During *production* testing, accuracy of naming (defined as proportion accuracy in producing the appropriate English translation) and efficiency of naming (defined as length of time between the offset of the foreign word and the offset of the English translation pronounced by the participant) were measured. During *recognition* testing, accuracy of recognition (defined as proportion accuracy in selecting the appropriate response out of 5 offered), and efficiency of recognition (defined as the reaction time for selection of the correct translation) were measured.

6.2.2 Participants

Twenty-four native speakers of English (Mean Age = 21.5, SE = 0.26) recruited for Study 1 were used as the monolingual comparison group in study 2. Participants' language proficiency was assessed using the *Language Experience and Proficiency Questionnaire* - *LEAP-Q*, (Marian, Blumenfeld, & Kaushanskaya, in press). The *LEAP* questionnaire proved to be a valid and reliable self-assessment tool, with self-reported proficiency levels correlating highly with performance on standardized tests of language ability. Only participants who rated their proficiency in a language other than English lower than 3 on a scale from 1 (minimal knowledge) to 5 (highly proficient) were recruited.

Two groups of bilingual participants were recruited for Study 2 (see Table 6). Special care was taken to ensure that all bilinguals recruited for study were early and highly proficient bilinguals. Therefore, only bilinguals who reported L2 Acquisition Age of as 12 years of age

Table 6

Study 2 Participant Data

	Monolinguals	English-Spanish Bilinguals	English-Mandarin Bilinguals	*F* and *p* values
N	24	24	22	
Age (years-months)	23-02 (0-11)	21-08 (0-11)	20-11 (1-2)	F (2, 63) = 1.27, p = 0.29
Years of Education	16.14 (0.49)	15.36 (0.50)	14.67 (0.55)	F (2, 59) = 1.95, p = 0.15
PPVT-III (Percentile)	86.91 (2.76)	86.25 (3.25)	85.89 (3.40)	F (2, 63) = 0.02, p = 0.98
EVT (Percentile)	92.18 (3.23)	86.76 (3.54)	90.29 (3.71)	F (2, 63) = 0.59, p = 0.56
CTOPP digit span (Percentile)	75.32 (3.89)	80.22 (3.79)	75.48 (3.97)	F (2, 63) = 0.53, p = 0.59
CTOPP non-word repetition (Percentile)	27.36 (4.08)	28.70 (3.72)	25.38 (3.90)	F (2, 63) = 0.19, p = 0.83
Reading Fluency (Percentile)	86.34 (5.48)	75.48 (4.67)	80.69 (5.17)	F (2, 53) = 1.15, p = 0.33

or younger (widely considered to be the cut-off for early vs. late bilingualism), and speaking proficiency levels of 6 or more (on the scale from 1 to 10, where a rating of 6 denoted a more than adequate level of proficiency) were recruited for the study. Moreover, all bilinguals were native speakers of English, in order to make the comparison between monolinguals and bilinguals meaningful, and to ensure that bilinguals' performance in their native language was being tested.

Twenty-five bilingual speakers of English and Spanish were recruited for the study. One participant revealed a learning disability post-testing, and her data were not analyzed. The remaining 24 participants reported high levels of proficiency in Spanish. On a scale from 0 (no knowledge of Spanish) to 10 (native speaker of Spanish), English-Spanish bilingual participants rated their speaking proficiency in Spanish as 7.23 (*SE* = 0.34), understanding spoken Spanish as 7.60 (*SE* = 0.32), and reading Spanish as 7.18 (*SE* = 0.50). English-Spanish bilinguals reported spending an average of 2 years immersed in a Spanish-speaking country (*SE* = 1.29), an average of 4.25 years immersed in a Spanish-speaking family (*SE* = 1.74), and an average of 2.91 years (*SE* = 1.01) immersed in a Spanish-speaking school or working environment.

Twenty-seven bilingual speakers of English and Mandarin were recruited for the study. However, it was revealed post-testing that three of the participants were native speakers of Mandarin who learned English after age 5, and that two of the participants were proficient speakers of a third language. Therefore, these five participants were dropped from the study. The remaining 22 English-Mandarin bilinguals reported high levels of proficiency in Mandarin. On a scale from 0 (no knowledge of Mandarin) to 10 (native speaker of Mandarin), participants rated their speaking proficiency in Mandarin as 6.67 (*SE* = 0.37), understanding spoken Mandarin as 7.39 (*SE* = 0.35), and reading Mandarin as 4.5 (*SE* = 0.56). English-Mandarin bilinguals reported spending an average of 6.94 years immersed in a Mandarin-speaking country (*SE* = 1.42), an average of 13.64 years immersed in a Mandarin-speaking family (*SE* = 13.64), and an average of 6.17 years (*SE* = 1.12) immersed in a Mandarin-speaking school or working environment.

The three groups did not differ in age, education level, gender distribution, and performance on standardized measures of short-term phonological memory (non-word repetition sub-test of the *Comprehensive Test Of Phonological Processing*, *CTOPP*, Wagner, Torgesen, & Rashotte, 1999), digit span (memory for digits sub-test of the *CTOPP*), vocabulary knowledge (*Peabody Picture Vocabulary Test*, Dunn & Dunn, 1997, and the *Expressive Vocabulary Test*, Williams, 1997), or reading fluency (*Reading Fluency* sub-test of the *Woodcock Johnson II Tests of Achievement*, Woodcock, McGrew, & Mather, 2001). In addition, the two bilingual groups did not differ in their self-reported proficiencies speaking (F (1, 38) = 1.26, p = 0.27) and understanding (F (1, 38) = 0.18, p = 0.67), or in the overall exposure to their second language at the time of the study, F (1, 38) = 0.001, p = 0.97.

6.2.3 Procedure and Materials

The vocabulary-learning and testing procedure employed in Study 2 was identical to the procedure used in Study 1 in order to allow for comparisons across the three groups. In addition to completing standardized measures of vocabulary knowledge and short-term phonological memory, bilingual participants filled out the *Language Experience and Proficiency Questionnaire* or LEAP-Q, (Marian, Blumenfeld, & Kaushanskaya, in press). Bilinguals rated their proficiency in speaking, understanding, and reading Spanish or Mandarin, as well as specified patterns of use for each of their languages, modes and ages of acquisition, and lengths of immersion for each language. In addition, both monolingual and bilingual participants were administered a digit span measure (Memory for Digits sub-test of the *CTOPP,* Wagner, Torgesen, & Rashotte, 1999), and a measure of reading skills in English (Reading Fluency sub-test of the *Woodcock Johnson Tests of Achievement*, Woodcock, McGrew, & Mather, 2001). These additional measures were administered in order to control for as many differences as possible across the three groups.

The set of stimuli used in Study 1 was used in Study 2. These stimuli include 4 sounds that are not present in the English phonemic inventory; yet, they are spelled using English letters (-P+O Condition).

6.2.4 Analyses

Accuracy and Reaction Time data were analyzed using 2 x 2 x 2 x 3 Analyses of Variance, with learning modality (auditory-only vs. auditory-and-written), testing (production vs. recognition), and testing session (immediate vs. delayed) as within-subjects independent variables, and group (monolinguals, English-Spanish bilinguals) as a between-subjects independent variable.

6.3 Results

The results are presented in the following order. First, results obtained in the overall 2 x 2 x 2 x 3 Analyses of Variance are reported. Then, between-group comparisons for each learning condition are reported. Finally, within-group comparisons for English-Spanish bilinguals, followed by within-group comparisons for English-Mandarin bilinguals are presented. Immediate testing findings are always presented first, followed by delayed testing findings. Accuracy findings are always presented first, followed by reaction time findings. Production performance findings are always presented first, followed by recognition performance findings.

6.3.1 Overall Analyses

For *accuracy*, a 2 x 2 x 2 x 3 Analysis of Variance revealed a main effect of group, F (2, 59) = 5.36, $p < 0.01$, $\eta_p^2 = 0.15$, with English-Spanish bilinguals (M = 0.48, SE = 0.03) demonstrating higher accuracy rates than monolinguals (M = 0.40, SE = 0.03), and English-Mandarin bilinguals (M = 0.54, SE = 0.03) demonstrating higher accuracy rates than monolinguals (least significant post-hocs, all p values < 0.05). In addition, the analysis revealed a main effect of testing session, F (1, 59) = 188.86, $p < 0.0001$, $\eta_p^2 = 0.76$, with participants performing more accurately during immediate testing (M = 0.56, SE = 0.02) than during delayed testing (M = 0.39, SE = 0.02), and a main effect of testing type, F (1, 59) = 1585.09, $p < 0.0001$, $\eta_p^2 = 0.96$, with participants showing greater accuracy rates during recognition testing (M = 0.67, SE = 0.02) than during production testing (M = 0.27, SE = 0.02). In addition, a two-way interaction between testing session and group, F (2, 59) = 9.03, $p < 0.001$, $\eta_p^2 = 0.24$, a two-way interaction between modality and group, F (2, 59) = 2.81, $p = 0.06$, $\eta_p^2 = 0.09$, and a marginal four-way interaction between testing session, testing type, modality, and group, F (2, 59) = 2.63, $p = 0.08$, $\eta_p^2 = 0.10$, were observed.

For reaction times, a 2 x 2 x 2 x 3 Anova revealed a main effect of testing type, F (1, 47) = 196.00, $p < 0.0001$, $\eta_p^2 = 0.82$, with participants showing greater retrieval times during production testing (M = 5661.27, SE = 221.49) than during recognition testing (M = 3533.15, SE = 163.57). The analysis also revealed a two-way interaction between testing type and group, F (2, 47) = 3.23, $p < 0.05$, $\eta_p^2 = 0.13$, and a two-way interaction between testing session and testing type, F (1, 47) = 6.33, $p < 0.05$, $\eta_p^2 = 0.13$.

Both accuracy and reaction time data were analyzed using planned post-hoc comparisons. First, between-group comparisons were conducted in order to examine differences across groups for each performance measure. Next, within-group comparisons were conducted in order to examine patterns of performance for each group.

6.3.2 Between-Group Comparisons

One-way three-level Analyses of Variance with group (Monolingual, English-Spanish bilinguals, English-Mandarin bilinguals) as a between-subjects independent variable were performed for each performance measures.

Immediate Testing

Results obtained during immediate testing are summarized in Tables 7 (auditory-only modality) and 8 (auditory-and-visual modality).

Accuracy Analyses. For foreign words learned in the *auditory-only* modality, significant differences across the three groups were revealed for both *recognition* testing, $F\ (2, 67) = 3.22$, $p < 0.05$, $\eta_p^2 = 0.09$, and *production* testing, $F\ (2, 64) = 9.19$, $p < 0.001$, $\eta_p^2 = 0.24$. During recognition testing, English-Mandarin bilinguals outperformed monolinguals, $\eta_p^2 = 0.14$. However, English-Spanish bilinguals did not differ significantly from monolingual participants, $\eta_p^2 = 0.04$, and the two bilingual groups did not differ from each other. During *production* testing, both groups of bilinguals outperformed monolingual speakers of English. Specifically, English-Mandarin bilinguals demonstrated higher accuracy rates than monolingual speakers of English, $\eta_p^2 = 0.33$, and English-Spanish bilinguals demonstrated higher accuracy rates than monolingual speakers of English, $\eta_p^2 = 0.14$. A similar pattern of performance was observed for foreign words learned in the *auditory-and-visual* modality. Significant differences across the three groups were revealed for both recognition testing, $F\ (2, 67) = 11.41$, $p < 0.0001$, $\eta_p^2 = 0.27$, and for production testing, F (2, 65) = 8.26, $p < 0.01$, $\eta_p^2 = 0.21$. For recognition testing, English-Mandarin bilinguals demonstrated higher accuracy rates than monolinguals, $\eta_p^2 = 0.25$. Similarly, English-Spanish bilinguals demonstrated higher accuracy rates than monolinguals, $\eta_p^2 = 0.26$. There was no difference between the two bilingual groups. For production testing, an identical pattern of finding was observed. English-Mandarin bilinguals outperformed monolinguals, $\eta_p^2 = 0.28$, and English-Spanish bilinguals outperformed monolinguals, $\eta_p^2 = 0.20$, but the two bilingual groups demonstrated comparable accuracy levels.

Reaction Times Analyses. Post-hoc univariate Analyses of Variance for reaction times revealed differences across groups. Specifically, for words learned in the *auditory-only modality*, significant differences across groups were revealed at *production testing*, F (2, 62) = 4.25, $p < 0.05$, $\eta_p^2 = 0.12$. This difference was driven by English-Spanish bilinguals, who showed longer retrieval times than monolinguals, $\eta_p^2 = 0.14$, and than English-Mandarin bilinguals, $\eta_p^2 = 0.09$. A similar trend was observed for words learned in the *auditory-and-visual modality*, F (2, 64) = 2.00, $p = 0.15$, $\eta_p^2 = 0.06$, with English-Spanish bilinguals demonstrating longer *production* times than English-Mandarin bilinguals, $\eta_p^2 = 0.11$.

Delayed Testing

Accuracy Analyses. For items learned in the *auditory-only* condition, analyses revealed differences across groups for *production* testing, F (2, 61) = 3.28, $p < 0.05$, $\eta_p^2 = 0.10$, and a similar trend for *recognition* testing, F (2, 63) = 2.35, although it did not reach significance ($p = 0.10$, $\eta_p^2 = 0.07$). In both cases, the pattern was driven by a difference in performance between the English-Mandarin bilingual group and the monolingual group. For *recognition* testing, English-Mandarin bilinguals ($M = 0.67$, $SE = 0.04$) outperformed monolingual speakers of

Table 7

Between-Group Comparisons for Immediate Testing of Foreign Words Learned in the Auditory-Only Modality

A. Production – Accuracy			
Group	Mean (SE)	Comparison to:	
		ESB	EMB
Monolinguals	0.27 (0.04)	*t* (44) = -2.41*	*t* (41) = -4.46**
English-Spanish Bilinguals (ESB)	0.42 (0.05)	--	*t* (43) = -1.79
English-Mandarin Bilinguals (EMB)	0.54 (0.05)	--	--
B. Production - Reaction Times			
		ESB	EMB
Monolinguals	5284.31 (309.66)	*t* (42) = -2.49*	*t* (40) = -0.22
English-Spanish Bilinguals (ESB)	7079.76 (628.99)	--	*t* (46) = 2.12*
English-Mandarin Bilinguals (EMB)	5404.33 (456.39)	--	--
C. Recognition – Accuracy			
		ESB	EMB
Monolinguals	0.70 (0.04)	*t* (46) = -1.02	*t* (44) = -2.63*
English-Spanish Bilinguals (ESB)	0.76 (0.04)	--	*t* (44) = -1.40
English-Mandarin Bilinguals (EMB)	0.83 (0.03)	--	--
D. Recognition - Reaction Times			
		ESB	EMB
Monolinguals	3347.96 (251.19)	*t* (46) = -0.24	*t* (44) = 1.09
English-Spanish Bilinguals (ESB)	3439.87 (287.54)	--	*t* (44) = 1.26
English-Mandarin Bilinguals (EMB)	2999.84 (187.67)	--	--

Note. Significance of comparisons (p) is marked by asterisks next to the t values. Significance at $p < 0.01$ is marked by two asterisks **; significance at $p < 0.05$ is marked by one asterisk *.

Table 8

Between-Group Comparisons for Immediate Testing of Foreign Words Learned in the Auditory-and-Visual Modality

A. Production – Accuracy			
Group	Mean (SE)	Comparison to:	
		ESB	EMB
Monolinguals	0.23 (0.04)	*t* (45) = -3.05**	*t* (42) = -3.90**
English-Spanish Bilinguals (ESB)	0.39 (0.04)	--	*t* (43) = -0.77
English-Mandarin Bilinguals (EMB)	0.43 (0.04)	--	--
B. Production - Reaction Times			
		ESB	EMB
Monolinguals	5818.81 (563.35)	*t* (44) = -1.42	*t* (41) = 0.24
English-Spanish Bilinguals (ESB)	6738.08 (346.00)	--	*t* (43) = 2.32*
English-Mandarin Bilinguals (EMB)	5662.42 (297.87)	--	--
C. Recognition – Accuracy			
		ESB	EMB
Monolinguals	0.61 (0.04)	*t* (46) = -3.26**	*t* (44) = -4.01**
English-Spanish Bilinguals (ESB)	0.77 (0.03)	--	*t* (44) = -0.36
English-Mandarin Bilinguals (EMB)	0.79 (0.02)	--	--
D. Recognition - Reaction Times			
		ESB	EMB
Monolinguals	3798.28 (277.45)	*t* (46) = -0.61	*t* (44) = 0.57
English-Spanish Bilinguals (ESB)	4026.10 (250.64)	--	*t* (44) = 1.21
English-Mandarin Bilinguals (EMB)	3572.95 (278.07)	--	--

Note. Significance of comparisons (*p*) is marked by asterisks next to the *t* values. Significance at $p < 0.01$ is marked by two asterisks **; significance at $p < 0.05$ is marked by one asterisk *.

English (*M* = 0.55, *SE* = 0.04), *t* (41) = 2.20, $p < 0.05$, $\eta_p^2 = 0.09$. Similarly, for *production* testing, English-Mandarin bilinguals (*M* = 0.24, *SE* = 0.03) outperformed monolingual speakers of English (*M* = 0.15, *SE* = 0.03), *t* (39) = 2.26, $p < 0.05$, $\eta_p^2 = 0.11$, and marginally outperformed English-Spanish bilinguals (*M* = 0.17, *SE* = 0.02), *t* (41) = 1.85, $p = 0.07$, $\eta_p^2 = 0.09$. No differences were observed between English-Spanish bilinguals and monolinguals. No differences across groups were observed for items learned in the auditory-and-visual modality.

Reaction Time Analyses. No differences across groups were observed in reaction times for words learned in either the auditory-only or the auditory-and-visual modality.

In sum, across-group comparisons revealed a consistent and reliable pattern of performance, with bilingual speakers outperforming monolingual speakers on most accuracy-of-performance measures. Differences between bilingual groups and the monolingual group were mostly localized to immediate testing; however, English-Mandarin bilinguals also demonstrated an advantage over monolinguals during delayed testing. While consistently outperforming monolinguals on accuracy measures, English-Spanish bilinguals demonstrated longer retrieval times than monolinguals and than English-Mandarin bilinguals during immediate production testing. This suggests that for the English-Spanish group, an advantage in terms of performance accuracy carried costs in terms of performance efficiency.

6.3.3 Within-Group Comparisons

Monolingual, English-Spanish bilingual, and English-Mandarin bilingual data are presented in Figures 3 (accuracy data) and 4 (reaction time data). Monolingual participants' data were discussed in detail in Study 1, and can be found on pages 50-51. To summarize, *monolingual participants* were hindered by bimodal presentation during learning, and performed better on items learned in the auditory-only modality than on items learned in the auditory-and-visual modality. This pattern held over time, and persisted during delayed testing in terms of performance efficiency.

English-Spanish bilinguals. During immediate testing, *accuracy* analyses revealed similar patterns of results across the two learning modalities. English-Spanish bilinguals demonstrated comparable accuracy rates when *producing* English translations for foreign items learned in the auditory-only modality (M = 0.42, SE = 0.05) and foreign items learned in the auditory-and-visual modality (M = 0.39, SE = 0.04), F (1, 23) = 0.70, p = 0.41, *partial* η^2 = 0.03. Similarly, English-Spanish bilinguals were just as accurate at *recognizing* English translations of foreign words learned in the auditory-only modality (M = 0.76, SE = 0.04) as words learned in the auditory-and-visual modality (M = 0.77, SE = 0.04), F (1, 23) = 0.18, p = 0.68, *partial* η^2 = 0.01. *Reaction time* analyses at recognition testing revealed that participants responded faster to foreign words learned in the auditory-only modality (M = 3439.87, SE = 287.54) than in the auditory-and-visual modality (M = 4026.10, SE = 250.64), F (1, 23) = 4.59, $p < 0.05$, *partial* η^2 = 0.17. Reaction times at production testing were comparable across the two learning modalities, F (1, 22) = 0.30, p = 0.59, η_p^2 = 0.01. During delayed testing, analyses revealed that English-Spanish bilinguals were faster at recognizing correct English translations of foreign words learned in the auditory-only modality (M = 3699.83, SE = 287.75) than in the auditory-and-visual modality (M = 4173.77, SE = 401.87), F (1, 22) = 3.85, p = 0.06, *partial* η^2 = 0.16. No other significant results were observed during delayed testing.

In sum, unlike monolinguals, English-Spanish bilinguals' accuracy of performance was not hindered by bimodal presentation, and they demonstrated comparable accuracy rates for items learned bimodally and unimodally. However, English-Spanish bilinguals showed reaction-time costs associated with learning foreign words bimodally. For reaction times, English-Spanish

Figure 3. Accuracy of retrieving English translations immediately after foreign-word learning. Performance for the monolingual group is shown in panel A; English-Spanish group is shown in panel B; English-Mandarin group is shown in panel C.

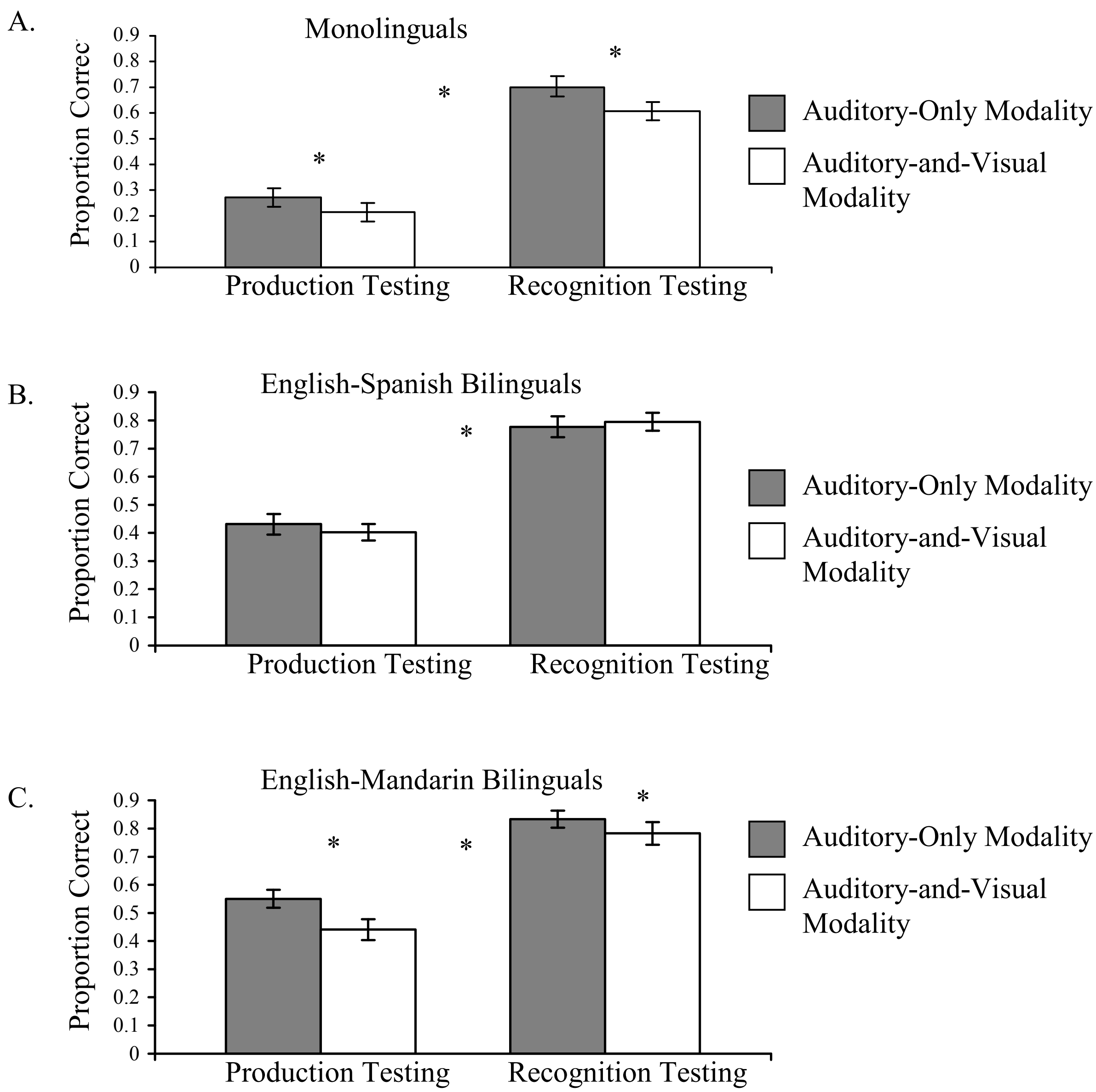
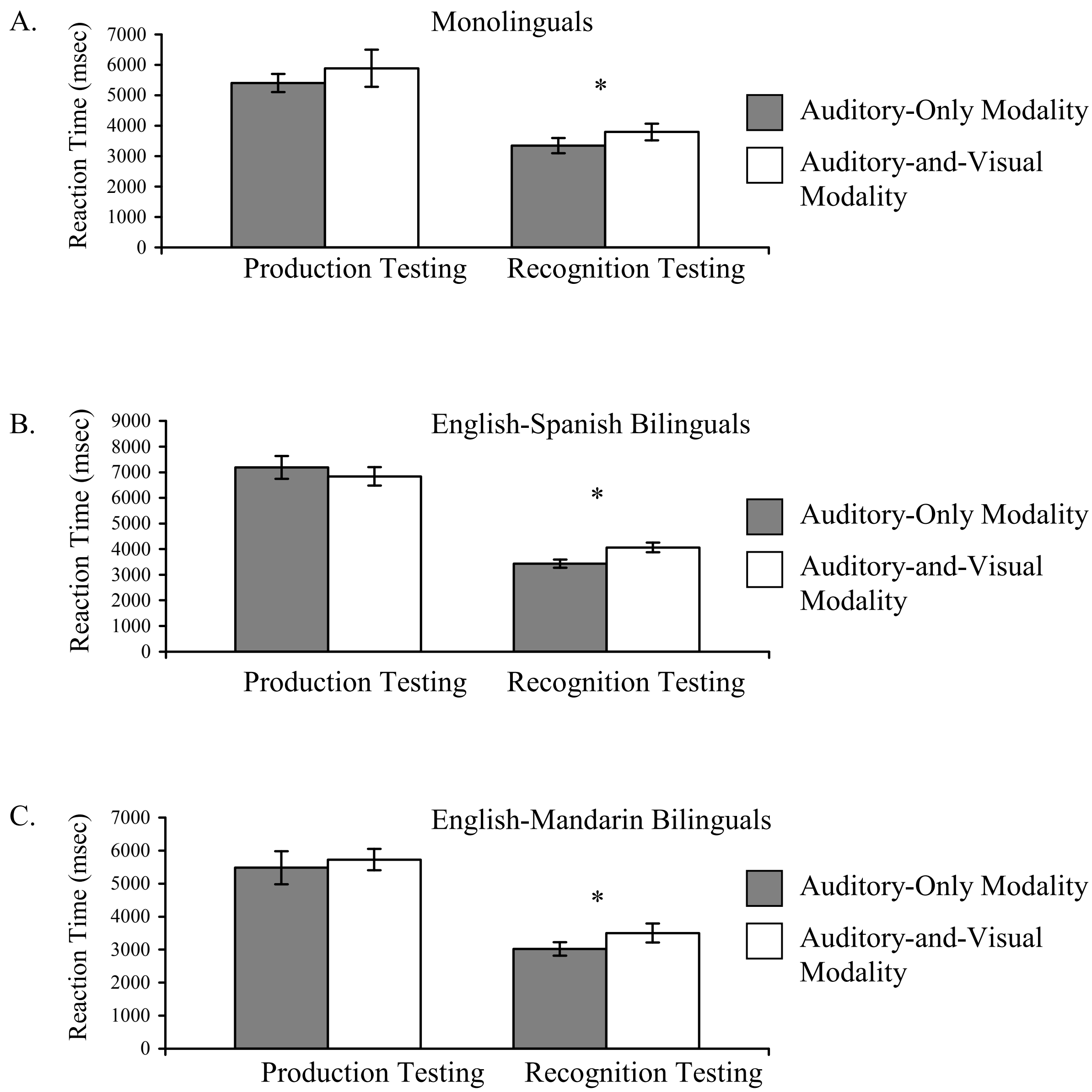


Figure 4. Reaction times for correctly-retrieved English translations immediately after foreign word learning. Performance for the monolingual group is shown in panel A; English-Spanish group is shown in panel B; English-Mandarin group is shown in panel C.



bilinguals' performance during both immediate and delayed testing resembled that of monolingual participants, with longer retrieval times for bimodally-learned foreign words.

English-Mandarin Bilinguals. During immediate testing*, accuracy* analyses revealed similar patterns of results for production and recognition testing. English-Mandarin bilinguals were more accurate at *producing* English translations for foreign items learned in the auditory-only modality (M = 0.54, SE = 0.05) than in the auditory-and-visual modality (M = 0.43, SE = 0.04), F (1, 20) = 12.26, $p < 0.01$, *partial* $\eta^2 = 0.38$. Similarly, English-Mandarin bilinguals were more accurate at *recognizing* English translations of foreign items learned in the auditory-only modality (M = 0.83, SE = 0.03) than in the auditory-and-visual modality (M = 0.79, SE = 0.02), F (1, 21) = 3.24, $p < 0.05$, *partial* $\eta^2 = 0.13$. *Reaction time* analyses revealed that participants were faster to recognize foreign words learned in the auditory-only modality (M = 2999.85, SE = 187.67) than in the auditory-and-visual modality (M = 3572.95, SE = 278.07), F (1, 21) = 10.73, $p < 0.01$, *partial* $\eta^2 = 0.34$.

During delayed testing, analyses revealed that participants were more accurate at producing English translations for foreign items learned in the auditory-only modality (M = 0.24, SE = 0.03) than in the auditory-and-visual modality (M = 0.18, SE = 0.02), F (1, 19) = 5.01, $p <$ 0.05, *partial* $\eta^2 = 0.21$. In addition, English-Mandarin bilinguals were faster at recognizing correct English translations of foreign words learned in the auditory-only modality (M = 3315.41, SE = 213.75) than in the auditory-and-visual modality (M = 3707.99, SE = 320.34), F (1, 20) = 4.73, $p < 0.05$, *partial* $\eta^2 = 0.19$.

In sum, like monolinguals, English-Mandarin bilinguals were hindered by bimodal presentation during learning, and performed better on items learned in the auditory-only modality than on items learned in the auditory-and-visual modality. This was the case for both the accuracy and the efficiency measures. Moreover, hindrance associated with bimodal learning persisted over time, and was observed during delayed testing in terms of both performance accuracy and performance efficiency.

6.4 Study 2 Discussion

The objective of Study 2 was to compare monolingual and bilingual speakers on their ability to learn words from the foreign language in two modality conditions – auditory-only vs. auditory-and-visual. The foreign language was constructed to simulate learning of a Germanic or a Romance language by native speakers of English. It mismatched English in some of its phonemes, but maintained the English orthography. Therefore, the artificially-constructed foreign words mismatched English in the same way that Spanish mismatches English. This similarity between the artificial foreign language and Spanish was structural, and did not extend to the identity of the specific sounds. Thus, the artificial foreign language and Spanish did not share phoneme-to-letter mappings. However, they shared the presence of mismatch in letter-to-phoneme mappings that proved so difficult for monolingual speakers of English. In contrast, the artificial foreign language did *not* resemble Mandarin, since the Chinese writing system does not incorporate individual letter symbols. Therefore, comparing the group of English-Spanish bilinguals and the group of English-Mandarin bilinguals on their performance with -P+O language should reveal whether different language-learning experiences result in distinct foreign-vocabulary-acquisition performance profiles.

Results revealed that both bilingual groups were better at learning foreign words than monolingual speakers of English, indicating a general advantage associated with bilingual experience for subsequent language-learning. However, the bilingual advantage in foreign word learning was observed only for performance accuracy, but not for efficiency. Reaction times were either comparable across the monolinguals and the two groups of bilinguals, or were faster for the monolingual group than for the English-Spanish bilingual group. This discrepancy between accuracy and efficiency measures suggests that bilingual experience modifies language-learning mechanisms responsible for strength of retained representations, but does not facilitate the efficiency of their retrieval. In fact, within each group, reaction time patterns were very similar. For all three groups, words learned in the auditory-only modality were recognized faster than words learned in the auditory-and-visual modality. Moreover, the "bimodal hindrance" patterns in RTs associated with bimodal learning maintained long-term, and persisted with delayed testing for all three groups. This indicates that bimodal exposure has a fundamental and general impact on efficiency of retrieval that is not modified by linguistic experience. Processing -P+O foreign words in both the auditory and the visual modalities during learning incurs retrieval-efficiency costs that appear to be comparable across different participant groups.

While both bilingual groups outperformed monolingual speakers of English, some differences between the two bilingual groups were also revealed. For instance, the advantage experienced by English-Spanish bilinguals was found more reliably for foreign words learned in the auditory-and-visual modality compared to words learned in the auditory-only modality. Specifically, both recognition and production performance measures for words learned in the *auditory-and-visual modality* yielded higher accuracy rates for English-Spanish bilinguals compared to monolinguals. However, English-Spanish bilinguals and monolinguals demonstrated comparable recognition accuracy rates for foreign words learned in the *auditory-only modality*. English-Mandarin bilinguals, on the other hand, consistently outperformed monolingual speakers of English, both for foreign words learned in the auditory-only, and in the auditory-and-visual modality and for production and recognition testing. Additional differences between the two bilingual groups were also found during delayed testing. The superior performance of the English-Spanish bilingual group was observed only during immediate testing, but not during delayed testing. In contrast, the advantage observed for English-Mandarin bilinguals at immediate testing maintained long-term, and English-Mandarin bilinguals demonstrated more accurate performance than monolingual participants during delayed testing.

Within-group comparisons revealed that while both groups of bilinguals outperformed monolingual participants on most performance measures, the patterns of performance within each group were distinct. Specifically, bilingual speakers of English and Mandarin resembled monolingual speakers of English, and bimodal presentation consistently hindered retention of foreign words (compared to unimodal presentation) in both groups. For bilingual speakers of English and Spanish, however, bimodal presentation did not hinder retention of foreign words (compared to unimodal presentation). In fact, English-Spanish bilinguals demonstrated nearly identical accuracy rates across the two learning modalities, during both immediate and delayed testing.

6.4.1 Possible Mechanisms of Bilingual Advantage in Foreign Word Learning

The distinct performance profiles for English-Spanish and English-Mandarin bilinguals suggest differences between the two groups in either the underlying cognitive mechanisms responsible for foreign word learning, the degree to which the mechanisms can be modified by a particular linguistic experience, or both. Within the context of Baddeley's working memory model, modulation of the learning process by experience may take place at the level of the central executive module, the articulatory loop, or the episodic buffer. For instance, it is possible that language-learning experience enables the central executive to distribute attentional resources in a more efficient manner. Alternatively, it is possible that language-learning experience increases the capacity of the phonological store, and/or increases the efficiency of the rehearsal component of the articulatory loop. Yet another explanation would suggest the language-learning experience increases the flexibility and functionality of the episodic buffer, enabling it to integrate the foreign input and the conflicting long-term knowledge in a more efficient manner.

Contextualizing bilingual performance within the working memory model can explain performance patterns of both groups of bilinguals. For example, in line with the Van Hell and Manhn (1997) and Papagno and Vallar (1995) explanation, the experience of learning a foreign language (Mandarin or Spanish) may have improved the function of the phonological loop. In such a scenario, bilingual experience may have resulted in an increased phonological-store capacity and/or in an increased efficiency of the rehearsal mechanisms. Alternatively, bilingualism may have improved the functioning of the central executive, allowing it to distribute attentional resources in a more efficient manner. As a result, bilinguals were able to learn more effectively, and thus retain a greater proportion of foreign words. However, different performance patterns across the two bilingual groups suggest that a single common mechanism underlying bilingual advantage in foreign word learning may not be a sufficient explanation. Instead, it is likely that different language-learning experiences have influenced the function of the working memory in different ways.

The finding that the experience of learning Spanish enabled participants to process bimodal input without incurring retention costs (compared to processing unimodal input) may suggest a very specific modification of the language-learning mechanism as a result of language-learning experience. This change may take place at the level of the episodic buffer. Since the episodic buffer is the locus of interaction between long-term memory and working memory, it is the most likely locus of interference associated with bimodal learning in the -P+O condition in monolinguals. (In monolinguals, costs associated with bimodal learning in the -P+O condition are likely due to activation of native language phonology that competes with foreign phonology perceived auditorily. This competition likely takes place at the level of the episodic buffer.) Thus, it could be hypothesized that experience with Spanish (a -P+O language in relation to English) may have impacted the way the episodic buffer integrates native-language information and foreign-language input. This modulation may have at its root the fundamental principle of parallel processing in a bilingual language system.

The parallel-processing account of language function in bilinguals suggests that recognition (and production) of written (and auditory) input proceeds in parallel for the bilinguals' two languages. Prior research suggests that written input in the native language can activate phonological information in both the native and the foreign language (e.g., Jared & Kroll, 2001; Kaushanskaya & Marian, 2007). Given the orthographic overlap between English and Spanish, it is highly likely that English-Spanish bilinguals consistently activate Spanish phonology in response to written input in English, and vice versa. Therefore, they may have developed an efficient mechanism that allows them to selectively inhibit English letter-to-phoneme mappings when processing Spanish, and inhibit Spanish letter-to-phoneme mappings when processing English. By using this mechanism during learning of -P+O words, English-Spanish bilinguals may have been able to process bimodal input in a more efficient manner. Therefore, accuracy findings (with comparable performance for words learned unimodally and bimodally) may suggest that the locus of bilingual advantage in English-Spanish bilinguals is the episodic buffer. Experience with learning Spanish may have improved the buffer's capacity for processing foreign-language input that conflicts with native-language knowledge.

It should be noted that rooting English-Spanish bilinguals' performance in parallel processing accounts necessarily suggests two outcomes of knowing Spanish. *First*, as discussed earlier, it is possible that the experience of learning Spanish may make activation of native-language English phonology during written word processing in English less habitual. This may, in turn, enable English-Spanish bilinguals to process the written input that activates conflicting native-language phonology more efficiently, resulting in comparable levels of performance for words learned in two modality conditions. *Second*, it is possible that the experience of learning Spanish may result in activation of both native-language English phonology *and* second-language phonology during written word processing in -P+O learning condition. This may, in turn, result in even more interference and competition with phonological input perceived auditorily, and yield performance costs in English-Spanish bilinguals for the auditory-and-visual modality compared to the auditory-only modality, and higher performance costs compared to monolinguals. Interestingly, both patterns were found. The benefits associated with learning Spanish were localized to performance accuracy, while the costs were localized to performance efficiency. This may indicate that different components of the working memory are responsible for retention of the novel verbal representation (accuracy measure) and for efficiency of access to this representation (reaction time measure).

6.4.2 Relating the Bilingual Advantage in Foreign Word Learning to the Bilingual Advantage in Executive Control Tasks

It is possible that the common mechanism underlying the global bilingual advantage in the current data is the central executive module of the working memory. Thus, language-learning experience may train the central executive to be more efficient at allocating resources during learning. Finding the bilingual advantage in both English-Spanish and English-Mandarin bilinguals indicates a commonality in the cognitive mechanisms underlying their performance. Localizing the bilingual advantage for foreign word learning to the central executive component of the working memory model is consistent with the work by Bialistok et al. Bialystok has shown that bilingualism improves not only bilinguals' inhibitory control, but their overall executive functioning, as well. For instance, bilingualism was found to positively influence performance on working memory tasks in younger and older adults (e.g., Bialystok, Craik, Klein, & Viswanathan, 2004). If executive function, in general, is presumed to be the same central executive that is responsible for allocation of resources in the working memory framework, then the bilingual advantage for foreign word learning may be driven by the exact same mechanisms as the bilingual advantage for non-linguistic executive function. However, this explanation alone is not sufficient to account for the pattern of findings in the current study. Specifically, the qualitative differences between the two groups of bilingual participants appear to suggest presence of another mechanism, in addition to the executive control. Such a mechanism would have to account for the finding that Spanish-English bilinguals appeared to show no costs associated with bimodal processing of conflicting auditory and written information – a finding that suggests a very specific modification of the foreign-word-learning mechanisms, and not a general one. It is therefore, difficult to ascribe this pattern of performance to the function of the central executive alone, unless one were willing to propose that bilingual experience impacts the central executive both quantitatively (in terms of a general bilingual advantage over monolinguals) and qualitatively (in terms of a specific bilingual advantage that arises as a result of dealing with a specific combination of two languages).

While it is difficult to localize the effect of language-learning experience to any one component of the working memory, future lines of research may attempt do so. Future research will need to examine the effects of bilingualism on working memory by selectively targeting each working-memory component. If different language-learning experiences influence the working-memory mechanisms in distinct ways, it may be possible to isolate the impacted components using methodologies that localize processing effects in the working memory. Thus, English-Spanish and English-Mandarin bilinguals may be compared on their ability to memorize longer vs. shorter lists (a function of the storage component of phonological loop), or to memorize verbal information during articulatory suppression (a task that overloads the rehearsal component of the phonological loop). Another approach would be to relate bilinguals' performance on a word-learning task to their performance on the executive-control tasks such as the Simon or the Stroop. If the same central-executive mechanisms underlies both types of tasks, then bilinguals (and monolinguals) who perform better on the executive-control tasks should be better at learning foreign words. Future studies may also examine foreign word learning within a more constrained learning paradigm, and impose time limits on learning.

In conclusion, the findings of Study 2 substantiate both the bilingual-general and the bilingual-specific hypotheses regarding the effects of bilingual experience on subsequent foreign language learning. The finding that both bilingual groups outperformed monolingual speakers of English demonstrate that bilingual experience (independent of specific language history – Mandarin or Spanish) results in superior foreign word learning performance. The finding that performance patterns within each group differ indicates that different bilingual experiences result in distinct foreign-vocabulary-learning performance profiles. Study 2 also raises a number of questions regarding possible underlying mechanisms that drive performance patterns across the two bilingual groups, and the difference between bilingual and monolingual participants. Future studies that manipulate different working-memory components in different groups of bilinguals are necessary before any conclusions can be made regarding the working memory mechanisms that may be influenced by linguistic experiences. In the meantime, the current data provide an opportune ground for exploring two possible factors that may influence the degree to which bilingual experiences influences subsequent language learning. These two factors are related to the role Age of Acquisition and proficiency may play in the development of bilingual advantage for language learning. Because the current data yield themselves to exploring the roles of AOA and proficiency in development of bilingual advantage, the next chapter provides a brief review of the literature that substantiates their influence on bilingual language processing, and presents preliminary analyses that examine the impact of each factor on development of the bilingual advantage for foreign word learning.

CHAPTER VII.

EXPLORING AGE-OF-ACQUISITION AND PROFICIENCY FACTORS IN THE DEVELOPMENT OF THE BILINGUAL ADVANTAGE FOR FOREIGN LANGUAGE LEARNING

Bilingual performance in a given language varies as a function of multiple factors, some of which are associated with aspects of language acquisition (e.g., classroom vs. immersion-based acquisition; early vs. late acquisition; limited vs. extended linguistic exposure, etc.). The two potential determiners of bilingual performance in the second language (L2) that received the most attention in the literature are (1) age of L2 acquisition and (2) L2 proficiency. The general findings are that earlier L2 acquisition age and higher levels of L2 proficiency result in better L2 performance. While it is difficult to tease the AoA and proficiency effects apart, since earlier AoA frequently results in longer duration of language learning, and therefore, in higher proficiency levels, Study 2 offers an exciting opportunity to explore the effects of each on development of bilingual advantage. The effects of AoA on the development of bilingual advantage for foreign word learning was explored in the English-Spanish bilingual group, while the effects of L2 proficiency on the development of bilingual advantage for foreign word learning was explored in the English-Mandarin bilingual group.

English-Spanish bilinguals tested in Study 2 were all highly proficient bilinguals, who acquired Spanish before the age of 12. However, some English-Spanish bilinguals started acquiring Spanish very early on (at birth or within the first few years of life), while others started acquiring Spanish later in life. Both early and later English-Spanish bilinguals, however, were equally proficient in Spanish. Therefore, comparisons of early English-Spanish bilinguals to late

English-Spanish bilinguals allowed for examining the effects of L2 acquisition age on the development of bilingual advantage, controlling for the effects of language proficiency. In contrast, English-Mandarin bilinguals tested in Study 2 were all early bilinguals, who acquired Mandarin at birth or very early in life. Their proficiency in Mandarin varied, however, especially for reading skills. Thus, some English-Mandarin bilinguals were proficient readers of Mandarin, while others possessed only rudimentary reading skills in Mandarin. Both high-proficiency and low-proficiency English-Mandarin speakers, however, acquired Mandarin very early in life. Therefore, comparisons of high-proficiency English-Mandarin bilinguals to low-proficiency English-Mandarin bilinguals allowed for examining the effects of L2 proficiency on the development of bilingual advantage, controlling for the effects of AoA. Unfortunately, because of a limited range of proficiency values in the English-Spanish bilingual group (all highly-proficient Spanish speakers) and of a limited range of age values in the English-Mandarin bilingual group (all early bilinguals), the effects of *both* the AoA and of the L2 proficiency could not be examined for each of the bilingual groups. In order to firmly establish the effects of AoA and of L2 proficiency on the development of bilingual advantage, the two have to be studied within the same group of bilinguals. Therefore, the current preliminary analyses should be interpreted with caution, and the findings must await confirmation from future studies.

In this chapter, a brief review of AoA and proficiency effects on bilingual language processing is presented, followed by results and a discussion of the findings. Then, promising lines of research that would examine AoA and proficiency effects in development of bilingual advantage for foreign word learning are outlined.

7.1 Age-of-Acquisition Effects in Bilingual Language Processing

There is overwhelming evidence for age-of-acquisition effects in second language learning. While avid proponents and vehement opponents of the critical period hypothesis debate whether there are maturational constraints on second language acquisition, it is impossible to argue with the fact that earlier language acquisition leads to superior language performance (e.g., Johnson & Newport, 1989; Weber-Fox & Neville, 1999; Bialystok & Miller, 1999; Flege, Yeni-Komshian, & Liu, 1999; Mayo & Florentine, 1997). It appears that early learning of a language makes native-like language attainment more likely, although the effects of acquisition age and length of exposure on the attained proficiency are confounded (e.g., Bialystok & Miller, 1999).

The impact of acquisition age on development of the bilingual advantage has not been explicitly studied, in either the linguistic domain or the general cognitive domain. However, in Bialystok's studies of bilingual advantage for executive-control tasks, adult bilingual participants were all early bilinguals, who acquired their second language no later than 6 to 12 years of age (e.g., Bialistok, Craik, & Ryan, 2006; Bialystok, Klein, Craik, & Viswanathan, 2004). It is possible, therefore, that bilingual advantage for executive function develops only as a result of early exposure to two languages, with early exposure to the two languages in turn resulting in an extensive period of time when both languages are used and activated in parallel. However, this may not necessarily be the case, and it is possible that later acquisition of a second language is sufficient to modify the executive control mechanisms. For instance, it may be that successful acquisition of a second language even later in life brings about a cognitive benefit, especially when the second language is acquired to the level of high proficiency. While studies that would explicitly test the effects of early vs. late bilingualism on development of executive control are necessary, the current data lend themselves to examining the role of L2 acquisition age on development of the bilingual advantage for foreign vocabulary acquisition. If differences between early vs. late bilinguals in foreign vocabulary learning were observed, they would indicate that age of L2 acquisition mediates the development of bilingual advantage. Because bilingual advantage for foreign word learning may be underlied by the same cognitive mechanisms that drive the general cognitive bilingual advantage (i.e., inhibitory control), the AoA effects in the current data may point to presence of AoA effects in the general cognitive domain.

Examination of AoA effects in the development of the bilingual advantage was possible within the context of English-Spanish bilinguals' data. English-Spanish bilinguals recruited for Study 2 were all highly-proficient speakers of Spanish, and all acquired Spanish as their second language early in life. However, some English-Spanish bilinguals acquired Spanish at birth or very early in life, while others acquired Spanish later in life. Two types of analyses were conducted to examine the effects of AoA on the development of bilingual advantage. The first analysis used correlation statistics to examine the relationship between L2 acquisition age and English-Spanish bilinguals' performance on the word-learning task. If earlier L2 acquisition yields a stronger bilingual advantage, then there should be a strong negative correlation between L2 acquisition age and word-learning performance (i.e., earlier L2 acquisition age should be associated with higher accuracy on the word-learning task). The second analysis used Univariate ANOVAs to examine the categorical effect of AoA on the development of bilingual advantage. By splitting the English-Spanish bilingual group into early and late bilinguals, the effect of L2 acquisition age on bilinguals' word-learning performance could be explored. Because the two groups were both highly proficient in Spanish, the division of English-Spanish bilinguals into early and late resulted in two groups of bilinguals with comparable L2 proficiency levels, but different L2 acquisition ages. Comparison of the two groups to that of monolingual participants was therefore likely to reveal the impact of L2 acquisition age on development of bilingual advantage in foreign vocabulary learning.

7.2 Method

In order to tease out the effect of age of L2 acquisition on bilinguals' performance, the L2 acquisition age was first correlated with word-learning performance, and then the English-Spanish bilingual group was split into two groups – early and late. The median split for L2 acquisition age yielded a group of 12 English-Spanish bilinguals with the mean acquisition age of 5.7 years (*SE* = 1.51) and a group of 11 English-Spanish bilinguals with the mean L2 acquisition age of 10.17 years (*SE* = 1.38), F (1, 20) = 4.80, $p < 0.05$, $\eta_p^2 = 0.19$. The two groups did not differ in self-reported reading proficiency, speaking proficiency, or understanding proficiency in Spanish (all p values > 0.05). The two groups of English-Spanish bilinguals (early and late) were compared to monolingual speakers of English in order to examine the age-of-acquisition effects in development of the bilingual advantage for foreign word learning.

7.3 Analyses

Correlation analyses did not yield any significant relationships between AoA and word-learning performance (all p values > 0.2). However, for words learned in the *auditory-and-visual* modality, there was a consistent negative correlation trend, and earlier L2 acquisition age was associated with higher accuracy scores on the immediate recognition testing (R = -0.18), immediate production testing (R = -0.22), delayed recognition testing (R = -0.23), and delayed production testing (R = -0.21).

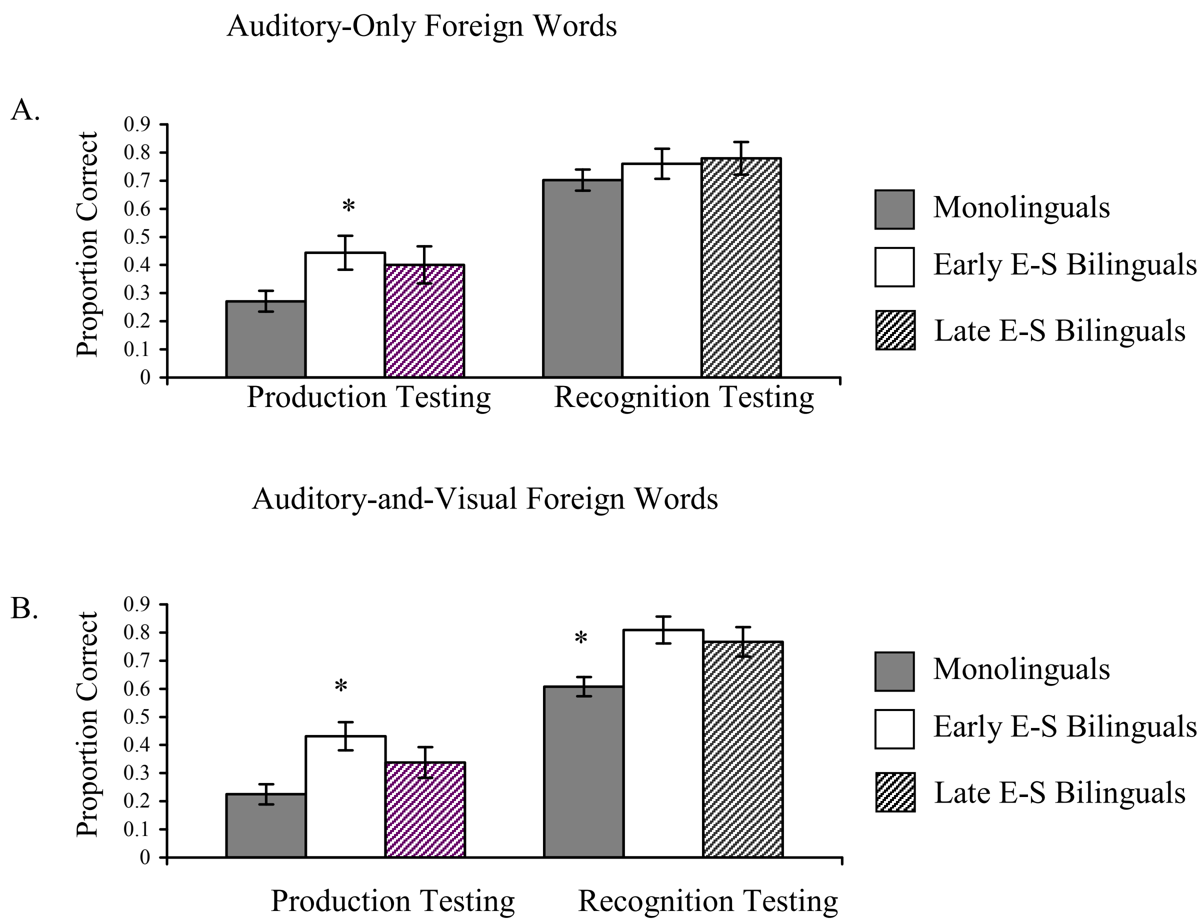
Because of relatively small sample sizes for each English-Spanish bilingual group, AOA effects in foreign word learning were examined using a-priori univariate ANOVAs with group (early English-Spanish bilinguals, late English-Spanish bilinguals, and monolinguals) as an independent variable, and each measure of performance as a dependent variable. In addition, within-group analyses were conducted in order to examine the effect of learning modality on performance in the early and late bilingual groups.

7.4 Between-Group Results

7.4.1 Accuracy

For *accuracy*, during immediate testing, both early (M = 0.81, SE = 0.04) and late English-Spanish bilinguals (M = 0.77, SE = 0.05) demonstrated higher *recognition* accuracy rates than monolingual speakers of English (M = 0.61, SE =0.03) for words learned in the *auditory-and-visual* modality, F (2, 43) = 7.14, $p < 0.01$, $\eta_p^2 = 0.25$, post-hoc $p < 0.05$. However, only early bilinguals (M = 0.44, SE = 0.06) demonstrated higher *production* accuracy rates than monolinguals (M = 0.27, SE = 0.04), t (32) = 2.45, $p < 0.05$, for words learned in the *auditory-only* modality, and for words learned in the *auditory-and-written* modality (*Early* M = 0.43, SE = 0.05; *Mono* M = 0.23, SE = 0.04, t (33) = 3.25, $p < 0.01$). Conversely, late bilinguals demonstrated accuracy rates that were only marginally different from those of the monolinguals for both unimodally-learned words (M = 0.40, SE = 0.07), t (30) = 1.73, $p = 0.09$, and bimodally-learned words (M = 0.34, SE = 0.06), t (31) = 1.76, $p = 0.09$. No significant differences were observed between early and late bilinguals on any accuracy measure, $p > 0.1$.

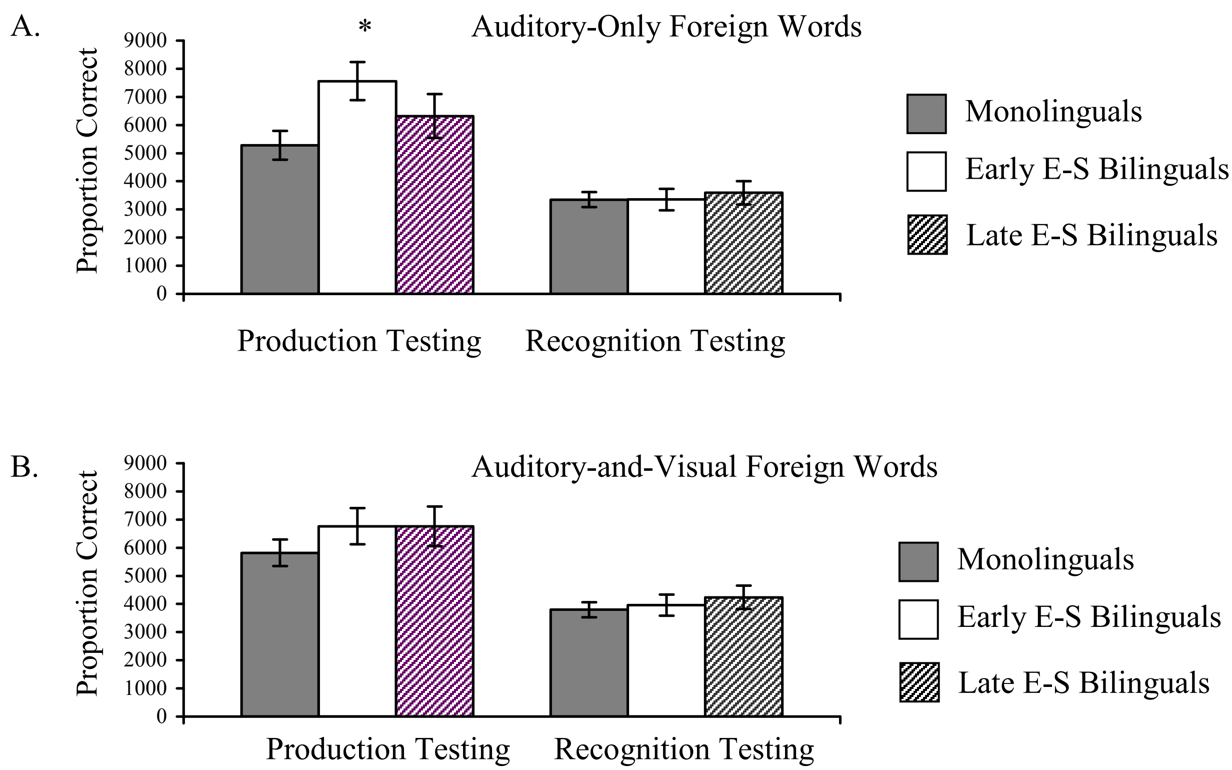
Figure 5. Comparing Early vs. Late English-Spanish bilinguals to monolinguals on <u>accuracy</u> of retrieving English translations immediately after foreign-word learning. Performance on words learned in the auditory-only modality is presented in Panel A. Performance on words learned in the auditory-and-visual modality is presented in Panel B.



7.4.2 Reaction Times

For reaction times, only early bilinguals demonstrated longer reaction times (M = 7557.80, SE = 677.27) than monolinguals (M = 5284.32, SE = 511.97) when producing English translations for foreign words learned in the auditory-only condition, t (31) = 2.65, $p < 0.05$, while late bilinguals demonstrated reaction times (M = 6319.48, SE = 782.04) that were

Figure 6. Reaction times for correctly-retrieved English translations immediately after foreign word learning. Performance on words learned in the auditory-only modality is presented in Panel A. Performance on words learned in the auditory-and-visual modality is presented in Panel B.



comparable to monolingual RTs, t (28) = 1.53, $p = 0.14$. No differences were observed between early and late bilinguals, $p > 0.1$, and no differences across groups were observed during delayed testing.

7.5 Within-Group Results

7.5.1 Early Bilinguals

For accuracy, early bilinguals demonstrated comparable accuracy rates for words learned bimodally and unimodally, and this was the case for both recognition (F (1, 11) = 0.91, p = 0.36), and production testing (F (1, 11) = 0.08, p = 0.78) at immediate testing, and recognition (F (1, 11) = 0.83, p = 0.38) and production (F (1, 11) = 0.24, p = 0.64) at delayed testing.

For reaction times at immediate testing, early bilinguals demonstrated marginally longer recognition times for words learned bimodally (M = 3959.13, SE = 307.31) than for words learned unimodally (M = 3354.99, SE = 276.17), F (1, 11) = 3.83, p = 0.076, η_p^2 = 0.26, but comparable production times, F (1, 11) = 0.66, p = 0.43. For reaction times at delayed testing, early bilinguals showed comparable retrieval times for words learned unimodally and bimodally, and this was the case for both recognition, F (1, 11) = 0.41, p = 0.54, and production, F (1, 9) = 1.13, p = 0.32.

7.5.2 Late Bilinguals

For accuracy, late bilinguals demonstrated comparable accuracy rates for words learned bimodally and unimodally, and this was the case for both recognition (F (1, 9) = 0.04, p = 0.85), and production testing (F (1, 9) = 1.03, p = 0.34) at immediate testing, and recognition (F (1, 9) = 0.23, p = 0.64) and production (F (1, 9) = 0.12, p = 0.74) at delayed testing.

For reaction times at immediate testing, late bilinguals demonstrated comparable recognition (F (1, 9) = 1.59, p = 0.24) and production times (F (1, 8) = 0.19, p = 0.67) for words learned unimodally and bimodally. For reaction times at delayed testing, late bilinguals showed longer recognition times for words learned bimodally (M = 4677.67, SE = 826.51) than for words learned unimodally (*M* = 3368.21, *SE* = 423.63), F (1, 9) = 6.89, $p < 0.05$, $\eta_p^2 = 0.43$, but comparable production times (F (1, 8) = 0.01, $p = 0.91$).

7.6 Effects of L2 Acquisition Age on development of the Bilingual Advantage for Foreign Word Learning: Discussion

The exploratory analyses of AoA effects in the development of the bilingual advantage for foreign word learning suggest that earlier acquisition age amplifies bilingual advantage. While early English-Spanish bilinguals differed strongly from monolinguals in terms of foreign word retention, the performance of late English-Spanish bilinguals fell in-between that of early English-Spanish bilinguals and monolinguals. As a result, late English-Spanish bilinguals outperformed monolingual speakers of English, but only marginally, and less consistently than early bilinguals. Two conclusions can be drawn from these preliminary findings. *One*, earlier L2 acquisition age yields a more reliable and more robust bilingual advantage for foreign word learning than later L2 acquisition age. (Whether it is the early acquisition itself, or the more extended length of time during which the two languages are used concurrently that is driving the AoA effect is a question for follow-up studies.) *Two*, later L2 acquisition age can also yield a bilingual advantage for foreign word learning, albeit a weaker one than earlier L2 acquisition age. Lack of significant correlations between L2 acquisition age and word-learning performance is consistent with the finding that early and late bilinguals did not differ significantly from each other. Correlation analyses suggest that the effect of L2 acquisition on word-learning performance is *not* continuous (i.e., AoA does not correlate with word-learning performance), and the univariate analyses suggest that the effect of L2 acquisition on word learning performance is also *not* categorical (i.e., the two bilingual groups do not differ from each other).

Comparisons of early and late bilinguals to the monolinguals, however, indicate that the two age-groups differ in the relative magnitude of "bilingual advantage," with early bilinguals differing from monolinguals more than late bilinguals. In effect, these findings suggest a continuum of word-learning skills, with early bilinguals and monolinguals occupying the two ends of the continuum, and the late bilinguals occupying the middle-point of the continuum. It is possible, however, that lack of differences between early and late bilinguals, as well as lack of significant correlations between AoA and word-learning performance, is driven by a relatively small sample size, with only 12 participants per group, and only 24 data-points in the correlation analysis. As more data are acquired, it is possible that differences between early and late bilinguals, as well as significant correlations between age and word-learning performance, will be revealed.

Comparisons conducted within each bilingual group (early and late) suggest similar patterns of performance, in terms of processing unimodal and bimodal input. Both early and late bilinguals demonstrated similar accuracy rates for unimodally vs. bimodally-learned foreign words. This suggests that experience of learning Spanish, whether earlier or later in life, allows for efficient processing of conflicting phonological input perceived via the auditory and the visual modalities. The finding that second language learning, even at a later age, can instigate changes in foreign-word-learning performance is promising, because it offers an exciting possibility that the underlying cognitive mechanisms supporting language learning remain flexible and modifiable throughout the life span. If the benefits of bilingualism for subsequent language learning are indeed rooted in the general executive control mechanism, the findings of learning benefits in late bilinguals suggest that these basic control mechanisms are receptive to change, even later in life.

7.7 Proficiency Effects in Bilingual Language Processing

While L2 acquisition age is strongly associated with the ultimate attainment of L2, L2 proficiency itself is a significant factor in bilingual language processing. For instance, it has been demonstrated that parallel language processing, where lexical information in both languages is activated in response to single-language input, is more likely to occur if the two languages are both highly-proficient. Conversely, low-proficiency L2 is not activated in response to L1 input (Blumenfeld & Marian, in press), or is activated less consistently than high-proficiency L2 (Marian & Spivey, 2003; Weber & Cutler, 2004). This suggests that highly-proficient bilinguals with comparable knowledge of the two languages are more likely to engage parallel processing mechanisms than non-proficient bilinguals with low levels of L2 proficiency. This observation has consequences for the development of the bilingual advantage, as conceptualized by Bialystok et al. (2004; 2006), who credits parallel processing with engendering bilingual advantage for cognitive control. According to the Bialystok argument, habitual need to suppress one language while comprehending or producing in the other language may train cognitive control mechanisms in bilinguals to process information (linguistic and non-linguistic) in a more efficient manner. If the general cognitive control mechanisms identified by Bialystok also underlie performance on a foreign-word-learning task, it is possible that bilingual advantage in foreign word learning will only be observed in proficient speakers of both languages, but will not be observed in less-proficient L2 speakers.

Examination of proficiency effects in mediating the bilingual advantage for foreign word learning was possible within the context of English-Mandarin bilingual data. English-Mandarin bilinguals recruited for Study 2 were all early bilinguals, who acquired Mandarin either from birth or very early in life. However, there was a range of proficiencies in Mandarin participants, especially for reading. Thus, while all bilinguals reported high levels of proficiency speaking and understanding Mandarin, some were also proficient readers of Mandarin, while others had minimal knowledge of the Mandarin writing system. As with the age-of-acquisition analyses, two types of comparisons were conducted. First, proficiency was treated as a continuous variable, and correlation analyses between bilinguals' Mandarin proficiency and word-learning performance were performed. Second, proficiency was treated as a categorical variable. By splitting English-Mandarin bilinguals into high-proficiency readers and low-proficiency readers, the influence of L2 proficiency on the development of the bilingual advantage in foreign word learning could be explored. Because this division yielded two groups of English-Mandarin bilinguals with comparable L2 acquisition ages, but different L2 reading proficiency levels, proficiency was likely to be the mediating variable in different performance patterns for the two English-Mandarin groups. Another advantage to exploring the impact of L2 reading proficiency on English-Mandarin bilinguals' performance is that it may account for a difference between bilingual groups that is not based on language characteristics, per se, but on the different acquisition strategies that may have been used while learning the L2. Namely, it is possible that the task of learning the Mandarin writing system is not only qualitatively, but also quantitatively different from learning Spanish, in that it places much greater demands on memory. Thus, in learning to read Chinese, a typical Chinese student acquires about 2,557 characters during the first six years of school (Shu & Anderson, 1999). Most of these are compound characters whose meanings are not predictable from their radicals (components that carry meaning) and phonetics (components that denote pronunciation). In memorizing the Chinese characters, a learner of Chinese undergoes massive memory training, which far surpasses the memory load necessary to learn to read Spanish. Therefore, differences observed between monolinguals and English-

Mandarin bilinguals may be due to English-Mandarin bilinguals' increased memory capacity that pervades not only short-term phonological memory, but possibly, memory, in general. By dividing English-Mandarin bilinguals into high-proficiency and low-proficiency Mandarin readers, the possible impact of learning Mandarin writing system, and through it, of the potential increase in the overall memory capacity, on foreign word learning can be examined.

7.8 Method

English-Mandarin bilinguals were split based on literacy skills in Mandarin (self-reported proficiency reading Mandarin), resulting in 10 English-Mandarin bilinguals with good literacy skills in Mandarin (M = 6.80, SE = 0.44) and 11 English-Mandarin bilinguals with poor literacy skills in Mandarin (M = 1.63, SE = 0.50), t (19) = 60.51, $p < 0.0001$, $\eta_p^2 = 0.79$. Literacy was chosen as the marker of Mandarin proficiency because it offered the widest range of values in the data. Moreover, it allowed for examination of possible effects associated with learning to read Chinese on English-Mandarin bilinguals' performance. The two groups also differed in their speaking proficiency, with high-proficiency readers reporting higher speaking proficiency (M = 7.40, SE = 0.46) than low-proficiency readers (M = 5.75, SE = 0.52), although this difference was less pronounced than the difference in their reading skills, F (1, 19) = 5.71, $p < 0.05$, $\eta_p^2 =$ 0.26. The two groups did not differ in proficiency understanding, $p = 0.11$, or in ages of L2 acquisition, with good readers reporting an acquisition age of 3.8 (SE = 1.38) and poor readers reporting an acquisition age of 2.00 (SE = 1.54), t (19) = 0.76, $p = 0.38$, $\eta_p^2 = 0.05$.

7.9 Analyses

First, correlation analyses between language proficiency and word-learning performance were conducted for each measure of accuracy and reaction time. Second, proficiency effects in foreign vocabulary learning were examined using a-priori comparisons between high-proficiency Mandarin readers and monolinguals, and between low-proficiency Mandarin readers and monolingual, for each performance measure. Within-group comparisons were also conducted in order to examine effects of learning modality on performance within each group.

7.10 Results

Correlation analyses between Mandarin proficiency and word-learning performance did not yield significant findings (all p levels > 0.1). This was the case not only for reading proficiency, but for speaking and understanding proficiency, as well.

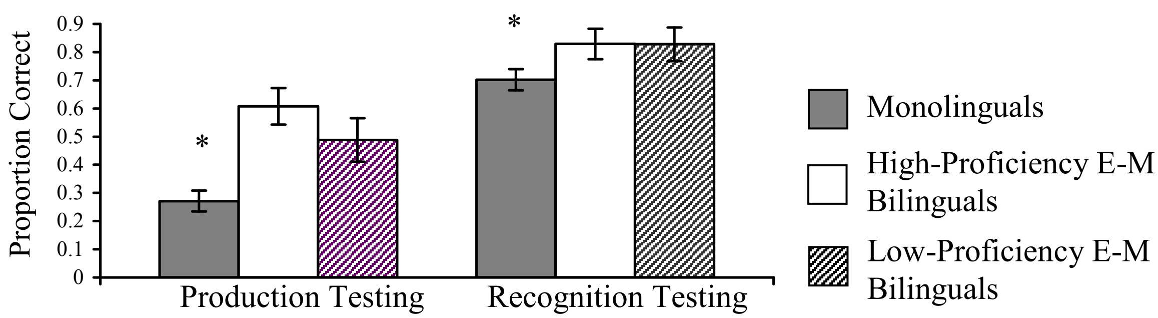
7.10.1 Between-Group Comparisons

During *immediate testing*, both groups of English-Mandarin bilinguals outperformed monolingual speakers of English. For *recognition* accuracy, both high-proficiency ($M = 0.83$, $SE = 0.06$) and low-proficiency Mandarin readers ($M = 0.83$, $SE = 0.06$) outperformed monolingual speakers of English ($M = 0.70$, $SE = 0.04$) on words learned in the auditory-only modality: high-proficiency vs. monolingual $t\ (32) = 2.03$, $p = 0.056$; low-proficiency vs. monolingual $t\ (33) = 2.22$, $p < 0.05$, with comparable effect sizes for each comparison (0.10 and 0.095). A similar pattern emerged for words learned in the auditory-and-visual modality, with high-proficiency readers ($M = 0.79$, $SE = 0.05$) outperforming monolinguals ($M = 0.61$, $SE = 0.04$), $t\ (32) = 2.80$, $p < 0.01$, and low-proficiency readers ($M = 0.78$, $SE = 0.03$) outperforming monolinguals, t (33)

Figure 7. Comparing High-Proficiency vs. Low-Proficiency English-Mandarin bilinguals to monolinguals on <u>accuracy</u> of retrieving English translations immediately after foreign-word learning. Performance on words learned in the auditory-only modality is presented in Panel A. Performance on words learned in the auditory-and-visual modality is presented in Panel B.

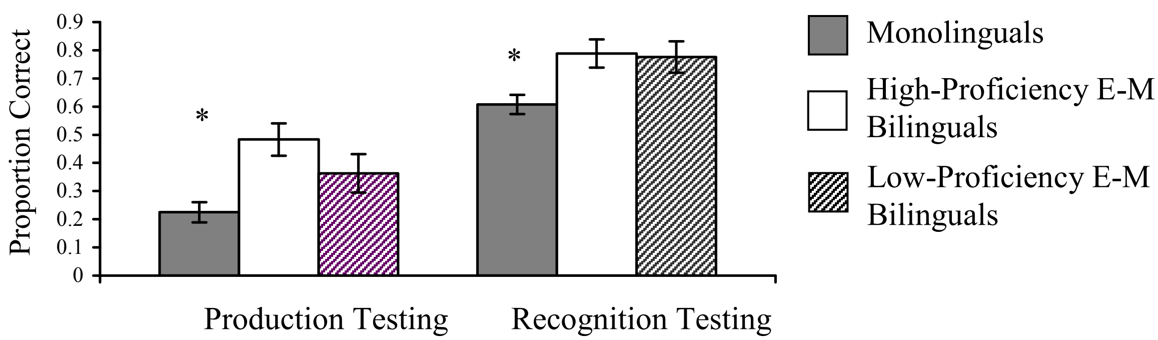
Auditory-Only Foreign Words

A.



Auditory-and-Visual Foreign Words

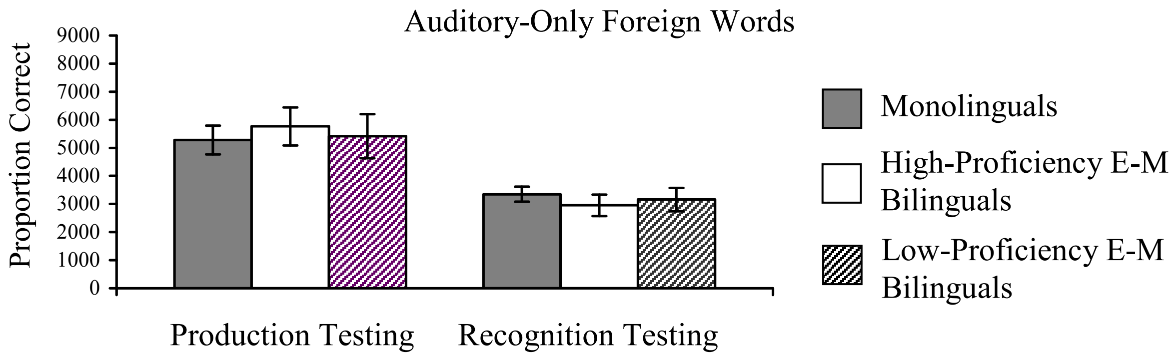
B.



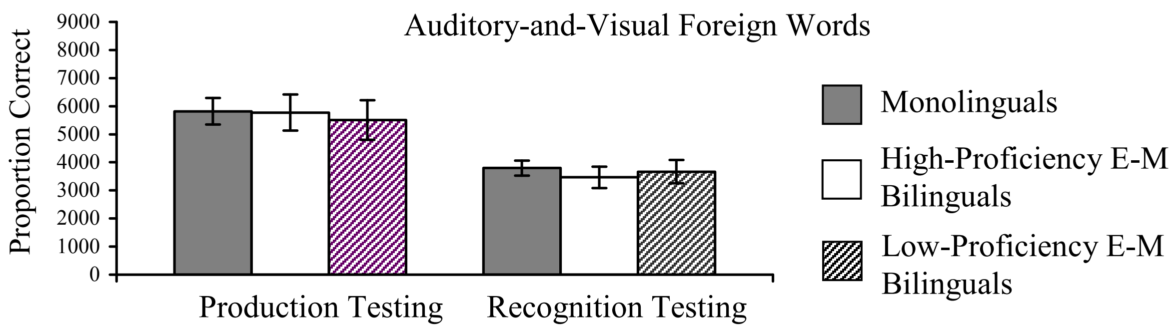
= 2.46, $p < 0.05$), with somewhat higher effect size for the high-proficiency vs. monolingual comparison (0.20) than for the low-proficiency vs. monolingual comparison (0.17). Similar findings were observed for *production* accuracy. Specifically, for words learned in the auditory-only modality, both high-proficiency ($M = 0.61$, $SE = 0.07$) and low-proficiency Mandarin readers ($M = 0.49$, $SE = 0.07$) outperformed monolingual speakers ($M = 0.27$, $SE = 0.04$),

Figure 8. Reaction times for correctly-retrieved English translations immediately after foreign word learning. Performance on words learned in auditory-only modality is presented in Panel A. Performance on words learned in auditory-and-visual modality is presented in Panel B.

A.



B.



although the effect was stronger in high-proficiency readers t (30) = 4.31, $p < 0.0001$, $\eta_p^2 = 0.38$, than in low-proficiency readers t (30) = 2.81, $p < 0.01$, $\eta_p^2 = 0.23$. For words learned in the auditory-and-visual modality, however, only high-proficiency readers (M = 0.48, SE = 0.06) outperformed monolinguals (M = 0.23, SE = 0.04), F (1, 31) = 13.66, $p < 0.01$, $\eta_p^2 = 0.31$, while low-proficiency Mandarin readers (M = 0.36, SE = 0.06) differed from monolinguals only marginally, F (1, 31) = 3.65, $p = 0.066$, $\eta_p^2 = 0.12$.

During *delayed testing* for words learned in the auditory-only modality, high-proficiency Mandarin readers demonstrated higher recognition accuracy rates (M = 0.68, SE = 0.06) than monolinguals (M = 0.55, SE = 0.04), F (1, 30) = 3.82, p = 0.06, η_p^2 = 0.11, while low-proficiency Mandarin readers (M = 0.64, SE = 0.06) showed accuracy rates that were comparable to monolinguals, F (1, 31) = 1.27, p = 0.27, η_p^2 = 0.04. Similarly, high-proficiency Mandarin readers demonstrated higher production accuracy rates (M = 0.26, SE = 0.04) than monolinguals (M = 0.15, SE = 0.03), F (1, 29) = 5.82, η_p^2 = 0.17, while low-proficiency Mandarin readers (M = 0.20, SE = 0.04) showed accuracy rates that were comparable to monolinguals, F (1, 30) = 1.15, p = 0.29, η_p^2 = 0.04. For words learned in the auditory-and-visual modality, a similar pattern emerged. While high-proficiency Mandarin readers (M = 0.21, SE = 0.04) demonstrated higher production accuracy rates than monolinguals (M = 0.12, SE = 0.03), F (1, 29) = 3.57, p = 0.07, η_p^2 = 0.11, low-proficiency Mandarin readers (M = 0.14, SE = 0.04) demonstrated accuracy rates that were comparable to monolinguals, F (1, 30) = 0.19, p = 0.67, η_p^2 = 0.007.

For all comparisons, the differences between high-proficiency and low-proficiency English-Mandarin bilinguals were not significant, suggesting comparable levels of performance across the two proficiency groups. In addition, no differences across the three groups were observed for reaction times.

7.10.2 Within-Group Comparisons

During immediate testing, *high-proficiency Mandarin readers* demonstrated higher accuracy rates for unimodally-learned foreign words than for bimidally-learned foreign words. This difference was significant for production testing, F (1, 9) = 5.83, $p < 0.05$, η_p^2 = 0.39, but did not reach significance for recognition testing, F (1, 9) = 2.23, p = 0.17. High-proficiency readers demonstrated longer recognition times for bimodally-learned foreign words (*M* = 3465.05, *SE* = 278.06) than for unimodally-learned foreign words (*M* = 2952.80, *SE* = 242.70), $F(1, 9) = 5.83$, $p < 0.05$, $\eta_p^2 = 0.39$. Production times were comparable for unimodally and bimodally learned foreign words.

During delayed testing, *high-proficiency Mandarin readers* demonstrated comparable recognition ($F(1, 9) = 0.38$, $p = 0.56$) and production ($F(1, 9) = 2.30$, $p = 0.16$) accuracy rates for unimodally and bimodally learned foreign words. For reaction times, high-proficiency Mandarin readers demonstrated longer recognition times for bimodally-learned foreign words (*M* = 3681.58, *SE* = 365.20) than for unimodally-learned foreign words (*M* = 3681.58, *SE* = 365.20), $F(1, 9) = 5.58$, $p < 0.05$, $\eta_p^2 = 0.38$. Production times, on the other hand, were comparable across foreign words learned unimodally and bimodally, $F(1, 9) = 0.001$, $p = 0.98$.

During immediate testing, *low-proficiency Mandarin readers* demonstrated higher accuracy rates for unimodally-learned foreign words than for bimidally-learned foreign words. This difference was significant for production testing, $F(1, 9) = 6.21$, $p < 0.05$, $\eta_p^2 = 0.41$, but did not reach significance for recognition testing, $F(1, 10) = 0.67$, $p = 0.43$. Low-proficiency readers demonstrated comparable recognition ($F(1, 10) = 2.29$, $p = 0.16$) and production ($F(1, 9) = 1.20$, $p = 0.30$) times for unimodally and bimodally learned foreign words, although RTs for bimodally-learned words were consistently longer than for unimodally-learned foreign words.

During delayed testing, *low-proficiency Mandarin readers* demonstrated comparable recognition ($F(1, 10) = 0.39$, $p = 0.55$) and production ($F(1, 10) = 2.41$, $p = 0.15$) accuracy rates for unimodally and bimodally learned foreign words. For reaction times, low-proficiency Mandarin readers demonstrated comparable recognition ($F(1, 10) = 2.07$, $p = 0.18$) and production ($F(1, 9) = 0.02$, $p = 0.90$) times for foreign words learned unimodally and bimodally.

7.11 Effects of L2 Proficiency on the Development of the Bilingual Advantage for Foreign Word Learning: Discussion

Preliminary analyses examining proficiency effects in modulating the bilingual advantage for foreign word learning suggest that higher L2 proficiency magnifies the bilingual advantage. While both high-proficiency and low-proficiency readers outperformed monolingual speakers of English, the effect was stronger for high-proficiency readers. Moreover, only high-proficiency readers maintained this benefit long-term, while low-proficiency readers demonstrated it only during immediate testing. Similar to age-of-acquisition effects observed in the English-Spanish bilingual group, correlation analyses between L2 proficiency and word-learning measures were not significant in English-Mandarin bilinguals. Lack of significant correlations suggests that in this group of bilinguals, language proficiency and word-learning performance were not associated with each other in a continuous manner. Neither was the effect of language proficiency on bilinguals' performance categorical, since high-proficiency and low-proficiency bilinguals did not differ significantly from each other when they were split into two groups. As was the case for the AoA analyses, these findings could be a result of a relatively small number of English-Mandarin bilinguals in the sample, which was not sufficient to reveal a difference between high- and low-proficiency bilinguals. However, these results could be indicative of the graded effect of L2 proficiency on word-learning performance, with higher L2 proficiency yielding a stronger, but not significantly so, advantage over lower L2 proficiency.

Within-group comparisons demonstrated comparable patterns of performance in the two proficiency groups, although the limited number of participants in each group rendered some of the analyses non-significant. Nevertheless, while some comparisons across the two learning modalities were not significant, the general pattern of results, with unimodally-learned foreign words retained better than bimodally-learned foreign words, persisted for both proficiency-groups. This suggests that acquisition of Mandarin to any degree of proficiency did not influence participants' ability to process conflicting phonological input. Instead, acquisition of Mandarin conferred a general benefit onto the system, and influenced the process of foreign vocabulary acquisition independent of the specifics of the input.

The advantage observed for English-Mandarin bilinguals cannot be localized to parallel language processing phenomena in the same sense as for English-Spanish bilinguals. In learning to read Mandarin, English-Mandarin bilinguals do not develop a parallel processing pattern for visual word recognition, since the two writing systems are vastly different. However, phonological information associated with the visually-presented Chinese word can activate the English lexicon (e.g., Lee, Wee, Tzeng, & Hung, 1992). Moreover, parallel processing in the auditory modality, with the auditory signal activating both the English and the Mandarin lexicon is quite likely. Therefore, while parallel language processing in English-Mandarin bilinguals may not be driven by the written input to the same extent as in English-Spanish bilinguals, parallel language activation remains the most parsimonious account of bilingual-advantage development. Alternatively, it is possible that better performance of high-proficiency Mandarin readers is tied to their higher general memory capacity. This higher memory capacity may have developed as a result of learning to read Mandarin to high proficiency – an endeavor that required intense memorization, and may have qualitatively changed the learning mechanisms. This explanation is consistent with the finding that only high-proficiency Mandarin readers outperformed monolinguals during delayed testing.

Whatever the exact explanation, these preliminary findings have to be interpreted with caution, since the number of bilinguals in each proficiency-group was limited. Therefore, marginal and non-significant effects obtained with low-proficiency readers may have been driven by the lack of power, rather than by the true lack of difference between their performance and performance of monolingual speakers. Future studies that experimentally manipulate proficiency levels of bilingual participants are necessary before any claims can be made about the role of proficiency in the development of the bilingual advantage for foreign vocabulary acquisition, and for cognitive function, in general. Moreover, proficiency levels of other bilingual groups, whose two languages do not differ as drastically as English and Mandarin, have to be manipulated in future studies in order to uncover the role of proficiency in mediating the bilingual advantage. Because L2 acquisition is not a modular process, but instead, builds on the knowledge acquired in the native language, the concept of transfer is especially important to consider in future studies of bilingual advantage. Transfer of skills from L1 to L2 is more likely if the two languages are similar to each other than if the two languages are distinct. Therefore, acquisition of high proficiency in Mandarin may involve a different process than acquisition of high proficiency in Spanish. In fact, differences in acquisition strategies for the two bilingual groups may mediate the degree to which underlying cognitive measures (e.g., vocabulary knowledge and phonological short-term memory) contribute to foreign vocabulary learning. Relating cognitive measures to participants' performance on the foreign-word-learning task is the focus of Chapter VIII.

CHAPTER VIII.

THE ROLE OF NATIVE-LANGUAGE VOCABULARY KNOWLEDGE AND PHONOLOGICAL SHORT-TERM MEMORY IN FOREIGN WORD LEARNING BY MONOLINGUAL AND BILINGUAL SPEAKERS: EXPLORATORY CORRELATION ANALYSES

8.1 The Role of Vocabulary Knowledge and Phonological Short-Term Memory in Children's Word Learning

Research on word learning in children consistently reveals that two cognitive skills underlie their ability to learn novel words: Phonological short-term memory and vocabulary knowledge. The two skills contribute to foreign vocabulary learning differently depending on whether the acquired words share phonological structure with the native language (Gathercole & Baddeley, 1990; Papagno, Valentine, & Baddeley, 1991), and depending on the age of the tested children (De Jong, Seveke, & Van Veen, 2000).

The role of phonological short-term memory in word learning has been substantiated by a number of studies demonstrating that children with good non-word repetition skills outperform their poor non-word repetition peers on novel-word-learning tasks (Cheung, 1996; Gatherocole & Baddeley, 1990; Service, 1992; Service & Kohonen, 1995). For instance, Service (1992) found that repetition accuracy for L2 pseudowords was a good predictor of learning L2 vocabulary for primary school students. Phonological short-term memory seems to be especially important for learning phonologically unfamiliar foreign words. For example, children with poor non-word repetition skills were shown to be slower at learning phonologically unfamiliar names for toys, but not at learning familiar names for them. As further evidence for contribution of phonological short-term memory to foreign vocabulary learning, Papagno, Valentine, and Baddeley (1991) demonstrated that articulatory suppression (repeating a single phrase aloud while trying to learn) disrupted memorization of foreign words to a greater degree than acquisition of native words. Recent findings show that for children older than 5 years of age, phonological sensitivity (ability to detect and manipulate sound units in words) contributed to learning of novel words with unfamiliar phonological structure, but not to learning of familiar names (e.g., De Jong, Seveke, & Van Veen, 2000) and that non-word repetition scores predicted knowledge of foreign, but not of native vocabulary (e.g., Masoura & Gathercole, 1999).

The stronger contribution of phonological short-term memory to learning unfamiliar foreign words than to learning familiar foreign words stems from the fact that acquisition of familiar foreign words is better-supported by long-term phonological knowledge. Thus, children with poor non-word repetition skills can acquire novel words that correspond to their native-language phonology, since long-term phonological knowledge can bolster their performance, and compensate for difficulties associated with learning. However, they cannot rely on this long-term phonological knowledge when learning phonologically-unfamiliar foreign words, and therefore perform particularly poorly when the novel words do not correspond to the phonological structure of the native language. This ability to rely on native-language skills during learning incorporates not only the sub-lexical knowledge of phonology, but also the lexical knowledge associated with native-language vocabulary.

In addition to phonological ability, vocabulary abilities in the native language have also been linked with second language acquisition. For instance, Masoura and Gathercole (1999) showed that the ease of learning L2 vocabulary is strongly influenced by the stability and extent of representations in L1 vocabulary. In addition, recent studies of the “critical period” phenomenon have found that adults are capable of attaining near-native performance in the foreign language if they possess high verbal ability in their native language (De Keyser, 2002).

While early acquisition of native-language vocabulary may rely on phonological short-term memory, the two skills – phonological short-term memory and vocabulary knowledge appear to dissociate later in life, and contribute separately to foreign vocabulary acquisition. Therefore, it may be expected that contributions of phonological short-term memory and vocabulary knowledge will be observed for adults learning words from a foreign language.

8.2 The Role of Vocabulary Knowledge and Phonological Short-Term Memory in Adults' Word Learning

Given the evidence for the role of phonological short-term memory and vocabulary knowledge in children's word learning, two predictions can be made about the contribution of these cognitive skills to word learning in adults. *First*, it could be hypothesized that phonological short-term memory will be predictive of word-learning performance in adults when the foreign language incorporates unfamiliar phonology. *Second*, it could be hypothesized that native-language vocabulary knowledge will be predictive of word-learning performance in adults when the foreign language is based on native-language phonology. However, the role of native-language vocabulary knowledge in adult word-learning has received little attention in the literature (Speciale, Ellis, & Bywater, 1994), and some studies have not been able to demonstrate a link between phonological short-term memory and word learning in adults (Service & Craik, 1993).

To date, a number of studies have examined the relationship between phonological short-term memory and word-learning in adults (Gupta, 2003; Papagno & Vallar, 1995; Sevice &

Craik, 1993; Speciale, Ellis, & Bywater, 2004). The results of these studies did not converge, with some demonstrating significant correlations between word-learning and phonological short-term memory (Gupta, 2003; Papagno & Vallar, 1995), some failing to show the relationship between the two (Service & Craik, 1993), and some demonstrating it but only for productive (and not receptive) vocabulary (Specialie, Ellis, & Bywater, 2004). Specifically, the role of phonological short-term memory in foreign vocabulary acquisition has not been substantiated by Service and Craik (1993). The authors examined word learning in younger and older participants, and found that in young adults, repetition performance for unfamiliar L2 words (indexing phonological short-term memory) did not correlate with learning performance on the same words. However, a significant correlation between the two was obtained in older participants. The authors suggest that lack of correlations in the younger group is due to the limited range of performance in that group, since all participants performed near ceiling on both the repetition and the word-learning task.

The role of phonological short-term memory in word learning has been substantiated by Gupta (2003), Papagno and Vallar (1995), and Speciale, Ellis, and Bywater (2004), but the three studies did not completely converge. Papagno and Vallar (1995) demonstrated that non-word repetition correlated highly with participants' word-learning performance. Moreover, the two skills loaded onto the same factor in the Principle Component Analysis, suggesting that they were underlied by the same cognitive construct. Gupta (2003) also demonstrated a correlation between non-word repetition performance and word-learning in adults; however, the relationship was mediated by participants' performance on the digit span task. When digit-span performance was partialed out, correlations between non-word repetition and word-learning failed to reach significance. Speciale, Ellis, and Bywater (2004) found that non-word repetition correlated with participants' ability to learn L2 words, but only when learning was tested "productively" – i.e., when participants produced the novel L2 word in response to its L1 translation. When the direction of testing changed (i.e., participants had to produce L1 translations for the L2 words), non-word repetition scores were not related to performance.

Thus, studies substantiating the role of phonological short-term memory in adult word learning are not conclusive. Methodological idiosyncrasies across studies make it difficult to localize the discrepancies to a single variable in the design. For one, Papagno and Vallar (1995) tested both multilingual and bilingual participants, and collapsed across all participants in order to obtain the correlation values. Given the limited number of subjects in their study, and inclusion of polyglots in the sample, Papagno and Vallar (1995) findings may not be generalizable to the monolingual adult population. Gupta (2003) failed to find the relationship between non-word repetition and word-learning beyond the fact that two were commonly mediated by digit-span performance. Gupta suggests that the link between the three skills lies in the common sequence-learning mechanism that drives performance on all three tasks. Moreover, the paradigm used by Gupta resembled novel word learning in the native language, and not foreign word learning. Participants learned novel labels by associating them with novel objects, and not with known concepts, thus simulating acquisition of native-language vocabulary later in life. However, participants' native-language vocabulary was not measured, and therefore the relative contributions of lexical long-term knowledge and phonological short-term memory to foreign word learning in adults remain unexplored. The study by Speciale et al. (2004) did find significant correlations between non-word repetition and foreign-word-learning performance, but only when task demands at testing required production of the foreign word. Moreover, when the authors attempted to correlate non-word repetition scores with word learning in a more natural acquisition context (i.e., the language classroom) they failed to obtain a significant relationship between the two.

While it was not the objective of the current research to examine the role of phonological short-term memory and lexical knowledge in foreign vocabulary acquisition, the data lent themselves to exploring these effects. Therefore, correlation analyses between cognitive skills (phonological short-term memory as measured by digit span and non-word repetition, and lexical knowledge as measured by a receptive and an expressive vocabulary test in English) on the one hand, and word-learning performance on the other hand, were performed. These correlations were first performed in the four groups of monolingual participants, with the data obtained in Study 1. Similar correlations were then performed in two groups of bilingual participants, with the data obtained in Study 2.

Given the results of prior studies, it was predicted that both phonological short-term memory measures and vocabulary measures would correlate with learning performance in the two studies. In addition, it was expected that correlation patterns would depend on the phonological structure of the foreign language (i.e., whether the foreign language corresponded to the native language in phonology and orthography). It was also expected that correlation patterns will be mediated by linguistic experience, with monolingual participants differing from bilingual participants in the degree and/or the strength of correlations.

8.3 Correlation Analyses for Study 1

Correlation analyses for Study 1 were conducted, and all word-learning performance measures were correlated with all cognitive measures, including the digit span, the non-word repetition, receptive vocabulary and expressive vocabulary. Because cross-linguistic similarity was expected to mediate correlation patterns, the results for two groups learning foreign words that matched English in phonology (+P+O and +P-O) are presented first, and results for two groups learning foreign words that mismatched English in phonology (-P+O and -P-O) are presented second.

8.3.1 Correlations for Phonologically-Matching Conditions

Correlations between all word-learning measures and all cognitive measures are presented in Tables 9, 10, 11, and 12. For the +P+O group (see Table 9), significant correlations were obtained between expressive vocabulary scores and word-learning. Specifically, the EVT scores correlated with testing accuracy during recognition and production of unimodally-learned foreign words, both short-term and long-term. A similar pattern emerged for the +P-O group (see Table 10), with significant correlations observed between the EVT scores and testing accuracy during recognition and production of bimodally-learned foreign words, but only long-term. The disparity between the two patterns may stem from the fact that auditory-only learning was more difficult for the +P+O group than auditory-and-visual learning, and thus yielded greater variability in the data. Conversely, auditory-and-visual learning was more difficult than auditory-only learning for the +P-O group, and thus yielded greater variability in the data.

Correlations between word-learning performance and phonological short-term memory measures were also observed in the +P+O group and the +P-O group, but they were limited to only a few performance measures. Specifically, for the +P+O group, a significant negative correlation was observed between non-word repetition score and retrieval time for delayed production testing of bimodally-learned foreign words. This correlation suggests that higher non-

Table 9

Correlation Analyses for the +P+O Group: The Relationship between Performance Measures and Cognitive Skills

Performance Measure	Lexical Knowledge		Phonological Short-Term Memory	
	Productive Vocabulary (PPVT)	Expressive Vocabulary (EVT)	Digit Span	Non-Word Repetition
Immediate Testing				
A. Auditory-Only Foreign Words				
Recognition (Accuracy)	0.096	0.495*	-0.272	0.130
Recognition (RT)	-0.403	-0.209	0.185	0.095
Production (Accuracy)	0.218	0.464*	-0.118	0.291
Production RT	-0.216	0.041	0.014	-0.207
B. Auditory-and-Visual Foreign Words				
Recognition (Accuracy)	-0.10	0.245	-0.333	0.115
Recognition (RT)	-0.297	-0.089	0.031	0.013
Production (Accuracy)	0.088	0.343	-0.168	0.285
Production RT	--0.076	0.128	0.053	-0.276
Delayed Testing				
C. Auditory-Only Foreign Words				
Recognition (Accuracy)	-0.136	0.226	-0.262	0.020
Recognition (RT)	-0.277	-0.148	-0.199	-0.077
Production (Accuracy)	0.111	0.426*	0.019	0.341
Production RT	0.054	0.038	-0.285	-0.375
D. Auditory-and-Visual Foreign Words				
Recognition (Accuracy)	-0.007	0.356	-0.362	0.101
Recognition (RT)	-0.234	0.048	-0.045	0.106
Production (Accuracy)	0.013	0.303	-0.155	0.053
Production RT	-0.270	-0.183	-0.323	-0.538*

Note. Significance of correlations is marked by asterisks next to the R values. Significance at $p <$ 0.05 is marked by an asterisk *.

Table 10

Correlation Analyses for the +P-O Group: The Relationship between Performance Measures and Cognitive Skills

Performance Measure	Lexical Knowledge		Phonological Short-Term Memory	
	Productive Vocabulary (PPVT)	Expressive Vocabulary (EVT)	Digit Span	Non-Word Repetition
Immediate Testing				
A. Auditory-Only Foreign Words				
Recognition (Accuracy)	-0.056	0.142	0.163	-0.231
Recognition (RT)	-0.161	-0.251	-0.163	0.059
Production (Accuracy)	0.038	0.088	0.254	-0.048
Production RT	0.228	0.097	-0.305	0.108
B. Auditory-and-Visual Foreign Words				
Recognition (Accuracy)	0.102	0.353	0.363	-0.064
Recognition (RT)	-0.414*	-0.275	-0.100	-0.072
Production (Accuracy)	0.044	0.366	0.298	0.124
Production RT	0.370	-0.049	0.168	0.167
Delayed Testing				
C. Auditory-Only Foreign Words				
Recognition (Accuracy)	0.024	0.232	0.333	0.076
Recognition (RT)	-0.205	-0.190	-0.059	0.127
Production (Accuracy)	0.198	0.240	0.211	-0.305
Production RT	-0.233	-0.181	0.037	-0.039
D. Auditory-and-Visual Foreign Words				
Recognition (Accuracy)	0.342	0.495*	0.575**	0.255
Recognition (RT)	-0.149	-0.315	-0.113	-0.104
Production (Accuracy)	0.235	0.481*	0.540**	0.171
Production RT	0.166	0.094	0.281	0.036

Note. Significance of correlations is marked by asterisks next to the R values. Significance at $p < 0.01$ is marked by two asterisks **; significance at $p < 0.05$ is marked by one asterisk *.

word repetition performance correlated with faster responses during testing. For the +P-O group, non-word repetition did not correlate with any performance measures. However, another measure of phonological short-term memory, digit span, correlated with the accuracy of retrieval for bimodally-learned foreign words, but only during delayed testing.

In sum, correlation patterns for +P+O and +P-O groups suggest that more extensive native-language vocabulary and better phonological short-term memory were related to better word-learning performance. However, the relationship between vocabulary knowledge and word-learning was obtained for a greater number of performance measures, and was more consistent than the relationship between phonological short-term memory and word-learning. This finding is in line with previous research indicating that learning words that are phonologically-similar to the native language is supported by native-language lexical knowledge (Gathercole, 2006; Papagno, Valentine, & Baddeley, 1991). It is also consistent with previous studies showing that phonological short-term memory is not as important for learning phonologically-similar words later in life, when vocabulary knowledge takes on a greater role (Masoura & Gathercole, 1999).

8.3.2 Correlations for Phonologically-Mismatching Conditions

For the -P+O group (see Table 11), very few significant correlations between word-learning performance and cognitive measures were observed. Neither receptive, nor productive vocabulary measure correlated with word-learning performance, suggesting that knowledge of native-language vocabulary did not mediate learning in this condition. Correlation analyses between phonological short-term memory measures and foreign word learning revealed that non-word repetition scores did *not* correlate with word-learning. This was a surprising finding, given

Table 11

Correlation Analyses for the -P+O Group: The Relationship between Performance Measures and Cognitive Skills

Performance Measure	Lexical Knowledge		Phonological Short-Term Memory	
	Productive Vocabulary (PPVT)	Expressive Vocabulary (EVT)	Digit Span	Non-Word Repetition
		Immediate Testing		
		A. Auditory-Only Foreign Words		
Recognition (Accuracy)	0.197	0.133	0.324	-0.295
Recognition (RT)	0.100	-0.002	0.269	0.083
Production (Accuracy)	0.131	0.244	0.168	-0.015
Production RT	0.075	0.187	0.298	0.217
		B. Auditory-and-Visual Foreign Words		
Recognition (Accuracy)	0.059	0.003	0.111	0.131
Recognition (RT)	-0.331	-0.252	0.316	-0.075
Production (Accuracy)	0.305	0.331	0.010	0.145
Production RT	-0.397	-0.187	0.228	-0.020
		Delayed Testing		
		C. Auditory-Only Foreign Words		
Recognition (Accuracy)	0.138	-0.003	0.452*	-0.171
Recognition (RT)	0.215	0.100	0.172	-0.282
Production (Accuracy)	0.161	0.161	0.256	0.055
Production RT	-0.136	0.060	0.321	0.267
		D. Auditory-and-Visual Foreign Words		
Recognition (Accuracy)	0.059	-0.034	0.311	-0.024
Recognition (RT)	0.063	0.052	0.308	-0.256
Production (Accuracy)	0.411	0.340	0.025	0.022
Production RT	0.223	0.095	0.382	-0.065

Note. Significance of correlations at $p < 0.05$ is marked by an asterisk * next to the R values.

Table 12

Correlation Analyses for the -P-O Group: The Relationship between Performance Measures and Cognitive Skills

Performance Measure	Lexical Knowledge		Phonological Short-Term Memory	
	Productive Vocabulary (PPVT)	Expressive Vocabulary (EVT)	Digit Span	Non-Word Repetition
Immediate Testing				
A. Auditory-Only Foreign Words				
Recognition (Accuracy)	-0.122	-0.042	0.147	-0.107
Recognition (RT)	-0.380	-0.397	0.068	-0.134
Production (Accuracy)	-0.127	0.088	0.036	0.128
Production RT	0.043	-0.400	-0.342	-0.334
B. Auditory-and-Visual Foreign Words				
Recognition (Accuracy)	-0.068	0.032	0.450*	0.177
Recognition (RT)	-0.635**	-0.504*	-0.019	-0.119
Production (Accuracy)	-0.123	0.297	0.388	0.419
Production RT	-0.124	-0.446	-0.040	-0.369
Delayed Testing				
C. Auditory-Only Foreign Words				
Recognition (Accuracy)	-0.079	0.169	-0.055	-0.120
Recognition (RT)	-0.208	-0.275	-0.135	-0.220
Production (Accuracy)	-0.398	-0.40	0.001	-0.135
Production RT	-0.456	-0.601*	-0.066	-0.705**
D. Auditory-and-Visual Foreign Words				
Recognition (Accuracy)	0.226	0.468*	0.378	0.388
Recognition (RT)	-0.337	-0.369	-0.163	-0.325
Production (Accuracy)	-0.083	0.235	0.251	0.161
Production RT				

Note. Significance of correlations is marked by asterisks next to the R values. Significance at $p < 0.01$ is marked by two asterisks **; significance at $p < 0.05$ is marked by one asterisk *.

the link between non-word repetition and word-learning observed in previous studies where the foreign language differed phonologically from the native language. The digit-span measure did correlate significantly with recognition accuracy for words learned in the auditory-only condition, but only during delayed testing. No other significant correlations were observed.

A similar pattern was observed for -P-O condition (see Table 12). Vocabulary knowledge did not correlate with foreign-word-learning performance, and phonological short-term memory measures did so only for a limited number of performance measures. Thus, digit span correlated significantly with recognition accuracy for words learned in the auditory-and-visual modality, but only during immediate testing. Non-word repetition correlated negatively with retrieval speed during production testing for foreign words learned in the auditory-only condition (delayed testing), and correlated marginally with production accuracy for foreign words learned in the auditory-and-visual condition (immediate testing), as well as with recognition accuracy for foreign words learned in the auditory-and-visual condition (delayed testing).

In sum, correlation patterns for the -P+O and the -P-O conditions suggest that native-language vocabulary knowledge is less related to word-learning performance than phonological short-term memory when foreign words do not correspond to the native language in phonology. These findings are in direct contrast to correlation patterns observed for the +P+O and the +P-O conditions, where native language vocabulary was strongly related to word-learning performance. The relative importance of L1 vocabulary skills for foreign-vocabulary acquisition when learning a phonologically-matching L2 vs. a phonologically-mismatching L2 is consistent with previous studies of foreign word learning (e.g., De Jong, Seveke, & Van Veen, 2000; Masoura & Gathercole, 1999). Native-language vocabulary skills can support acquisition of novel vocabulary, but only when phonological structures of L2 correspond to those of the native language.

Correlations between phonological short-term memory measures and word-learning in phonologically-mismatching conditions were not consistent across groups or across performance measures. These inconsistencies in correlation patterns across the -P+O and -P-O conditions may be due to the role of orthography in mediating the relationship between phonological short-term memory and word learning, and/or to the variability levels in the data. Thus, it is possible that lower overall performance level for the -P+O group rendered performance scores homogeneously low, and thus did not yield enough variability in the learning measures. It is also possible that non-word repetition scores lacked sufficient range to reveal a relationship between non-word repetition and word-learning. The CTOPP non-word repetition subtest that was used to measure phonological short-term memory consists of 18 non-words of varying length and difficulty levels. It is scored in a binary manner, thus yielding generally low performance scores that may make correlations with the CTOPP measure less detectable.

8.4 Correlation Analyses for Study 2

Performance of English-Spanish and English-Mandarin bilinguals on the word-learning task was correlated with their scores on the cognitive measures. There were no clear predictions for correlation patterns in the two bilingual groups, given the lack of previous data on the subject. However, in light of comparison between Service and Craik (1993) and Papagno and Vallar (1995) studies, a few hypotheses can be entertained. While Papagno and Vallar (1995) found robust correlations between phonological short-term memory and word-learning performance, Service and Craik (1993) failed to observe such a relationship in their young adult subjects. Gupta (1999) suggests that the disparity in findings may be due to the fact that half of the participants in the Papagno and Vallar (1995) study were polyglots, and the other half had experience with learning a foreign language at some point in their lives. It is possible that bilingual experience may strengthen the relationship between short-term memory and word learning, and data collected in Study 2 lend themselves to exploring this possibility.

8.4.1 Correlations for English-Spanish bilinguals

Correlation analyses between cognitive measures and word-learning performance in English-Spanish bilinguals yielded a number of significant relationships (see Table 13). In terms of vocabulary knowledge, PPVT scores correlated negatively with recognition speed for foreign words learned in the auditory-only modality, suggesting that more extensive vocabulary in the native language was related to faster retrieval of newly-learned foreign words. Most notably, the phonological short-term memory measures were found to correlate strongly with word-learning performance in English-Spanish bilinguals. Specifically, non-word repetition correlated positively with recognition accuracy for foreign words learned unimodally and production accuracy for foreign words learned bimodally (immediate testing), as well as with recognition and production accuracy for foreign worlds learned bimodally (delayed testing). Moreover, digit span correlated negatively with retrieval times observed for recognition of bimodally-learned and for production of unimodally-learned foreign words during delayed testing. These findings indicate a relationship between phonological short-term memory and word-learning performance in English-Spanish bilinguals. This relationship is more consistent and more robust than the relationship observed between phonological short-term memory and word-learning in monolingual speakers of English.

Table 13

Correlation Analyses for English-Spanish bilinguals: The Relationship between Performance Measures and Cognitive Skills

Performance Measure	Lexical Knowledge		Phonological Short-Term Memory	
	Productive Vocabulary (PPVT)	Expressive Vocabulary (EVT)	Digit Span	Non-Word Repetition
Immediate Testing				
A. Auditory-Only Foreign Words				
Recognition (Accuracy)	0.116	-0.067	-0.031	0.457*
Recognition (RT)	-0.423*	-0.061	-0.256	0.018
Production (Accuracy)	-0.018	-0.155	-0.227	0.270
Production RT	0.034	0.277	0.045	-0.220
B. Auditory-and-Visual Foreign Words				
Recognition (Accuracy)	0.095	-0.029	-0.129	0.213
Recognition (RT)	-0.176	-0.067	-0.360	-0.304
Production (Accuracy)	0.277	0.038	0.005	0.494*
Production RT	-0.338	-0.148	-0.258	-0.304
Delayed Testing				
C. Auditory-Only Foreign Words				
Recognition (Accuracy)	0.079	0.204	0.095	0.270
Recognition (RT)	0.103	0.325	-0.088	-0.067
Production (Accuracy)	-0.032	0.017	-0.036	0.372
Production RT	-0.139	0.031	-0.550*	-0.099
D. Auditory-and-Visual Foreign Words				
Recognition (Accuracy)	0.209	0.264	0.260	0.555**
Recognition (RT)	-0.319	0.041	-0.455*	-0.027
Production (Accuracy)	0.136	0.059	0.110	0.547**
Production RT	-0.573**	0.025	-0.359	0.154

Note. Significance of correlations is marked by asterisks next to the R values. Significance at $p < 0.01$ is marked by two asterisks **; significance at $p < 0.05$ is marked by one asterisk *.

The difference between bilingual and monolingual correlation patterns may stem from the possibility that bilinguals rely on phonological short-term memory more than monolinguals do when learning foreign words. This conjecture is consistent with the accounts localizing bilingual advantage in foreign vocabulary acquisition to greater capacity of the phonological loop (Van Hell & Mahn, 1997; Papagno and Vallar, 1995).

8.4.2 Correlations for English-Mandarin bilinguals

Correlation analyses between cognitive measures and word-learning performance for English-Mandarin bilinguals yielded only a few significant relationships (See Table 12). In terms of vocabulary knowledge, PPVT scores correlated positively (but marginally) with recognition accuracy for foreign words learned in the auditory-and-visual modality, and EVT scores correlated negatively (but marginally) with recognition speed for foreign words learned in the auditory-and-visual modality. These findings suggest that a more extensive vocabulary in the native language was related to greater accuracy and faster retrieval of newly-learned foreign words.

In contrast to English-Spanish bilinguals, phonological short-term memory measures correlated minimally with word-learning performance in English-Mandarin bilinguals. Digit-span correlated negatively with recognition speed of unimodally and bimodally-learned foreign words during delayed testing, indicating that larger phonological short-term memory span was related to faster access to newly-learned foreign words. Surprisingly, there was a negative (albeit, marginal) correlation between non-word repetition score and production accuracy for unimodally-learned foreign words. Moreover, all correlations between non-word repetition and accuracy measures for foreign words were negative. While these were not statistically

Table 14

Correlation Analyses for English-Mandarin Bilinguals: Relationship between Performance Measures and Cognitive Skills

Performance Measure	Lexical Knowledge		Phonological Short-Term Memory	
	Productive Vocabulary (PPVT)	Expressive Vocabulary (EVT)	Digit Span	Non-Word Repetition
Immediate Testing				
A. Auditory-Only Foreign Words				
Recognition (Accuracy)	0.136	-0.178	0.165	-0.353
Recognition (RT)	0.194	0.000	-0.260	0.007
Production (Accuracy)	0.192	0.034	0.196	-0.442
Production RT	0.226	-0.012	-0.042	-0.220
B. Auditory-and-Visual Foreign Words				
Recognition (Accuracy)	0.453	0.023	0.257	-0.245
Recognition (RT)	0.250	0.000	-0.230	-0.041
Production (Accuracy)	0.138	-0.016	0.076	-0.151
Production RT	0.192	-0.158	-0.090	0.002
Delayed Testing				
C. Auditory-Only Foreign Words				
Recognition (Accuracy)	0.377	0.132	0.114	-0.287
Recognition (RT)	0.381	-0.361	-0.635*	-0.261
Production (Accuracy)	0.138	-0.028	0.035	-0.376
Production RT	0.234	-0.075	0.052	-0.387
D. Auditory-and-Visual Foreign Words				
Recognition (Accuracy)	0.262	0.216	0.112	-0.082
Recognition (RT)	0.223	-0.461	-0.442	-0.383
Production (Accuracy)	-0.032	0.184	0.026	-0.149
Production RT	0.024	0.132	0.005	-0.245

Note. Significance of correlations at $p < 0.05$ is marked by an asterisk * next to the R values.

significant, the direction of correlation suggests a fundamentally different relationship between phonological short-term memory and word learning in English-Mandarin bilinguals vs. English-Spanish bilinguals. The pattern observed with English-Mandarin bilinguals resembles correlation results observed with monolingual speakers of English, although the inverse relationship between non-word repetition scores and word-learning is more detectable and more consistent for English-Mandarin bilinguals than for monolinguals.

In order to examine whether the relationship between phonological short-term memory (as measured by non-word repetition) and word-learning performance differed qualitatively across the three groups, correlation coefficients between non-word repetition and word-learning obtained for monolinguals, English-Spanish bilinguals, and English-Mandarin bilinguals were directly compared to each other. Using the Fisher Z-transform, we tested the null hypothesis that correlation strength between non-word repetition and word-learning performance is comparable across the three groups. Results revealed differences across groups, such that correlations for English-Spanish bilinguals were consistently stronger than for monolinguals and for the English-Mandarin bilinguals. Specifically, compared to monolinguals, English-Spanish bilinguals showed stronger correlations between non-word repetition and recognition accuracy for unimodally-learned foreign words at immediate testing ($p < 0.01$), and for bimodally-learned foreign words at delayed testing ($p < 0.05$). Similarly, English-Spanish bilinguals showed stronger correlations than English-Mandarin bilinguals between non-word repetition and immediate ($p < 0.01$) and delayed ($p = 0.06$) recognition accuracy for unimodally learned foreign words; immediate ($p < 0.05$) and delayed ($p < 0.05$) production accuracy for unimodally learned foreign-words; and delayed recognition accuracy for bimodally ($p < 0.05$) learned foreign words. In contrast, the comparison between monolinguals and English-Mandarin bilinguals revealed comparable strengths of correlations between non-word repetition and all measures of word-learning performance. These analyses suggest that while monolinguals and English-Mandarin bilinguals do not draw on phonological short-term memory (as measured by non-word repetition) during foreign word learning, English-Spanish bilinguals do.

It is unclear why correlations between non-word repetition and foreign word learning would differ across the three groups (monolinguals, English-Spanish bilinguals, English-Mandarin bilinguals) not only in the strength, but also the direction of the observed relationship. It is possible that lack of the relationship between non-word repetition and word learning in the -P+O condition, as demonstrated by monolingual participants, is due to the fact that stimuli in the non-word repetition test and word-learning task differed with respect to phonological characteristics. The non-words used in the CTOPP are phonologically and phonotactically legal English pseudowords, while the non-words used in the word-learning task incorporate non-native phonemes. High performance on the CTOPP is indicative not only of superior phonological short-term memory, but also of superior phonetic, phonological, and phonotactic knowledge of English. Because foreign words on the word-learning task were purposefully constructed to be different from the English phonology, it is not surprising that the relationship between CTOPP non-word repetition scores and word-learning scores was limited. A similar point was alluded to by Thorn and Gathercole (1999), who suggested that phonological short-term memory may be "language-specific." While they did not explicitly test this hypothesis, they did find that in bilingual children, non-word repetition performance in one of their languages was correlated with vocabulary knowledge in the same language, and that the strength of the relationship was mediated by the child's proficiency in that language. Moreover, Speciale et al. (2004) found that participants' ability to learn Spanish vocabulary was related to their scores on the Spanish non-word repetition test, but not to their scores on the English non-word repetition test. Similarly, the relationship between non-word repetition and word-learning observed in the Gupta (2003) study may be specific to that particular study, since both non-word repetition and non-word learning tasks used stimuli that were phonotactically and phonetically legal in English. The findings in the current study, together with evidence provided by Thorn and Gathercole (1999) and Speciale et al. (2004), suggest that in adulthood, the link between phonological short-term memory and word-learning is observed only when the two tasks probe the same underlying phonological structure.

While the lack of relationship between non-word repetition and word-learning in the monolingual group is explicable, the findings in the two bilingual groups are less so. In the Spanish-English bilingual group, the relationship between non-word repetition and word-learning performance was positive and robust. In the English-Mandarin bilingual group, the relationship between non-word repetition and word-learning performance was negative and inconsistent. It appears that bilingual experience amplifies the relationship between phonological short-term memory and word-learning, but that the direction of amplification (positive vs. negative) depends on the specific bilingual experience. It is possible that experience with learning Spanish, an alphabetic language with similar structural relationships between letters and phonemes, has trained English-Spanish bilinguals to rely on their phonological short-term memory during learning, independent of whether novel verbal information shares phonology with the native language. In a sense, this would imply that phonological short-term memory in English-Spanish bilinguals is not “language-specific” like in monolinguals. Instead, English-Spanish bilinguals’ ability to repeat non-words on the CTOPP draws on the common pool of phonological-memory resources, and the same resources are used to store novel foreign words in the phonological loop during learning. Conversely, experience with Mandarin (a logographic language where a structural relationship between phonemes and logographs differs from English) has not resulted in formation of a common phonological-short-term-memory storage. Instead, it may be that learning Mandarin has resulted in development of a highly-segregated mechanism, by which native-language phonological knowledge is barred from participation in foreign-word learning. In fact, negative correlations between CTOPP scores and foreign-word learning performance in English-Mandarin bilinguals suggest that reliance on English phonological knowledge (as measured by the CTOPP non-word repetition subtest) yielded inferior word-learning performance in that group.

Alternatively, it may be that the difference between the two bilingual groups lies not in the specifics of the phonological short-term memory mechanisms, but in the groups' preferred learning strategies. For instance, it is possible that learning Spanish and learning Mandarin has resulted in distinct learning styles for the two groups. The English-Spanish bilingual group, which contained bilinguals who acquired Spanish in a classroom setting, may have been trained to learn foreign words by association with native words. Thus, experience with learning Spanish may have resulted in the development of a word-learning strategy that would rely on native-language phonological knowledge during learning. Such a strategy would yield positive correlations between native-language phonological knowledge (as measured by the CTOPP) and foreign-word learning. The English-Mandarin group, which contained mostly early bilinguals who acquired Mandarin in immersion-type settings, may have acquired most of their Mandarin vocabulary incidentally, and not by association with native words. Thus, experience of learning Mandarin may not have been conducive to developing a learning strategy by which native-language phonology would support acquisition of novel words.

Whatever the exact account of phonological short-term memory's involvement in foreign word learning, it appears that phonological short-term memory continues to influence vocabulary acquisition in adulthood. The exact nature of this influence varies with the phonological structure of the foreign words, and with the linguistic experience of the learner. The offered accounts are highly speculative, and indicate the necessity for future work that would explicitly test the relationship between phonological short-term memory, vocabulary knowledge, and word learning in different groups of learners. For instance, it is essential to incorporate two different measures of non-word repetition – with one measure focusing on native-language phonological knowledge (the way CTOPP does), and one measure focusing on language-independent phonological knowledge (for example, by using non-words that do not correspond to phonological/phonotactic constraints of the native language). It is also necessary to control for language-learning strategies that may have been used by some learners, but not others. Finally, it is important to test the relationship between vocabulary knowledge and phonological short-term memory, on the one hand, and foreign word learning, on the other hand, in an experimental, rather than in a correlational fashion. Future studies will need to split participants according to their vocabulary knowledge (high vs. low) and phonological short-term memory (high vs. low) in order to test the relative contributions of the two skills to foreign word learning.

In conclusion, exploratory correlation analyses strongly suggest that word learning in adults relies on phonological short-term memory and on native-language vocabulary knowledge. The degree of reliance on phonological short-term memory and on vocabulary knowledge varies with the phonological structure of the foreign language, and with the phonological similarity between the foreign language and the native language. When the foreign language and the native language share phonology, native-language vocabulary skills take on a greater role in foreign vocabulary learning, likely because stronger L1 vocabulary allows the learner to rely on L1 lexical phonology during learning. When the foreign language and the native language do not share phonology, native-language vocabulary skills do not support foreign vocabulary learning, likely because reliance on L1 lexical phonology does not help with learning phonologically unfamiliar foreign words. The role of phonological short-term memory in adult foreign vocabulary learning has not been conclusively demonstrated by the current analyses. Contrary to the predictions, there was no detectable relationship between monolinguals' non-word repetition and vocabulary learning performance in situations where the foreign language mismatched the native language in phonology. It is possible that this lack of association is due to the specifics of the non-word repetition test used in the current study. However, the fact that a robust relationship was found between non-word repetition and word learning in English-Spanish bilinguals, but not in monolinguals or English-Mandarin bilinguals, suggests that the nature of the test is not a sufficient explanation for the observed findings. Instead, the complex relationship between word learning and phonological short-term memory seems to vary not only with the phonological structure of the foreign language, but also with the linguistic experience of the learner.

CHAPTER IX.

MAPPING PHONOLOGICAL INFORMATION FROM AUDITORY TO WRITTEN MODALITY DURING FOREIGN VOCABULARY LEARNING

When learning to read in a new language, adults will often have to map printed words onto their phonological representations in order to recognize them. The ability to do so accurately and efficiently may contribute to successful acquisition of the foreign language. Within the context of the present research, it was possible to test adults' ability to map phonological information from the auditory onto the written modality at different levels of overlap between the native language and the foreign language. This allowed for examining the role of cross-linguistic similarity, native-language vocabulary and phonological skills in adults' ability to map phonological information across modalities.

9.1 Testing the Effect of Cross-Linguistic Similarity and of Cognitive Variables on Adults' Ability to Map Phonological Information from Auditory onto Written Modality

As discussed previously, cross-linguistic similarity in phonological and orthographic properties can facilitate foreign vocabulary acquisition (e.g., Ellis & Beaton, 1993a; Ellis & Beaton, 1993b; Willis, Emslie, & Baddeley, 1991) because learners can rely on native-language knowledge to support learning (e.g., Gathercole and Baddeley, 1990; Papagno, Valentine, & Baddeley, 1991; De Jong, Seveke, & Van Veen, 2000; Masoura & Gathercole, 1999). Since learning to read in an alphabetic foreign language requires integration of novel phonological and orthographic information, it is likely that similarity in phonological and orthographic properties across L1 and L2 would facilitate reading acquisition in the second language. In situations where the foreign language is similar to the native language, learners would be able to rely on their long-term knowledge of orthography and phonology to support learning. This chapter focuses on the role of cross-linguistic similarity in acquisition of early reading in a foreign language. Early reading in a foreign language was operationally defined as participants' ability to map phonological information acquired in the auditory modality onto the written modality. It was hypothesized that cross-linguistic similarity would facilitate adults' ability to map phonological information from the auditory onto the written modality because it would enable reliance on native-language phonological and orthographic knowledge.

In addition to testing the effect of cross-linguistic similarity, cognitive skills associated with phonological abilities and vocabulary knowledge that may underlie acquisition of early literacy in adults were also of interest. Phonological abilities and vocabulary skills have consistently been identified as necessary for acquisition of reading in both children (e.g., Corneau, Cormier, Grandmaison, & Lacroix, 1999) and adults (e.g., Cisero & Royer, 1995; Majeres, 2005), as well as for acquisition of foreign vocabulary (e.g, Cheung, 1996; Gatherocole & Baddeley, 1990; Service, 1992; Service & Kohonen, 1995). For acquisition of reading by children, it has been demonstrated that the more words the child knows, the easier it is to learn to read, since a greater number of words can be phonologically-mapped and recognized. In fact, children's vocabulary skills are highly predictive of their ability to acquire print knowledge (e.g., Stahl & Fairbanks, 2006). Equally, if not more, important for acquisition of reading, are the child's phonological skills (e.g., Corneau, Cormier, Grandmaison, & Lacroix, 1999). Children who demonstrate superior phonological awareness tend to acquire the alphabetic reading principles with greater efficiency, since they are better able to rely on their phonological skills in mapping orthographic forms onto their phonological representations. For acquisition of reading in adults, it has also been shown that poor phonological skills result in less-accurate and less-efficient reading performance (e.g., Majeres, 2005). As discussed previously, for foreign vocabulary learning, research consistently demonstrates that higher scores on various phonological measures (e.g., non-word repetition, phoneme manipulation, etc.) are associated with increased retention of foreign vocabulary, in both children (e.g., Gatherocole & Baddeley, 1990; Service, 1992) and in adults (e.g., Gupta, 2003; Papagno & Vallar, 1995; Speciale, Ellis, & Bywater, 2004). Additionally, vocabulary abilities in the native language have also been linked with second language acquisition (De Keyser, 2002; Masoura and Gathercole, 1999).

Given the role of phonological memory and vocabulary knowledge in acquisition of a foreign language and in acquisition of reading in the native language, it is likely that the same skills would underlie acquisition of early literacy in the foreign language. However, the extent of involvement of phonological memory and vocabulary knowledge in the learning process may vary according to how much L1 and L2 overlap. For instance, previous work suggests that phonological capacity may be especially important for learning phonologically unfamiliar foreign words (De Jong, Seveke, & Van Veen, 2000; Papagno, Valentine, & Baddeley, 1991). Therefore, it is possible that phonological skills and L1 vocabulary would influence acquisition of L2 reading skills differently, depending on the extent of cross-linguistic overlap between the native and the foreign languages.

In the current research, the foreign vocabulary-learning task made it possible to explore acquisition of early reading skills in a foreign language. Early literacy skills were defined as adults' ability to decode novel written forms of foreign words that they had learned auditorily. In order to be able to recognize previously-unseen written foreign words, participants would have to map them onto their corresponding phonological representations, and to compare these with the phonological representations they had stored as a result of auditory learning. It is likely that just such a process, on a global scale, underlies adults' acquisition of reading skills in a foreign language. In the current chapter, data obtained from monolingual participants tested in Study 1 were analyzed further to examine participants' ability to map phonological information from the auditory onto the written modality at different levels of cross-linguistic overlap (+P+O; -P+O; +P-O; -P-O). This was possible because participants completed testing in the auditory modality first, and then, unexpectedly, in the written modality. It was hypothesized that cross-linguistic overlap, phonological skills, and vocabulary abilities would be associated with adults' ability to map phonological information across modalities. It was expected that cross-linguistic similarity would modulate participants' ability to map phonological information across modalities. It was also expected that phonological short-term memory and vocabulary knowledge would influence adults' ability to map phonological information across modalities.

9.2 Method

9.2.1 Design, Participants, and Procedure

The study followed a 3-way mixed design, where within-subjects independent variables were modality of testing (auditory vs. written) and testing session (immediate vs. delayed), and the between-subjects independent variable was group (+P+O, -P+O, +P-O, and -P-O). Performance on auditory and written testing after the auditory learning phase was examined for the ninety-six monolingual speakers of English tested in Study 1. During *auditory* testing, participants heard foreign words over headphones and chose the correct English translations from five alternatives listed on the computer screen as fast as possible. Immediately after completing the auditory recognition test, participants completed the written recognition test.

During *written* testing, participants saw foreign words spelled out on the computer screen, and chose the correct English translation from five alternatives. The alternatives were the same choices offered to the participants during auditory testing; they were presented in the same order as during the auditory testing. Therefore, performance on the written test indicated the accuracy and the speed with which participants could map newly learned phonological information onto the written modality. During delayed testing, participants completed both the auditory and the written recognition tasks in the same manner as during immediate testing. Standardized assessment measures of vocabulary knowledge and phonological short-term memory were administered at the end of the study.

9.2.2 Analyses

For each dependent variable (accuracy and RT), univariate Analyses of Variance, with group (+P+O, -P+O, +P-O, -P-O) as a between-subjects independent variable were conducted. Next, accuracy and Reaction Time data for each group were analyzed using repeated measures Analyses of Variance, comparing performance on the written recognition test to performance on the auditory recognition test, both immediately after learning and during delayed testing.

In addition, a difference score between performance on the written test and performance on the auditory test was determined for each group (score on written testing minus score on auditory testing). This difference score reflected the gain or drop in accuracy rates or reaction times with repeated testing in a different modality. For accuracy rates, a score above zero reflected higher accuracy rates on the written testing than on the auditory testing, and a score below zero reflected lower accuracy rates on the written testing than on the auditory testing. For reaction times, a lower difference score reflected shorter reaction times on written testing in relation to auditory testing. Therefore, a successful learner capable of transferring phonological information from the auditory modality into the written modality would receive a higher difference score for accuracy, and a lower difference score for RT. Correlation analyses between cognitive measures and difference-scores were conducted, in order to examine which cognitive skills might underlie the ability to transfer phonological information across modalities at different levels of cross-linguistic overlap.

9.3 Results

9.3.1 Between-Group Differences in Recognition Performance

To examine between-group differences in recognition performance as a function of cross-linguistic overlap, accuracy rates and reaction times were examined using univariate Analyses of Variance with group (+P+O; -P+O; +P-O; -P-O) as a between-subjects independent variable. Table 15 shows the accuracy rates (means and standard deviations) for each group and testing condition. Table 16 shows the reaction times (means and standard deviations) for each group and testing condition.

During written testing, significant between-group differences were observed for *accuracy* rates during both immediate $F\ (3, 89) = 5.30$, $p < 0.01$, $\eta_p^2 = 0.15$ and delayed testing, $F\ (3, 86) = 3.95$, $p < 0.05$, $\eta_p^2 = 0.12$. Post-hoc analyses revealed that participants in the +P+O group were more accurate than participants in the -P+O group and than participants in the -P-O group, all least-significant p values < 0.05 (see Table 15). Similarly, participants in the +P-O group were more accurate than participants in the -P+O group and than participants in the -P-O group, all least-significant p values < 0.05. These findings indicate that participants were more accurate at mapping phonology onto orthography in a new language if the foreign-language phonology matched native-language phonology.

Table 15

Recognition Accuracy Rates for Written and Auditory Testing

Group	Auditory Testing Mean (SE)	Written Testing Mean (SE)	Between-Group Comparisons (for difference scores)		
Immediate Testing					
			+P+O	-P+O	+P-O
+P+O	0.77 (0.03)	0.79 (0.03)	--		
-P+O	0.71 (0.04)	0.63 (0.04)*	$p < 0.05$	--	
+P-O	0.78 (0.04)	0.75 (0.05)	N.S.	N.S.	--
-P-O	0.71 (0.03)	0.60 (0.04)*	$p < 0.05$	N.S.	$p < 0.05$
Delayed Testing					
			+P+O	-P+O	+P-O
+P+O	0.66 (0.04)	0.66 (0.04)	--		
-P+O	0.55 (0.04)	0.54 (0.04)	N.S.	--	
+P-O	0.63 (0.04)	0.67 (0.03)	N.S.	N.S.	--
-P-O	0.61 (0.04)	0.55 (0.03)	N.S.	N.S.	$p < 0.05$

Note. A significant difference between written and auditory recognition accuracy is marked by an asterisk next to the Written Testing Mean (SE)*, indicating a $p < 0.05$.

Table 16

Recognition Reaction Times for Written and Auditory Testing

Group	Auditory Testing Mean (SE)	Written Testing Mean (SE)	Between-Group Comparisons (for difference scores)		
		Immediate Testing			
			+P+O	-P+O	+P-O
+P+O	3305.48 (215.79)	4420.92 (229.90)*	--		
-P+O	3320.45 (277.27)	6531.72 (471.64)*	$p < 0.05$	--	
+P-O	3105.93 (166.21)	7217.44 (733.68)*	$p < 0.05$	N.S.	--
-P-O	2964.17 (128.60)	7216.96 (515.01)*	$p < 0.05$	N.S.	N.S.
		Delayed Testing			
			+P+O	-P+O	+P-O
+P+O	3431.80 (182.27)	4095.69 (252.50)*	--		
-P+O	3238.67 (234.24)	4982.54 (352.15)*	$p < 0.05$	--	
+P-O	3607.07 (261.63)	5530.68 (364.45)*	$p < 0.05$	N.S.	--
-P-O	3430.06 (203.92)	5538.95 (339.56)*	$p < 0.05$	N.S.	N.S.

Note. A significant difference between written and auditory recognition RT is marked by an asterisk next to the Written Testing Mean (SE)*, indicating a $p < 0.05$.

In addition to accuracy differences, significant between-group differences were also observed for *reaction times*, both during immediate written testing, F (3, 89) = 6.74, $p < 0.001$, $\eta_p^2 = 0.19$ and during delayed written testing, F (3, 86) = 4.35, $p < 0.01$, $\eta_p^2 = 0.43$. Participants in the +P+O group were faster than participants in the –P+O group, +P-O group, and -P-O group, all least significant p values < 0.01 (see Table 16).

During auditory testing, results revealed comparable *accuracy* and *reaction time* rates across the four groups for both immediate and delayed testing, $p > 0.1$.

9.3.2 Within-Group Differences in Recognition Performance

To examine within group differences in recognition performance as a function of testing modality, accuracy and reaction time measures were analyzed using repeated measures ANOVAs. The difference scores between performance on the written test and the auditory test (written minus auditory) are plotted in Figure 9 (accuracy) and Figure 10 (Reaction Times).

For the +P+O group, repeated-measures ANOVAs revealed comparable accuracy rates for auditory and written testing, both immediately after learning, F (1, 23) = 0.82, $p = 0.37$, $\eta_p^2 = 0.04$, and during delayed testing, F (1, 22) = 0.06, $p = 0.82$, $\eta_p^2 = 0.003$. Conversely, analyses revealed longer reaction times during written than during auditory testing, both immediately after learning, F (1, 23) = 56.32, $p < 0.001$, $\eta_p^2 = 0.71$, and at delayed testing, F (1, 22) = 16.81, $p < 0.001$, $\eta_p^2 = 0.43$. Thus, participants in the +P+O group were slower, but not less accurate, when tested in the written modality than when tested in the auditory modality.

For the -P+O group, repeated-measures ANOVAs revealed that when tested immediately after learning, participants were less accurate when tested in the written modality than in the

Figure 9. Accuracy-difference scores (written testing minus auditory testing) for each group (+P+O; -P+O; +P-O; -P-O), during immediate (blue line) and delayed (red line) testing.

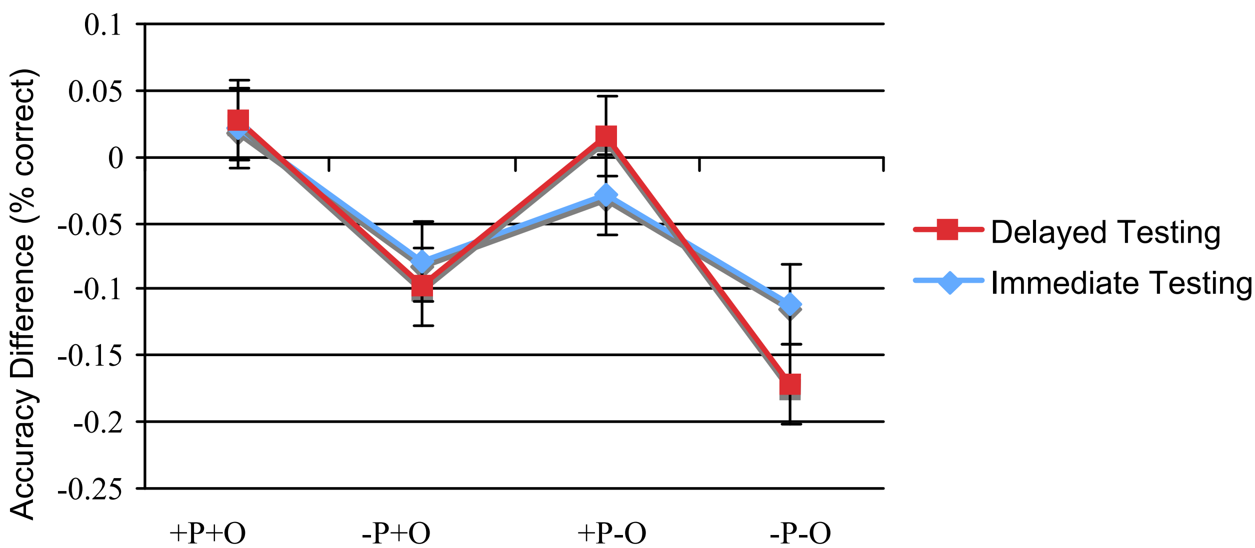
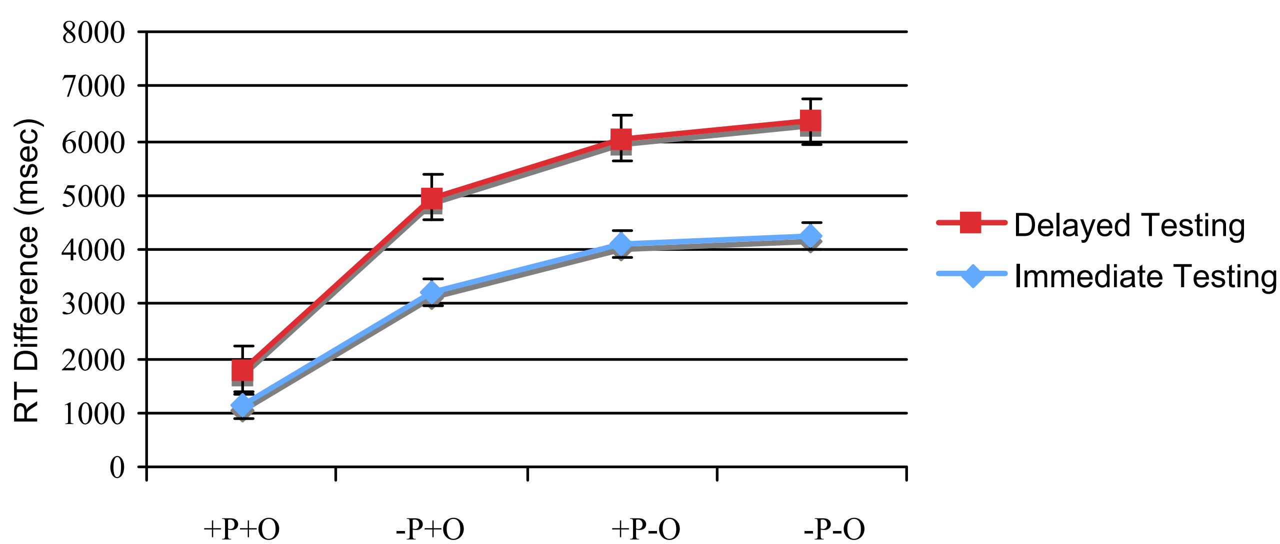


Figure 10. RT-difference scores (written testing minus auditory testing) for each group (+P+O; -P+O; +P-O; -P-O), during immediate (blue line) and delayed (red line) testing.



Note: A difference score of zero denotes comparable performance on written and auditory tests.

auditory modality, F (1, 22) = 12.89, $p < 0.01$, $\eta_p^2 = 0.37$. However, testing-modality differences disappeared with delayed testing, F (1, 20) = 0.37, $p = 0.55$, $\eta_p^2 = 0.02$, and participants were just as accurate during written as during auditory testing. RT analyses revealed longer reaction times during written than during auditory testing, both immediately after learning, F (1, 22) = 91.80, $p < 0.001$, $\eta_p^2 = 0.81$, and at delayed testing, F (1, 20) = 31.42, $p < 0.001$, $\eta_p^2 = 0.61$. Thus, participants in the -P+O group were slower, *and* less accurate, when tested in the written modality than when tested in the auditory modality.

For the +P-O group, repeated-measures ANOVAs revealed comparable accuracy rates for the auditory and the written testing, both immediately after learning, F (1, 22) = 1.67, $p = 0.21$, $\eta_p^2 = 0.07$, and during delayed testing, F (1, 22) = 2.19, $p = 0.15$, $\eta_p^2 = 0.09$. Conversely, analyses revealed longer reaction times during written than during auditory testing, both immediately after learning, F (1, 22) = 40.82, $p < 0.001$, $\eta_p^2 = 0.65$, and at delayed testing, F (1, 22) = 66.87, $p < 0.001$, $\eta_p^2 = 0.75$. Thus, similar to participants in the +P+O group, participants in the +P-O group were slower, but not less accurate, when tested in the written modality than when tested in the auditory modality.

For the -P-O group, repeated-measures ANOVAs revealed that when tested immediately after learning, participants were less accurate when tested in the written modality than in the auditory modality, F (1, 22) = 11.76, $p < 0.01$, $\eta_p^2 = 0.35$. This testing-modality difference attenuated, and became marginal with delayed testing, F (1, 22) = 3.57, $p = 0.07$, $\eta_p^2 = 0.14$, but participants remained less accurate at written than at auditory testing. Similarly, analyses revealed longer reaction times during written than during auditory testing, both immediately after learning, F (1, 22) = 91.85, $p < 0.001$, $\eta_p^2 = 0.81$, and at delayed testing, F (1, 22) = 72.30, $p <$

0.001, $\eta_p^2 = 0.77$. Thus, participants in the -P-O group were slower, *and* less accurate, when tested in the written modality than when tested in the auditory modality.

9.3.3 Relating Cognitive Abilities and Recognition Performance

Correlation analyses were used to examine which cognitive skills would be associated with the ability to map phonological information from the auditory modality onto the written modality. Participants' performance on cognitive measures was correlated with the difference scores between the written and the auditory testing modalities. Because a higher difference score for accuracy would indicate better performance on written compared to auditory testing, positive correlations between cognitive measures and accuracy-difference would indicate that better performance on the cognitive test was associated with better ability to map phonological information across modalities. Conversely, because a higher difference score for RT would indicate less efficient performance on written testing, positive correlations between cognitive measures and RT-difference would indicate that better performance on cognitive measures was associated with lower ability to map phonological information across modalities.

In the *+P+O* group, no significant correlations were observed among any of the cognitive measures and difference scores obtained immediately after learning, for accuracy or RTs. For delayed testing, RT-difference correlated negatively with expressive vocabulary (EVT $R = -0.39$, $p = 0.06$), indicating that higher vocabulary knowledge was associated with more efficient mapping of phonological information onto the written modality. RT-difference also correlated positively with performance on the digit span measure of phonological memory ($R = 0.40$, $p = 0.05$), indicating that a larger digit span was associated with less efficient mapping of phonological information onto the written modality.

In the *-P+O* group, significant correlations were observed between the digit span measure of phonological memory and accuracy-difference scores, both immediately after learning ($R = -0.46$, $p < 0.05$) and during delayed testing ($R = -0.45$, $p < 0.05$), indicating that a larger digit span was associated with less accurate mapping of phonological information from the auditory onto the written modality. Interestingly, the non-word repetition measure of phonological memory correlated positively with accuracy-difference scores during delayed testing ($R = 0.52$, $p < 0.05$), suggesting that participants with a higher phonological short-term memory span tended to be more successful at mapping newly-learned phonological information onto the written modality.

For the *+P-O* group, RT-difference scores during delayed testing correlated negatively with expressive vocabulary (EVT $R = -0.42$, $p < 0.05$) and with non-word repetition ($R = -0.48$, $p < 0.05$); no other significant correlations were observed. This suggests that better vocabulary knowledge and phonological short-term memory skills were associated with more efficient mapping of phonological information from the auditory onto the written modality.

For the *-P-O* group, no significant correlations were observed among any of the cognitive measures and difference scores, suggesting that in this condition, phonological short-term memory and vocabulary knowledge were not associated with participants' ability to map phonological information from the auditory onto the written modality.

9.3 Mapping Foreign Phonological Information Across Modalities as an Indicator of Early Reading Skills: A Discussion

Learning to read in a foreign language often entails recognition of printed words originally acquired in the auditory modality. This recognition relies on the ability to map phonological representations across modalities (auditory to written). In these analyses, adults' ability to map phonological information from the auditory onto the written modality was examined within the context of a foreign-word-learning task. Of interest was whether the underlying cognitive skills that may support mapping of phonological information from the auditory onto the written modality would vary depending on the degree of cross-linguistic similarity between the native and the foreign language.

9.4.1 Cross-Linguistic Similarity in Early Reading

Results revealed that cross-linguistic overlap influenced adults' ability to map phonological information across modalities. Specifically, adults found it easier to map phonological information onto the written modality when it matched the phonology of their native language (+P+O and +P-O groups) than when it mismatched the phonology of their native language (-P+O and -P-O groups). Switching modalities at testing carried efficiency costs for all participants, but accuracy costs were observed only for participants who acquired a phonologically mismatching foreign language (-P+O and -P-O).

The role of cross-linguistic similarity in foreign vocabulary acquisition has been substantiated by previous research (e.g., Ellis & Beaton, 1993a; Willis, Emslie, & Baddeley, 1991). The current work suggests that cross-linguistic similarity also plays an important role in participants' ability to transfer phonological information across modalities (auditory to written). This ability may be fundamental for literacy acquisition in a foreign language, and the results of this research suggest that phonological similarity between L1 and the foreign language makes this task easier. Interestingly, phonological, but not orthographic similarity across languages facilitated participants' performance. Thus, participants who acquired a foreign language that mismatched L1 in orthography, yet matched it in phonology (+P-O) maintained their accuracy of mapping a foreign word to its English translation when tested in the written modality. Conversely, participants who acquired a phonologically-mismatching foreign language showed accuracy costs when the testing modality switched from auditory to written. This pattern of findings may be due to the initial weak encoding of phonologically mismatching information, and not to difficulty mapping phonological information onto a different modality. However, the fact that all four groups of participants demonstrated comparable accuracy rates on auditory testing indicates that participants across the four groups retained comparably strong phonological representations. Thus, it is more likely that the difficulty observed during written testing for participants in the -P+O and -P-O groups was due to a more effortful mapping of phonologically-unfamiliar information onto the corresponding orthography, and not to the less-robust representation of phonological information.

9.4.2 Relating Measures of Cognitive Function to Early Reading

Results revealed that different sets of cognitive skills were associated with adults' ability to map phonological information across modalities, and patterns of correlation depended on the degree of cross-linguistic overlap between the native and the foreign languages. Specifically, better vocabulary knowledge in L1 led to better ability to map phonological information across modalities, but only when L1 and the foreign language shared phonology (+P+O and +P-O groups). Interestingly, distinct correlation patterns between word-learning performance and the two phonological memory measures (the digit-span and the non-word repetition) were found. Higher performance on the digit-span measure led to less efficient and/or less accurate mapping of phonological information across modalities in cases when participants learned a foreign language that matched L1 in orthography (+P+O and -P+O groups). Conversely, higher non-word repetition performance was positively associated with adults' ability to map phonological information across modalities, but only for groups who learned a foreign language that mismatched L1 in either phonology (-P+O) or orthography (+P-O).

The finding that better L1 vocabulary skills led to better recognition performance is consistent with previous studies showing that native-language vocabulary becomes an important predictor of foreign word learning (e.g., Masoura & Gathercole, 1999). Better vocabulary skills in the native language can support further word learning, since new words can be incorporated into the existing system with greater ease. Note that vocabulary skills were associated with performance only by participants who acquired foreign languages that matched L1 in phonology, and were not associated with performance by participants in phonologically mismatching groups. This pattern is likely due to the fact that L1 vocabulary knowledge is indicative of the strength of lexical-level phonological representations. When a foreign word fits the phonology of the native language, the native-language phonological lexicon can support learning; however, when the foreign word does not fit the phonology of the native language, the native-language phonological lexicon cannot support learning. This differential impact of L1 vocabulary on participants' ability to map phonology across modalities suggests that native-language vocabulary can support further language learning, but only when the phonological systems of the two languages are aligned.

The finding that higher non-word repetition scores led to better performance for the -P+O and the +P-O groups is consistent with a number of previous studies showing that phonological short-term memory skills are predictive of foreign word-learning performance (e.g., Gatherocole & Baddeley, 1990; Gupta, 2003; Speciale, Ellis, & Bywater, 2004). In the current study, better ability to maintain the phonological shape of the foreign word in working memory (non-word repetition score) led to better ability to map this phonological representation onto a different modality. Interestingly, this relationship was observed only for situations when the foreign language mismatched the native language in one of the parameters – phonology or orthography. The finding that non-word repetition scores predicted learning in the phonological mismatch condition is consistent with previous studies showing stronger contribution of phonological short-term memory to learning unfamiliar foreign words than to learning familiar foreign words (De Jong, Seveke, & Van Veen, 2000; Papagno, Valentine, & Baddeley, 1991). While acquisition of phonologically-familiar foreign words is supported by long-term phonological knowledge, acquisition of phonologically-unfamiliar foreign words must rely entirely on one's phonological short-term memory (e.g., Papagno, Valentine, & Baddeley, 1991). Moreover, in the current study, non-word repetition scores were also associated with learning in the orthographic mismatch condition. It is possible that in situations of mismatch (phonological or orthographic), one's capacity for maintaining phonological information in short-term memory is especially important for mapping across modalities. However, when both foreign phonology and orthography match that of the native language, it may be unnecessary to maintain the phonological shape of the word in working memory, since it can be easily reconstructed on-line when presented with the orthographic shape of the word. In a situation when neither foreign phonology nor orthography matches that of the native language, one's skill in maintaining the phonological shape of the word in working memory may not be sufficient to facilitate mapping onto the novel orthography. The task of mapping unfamiliar phonology onto unfamiliar orthography may draw upon a set of skills that is distinct from those relied on when the two languages overlap in at least one dimension. Lack of significant correlations between recognition performance and cognitive skills for the -P-O group supports this notion and suggests the need to explore cognitive skills other than those tested here.

In contrast to non-word repetition performance, digit-span performance correlated negatively with participants' ability to map phonological information across modalities, but only for foreign languages that matched L1 in orthography (+P+O and -P+O). It is possible that the inverse relationship between the digit span and performance accuracy is driven by the mismatch between phonological information maintained in working memory and the phonological information activated during written testing. In both the +P+O, and the -P+O conditions, orthographic information presented during written testing consisted of familiar English letters. Due to firm bi-directional connections that exist between letters and phonemes in the native-language (e.g., Seidenberg & McClelland, 1989; Van Orden & Goldinger, 1994), it is likely that orthographic information presented at testing activated native-language phonology. This phonology was likely to conflict with phonology remembered by participants (since the foreign words in the -P+O condition contained non-English phonemes). Participants with high digit-span may have been more capable of remembering phonological information associated with auditorily-learned foreign words than participants with low digit-span. This high phonological capacity may have lead high-digit-span participants to activate the remembered phonological representation during testing. However, the remembered phonology would conflict with phonological representations activated during written testing, resulting in less-successful written recognition performance in participants with high digit-spans. While this account can explain the findings in the -P+O group, it is less clear why an inverse relationship between digit span and reaction times would be obtained in the +P+O condition. The ability to maintain phonological information in the working memory should help participants map this same phonological information onto the written modality, not hinder it. One explanation for this observed pattern is a possibility that phonological information activated via orthography in the +P+O condition did not *exactly* match phonological information acquired during auditory learning. In the +P+O foreign language constructed for the present study, the mappings between letters and phonemes were always consistent; for example, the letter “A” was always pronounced as /ʌ/. This is not the case in English, however, where the closed-syllable “A” often maps onto the phoneme /æ/. It is possible that such inconsistencies in mappings between letters and phonemes of L1 and the foreign language led to the observed negative correlation between the digit-span and the recognition performance in the +P+O group.

The distinct correlation patterns between participants’ ability to map phonological information across modalities, on the one hand, and non-word repetition and digit-span, on the other hand, suggest that non-word repetition and digit-span performance may reflect different sub-components of working memory. It is possible that non-word repetition is more reflective of sub-lexical phonological abilities, while digit-span is more reflective of lexically-based phonological memory. It is also possible that digit-span incorporates a sizable sequencing component, with performance reflective not only of one’s ability to maintain phonological information in short-term memory, but also one’s ability to maintain it in a very specific order (e.g., Gupta, 2003). This difference between the tasks cannot explain, however, why the two load differently and inversely onto participants’ ability to map phonological information across modalities, and future studies may examine this question.

In sum, there appears to be a pattern of complex interactions between adults’ ability to map phonological representations across modalities, cross-linguistic similarity, and underlying cognitive skills. Phonological similarity across the native and the foreign language facilitates one’s ability to map phonological information onto a new modality, and vocabulary knowledge in the native language supports this ability. In general, the findings suggest that adult acquisition of early literacy in different foreign-language systems is associated with distinct sets of skills, and depends, to a large extent, on the overlap between the phonological and the orthographic inventories in the native and the foreign languages. Future work may examine more closely the developmental course of the interplay between cross-linguistic similarity and cognitive skills. A more immediate goal may be to perform a large-scale study that would employ Factor-Analysis techniques to examine whether word learning would cluster with the digit-span measure of phonological memory or with the non-word repetition measure of phonological memory, and whether the clustering patterns would depend on the degree of cross-linguistic overlap between the native language and the foreign language.

CHAPTER X.

LINGUISTIC AND COGNITIVE MECHANISMS IN FOREIGN VOCABULARY ACQUISITION: GENERAL DISCUSSION AND CONCLUSION

10.1 Summary of Findings

The current dissertation research aimed to examine linguistic and cognitive mechanisms in foreign vocabulary learning. In *Study 1*, interactions between cross-linguistic similarity and learning modality were examined. Findings suggest that learning modality interacts with cross-linguistic similarity in foreign vocabulary learning. Bimodal learning facilitates retention of foreign words when the foreign language matches the native language in letter-to-phoneme mappings. Conversely, bimodal learning hinders retention of foreign words when the foreign language mismatches the native language in either phonology, orthography, or both. Further, Study 1 suggests that phonological mismatch across the two languages impacts foreign vocabulary learning to a greater extent than orthographic mismatch. Results of Study 1 inform the Working Memory model, and contribute to theoretical knowledge of phonological loop function. Practically speaking, Study 1 suggests that exposing a novice language learner to both the auditory and the written form of a foreign word at the same time may negatively impact retrieval in some learning situations.

In *Study 2*, the effect of language-learning experience on foreign vocabulary learning was examined. Findings suggest that language-learning experience facilitates subsequent foreign vocabulary learning, and that different types of language-learning experience incur specific benefits. Preliminary explorations of age-of-acquisition and L2 proficiency effects in the development of bilingual advantage indicate that both, earlier acquisition of a second language, and high proficiency in the second language, amplify bilingual advantage for foreign word learning. Study 2 informs theories and models of language-learning, memory function, and cognitive function in bilingual and monolingual speakers. Results of Study 2 may be useful in localizing the effects of language-learning experience on the foreign word learning process to specific components of the working memory model. It is possible that all three components, the central executive, the episodic buffer, and the phonological loop are affected by language-learning experience. It is also possible that different types of language-learning experience affect different components of the working memory.

Preliminary correlation analyses suggest that both, native language vocabulary knowledge and phonological short-term memory span influence adults' ability to acquire foreign words. The degree and the exact patterns of correlations between foreign word learning and cognitive measures depend on the structure of the foreign language (phonologically-similar vs. phonologically-different from the native language) and on the linguistic experience of the learners (monolinguals vs. bilinguals). Moreover, the specifics of bilingual experience (Spanish L2 vs. Mandarin L2) also influence the degree of the relationship between phonological short-term memory and foreign vocabulary learning. Further, adults' ability to map phonological information from the auditory onto the written modality (which may be indicative of the early stages of L2 reading acquisition) is supported by different cognitive abilities depending on the extent of cross-linguistic overlap. In its totality, this work informs theories and models of foreign vocabulary learning, specifically, and learning and memory, in general.

10.2 Future Directions

10.2.1 Rehearsal Mechanisms Underlying Foreign Vocabulary Acquisition

The paradigm used in Study 1 may be extended to examine the rehearsal component of the phonological loop more closely. The working memory model suggests that in addition to a phonological store that maintains novel memory traces, rehearsal mechanisms that facilitate translation of a novel phonological trace into a long-term representation are fundamental for foreign vocabulary learning. In Study 1, it was demonstrated that *vocal* rehearsal was successfully used by monolingual English speakers to learn novel foreign words. Moreover, foreign words containing English phonemes spelled using English letters (+P+O Condition) were learned better than foreign words containing non-English phonemes spelled using English letters (-P+O Condition). These findings suggest that vocal rehearsal facilitates learning when foreign words are phonologically-similar to the native language; alternatively, vocal rehearsal strategy may facilitate learning less when foreign words differ from the native language in phonology. Future studies will examine whether vocal and sub-vocal rehearsal strategies facilitate learning of foreign vocabulary items to the same degree, or whether the type of rehearsal strategy interacts with cross-linguistic similarity. It may be hypothesized that vocal rehearsal will be more conducive to learning foreign vocabulary items that share English phonology and orthography. Alternatively, it may be hypothesized that sub-vocal rehearsal would be more conducive to learning foreign vocabulary items that contain non-English sounds spelled using English letters. These hypotheses are based on the articulatory rehearsal literature suggesting that articulation in sub-vocal rehearsal involves a more abstract articulatory code than vocal rehearsal (Baddeley, 1986; Vallar & Cappa, 1987; Belleville, Peretz, & Arguin, 1992). Thus, the sub-vocal rehearsal procedure implemented when learning foreign vocabulary items in the -P+O Condition may deemphasize the presence of non-English phonemes, and facilitate vocabulary-learning process. This study is currently under way, and pilot data have been collected.

Similarly, future work may examine whether modality of rehearsal – auditory (vocal) vs. visual (written) – influences retention of foreign words differently at different levels of cross-linguistic overlap. For instance, it is possible that written rehearsal (writing the foreign word three times) would be a more efficient strategy than auditory rehearsal (saying the foreign word out-loud three times) in situations where the foreign language matches the native language in orthography. The converse (auditory rehearsal being more beneficial than written rehearsal) is likely to be the case in situations where the foreign language matches the native language in phonology. Further, a comparison between written and subvocal rehearsal is an interesting one to consider, since both involve more abstract phonological codes than vocal rehearsal, and thus may reveal whether activation of phonology during writing is qualitatively and quantitatively comparable to phonological activation during silent rehearsal.

10.2.2 Obligatory Processing of Print

Experiments conducted within the context of the current dissertation research were fueled by the notion of bi-directional connections thought to exist between the orthographic and the phonological systems of a language (e.g., Booth, Perfetti, & MacWhinney, 1999; Van Orden & Goldinger, 1994). Facilitation and inhibition effects associated with presence of written information during learning (bimodal condition) were attributed to obligatory activation of phonological information associated with the written input. The underlying assumption was that participants would not be able to ignore the written input, although they were never told that they had to learn the words' spelling. The findings appear to suggest that presence of written information during learning did influence the retention of the foreign word, even when the processing of this written information was not necessary, and sometimes disadvantageous (e.g., in situations of cross-linguistic mismatch). However, a possibility remains that processing of print may be suppressed under specific circumstances. Some studies of Stroop effects find that in certain conditions, the automatic reading of the color word does not occur. For instance, spatial separation of a color bar and a written color term (e.g., Risko, Stolz, & Besner, 2005; Brown, et al., 2002), participants' expectations about the task (e.g., Tzlegov, Henik, & Berger, 1992), and stimulus characteristics such as visual saliency (e.g., Besner & Stolz, 1999) can act to reduce or even eliminate the Stroop effect.

In the context of the present work, it remains to be seen whether the effects of bimodal exposure on foreign word learning would persist if participants expected the written information to be irrelevant to the task (for instance, if they were told that they would not be tested on the words' spelling). It may be that participants would find it impossible to ignore written information, under any circumstances. This pattern would most likely be found in situations where the written information corresponds to the native-language alphabet. Alternatively, it may be that when told to ignore written input, participants would be less facilitated or inhibited by its presence during learning. This pattern would most likely be found in situations where the written information does not correspond to the native-language alphabet.

10.2.3 Foreign Word Learning in Speech-Language Impaired Populations

Results of Study 1 may be used to formulate studies of foreign language learning in special populations. Currently, mechanisms of second-language learning in special populations are virtually unknown. Yet, children with speech, language, and hearing impairments, as well as children with learning disabilities are often raised in bilingual contexts. Moreover, foreign language requirements shared by many schools in the United States may pertain to children with speech and/or language impairment. Knowing if and how a speech and/or language impairment impacts second language acquisition is imperative for formulation of intervention strategies, as well as for informing education policies. Moreover, examining second-language learning mechanisms in special populations would serve to inform theories and models of second-language acquisition, as it may reveal abilities and skills that are necessary for second-language learning vs. the abilities and skills that are secondary to the second-language learning process.

Motor control. Based on the results of Study 1, it may be possible to examine whether stuttering affects foreign vocabulary learning. Examination of foreign vocabulary learning in people who stutter vs. people who do not stutter has the potential to increase the knowledge of basic cognitive mechanisms underlying second-language learning. Foreign vocabulary learning is known to rely on phonological memory and rehearsal mechanisms. Disruptions in the rehearsal process impair memory, as shown by studies of articulatory suppression (e.g., Papagno, Valentine, & Baddeley, 1991). Therefore, a motor impairment that impacts rehearsal should also impact memory for novel verbal information. For instance, it has been shown that patients with central neural deficits associated with motor programming lose their ability to rehearse verbal material (e.g., Caplan & Waters, 1995). Since the identifying characteristic of a stuttering disorder is impaired motor control (e.g., Peters & Boves, 1988; Peters, Hulstijn, & Starkweather, 1989; Caruso, Gracco, & Abbs, 1987; Freeman & Ushijima, 1978; Shapiro, 1980; Janssen & Wieneke, 1987; Watson & Alfonso, 1987), foreign vocabulary learning may be more difficult for people who stutter than for people who do not stutter, especially when the rehearsal procedure is vocal. It may be hypothesized that motor control difficulties will impact vocal rehearsal to a greater extent than sub-vocal rehearsal, because sub-vocal rehearsal relies less on articulatory gestures, and therefore, should be less impacted by disfluencies.

Reading difficulties. Exploration of how bimodal auditory-visual exposure may influence word learning in children and adults with reading difficulties is potentially a very interesting research direction. While different accounts and different types of reading difficulties exist, their causes do appear to be rooted in phonological processing, at least for some types of reading disorders (e.g., Harm & Seidenberg, 2001). Poor readers seem to activate phonological information associated with the written input slower and less automatically than good readers (e.g., Booth, Pefetti, & MacWhinney, 1999). Less automatic activation of phonological information associated with the written input may be disruptive to bimodal learning of words in the +P+O condition, but be helpful for learning words in the -P+O condition. In the current study, bimodal facilitation for learning +P+O foreign words, and bimodal inhibition for learning -P+O foreign words was attributed to automatic activation of English phonology associated with English orthography. If such activation were less automatic and/or slower, it is possible that inhibition effects observed for bimodal learning in the -P+O mismatch condition and facilitation effects observed for bimodal learning in the +P+O condition would be reduced or even eliminated. Therefore, reading difficulties in the native language may actually be conducive to learning foreign words in conditions where the native language and the foreign language share orthography, but not phonology. Similarly, reading difficulties may make it difficult to take advantage of overlapping phonological codes retrieved via the visual and the auditory modality in conditions where the native language and the foreign language share both phonology and orthography.

One way to examine whether reading difficulties in the native language might make learning foreign words in the -P+O condition easier is to split monolingual adults into two groups based on their performance on the reading fluency task. The hypothesis would be that lower-scoring adults would perform better than high-scoring adults on words learned bimodally, because for them, the activation of native-language phonology via the written input would not be obligatory or automatic. Alternatively, based on dual-route models of readings, skilled reading may actually be characterized by an ability to bypass phonological activation, and to map written information onto the semantic system directly (Coltheart, Curtis, Atkins, & Haller, 1993). If this were the case, then adults who scored high on the reading task would be more capable of bypassing the phonological recoding stage than adults who scored low on the reading task. Therefore, good readers would be less likely to activate phonological information associated with the written input during bimodal learning than poor readers, and thus less likely to be disrupted in their learning of -P+O foreign words. Another way to test the effects of reading difficulties on foreign vocabulary acquisition is by an a-priori examination of adults and children with diagnosed reading disorders.

10.2.4 Computational Modeling of Foreign Word Learning at Different Levels of Cross-Linguistic Overlap

The findings for Study 1 may be used to formulate further experiments on the role of cross-linguistic similarity in learning. In the future, it may be possible to computationally model the effects obtained in these experiments. For instance, it may be fruitful to model foreign word learning using the computational model of word reading proposed by Seidenberg and McClelland (1989) in order to observe whether it can accommodate foreign word learning patterns that vary depending on the degree and type of cross-linguistic overlap.

10.2.5 Mechanisms of Bilingual Advantage for Foreign Word Learning

The findings of Study 2 raise questions than can motivate a number of future research directions. For instance, the finding that the experience of learning Spanish affects foreign word learning differently than learning Mandarin may indicate that learning Spanish vs. learning Mandarin impacts *different* components of the working memory. Future studies that computationally-model these findings may be fruitful in pinpointing the exact loci of language-experience effects. It may also be possible to localize the effect of language-learning experience on the working memory by implementing procedures known to affect different components of the working memory during learning. For instance, articulatory rehearsal is known to be affected by articulatory suppression (repeating a single phrase out loud while trying to learn). Therefore, if language-learning experience improves rehearsal abilities, then bilinguals should be less affected by articulatory suppression than monolinguals. Similarly, the phonological store is known to be affected by the number of the to-be-learned items: The greater the number of words in a list, the worse people are at learning the words. Therefore, if language-learning experience increases the phonological store capacity, then bilinguals should be less affected by the increased number of the to-be-learned foreign items than monolinguals. Correlating bilingual's performance on the word-learning task with their performance on the executive-control tasks such as the Simon and the Stroop may be one way to determine if the central-executive is the locus of bilingual advantage. For instance, if it were found that success on the word-learning task and successful inhibition on the switch trials in the Simon task were correlated, it would suggest that the two tasks draw upon the same underlying skill. Given that the Simon task measures cognitive control associated with inhibition, such a relationship would indicate that the same control mechanism is the likely locus of bilingual effects in word-learning. Another way in which the role of the central executive in the development of the bilingual advantage can be examined is through testing bilinguals not only on the verbal tasks, such as word-learning, but also on the visual-spatial tasks, such as learning of novel shapes. The central executive is thought to be responsible for distribution of resources for all tasks – verbal or visual-spatial. If the mechanism of bilingual advantage is associated with the more efficient function of the central executive, then bilinguals should also be better than monolinguals on visual-spatial memory tasks as well, and their performance on the verbal task should be related to their performance on the visual-spatial task.

Another line of work would look more closely at the role of AoA and proficiency in the development of the bilingual advantage. Preliminary look into the influence of AoA and of L2 proficiency on the development of the bilingual advantage suggest that early acquisition and higher proficiency in the second language amplify the bilingual advantage for foreign vocabulary learning. However, the effects of L2 acquisition age and of L2 proficiency on the development of bilingual advantage have to be examined in an a-priori manner in future studies, with findings in the current research serving as pilot data. It is necessary for the effect of age of L2 acquisition and L2 proficiency to be examined in the same group of bilingual speakers. If parallel processing is the underlying mechanism for bilingual advantage in cognitive function, then proficiency should be more important than acquisition age in the development of bilingual advantage for foreign vocabulary acquisition. If, on the other hand, early, but not late acquisition of a language institutes a fundamental change in the learning mechanisms, then age of L2 acquisition should be more important than L2 proficiency in the development of the bilingual advantage for foreign vocabulary acquisition. In the future, English-Spanish bilinguals will be split into four groups according to age-of-acquisition and proficiency levels in Spanish: early and more proficient; early and less proficient; late and more proficient; late and less proficient, and separate effects of AOA and proficiency on foreign vocabulary acquisition and cognitive function will be examined.

10.2.6 Cognitive Skills that Underlie Foreign Word Learning in Adults

The relationship between cognitive function and foreign vocabulary learning in adults is an under-explored and an interesting area of future research. The link between phonological short-term memory and ability to learn foreign words is clearly influenced by the degree of cross-linguistic phonological overlap, and by the linguistic experience of the participants. However, to determine the exact patterns of relationship between vocabulary knowledge, phonological short-term memory, cross-linguistic overlap, and linguistic experience, an extensive research program focusing on these variables is required. The first step will be relating non-word repetition as a measure of phonological-loop function, on the one hand, and foreign word learning, on the other hand. The idea that the phonological loop functions in a language-specific manner is intriguing, in that it suggests that non-word repetition performance on non-words that follow native-language phonological and phonotactic rules may have little to do with ability to acquire foreign words, which invariably involve unfamiliar phonology and phonotactics. It would also be interesting to examine whether the type of learning (by association, by immersion, etc.) influences the degree to which people draw on their phonological short-term memory during learning.

10.2.7 Foreign Word Learning Along the Developmental Continuum

Another avenue of research would focus on the effects of literacy acquisition on phonological development and on foreign language learning. One of the most important landmarks in language development is acquisition of literacy. When acquisition of literacy involves learning an alphabet, the underlying phonological system is reorganized into categories that correspond to the learned letter symbols (e.g., Burnham, 2003). The impact of literacy-acquisition on phonological development carries consequences for foreign word learning.

Specifically, it is possible that foreign language learning is made more difficult post-literacy, since learning to read may make the native phonological system less permeable and therefore less capable of incorporating foreign phonology. In order to examine this question, I intend to test foreign word learning in children matched in age and in IQ, but differing in literacy levels as a result of class placement.

In related work, I would like to examine the development of the phonological system and the impact of literacy on phonological development using eye tracking. Adults possess a highly interactive phonological lexicon, where shared phonemes activate all the words that could potentially be the target of the auditory signal. Parallel activation of phonologically-related lexical items may be a result of a developmental process, with acquisition of literacy playing a crucial role in the development of the phonological system. I intend to use eye-tracking methodology to examine the course of phonological development, and to test the impact of literacy on the phonological system by comparing pre-literate and post-literate children to each other, as well as to younger and older adults. Once the use of eye-tracking methodology has been validated in unimpaired children, I intend to examine phonological processing in clinical populations with phonological impairments. Since parallel processing of lexical candidates is a function of a mature and sophisticated phonological system, impairments at the level of phonology should result in less efficient co-activation. Therefore, comparing lexical co-activation across clinical populations with phonological impairments at different levels of the cognitive system may reveal the nature of cognitive mechanisms that underlie parallel processing. Such findings will not only expand our understanding of cognitive precursors to linguistic fluency, but may also reveal clinically-valuable indicators of various speech and language impairments.

10.3 Conclusion

In sum, the line of research started by this dissertation may be promising both theoretically and practically. Knowledge of how long-term knowledge interacts with working memory mechanisms in monolingual and bilingual speakers will inform memory and learning theories, and may provide specific information regarding the role of various components of the working memory in the learning process. Findings pertaining to modality effects in learning can be potentially useful in clinical and education practice. In second-language classrooms, the methodology of multimodal exposure to facilitate language learning is pervasive (e.g., Blachowicz & Fisher, 2001). The findings of the current work strongly suggest that multimodal (auditory and visual) exposure is a beneficial teaching strategy only under specific conditions, and indicate that further research into the timing of multimodal teaching (earlier vs. later in the language-acquisition process) is needed. Multimodal teaching strategies are used not only in the classrooms, but also in the speech-language pathology practice. For instance, accent reduction, articulation, and phonological therapy often involve a client reading a written word and hearing the clinician pronouncing the word at the same time. While current work did not test the effect of bimodal exposure on participants' ability to pronounce the foreign words, it did suggest that retention of the words' meaning was not necessarily facilitated by bimodal exposure. Analogously, presenting the word in both the auditory and the visual modality during speech treatment (whether for purposes of accent reduction, articulation or phonological treatment) may not be beneficial across the board. The dissertation findings can also be used as tentative guidelines for structuring the ESL and the Foreign Language curricula in schools. Specifically, preliminary findings strongly suggest that the benefits of bilingualism are amplified with early acquisition of a second language. Therefore, the decision about the age at which children should start learning a foreign language in school can be informed, at least in part, by findings from the current study. Future work will build on the current findings, and will explicitly test the effects of multimodal exposure on the success of speech-language therapy, of age of acquisition on the development of bilingual advantage, and of the various cognitive skills on novel word learning across the lifespan.

References

Adams, M.R. (1984). Laryngeal onset and reaction time of stutterers. In W. Perkins and R. Curlee (Eds.), *The Nature and Treatment of Stuttering*, pp. 12–27. San Diego: College-Hill Press.

Alario, F.-X., Perre, L., Castel, C., & Ziegler, J.C. (2007). The role of orthography in speed production revisited. *Cognition, 102*, 464-475.

Baddeley, A.D. (1986). *Working Memory*. Oxford, UK: Clarendom.

Baddeley, A.D. (2000). The episodic buffer: A new component of working memory? *Trends in Cognitive Scientists, 4,* 417-423.

Baddeley, A.D. (2001). Is working memory still working? *American Psychologist, 56*, 849-864.

Baddeley, A.D., Gathercole, S., & Papagno, C. (1998). The phonological loop as a language learning device. *Psychological Review, 105*, 158-173.

Baddeley, A.D., Papagno, C., & Vallar, G. (1988). When long-term learning depends on short-term storage. *Journal of Memory and Language, 27*, 586-595.

Baron, J., & Strawson, C. (1976). Use of orthographic and word-specific knowledge in reading words aloud. *Journal of Experimental Psychology: Human Perception and Performance, 2*, 386-393.

Beitchman, J.H., Nair, R., Clegg, M., & Patel, P.C. (1986). Prevalence of speech and language disorders in 5-year-old kindergarten children in the Ottawa-Carleton region. *Journal of Speech and Hearing Disorders, 51*, 98-110.

Belleville, S., Peretz, I., & Arguin, M. (1992). Contribution of articulatory rehearsal to short-term memory: Evidence from a case of selective disruption. *Brain and Language, 43*, 713-746.

Berry, D.C., Banbury, S., & Henry, L. (1997). Transfer across form and modality in implicit and explicit memory. *The Quarterly Journal of Experimental Psychology, 50A(1)*, 1-24.

Besner, D., & Stolz, J.A. (1999). What kind of attention modulates the Stroop effect? *Psychonomic Bulletin & Review, 6*, 99-104.

Bialystok, E. (1999). Cognitive complexity and attentional control in the bilingual mind. *Child Development, 70*, 636-644.

Bialystok, E. (2006). Effects of bilingualism and computer video game experience on the Simon Task. *Canadian Journal of Experimental Psychology, 60*, 68-79.

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.

Bialystok, E., Craik, F.I.M., & Ryan, J. (2006). Executive control in a modified antisaccade task: Effects of aging and bilingualism. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 32*, 1341-1354.

Bialystok, E., Luk, G., & Kwan, E. (2005). Bilingualism, biliteracy, and learning to read: interactions among languages and writing systems. *Scientific Studies of Reading, 9*, 43-61.

Bialystok, E., Majumder, S., & Martin, M.M. (2003). Developing phonological awareness: Is there a bilingual advantage? *Applied Psycholinguistics, 24*, 27-44.

Bialystok, E., & Martin, M.M. (2004). Attention and inhibition in bilingual children: evidence from the dimensional change card sort task. *Developmental Science, 7*, 325-339.

Bialystok, E., & Miller, B. (1999). The problem of age in second-language acquisition: Influences from language, structure, and task. *Bilingualism: Language and Cognition, 2*, 127-145.

Bialystok, E., & Shapero, D. (2005). Ambiguous benefits: the effect of bilingualism on reversing ambiguous figures. *Developmental Science, 8*, 595-604.

Bird, S., & Williams, J.N. (2002). The effects of bimodal input on implicit and explicit memory: An investigation of within-language subtitling. *Applied Psycholinguistics, 23*, 509-533.

Birdsong, D., & Mollis, M. (2001). On the evidence for maturational constraints in second-language acquisition. *Journal of Memory and Language, 44*, 235-249.

Blachowicz, C., & Fisher, P. (2001). *Teaching Vocabulary in All Classrooms. 2nd Ed.* Columbus, OH: Merrill-Prentice Hall

Blumenfeld, H.K., & Marian, V. (in press). Constraints on parallel activation in bilingual spoken language processing: Examining proficiency and lexical status using eye-tracking. *Language and Cognitive Processes.*

Brown, T.L., Gore, C.L., & Carr, T.H. (2002). Visual attention and word recognition in Stroop color naming: Is word recognition "automatic"? *Journal of Experimental Psychology: General, 131*, 220-240.

Booth, J.R., Perfetti, C.A., & MacWhinney, B. (1999). Quick, automatic, and general activation of orthographic and phonological representations in young readers. *Developmental Psychology, 35*, 3-19.

Buck, M., & Genesee, F. (1995). Phonological awareness in young second language learners. *Journal of Child Language, 22*, 307-324.

Burnham, D. (2003). Language specific speech perception and the onset of reading. *Reading and Writing: An Interdisciplinary Journal, 16*, 573-609.

Caruso, A., Gracco, V., & Abbs, J. (1987). A speech motor control perspective on stuttering:

Preliminary observations. In H.F.M. Peters & W. Hulstijn (Eds.), *Speech Motor Dynamics in Stuttering*, pp. 39 – 45. Wien/New York: Springer Verlag.

Chereau, C., Gaskell, M.G., & Dumay, N. (2006). Reading spoken words: Orthographic effects in auditory priming. *Cognition, in press.*

Cheung, H. (1996). Nonword span as a unique predictor of second-language vocabulary learning. *Developmental Psychology, 32*, 867-873.

Coltheart, M., Curtis, B., Atkins, P. & Haller, M. (1993). Models of reading aloud: Dual-route and parallel-distributed-processing approaches. *Psychological Review*, *100*, 589–608.

Coltheart, M., Rastle, K., Perry, C., Langdon, R., & Ziegel, J. (2001). DRC: a dual route cascaded model of visual word recognition and reading aloud. *Psychological Review*, *108*, 204-256.

Conture, E.G., Louko, L.J., & Edwards, M.L. (1993). Simultaneously treating stuttering and disordered phonology in children: Experimental treatment, preliminary findings. *American Journal of Speech-Language Pathology, 2*, 72-81.

Cowan, N. (1995). *Attention and Memory, an Integrated Framework.* Oxford, UK: Oxford University Press.

Cowan, N. (1999). An embedded-process model of working memory. In A. Miyake & P. Shah (Eds.), *Models of Working Memory* (pp. 62-101). Cambridge, UK: Cambridge University Press.

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.

Danan, M. (1992). Reversed subtitling and dual coding theory: New directions for foreign language instruction. *Language Learning, 42*, 497-527.

Danan, M. (2004). Captioning and subtitling: Undervalued language learning strategies. *Meta, 54*, 67-77.

De Groot, A.M.B., & Keijzer, R. (2000). What is hard to learn is easy to forget: the roles of word concreteness, cognate status, and word frequency in foreign-language vocabulary learning and forgetting. *Language Learning, 50(1)*, 1-56.

De Jong, P.F., Seveke, M-J., & van Veen, M. (2000). Phonological sensitivity and the acquisition of new words in children. *Journal of Experimental Child Psychology, 76*, 275-301.

De Keyeser, R.M. (2000). The robustness of the critical period effects in second language acquisition. *Studies in Second Language Acquisition, 22*, 499-533.

Dijkstra, T., Roelofs, A., & Fiews, S. (1995). Orthographic effects on phoneme monitoring. *Canadian Journal of Experimental Psychology, 49(2)*, 264-271.

Dunn, L. M., & Dunn, L. M. (1997). Peabody Picture Vocabulary Test (3rd ed.). Circle Pines, MN: American Guidance Service.

Duyck, W., Desmet, T., Verbeke, L.P.C., & Brysbart, M. (2004). WordGen: A tool for word selection and nonword generation in Dutch, English, German, and French. *Behavior Research Methods, Instruments, & Computers, 36*, 488-499.

Duyck, W., Szmalec, A., Kemps, E., & Vandierendonck, A. (2003). Verbal working memory is involved in associated word learning unless visual codes are available. *Journal of Memory and Language, 48*, 527-541.

Ellis, N.C., & Beaton, A. (1993a). Psycholinguistic determinants of foreign language vocabulary learning. *Language Learning, 43(4)*, 559-617.

Ellis, N., & Beaton, A. (1993 b). Factors affecting the learning of foreign language vocabulary: Imagery keyword mediators and phonological short-term memory. *The Quarterly Journal* *of Experimental Psychology, 46A(3)*, 533-558.

Ellis, N.C., & Sinclair, S.G. (1996). Working memory and acquisition of vocabulary and syntax: Putting language to good order. *The Quarterly Journal of Experimental Psychology, 49A*, 234-250.

Erdener, V.D., & Burnham, D.K. (2005). The role of audiovisual speech and orthographic information in nonnative speech production. *Language Learning, 55*, 191-228.

Flege, J. E., Yeni-Komshian, G. H., & Liu, S. (1999). Age constraints on second-language acquisition. *Journal of Memory and Language, 41,* 78-104.

Francis, W.N., & Kucera, H. (1982). *Frequency Analysis of English Usage: Lexicon and Grammar*. Boston: Hougton Mifflin Company.

Frauenfelder, U.H., Segui, J., & Dijkstra, T. (1990). Lexical effects in phoneme processing: Facilitatory or inhibitory? *Journal of Experimental Psychology: Human Perception and Performance, 16(1)*, 77-91.

Freeman, F., & Ushijima, T. (1978). Laryngeal muscle activity during stuttering. *Journal of Speech and Hearing Research, 21*, 358-362.

Frost, R., Repp, B.H., & Katz, L. (1988). Can speech perception be influenced by simultaneous presentation of print? *Journal of Memory and Language, 27*, 741-755.

Galambos, S.J. & Goldin-Meadow, S. (1990). The effects of learning two languages on levels of metalinguistic awareness. *Cognition, 34*, 1-56.

Gathercole, S.E. (1995). Is non-word repetition a test of phonological memory or long-term knowledge? It all depends on the nonwords. *Memory and Cognition, 23*, 83-94.

Gathercole, S.E. (1996). Nonword repetition and word learning: The nature of the relationship. *Applied Psycholinguistics, 27*, 513-543.

Gathercole, S.E., & Baddeley, A.D. (1990). The role of phonological memory in vocabulary acquisition: A study of young children learning new names. *British Journal of Psychology, 81*, 439-454.

Gathercole, S.E., Frankish, C.R., Pickering, S.J., & Peaker, S. (1999). Phonotactic influences on short-term memory. *Journal of Experimental Psychology: Human Learning and Memory, 25*, 84-95.

Gathercole, S. E., Willis, C., Emslie, H., & Baddeley, A. D. (1991). The influences of number of syllables and wordlikeness on children's repetition of nonwords. *Applied Psycholinguistics, 12,* 349-367.

Gilhooly, K.J., & Logie, R.H. (1980). Age of acquisition, imagery, concreteness, familiarity and ambiguity measures for 1944 words. *Behavior Research Methods and Instrumentation, 12*, 395-427.

Gupta, P. (2003). Examining the relationship between word learning, nonword repetition, and immediate serial recall in adults. *The Quarterly Journal of Experimental Psychology, 56A*, 1213-1236.

Hanten, G., & Martin, R.C. (2001). A developmental phonological short-term memory deficit: A case study. *Brain and Cognition, 45*, 164-188.

Harm, M.W., & Seidenberg, M.S. (2001). Are there orthographic impairments in phonological dyslexia? *Cognitive Neuropsychology, 18*, 71-92.

Huber, B.J. (1992). Characteristics of foreign language requirements at the US colleges and universities: Findings from the MLA's 1987-89 survey of foreign language programs. *ADFL Bulletin, 24*, 8-16.

Hulme, C., Maughan, S., & Brown, G.D. (1991). Memory for familiar and unfamiliar words: Evidence for a long-term memory contribution to short-term memory span. *Journal of Memory and Language, 30*, 685-701.

Jakimik, J., Cole, R.A., & Rudnicky , A.I. (1985). Sound and spelling in spoken word recognition. *Journal of Memory and Language, 24*, 165-178.

Janssen, P., & Wieneke, G. (1987). The effects of fluency-inducing conditions on the variability in the duration of laryngeal movements during stutterers' fluent speech. In In H.F.M. Peters & W. Hulstijn (Eds.), *Speech Motor Dynamics in Stuttering*, pp. 57 – 83. Wien/New York: Springer Verlag.

Jared, D. & Kroll, J. F. (2001). Do bilinguals activate phonological representations in one or both of their languages when naming words? *Journal of Memory and Language, 44*, 2-31.

John-Baptiste A., Naglie, G., Tomlinson, G., Alibhai, S.M., Etchells, E., Cheung, A., Kapral, M., Gold, W.L., Abrams, H., Bacchus, M., & Krahn M. (2004). The effect of English language proficiency on length of stay and in-hospital mortality. *Journal of General Internal Medicine 19(3)*, 221-8.

Johnson, J.S., & Newport, E.L. (1989). Critical period effects in second language learning: The influence of maturational state on the acquisition of English as a second language. *Cognitive Psychology, 21*, 60-99.

Jones, D.M., Hughes, R.W., & Macken, W.J. (2006). Perceptual organization masquerading as phonological storage: Further support for a perceptual-gestural view of short-term memory. *Journal of Memory and Language, 54*, 265-281.

Kaushanskaya, M., & Marian, V. (submitted). Non-target language competition in the Picture-

Word Interference Task modified for eye-tracking. *Journal of Experimental Psychology: Human Perception & Performance.*

Kellerman, E. (1995). Age before beauty. In L. Eubank, L. Selinker, & M. Sharwood Smith (Eds.), *The Current State of Interlanguage: Studies in Honor of William E. Rutherford* (pp. 219-231). Amsterdam: John Benjamins.

Kormi-Nouri, R., Moniri, S., & Nilsson, L-G. (2003). Episodic and semantic memory in bilingual and monolingual children. *Scandinavian Journal of Psychology, 44*, 47-54.

Kroll, J.F., Michael, E., & Sankaranarayanan, A. (1998). A model of bilingual representation and its implications for second language acquisition. In A.F. Healy and L.E. Bourne (Eds.), *Foreign Language Learning: Psycholinguistic Experiments on Training and Retention.* Mahwah, NJ: Lawrence Erlbaum Associates, pp. 365-395.

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.

Larsen, J. D., & Baddeley, A. (2003). Disruption of verbal STM by irrelevant speech, articulatory suppression, and manual tapping: Do they have a common source? *Quarterly Journal of Experimental Psychology, 56A,* 1249-1268.

Lee, W.L., Wee, G.C., Tzeng, O.J.L., & Hung, D.L. (1992). A study of interlingual and intralingual Stroop Effect in three different scripts: Logograph, Syllabary, and Alphabet. In R.J. Harris (Ed.), *Cognitive Processing in Bilinguals*, pp. 427-442, Elsevier Science Publishers.

Lovemann, E., van Hoff, J.C., & Gale, A. (2002). A systematic investigation of same and cross modality priming using written and spoken responses. *Memory, 10(4)*, 267-276.

Majerus, S., & Van der Linden, M. (2003). Long-term memory effects on verbal short-term memory: A replication study. *British Journal of Developmental Psychology, 21*, 303-310.

Majerus, S., Van der Linden, M., Mulder, L., Meulemans, T., & Peters, F. (2004). Verbal short-term memory reflects the sublexical organization of the phonological language network: Evidence from an incidental phonotactic learning paradigm. *Journal of Memory and Language, 51,* 297-306.

Marian, V., Blumenfeld, K.H., & Kaushanskaya, M. (in press). The Language Experience and Proficiency Questionnaire (LEAP-Q): Assessing language profiles in bilinguals and multilinguals, *Journal of Speech, Language, and Hearing Research.*

Marian, V. & Spivey, M. (2003). Competing activation in bilingual language processing: Within- and between-language competition. *Bilingualism: Language and Cognition, 6,* 97-115.

Martin, N., & Saffran, E.M. (1999). Effects of word processing and short-term memory deficits on verbal learning: evidence from aphasia. *International Journal of Psychology, 34*, 339-346.

Masoura, E.V, & Gathercole, S.E. (1999). Phonological short-term memory and foreign language learning. *International Journal of Psychology, 34(5/6)*, 383-388.

Massaro, D.W., Cohen, M.M., & Thompson, L.A. (1990). Visible language in speech perception: lipreading and reading. *Visible Language, 22*, 8-31.

Mayo, L.H., & Florentine, M. (1997). Age of second-language acquisition and perception of speech in noise. *Journal of Speech, Language, and Hearing Research, 40*, 689-693.

McClelland, A.G.R., & Pring, L. (1991). An investigation of cross-modality effects in implicit and explicit memory. *Quarterly Journal of Experimental Psychology, 43A*, l9-33.

McMillen, M., Kaufman, P. and Klein, S. (1997). Dropout Rates in the United States: 1995.

NCES, 97-473. Washington: US Dept of Education.

Muneaux, M., & Ziegler, J.C. (2004). Locus of orthographic effects in spoken word recognition: Novel insights from the neighbor generation task. *Language and Cognitive Processes, 19*, 641-660.

Paivio, A., Yuille, J.C., & Madigan, S.A. (1968). Concreteness, imagery, and meaningfulness values for 925 words. *Journal of Experimental Psychology Monograph Supplement, 76*, 1-25.

Papagno, C., Valentine, T., & Baddeley, A. (1991). Phonological short-term memory and foreign-language vocabulary learning. *Journal of Memory and Language, 30*, 331-347.

Papagno, C., & Vallar, G. (1992) Phonological short-term memory and the learning of novel words: The effects of phonological similarity and item length. *Quarterly Journal of Experimental Psychology, 44A*, 44-67.

Papagno, C., & Vallar, G. (1995). Verbal short-term memory and vocabulary learning in polyglots. *Quarterly Journal of Experimental Psychology, 48A*, 98-107.

Peters, H.F.M., & Boves, L. (1987). Coordination of aerodynamic and phonatory processes in fluent speech utterances in stuttering. *Journal of Speech and Hearing Research, 31*, 352-361.

Peters, H.F.M., Hulstijn, W., & Starkweather, C.W. (1989). Acoustic and physiological reaction times of stutterers and nonstutterers. *Journal of Speech and Hearing Research, 32*, 668-680.

Peters, H.F.M., & Starkweather, C.W. (1990). The interaction between speech motor coordination and language processes in the development of stuttering. *Journal of Fluency Disorders, 15*, 115-125.

Risko, E.F., Stolz, J.A., & Besner, D. (2005). Basic processes in reading: Is visual word recognition obligatory? *Psychonomic Bulletin & Review, 12*, 119-124.

Roelofs, A. (2006). The influence of spelling on phonological encoding in word reading, object naming, and word generation. *Psychonomic Bulletin & Review, 13*, 33-37.

Rogers, T.S. (1969). On measuring vocabulary difficulty: An analysis of item variables in learning Russian-English vocabulary pairs. *International Review of Applied Linguistics, 7*, 327-343.

Romani, C., McAlpine, S., Olson, A., Tsouknida, E., & Martin, R. (2005). Length, lexicality, and articulatory suppression in immediate recall: Evidence against the articulatory loop. *Journal of Memory and Language, 52*, 398-415.

Roodenrys, S., Hulme, C., Alban, J., & Ellis, A.W. (1994). Effects of word frequency and age of acquisition on short-term memory span. *Memory and Cognition, 21*, 168-175.

Saito, S. (1998). Phonological loop and intermittent activity: A whistle task as articulatory suppression. *Canadian Journal of Experimental Psychology, 52*, 18-23.

Schmitt, N. (1998). Tracking the incremental acquisition of second language vocabulary: A longitudinal study. *Language Learning, 48(2)*, 281-317.

Schwartz, A. I., Kroll, J. F., & Diaz, M. (in press). *Reading words in Spanish and English: Mapping orthography to phonology in two languages*.

Service, E. (1992). Phonology, working memory, and foreign-language learning. *The Quarterly Journal of Experimental Psychology, 45A(3)*, 21-50.

Service, E., & Craik, F.I.M. (1993). Differences between young and older adults in learning a foreign vocabulary. *Journal of Memory and Language, 32*, 608-623.

Service, E., & Kohonen, V. (1995). Is the relationship between phonological memory and foreign language learning accounted for by vocabulary acquisition? *Applied Psycholinguistics, 16*, 155-172.

Seidenberg, M.S., & McClelland, J. (1989). A distributed, developmental model of word recognition and naming. *Psychological Review*, *96*, 523-568.

Seidenberg, M.S., & Tanenhaus, M.K. (1979). Orthographic effects on rhyme monitoring. *Journal of Experimental Psychology: Human Learning and Memory, 5*, 546-554.

Shapiro, A. (1980). An electromyogrpahic analysis of the fluent and dysfluent utterances of several types of stutterers. *Journal of Fluency Disorders, 5*, 203-231.

Shu, H. & Anderson, R. (1999). Learning to read Chinese: The developmetn of metalinquistic awareness. In Wang, J., Inhoff, A., & Chen, H., *Reading Chinese Script: A Cognitive Analysis* (pp. 1-18). Mahwah, New Jersey: Lawrence Erlbaum Associates.

Slowiaczek, L.M., Soltano, E.G., Wieting, S.J., & Bishop, K.L. (2003). An investigation of phonology and orthography in spoken-word recognition. *Quarterly Journal of Experimental Psychology, 56A*, 233-262.

Speciale, G., Ellis, N.C., & Bywater, T. (2004). Phonological sequence learning and short-term store capacity determine second language vocabulary acquisition. *Applied Psycholinguistics, 25*, 293-321.

Thorn, A.S.C., & Gathercole, S.E. (1999). Language-specific knowledge and short-term memory in bilingual and non-bilingual children. *The Quarterly Journal of Experimental Psychology, 52A*, 303-324.

Toglia, M.P., & Battig, W.F. (1978). *Handbook of Semantic Word Norms.* New York: Erlbaum.

Tzelgov, J., Henik, A., & Berger, J. (1992). Controlling Stroop effects by manipulating expectations for color words. *Memory & Cognition, 20*, 727-735.

US Census data (2000). http://www.census.gov/main/www/cen2000.html. Retrieved on October 31st, 2004.

Vallar, G., & Cappa, S. F. (1987). Articulation and verbal short-term memory: Evidence from anarthria. *Cognitive Neuropsychology, 4*, 55–78.

Van Atteveldt, N., Formisano, E., Goebel, R., & Blomert, L. (2004). Integration of letters and speech sounds in the human brain. *Neuron, 43*, 271-282.

Van Hell, J.G., & Mahn, A.C. (1997). Keyword mnemonics versus rote rehearsal: Learning concrete and abstract foreign words by experienced and inexperienced learners. *Language Learning, 47*, 507-546.

Van Orden, G. C., & Goldinger, S. D. (1994). Interdependence of form and function in cognitive systems explains perception of printed words. *Journal of Experimental Psychology: Human Perception and Performance, 20*, 1269-1291.

Van Orden, G. C., Pennington, B. F., & Stone, G. O. (1990). Word identification in reading and the promise of subsymbolic psycholinguistics. *Psychological Review, 97*, 488-522.

Vanderplank, R. (1993). A very verbal medium: Language learning through closed captions. *TESOL Journal, 3(1)*, 10-14.

Vitevitch, M.S., & Luce, P.A. (2004). A web-based interface to calculate phonotactic probability for words and nonwords in English. *Behavior Research Methods, Instruments, & Computers, 36*, 481-487.

Wagner, R.K., Torgesen, J.K., & Rashotte, C.A. (1999). Comprehensive Test of Phonological Processing. Pro-Ed, Inc.: Austin, TX.

Walker, I., & Hulme, C. (1999). Concrete words are easier to recall than abstract words: Evidence for a semantic contribution to short-term serial recall. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 25*, 1256-1271.

Watson, B., & Alfonso, P.J. (1987). Coordination of prephonatory events in mild and severe stutterers. In H.F.M. Peters & W. Hulstijn (Eds.), *Speech Motor Dynamics in Stuttering*, pp. 16 – 38. Wien/New York: Springer Verlag.

Weber, A., & Cutler, A. (2004). Lexical competition in non-native spoken- word recognition. *Journal of Memory and Language, 50*, 1-25.

Weber-Fox, C. and Neville, H.J. (1999). Functional neural subsystems are differentially affected by delays in second-language immersion: ERP and behavioral evidence in bilingual speakers. In D. Birdsong (Ed), *New perspectives on the critical period for second language acquisition,* Hillsdale NJ: Lawrence Erlbaum, pp. 23-38.

Williams, K.T. (1997). *Expressive Vocabulary Test,* Circle Pines, MN: American Guidance Service.

Woodcock, R.W., McGrew, K.S., & Mather, N. (2001). *Tests of Achievement* (Woodcock-Johnson, III). Itasca, IL: Riverside Publishing Company.

Ziegler, J.C., Ferrand, L. (1998). Orthography shapes the perception of speech: The consistency effect in auditory word recognition. *Psychonomic Bulletin and Review, 5*, 683-689.

Ziegler, J.C., Muneaux, M., & Grainger, J. (2003). Neighorhood effects in auditory word recognition: Phonological competition and orthographic facilitation. *Journal of Memory and Language, 43,* 779-793.

Appendix 1: Non-words List A.

List A					
Non-Word	Non-Word (IPA)	Sum of Phoneme Frequencies	Sum of Biphone Frequencies	Number of Orthographic Neighbors	Bigram Frequency
TUF	tuf	1.0863	1.0025	6	1077
GEF	gɛf	1.1186	1.002	7	2113
IGUF	iguf	1.0393	1.0007	0	1750
EGUN	ɛgun	1.0842	1.001	0	2904
ETUG	ɛtug	1.0733	1.0012	0	3198
UTAF	utʌf	1.055	1.0019	0	4125
EFIT	ɛfit	1.1309	1.0015	3	4338
ITUN	itun	1.0922	1.0018	1	5710
UNEF	unɛf	1.0999	1.0014	0	6129
TUGI	tugi	1.1277	1.0028	0	2010
FIGA	figa	1.1038	1.0025	1	2913
FUNA	funa	1.1723	1.0033	4	4225
GITU	gitu	1.1351	1.0033	0	4386
FITU	fitu	1.1557	1.0051	0	4701

FETI	feti	1.2287	1.0106	2	7633
GAFUN	gʌfun	1.1713	1.0045	0	3712
NIGAF	nigʌf	1.0943	1.0024	0	3864
GITUF	gituf	1.1484	1.0033	0	4534
TAFUN	tʌfun	1.1898	1.0043	0	5234
NAFIT	nʌfit	1.2054	1.0046	0	5708
NEFAG	nefʌg	1.1347	1.0042	0	5746
FUTIN	futin	1.253	1.0082	0	14397
FANET	fanet	1.288	1.0097	1	10339
NUTIG	nutig	1.1659	1.0083	0	8100
Mean		1.13974167	1.00379583	1.04166667	4951.91667
SD		0.06190974	0.00277481	1.9886453	2925.50837

Appendix 1: Non-Word List B.

List B					
Non-Word	Non-Word (IPA)	Sum of Phoneme Frequencies	Sum of Biphone Frequencies	Number of Orthographic Neighbors	Bigram Frequency
GAF	gʌf	1.0849	1.0032	9	1101
NAF	nʌf	1.0827	1.003	6	1936
UFAG	ufʌg	1.0306	1.0005	0	1751
AGUT	ʌgut	1.1217	1.0019	1	2923
EFUN	ɛfun	1.0841	1.0009	0	3177
ITGU	itug	1.0592	1.0013	0	4143
AGET	ʌgɛt	1.1325	1.0012	2	4373
ATUF	ʌtuf	1.0703	1.0013	0	5781
IGAN	igʌn	1.0669	1.0018	1	6221
FAGU	fʌgu	1.115	1.0024	0	2048
NAFI	nʌfi	1.1259	1.0036	1	2913
GUTA	gutʌ	1.1216	1.0033	1	4248
FUTA	futʌ	1.1422	1.0032	0	4428
NEGI	nɛgi	1.1578	1.0044	1	4712

GENA	gɛnʌ	1.2025	1.0159	2	7602
GIFET	gifɛt	1.1836	1.0042	0	3744
TAGUF	tʌguf	1.1262	1.0028	0	3870
NAGUT	nʌgut	1.1717	1.0039	0	4537
NEGIF	nɛgif	1.1711	1.0049	0	5272
TAGUN	tʌgun	1.188	1.004	0	5708
NITUG	nitug	1.1437	1.0049	0	5749
GATEN	gʌtɛn	1.2329	1.013	0	14493
FITAN	fitʌn	1.227	1.0052	1	10358
FIGEN	figɛn	1.198	1.0092	0	8122
Mean		1.13500417	1.00416667	1.04166667	4967.08333
SD		0.05487925	0.00368731	2.13621296	2945.73377

Appendix 2.

English words list A.

List A							
English word	Freq Use	# Letters	# Phonemes	# Syllables	Concr. Rating	Fam. Rating	Imagb. Rating
CUBE	1	4	4	1	530	502	575
HOCKEY	1	6	4	2	535	514	593
BOSS	20	4	3	1	552	574	554
LAWN	15	4	3	1	588	534	608
INSECT	14	6	6	2	593	542	586
CIGAR	10	5	4	2	580	536	619
OCEAN	34	5	4	2	593	526	623
LAWYER	43	6	4	2	569	520	557
LEG	58	3	3	1	626	589	601
RAIN	70	4	3	1	600	604	618
SUNBURN	5	7	6	2	563	501	629
BUCKET	7	6	5	2	594	506	586
HAMMER	9	6	4	2	605	515	618
CEMENT	11	6	6	2	646	516	578

STOMACH	37	7	6	2	617	547	551
SIGN	94	4	3	1	520	543	534
ENVELOPE	21	8	7	3	579	542	565
MOUTH	103	5	3	1	568	572	613
MORNING	211	7	5	2	515	605	579
BOOK	193	4	3	1	609	643	591
BEACH	61	5	4	1	612	553	667
STORM	26	5	4	1	527	555	587
ROSE	86	4	3	1	608	556	623
STEAM	17	5	4	1	552	545	591
Mean	47.79	5.25	4.21	1.54	578.38	547.5	593.58
SD	56.24	1.26	1.22	0.59	35.71	35.84	30.15

English words List B.

List B							
English word	Freq Use	# Letters	# Phonemes	# Syllables	Concr. Rating	Fam. Rating	Imagb. Rating
PLUM	1	4	4	1	632	547	611
ZIPPER	1	6	4	2	599	556	632
CAPE	20	4	3	1	581	521	566
ROPE	15	4	3	1	608	539	596
SUNSET	14	6	6	2	525	539	633
ELBOW	10	5	4	2	607	564	602
SUGAR	34	5	4	2	620	608	595
LIQUOR	43	6	4	2	630	579	576
SKY	58	3	3	1	542	607	618
SONG	70	4	3	1	514	603	578
LAUNDRY	5	7	6	2	576	502	559
ROCKET	7	6	5	2	645	525	612
LOCKER	9	6	4	2	586	538	569
INFANT	11	6	6	2	579	513	600
CHICKEN	37	7	6	2	614	544	619

PARK	94	4	3	1	579	571	573
MAGAZINE	39	8	7	3	588	585	588
TEETH	103	5	3	1	618	593	611
COLLEGE	267	7	5	2	554	620	590
ROAD	197	4	3	1	583	604	609
COAST	61	5	4	1	562	541	588
CLOUD	28	5	4	1	554	553	595
SHIP	83	4	3	1	615	553	612
FLAME	17	5	4	1	582	551	598
Mean	51	5.25	4.21	1.54	587.21	560.67	597.08
SD	63.98	1.26	1.22	0.59	33.70	32.81	20.06

CURRICULUM VITAE

April, 2007

Margarita Kaushanskaya, M.A.

Education

Northwestern University, Evanston, IL
Department of Communication Sciences and Disorders with concentration in Cognitive Science

Ph.D. in Communication Sciences and Disorders — June, 2007
Dissertation Title:
Linguistic and Cognitive Mechanisms in Foreign Vocabulary Acquisition
Committee Members: Dr. Viorica Marian (chair), Dr. Doris Johnson,
Dr. James Booth, Dr. Karla McGregor

Northwestern University, Evanston, IL
Department of Communication Sciences and Disorders

M.A. in Speech-Language Pathology — December, 2003
Northwestern University

University of California, Berkeley, CA
Department of Psychology and Department of Linguistics

B.A. in Linguistics and Psychology (double-major) — June, 1999

Honors, Grants, and Scholarships

National Science Foundation, Dissertation Improvement Grant BCS0617455 — 2006-2008
"*Linguistic and Cognitive Mechanisms in Foreign Vocabulary Acquisition,*" $11,207.00

Northwestern University, School of Communication — 2005 - 2006
Joseph Levin Foundation Scholarship, $16,000.00

Northwestern University, Conference Travel Award — 2006, 2005, 2004, 2003

Northwestern University, Summer Research Fellowship — 2004, 2003, 2002, 2001

Northwestern University, *Graduate Research Grant*, $1,500.00 — 2003

Northwestern University, *Graduate School Scholarship*, $14,000.00 — 1999 – 2001

National AMBUCS Scholarship for Therapists, Award, $500.00 — 1999 – 2000

Peer-Reviewed Journal Articles (in chronological order)

Marian, V., & **Kaushanskaya, M.** (2004). Language-mediated self-construal and emotion in bicultural bilinguals. *Journal of Memory and Language, 51,* 190-201. Paper received honorable mention from *2005 Otto Klineberg Intercultural & International Relations Award Committee*.

Kaushanskaya, M., & Marian, V. (2007). Non-target language recognition and interference in bilinguals: Evidence from eye tracking and picture naming. *Language Learning, 57:1*, 119-163.

Marian, V., Blumenfeld, H.K., & **Kaushanskaya, M.** (in press). The Language Experience and Proficiency Questionnaire (LEAP-Q): Assessing language profiles in bilinguals and multilinguals, *Journal of Speech, Language, and Hearing Research.*

Marian, V., & **Kaushanskaya, M.** (2007). Cross-linguistic transfer and borrowing in bilinguals. *Applied Psycholinguistics, 28*, 369-390.

Marian, V., Shildkrot, Y., Blumenfeld, H.K., **Kaushanskaya, M.**, Faroqui-Shah, Y., & Hirsch, J. (in press). Cortical activation during word processing in late bilinguals: Similarities and differences as revealed by fMRI. *Journal of Clinical and Experimental Neuropsychology.*

Marian, V., & **Kaushanskaya, M.** (in press). Language context guides memory content. *Psychonomic Bulletin & Review*.

Kaushanskaya, M., & Marian, V. (revision in preparation). Non-target language competition in the Picture-Word Interference Task modified for eye-tracking. *Journal of Experimental Psychology: Human Perception & Performance.*

Kaushanskaya, M., & Marian, V. (revision in preparation). Learning modality and cross-linguistic similarity effects in foreign vocabulary acquisition. *Journal of Memory and Language.*

Kaushanskaya, M., & Marian, V. (invited). Mapping phonological information from auditory to written modality during foreign vocabulary learning. *Annals of the New York Academy of Sciences, Special Issue on Neural Basis of Skill Acquisition, Reading, and Dyslexia.*

Marian, V., & **Kaushanskaya, M.** (invited). Words, feelings, and bilingualism: Cross-linguistic differences in emotionality of autobiographical memories. *Mental Lexicon.*

Conference Presentations (International and National)

Kaushanskaya, M., Marian, V. (2007, November). The role of vocabulary knowledge and phonological memory in adult word learning. Paper submitted to the *American Speech, Language, and Hearing Association Convention*. Boston, Massachusetts.

Kaushanskaya, M., & Marian, V. (2007, May). Do bilinguals learn foreign words better than monolinguals? Paper accepted to the *Second Midwestern Conference on Culture, Language, and Cognition*. Evanston, IL.

Blumenfeld, H., **Kaushanskaya, M.**, & Marian, V. (2007, May). Meta-cognitive awareness of language attrition: Evidence from standardized tests and self-reports. Paper accepted to the *Second Midwestern Conference on Culture, Language, and Cognition*. Evanston, IL.

Kaushanskaya, M., & Marian, V. (2007, May). Role of language-learning experience in foreign vocabulary acquisition. Paper accepted to the *Sixth International Symposium on Bilingualism.* Hamburg, Germany.

Marian, V., & **Kaushanskaya, M.** (2007, May). "Somewhere under Rome": Cross-linguistic transfer as a window into mental representation. Invited Paper, the *Sixth International Symposium on Bilingualism.* Hamburg, Germany.

Kaushanskaya, M., & Marian, V. (2006, November). Effects of cross-linguistic similarity on foreign word learning in adults. Poster presented at the *American Speech, Language, and Hearing Association Convention*. Miami, FL.

Marian, V., Blumenfeld, H.K., **Kaushanskaya, M.**, & Rabin, A. (2006, November). Language history predicts second-language proficiency. Poster presented at the *American Speech, Language, and Hearing Association Convention*. Miami, FL.

Marian, V., & **Kaushanskaya, M.** (2006, November). Memory observed, in different languages. Paper presented at the *Forty-Seventh Annual Meeting of the Psychonomic Society*. Houston, TX.

Kaushanskaya, M., & Marian, V. (2006, October). Cross-linguistic orthographic-phonological overlap interacts with modality during foreign vocabulary learning. Poster presented at the *Twenty-Fifth Rodin Remediation Academy Conference on Neural Basis of Skill Acquisition, Reading, and Dyslexia.* Washington, DC.

Kaushanskaya, M., & Marian, V. (2006, August). Non-target language competition in the Picture-Word Interference task modified for eye-tracking. Poster presented at the *Third International Workshop on Language Production*. Chicago, IL.

Kaushanskaya, M., & Marian, V. (2006, July). Learning foreign words under dual-task conditions. Poster presented at the *Twenty-Eighth Annual Meeting of the Cognitive Science Society.* Vancouver, Canada.

Marian, V., & **Kaushanskaya, M.** (2006, June). Emotional intensity and valence in bilingual autobiographical memories. Invited paper, *Second Biannual Russian Conference on Cognitive Science*. Special workshop on Emotions, Bilingualism and Cognition. St. Petersburg, Russia.

Marian, V., Blumenfeld, H.K., & **Kaushanskaya, M.** (2006, June). Parallel activation in bilingual language processing: Evidence from eye-tracking. Paper presented at the *Second Biannual Russian Conference on Cognitive Science*. St. Petersburg, Russia.

Marian, V., Blumenfeld, H.K., **Kaushanskaya, M.**, & Rabin, A. (2006, May). Self-reported profiles as a window into language acquisition. Poster presented at the *Language Acquisition and Bilingualism Conference*. Toronto, Canada.

Blumenfeld, H.K., Marian, V., **Kaushanskaya, M.**, Rabin, A., & Cone, N. (2005). Relating self-reported and behavioral language skills in bilinguals. Poster presented at the annual *American Speech, Language, and Hearing Association*, San Diego, CA.

Kaushanskaya, M., & Marian, V. (2005). Cross-linguistic transfer and borrowing in bilingual narratives. Paper presented at the annual *Midwestern Culture, Language, and Cognition Conference*. Evanston, IL.

Kaushanskaya, M. , & Marian, V. (2005). Activation and interference in bilingual visual word recognition: Evidence from eye-tracking. Paper presented at the *Fifth International Symposium on Bilingualism*. Barcelona, Spain.

Marian, V., & **Kaushanskaya, M.** (2005). Language interaction in bilingual narratives. Paper presented at the *Fifth International Symposium on Bilingualism*. Barcelona, Spain.

Kaushanskaya, M., & Marian, V. (2004). Activation and interference of non-target language phonology during visual word recognition in bilinguals. Paper presented at the *Twenty-Sixth Annual Meeting of the Cognitive Science Society*. Chicago, IL.

Marian, V., & **Kaushanskaya, M.** (2004). Mapping written input onto orthographic representations: The case of bilinguals with two partially overlapping orthographies. Poster presented at the *Twenty-Sixth Annual Meeting of the Cognitive Science Society*. Chicago, IL.

Marian, V., **Kaushanskaya, M.**, & Fausey, C. (2003). Autobiographical narratives and the self in bicultural bilinguals. Paper presented at the *Fourth International Symposium on Bilingualism*. Tempe, AZ.

Marian, V., Fausey, C., & **Kaushanskaya, M.** (2003). Language-mediated emotions and self-construal in bilinguals. Paper presented at the *Seventy-Fifth Annual Meeting of the Midwestern Psychological Association*. Chicago, IL.

Marian, V., Blumenfeld, H., Garstecki, D., **Kaushanskaya, M.**, Fausey, C., & Lu, D. (2003). Developing a tool for assessing Language Experience and Bilingual Status (LEABS-Q). Poster presented at the *Seventy-Fifth Annual Meeting of the Midwestern Psychological Association*. Chicago, IL.

Teaching Experience

Invited Lecturer, *Northwestern University, Evanston, IL*
CSD 551: Bilingualism: Cognition, Language, and Brain 2007
CSD 309: Culture, Language, and Learning 2006

Directed Teaching, *Northwestern University, Evanston, IL* 2005
CSD 309: Culture, Language, and Learning

Teaching Assistant, *Northwestern University, Evanston, IL*
CSD 491-2: Language Disorders in School-Aged Children 2005
CSD 309: Culture, Language, and Learning 2003, 2004
CSD 396: Diagnostic Procedures in Speech-Language Pathology 2003, 2004
CSD 491-1: Articulation and Phonological Disorders 2004
CSD 201: Introduction to Phonetics and Phonology 2003

Clinical Experience

Bilingual Speech-Language Pathology Consultant, Glenview School District 2004-2006
Glenview, IL

Speech-Language Pathology Intern, St. Joseph's Hospital January, 2003-March, 2004
Chicago, IL

Speech-Language Pathology Intern, RUSH Hospital June, 2001-September, 2001
Skokie, IL

Professional Experience and Service

Journal and Grant Reviewer
Acta Psychologica, Language Learning, National Science Foundation 2007-present

Conference Reviewer
Annual Meeting of the Cognitive Science Society 2005, 2006

Graduate Student Mentor
National Science Foundation Research Experience for Undergraduates 2004, 2005
Summer Program, Northwestern University, Evanston, IL

Professional Affiliations

American Speech-Language-Hearing Association; Cognitive Science Society; Women in Cognitive Science