CONCEPT MEDIATION IN THE ADULT LANGUAGE LEARNER

by

MARITZA M. MARÍN

A dissertation submitted to the Graduate Faculty in Psychology in partial fulfillment of the requirements for the degree of Doctor of Philosophy, The City University of New York

2012

This manuscript has been read and accepted by the Graduate Faculty in Psychology in satisfaction of the dissertation requirement for the degree of Doctor of Philosophy

______________________________ ______________

Laraine McDonough, Associate Professor
Chair of Examining Committee, Psychology
Brooklyn College/CUNY Date

______________________________ ______________

Maureen O'Connor, Professor
Executive Officer, Psychology
Graduate Center/CUNY Date

Supervisory Committee:

Benzion Chanowitz, Associate Professor
Psychology
Brooklyn College/CUNY

Laura A. Rabin, Associate Professor
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Patricia Brooks, Professor
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College of Staten Island/CUNY

Isabelle Barriere, Assistant Professor
Speech Communication Arts and Sciences
Brooklyn College/CUNY

THE CITY UNIVERSITY OF NEW YORK

Abstract

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Maritza M. Marín

Advisor: Professor Laraine McDonough

The purpose of the present research was to investigate the time course of lexical and conceptual development in the adult language learner. A review of the literature indicates that there is still no definitive model that encapsulates all degrees of bilingualism, including the adult language learner. One model, the revised hierarchical model (RHM) proposed by Kroll and Stewart (1994) has a developmental component that attempts to explain why memory is represented differently in the less fluent (beginning) bilingual speaker. Since its inception the predictions of the RHM have been challenged. Three novel experiments were presented and their results reviewed with regards to the predictions of the RHM. Several factors (i.e., orthography, phonology) were identified as being either facilitative or inhibitory to successful language learning. In Experiment 1, using a bilingual Russian-English Stroop task, language dominance (i.e., greater usage) rather than language proficiency (i.e., knowledge) was found to be a better predictor of performance for the fluent native Russian speakers. Moreover, while lexical and conceptual development appeared to be asymmetrical for the native English speakers, the results were moderated by orthography and phonology for these novice (i.e., non-Russian) language learners. To further investigate the effects of orthography and phonology on language learning, new stimuli and a novel training paradigm were introduced in Experiments 2 and 3. In both experiments, a modified Russian-English (using Romanized transliterations instead of Cyrillic script) version of the Stroop color-word interference task was used. Native English speakers were trained with and then tested on transliterated Russian and English color words. Verbal responses in both English and Russian were required. Experiment 3 extended the findings of Experiment 2 by adding a nonverbal (i.e., key press) condition. Results from both Experiments 2 and 3 suggest that access to conceptual representations in a second language are available early on during the language learning process; moreover, the influence of orthography, phonology and the language-learning environment appear to be important determinants in language learning. Implications for models of visual word processing and bilingual memory are discussed as they relate to second language learning and the dynamic nature of bilingualism.

For my mother, Audberta Ruíz Dávila

And my siblings, Alberto, Miguel, Miroslava, Samuel, and Ulysses Marín

Con mucho amor and cariño

Acknowledgements

I would like to thank my advisor, Associate Professor Laraine McDonough, for taking me on as her student even though my topic was not in her primary area of research. This has been a long and eventful journey with equal parts of tears and laughter and mutual discovery. With the end of this project you have finally made that wonderful transition from teacher to mentor to friend.

Along with the rest of my committee members, the entire faculty and staff of the Department of Psychology at Brooklyn College, I am indebted to you all. I have learned much during my stay and will treasure the many experiences I have had there.

I would like to extend a special thank you to Professor David Owen for his unflinching support of me throughout the years. I will miss you the most. I would also like to thank Professor Valerie J. Cook-Morales from San Diego State University, for inspiring me all those many years ago to pursue my passion and for instilling in me the importance of conducting research to answer the 'hard' questions. Thank you.

Finally, to my immediate family, which includes my best friend Vicky Elfe and my 'second' mother Barbara Fortune Ruddy. You have all supported me throughout this journey and like me, have waited a long time for this moment. I say to you all: '*The kid'* is finally done!

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1. GENERAL INTRODUCTION

Researchers in bilingualism have tried to tease apart the manner in which a person acquires, maintains, and ultimately uses his or her two languages. Within the field of psycholinguistics, interest in understanding bilingualism has been very active in the areas of memory representation and language processing. The focus has been on uncovering the cognitive basis of relations between each language and their respective relations to concepts and meanings. However, whether exploring memory representation or the underlying cognitive processes of bilingualism, most researchers look at bilinguals during early to late childhood (i.e., *simultaneous bilingualism)* or compare fluent bilinguals to 'less fluent' bilingual speakers (i.e., *successive bilingualism)*. Yet few have focused their attention on the systematic examination of the cognitive basis of second language acquisition in adult language learners (Altarriba & Heredia, 2008; Francis, 2005; Kroll & de Groot, 2005). One of the first to do so was Kroll and her colleagues (e.g., Dufour & Kroll, 1995; Kroll & Curley, 1988; Kroll & Stewart, 1994; Kroll & Sholl, 1992; Kroll & Tokowicz, 2001; Kroll & Sunderman, 2003; Talamas, Kroll, & Dufour, 1999).

One reason that this line of research has not been as actively pursued lies in the erroneous assumption that adding a second language has little to no impact on one's first language performance. That is, language learning was assumed to be parasitic and reliant on one's native language structure and therefore not interesting in and of its own right. However, the last 25 years of research on the psycholinguistics of bilingualism and second language acquisition have painted a very different picture. Researchers are no longer looking for 'balanced bilinguals' nor, is bilingualism (and multilingualism) considered to be the exception(s). Rather, more and more evidence points to the fact that, on average, most people speak at least two languages and their proficiency level in those languages varies as a function of their daily exposure to and use of those languages (Grosjean, 1982, 1989, 1997, 1998, 2001; Heredia, 1997; Heredia & Altarriba, 2001; Heredia & Brown, 2004). This suggests, that in reality, there is a greater degree of interconnectedness between the two (or more) languages spoken by an individual than what was previously believed (e.g., Ervin & Osgood, 1954; Weinreich, 1953).

This new, more dynamic description of bilingualism has stimulated interest in research on individuals who may or may not be fluent bilinguals and who learned their second language well after their first language was fully in place, i.e., adult language learners. As a result, questions regarding the accuracy of existing models of bilingual language processing have been raised. One such question revolves around the discussion of *when* access to conceptual knowledge occurs in a second language. A second, related question is by what mechanisms is this access accomplished. Thus, a major dispute to be resolved when studying bilingual language processing in adult language learners is whether access to the conceptual system involves mediation of the first language (L1) (i.e., via a translation process) (e.g., Kroll & Stewart 1994) or whether access to concepts and word meanings is available early on in the language learning process (i.e., via a *conceptual mediation* process) (e.g., Altarriba & Mathis, 1997; Comesaña, Perea, Piñeiro, & Fraga 2009; Finkbeiner & Nicol, 2003; Potter, So, von Eckhardt, & Feldman, 1984).

Given this dispute, the main goal of this dissertation is to study, in an adult population, the time course of the creation of conceptual representations in a second language. One way to measure this is to simultaneously study language processing in fluent bilinguals and novice language learners. In this manner we have the beginning (i.e., novice learner) and the endpoint (i.e., fluent bilingual speaker) for comparison. Many factors contribute to language processing; given the constraints of research, however, only three will be explored in the current research: (1) the influence of language dominance (i.e., usage) in bilingual language processing; and the roles that (2) orthography and (3) phonology play in language learning. Moreover, while there are a few connectionist models of bilingual language processing (e.g., *BIA model,* van Heuven, Dijkstra, & Grainger, 1998; *BIA+ model,* Dijkstra & van Heuven, 2002) these models will not be reviewed, per se when discussing the hierarchical models of bilingual memory. Instead, this paper will focus on Kroll and Stewart's (1994) model because it alone contains a developmental component, i.e., a shift in how language is processed as proficiency increases, and therefore makes predictions about the performance of novice language learners.

2. ORGANIZATION IN BILINGUAL MEMORY: HIERARCHICAL

Levels of Representation in Memory

There are various ways in which memory can be conceptualized. For our purposes, the contents of memory will be divided into two general types: semantic and episodic as originally described by Tulving (1972) and expanded by Collins and Loftus (1975). Semantic memory is understood to be a warehouse (i.e., *store*) of general knowledge about the world, which is shared by members of one's cultural group (Snodgrass, 1984; Tulving, 1972). Included in this knowledge is information about how things look (perceptual representation) and where they are located (spatial representation). Most importantly, semantic memory is where language terms, their definitions, and their relations to one another are "housed" (Bjorklund, 2005; Collins & Loftus, 1975; Tulving, 1972).

In contrast, episodic memory represents information about the 'when' and 'where' of events that is specific and personal to an individual (Tulving, 1972). For example, my knowledge of the word *idiomatic* and its meaning (characteristic of native-speaker use) is part of my semantic memory. But since I can also remember the specific context in which I learned the word *idiomatic* (in a course on oral language development) it is also part of my episodic memory. My focus, in this paper, will be on semantic memory since it is germane to language and language learning.

Another distinction to be made is between the terms *semantic* and *conceptual*. In this paper, the term semantic will refer specifically to word meanings and semantic representations will refer specifically to how word meanings are coded, in memory, across and within languages. Moreover, the term *representation* itself is a symbol or image of a particular idea, i.e., *concept*.

Therefore, the term conceptual will be used to refer to a larger representational system that contains both semantic information (i.e., word meanings) and all other types of concepts not specified by language itself (i.e., abstract ideas, images, symbols, etc.). In this view, semantic representations are a subset of all possible representations that are housed within a larger conceptual system or conceptual store (Francis, 1999, 2005).

What is most important for our purposes is that all models of bilingual memory, be they theoretical (i.e., Kroll & Stewart, 1994) or connectionist (i.e., van Heuven, Dijkstra, & Grainger, 1998), maintain that the name of a word (i.e., *lexical form)* and its meaning (i.e., *semantics*) are not housed together. Instead, words are described as being housed in a '*mental lexicon'* or dictionary as it were, and the words meaning (e.g., concrete meaning and connotations) are housed in a separate '*conceptual store*' (see Collins & Loftus, 1975). Thus memory is hierarchically structured with at least two levels: lexical and conceptual. This modified quote from Collins and Loftus (1975) sums up the notion of how memory is structured more clearly:

> "There are three assumptions in the extended theory concerned with the global structure of memory and its processing. These are generalizations of Loftus's … arguments that semantic memory is organized primarily into noun categories and that there is a 'dictionary' (or lexical memory) separate from the conceptual network. ... The conceptual (semantic) network is organized along the lines of semantic similarity. The more properties two concepts have in common, the more links there are between the two nodes via these properties and the more closely related are the concepts. … The names of concepts are stored in a lexical network (or dictionary) that is organized along lines of phonemic (and to some degree orthographic) similarity. …Loftus's … data lead to the further assumption that a person can control whether he primes the lexical network, the semantic network, or both." (pp. 413-4).

Therefore, most models of memory, whether describing monolingual or bilingual speakers, own their underlying framework to this earlier spreading activation model of memory representation.[1] When extended to bilingual memory, most theorists (and modelers) postulate two separate and *independent* lexicons, one for each language known to the individual (however, over the years the position as changed; see Brysbaert, 1998; Brysbaert, Van Dyck, & Van de Poel, 1999; de Groot, Delmaar, & Lupker, 2000; Dijkstra & van Heuven, 1998; Dijkstra, van Jaarsveld, & Ten-Brinke 1998; Dijkstra, Grainger, & van Heuven, 1999; Dijkstra, Timmermans, & Schriefers, 2000) and a major question became how much interconnections exist between the two lexicons and the conceptual system.

Shared or Separate Memory Stores

Since the early 1940's, bilingual researchers have tried to provide descriptions of the structure and organization of bilingual memory (e.g., Ervin & Osgood, 1954; Paivio, 1991; Paivio & Desrocher, 1980*;* Weinreich, 1953). The principal question was and continues to be whether or not the two languages of a bilingual are represented jointly or separately in memory. This discussion is commonly referred to as the *shared* versus *separate* store model of bilingual memory representation. The *shared* or *common store* model holds that both languages access the same underlying concepts housed in a single (shared) conceptual system. In contrast, the *separate system* model holds that each language has its own unique, language-specific conceptual system. Both of these models presuppose that each language has a separate store for labels and words, i.e., there are two separate lexicons, one for each language, and that words are housed separately from their meanings. These early models were also built on the (then) current models of monolingual language processing. Thus, these researchers extended the monolingual model to the bilingual question and proposed a variety of hypotheses about how memory was

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[1] The connectionist model of memory put forth by McClelland and Rumelhart (1981) is the underlying basis of the BIA and BIA+ models of bilingual memory.

organized in the bilingual. An example of this was Weinreich's (1953) lexico-semantic model of bilingual memory representation. Weinreich was the first to propose multiple representations for words and concepts in a bilingual speaker. As such, his model was one of the first to propose two separate lexicons, one for each language known to the bilingual speaker. Weinreich originally proposed that a bilingual had separate phonological (label) and semantic (meaning) representations for translation equivalents in their two languages and identified three different possible configurations of memory in a bilingual speaker: coexistent bilingualism (*coordinate)*, merged bilingualism (*compound),* and subordinate bilingualism (*sub-coordinative)* (see Figure 2.1) (Francis, 1999, 2005; Keatley, 1992; Laeufer, 1996). As such, Weinreich's model is the first in a series of hierarchical models of bilingual memory representation.

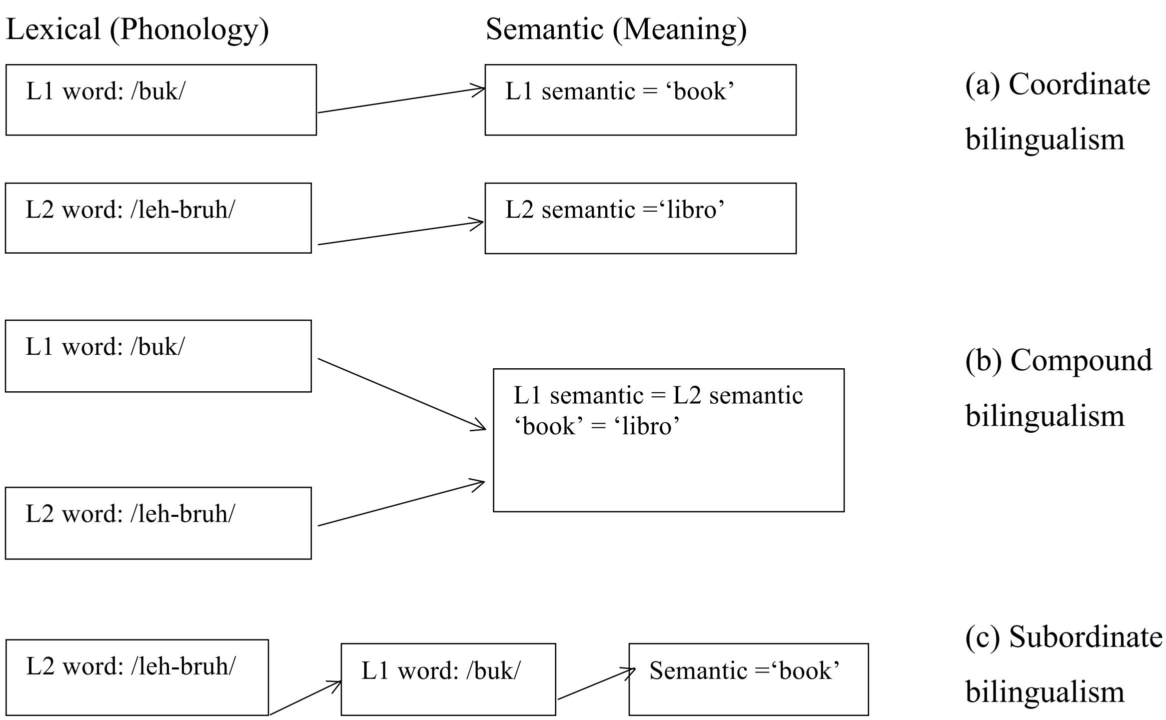

Figure 2.1. Weinreich's (1953) model of lexico-semantic organization in bilinguals.

Ervin and Osgood (1954) modified Weinreich's (1953) model by proposing that connections between meanings (semantics) and the labels and words (lexical entries) that name them were dependent on the context in which the two languages were acquired. Thus, Ervin and Osgood attached the designations of simultaneous acquisition (both languages learned in the same setting) and successive acquisition (both languages learned in different settings) to Weinreich's compound and coordinate distinctions. According to Ervin and Osgood, a coordinate bilingual learns their two languages in separate environments, i.e., *home* vs. *school,* and has one label or word for each concept known in each language, hence successive acquisition. For example, a Spanish-English coordinate bilingual would have the words *libro* and *book* to separately signify the concept of 'book' in each language, i.e., *two labels* for *two separate semantic representations*. In contrast, a compound bilingual learns their two languages in the same environment at the same time, i.e., *at home*, and has two labels or words for one concept, i.e., *two labels* for *one shared semantic representation,* hence simultaneous acquisition. For instance, a Spanish-English compound bilingual would have the organization where *libro* = *book* so that either word can be used to signify the concept of 'book'. Finally, sub-coordinative bilinguals use their 'stronger', first language (L1) as a bridge to understanding their 'weaker', second language (L2). Here, for a Spanish-dominant/English bilingual the word *libro* signifies the concept 'book' in both Spanish *and* English. Thus, sub-coordinative bilinguals are always 'translating' between their two languages and presumably never attain full mastery of L2. It is this type of bilingual speaker, sub-coordinative, that forms the basis of Kroll and Stewart's (1994) model of bilingual language processing. However, while Weinreich's typology (and Osgood and Ervin's modifications) was phonologically based, that is, Weinreich discussed the possible relationships between semantic units (i.e., word meaning) and their *phonological* *representations* (i.e., words sounds) Kroll & Stewart's (1994) model is lexically based (e.g., *whole word forms* versus word sounds). This distinction marks a departure from Weinreich, which we will see, has potentially negative consequences for explaining how language learning occurs in some adult learners.

One or Two Codes

Coinciding with the cognitive revolution that swept through much of psychology in the 1960's and early 1970's, the classic argument regarding how memory and language were represented in a bilingual was re-casted as the *single-code* versus *dual-code* model of information processing. Researchers began to discuss whether information learned in one language was shared across a bilingual's two languages or held separately in two, independent information systems. Here, the word *code* refers to whether or not there are *language-dependent representations* or *processes* for each language or *language-independent representations* or *processes* that are the same, hence shared, between the two languages. That is, does a bilingual speaker have *two sets* of information that was learned in each language and only available through that language or is this general information that is transferable between (accessible to) either of their languages? (see Gerard & Scarborough, 1989; Scarborough, Gerard, & Cortese, 1984). To date this question has not been resolved completely and continues to generate discussions about bilingual memory and language processing.

However, the dual-code term also refers to a model of bilingual memory proposed by Paivio and Desrochers (1980). In this model, each language had its own separate verbal, i.e., semantic, store but each is linked to the other as well as to a separate nonverbal (image) system (see Paivio, 1986, 1991; Paivio & Desrocher, 1980) (see Figure 2.2). In Paivio and Desrochers's bilingual dual-code model a division was made between verbal systems, which independently housed the words of a language (abstract and concrete), and the nonverbal (perceptual/visual) system, which housed concepts. Within the image system further separation was made between those concepts that had concrete and/or perceptual representations (visual referents) and those concepts that did not (i.e., were abstract and imageless). For example, a dove carrying an olive branch could visually represent the concept of 'peace', but such an image requires a cultural context to link it to the abstract concept of 'peace' and therefore may be more language-specific than a more easily imaged concept of 'table'. Therefore, words in either language that have high imageability are more readily remembered than those that do not. While this model can be understood as a precursor to the current hierarchical models of bilingual memory representation (Heredia, 2008), all hierarchical models of bilingual memory owe their theoretical roots to Weinreich's (1953) model.

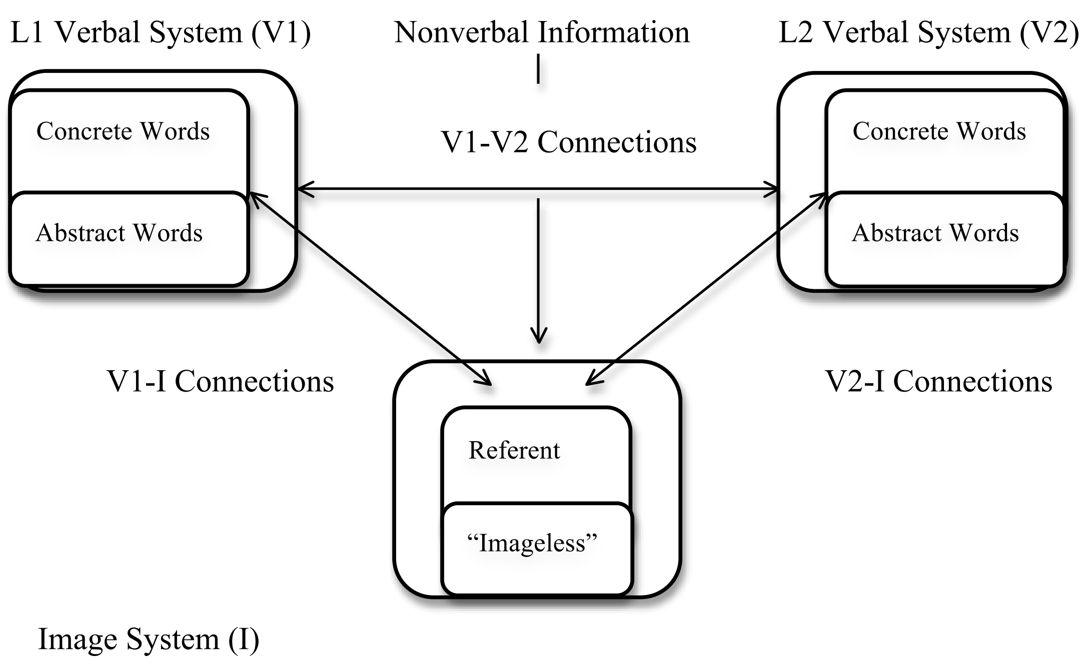

Figure 2.2. Paivio and Desrocher's (1980) dual-code model of bilingual memory.

Whereas the compound-coordinate distinction lacked sufficient specificity and testability for its proposal of how bilingual memory was organized (see de Groot, 1993, 1995; Keatley, 1992), Paivio's (1986, 1991) bilingual dual-coding theory proved more effective in its descriptive and predictive abilities (Heredia, 2008). Yet, researchers continued to grapple with the same overarching question. That is, do the two languages of a bilingual share a single representational system or does each language have its own organized representational system.

During the mid-80s to the late 90s how more than one language was structured and represented in memory continued to be a central issue to bilingual researchers. Based on earlier studies (e.g., Gerard & Scarborough, 1989; Scarborough, Gerard, & Cortese, 1984) research on bilingual memory provided evidence that both views (i.e., separate and coordinate systems of representation) were correct, but at different levels of representation (Durgunoglu & Roediger, 1987; Potter, et al., 1984; Schwanenflugel & Rey, 1986). At the lexical level, each language appeared to be stored independently, but at the conceptual level, each language appeared to access a common semantic representation. This division in levels of representation reinforced the notion that words and concepts were hierarchically arranged (e.g., Collins & Loftus, 1975), with separation at the lexical level but with connections to a shared semantic system (Chen & Leung, 1989; Dufour & Kroll, 1995; Kroll & Curley, 1988; Kroll & Stewart, 1994).

However, more recent research (Brysbaert, 1998; Brysbaert, Van Dyck, & Van de Poel, 1999; de Groot, Delmaar, & Lupker, 2000; Dijkstra & van Heuven, 1998; Dijkstra, van Jaarsveld, & Ten-Brinke 1998; Dijkstra, Grainger, & van Heuven, 1999; Dijkstra, Timmermans, & Schriefers, 2000) suggests that separation at the lexical level is no longer accurate. Instead, at the lexical level, each language appears to be stored in an integrated lexicon. Much of this evidence has come from masked priming and interference type studies that have demonstrated 1) the non-selective nature of word activation in bilingual/multilingual speakers and 2) an inability to completely suppress the non-targeted language even when operating in a monolingual mode. This finding, of an integrated lexicon for bilingual speakers, is a powerful contradiction of Weinreich's (1953) complete separation of the two (or more) languages in a bilingual speaker. Interestingly enough, despite numerous studies indicating an integrated lexicon for bilingual speakers, the most prominent model of bilingual language processing, the *Revised Hierarchical Model,* put forth by Kroll & Stewart (1994) continues to maintain the existence of two separate lexicons. Moreover, the role of phonology in bilingual word processing is not addressed in Kroll & Stewart's model. What follows is an overview of the emergence of Kroll and Stewart's model.

3. CURRENT HIERARCHICAL MODELS OF BILINGUAL LANGUAGE PROCESSING

Bilingual Language Processing: Naming Pictures, Words, and Translating

The fascination with bilingual language processing is not a new phenomenon. The first documented experiments in the literature were reaction time studies conducted by James McKeen Cattell (1886) (also see Lee & Chan, 2000; MacLeod, 1991; Snodgrass, 1993). Snodgrass (1993) notes that Cattell was the first to compare a) word naming across two languages, b) picture naming across two languages, c) translating from first language (L1) to second language (L2), d) picture naming in two languages with word naming in two languages, and e) translating from one language to the other with picture naming in two languages. Making several predictions regarding how quickly bilinguals could accomplish these tasks, Snodgrass (1993) analyzed data from Cattell (1886) as well as several other reaction time studies (e.g., Chen & Leung 1989; Kroll & Curley 1988; Potter, et al., 1984). These predictions have stimulated endless studies aimed at measuring bilingual linguistic performance.

Based on possible differences between fluency categories (fluent vs. less fluent vs. non-fluent) Snodgrass concluded the following (see Figure 3.1): First, regardless of the task (naming words, naming pictures, or translating) it takes less time to verbalize a response in L1 than L2. Cattell used this finding as a measure of one's familiarity with L2, i.e., one's fluency level in L2. Second, irrespective of the response language, or one's level of fluency, it takes longer to name pictures than it does to name words. Cattell reasoned that word reading was more automatic relative to picture naming because: 1) associations made between "ideas" (concepts) and the words that name them is a highly practiced skill, and 2) naming pictures requires an additional step: "whereas in the case of colours and pictures we must by a voluntary effort choose the name" (Cattell, 1886, p. 65). Third, it takes longer to translate from L2 to L1 than it does to name pictures in L1, reflecting the fact that object labeling receives more practice than translating. Fourth, the time it takes to name pictures in L2 is equal to the time it takes to translate from L1 to L2. This indicates that picture naming and translation require not only translation but also concept retrieval and are comparable tasks for measuring conceptual or semantic processing (e.g., Potter, et al., 1984; Snodgrass, 1993). In testing these predictions researchers began to reformulate how we view bilingual memory and bilingual language processing.

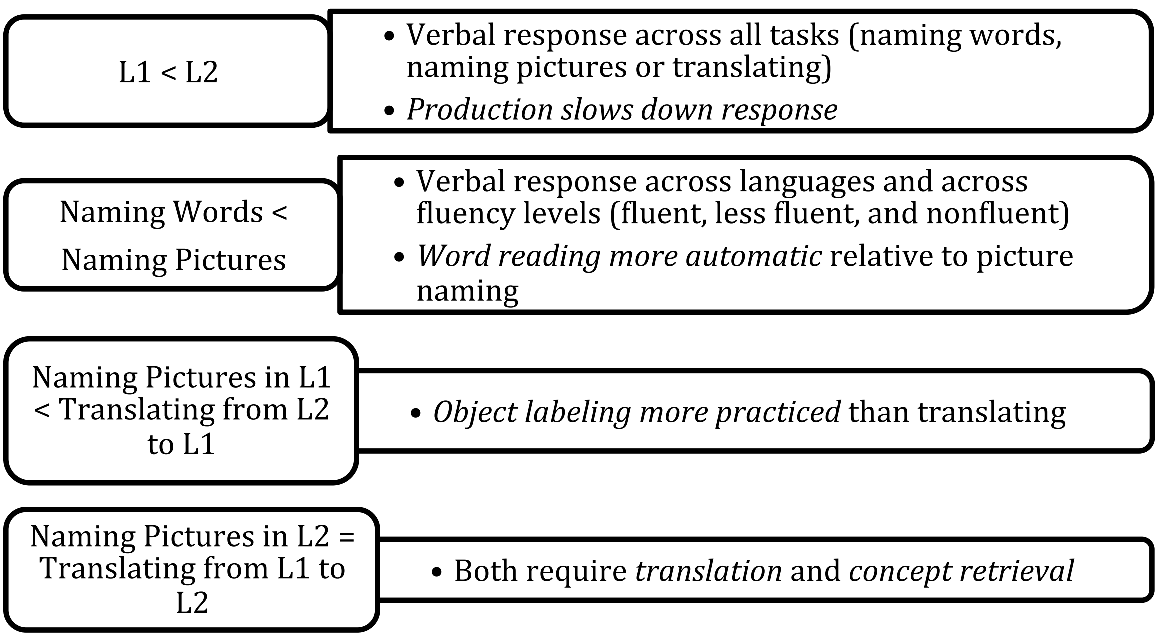

Figure 3.1. Summary of reaction time studies analyzed by Snodgrass (1993).

Word Association and Concept Mediation Hypotheses

In an attempt to describe bilingual memory representation, Potter et al. (1984) reviewed two hypotheses about how people store and process words in their second language. Each of these processing hypotheses is based on a general representational model that contains both modality-specific, i.e., dependent of the manner in which the information was encoded, and modality-independent, i.e., shared encoded information, memory stores. Here modality refers to the language of encoding, L1 versus L2. Each postulates separate modality-specific stores for labels and words in each language (L1 and L2 lexicons), a modality-specific store for pictures (image store), and a modality-independent store for shared ideas and meaning (conceptual store) (see Figure 3.2).

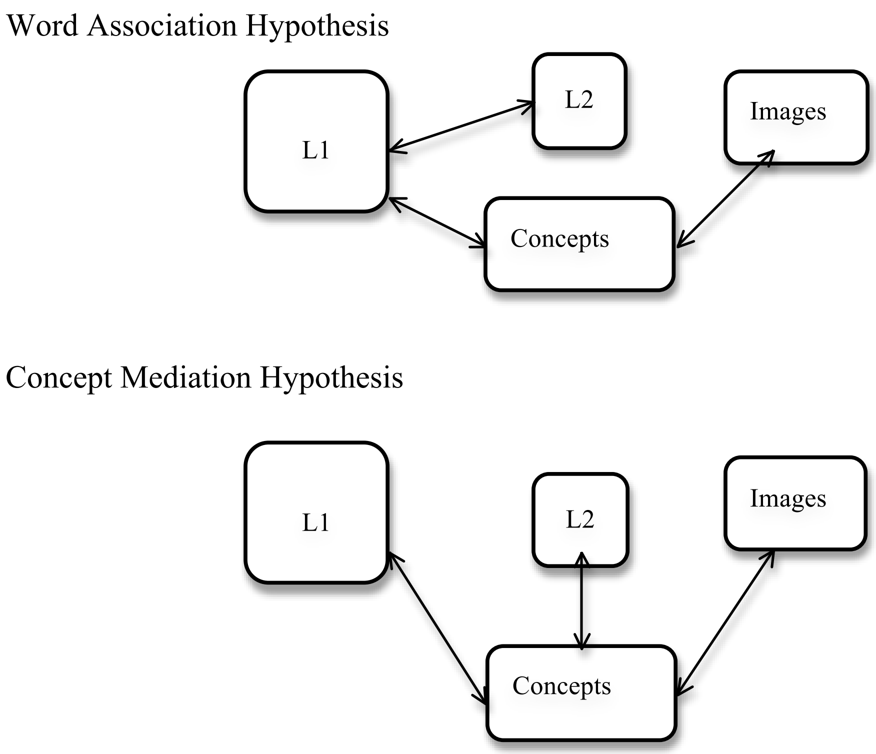

Figure 3.2. Potter, So, von Eckhardt, and Feldman's (1984) word association and concept mediation hypotheses regarding bilingual memory representation (adapted from Potter et al., 1984).

According to the *word association hypothesis* there is no connection between the words in L2 and the shared conceptual store. Words in L2 are directly connected to their corresponding translation equivalent in L1, rather than to their underlying meaning in the shared conceptual store. Thus, when a person uses his or her second language, these word-to-word connections are activated. In contrast, the *concept mediation hypothesis* posits that words in L1 *and* L2 can independently access their underlying meanings in the shared conceptual store. In addition, words in the two languages are not directly associated but are instead linked through the shared conceptual system. Thus, when people use their second language they access the underlying shared concept first, *and then* they access the appropriate second language word. In theory, although not actually specified by Potter et al., this process *may be* 'mediated' by (e.g., *influenced by*) the individual's proficiency level in their second language.

In two separate experiments, Potter et al. (1984) tested out these two hypotheses using two groups of second language learners (proficient Chinese-English bilinguals and less fluent English-French language learners). In each experiment, comparisons were made between: 1) word reading to word translation, and 2) picture naming to word translation. The critical comparisons were between picture naming in L2 versus translation from L1 to L2. Three types of items were used: line drawings (pictures), their label in Chinese (logograms) and their label in English (word). In experiment 1, 24 proficient Chinese-English bilinguals were divided into two groups of 12. Group 1 named or translated each of the items and responded half of the time in Chinese and half of the time in English. Participants in Group 2, using the same 96 items as Group 1, were asked to match the items to a superordinate category named by the researcher 500 milliseconds before the item was presented. Following an intervening task of naming 30 new items, each participant was asked to recall (write down in any order and in any language) the items used in the experiment. In the second experiment, 28 less fluent English-French bilinguals completed the same translation task but the 96 pictures and their English labels were modified to represent "French names we thought would be familiar to relative novices" (p.32.). Of these 28, eight participants were asked to recall as many items as they could, in any order and in any language.

The word association hypothesis predicts that translating from the first language (L1) to the second language (L2) would involve three processing steps: recognition of the L1 word, retrieval of the L2 word, and speaking the L2 word (see Figure 3.3). In terms of picture naming in L2, five steps are involved: picture recognition, concept retrieval, retrieval of the L1 word, retrieval of the L2 word, and speaking the L2 word (see Figure 3.3). In contrast, the concept mediation hypothesis predicts that these two tasks (translation and picture naming) would involve the same number of steps (see Figure 3.4). The translation task would involve recognition of the L1 word, concept retrieval, retrieval of the L2 word, and speaking the L2 word. For the picture naming task the same sequence of steps would be followed except that the first step involves picture recognition instead of word recognition. Equal processing time is assumed for pictures and words since words and pictures have equal access to the shared conceptual store. Thus, picture naming in L2 and translating words from one language to another should take approximately the same amount of time to complete (Kroll & Potter, 1984; Potter et al., 1984).

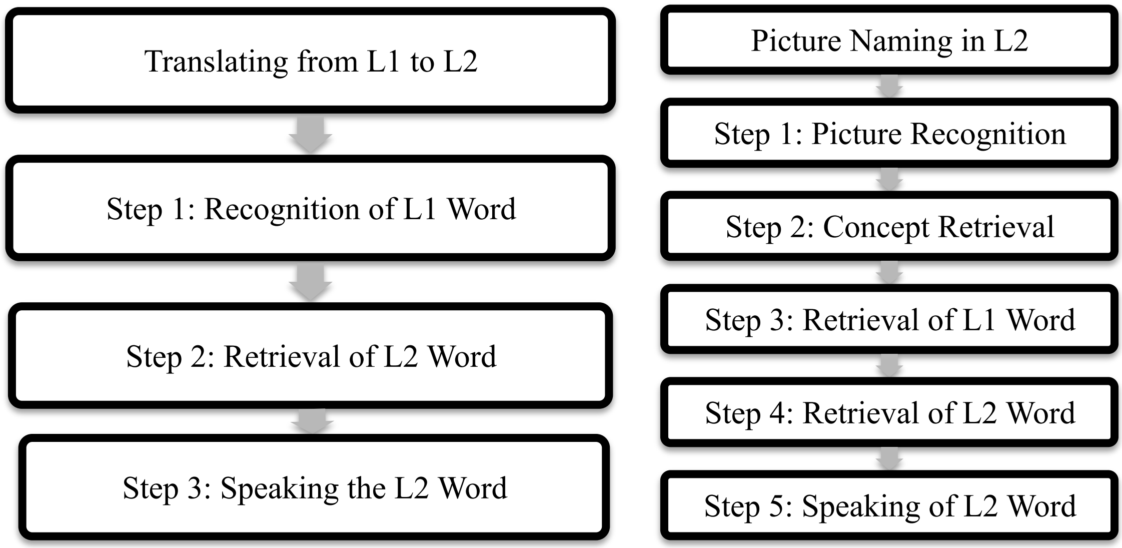

Figure 3.3. Processing steps according to the word association hypothesis.

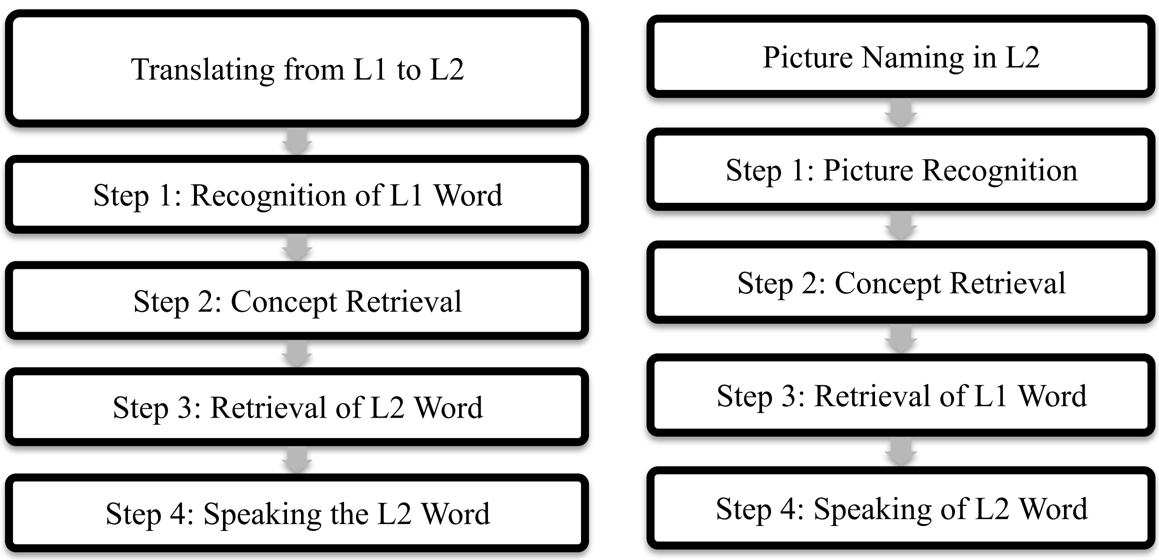

Figure 3.4. Processing steps according to the concept mediation hypothesis.

Several similarities between these two hypotheses are problematic and need to be highlighted. First, both hypotheses focus only on translation equivalent words in a bilingual's two languages. Each assumes that both terms correspond in a one-to-one fashion and that the bilingual speaker knows both terms. However, there are many instances where there is no translation equivalent across two languages. For example, the words *love* and *amor* are similar but not translation equivalent. In English, *love* is a general concept that can be applied to almost anything (e.g., *I love* this book!). However, in Spanish, *amor* is a more reserved concept and typically applies only to an intimate other (e.g. *Amo* a mi esposa: *I love* my wife) (Heredia, 1996, 2008). Second, neither hypothesis predicts differential outcomes based on the direction of translation across languages (Kroll & Stewart, 1994). That is, both predict that translating from L1 to L2 requires the same amount of time as translating from L2 to L1.

Potter et al. (1984) found no evidence to support the word association hypothesis, even for their less fluent English-French bilinguals. Instead, Potter and her colleagues proposed that words in the two languages are directly associated to concepts in an integrated conceptual store. In addition, Potter et al. found that translation of a word from L1 to L2 as well as picture naming required bilinguals, regardless of their fluency level to go through this shared conceptual system. They concluded that their findings provided evidence for the concept mediation hypothesis. Additional evidence for the concept mediation hypothesis has been reported elsewhere in the literature using similar translation and categorization tasks (e.g., Altarriba & Mathis, 1997; Bloem & La Heij, 2003; de Groot & Poot, 1997; La Heij, Hooglander, Kerling, & Van der Velden, 1996).

It should be noted that Potter et al. (1984) had originally proposed a variation of the word association and concept mediation hypotheses, which they termed the *intermediate hypothesis*. The intermediate hypothesis focuses on the lexical processing of beginning and fluent bilinguals. It proposes that beginning and fluent bilinguals use different pathways to access words in their two languages. According to this hypothesis, during the beginning stage of second language acquisition, L2 is accessed directly through L1. As fluency in L2 develops, however, independent access to the shared conceptual system via L2 is gradually achieved. Thus, the intermediate hypothesis included a *fluency shift* in second language acquisition where dependency on word-to-word links was eventually replaced by direct access to concepts. Since their data did not demonstrate this asymmetry Potter et al. did not pursue it further. However, this fluency shift is the basis of the next model to be discussed.

Revised Hierarchical Model

Kroll and Curley (1988) had speculated that the less fluent bilingual in the Potter et al. (1984) study, while not yet proficient in L2, had nevertheless passed the point at which reliance on lexical links between L1 and L2 was necessary for processing L2 words (also see Chen & Leung, 1989). To test their hypothesis, Kroll and Curley replicated Potter et al.'s study. They compared both fluent and less fluent participants but included a wider range of fluency levels than Potter et al., i.e., they included participants who had studied their L2 for less than two years. Whereas Kroll and Curley found similar results as those reported by Potter et al. (1984) for the fluent L2 participants and participants who made studied their L2 for more than two years, the least fluent bilingual participants seemed to perform more in line with the word association model. According to Kroll and Curley, their results indicate that: 1) fluent and less fluent bilinguals may access their two languages through different sets of mental links and 2) there is a shift in language processing skills as a function of L2 expertise (also see Chen & Leung, 1989; Dufour & Kroll, 1995; Kroll & Stewart, 1994).

These findings prompted Kroll and Stewart (1994) to propose a revised version of the concept mediation model, which they called the *Revised Hierarchical Model* (RHM) (see Figure 3.5). In essence, Kroll and Stewart combined the word association and concept mediation hypotheses and further specified differences in bilingual language processing based on the *order* in which the languages were acquired. According to the RHM, both lexical and conceptual links are active in bilingual memory. However, the strengths of these connections differ as a function of fluency in L2 and the relative dominance of L1 to L2. In addition, the lexical capacity of L1 is *always* purported to be larger than the lexical capacity of L2, i.e., L1's lexicon is always larger than L2's. Moreover, regardless of how fluent a second language learner becomes, the link between L2 and the conceptual system is always weaker than the link between L1 and the conceptual system. Thus, connections between L1 and L2 words and L1, L2, and their meanings are asymmetric. Specifically, L2 is always subordinate to L1 regardless of L2 fluency. The RHM does not state that only fluent bilinguals can directly access the shared conceptual store. Rather, it is proposed that the link between L2 and L1 is stronger, hence more accessible, than the link between L2 and concepts.

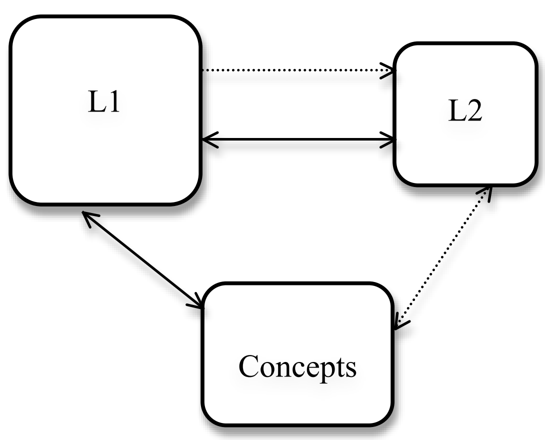

Figure 3.5. The revised hierarchical model (RHM) of bilingual memory representation (adapted from Kroll and Stewart, 1994).

Kroll and Stewart (1994) also state that the process by which lexical and conceptual links are activated in bilingual memory differs based on the direction of translation. Translations from L2 to L1 (backward translation) are accessed primarily by lexical links whereas translations from L1 to L2 (forward translation) are always conceptually mediated. Based on these activation patterns, the RHM makes two predictions: First, translations from L2 to L1 will be faster than translations from L1 to L2. This is because translation from L2 to L1 can be accomplished by accessing lexical-level connections whereas; translation from L1 to L2 requires concept mediation. Second, only fluent bilinguals will experience interference (difficulty) translating from L1 to L2. This is because translation from L1 to L2 requires concept mediation and less fluent bilinguals have yet to form the connections for this route. Therefore, a less fluent bilingual speaker is more likely to use lexical links when translating between languages and is less likely to be affected by manipulations of meaning when accessing concepts via L2.

In three experiments, Kroll and Stewart (1994) tested picture naming and bilingual translation using either semantically categorized or randomized lists. In Experiments 1 and 2 they used monolingual, native English speakers and in Experiment 3 they used fluent Dutch-English bilinguals. Results from Experiments 1 and 3 showed that picture naming and bilingual translation were slower when the material was presented in categorized versus randomized lists. These data support the predictions of the RHM: translations from L2 to L1 were faster than translations from L1 to L2 in both conditions and the categorized versus randomized lists manipulation only affected the reaction times of the fluent bilingual speaker when translating from L1 to L2. Together, these results were taken as evidence that translating from L1 to L2 is conceptually mediated whereas translating from L2 to L1 is lexically mediated (also see Sholl, Sankaranarayanan, & Kroll 1995).

Subsequent research has resulted in modifications to the RHM. In describing the development of conceptual mediation in less fluent bilinguals, Dufour and Kroll (1995) agree that some concepts are shared but propose that any two languages differ in the pattern of overall conceptual activation they produce, and these differences determine the degree of overlap in meanings between the two. They suggest that the size of the second language lexicon may establish the extent to which conceptual representations linked to L2 can gain from the activation of shared elements in L1. That is, activation of an L2 word is more likely to trigger a very limited set of category concepts known in L2 that do not include the equivalent set of category knowledge known in L1. On the other hand, activation of shared concepts in L1 is more likely to trigger many more concepts unknown in L2 since category knowledge in L1 is more exhaustive. Therefore, the benefit of activating shared concepts in L1 is dependent on the size of the L2 lexicon.

In their study, Dufour and Kroll (1995) found that less fluent English-French bilingual speakers were able, in a limited capacity, to access conceptual information from L2. However, Dufour and Kroll maintain that this direct link between L2 and concepts was accessible only in conditions where the task involves categorization within-languages but not in cross-language conditions. That is, when both the stimulus and target words were in the same language, i.e., categorizing *peas* as a *vegetable* and *pois* as a *legume* versus categorizing *peas* as a *legume* and *pois* as a *vegetable*. Thus, they maintain that direct conceptual mediation of L2 is a gradual process that unfolds as the L2 lexicon grows and differential activation of new words and concepts come under the control of the less fluent bilingual speaker.

However, not everyone agrees with the predictions of the RHM even with these additional modifications (e.g., Altarriba & Mathis, 1997; Brysbaert & Duyck, 2010; Duyck &

Brysbaert, 2002, 2008; Ferrè, Sánchez-Casas, & García, 2001; Heredia, 1997; 2008; Heredia & Altarriba, 2001). As researchers attempt to verify the claims put forth by Kroll and Stewart (1994) and Dufour and Kroll (1995), the status of the RHM has been called into question by those who have demonstrated conceptual mediation in both translation directions (e.g., de Groot & Poot, 1997; La Heij et al., 1996) and conceptual mediation with beginning second language learners (e.g., Altarriba & Mathis, 1997; Comesaña, Perea, Piñeiro, & Fraga, 2009; Finkbeiner & Nicol, 2003). It was this first study (e.g., Altarriba & Mathis) showing conceptual mediation with beginning second language learners in adult learners, using a Stroop (1935) task that piqued my interest.

Altarriba and Mathis: A bilingual Stroop Color-Word Study

In the original Stroop (1935) color-word task participants were shown a color word such as *blue*, in an incongruent ink color, such as *red.* Participants were then asked to ignore the words and name the ink color in which the word was written in. The difference in the time it takes to name the ink colors of incongruent words and name the ink colors of color patches is called Stroop interference. On the other hand, Stroop facilitation occurs when the inclusion of control trials such as a series of letters (i.e., *XXXXX*) enables participants to respond more quickly to congruent trials. A bilingual version of this task would include color words in two languages and participants would be asked to respond on some trials in L1 and on other trials in L2. Their responses would yield two within-language (i.e., L1 words and L1 responses; L2 words and L2 responses) and two cross-language (i.e., L1 words and L2 responses; L2 words and L1 responses) interference score. For example, using English and Spanish, a within-language condition in English would be seeing *RED* in green ink which requires "GREEN' as the correct response and in the Spanish condition, seeing *ROJO* in green ink requires "*VERDE"* as the correct response. A cross-language condition in English would be seeing *ROJO* in green ink which requires "GREEN' as the correct response and in the Spanish condition, seeing *RED* in green ink requires "*VERDE"* as the correct response.

The Stroop (1935) task has been used to demonstrate that the automaticity of *reading* a color word can be disrupted when semantic context is manipulated (i.e., manipulation of congruency across word meaning). As such, it has been used to measure both automaticity and conceptual processing. In bilingual research the Stroop task has also been used to settle the *selective/ nonselective* argument of language activation in bilingual speakers. Here the question becomes, can a bilingual speaker control the activation of the non-target language, say Spanish, in a dual-language (i.e., Spanish-English) task? It is the interaction among the four interference scores (i.e., L1-L1, L2-L2, L1-L2, and L2-L1) that is used to explain how bilingual speakers' store and access words in two languages (MacLeod, 1991). It has also been used to demonstrate that novice second language learners have access to the conceptual system in the very early stages of language learning (e.g., Altarriba & Mathis, 1997). Altarriba and Mathis's study was used a springboard for the experiments described in this paper.

Altarriba and Mathis's Findings

In a series of experiments designed to test Kroll and Stewart's RHM, Altarriba and Mathis (1997) attempted to measure the conceptual and lexical representation in bilingual memory of both novice and expert bilinguals. Altarriba and Mathis believed that lexical capacity (i.e., how big the lexicons are) is less salient than the quality of words known (i.e., how well bilinguals know the words in their repertoire). In Experiment 2 of their study, Altarriba and

Mathis used a bilingual (English-Spanish) version of the Stroop (1935) color word task to examine whether or not novice language learners could bypass the L1 lexicon and go directly to the conceptual system to access L2 words. Using monolingual English and bilingual English-Spanish participants they trained the monolingual participants *once* on four English-Spanish color word pairs (e.g., blue-*azul,* green-*verde,* red-*rojo,* and yellow-*amarillo*). This was followed by a series of questions, which included translations, sentence completions, matching tasks, and so forth designed to simulate conceptual processing.

Altarriba and Mathis (1997) found that even novice bilinguals, i.e., participants taught a limited vocabulary in a second language for the purpose of their experiments, could access L2 words at the conceptual level. That is, their novice language learners demonstrated a cross-language Stroop interference effect when presented with one of the four Spanish color words they learned and the required response was in English. More significant was the finding that these novice second language learners were capable of conceptual mediation after only one initial exposure to a second language (Altarriba & Mathis, 1997). This suggests that these "novice" second language learners had formed direct links between their newly acquired language and the amodal conceptual system. This finding is in direct opposition to the RHM which would predict that the responses of novice second language learners would be unaffected by the manipulation of semantic information.

It was the finding by Altarriba and Mathis that novice language learners have immediate and direct access to the conceptual system *without* lexical mediation that motivated the current research. What follows is a series of novel experiments in which the Stroop (1953) color-word task was used to investigate how and *when* novice L2 learners have access to word meaning. In addition, fluent bilingual speakers were also tested to show the influence that language dominance has on their language processing abilities.

4. EXPERIMENT 1: COMPARISONS BETWEEN RUSSIAN (CYRILLIC) AND ENGLISH COLOR WORDS ACROSS GROUPS AND RESPONSE CONDITIONS

Background

The current study was aimed at measuring, in an adult population, the development of access to conceptual representations via a second language. Experiment 1 was designed to test the developmental predictions of the RHM using novice L2 learners and fluent bilingual speakers. The main feature of the RHM's predictions is that as an individual achieves greater proficiency in his or her L2, the organization of bilingual memory also changes. First, at the beginning stages of L2 acquisition the language learner is only capable of making one-to-one associations between his or her newly acquired L2 words and L1 translation equivalents. As such, direct access to the conceptual system is unavailable to the beginning L2 learner; therefore the exchange of meaning between languages is done through a translation process from L2 to L1 and is accomplished at the lexical level. Second, as proficiency in L2 increases the capacity to connect directly to the conceptual system via L2 words develops. Now the beginning L2 learner can *bypass* the L1 lexicon and access word meaning directly from the conceptual system. Third, when fluency in L2 is achieved the links between the L2 lexicon and the conceptual system are *almost* as strong as the links between the L1 lexicon and the conceptual system (Kroll & Stewart, 1994). The end result is that the fluent L2 speaker is now capable of accessing word meaning directly from the conceptual system in either language however, the L1 lexicon always has a privileged status and it is always larger than the L2 lexicon. However, as we will see this is not necessarily true when fluent bilingual speakers become more dominant in their L2 than their L1 (Heredia & Altarriba, 2001; Heredia, 1997; 2008).

In Experiment 1, native English speakers were taught four Russian color word pairs using a Russian-English (Cyrillic and Roman script) bilingual variant of the Stroop color word task and tested, after only one practice session, to see if they would produce a cross-language Stroop effect (i.e., Russian words, English responses). Producing a cross-language Stroop effect by the native English speakers would be taken as evidence that word processing in L2 is conceptually mediated and not reliant on L1 lexical representations. That is, if a cross-language effect was found it would suggest that in the early stages of L2 learning novice language learners could directly access the conceptual system via L2 conceptual representations rather than through a L1 to L2 translation process. Native Russian speakers also participated in the Experiment 1 and functioned both as a comparison group for the native English speakers and as a way to measure the role of language dominance in the wording processing ability of fluent bilingual speakers.

Remember that in Altarriba and Mathis's (1997) study, English and Spanish were used. Yet, both of these languages use the same alphabet, which provides even a novice L2 learner with both orthographic and phonological cues for word processing. However, only a native Russian speaker would be able to 'pick' up on those cues when presented with words written in Cyrillic (see Figure 4.1). Therefore, the use of Cyrillic script was chosen because it was viewed to be a more stringent measure of cross-language interference in a Stroop task than a language like Spanish, which shares the same alphabet as English. Since Cyrillic would be non-phonetic for a non-native speaker this decreased the native English speakers' ability to automatically decode an unknown phonology (see Figure 4.2). It also increased the likelihood that the native English participants were truly *"novice"* language learners. Therefore, it was believed that using a different script would provide a better test as to 1) whether or not lexical and conceptual development co-occur, and 2) whether orthographic and/or phonological processing was involved. For fluent Russian-English speakers, who were equally familiar with both scripts, access to the phonology each language would prove either inhibitory (in terms of the word that is not to be processed) or facilitative (in terms of the word to be retrieved) and was presumed to be dependent on proficiency levels in both languages. As such, the use of Cyrillic provided a measure of how language proficiency influenced visual word processing in bilingual participants.

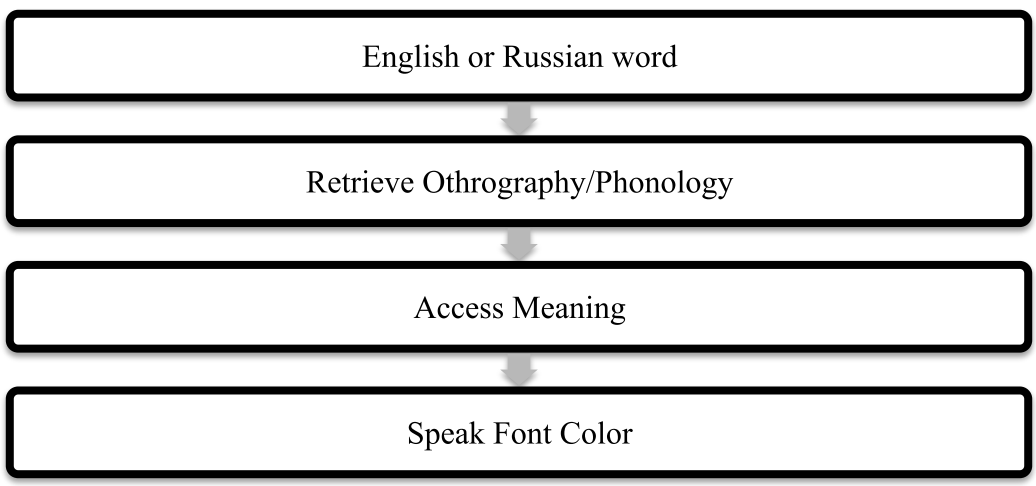

Figure 4.1. Hypothesized steps taken by native Russian (fluent English) speakers when decoding English versus Russian (Cyrillic) color words in Experiment 1.

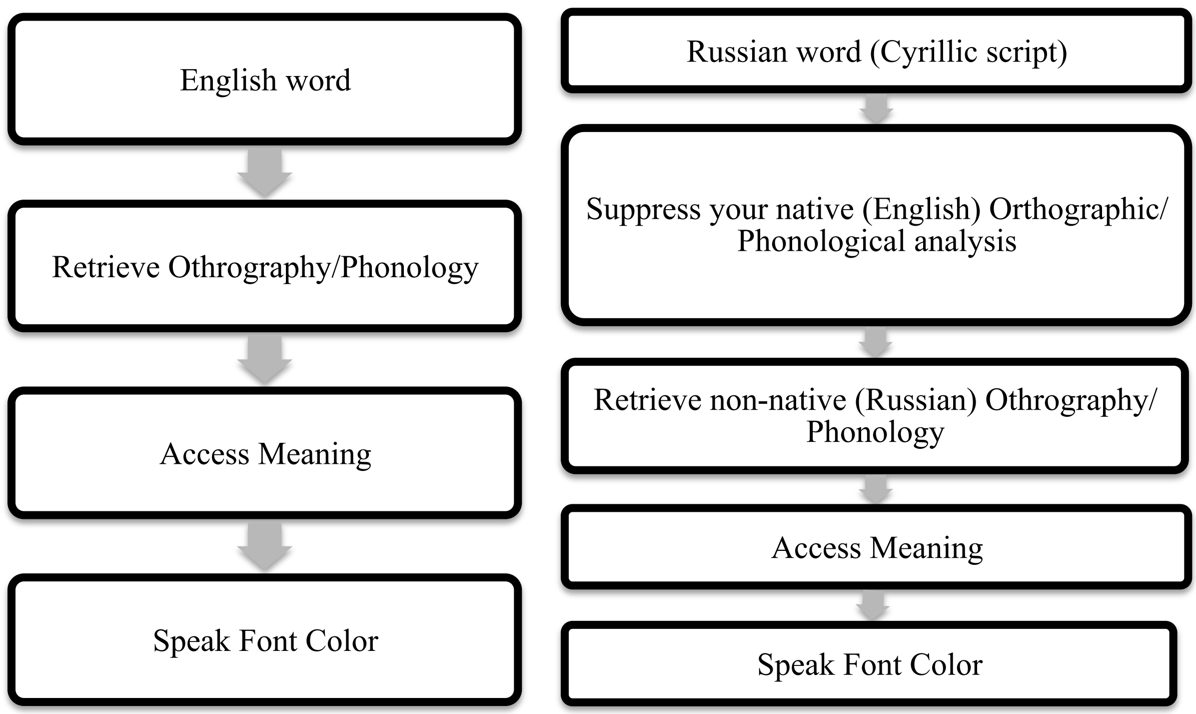

Figure 4.2. Hypothesized steps taken by native English speakers when decoding English versus Russian (Cyrillic) color words in Experiment 1.

The Stroop color word task was chosen because it has been used to measure semantic processing (see MacLeod, 1991) and, as noted by Altarriba and Mathis (1997) it only required the learning of four translation pairs for the native English participants (in this case English/Russian). More importantly, the Stroop task also requires the activation of the phonological system whether covertly (e.g., silent reading) or overtly (e.g., speech production). As such it provided additional information regarding the importance of phonology in word processing. To measure the robustness of the Stroop effect both verbal (i.e., voiced) and nonverbal (i.e., key press) responses were used. It should be noted that differential effects have been found favoring voiced responses over key press (i.e., nonverbal) responses such that the interference effects are typically greater when vocal responses are used (see Brown & Besner, 2001; MacLeod, 1991, 2004; Sharma & McKenna, 1998). However, both types of responses may allow for the disentanglement of orthography and phonology in visual word processing and provide evidence as to whether or not these underlying processes (orthography and phonology) are measurable using the Stroop task.

It was predicted that if lexical and conceptual development in a second language occurs simultaneously as the Altarriba and Mathis (1997) data suggest, then the native English participants would produce both within- and cross-language Stroop effects. However, only English responses were required. Therefore for the native English speakers the within-language condition represents English words (L1) paired with English responses (L1) (e.g., *BLUE* written in red requires “RED” as a response) and the cross-language condition represents Russian words (L2) paired with English responses (L1) (e.g., *ГОЛУБО* written in red requires “RED” as a response). If the native English speakers produce a cross-language Stroop effect, such a finding would be interpreted as 1) evidence that newly acquired words in a second language are simultaneously represented at the lexical and conceptual levels and 2) conceptual mediation between the second language and the shared conceptual system is immediately available to a novice language learner.

It was also predicted that native Russian speakers would produce both within- and between Stroop effects. Note that for the native Russian speakers the within- and cross-language conditions are the same, however, designation of L1 and L2 are different (L1 = Russian and L2 = English). In line with previous research (e.g., Dyer, 1971; Macleod, 1991) it was predicted that the within-language Stroop effect would be larger than the cross-language Stroop effect for both groups. Also, it was predicted that the voiced condition would be a more sensitive measure of conceptual processing than the key press condition for both groups. As a production measure, the voiced condition requires the additional step of articulating one’s response. This additional requirement adds a degree of interference that may or may not be present in the key press condition. It was reasoned that ignoring word meaning should be easier (i.e., resulting in shorter reaction time) when no verbal response is required. A final prediction was that the possible interference effects of orthography and phonology would be greatest for the native English speakers in the Russian conditions.

Experiment 1

Method

Participants

Forty-eight students from Brooklyn College of the City University of New York participated in this experiment. Participants had normal or corrected-to-normal visual acuity and had no known reading or hearing disorders. Twenty-eight students were native English speakers who had no prior classes or experience with the Russian language. Twenty students were native Russian speakers. Participation in the experiment was part of a course requirement in an introductory psychology course. All participants were administered a language-history questionnaire (see Appendix A) to ensure that a) native English speakers had no significant exposure to the Russian language and b) native Russian speakers were relatively balanced, Russian-English speakers. None of the native English speakers reported any prior experience with the Russian language (see Table 4.1). All of the native Russian speakers reported similar ratings on their ability to speak and read in both languages (see Table 4.2). It should be noted however, that fifteen of the native Russian speakers reported speaking (fluently) a third language and of those, six reported speaking (somewhat fluently) a fourth language. Moreover, all of the native English speakers reported speaking (somewhat fluently to fluently) a second language.

Table 4.1

Language History Results for Native English Speakers in Experiment 1

Mean age in years	23.7
Mean years in U.S.	22.6
Mean age emigrated to U.S.	0.9
Mean age learned English	0.00
Mean years studied English	14.6
Mean overall self-rating (6-point scale) of English ability	5.4
Mean self-rating (6-point scale) on ability to:	
read in English	5.7
write in English	5.1
listen to English	5.4
speak in English	5.6
Mean years of studying a second language	5.1
Mean overall self-rating (6-point scale) of second language ability	1.7
Mean self-rating (6-point scale) on ability to:	
read in second language	2.2
write in second language	1.6
listen to second language	1.6
speak in second language	1.7

Note that the most frequently reported second language was Spanish (seven), followed by Hebrew (six) and Creole/French (five).

Table 4.2

Language History Results for Native Russian Speakers in Experiment 1

Mean age in years	21.5
Mean years in U.S.	6.3
Mean age emigrated to U.S.	15.2
Mean age learned English	11.8
Mean years studied English	18
Mean overall self-rating (6-point scale) of English ability	4.9
Mean self-rating (6-point scale) on ability to:	
read in English	5.0
write in English	4.5
listen to English	5.2
speak in English	4.8
Mean overall self-rating (6-point scale) of Russian ability	5.3
Mean self-rating (6-point scale) on ability to:	
read in Russian	5.3
write in Russian	4.6
listen to Russian	5.7
speak in Russian	5.6
Percentage of time spent in English speaking environment	41.5
Percentage of time spent in Russian speaking environment	58.5

Note that 15 out of the 18 participants reported speaking a third language fluently and six of those reported speaking a fourth language somewhat fluently. The top third language was Hebrew (ten), followed by Spanish (five). The fourth language was Farsi (three), French (two), and Ukrainian (one).

Stimuli

The stimuli consisted of eight words: the four English color words, *BLUE*, *GREEN*, *RED*, YELLOW, and their Russian translations, *ГОЛУБО, ЗЕЛЕНЫЙ, КРАСНО*, and *ЖЕЛТЫЙ* respectively. Each of the eight words appeared in each of the four colors five times for a total of 160 experimental trials. The 160 trials were divided into four blocks of 40 (20 incongruent, 10 congruent) trials each. In each block, the four colors appeared 10 times. The stimulus words were mixed in a quasi-random design in each block, so that neither two of the same colors nor two of the same words were presented on consecutive trials. Four lists were generated to counterbalance the presentation order of the four blocks using a Latin square design. A set of eight practice trials was constructed using each of the four colors randomly paired twice by term and color of printed word so that each of the eight words was used once. Half of the practice trials were congruent (term and color matched) and half were incongruent (term and color did not match). The experimenter remained in the room throughout the experiment. All participants were tested individually. Each was randomly assigned to one of the four generated lists as they arrived for the experiment.

Apparatus

The experiment was created using *SuperLab Pro* (SLP) software (Cedrus Corporation, 1997) and was presented on a computer screen interfaced with an IBM-PC computer. Stimuli were displayed in uppercase letters on a black background in one of four colors (red, blue, green and yellow). For the English words, each letter was printed in *Times New Roman* font size at 225 x 125 pixels. For the Russian words, each letter was printed in *Cyrillic A* font size at 225 x 125 pixels. The computer kept track of all response times. Nonverbal (i.e., key press) responses were recorded and accuracy data were collected via the *SuperLab Pro RB600* color-coded response box. Verbal (i.e., voiced) responses were checked, by hand, against a master-response sheet for accuracy.

Materials and Procedure

Acquisition task: (native English speakers only). The acquisition task consisted of one set of four congruent Russian-English color word pairs presented cross-modally (visual-auditory). Instructions, describing the acquisition task, appeared in English on the computer screen. First, participants were presented with a "+" in the center of the monitor for 1000ms (milliseconds) as a pre-trial warning to focus attention. Next, a Russian color word appeared in the center of the screen for 500ms. While the Russian color word remained on the screen, its English translation appeared four lines directly below it. Both words remained on the screen for an additional 7500ms. Participants were wearing headphones and heard, in Russian and in English, the word pair repeated twice while viewing both of the Russian and English color terms on the screen. A fluent, Russian-English male speaker had recorded the stimulus words. The inter-trial interval (ITI) between the four pairs of color words was 750ms.

Translation task: (native English speakers). Immediately after being exposed to the acquisition task, native English speakers were given five sets of questions (see Appendix B). This task was designed to stimulate conceptual processing. In all five sets the participants were required to write their answers, in Russian, using Cyrillic letters. Each set provided the participants with the proper Cyrillic spelling of the Russian color words as multiple-choice items with corrective feedback given *only* on the first set. For the first set of questions, participants wrote the Russian color word that matched a given English color word. After completing this first set, the experimenter corrected any mistakes and allowed participants to look over the correct answers. For the second set, participants filled in the Russian color word that corresponded to a small patch of the actual colors. In the third set, participants completed simple closed-ended English sentences with a Russian color word (e.g., “The colors of the USA flag are __________, white, and blue”). For the fourth set, participants were asked to match the one emotion word (envy, anger, sad, or happy) that is typically associated with a particular color (e.g., "sad" is typically associated with the color blue). Participants were asked to write in the Russian color word that matched the given emotion. For the final set, participants were instructed to match a Russian color word with objects that commonly appear in a particular color (e.g., “a blade of grass” is typically _______). The accuracy criterion was set at 75% on the first set and 100% for the remaining four sets. All participants met these criteria.

Translation task: (native Russian speakers). For the native Russian speakers, the correct responses for the five sets of questions was reversed – instead of being asked to provide the Russian color words they were asked to provide the English color words (see Appendix C). On all five sets the participants were required to write their answers in English with corrective feedback given *only* on the first set. Since these participants were fluent native Russian-English speakers the accuracy criterion was set at 100% for all five sets of questions. All but one participant met this criterion and his data were not used (see Data Trimming section).

Intervening task. After the translation task all participants proceeded to the intervening task. In line with previous research (see Altarriba & Mathis, 1997), after completing their respective translation task, all participants were given an intervening task, which lasted approximately 15 minutes. Using a computerized version of past Graduate Record Examination (GRE) exams, the intervening task included verbal, quantitative, or analytical problems. This intervening *filler* task was not scored and was immediately followed by eight practice trials.

Practice trials. The practice trials proceeded as follows. Instructions appeared in English on the computer screen and were read aloud by the experimenter. Responses on the practice trials were recorded using the color-coded (blue, green, red and yellow) keys on the *SuperLab Pro* RB600 response box. A pre-trial warning appeared for 1000ms in the center of the computer screen. This was followed by one of the eight Russian or English color words, which appeared either in blue, green, red, or yellow. The participants were instructed to press the correct colored key on the *SuperLab Pro* RB600 response box that matched the color in which the word was printed. Only the correct response would advance the program to the next trial so accuracy and not speed was emphasized. The practice trials were immediately followed by the voiced English experimental trials.

Voiced English condition. The voiced experimental trials proceeded as follows. Instructions, describing the experimental trials, appeared in English on the computer screen and were read aloud by the experimenter. After a warning signal, which appeared for 1000ms, one of the eight Russian or English color words appeared in the center of the screen in either in blue, green, red or yellow. The participant's task was to name the color of the font (i.e., ink color) aloud in English into the microphone and not name the printed word itself. Note that English responses were also required on the Russian color word trials. Participants were told that the experiment was voice-activated and therefore any noises other than their desired response should be avoided. The word remained on the screen until a response was made. In other words, participants were given unlimited time to respond. After a response was made it was followed by a "+" for 600ms. This was immediately replaced by the next word. The computer recorded all reaction times (RTs) while the experimenter checked off the correct and incorrect responses on a master-response sheet.

Key press (nonverbal) condition. Following a five-minute break participants were instructed to complete the key press experimental trials. The procedure was the same as in the voiced experimental trials except that all responses were now nonverbal and recorded via the *SuperLab Pro* RB600 response box. Unlike the practice trials where only the correct response would advance participants to the next trial, in the experimental trials *any* key press response (correct or *incorrect*) would advance them to the next trial. Following the completion of the key press experimental trials, native English speakers were debriefed and given partial course credit for their participation.

Voiced Russian condition. Following a five-minute break native Russian speakers were instructed to complete the voiced Russian experimental trials. The procedure was the same as in the voiced English experimental trials except that now all responses were given in *Russian*. Given the role that phonology and, in the case of Cyrillic orthography have in word processing only the native Russian speakers were asked to complete the voiced Russian condition. Following the completion of the voiced Russian experimental trials, native Russian speakers were debriefed and given partial course credit for their participation.

Results

The design of this study was such that each participant was tested using English and Russian congruent and incongruent match trials in both key press (key press) and voiced (English) response modes. In addition, native Russian speakers were tested in a second voiced (Russian) condition. Thus for each participant mean reaction times (RTs) were calculated, one for each of the languages (English words and Russian words) by match (congruent and incongruent). In addition, these means were separately calculated by response mode (key press, voiced English and/or voiced Russian) for a total of eight mean RTs for native English speakers and 12 mean RTs for native Russian speakers.

Data Trimming

The data of ten native English speakers had to be eliminated. One participant's data was lost due to equipment failure (none of his responses were recorded). Two other participants completely misunderstood the task. One participant named, in English, the Russian color words irrespective of the color they were printed in. The other named, in English, the printed words irrespective of the language in which they were presented. During debriefing an additional seven participants were eliminated when they each revealed that English was not their native language but in fact their second language. The data of two native Russian participants were also eliminated. One was lost due to equipment failure and the other was color-blind, thus he was unable to discern the different colors in the Stroop Task. Therefore, the data of eighteen native English speakers and eighteen native Russian speakers were used for subsequent analyses.

Incorrect responses (e.g., matching 4.2% and/ or timing errors 7.7%), which constituted 11.9% of the total data, were not included in these analyses. In line with previous research (see Altarriba & Mathis, 1997) response times (RTs) that exceeded 2.5 standard deviations above or below the mean of each participant were replaced by the value *at* 2.5 standard deviations above or below the participant's mean. In addition, response times of less than 200ms or more than 1500ms were treated as outliers. Outliers constituted less than 1.4% of the overall data and were also not included in these analyses.

Preliminary Analyses

Difference scores. Difference scores were calculated by subtracting the mean RT of the congruent trials from the incongruent trials in each language and response mode. To determine whether or not the data indicate a Stroop effect for each group in each mode for the English color words, the difference scores were tested against an expected value of zero (null hypothesis). All difference scores were significantly greater than zero, p's < .001 for the key press and voiced English conditions (see t-values, Table 4.3). However, for native Russian speakers, the difference score for English color words was not significant in the voiced Russian condition. This indicates that the cross-language (i.e., English words, Russian response) Stroop effect did not occur for these native Russian speakers when responding in Russian. To determine whether or not the data indicate a Stroop effect for each group in each mode for the Russian color words, the difference scores were tested against an expected value of zero (null hypothesis). For the native English speakers the difference scores were not significant in either mode, $p > .05$ (see t-values, Table 4.4). This indicates that the cross-language (i.e., Russian word, English response) Stroop effect was not found for the native English speakers. However, as expected, all difference scores for Russian color words were significantly greater than zero (p's < .0.01) for the native Russian speakers (see t-values, Table 4.3).

Table 4.3

Reaction Time Data (in ms) for English Color Words by Match Across Response Mode for Both Groups in Experiment 1

Group	Mode	Incongruent (SE)	Congruent (SE)	Difference (SE)	*t*-value
Native English	Voiced English	981 (22)	908 (25)	73 (15)	4.787***
Native English	Key Press	791 (17)	761 (18)	30 (10)	2.930**
Native Russian	Voiced English	1033 (29)	896 (31)	137 (13)	10.248***
Native Russian	Voiced Russian	972 (19)	948 (21)	24 (13)	1.832
Native Russian	Key Press	745 (18)	721 (16)	24 (4)	6.805***

**p < .01
***p < .001

Table 4.4

Mean Response Times (in ms) for Russian (Cyrillic) Color Words by Match Across Mode for both Groups in Experiment 1

Group	Mode	Incongruent (SE)	Congruent (SE)	Difference (SE)	*t*-value
Native English	Voiced English	880 (24)	868 (24)	13 (8)	1.537
Native English	Key Press	773 (19)	766 (19)	7 (5)	1.370
Native Russian	Voiced English	1016 (30)	959 (28)	57 (10)	5.776***
Native Russian	Voiced Russian	992 (19)	876 (22)	116 (19)	6.075***
Native Russian	Key Press	748 (19)	734 (18)	14 (4)	3.689**

**p < .01
***p < .001

Reaction Time Analysis

First, a mixed design analysis of variance was conducted on the mean RTs (using difference scores) for the English color words with *Group* (native English speakers, native Russian speakers) as the between subjects factor and *Mode* (key press, voiced English) as the within subjects factor. Significant main effects were found for both factors: *group*, $F(1,34) = 5.109$, $p < .05$ and *mode*, $F(1,34) = 58.476$, $p < .001$. Interpretation of the main effects is qualified by a significant interaction, $F(1,34) = 11.867$, $p < .01$ (see Figure 4.3). A follow-up analysis for the key press condition showed that RTs were equivalent across the two groups of participants (native English speakers $MD = 30$ms; native Russian speakers $MD = 24$ms; $p = .62$). This result shows that the two groups were comparable in terms of the magnitude of the interference effect. However, in the voiced English condition, the mean difference score (*MD*s) was significantly larger for native Russian speakers ($MD = 137$ms) than for native English speakers ($MD = 73$ms), $F(1,34) = 8.935$, $p < .01$. Moreover, as can be seen from Figure 4.4, the mean RTs for the voiced conditions for both groups were significantly longer than the RTs for the key press condition (both *p*'s $< .001$). In line with previous research (see MacLeod, 1991), these results indicate that more interference was created in the voiced conditions than in the key press condition.

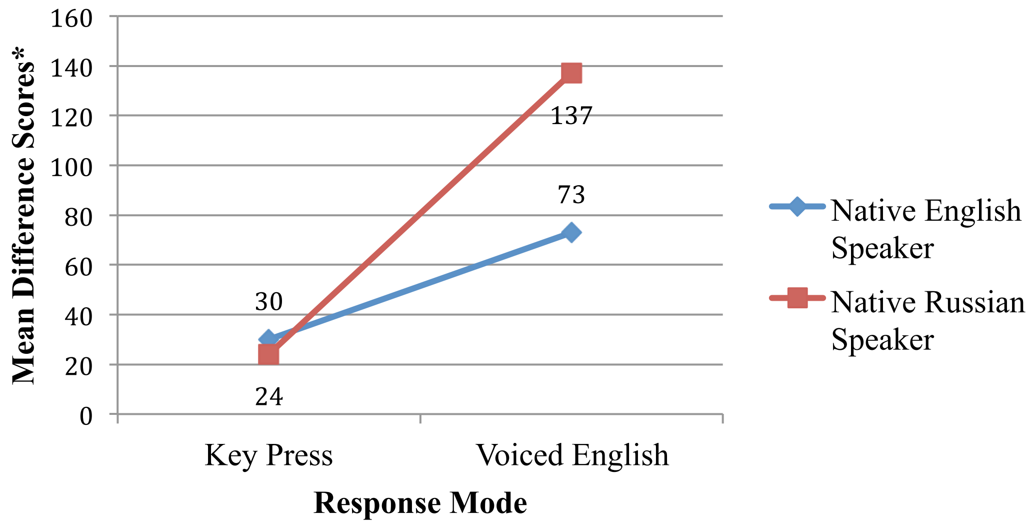

Figure 4.3. Interaction between response mode and group membership for English color words in Experiment 1. *Note that mean difference score were used in this figure.

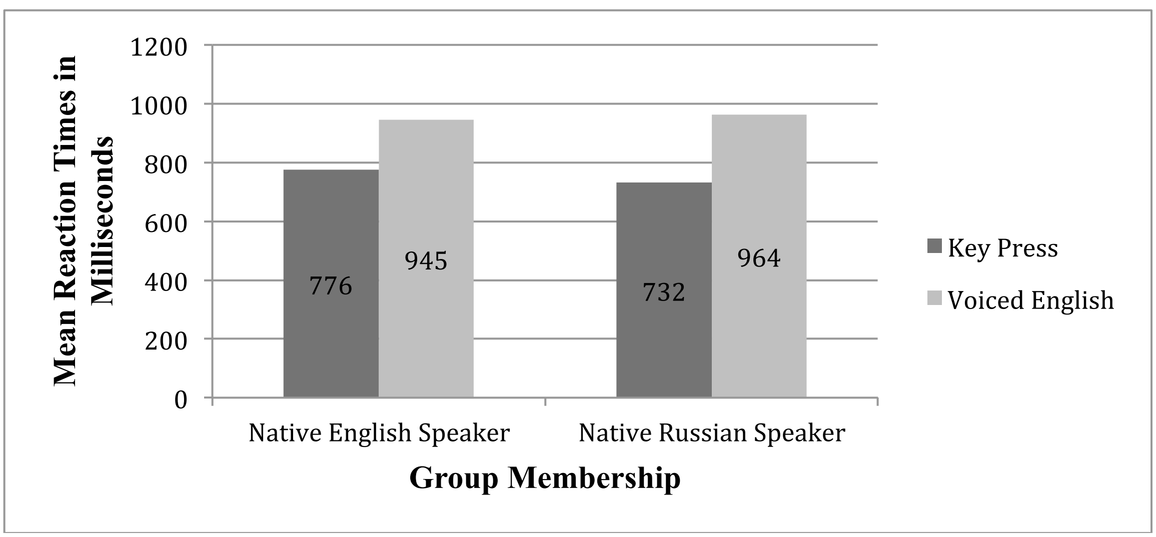

Figure 4.4. Mean reaction times for English color words for both groups across response mode in Experiment 1.

Also, while both groups showed a within-language (English words, English response) Stroop effect, the native Russian speakers showed larger mean difference scores than native English speakers. Note the longer RTs for the incongruent responses for the native Russian speakers on Table 4.3. One explanation for the greater Stroop effect with English words for the native Russian speakers is that these participants may be on the brink of becoming English dominant. This notion is further supported by the fact that their performance in the key press condition mirrored their performance in the voiced English condition (i.e., larger interference with English words). Considering that English is the language these native Russian speakers use with greater frequency (when reading and writing) the results of the key press and voiced conditions with English words make sense. A second and equally probable explanation for this finding is that the native Russian speakers not only had to detect agreement between a printed word and printed color but they also had to generate a linguistic response in their second language (recall that in the voiced English condition all responses were in English) which presumably took them longer to do. That is, the voiced condition already introduced the additional requirement of a verbal response but in addition to that, the native Russian speakers had two possible choices for a response – English or Russian –while the native English speakers had only one choice – English. Thus, producing a linguistic response in their second language may have placed an additional processing demand (i.e., greater interference) on the native Russian speaker that was not present for the native English speakers.

Next, an analysis of variance was conducted on the Russian words. Remember that the native English speakers showed no evidence for a Stroop effect with the Russian words so their data are not considered in the next analysis (see *t*-values, Table 4.4). Therefore a one-way repeated measures analysis of variance was conducted on the RTs (using difference scores) comparing the key press, voiced English and voiced Russian conditions for native Russian speakers only. Mauchly's test for sphericity indicated that the assumption of sphericity had been violated for the main effect of *Mode*, χ^2 (2) = 11.032, p < .004. Therefore degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity ($\varepsilon = .667$). A significant main effect for *mode* was found, $F(1.335, 22.694) = 18.057$, $p < .001$. The Stroop effect occurred in all three modes (key press, voiced English, voiced Russian) for the native Russian speakers. Follow-up analysis shows that they took longer to respond in the voiced Russian (Russian words, Russian response) condition (*MD* =116ms) than the voiced English (Russian words, English response) condition (*MD* = 57ms) and in the voiced English (*MD* = 57) condition compared to the key press condition (*MD* = 14ms), $F(1, 17) = 8.526$, $p < .01$ and $F = 22.043$, $p < .001$ respectively. This indicates that the within-language effect (Russian word, Russian response) was greater than the cross-language effect (Russian word, English response) for Russian words for these native Russian speakers. Taken together, these results also indicate that more interference is created in the voiced conditions than in the key press condition.

Conclusions and Discussion

To summarize, the native Russian speakers demonstrated the expected within language Stroop effect (English words, English response; Russian words, Russian response) in all response modes (key press, voiced English and voiced Russian). They also demonstrated a *larger* within-language Stroop effect when responding in English (i.e., English word-English response) than when responding in Russian (i.e., Russian word-Russian response). While within-language Stroop effects are typically larger than cross-language Stroop effects for bilingual/ multilingual speakers (see Francis, 1999, 2005; MacLeod, 1991), the effect is usually larger in their native and/or *dominant* language (Altarriba & Mathis, 1997; Chen & Ho, 1986; Mägiste, 1985; also see Heredia & Altarriba, 2001; Heredia, 1996; 1997; 2008). Therefore these data indicate that as language dominance *shifts* from L1 to L2 there is greater conceptual interference when responding in L2 as compared to responding in one's native language (L1). This contradicts Kroll and Stewart's (1994) position that L1 links to the conceptual system are always stronger and more susceptible to semantic manipulations. In addition, for these native Russian speakers, English may now be their dominant, i.e., *stronger,* language. The failure to produce a cross-language Stroop effect (English words, Russian response) in the voiced Russian condition, despite being relatively balanced bilinguals (see Table 4.2), also supports the language dominance position. This notion is further supported by the fact that their performance in the key press condition mirrored their performance in the voiced conditions (greater interference with English words). Considering that English is currently the language these native Russian speakers use with greater frequency (when reading and writing) the results of the key press and voiced English conditions make sense. Taken together, these data suggest that language dominance (e.g., use of a language) (Heredia, 1997; Heredia & Altarriba, 2001) is as important, if not more, than language proficiency (e.g., knowledge of a language) (Mägiste, 1985)[2]. This also is not predicted by the RHM since one's native language is always presumed to be better developed and to have greater accessibility to the conceptual system.

The native English speakers demonstrated the expected within-language Stroop effect in both response modes (voiced and key press). However, as novice language learners, these speakers did not demonstrate the predicted cross-language Stroop effect in either mode. This suggests, contrary to Altarriba and Mathis' (1997) data that, even though the difference was in

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[2] While Mägiste (1985) is known for the *proficiency hypothesis* when discussing the shift that may occur when bilingual speakers begin to use one language more frequently than the other the description is one of *dominance (i.e., usage)* rather than proficiency (i.e., knowledge).

the predicted direction, there was no statistically significant conceptual interference across languages. By extension, this indicates that these novice language learners were not automatically processing Russian words at the conceptual level as predicted. Instead, as the RHM predicts (Kroll & Stewart, 1994), these novice language learners were able to *ignore* the *meaning* of the Russian color words in order to process ink color because they *had yet to form a direct link* to the conceptual system and were therefore unaffected by the Cyrillic script. As such, these findings lend some credibility to the power of the RHM to accurately predict the performance of novice language learners at the earliest stage of second language acquisition.

However, the role of another factor, the presentation of Russian words in Cyrillic script, warrants further investigation. By using the Cyrillic alphabet, the native English speakers were kept from using orthography and more importantly, phonology to automatically access the conceptual system. According to Masoura and Gathercole (1999) the phonological loop plays the same vital role of supporting the long-term retention of phonological forms whether learning new and unfamiliar words in a foreign language or when learning new and unfamiliar words in one's native language. That is, phonology is just as vital for foreign language learning as it is for native language learning. Moreover, the ability of an experienced reader to 'decode' a previously unknown word is accomplished at the prelexical phonological level and not at the lexical and/or conceptual level (Van Orden, 1987; Baddeley, Gathercole, and Papagno, 1998; Gathercole, 2006).

It has also been shown that learning new words particularly in languages that share the same alphabet is significantly aided by phonological processing (Van Orden, 1987; Baddeley, Gathercole, and Papagno 1998; Frost, 1998; Dijkstra, Grainger, and van Heuven, 1999; Gathercole, 2006). This follows from evidence that when engaged in visual word recognition this process involves automatic but not necessarily obligatory phonological coding at a prelexical level (e.g., Frost, 1998; Perfetti & Bell, 1991; Van Orden, 1987; Van Wijnendaele, & Brysbaert, 2002). Such evidence has been taken to suggest that letters must first be converted to sounds before the actual printed word can be recognized, and that this conversion is automatic and not under conscious control. Given the amount of research that supports the importance of orthographic-to-phonemic conversions in word recognition and word production, the next two experiments were motivated by the fact that orthography *and* phonology do play vital roles in visual word processing, especially when learning a new language.

5. EXPERIMENT 2: EXPLORATIVE COMPARISONS BETWEEN RUSSIAN (TRANSLITERATED) AND ENGLISH COLOR WORDS IN THE VOICED CONDITION

Background

The data from Experiment 1 indicate that when novice language learners were presented with congruent and incongruent color word pairs in their native language (English) they experienced semantic interference. This finding was consistent across both response modes (key press and voiced). Thus, these novice language learners demonstrated the predicted within language Stroop effect in their native language. However, when presented with congruent and incongruent color word pairs in Russian, using Cyrillic script, they did not experience semantic interference. This finding was also consistent across response modes. Hence, these novice language learners did not demonstrate the predicted cross-language Stroop effect. However, it should be noted that the difference between congruent and incongruent trials was in the predicted direction but failed to reach significance. Therefore, these results support the developmental predictions of the RHM as related to beginning second language learners but fail to replicate those of Altarriba and Mathis (1997) since these authors had shown that novice second language learners could produce a cross-language Stroop effect.

As mentioned previously, there are several possible reasons for the differences in findings. First, Altarriba and Mathis used Spanish-English color words pairings in their study while I used Russian (Cyrillic) - English pairings. Not only is Spanish a frequently heard language but it is also a frequently seen language. Therefore, there is a degree of *familiarity* between Spanish and English that does not exist between Russian and English (in the United States). For example, even if people do not associate these familiar words (i.e., *amarillo* or *verde*) with the colors yellow or green, the words were likely to be familiar on some level either phonetic and/or semantic. Another example of how commonplace Spanish is can be found in the word *Amarillo* in Amarillo, Texas. While it may not be pronounced the same (unless you are a Spanish-speaking individual) *amarillo* identifies the color yellow as well as a town in Texas. Still another example is the word *verde*. Verde in *chili verde* means that the chili is green. Both of these are common terms (and there are many more) in the English lexicon despite being Spanish words. So while participants in Altarriba and Mathis' study may never have had formal instruction in Spanish it is probable that they may have been exposed to some Spanish words via school, television, the news media and/or the Internet. Given this, the likelihood that the participants in the Altarriba and Mathis study were true "novices" in the Spanish language, particularly when it comes to color words, is highly unlikely. In contrast, Russian is not as commonly seen nor heard in the United States. Thus, the use of Spanish by Altarriba and Mathis as the non-targeted language may have enhanced their study findings due to its similarity to and regular infusion into the English lexicon. As such, using Spanish calls into question the claim that the novice second language learners in the Altarriba and Mathis study were completely unfamiliar with Spanish.

Second, not only is Spanish a frequently seen and heard language but it also shares the same alphabet as English (with a few exceptions such a *ñ* and *ll*). The use of Cyrillic in Experiment 1 probably (significantly) hampered the word processing skills of the native English speakers on two levels. First, by presenting the Russian color words in Cyrillic the native English speakers did not receive any interference from the different script thereby enabling them to complete the task quickly (and correctly). In the Stroop task a major source of interference arises because a participant may experience difficulty inhibiting the natural (i.e., *automatic)* tendency of reading of the target color word when the task is to instead identify the color of ink that the word is printed in. Since the native English speakers could not *read* the Russian color words, because they were written in an unfamiliar script, they were unaffected by the potential orthographic cues (i.e., letters) embedded in each word. They could more easily refrain from reading the Russian color words, hence no cross-language Stroop interference was found.

Third, since Cyrillic would be non-phonetic for a non-native speaker it would decrease their ability to automatically decode the unknown phonology. That is, a second source of interference on the Stroop task arises because either the word's orthographic or *phonological* structure activates the automatic (i.e., non strategic) response of decoding the word (see Frost, 1998 for a review). So when the native English speakers were presented with color words written in Cyrillic they were also unaffected by the available phonological cues (i.e., individual phonemes) because they could not pronounce any phonemes within each of the Russian color words. Therefore this double mismatch (i.e., orthography and phonology) enabled the native English speakers to ignore the word and its accessible meaning.

While the Cyrillic script in Experiment 1 was utilized precisely because it did not share the same alphabet or phonological structure of English, it may have made it virtually impossible for the native English speakers to be affected by any source of interference from the Russian color words. This is one reason why using Spanish in the Altarriba and Mathis (1997) study may have contributed to the cross-language effect for their novice learners: even if the participants did not explicitly know the Spanish words they could still be affected by the similarities in the orthographic and phonological cues afforded in the Spanish color words. Moreover, since an overt L2 response was not required, the ability to test hypotheses regarding the facilitative effects that Spanish had in the Altarriba and Mathis study was limited.

Therefore, recognizing that orthography and phonology may serve to inhibit (or facilitate) the reading of words during visual word processing in a Stroop interference task the use of different stimuli was in order. Since Russian can be written in *both* Cyrillic and Roman script via *transliteration*, a new set of stimuli were designed to disentangle the influence of orthographic and phonological differences between Russian and English. It was reasoned that if native English speakers could use their native phonology (i.e., English phonetics) to help decode Russian color words then an interference effect could be demonstrated and by extension would reveal that lexical and conceptual representations develop together rather than separately when learning a new language.

In Experiment 2, using transliterated Russian color-terms (i.e., Russian color words written in Roman script), native English speakers (i.e., novice language learners) with no prior knowledge of written or spoken Russian, were trained and tested on a bilingual English-transliterated Russian Stroop task. Based on preliminary pilot testing, the particular spelling of the transliterations were chosen because they were phonetically distinct and pronounceable to both non-native Russian and native Russian speakers. It was predicted that the native English speakers would demonstrate a Stroop effect in both English and Russian because the use of Romanized script would make the transliterations more salient (i.e., pronounceable) and less easily ignored. This prediction was based on the recognition that orthography and phonology play significant roles in visual word processing. While orthography and phonology may play a different role in visual word processing, based on the task demands, only the voiced condition was used in Experiment 2 given the differential ability of each task to capture the effects of Stroop interference.

Given the null findings with Russian color words, written in Cyrillic, in Experiment 1 for native English speakers other changes were implemented to test participants under optimal conditions. It was reasoned that if a cross-language Stroop effect exists these procedural changes would enable its detection. Therefore, if a cross-language Stroop effect was found (using transliterations) in Experiment 2, further exploration in a third experiment would be warranted. These procedural changes are reported below.

First, participants were asked to respond in both English *and* Russian. It was reasoned that by making the Russian colors words pronounceable that the native English speakers could articulate a response in Russian when presented with transliterations instead of Cyrillic script. It was predicted that while responding in Russian would now be possible for the native English speakers, it would take longer to respond in Russian than in English. Second, unlike Experiment 1 where the stimuli were presented in mixed language lists (English and Russian interspersed), in Experiment 2 the stimuli were blocked by language one after the other (English list than transliterated Russian list or vice versa). It was believed that by presenting the stimuli in blocked lists by language, participants would be encouraged to take advantage of orthographic and phonological cues since they would know, ahead of time, which language to pronounce the words in.

By using transliterations the task becomes more comparable to a translation task where pseudowords are used. The difference here is that transliteration is the actual practice of converting text from one script to another by substituting the Cyrillic alphabet characters with Roman alphabet characters. Therefore, transliterations are *real* words not pseudowords (nonwords that are phonologically pronounceable to participants). Third, only within-language (English words, English response; transliterated Russian words, Russian response) conditions were used. This decision was motivated by the fact that within-language effects on the Stroop task are typically of a greater magnitude than those found in cross-language conditions. While cross-language effects are robust (about 68% to 75% of within-in language effects) the magnitude of the effect is usually moderated by a person's familiarity with his or her second language (e.g., Dyer, 1971; Macleod, 1991; Francis, 1999), and typically shows a greater degree of interference in the dominant language (e.g., Mägiste, 1985). Fourth, a third type of stimuli was introduced to help disentangle the facilitative aspects that congruent pairs may have on response times: the letters *X* and *O* (i.e., control trials) were randomly interspersed within each language block (see La Heij & Vermeij, 1987; MacLeod, 1991). It was predicted that the control and congruent trials would be responded to more quickly than the incongruent trials. Fifth, participants were only tested in the voiced conditions (English *and* Russian). As noted before, vocal responses tend to be more sensitive to the manipulations of the Stroop task than nonverbal, key press responses.

Experiment 2

Method

Participants

Sixteen native English speakers from the same population described in Experiment 1 were recruited to participate in Experiment 2. All were native English speakers who had no prior classes or experience with the Russian language. All received partial course credit as compensation for their participation.

Stimuli

The stimuli now consisted of eight words: the four English color words, *BLUE, GREEN, RED, YELLOW*, and their transliterated Russian counterparts, *SINIY, ZELYONIY, KRASNIY,* and *ZHOLTIY,* respectively. Each of the eight color words appeared in each of the four colors five times for a total of 160 experimental trials using the color words. The 160 trials were divided into two blocks of 80 trials each. In each block, the four colors appeared ten times. The stimulus words were mixed in a quasi-random fashion in each block, so that neither two of the same colors nor two of the same words were presented on consecutive trials. An additional 40 trials using the letters *X* and *O* (i.e., control trials) were randomly interspersed within each block so that the four colors were presented an additional ten times each per block for a total of 200 experimental trials. One of the two blocks was comprised of English color words and control trials and the remaining block was comprised of the transliterated Russian color words and control trials. Within each block of 80 color words trials (60 incongruent, 20 congruent) and 20 control trials, the stimulus word and response language were the same so as not to mix the languages within each block (e.g., English color word/English response; transliterated Russian color word/Russian response). Control trials were responded to in the same language in which the color words were presented such that the required response for control trials in the English blocks was English and in the Russian blocks the required response was Russian. To counterbalance for possible order effects, two experimental presentation orders were used.

Apparatus

As a result of the high amount of data that was lost, due to timing errors (7.7%) in Experiment 1, all verbal responses were now captured using the *SuperLab Pro SV-1* voice key recorder (Cedrus Corporation, 1997, 2003). The SLP software program kept track of all response times (key press in Experiment 3 and voiced in all remaining experiments). In addition, all verbal responses were again checked, by hand, against a master-response sheet for accuracy.

Materials and Procedure

Diagnostic tasks. To ensure that all participants could identify the colors to be used, the *Ishihara Test for Color Blindness* (ITCB) (Ishihara, 1939) was given. All participants passed the ITCB. Factors such as short-term memory span and executive functioning have been indicated in language learning (see Baddeley, 1986) and as such, two tasks were administered to each participant. To obtain a measure of short-term memory span, which was hypothesized to be instrumental in native language learning (see Gathercole & Baddeley, 1990; Michas & Henry, 1994) as well as foreign language learning (e.g., Cheng, 1996; Service, 1992), all participants were given the *Digit Span* (DS) subtest from the *Wechsler Adult Intelligence Scale – Third Edition* (WAIS-III) (Wechsler, 1997). To obtain a measure of executive functioning, which was hypothesized to be instrumental in measuring an individuals' ability to shift attention from one task to another (Miyake, Friedman, Emerson, Witzki, Howerter, & Wager, 2000), all participants were given the *Wisconsin Card Sorting Test* (WCST) (PAR, 1993).

Language history. All participants completed the *Language Experience and Proficiency Questionnaire* (LEAP-Q) (Marian, Blumenfeld, & Kaushanskaya, 2007) (see Appendix D) to ensure that the participants had no significant prior exposure to the Russian language.

Task administration. The diagnostic tasks were given in a fixed order, namely *ITCB*, *WCST*, and *DS*. Once the experiment was completed each participant completed the *LEAP-Q*. The learning and experimental tasks, however, were counterbalanced across languages, interleaved within the diagnostic tasks and blocked by language. The experimenter remained in the room throughout the experiment. All participants were tested individually. Upon arrival each participant was randomly assigned to one of the two experimental trial presentation orders (English first or Russian first).

Acquisition task. There was one learning (acquisition) task in Experiment 2, preceding the block with transliterated Russian trials. The procedures for the acquisition task were the same as those used in Experiment 1 except that now the Russian color-words were replaced with their transliterations using Roman script (see Stimuli, Experiment 2 and Acquisition Task, Experiment 1).

Translation task. Immediately after the acquisition task participants were given a new quiz (with the transliterations) consisting of five sets of questions (see Appendix E). As in Experiment 1, these questions were designed to stimulate conceptual processing. However, for these questions, participants were required to write their answers in transliterated Russian (i.e., Russian written with *Roman script)*. A copy of the proper spellings of all four transliterated Russian color words was provided to assist them. Corrective feedback was only given on the first set of questions. The format and grading of the five sets of questions was the same as those followed in Experiment 1. All participants met these criteria.

Intervening tasks. Before each practice session a diagnostic task (described above) was given. Each lasted approximately 15 to 20 minutes.

Practice trials. There were two practice sessions, one for each language. Two sets of eight practice trials were constructed using each of the four colors randomly paired twice by term and color of printed word so that each of the eight words were used twice. Half of the practice trials were congruent (term and color matched) and half were incongruent (term and color not matched). One set used only English color words and the other set used only transliterated Russian color words. All responses on the practice trials were *verbal*. Thus on the English practice trials an English response was required and on the transliterated Russian trials a *Russian* response was required. *All participants* met these criteria on the *first* try – no additional practice trials were needed. Practice trials preceded all experimental trials.

Voiced English condition. Instructions, describing the experimental trials, appeared in English on the computer screen and were read aloud by the experimenter. As in Experiment 1, after a warning signal ("+"), which appeared for 1000ms, one of the four English color words appeared in the center of the screen in *Times Roman, 225 pt* font either in red, blue, green, or yellow. The participant's task was to name the color of the font aloud in English into the microphone and not name the printed word itself. Participants were told that the experiment was voice-activated and therefore any noises other than their desired response should be avoided. All responses on the English experimental trials were in English. The word remained on the screen until a response was made and was then followed by a "+" for 600ms. This was immediately replaced by the next word. The computer recorded all RTs while the experimenter checked off the correct and incorrect responses on a master-response sheet.

Voiced Russian condition. Instructions, describing the experimental trials, appeared in English on the computer screen and were read aloud by the experimenter. After a warning signal, which appeared for 1000ms, one of the four transliterated Russian color words appeared in the center of the screen in *Times Roman, 225 pt* either in red, blue, green, or yellow. The participant's task was to name the color of the font aloud in *Russian* ("*SINIY", "ZELYONIY", "KRASNIY",* and/or "*ZHOLTIY"*) into the microphone and not name the printed word itself. Participants were told that the experiment was voice-activated and therefore any noises other than their desired response should be avoided. All responses to the transliterated Russian probes were in Russian. The word remained on the screen until a response was made and was then followed by a “+” for 600ms. This was immediately replaced by the next word. The computer recorded all RTs while the experimenter checked off the correct and incorrect responses on a master-response sheet. Note, since the experimental trials were blocked by language (English word, English response; transliterated Russian word, Russian response), Experiment 2 was entirely a within-language Stroop task. Following the completion of all experimental trials, all participants were asked to fill out the LEAP-Q (see table 5.1) and then debriefed.

Table 5.1

LEAP-Q (Marian, Blumenfeld, & Kaushanskaya, 2007) Results for Native English Speakers in Experiment 2

Mean age in years	28.1
Percentage of the time currently and on average exposed to English	74.2
Percentage of time currently and on average exposed to L2	25.8
Percentage of time you would choose to read a text in English	87.8
Percentage of time you would choose to read a text in your L2	12.2
Percentage of time you would choose to speak in English	73.9
Percentage of time you would choose to speak in L2	26.1
Mean self-rating (10-point scale) of your level of proficiency in:	
Speaking English	9.6
Understanding English	9.6
Reading English	9.6
Mean age of L2 acquisition	4.8
Mean overall self-rating (10-point scale) of second language ability	5.0
Mean self-rating (10-point scale) of your level of proficiency in:	
Speaking L2	5.2
Understanding L2	5.9
Reading in L2	3.9

Note: All but two participants reported language proficiency in a second language (L2), of those (14) four reported speaking a third language and two reported speaking a fourth language. The top second language was Creole (four), followed by two each for Cantonese, French, Spanish, and Ukrainian, followed by one each for Hebrew and Turkish. The third language was Spanish (three) and Hungarian (one). The fourth language was French (one). Also, on the LEAP-Q all comparisons between languages known to an individual must equal 100 percent however, participants in Experiment 2 were specifically asked to compare only English and their strongest L2 if they spoke more than two languages.

Results

The design of this study was such that each participant was tested in all conditions: English and Russian congruent, incongruent, and control match trials in the voiced response mode. Thus, for each participant, six mean RTs were calculated for each condition: English congruent voiced, English incongruent voiced, English control voiced, and so on with the same pattern for Russian (see Congruent, Incongruent and Control columns, Tables 5.2 and 5.3). All responses given corresponded to the language in which the stimuli were presented. Control stimuli required English or Russian responses as indicated by the language in which the stimuli were embedded. As such, control stimuli presented with English words were responded to in English, and control stimuli presented with transliterated Russian words were responded to in Russian.

Table 5.2

Reaction Time Data (in ms) for English Color Words by Match for Native English Speakers in Experiment 2

Comparison	Mean1 (SE) – Mean2 (SE)	Mean Difference (SE)	*t*-value
Incongruent – Congruent	1000 (43) – 939 (41)	61 (22)	2.736*
Incongruent – Control	1000 (43) – 921 (67)	79 (36)	2.195*
Control – Congruent	921 (67) – 939 (41)	-18 (38)	-0.46

*$p < .05$

Table 5.3

Reaction Time Data (in ms) for Russian (Transliterated) Color Words by Match for Native English Speakers in Experiment 2

Comparison	Mean1 (SE) – Mean2 (SE)	Mean Difference (SE)	*t*-value
Incongruent – Congruent	1176 (53) – 1066 (57)	110 (40)	2.720*
Incongruent – Control	1176 (53) – 1180 (43)	-4 (39)	-0.115
Control – Congruent	1180 (43) – 1066 (57)	114 (43)	2.655*

*$p < .05$

Data Trimming

Incorrect responses (0.9%) and outliers (4.4%) were not included in these analyses and constituted 5.3% of the overall data. Response times of less than 200ms or more than *3600ms* were treated as outliers. In addition, response times that exceeded 2.5 standard deviations above or below the mean of each participant were replaced by the value *at* 2.5 standard deviations above or below the participant's mean. These transformed data constituted 1.8% of the overall data and were *included* in the analyses reported here.

Preliminary Analyses

Correlations. Correlations between the predictor variables (digit span and WCST) were calculated to determine whether there were any significant inter-correlations among the variables (see Table 5.4). The results show that there were no significant inter-correlations between short-term memory span and the speed with which participants responded in either Russian or English. While all participants took longer to respond in Russian than in English the results suggest that short-term memory span and the ability to shift from one task to another were not implicated in this difference.

Table 5.4

Correlations Between Responses Across Language and Predictor Variables for Native English Speakers in Experiment 2

Factor	1	2	3	4	5
		English			
1. Mean English Matches	-----	.30	-.03	.00	-.32
2. Digit Span (Longest)		-----	.25	.38	.06
3. Perservative Response S.S			-----	.84**	.13
4. Percent Conceptual Level Responses S.S.				-----	-.20
5. Learning to Learn R.S.					-----
		Russian			
1. Mean transliteration Russian Matches	-----	.25	-.07	-.02	-.26
2. Digit Span (Longest)		-----	.25	.38	.06
3. Perservative Response S.S.			-----	.84**	.13
4. Percent Conceptual Level Responses S.S.				-----	-.20
5. Learning to Learn R.S.					-----

$p < .01$. Note that this positive correlation value of .84 between factors 3 and 4 is expected and is a function of inter-correlations between items on the WCST. Its presence is a reflection of how the factors on the WCST are designed to load.

Difference scores. Difference scores were calculated by subtracting a) the mean RT of the congruent trials from the incongruent trials, b) the mean RT of the control trials from the incongruent trials, and c) the mean RT of the congruent trials from the control trials in each language. To determine whether or not the data indicate a Stroop effect for the English color words, the difference scores were tested against an expected value of zero (null hypothesis). All difference scores were significantly greater than zero, *p*'s < .05 (see *t*-values, Table 5.2). No facilitation effects were found (i.e., control trials ≈ congruent trials). To determine whether or not the data indicate a Stroop effect for the Russian color words, the difference scores were tested against an expected value of zero (null hypothesis). All difference scores were significantly greater than zero, *p*'s < .05 (see *t*-values, Table 5.3). In addition, a facilitation effect (i.e., control > congruent) was found in the Russian condition. In brief, the calculation of difference scores indicates that the Stroop effect was found in both languages. All remaining analyses were conducted using raw mean scores. A 2 (language) x 3 (match) ANOVA was performed on each set of means for the participants.

Reaction Time Analysis

A 2x3 repeated measures ANOVA was conducted with *Language* (English, Russian) and *Match (*congruent, control, incongruent) as the within subjects factors. Significant main effects were found for both factors: *language*, F (1, 15) = 26.974, p < .001 and *match,* F (2, 30) = 8.272, p < .001. On average, participants took longer to respond in Russian (M = 1140.732ms) than in English (M = 953.631ms). Planned comparisons reveal that RTs were significantly longer for incongruent than congruent trials, F (1,15) = 13.618, p < .002, r = .476. This indicates that participants took significantly longer to respond to incongruent trials (M = 1088.113ms), than to control (M = 1050.902ms) or congruent (M = 1002.515ms) trials. As predicted, RTs between congruent and control trials were not statistically different from one another in the English-only condition. However, in the Russian-only condition there was evidence of facilitation (i.e., control trials > congruent trials), F (1,15) = 6.157, p = .05, r = .291). Thus the Stroop effect occurred between incongruent and congruent matches in both languages: English (*MD* = 61ms) and in Russian (*MD* =110ms) while facilitation only occurred between control and congruent matches in Russian (*MD* = 114ms). It should not be a surprise that the RT data mirrors the difference scores analyses.

Conclusions and Discussion

To summarize, the native English speakers demonstrated the expected within-language Stroop effect in both languages. That is, as novice language learners, these participants demonstrated the predicted interference effect in both English *and* Russian. As such, these data suggest that orthography and phonology play a significant role in visual word processing. More importantly, by modifying the stimuli used in the Stroop task, these novice language learners were able to *speak* (i.e., *lexicalize)* a limited vocabulary in a language unknown to them after only *one* training session. This is clear indication that participants were processing (i.e., *conceptually mediating)* the transliterated Russian words during the Stroop task. Otherwise there would have been no interference or facilitative effects in the Russian-only condition. Providing the native English speakers with a phonological structure they could use allowed the decoding of the transliterated words to occur which, in turn, allowed the decoding process to become *automatic* and unavoidable. This is because phonology actually *primes* the response, which is necessary in order to get a Stroop effect in *spoken* language.

In discussing the results obtained by Altarriba and Mathis (1997) Kroll, van Hell, Tokowicz, and Green, (2009) suggested that the real issue for beginning L2 learners is not gaining access to the L2 lexicon and/or conceptual system but that one cannot get beginning L2 learners to *lexicalize* their responses early in the learning process. By extension, this means that novice learners in the current study should have been *unable* to lexicalize their responses since they had had only one practice session with their new L2 words. However, as the results from Experiment 2 clearly show, not only did the novice L2 learners lexicalize new words after only one practice session with words in a new language but the Stroop task provided the measurement of *form-to-meaning* mappings at the earliest stages of L2 learning. To date there are no other studies that have had novice L2 learners provide a *verbal* response in a newly acquired language after only one practice session. In the next experiment, a replication of these findings was tested and extended to examine whether the findings could be produced in a task where orthography alone rather than combined with phonology exerts an influence (e.g., in the key press condition).

6. EXPERIMENT 3: COMPARISONS BETWEEN ENGLISH AND TRANSLITERATED RUSSIAN COLOR WORDS IN THE KEY PRESS AND VOICED CONDITIONS

Overview

The previous two experiments were designed to explore whether or not novice L2 learners were capable of processing words in a new language after being trained on a limited set of words in that language. It was argued that conceptual knowledge is not tied to any one particular language but that it is instead accessible to the language learner very early on during the acquisition process. Therefore, for an adult learner, minimal exposure to a new language is required to activate conceptual information for use in that language. It was also shown, in Experiment 1, that the predictions of the RHM were inaccurate for bilingual speakers when their L2 becomes their dominant language. In Experiment 1 the results did not bear this out for native English speakers who were introduced to a language unknown to them (Russian). Several reasons for these null results were presented and explained. Modifications were then made to address these concerns from Experiment 2. The results from Experiment 2 showed that modifying the task enabled the novice L2 learner to process words in a new language after only one practice session. That is, by modifying the new language (transliterated Russian) to resemble the phonology of the known language (English) access to the shared conceptual system was made possible. The resemblance was visually induced to increase the phonology salience.

To explore the possible effects of orthography with transliterations a third experiment was conducted. In Experiment 3, using the same stimuli and procedures from Experiment 2, a second group of native English speakers was trained and tested on a bilingual English-transliterated Russian Stroop task. The key press (i.e., nonverbal) condition was also reintroduced (from Experiment 1) to determine whether the Stroop effect found in Experiment 2 could be replicated when the task demands shifted from a verbal response, which automatically activates the phonological systems (see Frost, 1998; Van Orden, 1987), to a nonverbal response, which does not necessarily activate the phonological system (Frost, 1998). Remember that the key press condition was not as sensitive to the effects of Stroop interference because participants could adopt the strategy of ignoring the printed word by controlling reading. For the native Russian speakers in Experiment 1 this proved difficult (and unavoidable) because in both versions (English and Russian) of the key press condition the orthography and phonology of the printed words was accessible to them. For the native English participants the fact that they could not 'decode' the orthography or phonology of Cyrillic made the task of ignoring the printed word that much easier. However, since I controlled for both the orthographic and phonological difference in the scripts by using transliterations the advantage that the native English participants had in Experiment 1 in ignoring the printed word and controlling their reading may now be minimized.

Therefore, Experiment 3 was designed to address the discrepancies found between Experiment 1 and 2 by extending the findings of Experiment 2 using both key press and voiced modes. In addition, the changes that were made in Experiment 2 need to be replicated in order to determine if the interference effect found for the Russian-only condition was real. These changes included: 1) changes to control for orthographic and phonological differences in the two scripts and 2) inclusion of a control condition. Also, with the inclusion of the key press condition an additional practice session was provided (before the transliterated key press condition), which increased the number of practice sessions. This change brought the number of practice sessions to four: two in the Russian-only and two in the English-only conditions.

It was again reasoned that the task demand of articulating a word in a 'new' language would require more time than articulating a word in English. It was hypothesized that the native English speakers would demonstrate a Stroop effect in both English and Russian; that verbal responses would show a larger Stroop effect (i.e., slower RTs) than key press responses given that verbal responses required the additional step of *lexicalizing* (i.e., articulating) the response; and that the facilitative effects of congruent trails would be minimized by the inclusion of control trials.

Experiment 3

Method

Participants

Twenty-four native English speakers from the same population described in Experiments 1 and 2 were recruited to participate in Experiment 3. All were native English speakers who had no prior experience with the Russian language. All received partial course credit as compensation for their participation.

Stimuli

The same stimuli were used from Experiment 2. However, the ratio of presentation was increased since the key press task was added. Each of the eight color words appeared in each of the four colors ten times for a total of 320 experimental trials using the color words. The 320 trials were divided into four blocks of 80 trials each. In each block, the four colors appeared twenty times. An additional 80 trials using the letters *X* and *O* (i.e., control trials) were randomly interspersed within each block so that the four colors were presented an additional twenty times each per block for a total of 400 experimental trials (200 in each language, 100 per each condition).

Two of the four blocks were comprised of English color words and control trials and two blocks were comprised of the transliterated Russian color words and control trials. Within each block of 80 color word trials (60 incongruent and 20 congruent) and 20 control trials, the stimulus word and response language were the same so as not to mix the languages within each block (e.g., English color word/English response; transliterated Russian color word/Russian response). Control trials were responded to in the same language in which the color words were presented such that the required response for control trials in the English blocks was English and in the Russian blocks the required response was Russian. To counterbalance for possible order effects, four experimental presentation orders were used: Order 1 = English key press, English voiced, Russian key press, Russian voiced; Order 2 = English voiced, English key press, Russian voiced, Russian key press; Order 3 = Russian key press, Russian Voiced, English key press, English voiced; and Order 4 = Russian voiced, Russian key press, English voiced, English key press.

Materials and Procedure

Diagnostic tasks. All participants were given *ITCB*, *WCST* and *DS*. In addition, to obtain a measure of general reasoning ability, all participants were given the following subtests: *Block Design* (BD) and *Vocabulary* (Voc) from the *Wechsler Abbreviated Scale of Intelligence* (WASI) (Wechsler, 1999). BD provides a measure of nonverbal, visual-spatial reasoning ability while Voc provides a measure of verbal linguistic ability.

Language history. All participants completed the *Language Experience and Proficiency Questionnaire* (LEAP-Q).

Task Administration. The diagnostic tasks were administered in a fixed order, namely *ITCB*, *Block Design*, *Vocabulary*, *WCST*, and *Digit Span*. Separately, each task lasted 15 to 20 minutes and the entire experimental procedure took approximately two hours to complete. Once the experiment was completed each participant completed the *LEAP-Q*. The learning and experimental tasks, however, were counterbalanced across language and response mode, interleaved within the diagnostic tasks and block by language. The experimenter remained in the room throughout the experiment. All participants were tested individually. Upon arrival each was randomly assigned to one of the four presentation orders for participation in the experiment.

Acquisition and translation tasks. There were two learning (acquisition) tasks in Experiment 3, each proceeding a block with transliterated Russian trials (one in the key press condition and one in the voiced condition). The stimuli, procedures, and results for the acquisition task were the same as those used in Experiment 2 (see Acquisition task, Translation Task and Stimuli, Experiment 2). However, an additional set of questions was added following the second practice session with transliterated Russian words (see Appendix F). All participants met the criteria for passing the acquisition and translation tasks.

Practice trials. There were four practice sessions, one for each language by response mode condition. Four sets of eight practice trials were constructed using each of the four colors randomly paired twice by term and color of printed word so that each of the eight words was used twice. Half of the practice trials were congruent (term and color matched) and half were incongruent (term and color not matched). Two sets used only English color words, one for the key press condition and the other for the voiced condition. The other two sets used only transliterated Russian color words, one for the key press condition and the other for the voiced condition. *All participants* met these criteria on the *first* try – no additional practice trials were needed. Practice trials preceded all experimental trials.

Voiced condition in English and Russian. The same procedures and experimental trials from Experiment 2 were used.

Key press (nonverbal) condition in English and transliterated Russian. The procedure was the same as in the voiced experimental trials except that all responses were now nonverbal and recorded via the SuperLab Pro RB600 response box. Following the completion of all experimental trials, all participants were asked to complete the LEAP-Q (see Table 6.1), debriefed and given partial course credit for their participation.

Table 6.1

LEAP-Q (Marian, Blumenfeld, & Kaushanskaya, 2007) Results for Native English Speakers in Experiment 3

Mean age in years	17.6
Percentage of the time currently and on average exposed to English	94.4
Percentage of time currently and on average exposed to L2	5.6
Percentage of time you would choose to read a text in English	93.5
Percentage of time you would choose to read a text in your L2	6.5
Percentage of time you would choose to speak in English	92.8
Percentage of time you would choose to speak in L2	7.2
Mean self-rating (10-point scale) of your level of proficiency in:	
Speaking English	9.8
Understanding English	9.8
Reading English	9.9
Mean age of L2 acquisition	2.8
Mean overall self-rating (10-point scale) of second language ability	3.6
Mean self-rating (10-point scale) of your level of proficiency in:	
Speaking L2	3.9
Understanding L2	4.2
Reading in L2	2.8

Note: Fourteen (out of 24) participants reported language proficiency in a second language. The top L2 was Spanish (four), followed by Hebrew (three), Albanian (two), and one each for Cantonese, Creole, Greek, Polish, and Tagalog. None of the participants reported speaking a third language.

Results

The design of this study was such that each participant was tested in all conditions: English and transliterated Russian congruent, incongruent, and control match trials in both voiced and key press response modes. Thus, for each participant, 12 mean RTs were calculated for each condition: English congruent voiced, English incongruent voiced, English control voiced, English congruent key press, English incongruent key press, English control key press, and so on with the same pattern for transliterated Russian (see Congruent, Control and Incongruent columns, Tables 6.2 and 6.3). All responses given corresponded to the language in which the stimuli were presented. Control stimuli required English or Russian responses as indicated by the language in which the stimuli were embedded. As such, control stimuli presented with English words were responded to in English, and control stimuli presented with transliterated Russian words were responded to in Russian.

Table 6.2

Reaction Time Data (in ms) for Key Press Condition Across Language by Match for Native English Speakers in Experiment 3

English Color Words			
Comparison	Mean1 (SE) – Mean2 (SE)	Mean Difference (SE)	*t*-value
Incongruent – Congruent	826 (51) – 774 (40)	53 (24)	2.225*
Incongruent – Control	826 (51) – 782 (35)	44 (24)	1.846
Control – Congruent	782 (35) – 774 (40)	8 (15)	0.566
Transliterated Russian Words			
Comparison	Mean1 (SE) – Mean2 (SE)	Mean Difference (SE)	*t*-value
Incongruent – Congruent	1000 (121) – 898 (70)	102 (64)	1.580
Incongruent – Control	1000 (121) – 884 (67)	116 (78)	1.485
Control – Congruent	884 (67) – 898 (70)	14 (23)	0.549

*$p < .05$

Table 6.3

Reaction Time Data (in ms) for Voiced Condition Across Language by Match for Native English Speakers in Experiment 3

English Color Words			
Comparison	Mean1 (SE) – Mean2 (SE)	Mean Difference (SE)	*t*-value
Incongruent – Congruent	1106 (76) – 1086 (89)	20 (52)	0.386
Incongruent – Control	1106 (76) – 992 (82)	114 (37)	3.089**
Control – Congruent	992 (82) – 1086 (89)	-94 (63)	1.493

Transliterated Russian Color Words			
Comparison	Mean1 (SE) – Mean2 (SE)	Mean Difference (SE)	*t*-value
Incongruent – Congruent	1885 (141) – 1611 (100)	274 (79)	3.476**
Incongruent – Control	1885 (141) – 1597 (89)	288 (85)	3.389**
Control – Congruent	1597 (89) – 1611 (100)	-14 (59)	0.233

$^{**}p < .01$

Data Trimming

Incorrect responses were not included in these analyses and constituted 2.9% of the overall data. Response times of less than 200ms were treated as outliers. Outliers constituted less than 1% of the overall data and were also not included in these analyses. In addition, response times that exceeded 2.5 standard deviations above or below the mean of each participant were replaced by the value *at* 2.5 standard deviations above or below the participant's mean. These transformed data constituted 3% of the overall data and were *included* in the analyses reported here.

Preliminary Analysis

Correlations. Correlations between the predictor variables (*DS, BD, Voc and WCST)* were calculated to determine whether there were significant inter-correlations among the variables (see Table 6.4). As in Experiment 2, none of the diagnostic tasks correlated with the mean RTs for English matches. However, there was a negative correlation (-.53, $p < .01$) between mean RTs for Russian matches and BD (block design). This seems to indicate that weaker nonverbal, visual-spatial abilities corresponded to higher (i.e., longer) response times when presented with conflicting visual information such as was found on the Stroop tasks.

Table 6.4

Correlations Between Responses Across Language and Predictor Variables for native English Speakers in Experiment 3

Factor	1	2	3	4	5	6	7
			English				
1. Mean English Matches	-----	-.34	-.53**	-.22	-.04	.25	.24
2. Vocabulary S.S		-----	.43	.08	.04	-.15	-.09
3. Block Design S.S.			-----	-.12	.27	.22	.04
4. Digit Span (Longest)				-----	-.16	-.36	.03
5. Perservative Response S.S.					-----	.84**	.39
6. Percent Conceptual Level Responses S.S.						-----	.53**
7. Learning to Learn R.S.							-----
			Russian				
1. Mean transliterated Russian Matches	-----	.02	-.36	-.15	.15	.21	.12
2. Vocabulary S.S		-----	.43	.08	.04	-.15	-.09
3. Block Design S.S.			-----	-.12	.27	.22	.04
4. Digit Span (Longest)				-----	-.16	-.36	.03
5. Perservative Response S.S.					-----	.84**	.39
6. Percent Conceptual Level Responses S.S.						-----	.53**
7. Learning to Learn R.S.							-----

p < .01. Note that this positive correlation value of .84 between factors 3 and 4 is expected and is a function of inter-correlations between items on the WCST. Its presence is a reflection of how the factors on the WCST are designed to load.

Difference scores. To determine whether or not the data indicated a Stroop effect for the English color words in each mode, the difference scores were tested against an expected value of zero (null hypothesis). All difference scores indicating an interference effect (i.e., incongruent minus control and/ or congruent trials) were significantly greater than zero, *p*'s $< .05$ (see *t*-values, Table 6.2). To determine whether or not the data indicated a Stroop effect for the Russian color words in each mode, the difference scores were tested against an expected value of zero (null hypothesis). Difference scores indicating an interference effect in the voiced condition were significantly greater than zero, *p*'s $< .01$ (see *t*-values, Table 6.3). However, no interference effect was found in the key press condition. In addition, no facilitative effects were found in either mode. In brief, the analysis of difference scores indicates that the Stroop effect was found in both languages and was dependent on the response mode. All remaining analyses were conducted using raw mean scores.

Reaction Time Analysis

Preliminary analyses showed that RTs in the voicing condition were significantly longer than for the key press condition (voicing $M = 1379$ms; $SE = 76.05$; key press $M = 861$ms; $SE = 56.21$). An inspection of the data displayed in Tables 6.2 and 6.3 indicates that this finding was consistent across all factors. Because a comparison between these two dependent measures is not of central concern to this study, the following analyses were conducted on each dependent measure separately. The first analysis to be reported was conducted on the key press condition. A 2x3 repeated measures analysis of variance was conducted with *Language* (English, Russian) and *Match* (Congruent, Control, Incongruent) as the within subjects factors. Significant main effects were found for both factors: *language,* $F(1, 23) = 4.09$, $p < .05$ and *match,* $F(2, 46)$ 3.16, $p < .05$. However, there were no interaction effects to report. Follow-up analyses showed that the reaction times for the incongruent trials ($M = 826$; $SE = 51$) were significantly longer than the congruent trials ($M = 774$; $SE = 40$) for the English but not the Russian trials, $t(23) = 2.23$, $p <$

0.037. This finding indicates a Stroop effect in English but not Russian when key press responses were measured.

The second analysis on the same factors but using the voicing condition as a dependent measure showed a statistically significant interaction (see Figure 6.1) as well as main effects for both factors: *language,* F (1, 23) = 39.56, $p < 0.0001$ and *match,* F (2.46) = 7.85, p <0.001. In English, the incongruent trials (M = 1106; SE = 76) were significantly longer than the control trials (M = 992; SE =82) but not the congruent trials (M = 1086; SE = 89), t (23) = 3.089, $p <$ 0.005, whereas in Russian the incongruent trials (M = 1885; SE = 141) were longer than both the congruent (M = 1611; SE = 100), t (23) = 3.476, p <0.002 and control trials (M = 1597; SE = 89), t (23) =3.389, $p < 0.01$. This finding indicates a Stroop effect in both English and Russian when verbal responses were measured. As one might expect, these findings do not differ from those found using difference scores tested against zero (see Tables 6.2 and 6.3).

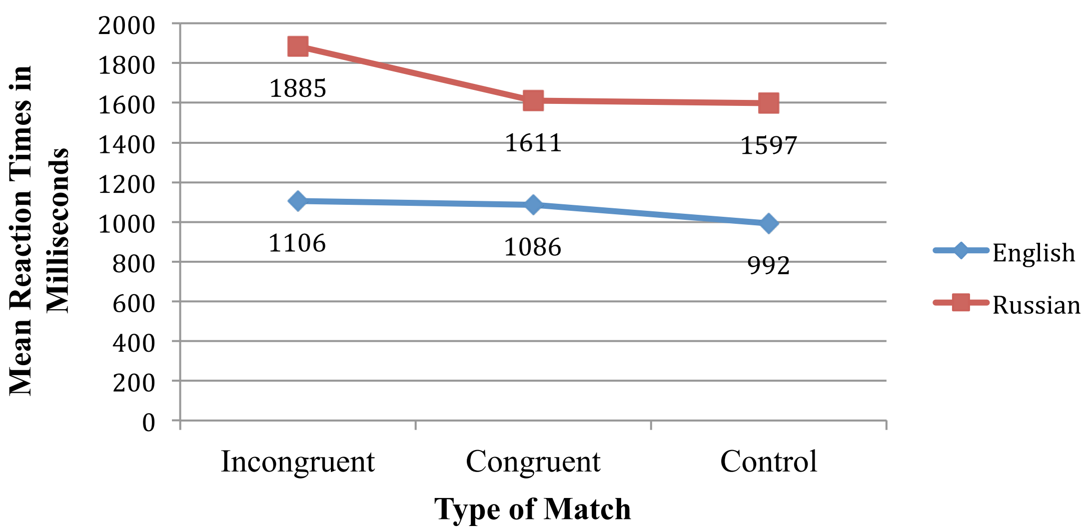

Figure 6.1. Interaction between language and match in the voiced condition for native English speakers in Experiment 3.

Conclusions

To summarize, the native English speakers again demonstrated the expected within-language Stroop effect in both languages. However, while the results were replicated in the voiced condition in both languages, they were only produced in the key press condition with English words. The null effect in the key press condition, with transliterated Russian color words, suggests that phonology combined with orthography plays a greater role than each factor plays independently in language learning.

7. GENERAL DISCUSSION

Language proficiency and/or language dominance are both characteristics of bilingual/ multilingual speakers that have been theorized to affect how language is represented in memory. Language proficiency is composed of oral (listening and speaking) and written (reading and writing) components as well as academic and nonacademic language (Hargett, 1998). Language dominance, on the other hand, is related to language usage, i.e., which language is used most and/or preferred more. To be proficient in a second language means to effectively communicate or understand thoughts or ideas through the language's grammatical system and its vocabulary, using its sounds and written symbols (National Clearinghouse for English Language Acquisition, 2008). Using these definitions, an expert bilingual is a fluent or relatively balanced bilingual, i.e., someone who has equal facility in both of his or her languages. An unbalanced bilingual is proficient but still less fluent in one of his or her two languages. A beginning second language learner has had less than two years of experience with his or her second language. All of these types of speakers (fluent, unbalanced, and beginning) may or may not demonstrate a dominant language. However, more often than not they do and for fluent bilinguals it is *not* always their first or native language.

A fourth type of language learner is a *novice learner* and this is the type of learner that was of most interest to me. A novice learner is a non-second language speaker prior to entering the laboratory setting. That is, they were introduced to another language for the purposes of an experimental study. As such, a novice learner provides the perfect opportunity to observe and document the *mapping on* (development) of *lexical items* (word forms) onto *concepts* (their underlying meaning) at the earliest stages of language learning. The research described in this dissertation was designed to explore this time course, of lexical and conceptual representations, in novice learners under optimal learning conditions.

Orthography and phonology were key features of language that were hypothesized to independently and collectively impact how quickly words are recognized and to assist in an individual's ability to access the meaning of words. Both of these features (i.e., factors) ultimately facilitate and/or inhibit the learning of a second (or third) language. Therefore, using two different alphabets (i.e., Cyrillic and Roman), both of these factors were independently and collectively manipulated in order to measure their influence on language learning. As such, the three experiments described here were also aimed at identifying how these two features facilitate and/or inhibit language learning. Together, the findings across the three experiments indicated that language dominance, in the case of fluent bilingual Russian-English speakers and phonology combined with orthography for native English/ non-Russian speakers, play significant and important roles in visual word processing. These results are discussed in relation to the developmental predictions of Kroll and Stewart's (1994) revised hierarchical model (RHM) of bilingual word processing.

Does Language Dominance (i.e., Usage) Have an Impact on How Fluent Bilinguals Process Words in Their Two Languages?

The data from Experiment 1 indicated that when bilingual participants were presented with congruent and incongruent color-word pairs in their native language (Russian) they experienced semantic interference, i.e., they demonstrated the predicted cross-language Stroop effect. This interference effect was consistent across response modes (key press and voiced). However, when presented with congruent and incongruent color-word pairs in their second language (English) they demonstrated an even larger within-language Stroop effect than the native English participants did. This larger within-language Stroop effect was also consistent across response modes and the direction of the magnitude was also the same (i.e., larger effect for the bilingual speakers vs. the native English participants). This larger within-language Stroop effect suggests that the dominant language for these bilingual participants may no longer be Russian. That is, despite being fluent Russian-English speakers, their second language may now be their dominant language (see Heredia, 1997; 2008; Heredia & Altarriba, 2001; Mägiste, 1985). Unfortunately, this result does not support the developmental predictions of the RHM as they relate to fluent bilingual participants.

There are several possible reasons for the larger within-language Stroop effect for the bilingual Russian-English speakers. Perhaps Heredia (1997; 2008) was correct when he asserted that the RHM does not sufficiently describe *all* types of bilinguals. That is, when the RHM is applied to bilinguals whose native language has become "dormant" from lack of use, the predictions of the RHM are incorrect. Heredia pointed out that since the effects of translation direction and strength of priming are not fixed qualities in bilingualism, the differences in bilinguals' performance may be a function of which language is used more frequently rather than a true measure of language fluency.

Likewise, using German-Swedish bilinguals, Mägiste (1985) found that the pattern of within- and cross-language interference on the Stroop task shifted over time. Using a cross-sectional design, Mägiste compared participants who had lived in Sweden an average of 1, 3, 6, 10, or 16 years. Initially, her bilingual but German-dominant participants experienced the greatest degree of interference with German color terms and when responding in German (e.g., within-language interference). After 7 years of residence in Sweden these bilingual participants demonstrated a shift in interference – they now exhibited greater interference with Swedish color terms when responding in German and visa versa (e.g., cross-language interference). However, after 16 years of residence in Sweden, Swedish had now become their dominant language. As a result, these bilingual participants came to experience the greatest degree of interference with Swedish color terms and when responding in Swedish (e.g., within-language interference). Based on these data, Mägiste proposed that the differential patterns of interference were the result of language usage. Thus, whichever language is dominant will determine the pattern of within- and cross-language interference. So like Heredia (1997; 2008), Mägiste believes that language dominance rather than fluency (i.e., size of the lexicons) is a better predictor of how well bilinguals will perform on conceptual and memory tasks.

The RHM does not take into account the possibility of a shift in language dominance and its effect on performance. If fact, Kroll and Stewart (1994) and Dufour and Kroll (1995) maintain that even in balanced bilinguals the L1 lexicon is larger than the L2 lexicon and that the links between the L1 lexicon and the conceptual system are *always stronger* than the links between L2 and the conceptual system. Hence the emphasis is placed on the size to the lexicons rather than on language use (i.e., dominance). However, the performance of the bilingual participants in Experiment 1 indicated that the direction of translation and strength of links between the two lexicons and the conceptual system had shifted as a function of language dominance. Given this, the RHM is not prepared to describe this type of bilingual speaker. Therefore, the RHM should be further modified to provide for a mechanism to address a shift in language dominance and its possible effects in performance.

Does the RHM Effectively Describe the Typical Beginning (i.e., Novice) Adult Second Language Learner?

The data from all three experiments reported here seem to suggest that second language learners are not easily captured by the tenets of the RHM. For example, the average age of L2 acquisition in Experiment 1 was 11.8 for the native Russian speakers (see Table 4.1), making them *late* L2 learners (i.e., after L1 is fully in place).[3] While the RHM was designed to describe and predict the behavior of late language learners found in many US college classrooms this kind of learner may, in fact, be an atypical language learner. That is, most late language learners (in and outside of the classroom) are attempting to master a second (or third) language for survival and/or employment purposes. As such their motivation is different (and possibly greater) than the typical college student who is attempting to complete a college language requirement. As such, the true nature that motivation (and *need)* may play in language learning seems to render the developmental predictions of the RHM incorrect. For example, recent immigrants (including children and adolescents who usually have a fully developed L1) *need* to master English in order to be successful in school and/or work. As such, the old adage *'necessity is the mother of invention'* may be more accurate in predicting the performance of many late language learners than the RHM. And while many may never completely master the phonology and particular aspects of grammar to '*sound native-like*', most will develop sufficient skill in English to be successful. And for many more, especially those who arrive here as youths, their real-world experiences with English will probably make English their dominant language. This is

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[3] Unfortunately the response to this question, age of L2 acquisition, was not gathered for the native English speakers in Experiment 1.

something, that in its current form, the RHM is not capable of explaining. Moreover, all of the native English speakers in the experiments reported speaking (somewhat fluently to fluently) a second (and in some cases a third) language. Therefore, the diversity of the participant population at Brooklyn College may be more reflective of the true nature of an international community within the USA rather than the picture of a 'pure monolingual' versus a 'pure bilingual' population that the RHM hypothesizes about.

Can Novice Adult L2 Learners Have Immediate Access to the Conceptual System Early on During the Learning of L2? And Does It Only Depend on the Size of the L2 Lexicon?

The results from both Experiments 2 and 3 clearly indicated that novice L2 learners could access the conceptual system early on during the learning of L2, as measured by Stroop interference with color words. Moreover, this can occur with minimal exposure. That is, with only one practice session using color words in a new language, novice L2 learners processed *and* verbalized (i.e., *lexicalized*) a response in a new language. This suggests that concepts, while not necessarily interchangeable (e.g., Whorf, 1956), some aspect of the shared and/or underlying meaning is available early on in language learning. It addition, as suggested by Altarriba and Mathis (1997) the size of the L2 lexicon is less important than the actual words known by the L2 learner.

For example, Dufour and Kroll (1995) agreed that some concepts were shared between the languages known to even a less fluent bilingual speaker. They proposed that the degree of overlap in meanings between the two concepts determines the pattern of meaning activation. However, they suggested that the size of the second language lexicon was the key factor in establishing the extent to which conceptual representations linked to L2 can gain from the activation of shared elements in L1. Specifically, it was the activation of an L2 word that was hypothesized to trigger a very limited set of category concepts known in L2 that did not include the equivalent set of category knowledge known in L1. However, in the case of color words, meanings tend to be equivalent across languages rather than approximates. For example, in Russian, the color blue can be divided into light blue (‘*GOLUBOI*’) or dark blue (‘*SINIY*’) yet either term would indicate the concept ‘blue’. Therefore, with color words, the benefit of activating shared concepts in L1 was *not* dependent on the size of the L2 lexicon since these L2 learners only knew four L2 color terms. Instead, the fact that they knew them *well* contributed to their ability to activate their meanings as evidenced by the Stroop effect in the Russian-only condition.

Under What Conditions is L2 Learning Optimized?

Kroll and her colleagues (e.g., Kroll et al., 2009) have suggested that the results of training studies, where novice language learners have demonstrated immediate access to the conceptual system (e.g., Altarriba & Mathis, 1997; Duyck & Brysbaert, 2004), are more a function of practice with a limited sampling of vocabulary than they are a reflection of true conceptual mediation. Yet, this is exactly what happens in language learning, be it native language acquisition or L2 acquisition: individuals, especially in a classroom setting, are exposed to a limited and highly practiced vocabulary set before moving onto more vocabulary and concepts. In fact, that is the whole point of structured language learning, to optimize the learners’ experiences so that they can build on their new vocabulary in order to use their new language as quickly and as efficiently as possible. This type of *over-learning* of familiar words (paired with their meanings) is explicitly encouraged in order to stimulate conceptual processing and hence, facilitate the mapping of new word forms onto '*old, known*' concepts. While native language acquisition is not as structured as it is in a L2 classroom setting, it often includes over-learning of a limited vocabulary that grows as the child learns to manipulate, use, and understand more and more words.

This was why a mixture of items (e.g., matching, sentence completion, etc.) was presented to all participants in the translation tasks across the experiments reported here. In fact, it is believed that the effectiveness of the translations tasks in stimulating conceptual processing was mostly responsible for the semantic interference effects found in Experiments 2 and 3. This type of language training, where multiple avenues for making connections between new and old (words and concepts) are reinforced (in addition to direct translation), are often used in educational and naturalistic settings. For example, via language learning programs such as The *Rosetta Stone,* people now learn a new language in a conceptually enriched environment that fosters rapid and long-lasting language learning. It mirrors native language learning and provides a better language-learning environment than that which was (is) the usual classroom-based learning of former years passed. As such, the simulation of an enriched language-learning environment, as provided via the translation tasks used, was also ecologically valid.

What Are the Implications for Models of Bilingual Language Processing and Adult Language Learners?

In general, the data presented indicate that any model of bilingual memory and language processing must be flexible enough to account for the dynamic nature of bilingualism as well as account for those factors that contribute to better language learning. Such a model must allow for changes in language usage in the bilingual speaker, prior language learning experience (s) of the multilingual speaker, and the language-learning environment of the novice language learner.

While the constraints imposed by any experimental manipulation of naturally occurring phenomena, i.e., bilingualism, force one to qualify his or her results and interpretations the overarching message that these data provided is that some phenomena require better models that can explain more than what is captured in a laboratory experiment. Current hierarchical models of bilingualism, such as the RHM, are not comprehensive enough to capture the full range of bilingual speakers and/or adult language learner. Moreover, these data were collected on adult language learners whose conceptual and linguistic systems are presumed to be mature and fully developed. As such, the data gathered here as well as current hierarchical models of bilinguals are limited in scope with regards to young children who are still in the process of developing both conceptually and linguistically. However, the discovery that access to the conceptual system is available early on in the language learning process, suggests that one can build on what the language learner already knows. That is, given the right learning environment, even the adult learner can 'master' a new language. Moreover, recognizing the dynamic nature of language as well as bilingualism can help one to develop and maintain the language skills of both the beginning and fluent bilingual speaker, irrespective of his or her age.

Appendix A

Language History Questionnaire for All Participants in Experiment 1

Background Questionnaire - Participant # _____
In order for us to analyze the results of this experiment, we need some background information about you and your language abilities. These data will remain strictly confidential.

1. Age: _____ 2. Gender: _____ 3. Level of Education: _________________
4. Major in: _______________ 5. Native Language(s): ______________________
6. Languages spoken at home: ____
7. Languages studied: How long?

Elementary:
______________________________ ______________________________
______________________________ ______________________________
______________________________ ______________________________

Junior High:
______________________________ ______________________________
______________________________ ______________________________
______________________________ ______________________________

High School:
______________________________ ______________________________
______________________________ ______________________________
______________________________ ______________________________

College:
______________________________ ______________________________
______________________________ ______________________________
______________________________ ______________________________

Other:
______________________________ ______________________________
______________________________ ______________________________
______________________________ ______________________________

8. Have you ever lived aboard or traveled for an extensive period of time?
Where? __________________________________ Year? ________________
How long? _____________ Language(s) spoken? ______________________

9. On a scale from 1 (very poor) to 6 (excellent), how do you rate your reading, writing, listening and speaking abilities in the languages you know?

Language: _______________	Language: _______________	Language: _______________
Reading: __________	__________	__________
Writing: __________	__________	__________
Listening: __________	__________	__________
Speaking: __________	__________	__________

10. What percentage of the day is spent speaking?
    English: __________ Russian: __________ Other: __________

11. Number of years lived in U.S.: __________
12. Number of years on U.S. schools: __________
13. Number of years studying English in a classroom setting: __________
14. Number of years studying Russian in a classroom setting: ___________

Thank You!

Appendix B

Translation task for native English speakers in Experiment 1

Participant No.: _________ Native Language: ______________________

1) Please write the Russian color word that matches the given English color word

ГОЛУБО **ЗЕЛЕНЫЙ** **КРАСНО** **ЖЕЛТЫЙ**

RED ____
BLUE ____
GREEN ____
YELLOW ____

2) Please fill in the Russian color word that corresponds to the colored patches.

____
____
____
____

3) Please complete the closed-ended English sentence with a Russian color word.
Once in a ___________________________moon something special happens.
The colors of the USA flag are ___________________________, white, and blue.
Inhabitants of the planet Mars are thought to be___________________________.
Strawberries are red but lemons are ____________________________.

4) Please match the emotion word that is typically associated with the given Russian color word.
ENVY ____________________________
ANGER ____________________________
SAD ____________________________
HAPPY ____________________________

5) Please match a Russian color word with the object that typically appears in that color.
School Bus _________________________
Fire Engine _________________________
Blade of Grass _________________________
Sky _________________________

Appendix C

Translation task for native Russian speakers in Experiment 1

Participant No.: ________ Native Language: ____________________

1) Please write the English color word that matches the given Russian color word

RED **BLUE** **GREEN** **YELLOW**

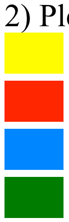
ГОЛУБО ____

ЗЕЛЕНЫЙ ____

КРАСНО ____

ЖЕЛТЫЙ ____

2) Please fill in the English color word that corresponds to the colored patches.



____

____

____

____

3) Please complete the closed-ended English sentence with an English color word.

Once in a _______________ moon something special happens.

The colors of the USA flag are _______________, white, and blue.

Inhabitants of the planet Mars are thought to be _______________.

Strawberries are red but lemons are _______________.

4) Please match the emotion word that is typically associated with the given English color word.

ENVY _________________________

ANGER _________________________

SAD _________________________

HAPPY _________________________

5) Please match an English color word with the object that typically appears in that color.

School Bus ______________________

Fire Engine ______________________

Blade of Grass ______________________

Sky ______________________________

Appendix D

The Language Experience and Proficiency Questionnaire (LEAP-Q) (Marian, Blumenfeld, & Kaushanskaya, 2007).

Language Experience and Proficiency Questionnaire (LEAP-Q)

Last Name First Name Today's Date
Age Date of Birth Male Female

(1) Please list all the languages you know **in order of dominance**:
1 2 3 4 5

(2) Please list all the languages you know **in order of acquisition** (your native language first):
1 2 3 4 5

(3) Please list what percentage of the time you are *currently* and *on average* exposed to each language. (*Your percentages should add up to 100%*):
List language here:
List percentage here:

(4) When choosing to read a text available in all your languages, in what percentage of cases would you choose to read it in each of your languages? Assume that the original was written in another language, which is unknown to you. *(Your percentages should add up to 100%*):
List language here: ____
List percentage here: ____

(5) When choosing a language to speak with a person who is equally fluent in all your languages, what percentage of time would you choose to speak each language? Please report percent of total time. (*Your percentages should add up to 100%*):
List language here: ____
List percentage here: ____
(
6) Please name the cultures with which you identify. On a scale from zero to ten, please rate the extent to which you identify with each culture. (Examples of possible cultures include US-American, Chinese, Jewish-Orthodox, etc):
List cultures here: ____

(7) How many years of formal education do you have? ___________ Please check your highest education level (or the approximate US equivalent to a degree obtained in another country):
Less than High School High School Professional Training
Some College College Some Graduate School
Masters Ph.D./M.D./J.D. Other:

(8) Date of immigration to the USA, if applicable_____________________________

If you have ever immigrated to another country, please provide name of country and date of immigration here. ____

(9) Have you ever had a vision problem ❒, hearing impairment ❒, language disability ❒, or learning disability ❒? (Check all applicable). If yes, please explain (including any corrections): ____

Language: ______________________________

This is my (please select from pull-down menu) language. All questions below refer to your knowledge of .

(1) Age when you:
began acquiring became fluent began reading became fluent reading

(2) Please list the number of years and months you spent in each language environment:
YearsMonths
A country where is spoken
A family where is spoken
A school and/or working environment where is spoken

(3) On a scale from zero to ten, please select your *level of* ***proficiency*** in speaking, understanding, and reading from the scroll-down menus:
Speaking Understanding spoken language Reading (click here for scale)

(4) On a scale from zero to ten, please select how much the following factors contributed to you learning ___________________________:
Interacting with friends (click here for pull-down scale)
Interacting with family (click here for pull-down scale)
Reading (click here for pull-down scale)
Language tapes/self instruction(click here for pull-down scale)
Watching TV (click here for pull-down scale)
Listening to the radio (click here for pull-down scale)

(5) Please rate to what extent you are currently exposed to ____________________in the following contexts:
Interacting with friends (click here for pull-down scale)
Interacting with family (click here for pull-down scale)
Watching TV (click here for pull-down scale)
Listening to radio/music (click here for pull-down scale)
Reading (click here for pull-down scale)
Language-lab/self-instruction (click here for pull-down scale)

(6) In your perception, how much of a foreign accent do you have in ________________? (click here for pull-down scale)

(7) Please rate how frequently others identify you as a non-native speaker based on your accent in ____________________: (click here for pull-down scale)

Appendix E

Translation task for native English participants in Experiments 2 and 3

QZ U1 Participant No. __________ Native Language ____________________________

1) Please fill in the appropriate transliterated Russian color-word.

KRASNIY **SINIY** **ZHOLTIY** **ZELYONIY**

BLUE ___________________________
GREEN ___________________________
RED ___________________________
YELLOW ___________________________

2) Please fill in the appropriate transliterated Russian color-word that corresponds to the colored patches.

 ____
 _____________________________
 _____________________________
 _____________________________

3) Please complete the closed-ended sentence with the appropriate transliterated Russian color-word.
Roses are red, violets are ______________________ .
The colors of the USA flag are ______________________, white, and blue.
Shrek, the ogre in *Shrek* and *Shrek II,* is what color? ______________________.
Strawberries are red but lemons are ______________________.

4) Please match the emotion word that is typically associated with the appropriate transliterated Russian color-word.
PASSION ____________________________
GREED ____________________________
SADNESS ____________________________
HAPPINESS ____________________________

5) Please match the appropriate transliterated Russian color-word with the object/ or thing that typically appears in that color.
SCHOOL BUS _____________________________
FIRE ENGINE _____________________________
NATURE _____________________________
SKY _____________________________

Appendix F

Translation task for native English participants in Experiment 3

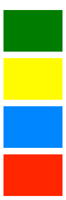
QZ U2   Participant No. ___________Native Language ________________________

1) Please fill in the appropriate transliterated Russian color-word.

KRASNIY   **SINIY**   **ZHOLTIY**   **ZELYONIY**

RED ___________________________
BLUE ___________________________
YELLOW ___________________________
GREEN ___________________________

2) Please fill in the appropriate transliterated Russian color-word that corresponds to the colored patches.



____
____
____
____

3) Please complete the closed-ended sentence with the appropriate transliterated Russian color-word.
Roses are red and the leaves on trees are ___________________________ .
The colors of the USA flag are red, white, and ___________________________.
Bumblebees are black and __________________________ .
Strawberries are ___________________________ but lemons are yellow.

4) Please match the emotion word that is typically associated with the appropriate transliterated Russian color-word.
JEALOUSY ____________________________
DEPRESSION ____________________________
DESIRE ____________________________
JOY ____________________________

5) Please match the appropriate transliterated Russian color-word with the object/ or thing that typically appears in that color.
STOP SIGN _____________________________
SWIMMING POOL _____________________________
SUN _____________________________
TREE _____________________________

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