SIMULTANEOUS LANGUAGE ACTIVATION: A NON-LINGUISTIC PICTORIAL EXPERIMENT WITH SECOND LANGUAGE LEARNERS OF AMERICAN SIGN LANGUAGE

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Todd LaMarr

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Department of Child Development
Abstract

of

SIMULTANEOUS LANGUAGE ACTIVATION: A NON-LINGUISTIC PICTORIAL EXPERIMENT WITH SECOND LANGUAGE LEARNERS OF AMERICAN SIGN LANGUAGE

by

Todd LaMarr

How bilinguals mentally store representations of their two languages in one mind is essential for understanding the mental processes involved during linguistic and nonlinguistic experiences. Research suggests that mental representations for both languages are simultaneously activated when bilinguals read, speak, write or listen to only one language (Kroll, Bogulski, McClain, 2012). However, this research is limited because the experiments have relied upon language-based stimuli and participants have primarily been highly proficient spoken language bilinguals. To address these limitations, the current study explored simultaneous language activation in second language learners of American Sign Language (ASL) using a non-linguistic pictorial task. The purpose of the current study was to explore simultaneous language activation in individuals learning ASL. The research question was whether second language learners of ASL simultaneously activate English and ASL and if so, whether priming would have an impact on the level of activation.
A sample of twenty-three hearing female college students was given a non-linguistic pictorial task. Ten of these participants received a priming treatment before taking the task. Response times were recorded for competitive stimuli (semantically unrelated but phonologically related in ASL) and non-competitive stimuli (semantically related and phonologically related in ASL) to measure simultaneous language activation.

Findings revealed that second language learners of ASL do not simultaneous activate ASL and English, even when primed. Statistically insignificant findings were found between competitive and non-competitive stimuli. Furthermore, statistically insignificant findings were found between the primed and control group. These results could suggest that simultaneous language activation may spread differently for bilinguals who learn a second language later in life. Additionally, perceiving pictorials may spread activation differently than has been demonstrated for perceiving language-based stimuli.

_______________________, Committee Chair
Dr. Li-Ling Sun

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Date
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Chapter 1

INTRODUCTION

Statement of the Problem

Bilingualism was once thought to be a disadvantage, causing cognitive and linguistic delay and confusion (Saer, 1923; Takakuwa, 2005). Contrary to these early assumptions, being bilingual today is predominately perceived positively and associated with cognitive and linguistic benefits (Bialystok, 2011; Bialystok & Barac, 2013; Petitto et al., 2012). Bilingualism continues to be an important topic in education, policy and research because of the high percentage of individuals knowledgeable of two languages. In the United States, children of immigrants are the fastest growing population in the education system at over 5.3 million in number (Calderon, Slavin & Sanchez, 2011). One specific group of bilinguals, Deaf and hard-of-hearing children, is at an estimated U.S. population of 37,828 (Gallaudet Research Institute, 2011). This bilingual population is of great interest because compared to hearing peers, Deaf and hard-of-hearing children demonstrate lower academic achievement, especially in English reading/literacy knowledge (Easterbrooks & Beal-Alvarez, 2012; Qi & Mitchell, 2012; Swanwick, Oddy

\[1\] Commonly, Deaf is capitalized to distinguish between Deafness as a cultural identity and deafness as a hearing loss. Individuals who are Deaf have a Deaf identity, participate in Deaf culture and use a signed language (Padden & Humphries, 2006). Aware of the sensitivities between the two forms, the current paper will consistently capitalize Deaf for all occasions.
Furthermore, there are also fewer resources and, arguably, unequal assessment measures and unequal academic and linguistic access for Deaf and hard-of-hearing children (Karchmer & Mitchell, 2003; Marschark & Knoors, 2012; Schick, Williams & Kupermintz, 2006). The perpetuating educational struggles paired with the continued debate of what are the best educational environments/methodologies for them, has brought Deaf and hard-of-hearing children to the forefront of discussion for educators and researchers alike (Corina & Singleton, 2009; Knoors & Marschark, 2012; Lederberg, Schick & Spencer, 2013; Swanwick & Marschark, 2010).

Deaf and hard-of-hearing individuals present more than an educational challenge; they also present an empirical challenge as researchers attempt to translate research into public practice (Petitto, 2012; Piñar, Dussias, & Morford, 2011). Recent research with sign language users has challenged notions that were once considered universals (established previously by studies based on users of spoken languages) and provides novel insight into human language, cognition and the brain (Slobin, 2008; Zou et al., 2012). Nevertheless, research on sign languages and its users is an underdeveloped field, with many questions remaining, especially in terms of the relationship between various sign language experiences (educational background, age of ASL acquisition, etc..) and cognitive and linguistic development (Lederberg, Schick & Spencer, 2013; Marschark & Spencer, 2003).
Significance

The purpose of the current study was to explore simultaneous language activation in individuals learning ASL as a second language. The current study has the potential to provide significant knowledge to the domains of child development, the psycholinguistics of bilingualism and bilingual education. The significance the current study can add to each of these domains will be discussed below.

From a child development perspective, this study adds to the literature exploring the important connections between language and the visual world. Previous research has shown that a child’s language experience and vocabulary knowledge can significantly impact their ability to map linguistic information to visual information (Borovsky, Elman & Fernald, 2013; Fernald, Marchman & Weisleder, 2013). Furthermore, the speed at which children are able to map linguistic information to visual information is predictive of later cognitive and linguistic outcomes (Fernald & Marchman, 2012; Marchman & Fernald, 2008). The conception that visual information and linguistic information may interact in significant processing ways is not a novel idea. Beginning in infancy, humans learn to link linguistic information with visual information. Sandra Waxman and colleagues have posited that infants have a universal expectation to connect words and objects (Waxman 2004; Waxman & Markow, 1995). Thus, children develop very specific associations between words and the visual world, with infants demonstrating the ability to link specific words with specific objects as early as 9-12 months of age (Fulkerson & Waxman, 2007; Waxman & Braun, 2005). Just as associations between linguistic and
visual information are important in early childhood, they are also important in adulthood (Huettig, Rommers & Meyer, 2011).

Since participants in the current study were adult learners of ASL, results may provide insight into the impact learning a second language can have on the first, especially when the second language is a signed language (Zou et al., 2012). Well after what is considered the sensitive period for learning a language (Birdsong, 2006), such second language experience could still have a significant influence on cognitive processing, perhaps even when presented through non-linguistic pictorials. If second language learners of ASL respond differently than Deaf native signers (Morford, Wilkinson, Villwock, Pinar & Kroll, 2011), it could suggest differences in developmental outcomes related to the age of second language acquisition.

From a psycholinguistics perspective, the current study has the potential to extend the understanding of how two languages interact in a bilingual’s mind. Most simultaneous language activation research has focused on language-based tasks (Brysbaert & Dijkstra, 2006; Kroll, Bogulski & McClain, 2012); however, non-linguistic visual information and linguistic information interact in the mind in important processing ways throughout the human lifespan (Huettig, Rommers & Meyer, 2011; Waxman & Leddon, 2011). By using non-linguistic pictorials, the proposed study will contribute new knowledge towards how non-linguistic information could also simultaneously activate both languages. If so, this study could suggest that both languages are mentally activated during many everyday visual experiences that adults and children experience.
Sign languages deserve more attention in the simultaneous language activation literature because sign languages have been associated with unique processing affordances, especially in nonlinguistic contexts. Experience using the visual-manual modality of sign language enhances spatial memory (Arnold & Mills, 2001; Flaherty, 2003), mental image transformations (Emmorey, Klima & Hickok, 1998; Keehner & Gathercole, 2007), facial discrimination (Bellugi et al., 1990; Bettger, Emmorey, McCullough & Bellugi, 1997) and motion analysis (Klima, Tzeng, Fok, Bellugi and Corina, 1996). As an example, individuals with ASL experience (Deaf and hearing) are faster than individuals unfamiliar with ASL at correctly locating rotated cubic patterns that match a target cubic pattern (Emmorey, Kosslyn & Bellugi, 1993). This enhanced ability for sign language users is reasoned to be because the practice of mental rotation is inherent in accustomed sign language discourse.

In addition to processing enhancements, the visual-manual modality affords unique processing abilities. Signed language’s modality affords a higher level of correspondence between the linguistic symbols of sign languages and the objects and events they represent. Therefore, many sign languages do carry iconic elements (see Figure 1.), which have been found to evoke mental images more so than spoken languages (Baus, Carreiras & Emmorey, 2013; Vigliocco, Vinson, Woolfe, Dye, & Woll, 2005).
The unique link between form and meaning can aid in lexical processing because sign form and sign meaning have a closer (iconic) resemblance and therefore require less time to process (Ormel, Hermans, Knoors & Verhoeven, 2009; Thompson, Vinson, & Vigliocco, 2009). The visual-manual forms of many signs have an intimate relationship with the meanings they represent, perhaps suggesting that sign language users may process and categorize visual information differently than individuals who do not know a sign language (Li & Zhang, 2009; Ormel et al., 2010). However, it is not clear if second language learners of ASL also develop these enhancements or how these enhancements relate to simultaneous language activation.

Psycholinguistic research has found that bilinguals have an enhanced ability to resist irrelevant information during tasks that involve attention, selection, inhibition and monitoring, known as cognitive functioning (Barac & Bialystok, 2012; Bialysok & Barac, 2013). This bilingual enhancement is developed because bilinguals must
continuously inhibit the activation of one language when both are simultaneously activated. However, enhanced executive functioning is not found for bimodal bilinguals; sign language users do not show this enhancement (Emmorey, Luk, Pyers & Bialystok, 2008). For bilinguals capable of speaking and signing, both languages can be expressed at the same time; therefore, there is no need to inhibit one language during the activation of the other. As a result, it is assumed that bilinguals knowledgeable of a spoken and signed language should demonstrate continuous, uninhibited simultaneous language activation.

From an educational perspective, the current study can augment the emerging field of research exploring the reading struggles of Deaf individuals (Corina, Lawyer, Hauser & Hirshorn, 2013). While it has been shown that reading ability in Deaf individuals is not dependent on accessing phonologic representations of English, a positive correlation between sign language ability and reading ability continues to mount (Mayberry, del Giudice & Lieberman, 2011; Miller et al., 2012). This relationship between sign language and reading has therefore become crucial to further understand. Simultaneous language activation research with sign language users can help in the understanding of this unique relationship between a spoken/written language and a signed language (Piñar, Dussias & Morford, 2011). If simultaneous activation from print for Deaf individuals is important to understand reading development, the possibility for simultaneous activation from pictorials could be important for even a further array of developmental abilities since individuals most likely process much more visual information, in general, than they do orthographic information.
Background

In general, children are born able to learn any linguistic system, spoken or signed (Krentz & Corina, 2008; Moon, Lagercrantz & Kuhl, 2013). The rapid speed and relative ease at which children acquire language involves the exceptional ability to mentally store linguistic information (Berwick, Friederici, Chomsky & Bolhuis, 2013; MacWhinney, 2011). Bilinguals are a unique population because, unlike monolinguals, bilinguals store and process two languages in their mind; nevertheless, how the bilingual mind accomplishes this feat is still not well understood (Grosjean & Li, 2013).

To account for how the mind stores and accesses language representations, it is hypothesized that every individual has a mental lexicon, a kind of mental storage site for language, comprised of all lexical (word) information (Bergmann, Hall & Ross, 2007; Libben & Jarema, 2002; Marschark, Convertino, McEvoy & Masteller, 2004). For monolinguals, it is posited that word knowledge is mentally stored in an organized network of connections (Caramazza, 1996; Traxler, 2012b). In this way, every lexical word is connected to a specific phonologic and semantic representation. While the conception of a mental lexicon may explain how monolinguals store language representations, the complication presented by bilinguals is that representations from two languages must be stored and accessed in one mind (Hartsuiker, Costa & Finkbeiner, 2008). The organization of a bilingual’s mental lexicon has been proposed by two competing hypotheses: the language selective hypothesis and the language non-selective hypothesis (Dijkstra & Van Heuven, 2002).
The language selective hypothesis posits that each of a bilingual’s two languages is stored separately and that a bilingual has a selective “switch mechanism”—to switch on one, the other must be switched off. In comparison, the non-selective hypothesis posits an integrated mental lexicon where both languages can be ‘on’ at the same time. This means that lexical candidates (possible word selections) from both languages become activated, irrespective of if only one language is in direct use. While early researchers studying bilingualism supported the language selective hypothesis, the majority of researchers today adopt the language non-selective hypothesis (Kroll, Bogulski, McClain, 2012).

Over the last two decades, a plethora of research has supported the language non-selective hypothesis, suggesting that a bilingual’s languages are integrated in the mind and are activated simultaneously with linguistic input from either language. Simultaneous language activation has been found during tasks of listening (Lagrou, Hartsuiker & Duyck, 2011; Shook & Marian, 2012;), reading (Ko, Wang & Kim, 2011; Zhou, Chen & Yang, 2010) and when producing or even planning to produce language (Emmorey, Petrich & Gollan, 2012; Hermans, Ormel, van Besselaar & van Hell, 2011). This activation holds true throughout a variety of tasks as well across many languages. Recently, researchers have adopted the simultaneous language activation approach and applied it users of sign languages (Morford, Wilkinson, Villwock, Pinar & Kroll, 2011; Ormel, Hermans, Knoors & Verhoeven, 2012; Shook & Marian, 2012). In one study of sign language users, Morford, Wilkinson, Villwock, Pinar & Kroll (2011) asked Deaf signers to judge whether pairs of written English words were related in
meaning. The results showed that they responded slower to word pairs that were semantically unrelated but phonologically related in their ASL translation equivalents (socks/star). In comparison, they needed less time to respond to word pairs that were semantically related as well as phonologically related in their ASL translation equivalents (coffee/tea). Hearing non-signers did not show a difference in response time to the two types of stimuli. The authors argue that response time differences for the Deaf participants were a result of both languages (English and ASL) being simultaneously active when the word pairs were presented. This means that ASL phonology, although not directly present in the English orthographic stimuli, had an influence on response time for participants familiar with ASL. The results reveal simultaneous language activation—when English is presented, ASL mental representations are simultaneously activated.

In summary, while a large body of research supporting simultaneous language activation exists, there is still much to be learned. To add to the body of simultaneous language activation literature, the current study will investigate two important factors. First, the current study will explore if representations from a spoken/written language and a signed language can be simultaneously activated. Most of the previous research has focused on the spoken languages. Recently, the importance of testing the language non-selective hypothesis with sign language users has been recognized (Ormel, Hermans, Knoors & Verhoeven, 2012; Shook & Marian, 2012), but it is still at an underdeveloped stage. Second, the current study will investigate if simultaneous language activation can occur through non-linguistic pictorials. Most of the previous research has focused on
linguistic stimuli (written/spoken language) to induce simultaneous language activation. The important role of non-linguistic representations, in conjunction with linguistic representation, has shown to be related to later cognitive and linguistic development (Borovsky, Elman & Fernald, 2012; Fernald & Marchman, 2012). As a result, this study will address the possibility of simultaneous language activation with second language learners of ASL to explore if both languages can be activated from the presentation of non-linguistic pictorials.

**Theoretical Framework**

One of the most widely accepted models for describing bilingual language representation and processing, following the language non-selective hypothesis, is the Bilingual Interactive Activation Plus (BIA+) model (Dijkstra & Van Heuven, 2002). The BIA+ model is a hierarchical model with three levels of language representation: phonological, lexical and semantic (See Figure 1). The hierarchical structure references how, based on the information perceived, lexical (word) activation may spread in either a top-down or bottom-up manner. If phonologically based information is perceived (spoken, written language), activation will begin at the phonological level and spread upward, activating candidates (possible word selections) at the lexical and semantic levels. If information involving word meaning is presented (i.e. pictures), activation begins at the semantic level and spreads downward, activating candidates at the lexical and phonological levels. While activation may begin in one direction, the model posits
continued spreading activation in any direction: upward, downward as well as lateral (activation spread between candidates at the same level).

As an example of how activation may spread, Figure 2 depicts possible activation for a Spanish/English bilingual who hears the Spanish word *cara*, meaning *face*. The initial sounds of *cara* can activate lexical candidates (possible word selections) in English, such as *car* and/or *card*. Word activation at the lexical level then activates the meaning of the words at the semantic level (as shown by the object pictures in Figure 2). In this way, language is processed in a non-selective manner, meaning that any input has the potential to activate possible word selections in either of a bilingual’s languages. As shown in Figure 2 *car* and *card* are only initially possible word selections; once the perceived word *cara* is completely processed (as shown by the line of dots) it becomes the only activated candidate to match the perceived input.
The reasons for using the BIA+ model as the framework for the current study are twofold. First, the model has been supported by bilinguals knowledgeable of languages from different language families as well as from different language modalities (Guo, Misra, Tam & Kroll, 2012; Moon & Jiang, 2012; Shook & Marian, 2012). These findings are important because they suggest the model may be universal—applicable to all languages. Second, because the BIA+ model assumes that a bilingual’s languages are integrated across three levels of representation (phonological, lexical and semantic), exploring activation from non-linguistic pictorials can be interpreted using the BIA+ model as the framework (as demonstrated in studies that using both language and pictorials as stimuli).
Methods

Participants

Participants were 23 hearing female college students between 20-40 years of age ($M = 24.55$, $SD = 5.60$) pursuing the American Sign Language/Deaf Studies BA. degree. At the time of the study, participants were either enrolled in or had finished taking the most advanced upper division ASL language course in the B.A. program (i.e., ASL 5). Participants were divided into two groups, such that the primed group received a priming treatment and the control group did not, but both were administered the same task.

Measures and Materials

Pictorial Task

Fifty-eight images (two were used twice to create 30 pairs) were paired together to represent English word pairs related at either the semantic and/or phonological levels. Pictorial pairs were divided between two phonological/semantic conditions. The first condition, competitive pairs, consisted of fifteen pictorial pairs that were not semantically related but were phonologically related in ASL. The second condition, non-competitive pairs, was fifteen pictorial pairs semantically related and phonologically related in ASL.
**Vocabulary Test**

The vocabulary test included two parts, a PowerPoint presentation to present the pictorial stimuli and an answer sheet for the researcher to document participants’ accuracy. The 58 pictorial items were randomly ordered in a PowerPoint presentation, one pictorial per slide. These were the same pictorials used in the task.

**Response Time**

Response time was measured by recording how long it took participants, both the primed and control group, to indicate their decision in the main task, by pressing specified computer keys. Response time began with pictorial onset (i.e., when pictorial pairs appeared on the laptop screen) and ended once participants entered a response. For each set of pictorials, a response time was recorded.

**Procedures**

**Pictorial Task**

After providing consent, participants completed a background questionnaire to provide basic demographics. They were then introduced to the target pictorial task. After a practice period, response time served as the measure of simultaneous activation. For the primed group only, the vocabulary test treatment was administered prior to the practice and the target pictorial task, to serve as a priming treatment. For the control group, the
vocabulary test was administered following the target task. Debriefing concluded the experimental session.

**Priming Treatment**

Only the primed group received the treatment. The 58 pictorial pairs that would be used in the target pictorial task, were presented one at a time on a laptop computer. Participants were asked to demonstrate the ASL sign for each pictorial. If they did not know the correct sign, the experimenter demonstrated it to them.

**Definition of Terms**

**American Sign Language**

The official sign language of the United States. It is a natural human language that shares many linguistic similarities and processing characteristics with spoken languages (Corina & Knapp, 2006; Emmorey, 2002).

**Simultaneous language activation**

A well-supported finding in bilinguals suggesting that both languages are, at the same time, mentally activated (Kroll, Bogulski & McClain, 2012). Simultaneous language activation is commonly measured by response times to experimental stimuli cross-linguistically related, unbeknownst to participants, at the phonological, lexical or semantic level.
Organization of the Study

This thesis is organized into five chapters, with the current chapter as an overview to the study. Chapter two is a review of the literature, divided into four sections: representation of language in the mind, the bilingual lexicon, the visual-manual modality and priming: the study of simultaneous activation. Chapter three describes the methods of the study, including the study’s research question, hypotheses, participants, materials, measures and procedures. Chapter four will present the results from the data, organized by hypothesis. Finally, chapter five discusses the major findings of the study, as well as the study’s implications and limitations.
Chapter 2

REVIEW OF THE LITERATURE

How humans mentally store and access language in their mind is critical for understanding language comprehension and production. While the mental processes involved in understanding how one language is stored and accessed is a complex feat, trying to understand how two languages are stored and organized, as with bilinguals, is an even greater challenge. A recent model, the BIA+, follows the hypothesis that bilinguals’ languages are mentally integrated and simultaneously activated, irrespective of which language is conveyed and the channel of the information (orthographic, oral or aural). This study will explore if individuals learning the visual-manual modality of American Sign Language (ASL) activate both languages simultaneously in a nonlinguistic task and whether priming has an effect on the level of activation.

Representation of Language in the Mind

The Mental Lexicon

The mental storage site for linguistic information is referred to as the mental lexicon (Bergmann, Hall & Ross, 2007). Language is stored and organized in the mental lexicon by at least three levels of representation: phonological, lexical and semantic (Caramazza, 1996; Dijkstra & Van Heuven, 2002; Schmitt, Münte & Kutas, 2000). At the
phonological level are the representations of the smallest contrastive parts (i.e. the sounds) of a language. At the lexical level are whole word representations. At the semantic level are the conceptual representations for the meanings words refer to. As an example, the lexical level representation of ‘dog’ is connected to its phonological sound components (d-o-g) at the phonological level and its conceptual meaning (characteristic qualities that categorize what a dog is) at the semantic level. The connections between these three levels are pivotal to understand how language representations become activated and selected.

**Activation and Lexical Selection**

To comprehend and produce language, individuals must traverse the phonological, lexical and semantic levels of language representations quickly and accurately. The mental process of traversing the three levels involves two key mechanisms, activation and lexical selection (Costa, 2005). Activation refers to which representations at the three levels are available as possible matches to the input/output information. In other words, representations that are similar phonologically (*car/card*), lexically (*car/bar*), or semantically (*car/truck*) will be activated. While many representations become activated, the level or strength of the activation (how well it matches the input/output information) will determine which representation is ultimately selected. This selection process is the other mechanism, known as lexical selection.

The mechanisms of activation and lexical selection are significant processes because specific language representations must be appropriately selected from the
thousands of language representations stored in a mental lexicon to comprehend and produce language. Activation and lexical selection help explain how individuals are able to search and select from the myriad of representations in their mental lexicon; however, the mechanisms of activation and lexical selection must also account for bilinguals with mental representations of two languages.

**Representation of Language in the Bilingual Mind**

**The Bilingual Mental Lexicon**

The mental lexicon, for monolinguals, is an organized storage site for only one language and as a result, the monolingual mental lexicon is organized in a fairly straightforward manner. For example, the basic organization can be described as phonological information being linked to specific whole word representations that are associated to specific semantic meanings. In comparison, for bilinguals, the mental lexicon is much more complex because two languages must be stored and accessed (without mixing languages) in only one mind (La Heij, 2005).

In order to explain how bilinguals store and access two languages, two hypotheses have been proposed (Dijkstra & Van Heuven, 2002; Schreuder & Weltens, 1993). The first hypothesis is the language-selective hypothesis and assumes that each language of a bilingual has its own separate, independent mental lexicon. Under this assumption, language input only activates the mental lexicon specific to the corresponding language. This hypothesis has been described as involving a “switch mechanism” so that a
Spanish/English bilingual processing Spanish, would only access the Spanish mental lexicon and would need to “switch” off the Spanish mental lexicon and “switch on” the English mental lexicon in order to process English. The language selective hypothesis was a foundational assumption of older bilingual language representational models (Gekoski, Jacobson & Frazao-Brown, 1982; Gerard & Scarborough, 1989; Kroll & Stewart, 1994; Macnamara, Krauthammer & Bolgar, 1968; Macnamara & Kushnir, 1972; Scarborough, Gerard & Cortese, 1984; Soares & Grosjean, 1984; Weinreich, 1964) but recent research has provided a wealth of evidence against it. Today, most psycholinguists studying bilingualism support the language-nonselective hypothesis (Brysbaert & Dijkstra, 2006; Brysbaert & Duyck, 2010; Kroll, Bogulski & McCain, 2012; Kroll, Dussias, Bogulski & Kroff, 2012). According to the language-nonselective hypothesis (Dijkstra & Van Heuven, 2002), the bilingual’s two mental lexicons are integrated and input, from either language, activates possible lexical candidates from both languages simultaneously. To describe the organization and processes involved in a bilingual’s mental lexicon, the Bilingual Interactive Activation Plus (BIA+) model was proposed following the language-nonselective hypothesis.

**The Bilingual Interactive Activation (BIA+) Model**

The Bilingual Interactive Activation Plus model (BIA+) was created to describe how bilinguals store and access two languages in one mind (Dijkstra & Van Heuven, 2002). It is based on the monolingual interactive activation model (McClelland and
The BIA+ model posits that a bilingual’s languages are integrated in the mental lexicon, rather than stored separately as previous research assumed (Brysbaert & Dijkstra, 2006). Furthermore, the model claims that when one language is mentally activated, the other language, at least initially, is simultaneously activated. However, such a claim of integration and activation must then explain how bilinguals do not commonly mix-up languages, as well as how, if both are activated, the appropriate language is selected over the other. To answer these questions, it is important to understand how the BIA+ depicts the levels of language representations and how these representations are accessed through the mechanisms of activation and lexical selection.

The BIA+ model offers three levels of mental language representation: phonological, lexical and semantic. These levels are important for understanding how the processes of language production and comprehension access mental representations in distinct ways (Rodriguez-Fornells Schmitt, Kutas & Münte, 2002). For example, language comprehension involves understanding the language production an individual conveys and therefore accesses the mental lexicon in a bottom-up approach. This means that the smaller parts of language are parsed (phonological level) before they activate what the words mean (semantic level). In comparison, language production involves a top-down approach as one must first decide the meaning to express (semantic level), before activating the representations involved in actually expressing the message (phonological level).

The organization of the bilingual mental lexicon is imperative for understanding how specific representations become activated during comprehension and production.
The BIA+ model posits language non-selective activation that spreads between the three levels of language representation. To illustrate, an English/Spanish bilingual, upon hearing the Spanish word for dog (*perro*), will activate the English representations connected to the word *pear* at the same time. Even though *perro* and *pear* are semantically and lexically distinct words, they share phonological units. According to the BIA+ model, because languages are integrated across the three levels, language input will activate lexical candidates from both languages without being language-specific. As a result, *pear* will initially be simultaneously activated when hearing the word *perro*. This activation between levels spreads in a cascading manner, meaning that once one level of representation is activated, there is a cascading effect that automatically activates lexical candidates at the other levels. Crucially, the model posits that each level contains integrated representations from both languages; therefore, activation at one level simultaneously activates lexical candidates from both languages at the other levels.

The initial flow of activation (top-down or bottom-up) is dependent on how the informational input enters the mental lexicon (Rodriguez-Fornells, Schmitt, Kutas & Münte, 2002). The mental lexicon can be accessed via different channels: oral (spoken), aural (auditory) and orthographic (written language that is visually accessed). While these three channels are different, they all simultaneously activate a bilingual’s two languages (Kroll, Bogulski & McClain, 2012) in accordance with the BIA+ model. Exactly how each of these channels simultaneously activates a bilingual’s languages will be explored below, focusing on each channel separately.
Orthographic Channel

Although not all bilinguals have or are able to use an orthographic system, simultaneous language activation has primarily been researched through this channel. The orthographic channel receives input from a source outside of the individual themselves through printed material, such as books, magazines, newspapers, penmanship, etc. Orthography specifies a language’s written system and is accessed through the eyes. To investigate how the orthographic channel accesses the mental lexicon, researchers commonly ask participants to perform tasks focusing on single word stimulation, such as printed word reading. Despite that single monolingual words are presented, the language not in use is activated simultaneously (Brysbaert, 1998; Brysbaert, Van Dyck & Van de Poel, 1999; Dijkstra, Timmermans & Schriefers, 2000; Duyck, 2005; Duyck, Diependaele, Drieghe & Brysbaert, 2004; Jared, Cormier, Levy & Wade-Woolley, 2012; Jared & Kroll, 2001; Lee, Kichun & Katz, 2005; Schwartz, Kroll & Diaz, 2007; Thierry & Wu, 2007; Van Assche, Duyck, Hartsuiker & Diependaele, 2009; van Heuven, Schriefers, Dijkstra & Hagoort, 2008; Wang, Deng, Li, Li & Fan, 2011). As an example, a common procedure has bilingual participants decide if words, in a specified language, are real words or not (unbeknownst to participants that it was a bilingual study). Results reveal that bilinguals have longer naming latencies when presented words (i.e. Dutch/English word ‘room’) share orthography across languages while differing in meaning (de Groot, Delmaar & Lupker, 2000; Von Studnitz & Green, 2002). In comparison, when the words are semantically and orthographically similar across languages (i.e. Spanish/English word ‘piano’), bilinguals are faster to make decisions.
While many researchers have used single word stimuli and, in doing so, found support for the language non-selective hypothesis, there are limitations. One limitation is that perceiving single words out of context is an uncommon bilingual experience that could automatically prompt learned translation equivalents. Sentence reading, in contrast to single word recognition, could be understood as placing the reader into a “monolingual mode” (Grosjean, 2013). During sentence reading, there is continuous input from only one language; therefore, there is no reason for the reader to activate the other language. However, a growing body of research is finding that reading words within sentences in one language, just as with single words, automatically activates the other language (Baten, Hofman & Loeys, 2011; Duyck, Assche, Drieghe & Hartsuiker, 2007; Jun-Hua & Lei, 2010; Libben & Titone, 2009; Schwartz & Kroll, 2006; Titone, Libben, Mercier, Whitford & Pivneva, 2011; Van Assche, Drieghe, Duyck, Welvaert & Hartsuiker, 2011; Van Assche, Duyck, Hartsuiker & Diependaele, 2009; van Hell & de Groot, 2008). Thus, simultaneous language activation transcends single word recognition by also being simultaneously active during sentence reading.

**Aural Channel**

Bilinguals not only perceive language through the orthographic channel; they also perceive language through the aural channel by listening to language’s spoken form. In line with the findings from the orthographic channel, listening to language in word or sentence form, also simultaneously activates a bilingual’s languages (Chambers & Cooke, 2009; Chéreau, Gaskell & Dumay, 2007; Dijkstra, Schriefers, Hasper &
Schulpen, 2003; Lagrou, Hartsuiker & Duyck, 2011; Marian, Blumenfeld & Boukrina, 2008; Marian & Spivey, 2003; Marian, Spivey & Hirsch, 2003; Schulpen, Dijkstra, Schriefers & Hasper, 2003; Spivey & Marian, 1999; Thierry & Wu, 2007; Weber & Cutler, 2004; Ziegler, Muneaux & Grainger, 2003). For example, Langrou, Hartsuiker and Duyck (2011) asked Dutch/English bilinguals to listen and judge whether spoken words, in one of their specified languages, were real or false words. The results revealed that the bilingual participants needed more time to decide when the presented words were phonologically similar but semantically different (Dutch ‘lief’ [sweet] and English ‘leaf’). If a bilingual’s languages were not stored in an integrated manner, processing language in Dutch should not activate English representations and not lead to response time latencies; however, such simultaneous activation, as demonstrated, is automatic.

**Oral Channel**

The oral channel is distinct compared to the orthographic and aural channels because it is initiated by the individual rather than outside resources (another individual, text, etc.). The oral channel involves activating and selecting desired language representations, then vocally producing them. Since the oral channel is self-initiated, it could be argued that both languages should not be simultaneously activated since the individual is aware early on what language they want to produce. Nevertheless, bilingual language production and even production planning, initially activates both languages simultaneously (Colomé, 2001; Costa, 2005; Costa, Caramazza, & Sebastian-Galles, 2000; Guo & Peng, 2006; Hermans, Bongaerts, De Bot & Schreuder, 1998; Hoshino &
Kroll, 2008; Kroll, Bobb & Wodniecka, 2006). To illustrate, when bilinguals are presented with sets of two pictures, they are quicker to name the pictures when the names are similar phonologically and semantically (English/Spanish: piano/piano) in both languages than when they are not (Costa, Caramazza, & Sebastian-Galles, 2000). This faster naming is reasoned to be due to a lack of competition between lexical candidates that speeds up lexical selection (Kroll, Bogulski & McClain, 2012).

In summary, bilinguals store language representations in a mental lexicon organized by the phonological, lexical and semantic level. The mental lexicon can be accessed through the orthographic, oral or aural channels. Once the mental lexicon is accessed, lexical candidates (possible word choices) from both languages are simultaneously activated across the three levels. While many representations are simultaneously activated, the strength of activation ultimately results in the final selection.

**The Visual-Manual Modality**

The mental lexicon is accessed through language channels and the channels available for a language depend on its form of expression, or modality. Language is produced and perceived through one of two language modalities (Meier, Cormier & Quinto-Pozos, 2002). The first language modality is the auditory-vocal modality of spoken languages. Spoken languages access the mental lexicon through three language channels: oral, aural and orthographic (for some languages). The second language
modality is the visual-manual modality of sign languages. In contrast to spoken languages, sign languages do not have a standard, commonly used orthographic system; therefore, sign languages activate the mental lexicon through two language channels: visual and manual. However, as language minorities, most Deaf individuals and sign language users also learn the main auditory-vocal language of the country they live in, either through spoken or orthographic means.

**Sign Language Structure**

Sign languages are complex natural languages, containing grammatical properties structural principles equivalent to spoken languages (Bellugi, Bihrlle & Corina, 1991; Corina & Sandler, 1993; Emmorey, 2002; Fischer & Hulst, 2003; Sandler, 1996; Schwager & Zeshan, 2008; Stokoe, 2005; Valli & Lucas, 2005). While auditory-vocal languages use spoken lexical units (words) to convey meaning, signed languages use visual-manual lexical units (signs). Signs, although constructed from a limited quantity of sublexical parts, create different signs by combining the sublexical parts in different ways (Corina & Sandler, 1993). These sublexical sign parts are the modality equivalent to the phonetic parts (sounds) of spoken languages (Sandler, 1996; Whitworth, 2011).

Phonology in spoken language refers to the organization and structure of the smallest contrastive linguistic units, sounds. In comparison, phonology in sign language refers to the organization and structure of the smallest contrastive linguistic units of signs: phonological parameters (i.e. handshape). Just as spoken languages have different phonologies, so too do the different sign languages around the world (Fischer, 2008;
Kozak & Tomita, 2012). This paper will focus specifically on American Sign Language (ASL) except where noted. Signs in ASL are constructed of five phonologically significant sublexical parts, called parameters. These five parameters are handshape, movement, location, orientation and nonmanual signals (facial expression). Therefore, each sign in ASL has a unique combination of sublexical parameters that, when combined, conveys a specific meaning (see Figure 3 below for pairs of ASL signs that differ in only one parameter (minimal pairs)).

Figure 3. ASL Minimal Pairs
Orientation

TRAIN
Both hands are in "H" handshapes (or loose "h" handshapes). The left hand stays stationary. The right one moves forward and back.

SHORT

Movement

SIT

CHAIR
The Sign Language Mental Lexicon

Despite differences in language channels between the language modalities, the mental lexicon of sign language users is organized similarly to that of spoken languages. Because the visual-manual modality of sign language involves entirely different channels for production and perception than spoken languages, it could be argued that sign language is represented differently in the mental lexicon; however, this does not seem to be the case. Despite modality differences, sign languages are mentally represented and processed similarly to oral-aural languages (Corina & Knapp, 2006; Emmorey, 2002; Ormel, Hermans, Knoors & Verhoeven, 2009). For example, just like spoken languages, the mental lexicon in sign language users has three main levels of linguistic representation: phonological, lexical and semantic (Baus, Gutierrez-Sigut, Quer &
Carreiras, 2008; Thompson, Emmorey, Gollan, 2005). Initial activation automatically spreads to related representations, just as with spoken languages (Carreiras, Gutierrez-Sigut, Baquero & Corina, 2008; Corina & Knapp, 2006; Dye & Shih, 2006; Gutierrez, Mueller, Baus & Carreiras, 2012). While research exploring sign language and its channels of lexical access is still in early stages of understanding, the evidence so far suggests that there are many foundational similarities between the language modalities (Corina & Knapp, 2006; Orfanidou, Adam, Morgan & McQueen, 2010; Shook & Marian, 2010).

**Sign Language and Simultaneous Language Activation**

The study of sign languages provides a unique window into the area of research on simultaneous language activation, an area developed and supported by studies and theories based primarily on oral-aural languages (Grosjean & Li, 2013; Traxler, 2012a). Sign language research affords a separation between findings that are universal for all languages and findings that are a result of language modality (Meier, Cormier & Quinto-Pozos, 2002). While simultaneous language activation in bilinguals is a well-documented phenomenon across a variety of languages, its application to sign languages is a recent and limited endeavor (Kroll, Bogulski & McClain, 2012). This section will cover the studies that have explored sign languages from the perspective of simultaneous language activation, focusing specifically on the two studies (Morford, Wilkinson, Villwock, Pinar & Kroll, 2011; Shook & Marian, 2012) that have spurred the conception of the current research.
Morford and her team (2011) explored simultaneous language activation in Deaf bilinguals using ASL and English (written). Despite the fact that sign languages do not have a commonly used orthographic system, they were curious if accessing the mental lexicon through the orthographic channel of English would simultaneously activate ASL representations. The Deaf participants were asked to decide if pairs of English words were related in meaning. The results showed that word pairs that were semantically related as well as phonologically related in their ASL translation equivalents (know-think), needed less decision time compared to word pairs that were semantically unrelated but were phonologically related (socks-star) in their ASL translation equivalents (see Figure 4). The authors argued that despite the task being in English and presented through the orthographic channel, the longer response times were a result of ASL being simultaneously activated. These results have been supported in a similar study (Ormel, Hermans, Knoors & Verhoeven, 2012). These studies suggest that simultaneous language activation is not modality specific, and furthermore, that both languages can be accessed irrespective of the channel that access the mental lexicon. These results also provide evidence that the BIA+ is a language universal model that can explain simultaneous language activation in all bilinguals, despite modality and channel differences.
Figure 4. Phonological Relatedness in ASL

ASL sign for KNOW

ASL sign for THINK

ASL sign for socks

ASL sign for stars

In an approach that made use of the visual and aural channels, Shook and Marian (2012) not only found support for simultaneous language activation in bimodal bilinguals, but found that both languages were, initially, activated from non-linguistic pictorials alone. Unlike the Morford, Wilkinson, Villwock, Pinar & Kroll, 2011) study that focused on linguistic stimuli presented through the orthographic channel, Shook and Marian used the visual and aural channels by recording participant’s eye-movements during a visual world paradigm. The visual world paradigm involves trials of four nonlinguistic pictures in which the participants were asked to simply look at the picture that would be orally named. The trials were categorized into two types: critical trials and filler trials. The critical trials were composed of a target picture (this picture’s name would be spoken in the auditory stimuli), a competitor picture with an ASL translation matching the target picture’s ASL translation in at least 3 phonological parameters, and two distractor pictures that did not match the other two in either English or ASL phonology. Filler trials were composed of a target picture (this picture’s name would be spoken in the auditory stimuli) and three other pictures that were phonological unrelated to the target in ASL and English. For each presented trial, an auditory stimulus would produce the name of the target picture in English while an eye-tracking machine captured eye movements and fixations.

The results revealed that bimodal bilinguals, upon hearing the auditory stimulus, would look longer at competitor pictures (phonologically similar in ASL) than filler pictures in the target trials. In contrast, the monolinguals (no ASL experience) did not discriminate looking times between competitor pictures and fillers. These results suggest
that despite modality differences and channel access, bimodal bilinguals activate ASL while comprehending spoken English. Most importantly for the present study, the authors noted that the bimodal bilinguals showed early visual competition (more eye gaze) between the target and competitor pictures based solely on the visual input of the pictures. This means that simply viewing the pictures themselves activated their lexical labels mentally, activating translation equivalents, which then activated shared phonological representations (i.e. parameters in ASL). Significantly, the results reveal that visual stimuli can interact with mentally stored linguistic information and have the ability to simultaneously activate both of a bimodal bilingual’s languages. It is the connections between visual information and mentally stored linguistic representations in sign language users that the current study sought to explore further.

**Investigating Simultaneous Language Activation**

Limited research has investigated if language representations from two different modalities are simultaneously activated, but those that have been conducted adopted a common approach known as priming. Priming, in psycholinguistics, refers to the phenomena of a prior linguistic experience increasing the processing of a subsequent linguistic experience (Ionin, 2013). For example, in one of the earliest studies on priming, Meyer and Schvaneveldt (1971) asked participants to decide if pairs of words presented at the same time (one above the other) were real words. Results revealed that participants responded faster when the words were semantically related (bread-butter) than when they
were unrelated (bread-chair) or non-words (bread-renclave), indicating that related words are more strongly connected and therefore that activating one representation activates related representations. Figure 5 is an example of some representations that might be activated when the representation of bread is first activated. The strength of activation is also depicted with stronger connections having two blue lines. Thus, the figure shows that ‘butter’ is more strongly activated than ‘dairy’ when ‘bread’ is first activated, although activating ‘butter’ may spread activation to ‘dairy’, it is a weaker activation.

**Figure 5. How Mental Activation Spreads**

*Figure 5. Automatic spread of activation from bread to related representations. (Figure from Galotti, 2007)*

Priming is important because it signifies that the mental representations of language are not randomly stored in an erratic manner, but rather are systematically
stored in an ordered fashion, beginning in early childhood (Mani, Durrant & Floccia, 2012; Rämä, Sirri & Serres, 2013; Von Holzen & Mani, 2012). Priming also demonstrates that some connections between representations are stronger and therefore activation of one representation automatically spreads activation to connected representations (Krishnan & Tiwari, 2008). The important effects of priming continue to be documented in language processing at the phonological, lexical and semantic levels (Apfelbaum, Blumstein & McMurray, 2011; Nakayama, Sears, Hino & Lupker, 2012; Neely, 1991; Wang, 2013). These priming studies suggest that multiple representations are simultaneously activated at each level during language processing; therefore, the appropriate/desired activation must be selected while activations inappropriate for the situation must be unselected. To investigate simultaneous language activation, two common approaches have been stimuli priming and temporal priming.

**Stimuli Priming**

The most common way priming has been used is through the manipulation of stimuli, presented to participants sequentially or concurrently. An example of this is the Myer and Schvaneveldt (1971) study (discussed above). They asked participants to decide if pairs of words presented concurrently (one above the other) were real words. As participants read one word at a time, activating the representations for one word had an effect on the activations for the other word.
**Temporal Priming**

Another important way priming has been used is through a practice session that is temporally distinguished from the main task. The goal of the practice session is to prime participants before they even begin the task. As an illustration of this, Kuipers and La Heij (2009) had participants practice the names of colors and pictures that would be used in the main task. Participants were to simply name the color of a monochromatic picture—not the name of the picture. Previous research had shown that picture names are automatically activated upon perceiving the picture (Meyer & Damian, 2007).

Unbeknownst to participants, some pictures had Dutch names phonologically related to their color (i.e. a brown (bruin) pair of glasses (bril)). The assumption was that practicing would increase the strength of the connection between the visual information (pictures and colors) and the mental representations for the words involved. This is exactly what they found: The practice session increased the phonological facilitation effect—colors with phonologically related picture names were named faster.

The current study will employ both types of priming but will only refer to the use of temporal priming (through a practice session) explicitly as priming. Stimuli priming will be referenced by the two types of stimuli used in the experiment: competitive and non-competitive. According to the above literature review, two hypotheses were formed for the current study:

1. Within subjects, second language learners of ASL will have longer response times for competitive stimuli than non-competitive stimuli.
2. Between subjects, primed participants will have longer response times for competitive stimuli than the non-primed, control group.

The purpose of the current study was to explore simultaneous language activation in second language learners of ASL. Since simultaneous activation research is limited with sign language users and also with adults learning a second language, a group of participants were primed through a practice session before the task was administered. The purpose of priming was to strengthen the link between pictorials that would be used in the task so that during the task, the likelihood that the pictorials would activate the ASL representations, along with English representations, would be much greater. The research question asked whether second language learners of ASL simultaneously activate English and ASL and if so, whether priming would have an impact on the level of activation.
Chapter 3

METHODOLOGY

The purpose of the current study was to explore simultaneous language activation in individuals learning American Sign Language (ASL) as a second language. Simultaneous language activation has widely been tested by comparing response times to experimental stimuli cross-linguistically related, unbeknownst to participants, at the phonological, lexical or semantic level (Kroll, Bogulski & McClain, 2012). The current study compared response times for competitive stimuli (semantically unrelated but phonologically related in ASL) and non-competitive stimuli (semantically related and phonologically related in ASL) to measure simultaneous language activation. Moreover, the research question was whether second language learners of ASL simultaneously activate English and ASL and if so, whether priming would have an impact on the level of activation. There were two hypotheses:

1. Within subjects, second language learners of ASL will have longer response times for competitive stimuli than non-competitive stimuli.
2. Between subjects, primed participants will have longer response times for competitive stimuli than the non-primed, control group.

To test the first hypothesis, a repeated measures t-test for dependent means was conducted. To test the second hypothesis, an independent-sample t-test was conducted to
examine the effect of priming on response times between subjects (primed and control groups).

**Participants**

Participants were 23 hearing female college students at California State University, Sacramento. They were selected using convenience sampling and recruited and tested on the university’s campus. To recruit participants, flyers were emailed to professors, asking them to share the information with their students and the researcher provided brief presentations to classes. At the time of the study, each participant was enrolled in or had finished taking the final course in the 5-semester ASL language series, after which students are expected to have greater than elementary command of receptive and productive fluency.

Participants’ ages ranged from 20-40 years of age ($M = 24.55, SD = 5.60$). To account for ASL productive and comprehensive fluency of the group, participants rated their fluency on a 7-point Likert scale. The group’s average self-rating for ASL productive fluency was 4.36 and their average self-rating for ASL comprehensive fluency was 4.68.

Participants were divided into two groups following a static–group comparison design. The primed group received a priming treatment while the control group did not. The groups were assigned in a non-random, first come first group basis, beginning with the control group.
The control group had 13 participants between 20-40 years of age \((M = 25.79, SD = 5.6)\). To account for ASL fluency of the control group, participants rated their fluency on a 7-point Likert scale. Their group average for ASL productive fluency was 4.36 and for ASL comprehensive fluency it was 4.64. The primed group had 10 participants between 21-24 years of age \((M = 22.37, SD = 1.2)\). To account for the ASL fluency of the primed group, participants rated their fluency on a 7-point Likert scale. Their group average for ASL productive fluency was 4.37 and for ASL comprehensive fluency it was 4.75.

**Measures and Materials**

**Computer and software**

A thirteen-inch Apple MacBook Pro laptop using the OS X Mountain Lion operating system was used for the current experimental study. The practice PowerPoint, priming treatment and the pictorial task were conducted using this laptop. PowerPoint, version 14.1 was used to run the practice PowerPoint, the priming treatment, the pictorial task and the vocabulary test. Java 7 software was used to create and run the pictorial task. It was programed to record response times and participant responses and to send this obtained data to an output folder.
Pictorials

Fifty-eight images were found through online Google searches. Adobe Photoshop Elements 11 was used to remove background content, unwanted image designs (e.g. additional images on the image, i.e. a flag on a train), remove all color by recoloring images under a unified grey scale and to improve overall image clarity. Images were resized to be visually harmonious with their pictorial pair in the task and if required, reoriented to remove directional relatedness (two pictorials are oriented in the same direction). Both real and cartoon images were used, but pictorial pairs were congruous—both were either real or cartoon.

The purpose of the pictorials was to represent English word pairs related at either the semantic and/or phonological levels. The pictorial pairs were divided between two phonological/semantic conditions. The first condition, competitive pairs, consisted of fifteen pictorial pairs that were not semantically related but were phonologically related in ASL (see Figure 7 and 8 for an example). The second condition, non-competitive pairs, was fifteen pictorial pairs semantically related and phonologically related in ASL (see Figures 9 and 10 for an example). Semantic relatedness was screened for during a pilot study (described below). Phonological relatedness in ASL was based on pictorial translation equivalents in ASL that, between each pair, shared at least two ASL phonological parameters.
Figure 6. Phonological Relatedness in ASL

Figure 6. ASL signs for SOCKS and STAR. Depicts the phonological relationship in a competitive pictorial pair (not semantically related but phonologically related in ASL). © 2013, William Vicars www.Lifeprint.com. Used by permission.

Figure 7. Pictorial Representations

Figure 7. Pictorial representations for the word pair socks and star.
Figure 8. Phonological Relatedness in ASL

Figure 8. ASL signs for HOUSE and TENT. Depicts the phonological relation in a non-competitive pictorial pair (semantically related and phonologically related in ASL). © 2013, William Vicars www.Lifeprint.com. Used by permission.

Figure 9. Pictorial Representations

Figure 9. Pictorial representations for the word pair house and tent.
Background Questionnaire

A paper and pen questionnaire was administered to participants to assure they met the criteria for inclusion as well as to collect important background information. The questionnaire requested information on language background (e.g. age of ASL acquisition), course grades in the ASL program and a self-rating of comprehensive and productive ASL fluency (see appendix).

Practice Task

A practice version of the pictorial task was comprised of ten interactive slides designed for participants to independently progress through at a comfortable self-paced rate. It described the design of the task, detailed the role of the participant and explained the instructions (See Figure 10).

Figure 10. A Slide from the Practice Task

Two pictures will appear.

Think about the meaning each picture represents and decide if these meanings are related.

IMPORTANT:

Do not compare the visual/physical features of the pictures themselves, such as shared color, patterns, shape, etc.

Only compare their meanings
Also included in the practice task is an example of a pictorial pair that participants respond to as expected in the pictorial task. Importantly, the pictorials used in the practice task were not used in the target task. The last slide requests that participants ask any questions to the researcher before beginning the task.

**Pictorial Task**

The pictorial task was programmed to simultaneously present pictorial pairs side by side in a random, pre-selected order that was the same for every participant. There were a total of thirty pictorial pairs (two were used twice, but in different pairings). Participants were asked to indicate whether each set of pictorial pairs were related to each other by pressing clearly labeled keys on the keyboard of the laptop (i.e., “yes” or “no”). Response time was recorded (in nanoseconds) from pictorial onset—when the pictorial pairs first appeared on the screen—to the time a key was pressed. Immediately after participants indicated a response, the next pair of pictorials appeared.

**Vocabulary Test**

The purpose of the vocabulary test was to differentiate between participants’ known and unknown ASL vocabulary. The 58 pictorial items from the target task were randomly ordered in a PowerPoint presentation, one pictorial per slide. For each, participants were asked to demonstrate the sign for each pictorial and the researcher recorded whether responses were correct or incorrect. This vocabulary test was also used
for the priming treatment but with two significant differences. The primed group were
given the vocabulary test *before* the pictorial task was administered and if primed
participants did not know the ASL sign for a pictorial, the experimenter demonstrated it.
In comparison, the control group were administered the vocabulary test after the pictorial
 task and were not provided with corrected signs during the test.

**Procedures**

**Pilot study**

The purpose of the pilot study was to screen for semantic relatedness for
competitive and noncompetitive pictorials. Ten participants were first shown the practice
PowerPoint and after finishing, any questions they had were answered before beginning
the task. The researcher emphasized that participants were to decide if the sets of two
pictures shown were “related in meaning” and that it was not a picture comparison task—
the goal was to compare the meanings the pictures represent. The task was administered
once participants confirmed they understood the directions. Lastly, to account for
semantic relatedness, participants filled out a 7-point Likert scale rating each set of
pictorials on how related they were in meaning.

**Main Study**

Data were collected during the Fall 2012 semester and Spring 2013 semester on
the California State University, Sacramento campus. Procedures were identical for all
participants except that participants assigned to the primed group received the priming treatment before the target task was administered and only the control group received the vocabulary. All communication and instructions were conveyed in spoken/written English and participants were clearly informed that this was a task exploring visual processing and that they would see only pictures.

For all participants, the first step was to obtain informed consent and to fill out the background questionnaire. Next, participants were told that they would see multiple sets of picture pairs appear, one pair at a time, and that they must decide if the pairs are “related in meaning” by pressing the “yes” or “no” keys on the keyboard. The practice task was given first, followed by the target task, with the vocabulary test being presented before (i.e. priming group) or after (i.e. control group) the pictorial task.
The purpose of the current study was to explore simultaneous language activation in second language learners of American Sign Language (ASL). The research question was whether second language learners of ASL simultaneously activate English and ASL and if so, whether priming would have an impact on the level of activation. There were two hypotheses:

1. Within subjects, second language learners of ASL will have longer response times for competitive stimuli than non-competitive stimuli.
2. Between subjects, primed participants will have longer response times for competitive stimuli than the control group.

For analysis, Microsoft’s Excel was used to organize the data and to compute descriptive statistics; the statistical package SPSS was used to conduct the statistical tests. The results are presented in two sections, according to hypothesis.

**Hypothesis 1**

To test the first hypothesis, a repeated measures t-test for dependent means was conducted. This test examined all participants as one group to explore if, within subjects,
second language learners’ response times were significantly different for the two types of stimuli. For the competitive stimuli, the mean response time was 1729ms ($SD = 720ms$). In comparison, for the non-competitive stimuli, the mean response time was 1635ms ($SD = 617ms$). Contrary to the hypothesis, the t-test revealed that there was not a significant difference $t(22) = .696$, $p \leq .05$.

**Table 1.** Mean Response Time for Competitive (C) and Non-competitive (NC) Stimuli
Hypothesis 2

To test the second hypothesis, an independent-samples t-test was conducted to examine the effect of priming on the response time. The descriptive statistics for each group will first be provided before they are compared statistically.

Control Group

The control group was tested without receiving the priming treatment. On the post-experimental vocabulary test (58 items), the group mean for correctly demonstrated ASL signs was 43.92 ($SD = 7.02$, range = 30 – 52). Of the total 30 stimulus pairs, 15 were competitive and 15 were non-competitive (two pictorials were used twice). For competitive stimuli, the number of correctly signed pictorial stimuli ranged from 4 to 13 with a group mean of 9. The correctly signed non-competitive stimuli ranged from 5 to 14 with a group mean of 8. There were two possible reasons why some response times were not included in the final analysis. First, if participants judged semantic relatedness for the pictorial pairs incorrectly, response times only for that specific pictorial pair were excluded. Second, if during the vocabulary test participants did not know the correct ASL sign for a pictorial, response times for the pictorial pair that included that specific pictorial were excluded. The number of incorrect semantic judgments ranged from 0 to 7 at the individual level with a group mean of 1.46.
Primed Group

Primed participants were administered the target pictorial task after receiving the priming treatment. All trials in the task were used for analysis unless participants judged incorrectly whether pictorials were related in meaning. If participants judged the semantic relatedness for pictorial pairs incorrectly, response time data associated with that specific judgment error were not included in the final analysis. The number of individual incorrect semantic judgments ranged from 0 to 8 with a group mean of 1.7.

Between Subjects

Mean response times on competitive stimuli were compared between subjects. The mean response time for the primed group on competitive stimuli was 1534ms ($SD = 398ms$). In comparison, the mean response time for the control group on competitive stimuli was 1878ms ($SD = 881ms$). Table 2 is a histogram, presenting the average response time frequencies for each group on competitive stimuli.
To find out if group response time differences were statistically significant, an independent-sample t-test was conducted to compare response times for competitive stimuli in the primed and control group conditions. Contrary to the hypothesis, for competitive stimuli, there was not a significant difference in response times for the non-primed group ($M = 1878\text{ms}$, $SD = 881\text{ms}$) and the primed group ($M = 1534\text{ms}$, $SD = 398\text{ms}$); $t(21)=1.17, p = 0.212$. 

<table>
<thead>
<tr>
<th>Group</th>
<th>Response Time (ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>1878</td>
</tr>
<tr>
<td>Primed</td>
<td>1534</td>
</tr>
</tbody>
</table>
Chapter 5

DISCUSSION

The research question was whether second language learners of ASL simultaneously activate English and ASL when perceiving non-linguistic pictorials and if so, whether priming would have an impact on the level of activation. There were two hypotheses:

1. Within subjects, second language learners of ASL will have longer response times for competitive stimuli than non-competitive stimuli.
2. Between subjects, primed participants will have longer response times for competitive stimuli than the non-primed, control group.

The findings do not support simultaneous language activation in second language learners of ASL when viewing pictorials. In consideration of the literature review and the plethora of research confirming simultaneous activation, the lack of support for either hypothesis was initially surprising. The following sections explore how the current findings could be interpreted in reference to the previous literature and how they may be applied to future research.

The Spread of Activation

Previous research in support of the BIA+ model suggests that activation initially begins at either the top (semantic) level or bottom (phonological) level and then spreads
in a top-down or bottom-up manner to the other levels (Brysbaert & Dijkstra, 2006; Shook & Marian, 2012). Figure 11 depicts such top-down and bottom-up activation in English/ASL bilinguals—the languages of the participants in the current study.

**Figure 11. Flow of Activation for ASL/English Bilinguals**

Once activation begins in one direction, it can then spread up or down as well as laterally (within same level) to representations at any level. For top-down activation, presenting a picture of cheese should activate the word *cheese* at the lexical level and automatically spread activation laterally to the lexical representation of *cheese* in ASL as well as spread downward to the phonological components of cheese both in English and ASL. Bottom-up activation starts at the phonological level with a spoken input that
activates the phonological make-up of the speech. Phonological activation then spreads further upward to the semantic level as well.

If the spread of activation was automatic between levels, as the BIA+ posits, then after viewing the pictorials (semantic level) the current participants should have responded differently to the two types of stimuli (phonological level). That is, the pictorials should have activated semantic representations that then should have automatically spread activation to the lexical and phonological levels. Surprisingly, even for the primed group, support for this automatic spread of activation was not found. It was assumed priming would strengthen the linkage between pictorials and ASL lexical representations and therefore induce simultaneous language activation (Kuipers & La Heij, 2009). In support of the current study, similar null priming effects were witnessed by Jescheniak et al. (2009) in their third experiment with monolingual German speakers, that repeated the presentation of stimuli pairs to increase priming in participants, only to find no phonological effect of the priming.

It was also assumed that users of a signed and spoken language should demonstrate an even greater likelihood of simultaneous activation compared to spoken language bilinguals because of their knowledge of two language modalities. Knowing two language modalities affords users to be able to produce both a spoken language and a signed language at the same time (Bishop, 2011; Emmorey, Borinstein, Thompson & Gollan, 2008; Emmorey, Petrich & Gollan, 2012). While spoken language bilinguals must eventually suppress one language when both are activated, users of a spoken and signed language do not need to suppress either language (Casey & Emmorey, 2009;
Emmorey, Luk, Pyers & Bialystok, 2008; Pyers & Emmorey, 2008; Shook & Marian, 2012; Zou et al., 2012). Since users of two language modalities do not need to suppress language activation, it was assumed that the bilinguals in the current study would indubitably demonstrate simultaneous language activation.

To account for the results of the current study, the BIA+ model could be modified to incorporate a kind of threshold mechanism between the semantic level and the lexical and phonological levels (Bloem & La Heij, 2003; Damian & Bowers, 2003). Such a mechanism could help explain the limited spread of activation from the semantic level to the other levels when non-linguistic pictorial information is perceived. For example, a threshold mechanism has also been proposed for entry into the mental lexicon. That is, nonlinguistic information that is irrelevant for the primary message (i.e., self-grooming gestures) is quickly rejected from the lexical processing system (Grosvald, Gutierrez, Hafer & Corina, 2012; Ziegler et al., 1997). Of course, in contrast to nonlinguistic irrelevant information, pictorials hold meaningful information that must be processed in the mental lexicon, but may not spread as has been suggested for language-based information. Bloem and La Heij (2003) posit that once the appropriate concept at the semantic level is activated, a threshold mechanism may permit only the concept’s lexical and phonological representations to be activated. Thus, rather than an automatic spread of activation that occurs in an effort to find the appropriate representations, a threshold mechanism would permit only the activated concept and its lexical representations to be activated. The lack of support for either hypothesis despite priming and despite
participants being bilingual in two modalities, suggests that the BIA+ model may have critical limitations.

**Age of Acquisition**

Age of second language acquisition is important because the ideal time to learn language has a biological age constraint, known as the critical (sensitive) period hypothesis. The critical period hypothesis posits a specific developmental period for the ultimate success (measured in comparison to native users) of language learning (DeKeyser, 2013; Mayberry, 2010). The age at which an individual learns a second language could impact the connections between their first and second language and therefore affect possible simultaneous activation at the phonological, lexical and semantic levels.

The semantic level of language representation, compared to the phonological and lexical levels, seems to be linked differently to first and second languages, depending on age of acquisition. Contrary to the BIA+ model, which assumes that all bilinguals integrate representations at every level; some research suggests that the semantic level is not shared for late second language bilinguals, even if they become proficient (Silverberg & Samuel, 2004). As the current findings cannot report simultaneous language activation, one of the possible reasons may be that the mean age of ASL acquisition for participants was 24.5 years of age and that at this age, English and ASL representations are not integrated or connected like they would be if both were acquired early. In the simultaneous activation research that has been reported with ASL users, Morford,
Wilkinson, Villwock, Pinar & Kroll (2011) recruited pre-lingual Deaf individuals, fluent in ASL (did not report ASL age of acquisition) while Shook and Marian (2012) recruited hearing bimodal bilinguals with a mean ASL acquisition age of 7.5 years. Ormel, Hermans, Knoors & Verhoeven (2012) did find simultaneous language activation with young children knowledgeable of the Sign Language of the Netherlands (NGT) and Dutch, but did not report age of NGT acquisition. The findings from the current research could be interpreted from the perspective of Silverberg and Samuel (2004), suggesting that second language age of acquisition may be critical for explaining bilingual language representation and activation and that perhaps, late second language learners do not share a semantic system.

In addition to the importance of age of second language acquisition, the current study’s use of nonlinguistic pictorials may be just as critical. It is clear that pictorial information can have a highly influential role in activating language representations in the mental lexicon of bilingual users of spoken and signed languages (Corina & Knapp, 2006; Costa, Caramazza & Sebastian-Galles, 2000; Huettig, Rommers & Meyer, 2011; Meyer & Damian, 2007; Morsella & Miozzo, 2002); however, these studies invariably use language-based stimuli or a language-based task in conjunction with pictorials. Nonlinguistic visual information alone can also activate mental language representations (Huettig, Rommers & Meyer, 2011), even in purely nonlinguistic tasks (Athanasopoulos, 2011; Bassetti & Cook, 2011; Boutonnet, Athanasopoulos & Thierry, 2012).

By using nonlinguistic pictorials, the current study provoked novel insight into how activation may spread. Findings from the current study support research suggesting
that linguistic and nonlinguistic information is processed differently (Grosvald, Gutierrez, Hafer & Corina, 2012; Damian & Bowers, 2003; Jescheniak et al., 2009). For example, pictorials may be processed at the semantic level but not automatically spread activation to the lexical and phonological levels (Damian & Bowers, 2003). This suggests that how activation spreads may depend on whether or not the input is linguistic or nonlinguistic.

In summary, the findings from the current study suggest three important things. First, activation may not spread automatically between all the levels of representation, as the BIA+ model predicts. Second, language integration may be incongruous across language representational levels if the second language is acquired after a sensitive period. Third, non-linguistic information may be processed differently than linguistic information.

**Limitations**

Results from this study should be interpreted with caution. Its sample, methods and materials limit this study. These limitations will be discussed below.

**Sample**

This study was possibly limited by a few characteristics of the participants. In terms of the sample, the size was small and participants were recruited using convenience sampling. Furthermore, participants were only recruited from one program, limiting
generalizability to the larger population of second language learners of ASL. It is possible that the differences between and within groups is small, thus requiring a larger sample size to detect differences. Additionally, all participants were female and therefore cannot be generalized to the male population.

Participants were also limited by their ASL proficiency. It could be argued that the lack of support for either hypothesis was related to the participants’ low ASL proficiency because proficiency could affect the strength of possible activation and connections of mental representations. From the spoken language literature examining second language learners, proficiency does not seem to be a determining factor for simultaneous language activation (Brenders, van Hell & Dijkstra, 2011; Brysbaert, Van Dyck & Van de Poel, 1999; Chambers & Cooke, 2009; Duyck, Diependaele, Drieghe & Brysbaert, 2004; Hermans, Ormel, van Besselaar & van Hell, 2011; Schwartz & Kroll, 2006; Van Wijnendaele & Brysbaert, 2002). Previous simultaneous activation research focusing on ASL users recruited only highly proficient participants (Morford, Wilkinson, Villwock, Pinar & Kroll, 2011; Shook & Marian, 2012), so it is unclear whether proficiency was impactful in the current study, but the literature with spoken languages would suggest that it was not.

Another limitation with participants could be the context of their second language learning. Participants for the current study were learning ASL in a college classroom context. The context could influence the connections between a first and second language depending on if instruction uses the first language to learn the second language or if second language learning takes place in an immersed context, such as a study abroad
program for spoken languages. Previous research has shown that college students learning a second language in a classroom setting, experience greater simultaneous activation than those who are immersed in a study abroad program (Linck, Kroll & Sunderman, 2009). Participants in the current study had at least two years of ASL experience from a classroom environment; therefore, the current study’s participants should have been more likely to activate both languages.

**Methods and Material**

There were limitations regarding the methods and materials used because of a limited degree of control, and consequentially limited internal validity. Due to these limitations, the results of the current study should not be used to draw cause and effect relationships or conclusive evidence. There were two reasons such experimental designs were used. First, due to financial and time constraints, the researcher was limited to a small sample. Second, since the current study explored novel variables that previously had not been well investigated (second language learners of ASL and non-linguistic pictorials), the objective of the study was to form tentative hypotheses that could be followed up in future more experimentally strong studies.

In terms of the materials, there were limitations with the pictorials and task. First, the materials were developed for this study and were not independently tested for reliability. Second, semantic relatedness was screened for during a pilot study of only 10 hearing participants. It could be that more participants would have further altered semantic relatedness or that Deaf ASL users have different semantic relationships than
hearing individuals unfamiliar with ASL. Third, only one professor in the American Sign Language/Deaf Studies program confirmed phonological relatedness, although the researcher used phonologically related word pairs from previously published research.

**Recommendations for Future Research**

If the lack of support for either hypothesis is interpreted from the perspective that age of second language acquisition has an effect on integration and activation, future studies should investigate the impact of age of second language acquisition in more depth. While age of acquisition had a more central role in earlier bilingual models (Kroll & Stewart, 1994), recent models have not focused on age of acquisition as a critical component (Kroll & Tokowicz, 2005; Kroll, van Hell, Tokowicz & Green, 2010). From the current results, the BIA+ model’s assumption for highly similar activation processes for bilinguals, irrespective of second language age of acquisition and proficiency, needs to be questioned.

Findings from the current study suggest limitations to how activation spreads. Some researchers claim that the lexical system spreads activation automatically (Humphreys, Boyd & Watter, 2010; Mani, Durrant & Floccia, 2012; Seiger-Gardner & Schwartz, 2008), while others claim that there are important limitations (Bloem & La Heij, 2003; Bonin, Roux, Barry & Canell, 2013; Damian & Bowers, 2003; Kuipers &
Heij, 2009). Future research needs to carefully consider the results of both sides and attempt to detail and sort through the mixed results.

The use of nonlinguistic pictorials to investigate processing, as in the current study, is an understudied area. Future research should explore what types of nonlinguistic and linguistic information are critical. For example, one key component for future research is to more clearly define what a picture-picture interference task involves. In the writing up of the current study, the term *non-linguistic* was used to clarify that the task did not overly involve linguistic information. In comparison, other picture-picture interference tasks, while involving pictorials, have a language-dependent task (Roux & Bonin, 2012). Clarity to the types of linguistic and nonlinguistic tasks in future research could alleviate the debate between how activation spreads in the mental lexicon. Future research should clearly sort out the relationships between participants (proficiency, age of acquisition, etc.), stimuli (linguistic/nonlinguistic) and tasks (spoken written, eye-tracking, etc.).

To conclude, the results suggest that second language learners of ASL do not simultaneous activate English and ASL when viewing non-linguistic pictorials. While the results are not consistent with the BIA+ model and the abundance of research supporting it, the results provoke two important insights for the lack of support. First, age of acquisition may play a pivotal role for how a second language is mentally stored and connected to the first language. Second, non-linguistic tasks may not automatically spread activation through the mental lexicon as has been demonstrated with linguistic-
based tasks. While the current study was exploratory in nature, the intriguing results provide a profound incentive to be replicated and expanded upon with future research.

APPENDIX A

Background Questionnaire
Background Questionnaire

Participant #

What is your age? _____
What is your gender? ____________________
What is your B.A. major? __________________
(If you have a second major: ______________)
What is your first language? ______________
Do you know any other languages? _________________________
At what age did you begin to learn ASL? _____

Below is a list of the courses for the BA Deaf Studies/ASL program at CSUS.
Please fill out the first and last columns. Leave blank the courses you have not yet taken.

First column:
Mark an “X” next to the courses you have previously taken
Mark a “C” next to the courses you are currently enrolled in this semester

Last column: please provide, to the best of your ability, a recall of the letter grades for each of the courses you have previously taken and write these grades in the last column for each course. (If you do not feel comfortable providing your grades, you may skip that column).

“X” = previously taken
“C” = currently enrolled in

<table>
<thead>
<tr>
<th>“X” OR “C”</th>
<th>Course #</th>
<th>Course Name</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EDS 51</td>
<td>American Sign Language 1</td>
<td></td>
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</tbody>
</table>
On the 7-point scale below, please rate your **ASL productive fluency** by placing an X in one of the boxes on the second row.

<table>
<thead>
<tr>
<th></th>
<th>1 (Lowest)</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7 (Highest)</th>
</tr>
</thead>
</table>

On the 7-point scale below, please rate your **ASL comprehensive fluency** by placing an X in one of the boxes on the second row.

<table>
<thead>
<tr>
<th></th>
<th>1 (Lowest)</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7 (Highest)</th>
</tr>
</thead>
</table>
References


Barac, R., & Bialystok, E. (2012). Bilingual effects on cognitive and linguistic development: Role of language, cultural background, and education. *Child Development, 83*(2), 413-422.


