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# SEMANTIC PRIMING EFFECTS BETWEEN A NATIVE LANGUAGE AND A SECOND AS MODERATED BY INDIVIDUAL AND HEMISPHERIC DIFFERENCES

by

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## Abstract

Semantic Priming Effects Between a First Language and a Second as Moderated by Individual and Hemispheric Difference

Catherine Antalek

The current study examined second language learners and employed a masked semantic priming paradigm paired with a lexical decision task in an attempt to better understand the processes of acquiring semantic information from a second language (L2) and organizing into the lexicon of a learner. Results from previous literature reveal discrepant results, with some studies providing support for the Revised Hierarchical Model (RHM) emphasizing direct translation links from the first language (L1) being essential for second language processing, while other studies find that an L1 is not necessarily needed in order to process semantic information, thus, supporting the Distributed Representation Model (DRM). Of additional interest, were both the role of hemispheric processing and the relationship of working memory on second language semantic integration. Results from our study revealed an asymmetrical priming effect from the L2-L1 direction with better accuracy for targets in the left hemisphere providing support for the RHM.

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## Chapter One:

## Introduction

Learning a first language is often a slow and natural process starting in early childhood. The established set of word-forms and rules from our native language make it difficult to integrate new words and new rules from a second language. Learning a second language (L2), after a first has been acquired, may be a different process from learning a native language (L1), as it involves the addition of new word-forms carrying the same semantic (i.e. related in meaning) information as words already established in memory (Midgley, Holcomb, & Grainger, 2009). Research in second language acquisition (SLA) can provide important insights and implement effective teaching methods that facilitate second language learning. Learning a second language has become important to being a competitive job applicant, especially for jobs in business, and for facilitating successful and rapid language acquisition for families relocating to other countries. Semantic priming and translation priming studies (studies that find a target is recognized faster if preceded by a prime related in meaning or the translation of the prime in a second language respectively) utilizing vocabulary from L1 and L2 offer an informative perspective into the underlying mental processes of language organization in second language learners. For example, research on second language acquisition has found that bilinguals and second language learners process the form of a word before meaning is processed (McClelland & Rumelhart, 1981). The findings from this type of research provide important insights that help implement effective teaching methods and facilitate learning as more students from elementary to high school are expected to learn a second language as part of their school's curriculum. Understanding the processes of learning a second language and its subsequent organization in memory enhances communication between native speakers and language learners across correspondences in all contexts. Thus, the purpose of the current study is to investigate semantic integration (meanings assigned to word forms) and retrieval of an L1 and an L2 in the memory of a language learner in order to provide a fuller picture of second language processing.

Several studies examining second language acquisition have found that one's first language can influence processing of a second language and vice versa (Basnight-Brown & Altarriba, 2007; Duyck, 2005; Keatley, Spinks & Gelder, 1994; Schoonbaert, Duyck, Brysbaert, & Hartsuiker, 2009; Voga, & Grainger, 2007). However, reported findings on the organization of multiple lexical representations of one meaning (for example *gato* and *cat* are two different words carrying the same semantic information) in the mind of a bilingual or second language learner yield contradictory results. For example, in translation studies using bilinguals, some researchers report more accurate and faster response times (RTs) to a word presented in one language (referred to as a target) when a direct translation in another language is presented prior to the target (referred to as a prime) than when a control or unrelated prime is presented (Chen & Ng, 1989; Finkbeiner, Forster, Nicol, & Nakamura, 2004; Gollan et al., 1997; Voga & Grainger, 2007). However, other studies report no comparable RTs and accuracy to a target when primed with either a translation or a control prime **(**Rastle, Davis, Marslen-Wilson, & Tyler, 2000; Holcomb et al., 2005**),** or even slower RTs and worse accuracy scores to the target (Duyck, 2005; Gollan et al., 1997; Grainger & French-Mestre, 1998; Jiang, 1999, Jiang & Forster, 2001; Kroll & Stewart, 1994; Schoonbaert et al., 2007). Further, if priming effects are found, there seems to be a discrepancy in the prime-target language direction in which these effects occur; a priming effect can be found when a prime in the L1 and a target in the L2 (L1-L2 direction) are presented or when the prime is presented in the L2 and the target in the L1 (L2-L1 direction). If faster RTs and better accuracy are found in one direction but not the other, it is referred to as a priming asymmetry. Some researchers find faster RTs to a target word only by presenting a native language (L1) as the prime and the second language (L2) as the target, with small or no effects presenting the L2 as the prime and L1 as the target indicating a priming asymmetry (Altarriba, 1992; Kroll & Stewart, 1994; Gollan, Forster, & Frost, 1997; Jiang, 1999; Jiang & Forster, 2001). Other studies however, have reported a priming effect in both directions such that presentation of a word prime in either language will facilitate processing in the subsequent target in the opposite language yielding no priming asymmetry (Chen & Ng, 1989; de Groot & Nas, 1991; Jin, 1990; Keatley et al. 1994; Schwanenflugel & Rey 1986). Based on these opposing findings, researchers have generated two models of language organization outlining how newly acquired word-forms in the second language are constructed to re-represent established meanings and how they are subsequently retrieved from memory.

The first model is the Revised Hierarchical Model (RHM; Kroll & Stewart, 1994) that asserts newly acquired forms in the L2 are connected directly to their equivalent translations in the L1, and retrieved only after first accessing the L1. Alternatively, the Distributed Representation Model (de Groot 1992a; de Groot 1992b) contends that the new form is acquired gradually and connects to any other associated item in the lexicon including the translation and other semantically related words. Evidence has been found to support both of these models, however replicable results are minimal rendering the evidence inconclusive. The purpose of the current study is to test the assumptions of each of these models. The models and their specific assumptions will be discussed later.

The discrepancy among findings in second language research needs to be resolved in order to build understanding of second language acquisition so that we can improve learning processes and bilingual communication. The current study investigated discrepancies in the literature by examining the interactions between an established native language and a second language actively being integrated into the memory. Specifically, the current research investigated the effects of priming a participant with one language paired with a semantically-related target in the other language. Additionally, the study investigated individual differences in working memory and hemispheric processing, as both may be moderators affecting RTs.

# Chapter Two:

# Literature Review

## Methodological Techniques in Cross-Language Experiments

A common and supported method of examining language acquisition, bilingual processing and organization, employs a Lexical Decision Task (LDT) paired with a priming paradigm (Meyer & Schvaneveldt, 1971). The LDT paradigm involves presenting the participants with a string of letters instructing them to indicate, as quickly as possible, whether the string of letters is a real word or a nonword. In this paradigm, accuracy and RTs are measured as dependent variables for each target item. Primes are a second string of letters, which precede the target item used for the lexical decision task. The purpose of a prime is to elicit an automatic or strategic lexical process that will affect the response to the target item. Generally, responses to LDTs preceded by an experimental prime are compared to responses following a neutral or a control prime. This paradigm allows researchers to manipulate automatic or conscious processing of presented stimuli in order to test lexical access, and the processing of a target. For example, in monolingual semantic priming experiments a response to the word *doctor* may be faster when primed by a semantically related word such as *nurse* than when primed by an unrelated word such as *bread* (Meyer & Schvaneveldt, 1971).

The LDT is also often used in cross-language priming where one language is presented as a prime, and a second language as a target. This paradigm is most commonly done in the form of translation priming where a target is presented in the one language and the prime is the target's direct translation (e.g., cat-*gato*). Research has found that when primes are a translation of a target, they facilitate RTs and accuracy generating a strong priming effect (Chen & Ng, 1989; Finkbeiner, Forster, Nicol, & Nakamura, 2004; Gollan et al., 1997; Voga & Grainger, 2007.) Generally however, a differential priming effect in translation priming in bilinguals is observed, such that the priming effect is stronger when the target word is presented in L2 and the prime is presented in L1. Very few studies have found a significant priming effect when the target is in L1 and the prime in L2, in fact, sometimes there is an inhibitory effect when RTs to the target are slower than at a normal control pace (Duyck, 2005; Gollan et al., 1997; Grainger & French-Mestre, 1998; Jiang, 1999, Jiang & Forster, 2001; Kroll & Stewart, 1990; Schoonbaert et al., 2007). As with monolingual studies, a cross-language priming technique used to investigate second language processing and bilingual memory storage is the semantic priming paradigm employed using both a native and a second language.

**Semantic priming.** Semantic priming refers to the technique used in language studies where a target is preceded by a semantically related prime. The primes and targets are not direct translations of each other as is done in translation priming (e.g., cat-*gato*), but instead the prime-target pair is related in meaning (e.g., cat-*perro* [dog]). Semantic priming is a common priming paradigm in many monolingual studies (Bleasdale, 1987; Ferrand & New, 2003; Neely et al., 1989; Perea & Rosa, 2002a, 2002b; Hutchison, 2003; Lucas, 2000; Neely, 1991), where findings show that RTs to targets are faster when the prime is semantically related (e.g., doctor-*nurse*) than when the prime is unrelated (e.g., doctor-*table*). Less common in the literature is cross-language semantic priming (Duyck, 2005; Kroll & Stewart, 1994; Schoonbaert et al., 2007; Chen & Ng, 1989; de Groot & Nas, 1991; Keatley et al. 1994; Schwanenflugel & Rey 1986; Basnight-Brown & Altarriba, 2007). In cross-language semantic priming, the prime-target pairs are still semantically related, but the prime and the target are in different languages (e.g., cat-*perro* [dog]). Cross-language semantic priming studies offer an investigation of the relationships between two different lexical structures in two separate languages conveying associated meaning. When a second language is acquired, meaning and form are learned as a single unit, so it is important to understand how meaning is integrated and retrieved from memory. Cross-language semantic priming studies can help determine whether or not the acquired meanings in an L2 are connected to all associated meanings in L1 and L2 or only to their translations in the L1. As mentioned earlier, in lexical decision tasks, a semantic priming effect in a single language domain is found when a semantically related prime word produces faster and more accurate RTs to targets than if the primes were unrelated to the target. For example, *bread* should prime *butter* faster than *cat* would prime *butter* (Meyer & Schvaneveldt, 1971). Very few experiments examining cross-language semantic priming effects have been conducted, and of the few studies that do exist, there seems to be a discrepancy in the results. Further, some studies using semantic priming consider translations from L1 to L2 (e.g., *perro* and dog) to be "semantically related" (Midgley et al., 2009), but the relationship between words often found together in context is neglected. For example, *bread* and *butter* are generally associated together and indeed generate a strong priming effect in a single language domain (Meyer & Schvaneveldt, 1971) and therefore are associated items in the lexicon.

There is little investigation into whether different forms in L1 and L2 representing the same meaning are also associated with these semantically associated items in both their L1 and L2 forms. For example if the word *bread* now changes its form to *pan* in Spanish but still conveys the same meaning, is *pan* still associated with the L1 form *butter*? Most research in second language acquisition focuses only on form processing or direct translation processing of L1 or L2 stimuli, and while that is important, it is also crucial to understand how meanings across all associated items in both languages are accessed. Studies involving semantic priming as well as translation priming have found a differential cross-language priming effect with an unmasked prime, which is a prime that is not hidden and consciously processed by the participant using a lexical decision task (Chen & Ng, 1989; de Groot & Nas, 1991; Keatley et al. 1994; Schwanenflugel & Rey 1986). In these studies, bilinguals respond faster to targets in one language (L1 or L2) when primed with the semantic translation in the opposite language (L1 or L2). The priming effects in these studies have been found to be larger in the L1 to L2 direction than from L2 to L1. The lack of replicable results could also potentially be due to flaws in the methodology (Altarriba & Basnight-Brown, 2007). One main methodological aspect that is not always carefully considered, is the length of time the prime is presented and the amount of time allotted between presentation of the prime and presentation of the stimulus. One effective way to control the presentation of a prime is to use a masked priming paradigm.

**Masked priming.** Masked priming (Forster & Davis, 1984) involves presenting a prime that is situated between a forward mask, and a backwards mask. The forward mask is usually a string of hashtags (#####) and the backwards mask can be either a string of random consonants (ZTKHWNPDQ) or is the target itself. When a prime is masked, it is unseen by participants and therefore not consciously processed, but automatically processed. In masked priming paradigms, the prime itself, as well as the interval of time between the presentation of the prime and the presentation of the target item, referred to as stimulus onset asynchrony (SOA), is generally controlled. It is important to control an SOA, especially in semantic priming experiments, because it allows for automatic processing of the presented prime (Altarriba & Basnight-Brown, 2007). In bilingual experiments this paradigm is generally used with translation priming and lexical decision tasks (Basnight-Brown & Altarriba, 2007; Duyck, 2005; Finkbeiner, Forster, Nicol, & Nakamura, 2004; Gollan et al., 1997; Grainger & Frenck-Mestre, 1998; Jiang, 1999; Jiang & Forster, 2001; Kim & Davis, 2003; Voga & Grainger, 2007). One benefit to using a masked semantic priming paradigm to examine cross-language processing is that it allows investigation of purely automatic unconscious processing. Very few studies have been used to examine cross-language semantic priming with a masked prime. Midgley et al. (2009) argued that the asymmetry of priming effects in translation and semantic priming studies are due to an overt translation strategy generated from a conscious processing of the word. Translation strategies and other expectancy strategies the participant generates from consciously processed stimuli may differ due to exposure to the language or proficiency level and therefore confounds conclusions drawn from these priming studies. A masked prime would allow for observation of the direct initial procedures the brain uses to organize and process the given stimuli. Some research using a masked priming technique indeed found evidence of strong semantic priming effect. A recent study of Dutch-English bilinguals found a priming effect with a prime lasting 57ms and an SOA of 114ms for L2 targets (e.g., *church)* primed by an L1 pseudophoneme (e.g., *pous*) of semantically related words (e.g., paus [pope]) (Duyck, 2005). This effect was not found when targets were instead in the L1 and pseudophoneme primes in the L2. Perea, Duñabeitia, and Carreiras (2008) also found a cross-language semantic priming effect in both directions, in balanced Basque–Spanish and Spanish–Basque bilinguals when showing a prime for 47ms with an SOA of 47ms. A study with unbalanced Dutch-English bilinguals found significant semantic priming effects in both directions when presenting a prime for 50ms and two SOA conditions; 100ms and 250ms. Though the 250ms condition generally showed a greater priming effect, it was not significantly different from the priming effects found with a 100ms SOA (Schoonbaert, Duyck, Brysbaert, & Hartsuiker, 2009). These studies all incorporate a masked prime, however prime presentation and SOAs are not kept the same across studies. We therefore cannot determine whether replicable results depend on the duration of the prime and an SOA, especially since other studies with similar durations have found contrasting results. An early study by de Groot and Nas (1991), found no cross-language semantic priming effects from an L1 prime to an L2 target, and a small effect from L2 to

L1 while testing Dutch– English bilinguals when the prime was presented for 40ms and an SOA of 60ms. Another study using Spanish-English bilingual participants also failed to find significant cross-language semantic priming effects with a prime and an SOA of 100ms in either priming direction, using prime–target pairs such as *dia* [day]–NIGHT (Basnight-Brown & Altarriba, 2007). Since studies with similar prime and SOA duration have found opposing results, it is necessary to conduct a study in which prime and SOA durations are varied within-subjects and tested against each other.

***Stimulus onset asynchrony (SOA) length***. One possible explanation for the different semantic priming effects found in the literature may come from the methods used in the experiments. Masked semantic priming is sometimes favored in language studies because it is meant to elicit automatic access to the meaning of the presented prime word. Neely, Keefe, and Ross (1989) argue that semantic priming may involve two processes. The first is that when a word is presented, its meaning is automatically processed and activation subsequently spreads to semantically related words. The second process involves the expectancy strategy used by the individual to predict quickly what will appear with the presented word. Semantically related words will be in this expectancy set and if the target word is in this set, it follows that participants would respond faster. Neely (1991) argued that the SOA used in the priming paradigm will affect whether or not this strategy is used, if the SOA is longer, participants will have more time to process and employ strategies. The masked priming paradigm elicits automatic semantic processing, in which shorter SOA's decrease the likelihood of using strategies. The slowest SOA where automaticity is thought to begin is 250 ms (Altarriba & Basnight-Brown, 2007). Therefore, the current study will employ a masked priming technique (Forster & Davis, 1984) with short SOAs in order to keep the processing of the prime automatic and to avoid expectancy strategies, without hindering semantic processing.

The translation and semantic priming asymmetry commonly found in cross-language research could not only be a result of differences in methodology, but may also result from either a qualitative difference or a quantitative one. A qualitative difference would support the RHM (Kroll & Stewart, 1994) model that suggests L2 is mapped differently than L1 and must be accessed through translation of L1. A quantitative difference would follow the DRM model (van Hell & de Groot, 1998) stating that there is one system processing both L1 and L2 and that processing is by means of spreading activation. The current study will examine if semantic processing can be accounted for with a cascaded model of activation, where processing happens sequentially, or one of spreading activation. If the RHM assertions are correct, then participants should be slower to respond to targets in the L2- L1 direction regardless of the SOA because meaning is being drawn from the direct translation and not a set of lexical set of representations as postulated in the DRM. RTs would be faster in the L1-L2 direction because the direct link is provided by the prime and facilitates lexical processing. If the DRM assertions are correct, then RTs should be generally the same in both directions regardless of the SOA because both and L1 and an L2 prime are accessing from the same pool of lexical resources and are not directly linked. The masked semantic priming techniques employed in the present experiment should produce a clearer picture of lexical access in language learners.

**Models of L1 and L2 Processing**

Two relevant models have been proposed in an attempt to explain priming effects, or lack thereof, in second language acquisition and bilingualism. These frameworks make specific hypotheses about language integration of L1 and L2, and retrieval routes of both languages. The Revised Hierarchical Model (RHM) (Kroll & Stewart, 1994), and the Distributed Representation Model (DRM) (de Groot 1992a; de Groot 1992b) make differing assumptions as to how newly learned L2 forms are integrated with established forms in L1 (Kroll & Stewart, 1994; Midgley, Holcomb, & Grainger, 2009; de Groot 1992a; de Groot 1992b). The RHM assumes a cascaded processing method where processing can be broken down into sequential stages where one word (usually the strongest in memory) has to be processed before any other related word can be activated. At the first stage, L1 is established in the lexicon, next, L2 words are directly linked to the established L1 set and must be retrieved through initial retrieval of the L1 form. The DRM (de Groot 1992a; de Groot 1992b) on the other hand, assumes a spreading-activation type of second language processing where L1 and L2 forms can link to any associated item of either language (represented as nodes in the memory system) when acquired, and may be activated by a stimulus in either language.

The RHM (Kroll & Stewart, 1994) maintains that as an L2 is acquired, it becomes directly linked to the pre-established L1 translation already existing in the lexicon, and that the processing of an L2 depends on a direct retrieval of the corresponding representation in the L1 subsequently translating to the L2. Languages are assumed to each have their own lexicon with one shared conceptual store and as a language is acquired, access to the L2 lexicon relies on initial access to the L1 lexicon because they do not have enough conceptual links. These lexical links remain even after conceptual links are later established between L2 words and concepts. As learners become more proficient, L2 words are connected to their equivalents in the L1 and retrieved through both lexical links conceptual information they share (Kroll & Stewart, 1994; Kroll, van Hell, Tokowicz, & Green, 2010). This model can account for evidence of an asymmetry in translation priming between L1 and L2. The model proposes that the links from L2 to L1 translations are stronger than links from L1 to L2. According to the RHM, this asymmetry occurs because processing of L2 starts by first accessing L1, which becomes difficult and requires additional processing time when primes are in the L1 and targets in the L2. However, processing would be faster when the prime is in the L2 and the target in the L1 since the direct link has been provided and additional processing to retrieve the link is not necessary. According to RHM, semantic-level processing should follow form-level processing very rapidly and should therefore elicit early semantic activation (McClelland, 1979; McClelland & Rumelhart, 1981). Once form representations are activated by a presented stimulus, activation immediately starts to spread to higher levels (i.e., meaning). The RHM model can also account for the finding that as language proficiency increases, the priming asymmetry decreases and a stronger prime is found in both the L1 to L2 and the L2 to L1 direction. As postulated by the RHM, the more proficient the participant is in the second language, the stronger the links are between L1 and L2 and the faster the access should be. The present study will recruit language learners at the intermediate level to test if proficiency level follows the assertions of the RHM.

The Distributed Representation Model (DRM) (de Groot 1992a; de Groot 1992b) considers both languages to be integrated into a single or shared lexicon represented as a group of "nodes." The DRM holds that faster RTs to a target in priming paradigms is mainly produced because of a single mechanism processing both L1 and L2 by means of spreading activation (Collins & Qulillian, 1969; van Hell & de Groot, 1998). If spreading activation processing is assumed, then a semantic priming effect would be the result of the activation of the meaning of the prime spreading to all other "nodes" that represent that same meaning or conceptual information. The DRM model suggests that when RTs are faster to targets in one language than the other, referred to as translation priming asymmetries, effects are small, and are found simply because of a richer and more established semantic representation for L1 than for the L2 and therefore more of the semantic "nodes" for the L1 are activated producing a stronger semantic priming effect in the L1 to the L2 direction (Duyck & Brysbaert, 2004; Schoonbaert et al., 2009; Tokowicz, Kroll, de Groot, & van Hell, 2002). Previous studies have also found evidence for faster RTs and better accuracy when translating words that have a unique meaning in the two languages than words with multiple translations (e.g., Boada, Sanchez-Casas, Garcia-Albea, Gavilan, & Ferre, 2009; Degani & Tokowicz, 2010; Laxen & Lavaur, 2010; Tokowicz & Kroll, 2007). Better RTs to words with unique meanings is supported within this framework because this model suggests that the amount of shared nodes for a concept or semantic representation for a given stimulus determines the speed of its processing. If only one node is shared, activation of that node will be faster than activating several nodes at once.

The current study is designed to test both assertions of the RHM and the DRM. Participants were semantically primed in both the L1 to L2 and the L2 to L1 direction in order to test the strength and direction of priming effects in second language learners. The current study attempted to differentiate between the two models to determine whether retrieval of one language may rely on a direct link to another or whether both languages are represented and processing relies on spreading activation. Since participants were language learners with a stronger English background than Spanish, called an unbalanced learner, if priming effects are only found from L1 to L2 and not from the L2 to L1 then we can assume that processing a second language must be linked directly to the translation of the first language and would fit within the RHM. Processing is facilitated when the direct link is already presented with a prime in the L1 and a target in the L2, but would be slowed when the direct link is not presented, and further processing is needed from the L2 to the L1. If priming effects are similar in both directions, we can assume that processing does not rely on a direct translation link in the native language, and therefore supports a spreading activation theory postulated by the DRM.

**Hemispheric Processing Differences in L1 and L2 Processing**

To get a clearer understanding of the organization and processes of second language acquisition we intended to examine where these processes are happening in the brain. The divided visual field paradigm (Beaumont, 1983) is a methodology used to isolate processing in the right or left hemisphere by presenting stimuli on opposite sides of the center of the visual field. Hemisphere processing effects in language processing have shown a favorable advantage for the left hemisphere such that processing is faster and more accurate. For example, Midgley, Holcomb, and Grainger (2009) found that participants had faster RTs in a lexical decision task using masked translation priming in when stimuli were presented in the left visual field than when processed in the right hemisphere. Better performances when processing in the left hemisphere could be a moderating factor in any of the proposed bilingual language processing models (Joss & Virtue, 2009). However, it has also been proposed that readers favor their right hemisphere when processing weakly related or unrelated information (Beeman et al., 1994; Chiarello & Richards, 1992). Beeman and colleagues proposed that semantic information is activated differently between the left and right hemisphere, which may support the spreading activation theory of the DRM. A recent study by Joss and Virtue (date) did not find that weakly related items were processed faster in the right hemisphere, but they did find a differential hemispheric processing effect. In their experiment, participants processed strongly related items better than weakly or unrelated items presented in the left visual field and processed by the right hemisphere, but processed both weakly and strongly related items better than unrelated ones in the left hemisphere. Hemispheric processing strength may be an important indicator of individuals who are better equipped to acquire a second language. Differences in hemispheric processing among individuals may also indicate which learning and teaching techniques fit the individual student. For example, strength in the left hemisphere may indicate better language abilities, however strength in the right hemisphere may indicate a better ability to draw inferences in language comprehension when two ideas are not explicitly related (Beeman et al., 1994; Chiarello & Richards, 1992), or when finding themes (Schneiderman, Murasugi, & Saddy, 1992). Since general language abilities as well as reading comprehension abilities are both important in second language acquisition, the present study presented the priming paradigm in both the left visual field (LVF) and the right visual field (RVF) in order to test hemispheric differences in semantic cross-language processing.

**L1 and L2 Processing Differences and Working Memory**

The present study will also focus on how semantic priming effects in a second language are moderated by working memory ability. Working memory (WM) is the ability to manipulate and maintain the flow of incoming information, and to organize it to be stored long term (Baddeley, 1992), and is a vital part of learning and processing any kind of presented information. WM is limited in capacity and functional speed of processing. WM ability plays a significant role in second language acquisition (Miyake & Friedman, 1998); findings indicate higher WM ability is related to accelerated comprehension and acquisition in a second language (e.g., Gorman, 2012; Swanson, Orosco, & Lussier, 2015). Bilinguals have shown more favorable working memory abilities as compared to non-bilinguals, however, bilinguals have rarely been compared to each other in the context of semantic processing, and language learners have not been compared at all. WM is activated differently among individual learners, with varying level of function and capacity, generally classifying a learner as high or low in WM (Baddeley, 1992). WM ability can also be used to accurately predict achievement of comprehension and language ability in a second language (Swanson et al., 2015), and individuals high in WM also show a higher second language vocabulary (Papagno & Vallar, 1995). Further, WM capacity may determine what kind of teaching methods fit the learner best. For example, individuals with lower working memories will have a harder time processing multimedia-learning materials because it creates extraneous processing (Baddeley, 1992).

**The Current Experiment**

Indeed there seems to be some discrepancies in the literature concerning semantic priming, especially across multiple languages. While some studies have found evidence of a cross-language semantic priming effect (Duyck, 2005; Perea, Duñabeitia, & Carreiras, 2008; Schoonbaert, Duyck, Brysbaert, & Hartsuiker, 2009), others have failed to find such an effect (de Groot and Nas, 1991). Also unclear is whether there are asymmetries in priming across the L1 and L2 and whether this is due to a qualitative difference in language processing or a quantitative one when a priming effect is found. The purpose of the current experiment was an attempt to resolve some of the opposing findings in the literature by investigating the effects of automatic activation of semantic information on processing in L1 and L2 in unbalanced Spanish language learners.

Many previous studies are also more than a decade old and are not up to date with current methodological considerations for studies of this nature. Along the same lines, many methods are not comparable to others, or are lacking important considerations such as SOA length and effective priming techniques. In addition, past studies have all used bilinguals, and while they are a reliable source of study, those in the process of learning a second language are an additional source to study second language processing and organization. Therefore, the current study examined participants who are not yet bilingual, but actively acquiring a second language, and enrolled in intermediate level Spanish college courses. The current study aimed to use an optimal SOA length in order to elicit automatic semantic processing but without allowing time for participants to use expectancy strategies in order to examine whether semantic information from L1 to L2 or from L2 to L1 is automatically processed for second language learners. This experiment employed a masked semantic priming paradigm with a lexical decision task to examine semantic priming effects between languages from the participant's native language (L1) to their second language (L2) as well as in the opposite direction. SOA's were manipulated in an attempt to better pinpoint the initiation and end of automatic processing before overt strategies are used and to attempt to create replicable results.

Past studies have not considered the unique contributions of working memory capacity as a moderator in second language processing, and very few have considered any role of differential hemispheric processing. The current study incorporated both of these variables in order to create a clearer, and more develop picture of second language lexical processing. Working memory was assessed to test the degree to which WM ability may be a moderator of any observed priming effects. Additionally, hemispheric processing differences were compared to test how semantic information is processed between the left and the right hemispheres. Using the DRM as our theoretical framework which emphasizes spreading activation of L2, we hypothesized that language learners would show comparable accuracy and RTs in both the L1-L2 and L2-L1 directions when primed with a semantically related word than when primed with an unrelated word regardless of the SOA length. Comparable RTs and accuracy in both directions with semantically related prime-target pairs would indicate a priming effect for semantically related words that is not asymmetrical across languages. We also expected to find faster RTs with a 57 SOA length compared to a 67 SOA because it will facilitate automatic processing to produce a priming effect, yet not enough time to produce any expectancy strategies. We predicted that participants with higher working memory scores will respond faster and more accurately than participants who are lower in working memory because they are better equipped to maintain and process two languages at a one time.

# Chapter Three:

# Methods and Materials

## Design

The current experiment employed a masked priming technique with two varying stimulus onset asynchronies (SOAs), two different priming conditions, and two different hemispheric processing conditions, thus, yielding a design of 2 (Prime direction: L1-L2 vs. L2-L1) x 2 relatedness (semantically related or unrelated) x 2 (Hemisphere processing: right vs. left) x 2 (SOA length: 57ms vs .67ms) within-subjects design. Accuracy scores and RTs were recorded as dependent variables. Accuracy scores were calculated as the percentage of correct responses, and RTs were recorded in milliseconds.

## Participants

The sample comprised thirty-three undergraduate students aged 18-35 ($M$ = 20.85, $SD$ = 3.56) from Towson University. Participants were right-handed native English speakers, with normal or corrected-to-normal vision, currently or previously enrolled in an intermediate or higher Spanish course. Participants were recruited from Spanish classrooms, and as compensation, were given a $10 Visa gift card.

## Materials

The visual stimuli included a total of 100 Spanish-English prime-targets pairs; 50 of the prime-target pairs were semantically (e.g., *gato* [cat] and *dog*) and 50 were unrelated prime-target pairs (e.g., *silla* [chair] and *wallet*). 100 non-word targets (50

Spanish and 50 English) paired with 50 English real-word primes and 50 Spanish real-word primes respectively were used as fillers to match the experimental pairs. The selected words ranged from three to ten letters in length (e.g., *guerra* [war] and *paz* [peace]) and did not include any cognates (i.e., words spelled almost the same in two languages and have virtually the same meaning, for example *capital* is the same in English and Spanish), or homographic noncognates (i.e. words that are spelled the same in both languages, but have different meanings [e.g., *pie* means *foot* in Spanish]) as suggested by Altarriba, (2005). The stimuli were matched for length, number of syllables, frequency, and orthographic neighbors ensuring the unrelated words were comparable to the related words. In the experiment, the stimuli presented first were referred to as the *prime* and the second as the *target*. In addition to the primes and targets, 50 English nonwords 50 Spanish nonwords were used in the lexical decision task. Thus, each participant was presented with 100 word pairs; 50 semantically related pairs, 50 unrelated pairs, and 100 word–nonword pairs. Within each word pair type, half of the pairs were in the Spanish (L2)–English (L1) direction and half in the English (L1)–Spanish (L2) direction. For example, of the 50 semantically related word pairs, 25 of the pairs were presented in the Spanish–English direction, and 25 of the pairs were presented in the English–Spanish direction. All pairs were randomized for participants such that they could not anticipate the target. Multiple versions of the study were created to ensure there was no list effect on accuracy and RTs.

**Working Memory**. Working memory was measured using the reading span task (RSPAN) adapted to E-prime (Unsworth et al., 2005). Participants were asked to read sentences and verify the logical accuracy of the sentences by selecting a true or false button while trying to remember a set of unrelated letters; one presented after each given sentence. The sentences were presented in groups that ranged in size from two to six and an 85% accuracy on the logic ratings was required. Letter recall was prompted at the completion of a set of sentences where participants chose which letters were presented, and in which order. Partial span scores were recorded and represented the total number of items recalled in the correct order.

**Procedure**

All participants completed a consent form, and a demographics and language history questionnaire before the start of the experiment. This was followed by the completion of the masked-prime lexical decision task, and a meaning generation task.

**Masked priming technique.** The masked priming technique (Forster & Davis, 1984; Forster, Mohan, & Hector, 2003) was used in the current experiment as way to test for automatic activation of semantic information. We followed the methodological procedures used by Midgley et al., (2009) with one amendment to the SOA. For this experiment, the priming task proceeded as follows:  First, a forward mask, 12 hash marks (############) was presented either to the left or right of the center of the screen for 200ms. The forward mask was followed by a 50ms presentation of the prime (in L1 or L2), and finally, a 10-character uppercase random consonant string backward mask (ZJGRRFMXHG) was presented for 17ms immediately preceding the target stimulus. The target was then presented until a response was given or for a total of 5000ms with no response. This procedure produced a 67ms stimulus onset asynchrony (SOA) which has been shown to be enough time to process semantic relationships. The procedure for trials presented with an SOA of 57ms, was identical, apart from the backward mask, which was presented for 7ms instead of 17ms. These SOAs were used specifically because they should be long enough to allow time to semantically process the prime automatically, but short enough to not leave time for the use of expectancy strategies (Neely, 1991; Altarriba, 2005).

At the presentation of the target, participants were asked to make a lexical decision as to whether the presented string of letters was a real word or a nonword (i.e. not existing in either the English or the Spanish language). Targets classified as real words were paired with a preceding prime word in the opposite language that was either semantically related or unrelated.

**Hemispheric Processing.** In order to test lateralized processes, the divided visual field paradigm was utilized. Half of the stimuli were presented in the right visual field, and half presented in the left visual field in blocks so that the participants were not switching back and forth. Fixation cues and stimulus presentation followed the guidelines outlined by Bourne (2006) in her article on methodological considerations in the divided visual field paradigm. A fixation was presented to the center of the screen following each trial in order to orient participants, and the stimuli were subsequently presented approximately 3.2 degrees of visual angle to the left or the right of the fixation point.

After all the stimuli were presented, participants performed a meaning generation task to test their knowledge of the Spanish stimuli. Only data from participants who score with 80% accuracy were considered for further analysis. Three participants were excluded from analysis due to a low accuracy score on the meaning generation task leaving a total of thirty participants.

# Chapter Four:

# Results

The current study tested the effects of presenting primes in either the English (L1) or Spanish (L2) to semantically related or unrelated targets in the opposing language. We hypothesized participants would respond with similar RTs and accuracy to regardless of prime-target direction. Secondly, we predicted that participants would respond faster and more accurately to semantically related prime-target pairs than unrelated ones. We expected faster RTs and better accuracy scores when stimuli were presented in the 57ms condition and also when it was presented to the RVF. Finally, working memory was assessed using the RSPAN and scores were analyzed as a correlate of RTs and accuracy measures.

## Behavioral Data

**Response times.** A 2 direction (L1-L2 vs. L2-L1) x 2 relatedness (related vs. unrelated) x 2 visual field (Left Visual Field vs. Right Visual Field) x 2 SOA length (57ms vs. 67ms) repeated measures ANOVA was computed on response times. Mean RTs to each condition are shown in *Table 1.*

Table 1. Mean RTs (ms)

| | SOA 57ms | | | | SOA 67ms | | | |
|---|---|---|---|---|---|---|---|---|
| | LVF | | RVF | | LVF | | RVF | |
| *Direction (Relatedness)* | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| L1-L2 (Related) | 915.97 | 206.02 | 937.23 | 214.16 | 899.46 | 191.98 | 1003.03 | 10.07 |
| L1-L2 (Unrelated) | 959.63 | 280.49 | 934.06 | 232.55 | 829.20 | 231.78 | 911.93 | 170.06 |
| L2-L1 (Related) | 824.93 | 168.15 | 734.14 | 188.26 | 747.84 | 153.95 | 745.96 | 114.96 |
| L2-L1 (Unrelated) | 839.54 | 188.41 | 791.08 | 150.41 | 726.28 | 185.11 | 752.57 | 114.73 |

As mentioned, we hypothesized that participants would have similar RTs regardless of the language direction, from L1-L2 or from L2-L1, but would respond faster to semantically related prime-target pairs than unrelated pairs. Results revealed a significant main effect of RT by direction $F(1,29) = 31.89$, $p < .01$. Contrary to predictions, participants responded significantly faster to prime-target pairs in L2 (Spanish)-L1 (English) direction ($M = 770.54$, $SD = 249.38$) than for targets L2-L1 direction ($M = 926.84$, $SD = 497.39$). Additionally, participants did not differ significantly in their RTs to semantically related and unrelated $F(1,29) = 0.64$, $p > .05$. However, there was a significant direction x relatedness interaction for RTs $F(1,29) = 4.32$, $p < .05$. *Figure 1* shows that participants responded significantly faster to semantically related prime-target pairs in the L2-L1 direction ($M = 764.35$, $SD = 150.14$) than to unrelated pairs in the same direction ($M = 776.74$, $SD = 153.25$). The opposite effect was observed in the L1-L2 direction; participants were faster to respond to unrelated pairs ($M = 912.14$, $SD = 203.39$) than to related pairs ($M = 941.53$, $SD = 196.00$).

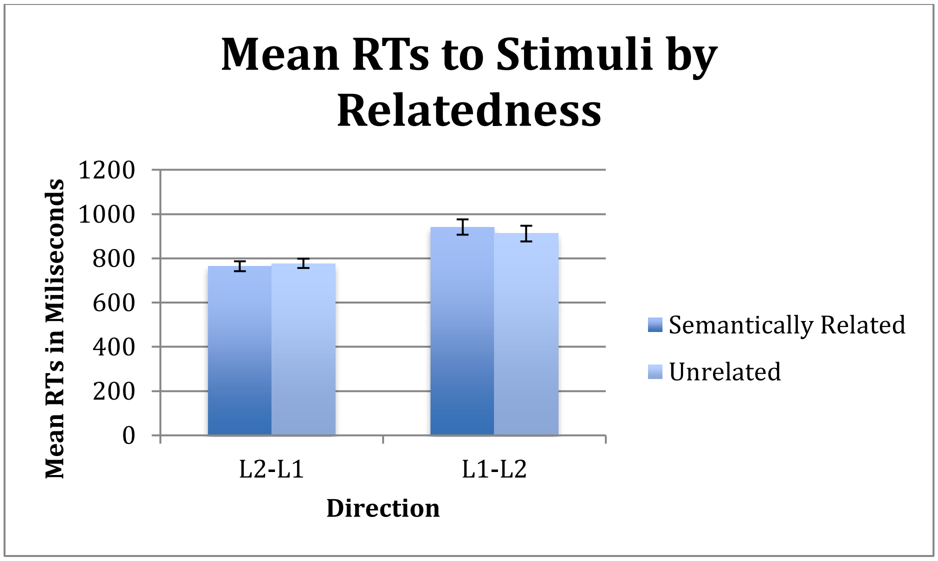


**Figure 1** *Mean RTs in Milliseconds for Related and Unrelated Pairs by Direction.*

For the second hypothesis, we predicted, that participants would respond faster to stimuli presented to the right visual field (RVF) than to stimuli presented to the left visual field (LVF). RTs did not significantly differ across visual fields $F(1,29) = 0.44$, $p > .05$. Significance was however found for a direction x visual field interaction for RTs $F(1,29) = 9.17$, $p < .01$. As indicated in *Figure 2*, participants responded faster to prime-target pairs in the L2-L1 direction when they were presented in the RVF ($M = 757.10$, $SD = 158.65$) than in the LVF ($M = 784.02$, $SD = 155.59$). When prime-target pairs were in the L1-L2 direction however, participants responded faster to pairs presented in the LVF ($M = 902.71$, $SD = 174.32$), than in the RVF ($M = 950.95$, $SD = 199.63$).

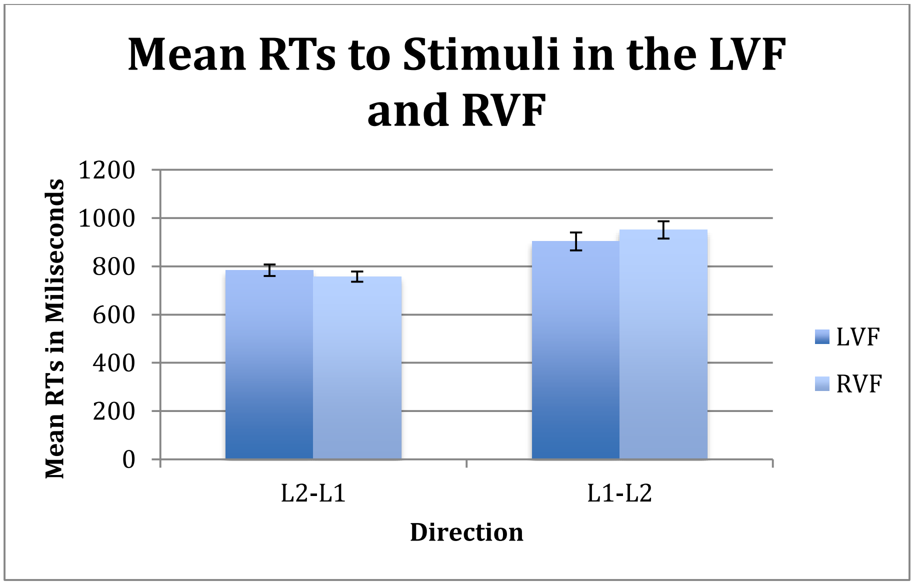


**Figure 2** *Mean RTs in the LVF and RVF by direction*.

For the third hypothesis, we predicted that participants would respond faster to stimuli presented with a stimulus onset asynchrony (SOA) of 57ms than an SOA of 67ms. Our results did not support this prediction; participants were significantly faster $F(1,29) = 7.491$, $p < .05$ at responding to stimuli in the 67ms SOA condition ($M$ = 827.34, $SD$ = 435.62) than in the 57ms SOA condition ($M$ = 870.34, $SD$ = 467.47). A significant interaction between visual field and SOA condition on RT $F(1,29) = 11.35$, $p < .01$ indicated that participants responded with comparable speeds to stimuli in the RVF for both the 57ms SOA ($M$ = 854.65, $SD$ = 449.62) and 67ms SOA conditions ($M$ = 853.37, $SD$ = 497.81), but in the LVF, responded much faster to stimuli in the 67ms SOA condition ($M$ = 800.70, $SD$ = 377.26) than to stimuli presented in the 57ms SOA condition ($M$ = 886.03, $SD$ = 452.96). As seen in *Figure 3* relatedness x SOA interaction, $F(1,29) = 10.71$, $p < .01$, suggested that participants responded at comparable speeds in both SOA conditions to semantically related prime-target pairs, but participants responded significantly faster to unrelated prime-target pairs in the 67ms SOA condition ($M$ = 805.00, $SD$ = 422.63) than the 57ms SOA condition ($M$ = 883.88, $SD$ = 489.35).

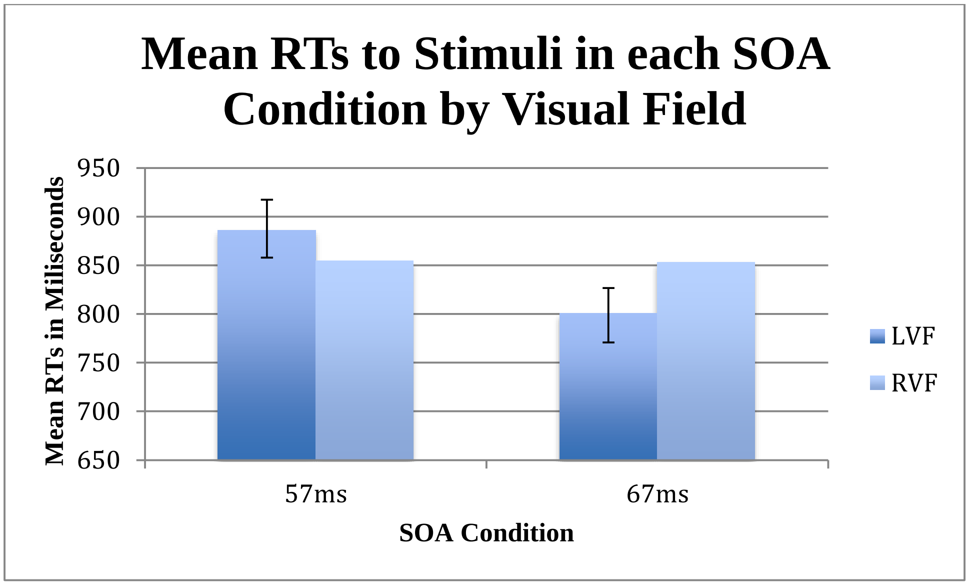


**Figure 3** *Mean RTs in Milliseconds to 57ms an 67ms SOA by Visual Field*.

**Accuracy.** A 2 direction (L1-L2 vs. L2-L1) x 2 relatedness (related vs. unrelated) x 2 visual field (Left Visual Field vs. Right Visual Field) repeated measures ANOVA was also computed on accuracy scores to test the hypotheses. Mean accuracy scores for each condition are shown in *table 2.*

Table 1. Mean %Accuracy

| | SOA 57ms | | | | SOA 67ms | | | |
|---|---|---|---|---|---|---|---|---|
| | LVF | | RVF | | LVF | | RVF | |
| *Direction and Relatedness* | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| L1-L2 (Related) | 90.47 | 9.43 | 93.22 | 9.45 | 91.45 | 10.07 | 91.52 | 10.07 |
| L1-L2 (Unrelated) | 90.84 | 13.34 | 95.86 | 6.73 | 97.30 | 4.95 | 95.79 | 8.38 |
| L2-L1 (Related) | 97.72 | 4.66 | 99.50 | 1.98 | 97.72 | 7.44 | 98.85 | 3.03 |
| L2-L1 (Unrelated) | 97.51 | 4.18 | 99.27 | 2.50 | 99.20 | 2.52 | 99.20 | 2.52 |

As with RTs, for our first prediction, we expected to see similar accuracy scores regardless of prime-target direction, but better accuracy for related prime-target pairs. Following the same trend as seen in RTs, a significant main effect of direction on accuracy was found $F(1,29) = 22.67$, $p < .01$ participants more accurately responded to a target in the L2-L1 direction ($M = 98.69$, $SD = 1.06$) than in the L1-L2 direction ($M = 93.33$, $SD = 1.65$). A significant effect of relatedness on accuracy $F(1,29) = 13.50$, $p < .01$ was found suggesting participants were more accurate when responding to unrelated pairs ($M = 96.96$, $SD = 0.98$) than to related pairs ($M = 95.05$, $SD = 2.13$). The interaction found between direction and relatedness on RTs was also found for accuracy scores $F(1,29) = 7.11$, $p < .05$, as shown in *Figure 4*. Participants responded slightly more accurately to unrelated prime-target pairs in the L2-L1 direction ($M = 98.51$, $SD = 1.01$) than related pairs in the same direction ($M = 98.86$, $SD = 0.88$) and more accurately to unrelated pairs in the L1-L2 direction ($M = 95.05$, $SD = 1.20$) than to semantically related pairs ($M = 91.60$, $SD = 1.59$).

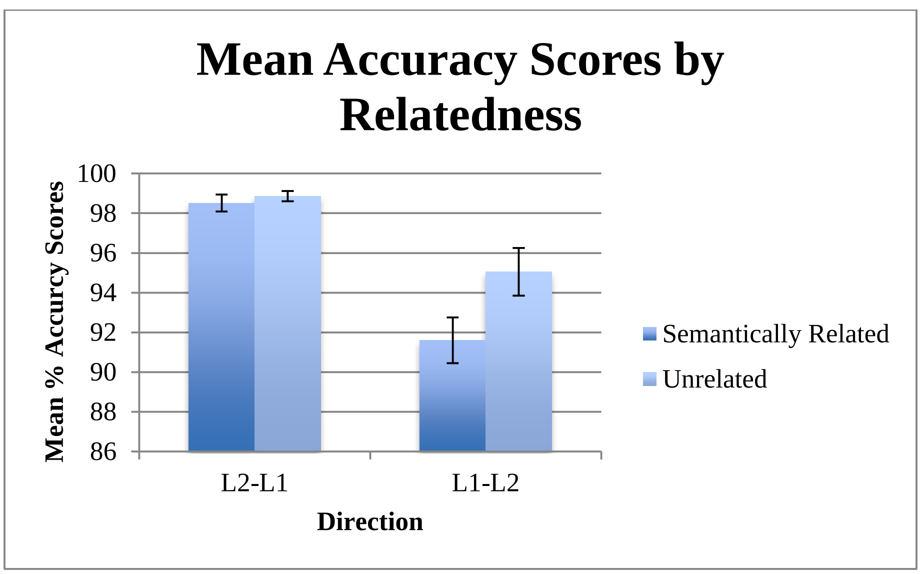


**Figure 4.** *Mean Accuracy Scores by Relatedness*.

We also predicted that participants would respond faster and more accurately to stimuli presented in the RVF. Though no significant main effects were found for visual field on RTs, significant main effects were found for accuracy $F(1,29) = 7.14$, $p < .05$ supporting the predictions. Participants responded more accurately when stimuli was presented to the RVF (*M* = 96.67, *SD* = 1.23) than when presented to the LVF (*M* = 95.34, *SD* = 1.92).

Contrary to the third hypothesis, predicting better accuracy scores when reacting to stimuli presented with a 57ms SOA, participants did not differ significantly in their accuracy scores between an SOA of 57ms and an SOA of 67ms $F(1,29) = 1.69$, $p > .05$. However, results revealed a significant interaction between visual field and SOA on accuracy $F(1,29) = 4.60$, $p < .05$ as they did for RT. As shown in *Figure 5*, participants responded had the most accurate responses on average to stimuli in the RVF in the 57ms SOA condition (*M* = 97.00, *SD* = 1.15) and had the least correct responses in the same SOA condition in the LVF (*M* = 94.28, *SD* = 2.32). Responses were comparably accurate in the 67ms SOA condition for both the RVF (*M* = 96.34, *SD* = 1.63) and the LVF (*M* = 96.40, *SD* = 1.78).

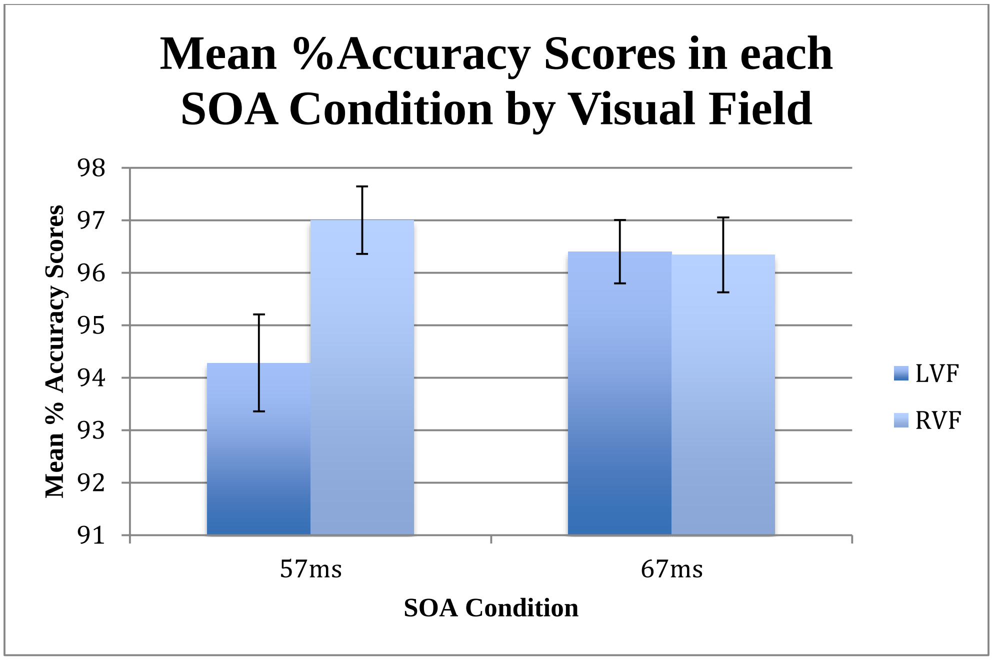


**Figure 5.** *Mean Accuracy Scores to 57ms and 67ms SOA by Visual Field.*

**Working Memory**

To determine whether individual differences were related to RT and accuracy scores, a bivariate correlation was computed between RSPAN partial scores and direction, relatedness, SOA condition, and hemisphere. Results revealed a significant positive correlation between RSPAN partial scores and accuracy scores for related prime-target pairs in the L1-L2 direction in the LVF r(29) = 0.39, $p < .05$.

## Chapter Five:

## Discussion

The aim of the current study was to investigate semantic integration of second language words into the lexicon of a second language learner. We also intended to resolve some of the methodological inconsistencies in previous literature and eliminate the use of strategy in processing by employing a masked priming paradigm with two different SOA conditions. Of additional interest, were both the role of hemispheric processing and the relationship of working memory on second language semantic integration. We examined these questions by performing a cross-language (English–Spanish) masked semantic priming paradigm with second language learners currently or recently enrolled in university-level intermediate Spanish courses. Each of the findings will be discussed in turn.

Results did not confirm the main hypotheses that participants would show a symmetrical priming effect in both directions. Contrary to predictions, unbalanced Spanish language learners, on average, responded significantly faster and more accurately to prime-target pairs presented in the L2-L1 direction than in the L1-L2 direction. Further, the interaction between direction x relatedness, indicated that participants responded faster in the L2-L1 direction when the prime-target pair was semantically related. Taken together, these findings imply that the primes were indeed processed and elicited an asymmetrical priming effect favoring the L2-L1, which does not provide support for the DRM as predicted. According to the DRM, priming effects should emerge from related prime-target pairs because activation would spread to related nodes faster than unrelated nodes. Results are also inconsistent with previous studies reporting priming asymmetries (Kroll & Stewart, 1994; Gollan, Forster, & Frost, 1997; Jiang, 1999; Jiang & Forster, 2001) emerging from the L1-L2 direction only. However, those findings were translation studies and involved different methodology than the current study such as unmasked primes or slow SOA lengths. The findings from the current experiment are consistent with the findings done from a study using a controlled masked priming paradigm by Basnight-Brown and Altarriba (2007) who found a semantic priming effect in the L2-L1 direction. They found their results to be surprising and inconsistent with the previous literature, and therefore reasoned that their participants were in fact more dominate in their L2 at the time and that the effects were a result of a switch in dominance. Additionally, L2–L1 translation priming effects have been obtained with cognates (De Groot & Nas, 1991; Sanchez-Casas et al., 1992; Gollan et al., 1997). Cognates (words that have the same meaning and spelling, or close to the same spelling in two different languages) are considered to have a significant overlap in orthography and phonology and therefore the priming asymmetries are thought to be a consequence of the overlap. However, the current study found an effect without using cognates and with participants who were L1 dominant. The findings from the current study could be evidence that stronger priming effects from the L2-L1 are the result of directly linked lexicons, which can be discussed within the framework of the RHM. In fact, it is commonly found that both proficient bilinguals, and early learners are much better at translating from an L2 to an L1 than from the other direction (Kroll & Stewart, 1994; Sholl, Sankaranarayanan, & Kroll, 1995).

This translation asymmetry of faster translations from the L2-L1 is considered a consequence of the use of lexical links, the direct lexical link is from the L2-L1 is stronger than the conceptual links coming from the L1-L2. Since participants in this study were not yet bilingual and in fact, language learners, perhaps the priming effect from an L2-L1 is the result of students actively engaging in translation tasks in classes. Generally, vocabulary tests and translation tasks are favored for beginners and intermediate students before engaging in conceptual activities such as essays or complex conversations. Since participants were all language learners from the same undergraduate university, it can be assumed they each had similar L2 learning experiences in the classroom. Professors may be favoring the learning process in the L2-L1 direction over translating L1-L2. In fact, it is a common method for professors to use the immersion method by only speaking the foreign language; encouraging students interpret meaning on their own. Research on immersion methods report faster language acquisition (Bialystok, Peets, & Moreno, 2014) and better attention, executive, and phonological skills (Nicolay & Poncelet, 2013). According to the RHM, as word-forms are integrated into the lexicon, they connect to directly to the translated meaning and that lexical links from the L2 to the L1 would be stronger than the reverse links. If participants are learning through the immersion method, they are integrating L2 words first and linking them to meaning in the L1, and are therefore able to translate faster from the L2 to the L1. This may lead to translations and conceptually related L1 words being more readily available in the lexicon when processing L2 as students learn, whereas if an L1 is presented, more words in the L1 will activate before words in the L2 begin to activate.

Faster RTs and better accuracy to unrelated prime target pairs in the L1-L2 direction indicate an inhibited priming effect, where RTs to targets are slowed instead of facilitated when primed with a translation or semantically related word. Inhibited priming effects found in this study are consistent with previous research showing slower reaction times to prime-target pairs that were direct translations of one another (Duyck, 2005; Gollan et al., 1997; Grainger & French-Mestre, 1998; Jiang, 1999, Jiang & Forster, 2001; Kroll & Stewart, 1994; Schoonbaert et al., 2007). Inhibited priming effects, especially in the L1-L2 may indicate a lack of a conceptual link between the L1 and the L2 lexicon in these learners. In the context of bilingualism and second language acquisition, the RHM asserts that a second language is processed only by direct access to the first language, and as proficiency increases, they will have an additional conceptual link between the L1 and the L2 (Kroll & Stewart, 1994). If semantically related words, which are arguably closest to the direct translation, are not activating L2 targets faster than unrelated words, then we can assume that there is no conceptual link yet available for processing semantically related words and that these learners are relying only on direct lexical links which are unavailable from the L1-L2.

Participants more accurately responded to stimuli presented to the RVF than the LVF confirming our predictions. Better performance in the RVF is consistent with literature indicating a left hemisphere advantage when processing language information. These results also replicate the ones found by Joss and Virtue (2009) who found that participants processed strongly related items better than unrelated ones in the left hemisphere. We did not find any evidence indicating that weakly related or unrelated information would be processed better in the right hemisphere or that semantic information is activated differently between the left and right hemispheres as proposed by Beeman and colleagues (1994). This lack of differential processing of semantic information between hemispheres does not provide support for the DRM and spreading activation.

We also expected that participants would respond faster and more accurately to targets presented with an SOA of 57ms than an SOA of 67ms. We hypothesized that the faster SOA time would prevent the use of expectancy strategies eliciting a more automatic response. Contrary to predictions, participants responded faster to stimuli presented with an SOA of 67ms than an SOA of 57ms. Priming effects have been found in studies using SOAs as short as 47ms (Perea, Duñabeitia, and Carreiras, 2008), and as long as 250ms (Altarriba & Basnight-Brown, 2007), however it seems that priming effects are stronger and more likely to occur as SOAs become shorter. It has been argued by Midgley et al. (2009), that priming asymmetries in cross-language priming studies may emerge from the participant's use of overt strategies in one of the directions but not the other. Overt processing strategies generate an expectancy set of words for participants, and if the target does not match any of those words in the set, reaction time is slowed. According to this account, the 67ms SOA should have produced a greater likelihood of the use of strategies and therefore slowed RTs. The results of this study appear to contradict this argument indicating that perhaps overt strategies begin at a slower SOA. Further, the results in the current experiment found that participants responded the fastest to unrelated prime-target pairs in the LVF. The greatest differences driving the surprising findings that participants were faster to respond to unrelated prime-target pairs than to related pairs, seem to be triggered by the mean RTs and accuracy scores in the LVF. These scores were especially faster in the 67ms SOA condition. In all other conditions, participants were generally faster and had more accurate responses to semantically related prime-target pairs than to unrelated pairs. Since participants were not more accurate in responding to unrelated prime-target pairs in the 67ms SOA condition, it is possible that participants did not completely process either the prime or the target completely before impulsively pressing a response key. This behavior is common with the standard yes/no lexical decision task. Perhaps future studies would be able to minimize this behavior with the use of a go/no-go lexical decision task in which participants are required to respond only if a word is presented, and to do nothing if a nonword is presented (Gordon, 1983; Gordon & Caramazza, 1982). This task has been found to minimize errors and increase response times.

Better working memories as measured by RSPAN scores, were positively correlated with accuracy scores for related prime-target pairs in the L1-L2 direction in the LVF. We had predicted that participants with better working memory would be faster and more accurate overall, but perhaps this condition was the only one in which difference can begin to emerge for learners. This may indicate a better ability of those with higher working memory to from conceptual connections in a second language. As previously mentioned, conceptual links are thought to begin to process better from the L1-L2 direction because they are no longer relying only on direct lexical links (Kroll & Stewart, 1994). Additionally, strength in the right hemisphere may indicate a better capability of forming relationships between concepts (Beeman et al., 1994; Chiarello & Richards, 1992), or when looking for themes (Schneiderman, Murasugi, & Saddy, 1992). Working memory allows individuals to manage higher cognitive load (Baddeley, 1992), which may be induced by processing word-form, meaning, and context together in a language class. Better working memory may allow learners to better cope with the increased cognitive load of learning a second language and allow them to integrate translations as well as conceptual information more quickly than those with weaker working memories. Working memory may be an important individual difference to consider when implementing effective teaching strategies and teaching conceptual information.

**Limitations and Future Directions**

Though findings from the current study contribute to previous literature on learning a second language, there are also several limitations that should be noted. First, the sample was limited; it would be worth examining these effects in a much larger group and groups with different L1s and L2s. It would also have been beneficial to report teaching styles and curriculum among second language classes in order to have a better understanding on how the students in this particular study learned their second language. It would be fairly quick and simple to interview professors at the university that these students attended to see if they had indeed used the immersion method. Future studies may want to consider learning and teaching styles when conducting experiments on second language acquisition. This information would also aid in comparing different groups across other studies. Second, although the methodology of the divided visual field paradigm in the current experiment was replicated methodology previous studies, we did not utilize a chin rest and therefore cannot be sure that participants kept their gaze central and did not move their head position to either side of the screen.

The findings in the current study seem to support the assertions of the RHM, however the results found in this study have not been commonly seen in previous literature. Future studies are needed in order to validate the results found in this experiment. Research may benefit from examining priming effects between semantically related words in the same language and between languages. If L2 is activating L1 faster than L1 activating and L2 in this study, our results may become clearer if we can examine how an L2 activates a related L2 in the context of the RHM. Further research is needed to create replicable results in order to confirm the validity of these findings.

The finding that the longer SOA length in this study did not result in slower RTs elicits further questions on automatic processing and overt strategies. Studies would benefit from testing multiple SOA lengths against one another in a constrained masked priming study in order to more accurately pinpoint the time when overt strategies are no longer used and automatic processing begins.

**Conclusion**

The results of this study will further aid in providing a more complete picture of second language acquisition, as well as methodological factors to consider in future studies. Results from studies on L2 acquisition yield important insights in the structure of second language organization in L2 language learners. This is particularly important as more and more children are entering schools speaking a native language other than English. Globalization and the push for international integration calls for jobs to be filled by bilingual applicants in order to effectively communicate goals and ideas. The more that is discovered in second language processing, the better our teaching methods and learning goals will be. Overall, this study aids in understanding second language acquisition as well as providing learning considerations for students of L2 acquisition.

# APPENDICES

## Appendix A

## IRB Approval Form

Gmail

**Catherine Antalek <catherineantalek@gmail.com>**

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### IRB Approval #1612011721

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**IRB** <irb@towson.edu> Mon, Feb 6, 2017 at 8:21 AM
To: "catherineantalek@gmail.com" <catherineantalek@gmail.com>
Cc: IRB <irb@towson.edu>, "Balass, Michal" <mbalass@towson.edu>

The IRB has approved your protocol "**Semantic Priming Effects between a Native Language and a Second Moderated by Individual and Hemispheric Differences**" **effective 2/6/2017 and expiring 2/5/2018.**

Your IRB protocol can now be viewed in MyOSPR. **Student investigators– protocols can be viewed by faculty advisors.** For more information, please visit: http://www.towson.edu/academics/research/sponsored/myospr.html

**<u>Please Note:</u>** Formal approval letters are now provided upon request. If you would like to have one drafted, please notify the IRB staff.

Appendix B

**Informed Consent**

TOWSON UNIVERSITY

CONSENT TO ACT AS PARTICIPANT IN AN EXPERIMENTAL STUDY

TITLE: Semantic Priming Effects between a Native Language and a Second as Moderated by Individual and Hemispheric Differences

PRINCIPAL INVESTIGATOR:

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***Why is this research being done?***

The purpose of the study is to investigate how the brain processes and organizes word definition and associated meanings between a native language and a second. The study will also examine whether or not performance is facilitated or hindered by the student's working memory capacity, and whether or not performance changes depending on whether information is presented to the left or the right brain hemispheres.

***Who is being asked to take part in this research study?***

Towson University students and adult members of the community will be recruited to participate in this study. They must have native English speakers' status (i.e., English was the primary language spoken at home), have completed an intermediate level or higher Spanish course, and be 18 years or age or older.

***What procedures will be performed for research purposes?***

The location of this study will take place at the Towson Reading and Psycholinguistics Lab, located at the Towson campus, in the Liberal Arts building, in room 1116. The total duration of the study can last up to 2 hours. After signing the informed consent, you will be presented with a computerized task where you will be exposed to a pair of Spanish and English words in which your job will be to classify the second word as a real word or a non-word using keys on a keyboard. Second, you will perform a working memory task where you will be presented with several sentences and asked to verify their validity while simultaneously remembering a set of several letters. Finally, you will be tested on all the Spanish vocabulary to ensure you are familiar with the words. For these tasks, sentences or words will be displayed on the screen, your job is to attend to these stimuli and respond appropriately by typing a response. Your experimenter will give you specific instructions before you begin.

***What are the possible risks, side effects, and discomforts of this research study?***

The procedures of this study have MINIMAL RISK that is typical of any activity where a person is sitting in front of a computer screen or is taking a pencil and paper exam for no more than 2 hours. The risk of this study to participants includes possible eye strain and boredom.

***What are the possible benefits from taking part in this research study?***
You will not receive any direct benefit for your participation in this research experiment. Your participation in the study may provide a general benefit to society in that it may contribute to the understanding of how people learn a second language and may help to improve second language teaching methodology.

***Will I be paid if I participate in this research study?***
As compensation for your voluntary participation in this study, you will earn $10 for participation.

***Who will know about my participation in this study?***
Any information about your research study participation or you will be treated as confidential as hospital medical records, and you will not be identified in any publication. Your information will only be identifiable by as assigned research identification number and your records will be in a locked storage cabinet. Any computer files will be password protected.

***Is my participation in this study voluntary?***
Your participation in this research study is completely voluntary. You do not have to take part in this research study and, should you change your mind, you can withdraw from the study at any time. Your current and future status with Towson university and any other benefits for which you quality will not be affected if you chose to participate in this study or not.

---

VOLUNTARY CONSENT

All of the above has been explained to me and all of my questions have been answered. I understand that I am encouraged to ask questions about any aspect of this research study during the course of the study, and any future questions will be answered by the principal investigator Catherine Antalek, listed on the first page of this form, or Dr. Debi Gartland, Chairperson of the Institutional Review Board for the Protection of Human Participants at Towson University at (410)-704-2236 or IRB@towson.edu

By signing this form, I agree to participate in this research study. A copy of this consent form will be given to me.

Participant's Signature: ____________________________ Date: ______________________

Witness Signature: ______________________________ Date: ______________________

---

INVESTIGATOR CERTIFICATION

I certify, as the principle investigator of this study, that the nature and purpose, the potential benefits, and the possible risks associated with participation in this research study have been explain to the above individual and that any questions about this information have been answered.

Investigator's Signature: ___________________________ Date: ______________________

Appendix C

**Demographics**

Demographics and Language History

Please answer the following questions about yourself and your background.

________________________________________ ________________________________________

Last name / Family name First name / Given name

________________________________________

Email address

________________________________________ ________________________________________

Telephone number Secondary telephone number
(optional)

1. Age (in years): ______________________

2. Sex: Male / Female 3. Are you right or left-handed? Right / Left

4. Are you a native speaker of English (i.e. did you learn English as a <u>first language)</u>?

Y / N

5. Did you speak any languages <u>other than English</u> as a child?

Y / N

If Yes, please list______________________________________________________________________________________________

6. What languages were spoken in your home while you were a child, and by whom (inc. English)?

______________________________________________________________________________

____________________________________________

7. What language(s) have you studied in school? Please list.

______________________________________________________________________________

____________________________________________

8. How many years of college have you completed (to the nearest half-year, e.g. “1.5”):

________________

9. Have you ever experienced any difficulty in reading?

Y / N

10. Have you been diagnosed with a reading disability?

Y / N

11. Do you currently have any hearing problems?

Y / N

12. Do you have normal (20-20) or corrected-to-normal vision?

Y / N

13. Have you had a serious head injury?

Y / N

14. Have you been diagnosed with epilepsy?

Y / N

Appendix D

**Stimuli**

| English Nonwords | Spanish | Spanish Nonwords | English |
|---|---|---|---|
| freathed | verde | quepriá | pain |
| psulch | espalda | costrién | glue |
| dwamn | Derrota | frebó | think |
| phoath | Triste | quetró | see |
| psauve | Ducha | berjuá | pin |
| spruzzed | Sano | meblá | pink |
| gnev | Madera | fesdó | deer |
| phrise | Bigote | etrió | orange |
| smogue | Pimienta | merdé | always |
| mive | Pobreza | quibó | spinach |
| thraimed | Tenedor | dintó | sweater |
| gwoins | Necio | fabó | rock |
| phoosts | Gastos | bisdó | smell |
| gnouched | Bolsa | prestié | yarn |
| coath | Sueno | prenó | strange |
| whusps | Deseo | armér | gleam |
| sloached | Sabio | masé | fight |
| chirds | Prisa | bostriá | base |
| gwenes | Miel | seixtrá | theatre |
| phloist | Chismes | clastiá | move |
| reant | Castor | ditriá | watch |
| haimed | Valiente | brolián | alone |
| yaith | Oscuro | prisé | sneak |
| glorth | Paloma | esás | jacket |
| twuffed | Fuerza | esiá | cereal |
| gwooge | Canela | chegá | police |
| shawse | Esperanza | gerió | expand |
| fricks | Pulpo | mepién | listen |
| rhalved | Risa | fliró | figure |
| dwimb | Caldero | prudá | tent |
| rhount | Dolor | pragá | blank |
| jalms | Exito | iruá | space |
| shiled | Rana | daquiá | pillow |
| preed | Amistad | garó | clear |
| twuised | Duda | insá | camp |
| throque | Corbata | dachiá | success |

| | | | |
|---|---|---|---|
| leethed | Alarde | dibó | wisdom |
| ghoust | Cuna | saudé | brick |
| rhooge | Lengua | ermá | juice |
| keaved | Fracaso | questá | spill |
| slubs | Pata | préler | shadow |
| phrobbed | Codicia | dráso | sale |
| rurg | Piso | menub | empty |
| shrusque | Enfermo | sarecó | country |
| splarse | Manta | meloblé | elbow |
| throared | Tina | ipadé | wonder |
| swuck | Tentador | sudabé | broccoli |
| goathe | Lobo | palurtó | sand |
| prosh | Pecado | maboqué | oak |
| slolls | Vaso | bipriocó | penny |
| smosed | Riesgo | piobracá | dig |
| spidge | Escoba | jatudó | wreath |
| chalve | Culpa | oborché | invite |
| knoffs | Plancha | lidusó | curtain |
| prees | Consejo | traguesó | ceiling |
| gnooch | Cuenta | aterfó | balloon |
| twulped | Peligro | pauchogiá | blanket |
| threap | espacio | nexdomó | pretend |
| buped | tia | quigiré | fly |
| broath | hermana | ipercó | cancel |
| shrawed | bicho | ebliñá | picture |
| snurf | buena | fabletó | vase |
| flurke | mojar | darimá | wallet |
| laits | tijeras | drulmedó | special |
| gweal | alfombra | sacordí | mother |
| clects | volar | tacrimá | daughter |
| pselm | hielo | edismó | grass |
| slith | ladrón | leisquebé | fall |
| dwiefed | secar | dasaniá | lead |
| plare | vuido | drescoró | green |
| scraimed | odiar | quenurdó | fancy |
| selte | orgulloso | pabarbó | pants |
| swarged | roca | jomortá | plank |
| crymn | lugar | ocranté | wood |
| scroad | cosa | iráibo | metal |
| sal | padre | biebáplio | necklace |
| rhasks | primo | danlícre | braces |
| struzzed | primavera | yagíntro | mask |
| riked | carta | carórbe | passport |

| | | | |
|---|---|---|---|
| rhosts | luchar | farásnia | snap |
| kent | escalera | nestóncha | place |
| knene | creer | sufúgrio | crate |
| flaubs | mundo | doléctra | angry |
| trufts | país | porguénia | basket |
| glorne | hondo | tindóbra | simple |
| screths | esperar | mosblétro | corner |
| snempts | freír | jorérmo | balcony |
| scobbed | jarabe | gauntégro | share |
| gind | esconder | goclído | waitress |
| kogged | baño | goráintio | style |
| thwocks | fantasmo | secrádo | matter |
| shromped | estudiante | uflópro | failure |
| gwirsts | cuerda | autébo | pineapple |
| toarse | coche | plorépre | serious |
| snoules | caja | beñósda | comfort |
| psaice | bonita | trarúle | bracelet |
| plact | cerdo | pablóña | kitchen |
| trears | traer | girnústa | together |
| thrurb | conducir | torísdo | final |
| speum | flor | meblérta | pickle |

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# CURRICULUM VITAE

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## EDUCATION

2017 *M.A., Experimental Psychology*. Towson University, Towson, MD

2013 *B.S., Psychology*. SUNY Albany, Albany, NY

2012 Study Abroad, Universidad Francisco de Vitoria, Madrid, Spain

## HONORS AND AWARDS

2009- 2013 Dean's List: 8 Semesters
2013 Graduated Cum Laude

## PROFESSIONAL MEMBERSHIP

2015 – Present Psychonomic Society, Student Member
2014 – 2015 American Psychological Association
2010 – 2013 National Society of Collegiate Scholars

## PROFESSIONAL AND RESEARCH EXPERIENCE

Nov 2016 – Present **Research Program Assistant**, **Medical Psychology Clinic** *The Johns Hopkins School of Medicine*, Baltimore, MD

May 2016- Present **Research Assistant, The Player's Lab** Towson University, Towson MD
*Teaching and learning Research Study*

Oct 2015- May 2016 **Student Investigator, Cognition Lab,** Towson University, Towson, MD
*Effects of Multimedia Design on Second Language learning*

October 2014-June 2015 **Assistant Teacher, Colegio Fuentesanta** Madrid, Spain

Jan 2013- Dec 2013 **Research Assistant, Cognition and Language Lab,** University at Albany, Albany NY

*Investigating Emotion-laden word translation among bilinguals*

PRESENTATIONS

November 2016 — *Effects of Different Formats of Instructional Design in Second Language Acquisition as Moderated by Individual Differences*
Psychonomic Society's 57th Annual Meeting
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April 2016 — *First impressions: The effect of self-disclosure and nature of information on perceptions of liking, attractiveness, and skin conductance level*
Towson University Undergraduate and Graduate Student Research Expo
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SKILLS

- **Computer Skills:** Microsoft Word, Microsoft Excel, Microsoft PowerPoint • Statistical
- **Software Skills:** Statistical Package for the Social Sciences (SPSS)
- **Physiological Lab Procedures**: BIOPAC 150/Acqknowledge 4.4 system: electrocardiography (ECG, heart rate variability), electrodermal activity (EDA), respiration belt. BrainVision actiCHamp: electroencephalogram (EEG) equipment.
- **Other Research Software**: E-Prime, Comprehensive Meta-Analysis, Qualtrics