ABSTRACT

Title of dissertation: PROCESSING OF COMPOUND WORDS BY ADULT KOREAN-ENGLISH BILINGUALS

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The purpose of this dissertation study is to investigate how Korean-English bilinguals process compound words in both English and Korean. The major research question is: when Korean-English bilinguals process Korean or English compound words, what information is used to segment compound words into their constituents and, in particular, does morphological information play an independent role irrelevant to the form and semantic information?

Four masked priming experiments were conducted with adult Korean-English bilinguals. Compound words (e.g., *bedroom, deadline*) and monomorphemic words with a compound-like structure (e.g., *hammock*) served as targets and were preceded by brief masked primes corresponding to the constituent of the target stimulus (e.g., *bed, room, dead*, and *mock*). In Experiments 1 and 2, within-language prime-target pairs (Korean-Korean for Experiment 1 and English-English for Experiment 2), co-varying morphological decomposability, semantic and form relatedness were presented. In Experiments 3 and 4, cross-language prime-target pairs (Korean-English for Experiment 3 and English-Korean for Experiment 4), varying morphological decomposability, semantic and phonological form relatedness were presented.

In Experiment 1, results showed that morphological information plays a role independent of the form information when Korean-English bilinguals decompose compound words into their individual constituent morphemes in their L1 (Korean). In Experiment 2, however, there was no significant priming effect in all conditions, indicating that morphological decomposition is not relied upon in their L2 (English) processing. In Experiment 3, morphological information plays an independent role in the early stage of cross-language activation irrelevant to the semantic factor at the prime duration of 36 ms. However, morphological decomposition is constrained by semantic transparency in the later stage of cross-language activation at the prime duration of 48 ms and 100 ms. There was no significant priming effect at the two short prime durations (both 36 ms and 48 ms). However, there was a marginally significant priming effect in the +M+S-P condition at the longest prime duration (100 ms) in Experiment 3. Based on the pattern of these results, it seems that at the earlier stage of processing, phonological relatedness was important for morphological processing. In Experiment 4, there were no significant priming effects in all conditions across all of the prime durations. These findings together point to a clear asymmetry in the masked cross-language priming between L1-L2 and L2-L1 directions.

PROCESSING OF COMPOUND WORDS BY ADULT KOREAN-ENGLISH BILINGUALS

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Chapter I: Introduction

Although the exact number of bilingual speakers in the world is unknown, it is estimated that more than half of the world's population can speak more than one language (Grosjean, 1982). Consequently, the topic of bilingualism has received a large amount of interest and attention from researchers. Recent studies have focused on how two language systems that may or may not share similar language features influence each other in bilingual processing. Furthermore, some researchers have used bilingual processing as a tool to investigate the nature of mental representation. Although lexical processing in bilinguals has been studied extensively in previous research, most studies have mainly focused on bilinguals of two Indo-European languages (e.g., English and Spanish: Basnight-Brown & Altarriba, 2007; Sánchez-Casas, Davis, & García-Albea, 1992; English and Dutch: De Groot & Nas, 1991). Moreover, previous bilingual research has largely been devoted to examining the processing of morphologically less complex words (e.g., monomorphemic words: Kim & Davis, 2003; Duñabeitia, Perea, & Carreiras, 2011).

The role of morphology in the human language system has been an important topic in psycholinguistic research over the past 30 years. A long-standing debate in this line of research regards whether the basic unit in lexical processing is the morpheme, that is, whether there is decomposition in the processing of morphologically complex words (e.g., *books, darkness*, or *honeybee*) at the morphological level. Although there is ample experimental evidence that morphological structure plays an important role in the processing of morphologically complex words, the majority of the research in this area has been conducted using derived and inflected words and focused on monolingual populations (Longtin & Meunier, 2005; Marslen-Wilson, Bozic, & Randall, 2008; Rastle, Davis, Marslen-Wilson, & Tyler, 2000; Rastle, Davis, & New, 2004). In this dissertation, four experiments were conducted to examine the within-language and cross-language activation of constituent morphemes in the lexical processing of compound words in Korean-English bilingual readers. The specific research questions that guided this dissertation are:

1. Do Korean-English bilinguals decompose Korean (L1) or English (L2) compound words into their individual constituent morphemes?

2. When Korean-English bilingual readers process Korean (L1) or English (L2) compound words, what information is used to segment compound words into their constituents and, in particular, does morphological information play a role independent of the orthographic and semantic factors?

3. What is the relative contribution of the first and second constituent morphemes in the processing of the compound words?

4. What is the role of morphological information in cross-language activation independent of the phonological and semantic factors?

5. How is the magnitude of priming effect different between the L1-L2 direction and the L2-L1 direction?

6. How do the effects of morphological, semantic, and phonological factors differ across prime durations in cross-language activation?

In the following sections, I will address the reasons for focusing on compound words and Korean-English non-balanced late bilinguals to study the questions of bilingual morphological processing. Furthermore, key theoretical issues relevant to this dissertation will be discussed.

Why non-balanced late adult bilinguals?

Recent studies of bilingual language development have been focused on children who acquire two languages simultaneously and have balanced proficiency between the two languages (Viberg, 2001). However, it is a common phenomenon in L2 acquisition that one of the languages is introduced after the other has been well established (late bilingual), and hence the speaker is more proficient in one language than the other, namely non-balanced bilingual. The level of L1 competence can be confirmed only when persons fully acquired their native language prior to the onset of language attrition. Since children are still in the process of developing their native language and reading skills, it is difficult to say that children possess fully the L1 competence. Moreover, since the rate of L1 acquisition is various among children, the children population is heterogeneous in terms of their L1 competence. Furthermore, it is likely that the level of L1 competence would be very limited in the case when children immigrated to an L2 speaking country prior to the entry of the primary school, or when they were born in the country where L2 is spoken. For these children, home language exposure and input is an important determining factor for their L1 competence such as the amount of the time of the L1 spoken by parents and siblings. In contrary, for the non-balanced, late adult bilinguals, clearly the dominant language is their L1 and their L2 is acquired later in life, and the L1 has been fully acquired. In addition, the L1 ability and cognitive ability of non-balanced, late adult bilinguals are relatively homogenous than children bilinguals. Therefore, the non-balanced, late adult bilinguals allow us to investigate the influence of completely developed L1 on L2, minimizing the confound of the varying levels of L1 competence.

The characteristics of compounds

Among the three types of morphologically complex words (i.e., compound, derived, and inflected), compound words are the best suited for addressing the issues of morphological processing in bilingual populations for several reasons. First, compounding is the most universal process for forming complex words across all languages (Dressler, 2006). If a language, such as English or Korean, has inflectional morphology and derivational morphology, it also has compound morphology but not the other way around. For example, there are some languages, such as Chinese, that are rich in compound morphology but limited (or even totally lacking) in derivation or inflection. The universality of compounds allows comparison of comparable structures across different languages. Second, the individual constituent morphemes of the compound words in one language have more direct one-to-one translations in the other language than those of the inflected or derived words. Compound words are composed of two or three free morphemes but inflected and derived words always include a bound morpheme. For example, each constituent morpheme in the compound word *honeybee* can be translated into 꿀 and 벌 in Korean, while the suffix *–ist* in the derived word *scientist* has no one-to-one translation in Korean. The suffix *–ist* is translated as -자 when rendering the derived word *scientist*, but is translated as -가 when rendering the derived word *novelist*. Third, the contribution of constituent morphemes to whole word recognition can be tested more directly with compound words. Inflected and derived words usually include a limited set of very frequent bound morphemes as an affix, the position of which is highly predictable (e.g., the suffix *-ed* is always placed in the final position of an inflected word). Thus, decomposition may be a result of the characteristics of the affixed words rather than the factors unique to the processing of morphologically complex words. Compound words, however, are composed of words in various syntactic categories (e.g., *football*; noun+noun, *sidestep*; noun+verb, *takeout*; verb+preposition) and the position of each constituent is not predictable (e.g., the morpheme *book* is the first constituent in *bookstore*, but it is the second constituent in *bankbook*). Therefore, morphologically complex word processing can be better tested in compound words without confounding factors such as the predictability of the position of the constituent morphemes and the frequency of the constituent morphemes (see Shoolman & Andrews, 2003).

Compound words in Korean

In the previous section, I noted that compound words provide a good opportunity for investigating the processing of multimorphemic words. In the present section, I discuss why Korean is an ideal language for testing the issues of compound processing in bilinguals.

Overall characteristics of Korean. Korean Hangul is an alphabetic syllabary. Korean Hangul follows the fundamental alphabetic principle in which graphemes correspond to phonemes (e.g., ㅏ maps onto */a/*). However, the Korean script has a nonlinear spatial layout, just like Chinese. The graphemes are composed into a square-shaped block, in which the graphemes are arranged left to right and top to bottom. Because the Hangul syllable blocks are separated, there is a clear syllable boundary for a Hangul word (e.g., 안녕하십니까 */an nyeng ha sim ni ka/ [hello]*). This visually prominent syllable boundary makes the morpheme boundary more salient in Korean

Hangul than that in English. Although Korean Hangul is a shallow orthography in which there is a consistent correspondence between graphemes and phonemes, it is a morphologically sensitive system. The Korean Hangul orthography operates on a morphophonemic principle (Woo, 1999). The morphology and phonology are harmonized. This means that while the pronunciation of the individual morphemes may be realized differently according to its context, its orthographic representation remains the same base form. The Korean root 깊 */gip/ [deep]*, for example, is pronounced as */gib/* or */gim/* depending on the syllable following it (e.g., */gip/* is changed to /*gim/* when followed by a syllable with an initial nasal consonant (e.g., 니 */ni/*)), nevertheless, it is always spelled as 깊 */gip/*. Therefore, Korean is not a pure alphabetic system in which each letter corresponds to one and only one sound but a morphologically sensitive system, in which morphology can be represented in the writing system by resolving the meaning ambiguity associated with a phonological form. This mixed system is similar to the derivational items in English that change the phonology of the base but preserve the morphology as in *national*. In both Korean and English, morphological form is preserved by compromising phonological mapping (see Perfetti, 2003 for discussion).

Korean compound words. Korean Hangul has a rich morphology. Most words in Korean are comprised of two or more morphemes, and these morphemes are often directly related to the meanings of the words. There are three types of morphological structures in Korean as in English: compounds, derivations, and inflections. Among these three types, the structure of compound in Korean is most similar to that in English. Compound words in Korean are generated by combining two or more stem morphemes. There are three types of compounding in Korean – subcompounding (e.g., 꿀벌

[honeybee]), co-compounding (e.g., 밤낮 *[day and night]*), and argument-predication (e.g., 악수 *[grasp-hand]*). The noun-noun combination, a type of subcompounding in which the first root modifies the second, is the most productive type of compounding (Sohn, 1999). In this case, like English, the head is always located in the right (final) position. For example, the compound word 눈물*[tears]* is generated by compounding the root 눈*[eye]* with 물*[water]* which is the head morpheme. In English, some compound words are written without a space and others are written with a space or a hyphen between constituent morphemes (e.g., *lifestyle, life style, or life-style*). Korean compound words do not have a space or hyphen between the constituent morphemes. Thus, given the richness of compounds in Korean and the overall similarity of the compound structure in Korean and English, Korean-English bilingual processing of compound words serves as a worthwhile area for research. In the following section, theoretical issues relevant to this dissertation will be discussed.

Theoretical Issues

Levy, Goral, and Obler (2006) observed and described an English-French bilingual child calling a *doghouse*, *chien-maison* (*chien* = *dog*, *maison* = *house*), a novel compound composed of French words. Although the translation equivalent of *doghouse* in English is *niche*, the child translated the individual constituents, and combined them to create a novel compound word in French. Similarly, a Korean-English bilingual may translate *bankbook* as 은행책 [*bank-book*], a novel compound word in Korean, by translating the individual constituents of an English compound word to Korean. However, they also may translate *bankbook* as a monomorphemic word, 통장 [*bankbook* in Korean]. This raises an interesting question – how do bilinguals represent and process compound words in their two languages? This question brings together two seemingly separate research fields: morphological processing and the bilingual lexicon.

Morphological processing. A question that has been extensively discussed in the native language morphological processing literature is whether a morphologically complex word is decomposed into its constituent morphemes. A large number of studies have found that constituent morphemes are activated in the processing of morphologically complex words (Fiorentino & Fund-Reznicek, 2009; Marslen-Wilson et al., 2008; Rastle et al., 2000; Rastle et al., 2004; Shoolman & Andrews, 2003). However, it is still unclear whether morphological structures play an independent role, given the fact that compound words and their constituent morphemes overlap partially or completely with their orthographic or phonological forms and meanings. For example, the compound word, *honeybee*, and the constituent morpheme, *bee*, are not only morphologically related but their form and meaning are also related.

Recent studies have sought to address the locus of morphological decomposition by dissociating morphology, form and meaning (e.g., Fiorentino & Fund-Reznicek, 2009; Marslen-Wilson et al., 2008; Shoolman & Andrews, 2003). In these studies, prime-target pairs varying in morphological decomposability and semantic and form relatedness were used in a masked priming paradigm. These studies suggested that during the early stage of processing, decomposition is based on the explicit morphological structure rather than the form overlap or semantic relatedness. In addition to testing the nature of decomposition, constraints such as word length, lexicality, position-in-string, headedness and word frequency have all been studied in previous research. However, the majority of the studies were conducted with English native speakers or native speakers of other Indo-

European languages (e.g., Duñabeitia, Laka, Perea, & Carreiras, 2009; Duñabeitia, Manuel, & Carreiras, 2007; Longtin & Meunier, 2005; Fiorentino & Fund-Reznicek, 2009; Marslen-Wilson et al., 2008; Rastle et al., 2000; Rastle et al., 2004; Shoolman & Andrews, 2003). Therefore, more research with different orthographies, such as Korean or Chinese, needs to be done before we can conclude that morphological decomposition is a language-independent process. Furthermore, research with bilingual populations will provide novel evidence of compound decomposition, as most previous studies have been conducted with monolingual populations.

The bilingual lexicon. The main research question in bilingual processing is whether the lexical representations of the bilinguals' two languages are separated or shared. The Revised Hierarchical Model (Kroll & Stewart, 1994) assumes that the two language systems are shared at the conceptual/semantic level, where the meaning of words is stored, but they are separated but interconnected at the lexical level, where the orthographic and phonological representations are stored. However, the nature of the connections within and between the conceptual/semantic and lexical form levels has been the topic of much debate. A masked cross-language priming paradigm is the primary technique for examining the organization of the bilingual lexicon. In this priming paradigm (Foster & Davis, 1984), the prime in one language is very briefly presented (30-60 ms) and immediately followed by the target in the other language. In addition, the prime is preceded by a forward mask (e.g., either a dummy word or a pattern mask such as nine hashmarks, i.e., #########) for 500 ms and sometimes followed by a backward mask of the same pattern. Since participants should not be able to identify the prime in this paradigm, factors related to processing strategies can be minimized.

Previous cross-language masked priming studies have shown an asymmetry of activation strength between L1 and L2, with a much stronger priming effect from L1 to L2 than from L2 to L1 (Gollan et al., 1997; Jiang, 1999; Jiang & Forster, 2001). This cross-language priming asymmetry suggested that L1 words are more likely to activate the concept than L2 words and thus produce stronger priming effects. However, most of the cross-language priming studies did not specifically state whether the stimuli included morphologically complex words. Thus, it was unclear whether cross-language activation occurred in processing single morpheme words as well as morphologically complex words. Thus, a clear distinction in processing between morphologically complex words and single morpheme words will provide a better understanding of cross-language activation.

In summary, the investigation of bilingual compound processing would bridge the two relatively independent research fields of morphological processing and the bilingual lexicon. The key theoretical issues in these two research fields are closely related to the levels of representation such as lexical representation (form level) and semantic representation (conceptual level). In this dissertation, two within-language experiments and two cross-language experiments were conducted. These experiments would help further the understanding of the representations and mechanisms of compound processing in the bilingual lexicon.

Chapter II: Literature Review

In this literature review, I begin with studies that examined morphological processing in monolingual populations. I address the questions of whether morphologically complex words are processed by decomposition into morpheme-level constituents, what kinds of information (such as morpho-orthographic and morpho-semantic information) play a role in morphological decomposition, and what kinds of potential constraints (such as frequency, semantic transparency, and position in string) play a role in determining whether words are represented and processed via the decomposition process. I then review the bilingual lexicon models and the relevant studies using the priming paradigm to study the bilingual mental lexicon.

Lexical representation of morphologically complex words

The main question in the area of processing morphologically complex words is whether the complex words are decomposed into individual constituent morphemes. Previous studies have examined whether decomposition occurs based on orthographic information or semantic information (e.g., Marslen-Wilson et al., 2008; Rastle et al., 2000; Rastle et al., 2004). Researchers have also examined the possible word properties that may influence decomposition, including position in the string (e.g., Kehayia et al., 1999), headedness (e.g., Jarema, Busson, Nikolova, & Tsapkini, 1999) or frequency (e.g., Juhasz, Starr, Inhoff, & Placke, 2003). Studies investigating the major factors in morphological decomposition will be discussed following a general description of the models of the processing of morphological complex words.

Models of morphologically complex words

There are three types of models that describe the representation and processing of morphological structures. These three models can be applied to all three types of morphologically complex words. The full-listing model (e.g., Butterworth, 1983) and the morphological decomposition model (e.g., Taft & Foster, 1975) are two major competing models. The interactive models (Caramazza, Laudanna & Romani, 1988; Taft, 1994; Verhoeven & Perfetti, 2003) are complementary to the previous two models by assuming that morphologically complex words can be represented as either a morphological decomposition model or a full listing model depending on the morphological structure and complexity (Nefs, Assink & Knuijt, 2003).

According to the full-listing model, the complex word as a whole-word is a lexical storage and access unit. For example, *blueberry* is represented as a whole word and the representations of *blue* and *berry* are not connected with *blueberry* (see Figure 1[a]). This model maximizes computational efficiency, but requires large storage capacity. According to this model, there should be no difference between the representation of monomorphemic words and multimorphemic words, since multimorphemic words can be simply activated in the mental lexicon without any computational process. The morphological decomposition model assumes that constituent morphemes are lexical storage and access units. For example, the constituent morphemes *blue* and *berry* are stored and accessed independently but *blueberry* is not represented as a whole in the mental lexicon (see Figure 1[b]). The interaction models assume that both word units and morpheme units are stored in the mental lexicon. For example, *blueberry* has a representation as a whole word, *blueberry*, and each constituent; *blue* and *berry* are also stored in the mental lexicon. Furthermore, the representation of *blueberry* is associated with *blue* and *berry* (see Figure 1[c]).

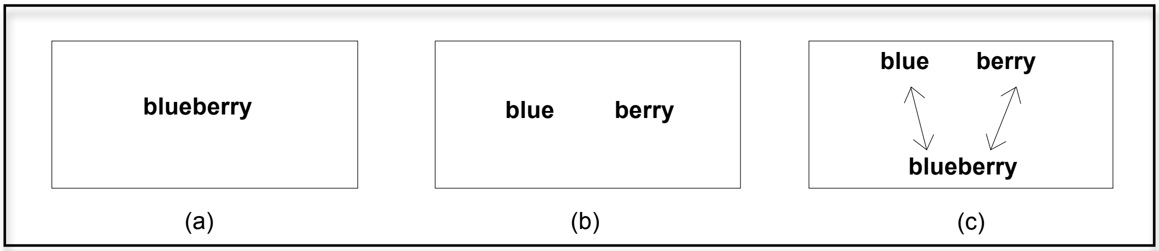


Figure 1. The representation of compounds in the full-list (a), decomposition (b), and interactive (c) hypotheses

Several different versions of interactive models have been proposed, suggesting that the selection between a whole-word or decomposition pathway depends on factors such as semantic transparency, lexicality, productivity, and frequency. Among the interactive models, the Augmented Address Morphology (AAM) model proposed by Caramazza et al. (1988) assumes that both the whole word representation and constituent morphemes can be activated simultaneously. This model posits that whole-word processing will be activated for familiar words, whereas decomposition will take place for novel words. The Morphological Race Model (MRM) (Shreuder & Baayen, 1995) is also a dual-route model that assumes that the whole word route and the decomposition route are in competition. The difference between the AAM and the MRM is that, in the MRM, even familiar words can be accessed via decomposition route depending on the properties of the whole word such as semantic transparency and frequency. For example, the constituent morphemes are activated when an unfamiliar complex word is semantically transparent, but the whole-word form is activated when a familiar complex word is semantically opaque. Another interactive model is the Interactive Activation Model (IA, Taft, 1994). According to the IA, there are several hierarchical levels of activation. The lowest level is the grapheme level, and the highest level is the concept level. There are morpheme level and word level between the grapheme level and the concept level. The orthographic input (e.g., *INVENT*) is first mapped onto the grapheme level (e.g., *I, N, V, E, T*), and then it is connected to the word level (e.g., *INVENT, VENT*) through the morpheme level (e.g., *IN*, *VENT*). The morpheme level and the word level are connected to the concept level (e.g., *"in", "create", "air outlet"*). In other words, there are representations for the whole-word as well as the morpheme, but whole-word information can be reached through the morpheme level (Figure 2).

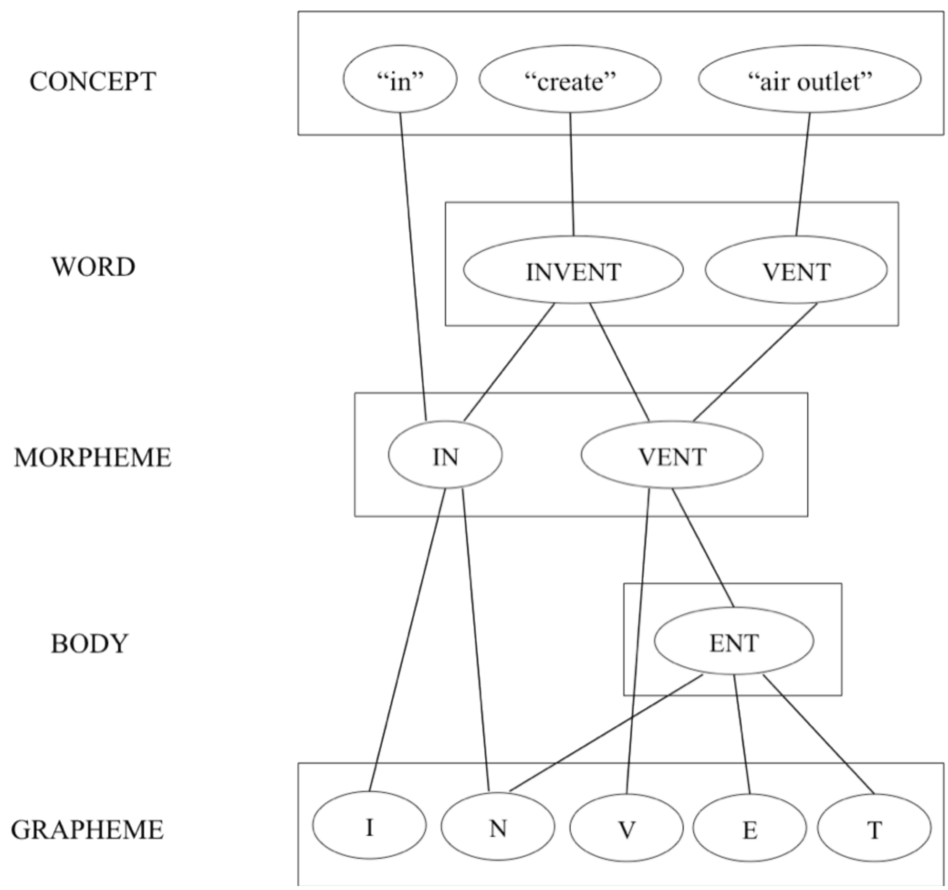


Figure 2. The interactive activation model incorporating a morpheme level, depicting the representation for *INVENT* (Taft, 1994)

In summary, according to the ARM and MRM models, whole-word units and morpheme units are at the same level, and orthographic input maps onto words and morphemes directly, whereas the IA assumes hierarchical levels in which the morpheme level (lower level) activates the word level (higher level)

Morphological decomposition

Morphological, semantic and form sensitivity in morphologically complex word recognition. The most common methodology for examining the role of morphology in word recognition is the priming paradigm. Lexical decomposition of complex words has been supported by partial repetition priming experiments, in which lexical decision of the stem target (e.g., *brave*) is preceded by the morphologically related prime (e.g., *bravely*). These morphological priming studies have demonstrated that the responses to a target word can be facilitated when it is preceded by a morphologically related prime (e.g., Marslen-Wilson et al., 2008, Rastle et al., 2000; Rastle et al., 2004).

Although the majority of research found that morphologically complex words are represented and processed in terms of their constituent morphemes (Caramazza et al., 1988; Taft, 2004; Taft & Ardasinski, 2006; Taft & Forster, 1975), whether morphological structures play an independent role still remains unclear, given the fact that morphologically related primes are usually partially or completely overlapping with their stem targets in orthographic/phonological forms and meanings. For example, when the derived word *baker* is the prime and the stem morpheme *bake* is the target, the *baker-bake* pair is not only morphologically related but is also related in form and meaning.

Some researchers have suggested that the morphological effects arise from the statistical regularities of form and meaning pairings rather than explicit morphological representations (Seidenberg & Gonnerman, 2000). According to this reasoning, adopted in the Parallel-Distributed Processing (PDP) model, the morphological effect reflects the combined effects of orthographic and semantic similarity (e.g., Plaut & Gonnerman, 2000; Rueckl, Mikolinski, Raveh, Miner, & Mars, 1997). For example, Rueckl et al. (1997) found that the magnitude of morphological priming effects is influenced by orthographic similarity. In their experiments, participants completed the study task (e.g., familiarity judgments) with the primes, and then they performed the masked fragment complement task with target words. During the study task, two types of primes, repeated forms of target words (e.g., *lose, wind*) and the past tense forms of target words (e.g., *lost, wound*), are presented. In the masked fragment complement task, participants were asked to identify a masked letter in a briefly presented word (e.g., *S* in *LO#E*, *N* in *WI#D*). Half of the targets were orthographically similar to their primes, differing in spelling from their past tense by a single letter (e.g., *lose [lo#e]*), while others were orthographically dissimilar to their primes, differing from their past tense by at least two letters (e.g., *wind [wi#d]*). The accuracy for identifying the masked letter was greater in the orthographically similar prime-target pairs (e.g., *lost-lose*) than in the orthographically dissimilar pairs (e.g., *wound-wind*). In other words, the long-term morphological priming effect was greater when the target words were orthographically similar to their past tense primes.

Similarly, Gonnerman, Anderson and Seidenberg (1998) also found that the magnitude of priming effects reflects the degree of semantic and phonological overlap between words rather than morphological relatedness. In Experiment 1, when the phonological factors of morphologically complex words were held constant, the magnitude of priming effects was modulated by the degree of semantic relatedness. For example, semantically related pairs such as *baker-bake* have stronger priming effects than semi-semantically related pairs such as *backer-back*, whereas semantically unrelated pairs showed no significant priming effects at all (e.g., *message-mess*). In Experiment 2, when the semantic relatedness of morphologically complex words was held constant, the magnitude of the priming effects was dependent upon the degree of phonological similarity. For example, the prime-target pairs in the coda-change condition (e.g., *absorption-absorb*) showed greater priming effects than the pairs in the coda-plus-vowel change condition (e.g., *decision-decide*). These results support the PDP model (Seidenberg & Gonnerman, 2000) in which morphological effects emerge in the course of associating the orthographic, phonological, and semantic information of words.

However, the PDP model has been challenged by findings from other empirical studies. These studies provided evidence that morphological effects cannot be explained from the combined effects of orthographic and semantic overlapping (e.g., Fowler, Napps, & Feldman, 1985; Grainger, Cole, & Segui, 1991; Stoltz & Besner, 1998). For example, Stoltz and Besner (1998) found stronger priming effects when primes are morphological related to stem targets (e.g., *marked-MARK*) than when primes are only orthographically related but not morphologically related to stem targets (e.g., *market-MARK*). Furthermore, they could not find a priming effect when primes are semantically related but not morphologically related to the targets (e.g., *king-QUEEN*).

The role of morphological, semantic, and orthographical information in visual word recognition has been examined by manipulating morphological, semantic and orthographical relatedness between prime-target pairs across the conditions: (1)

orthographically overlapped only (-M-S+O: *scandal-SCAN*), (2) morphologically decomposable, orthographically overlapped, but semantically unrelated (+M-S+O: *archer-ARCH*), and (3) morphologically decomposable, semantically related, and orthographically overlapped (+M+S+O: *bravely-BRAVE*) (e.g., Marslen-Wilson et al., 2008; Rastle et al., 2000; Rastle et al.,2004). If there are priming effects in condition 1, it could be concluded that merely form overlap is enough to produce priming effects without the morphological factor. If morphological decomposition is influenced by the morpho-semantic factor, then masked priming effects should be observed in condition 3 where the relationship between primes and targets is semantically transparent and these effects should be greater than condition 2 where the relationship between primes and targets is semantically opaque. If, however, decomposition is based on morpho-orthographical information, the same magnitude of priming effects should be observed in conditions 2 and 3 where the relationship between primes and targets is orthographically and morphologically related (e.g., *archer-ARCH* and *bravely-BRAVE*), and these effects should be greater than priming effects in condition 1 where there is no morphological relationship between primes and targets (e.g., *scandal-SCAN*). Most studies using such manipulations have shown priming effects in both condition 2 and condition 3, suggesting morphological decomposition regardless of semantic relatedness (Marslen-Wilson et al., 2008; Rastle et al., 2000; Rastle et al., 2004). However, some studies using the cross-modal priming paradigm (e.g., auditory primes and visual targets) have shown priming effects only when the prime-target pairs are semantically transparent (Marslen-Wilson et al., 1994). Therefore, the question regarding the nature of morphological representation remains controversial. In the following sections, this issue will be discussed in more details.

Orthographic priming versus morphological priming. A number of studies have investigated the role of the orthographical factor in morphological processing using the priming paradigm (Chateau, Knudsen, & Jared, 2002; Grainger, Colé, & Segui, 1991; Rastle et al., 2004; Marslen-Wilson et al., 2008). Most studies found that the orthographic factor alone is not sufficient to produce priming effects. For example, Chateau, Knudsen & Jared (2002) did not find a reliable orthographic priming effect when primes shared the same initial letters with target words (e.g., *element-elevator*). Furthermore, Grainger et al. (1991) showed an inhibitory effect when primes were orthographically similar to target words (e.g., *market-MARK*). In the Marslen-Wilson et al. (2008), when primes were orthographically overlapped with target words but not morphologically decomposable (e.g., *scandal-SCAN*), there was no priming effect. However, prime-target pairs that shared the root morpheme (e.g., *bravely-BRAVE*) showed a facilitation effect. Taken together, these results demonstrated that orthographically overlapped but morphologically unrelated primes are not sufficient to produce facilitative priming effects. However, both orthographically and morphologically related primes facilitated the lexical decision of stem words (e.g., *bravely* primes *BRAVE*; Devlin, Jamison, Matthews, & Gonnerman, 2004; Feldman, 2000; Feldman & Prostko, 2002; Feldman & Soltano, 1999; Longtin, Segui, & Halle, 2003; Marslen-Wilson et al, 2004; Marslen-Wilson et al, 2008; Rastle et al., 2004; Rastle et al., 2000). These results showed that morphological processing is independent of the orthographic factor.

Morpho-orthographic decomposition versus morpho-semantic decomposition. Semantic-based morphological decomposition has been supported by several cross-modal priming experiments (Gonnerman, Seidenberg, & Andersen, 2007; Longtin et al., 2003; Marslen-Wilson et al., 1994; Meunier & Longtin 2007). In cross-modal priming experiments, participants hear a spoken prime which is followed by a visually presented target word on which they are required to make a lexical decision. For example, Marslen-Wilson, Tyler, Waksler and Older (1994) found cross modal priming effects for both semantically and morphologically related prime-target pairs (e.g., *harmness-HARM*), but no priming effects for morphologically related but semantically unrelated prime-target pairs (e.g., *department-DEPART*). The absence of priming effects suggests that decomposition did not occur and morphologically related but semantically opaque primes were processed like monomorphemic words. Other studies have found that the occurrence of semantic-based decomposition is dependent on the prime duration (Ford, Marslen-Wilson, & Davis, 2003; Schreuder & Baayen, 1997) For example, in Rastle et al. (2000) significant priming effects were shown in both semantically transparent (+M+S+O) and opaque prime-target pairs (+M-S+O) when the prime durations were short (e.g., 43 ms). However, when primes were clearly visible (prime duration = 230ms), significant priming effects were only found in the semantically transparent condition but not in the semantically opaque condition.

The masked priming paradigm (Foster & Davis, 1984) is particularly useful experimental paradigm for examining morphological effects because it reduces the visibility of primes and allows researchers to study the unconscious and automatic processing of morphologically complex words. In masked priming, the prime is preceded by a forward mask and sometimes followed by a backward mask so that participants cannot consciously perceive the prime. Studies using the masked priming paradigm have shown that morphological decomposition is independent of semantic relatedness (e.g., Badecker & Allen, 2002; Boudelaa & Marslen-Wilson, 2005; Feldman & Soltano, 1999; Longtin & Meunier, 2005; Rastle et al., 2000; Rastle et al., 2004, Marslen-Wilson et al., 2008). In a masked priming experiment using a short prime duration (e.g., 50 ms), there was a facilitation effect in response time (RT) when the primes were morphologically related to the targets regardless of their semantic or orthographic relatedness (Rastle et al., 2000; Rastle et al., 2004, Marslen-Wilson et al. 2008). For example, Rastle et al. (2004) has provided strong support for morphological decomposition occurring in early visual word recognition independent of semantic relatedness between the prime and the target, demonstrating that morphologically related but semantically unrelated primes (e.g., *brother*) prime the stem targets (e.g., *broth*) while only orthographically related primes (e.g., *brothel*) fail to exert a priming effect despite their orthographic overlap (*broth*).

Marslen-Wilson, Bozic and Randall (2008) also suggested that, an early stage of visual word recognition as indicated by the short prime duration, morphological effects in masked priming are based on morphological decomposability which is independent of semantic relatedness. In their study, the degree of semantic relatedness between primes and targets was manipulated (e.g., high level of semantic relatedness [*bravely-BRAVE*], intermediate level of semantic relatedness [*barely-BARE*], and semantically unrelated [*archer-ARCH*]). The researchers found that the degree of semantic relatedness did not modulate the magnitude of the priming effect for (+M) items. Thus, we could conclude that at the early stage of processing, morphological decomposition of complex words occurs at the lexical level rather than at the semantic level. Findings from McCormick, Rastle, and Davis (2008) also supported the morpho-orthographic decomposition. The researchers used primes that could not be parsed perfectly into a stem and an affix (e.g., *fetish-FETE*). Their stimuli included three kinds of orthographic alternations in derivational words, missing *e* (e.g., *adorable–ADORE*), shared *e* (e.g., *lover–LOVE*), and duplicated consonant (e.g., *dropper–DROP*), and all three types of prime-target pairs showed a significant priming effect. In addition, masked priming effects were found for prime-target pairs that were not semantically related (e.g., *palatial-PALATE, badger-BADGE* and *committee-COMMIT* for the missing *e*, shared *e*, and duplicated consonant conditions, respectively). Using French derived words as experimental stimuli, Longtin et al. (2003) suggested that the morpho-orthographic decomposition is a sublexical phenomenon. In other words, the morpho-orthographic decomposition occurs regardless of the lexical status of the items. In Experiment 1, a visual masked priming experiment was conducted with four different types of prime-target pairs: (1) semantically transparent and morphologically decomposable (e.g., *gaufrette [wafer]-GAUFRE [waffle*]), (2) semantically opaque and morphologically decomposable (e.g., *fauvette [warbler]-FAUVE [wildcat]*), (3) pseudo-derived words that are monomorphemic but are composed of a legal stem (e.g., *bague*) and a suffix (e.g., *-ette*) (e.g., *barguette [little stick]-BAGUE [ring])*, and (4) orthographic overlap (e.g., *abricot [apricot]- ABRI [shelter]*). A significant facilitation priming effect was found not only in both morphologically decomposable conditions, regardless of semantic transparency, but also in the pseudo-derived condition. In contrast, prime-target pairs with only orthographic overlap (e.g., a legal stem [*abri*] + non-morphological ending [-*cot*]) showed an inhibition effect. Therefore, these results provided evidence for the claim that morphological decomposition is independent of the semantic relatedness. Furthermore, these results suggested that decomposition occurs even in monomorphemic words if they can be parsed into a legal stem and an affix.

Taken together, the literature reviewed above suggested that morphological decomposition occurs automatically and rapidly at the early stage of word recognition. Furthermore, the morphological decomposition process is independent of semantic relatedness and orthographic overlap.

Morphological, semantic and form sensitivity in compound word recognition. The studies I have reviewed above have focused on derivational morphology. However, compound words can provide strong support for the independent role of morphological information in the decomposition of complex words. Since in derived words, a limited set of affixes (bound morphemes) usually has a very high frequency in the same position, decomposition may reflect prelexical process rather than lexical process. Furthermore, the results from the study of affixed words are difficult to generalize to other types of multimorphemic words because affixed words consist of a stem and an affix while compound words consist of two stems. Compound words allow the combination of two or more constituent morphemes (open-class stems) that can take various syntactic categories such as noun-noun compounds (e.g., *peace treaty*), noun-adjective compounds (e.g., *leaf green*), verb-noun compounds (e.g., *draw-bridge*) and verb-verb compounds (e.g., *stir-fry*). In addition, the frequency of each constituent is usually not as high as that of affixes in derived and inflected words. Compound words are better suited for investigating the processing of morphologically complex words because the influence from the confounding factors such as the position and the frequency of constituents can be controlled.

There are many studies that have investigated the role of morpheme-level representation in compound processing using different methodologies such as lexical decision (Andrew, 1986; Duñabetitia, Perea & Carreiras, 2007; Juhasz, Starr, Inhoff & Placke, 2003; Libben et al., 2003), priming (e.g., Fiorention & Fund-Reznicek, 2009; Sandra, 1990; Shoolman & Andrews, 2003. Zwitserlood, 1994), and eye-tracking (e.g., Andrews, Miller, & Rayner, 2004; Betram & Hyönä, 2003; Frisson, Niswander-Klement, & Pollatsek, 2008; Pollatsek & Hyönä, 2005). For example, Duñabetitia, Laka, Perea and Carreiras (2009) conducted a masked priming experiment with the Basque language to investigate whether the morphological factor is independent of the orthographic factor in the recognition of compound words. There was a facilitative priming effect when primes were compounds that share either the first or second constituents with the target compounds (e.g., *lanordu* [*working hour*]-*lanpostu* [*workplace*]). However, there was no priming effect when primes were non-compound words that shared the same initial (e.g., *arrantza* [*fishing*]-*arrisku* [*danger*] or final letters (e.g., *molekula* [*molecule*]-*pelikula* [*film*]) with the targets. Thus, the researchers concluded that the priming effect from the compound words was not due to the orthographic factor, but rather the morphological factor.

The semantic relationship between constituents and the whole compound can be transparent (e.g., *honeybee* → *honey, bee*) or opaque (e.g., *hotdog* → *hot, dog*). The role of semantic relatedness in the processing of compound words has been investigated by manipulating semantic transparency of the individual constituents (Libben et al., 2003; Sandra, 1990; Zwitserlood, 1994).

Studies using the overt priming paradigm have provided evidence for morphological decomposition irrespective of semantic transparency. In these studies, the transparency of the individual constituents was manipulated: TT (transparent-transparent; e.g., *carwash*); OT (opaque-transparent; e.g., *strawberry*); TO (transparent-opaque; e.g., *jailbird*) and OO (opaque-opaque; e.g., *hogwash*). Some studies have included all four of these conditions whereas other studies have categorized TT compounds as semantically transparent compounds, and combining the OT, TO, and OO conditions as semantically opaque compounds. Zwitserlood (1994) investigated whether the decomposition of the compound words is independent of semantic relatedness between the whole word and the constituents. In Experiment 1, the priming effects for semantically transparent compounds (TT) are compared to that for semantically opaque compounds (TO and OO). The constituents of the compounds served as the prime and the compound whole words were the targets. Priming effects were found in both the semantically transparent (TT) and opaque (TO and OO) conditions. However, there was no priming effect on compound word targets from orthographically overlapped, but morphologically unrelated primes (e.g., *matchball-MAT*). Libben et al. (2003) found a priming effect for the OO compounds (e.g., *hogwash*) as well as the TT, TO, and OT compounds (e.g., *carwash, jailbird*, and *strawberry,* respectively) using the second constituent of the compounds as the prime (e.g., *wash, bird* and *berry*). However, the reaction times to the OT and TT compounds were shorter than that to the TO and OO compounds. These results indicated that morpho-orthographic decomposition has occurred in compound word recognition, but the degree of decomposition was greater for compounds with transparent second constituents than for those with opaque second constituents. However, since the primes were not masked in these studies, the visibility of the primes may result in to strategic rather than automatic processing. Therefore, several studies using the masked priming paradigm were conducted to prevent processing strategies that may have contaminated the results.

Shoolman and Andrews (2003) used a masked priming paradigm to test the independent role of the morphological factor in compound processing. In this study, the primes were monomorphemic words (e.g., *book, jay,* and *mock*) that were part of the target words, and the target words were transparent compounds (e.g., *bookshop*), opaque compounds (e.g., *jaywalk*), pseudo compounds (e.g., *hammock*), and monomorphemic words (e.g., *fracture*). Results showed that both the first and second constituents primed the compound targets regardless of semantic relatedness. In addition, the priming effects for the compound words, regardless of semantic transparency, were significantly greater than the pseudo compounds and monomorphemic words after controlling for the whole word frequency. These results were replicated in Fiorentino and Fund-Reznicek (2009) although the order of the prime-target pairs was reversed. In this study, primes were transparent compounds, opaque compounds, and pseudo compounds and targets were the first or second constituents of the primes. Results showed that both the transparent compounds and the opaque compounds primed the constituent targets. Taken together, the studies reviewed above suggested that morphological decomposition cannot be fully accounted for by form overlap or semantic transparency.

The position-in-string effect versus the headedness effect. Although most studies have provided evidence for the activation of constituent morphemes in compound processing, there is still controversy regarding the relative contribution between the first and the second constituents. Kehayia et al. (1999) found a clear position-in-string effect by using the priming paradigm to test Greek and Polish transparent compound words. If there is a significant effect of the first constituent in the left-to-right processing of compounds, we could assume that position-in-string plays an important role in compound processing. Although both Greek and Polish are right-headed languages, the magnitude of the priming effect was greater when the first constituent was the prime than when the second constituent was the prime. Therefore, the researchers concluded that position-in-string is a crucial factor in the recognition of compound words.

Taft and Foster (1976) also supported the position-in-string effect in their Experiments 1 and 5. In Experiment 1, the lexicality of the constituents in compound nonwords was manipulated: both constituents were real words (WW, e.g., *dustworth*), the first constituent is a real word and the second constituent was a nonword (WN, e.g., *footmilge*), the first constituent was a nonword and the second constituent was a real word (NW, e.g., *throwbreak*), and both constituents were nonwords (NN, e.g., *mowdflisk*). Response times for the compound nonwords were significantly longer when the first constituent was a word (WW and WN) than when the first constituent was a nonword (NW and NN). Furthermore, the lexical status of the second constituent did not influence the recognition of the compound nonwords. In other words, the response latencies for NW did not differ from the latencies for NN, and the latencies for WW did not differ from the latencies for WN. In Experiment 5, the response times to the compound words with high versus low frequency first constituent were compared, while the whole word frequency was held constant. The results showed that the response times were faster for compounds in which the first constituent had high frequency (e.g., *headstand*) than those in which the first constituent had low frequency (e.g., *loincloth*). These results suggested that the first constituent plays a more important role than the second constituent in compound processing.

This position-in-string effect can be explained by the left-to-right nature of the reading process. However, a positional advantage for the first constituents is not consistent with results from other studies. For example, Andrews (1986) suggested an equivalent role of the first and second constituents because the correlation between lexical decision time and the frequency of the constituents were the same for both the first and second constituents. Furthermore, some researchers argued that the second constituent is indeed more important than the first constituent. Similar to Experiment 5 of Taft and Foster's (1976) study, the relative importance of the first and second constituents has often been investigated via a factorial manipulation of the frequency of the first and second constituents: high-frequency first constituent/high-frequency second constituent (HH), high-frequency first constituent/low-frequency second constituent (HL), low-frequency first constituent/high-frequency second constituent (LH), and low-frequency first constituent/low-frequency second constituent (LL) (Andrews et al., 2004; Duñabeitia et al., 2007; Juhasz et al., 2003).

Juhasz et al. (2003) examined the constituent frequency effect of compound words in English using a lexical decision task and a naming task. Latencies in both the lexical decision task and the naming task were shorter when the frequency of the second constituent was high. However, the frequency effect of the first constituent was inconclusive and dependent on task demands. In the naming task, the frequency effect of the first constituents was significant only in subject analysis. In the lexical decision task, although there was a trend toward a frequency effect of the first constituent, this effect only occurred when the frequency of second constituents was low.

Libben et al. (2003) also showed that the second constituent play a more important role in lexical decision latencies. In this study, the semantic transparency of the constituents was manipulated. As previously mentioned, four experimental conditions, transparent-transparent (TT), transparent-opaque (TO), opaque-transparent (OT) and opaque-opaque (OO) were generated. Results showed that latencies were the longest when the second constituent was opaque (TO and OO compounds). Results from Juhasz et al. (2003) and Libben et al. (2003) have shown that the second constituent has a robust effect on the processing of compound words in English. Since compounds in English are right-headed (e.g., in the compound *toothbrush*, *brush* is the head and *tooth* is the modifier), it is possible that the second constituent effect is probably due to the fact that the meaning of a compound word is usually determined more by its head morpheme than by its modifier morpheme (Andrew et al., 2004).

However, the position of the constituent and headedness should be separated to test their relative importance for compound processing since some languages are right-headed such as English, German and Korean, while others are left-headed such as Hebrew. Furthermore, the compound structure in some languages such as French can be both left- and right-headed. Jarema et al. (1999) investigated the role of position-in-string and morphological headedness in the visual recognition of French compound words using a priming paradigm. French is the best candidate to investigate the independent role of headedness and position-in-string since headedness is not fully predictable from the position of the constituent in adjective-noun compound words. In other words, French adjective-noun compound words can be either left-headed or right-headed. Results showed that the priming effect of the first constituent was stronger than that of the second constituent in the left-headed OT compounds, but there was no difference in magnitude between the priming effect of the first and second constituent in the right-headed OT compounds. Since the stronger priming effect of the first constituent in left-headed compounds can be interpreted as the combined effects of position-in string and headedness, Jarema et al. (1999) concluded that position-in-string and headedness interact in compound processing.

Duñabeitia et al. (2007) found inconsistent results for the role of headedness in compound processing. This study showed that the high-frequency second constituent had a facilitative effect on response times in the lexical decision task with left-headed compound words in Basque as well as with right-headed compound words in Castilian Spanish. Thus, the effect of the second constituent morphemes occurred regardless of the headedness of the compound words in that language. Duñabeitia et al. (2009) also supported this argument in a series of masked priming experiments with Basque compounds. In Experiment 1, the primes were compounds that shared the same first (e.g., *milkshake-milkman*) or second constituents (e.g., *postman-milkman*) in the same position. In Experiment 2, the primes shared the same constituent morphemes but differed in positions (e.g., *postman-mankind*). Results showed a facilitative priming effect for both the first and second constituent morphemes. Furthermore, this priming effect was not influenced by the position of the shared constituent between the prime and the target (e.g., *postman* primes *mankind*).

In summary, results from previous studies on the relative importance between the first and second constituent is inconsistent and inconclusive. Different task demands (e.g., lexical decision task, naming task and masked priming task) may be the reason for the inconsistent results regarding the relative importance of the first and second constituents. Furthermore, position-in-string seems to interact with headedness in the processing of compounds across languages.

The bilingual lexicon

As reviewed in the previous sections, most of the previous studies have investigated compound processing in monolingual populations (Andrews et al., 2004; Duñabeitia et al., 2007; Juhasz et al., 2003). However, bilingual processing of compounds can also provide valuable insight into the representation of morphological structures. For research with bilingual speakers, we should consider bilingual lexicon models. One of the questions in this field is whether the two languages are stored and accessed together or separately in the mental lexicon. The Bilingual Interactive Activation (BIA) model assumes that the bilingual mental lexicon is integrated across languages. In contrast to the BIA model, models like the Revised Hierarchical Model (RHM) assume that the bilingual lexicon has shared semantic representation, but separated lexical representation (Kroll and Stewart, 1994).

Models of the bilingual lexicon

The Bilingual Interactive Activation Model. The Bilingual Interactive Activation (BIA) model proposes that the bilingual mental lexicon is integrated across languages and lexical access is non-selective (Dijkstra & Van Heuven, 1998; Dijkstra, Van Heuven, & Grainger, 1998; Van Heuven, Dijkstra, & Grainger, 1998). The BIA model is based on the monolingual Interactive Activation model (McClelland & Rumelhart, 1981), which suggests that word recognition is the consequence of competition between orthographically similar words. The BIA model includes four levels of representation - features, letters, words, and languages (see Figure 3). According to the BIA model, when bilinguals see a string of letters, the features of the letters at each letter position activate the corresponding letters that contained these features, while the letters that do not contain the features are inhibited. The activated letter units activate words in both languages when the activated letters occurred at the same position while all other words are inhibited. For example, when a Spanish-English speaker reads the letter *L*, the features of *L* are activated, and these features activate the letter *L* in both Spanish and English and other letters such as *A*, *M*, and *F* are inhibited. The activated letter *L* then excites words in both languages in which the activated letter occurs at the position in question while all other words that do not have this letter at the intended position are inhibited. At the word level, all words inhibit each other, regardless of the language.

Van Heuven, Dijkstra, and Grainger (1998) examined the effects of orthographic neighborhood in bilingual word recognition. Orthographic neighbors are a group of words having the same length and the same order of letters, but differing by only one letter (e.g., *cap* and *cam* are neighbors of *cat*). In Van Heuven et al. (1998), Dutch-English bilinguals and English monolinguals took the English lexical decision task. Results showed that the number of English orthographic neighbors affected English monolinguals' response times, but there was no effect of the Dutch neighbors. Response times were faster for words that had fewer English orthographic neighbors. However, Dutch-English bilinguals' response times were more sensitive to the number of Dutch orthographic neighbors than the English orthographic neighbors. This result supported the BIA model because even when participants do not use their L1 (Dutch), the Dutch lexicon still influenced lexical judgments in English. Dijkstra, Timmermans, and Schriefers (2000) found an effect for interlingual homographs in an English lexical decision task. Interlingual homographs are words that exist both in English and in Dutch but have different meanings in both languages (e.g., *ROOM* means *cream* in Dutch). Participants showed faster response times for non-homograph words than for homograph words. Dijkstra et al. (2000) thereby concluded that when English-Dutch bilinguals read English words, in addition to the English lexicon, the Dutch lexicon is also activated, suggesting that language activation is non-selective in word recognition.

Since the BIA model only focuses on orthographic interactions across languages, it is not sufficient to account for phonological priming effects across languages. Thus, Dijkstra and Van Heuven (2002) extended the BIA model by including phonological and semantic representations. The new model is called the BIA+ model. According to the BIA+ model, bilingual word recognition is influenced by phonological and semantic overlap as well as orthographic overlap between the two languages.

Taken together, the BIA and BIA+ models are supported from empirical evidence showing inter-lingual homograph or orthographic neighborhood effects. The two BIA models can account for empirical findings on proficient bilinguals. However, they cannot handle the processes of L2 learning since they cannot model the gradual development of

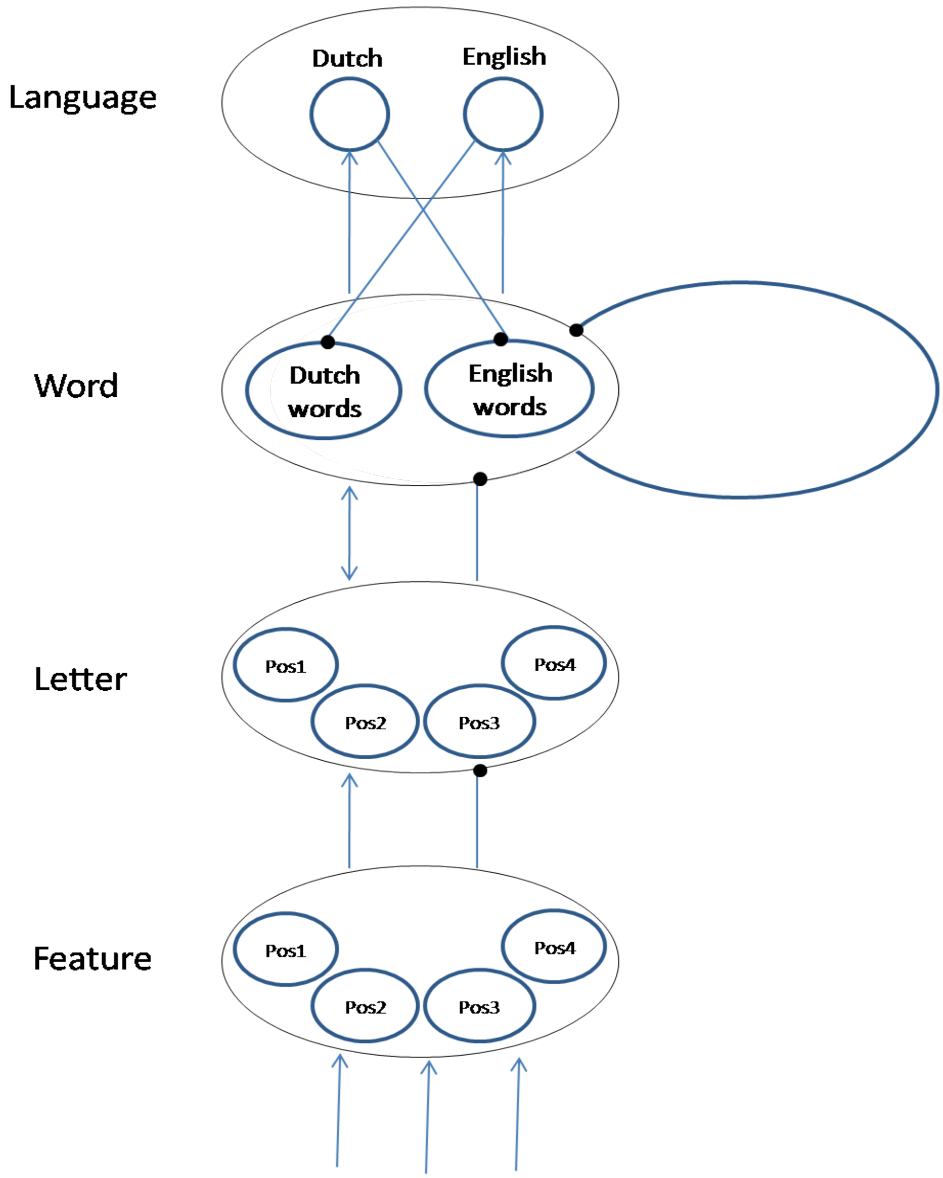


Figure 3. Bilingual Interaction Activation (BIA) model (adapted from Dijkstra, Van Heuven, and Gainger, 1998).

bilingual memory (French & Jacquet, 2004). In the following section, the Revised Hierarchical Model (RHM) that better reflects bilingual processing in less proficient bilinguals is discussed. The RHM model argues for integrated conceptual but separated lexical representation. Before introducing the RHM, the models (word association model and concept mediation model) on which the RHM was based will be discussed. Furthermore, the Distributed Feature Model that supports both shared and separated concepts will be introduced.

The Word Association Model and the Concept Mediation Model. Potter, So, Von Eckardt, & Feldman (1984) put forth two models of the bilingual lexicon—the Word Association Model and the Concept Mediation Model. According to the Word Association Model, words in the L2 are linked to words in the L1 through translation equivalents at the lexical level, and there are no direct links between L2 words and their concepts (see Figure 4[a]). For example, Korean-English bilinguals access the English word *school* by activating the Korean translation equivalent *학교* without any direct conceptual activation of school. The Conceptual mediation model, conversely, suggests that words in the L2 are linked to the corresponding concepts (see Figure 4[b]). Thus, two lexicons are connected via shared conceptual representations instead of via lexical forms.

Potter et al. (1984) used the L1-L2 translation task and the L2 picture-naming task with the Chinese-English and English-French bilingual speakers to test the Word Association Model and the Concept Mediation Model. The Word Association Model hypothesizes that translation from L1 to L2 is faster than naming a picture in L2. This is because L1-L2 translation can be attained through the direct link between L1 and L2 words at the lexical level (L1 words → L2 words), but picture naming in L2 needs to go through the links from image to concepts and then concepts to the L1 words (image → concepts → L1 words → L2 words). Therefore, picturing naming in L2 takes more steps and is more time consuming than L1-L2 translation. However, according to the Concept Association Model, there should be no difference in performance of the two tasks since

L2 word can be accessed through concepts in both the translation and picture naming tasks (L1 words → concepts → L2 words). Potter et al. (1984) found evidence that supports the Concept Mediation Model. Results showed that participants' performance did not differ between the translation task from L1 to L2 and the picture-naming task in L2.

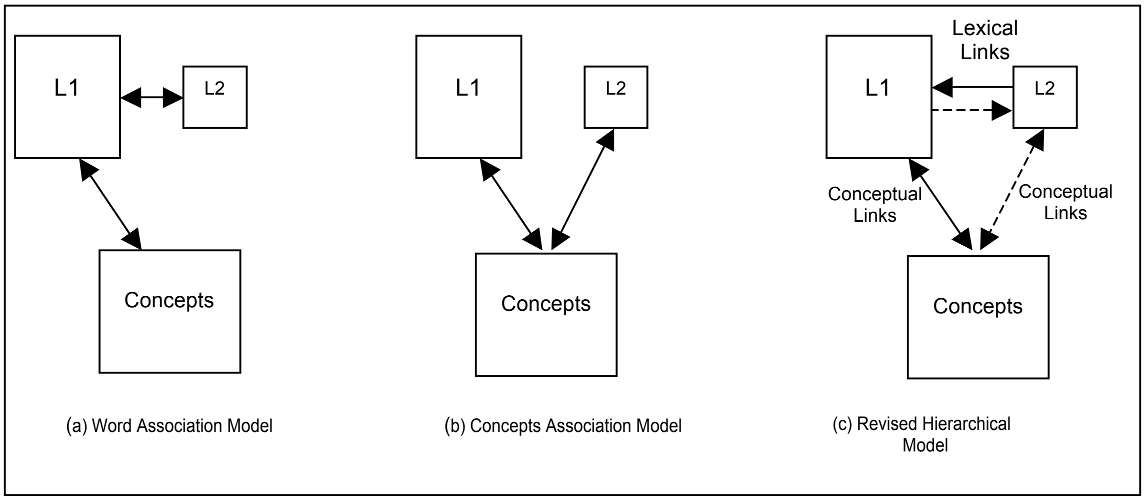


Figure 4. Word Association Model, Concept Association Model, and Revised Hierarchical Model (Adapted from Kroll and Stewart, 1994)

The Distributed Feature Model. De Groot and colleagues (De Groot, 1992, 1995; De Groot, Dannenburg, & Van Hell, 1994; Van Hell, 1998; Van Hell & De Groot, 1998) proposed the Distributed Feature Model. This model suggests that both shared and separate semantics exist simultaneously in the bilingual mental lexicon. L2 words can be accessed via either shared or separate concepts depending on the nature of the L2 words (see Figure 5). Representation of concrete words and cognates is more linked to a shared conceptual representation than representation of abstract words and noncognates. For example, Tokowicz, Kroll, De Groot, and Van Hell (2002) suggested that concrete translation equivalents are more likely to have shared meaning than abstract translation equivalents. Thus, according to the Distributed Feature Model, translation from one language to another language takes a shorter time when the words are concrete or cognates than when they are abstract or noncognate words (De Groot et al., 1994; Van Hell, 1998; Van Hell & De Groot, 1998).

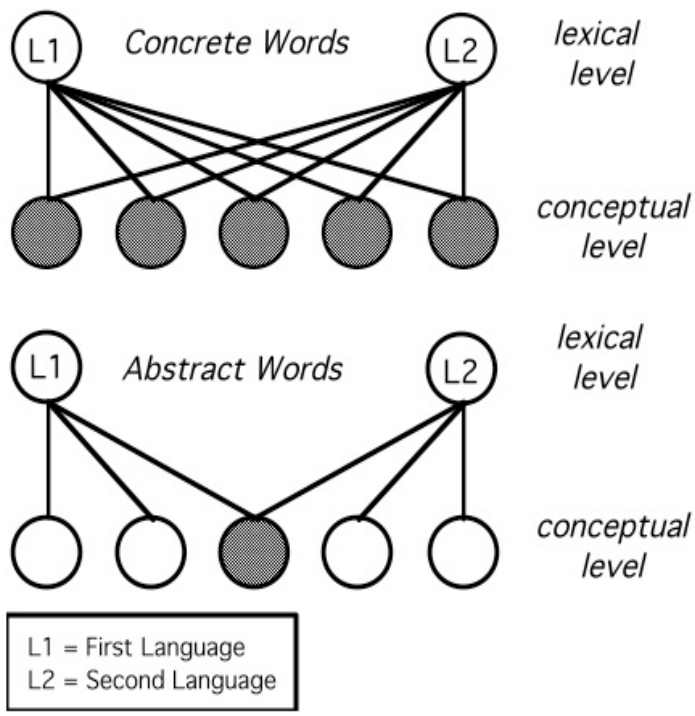


Figure 5. Distributed Feature model (Adopted from De Groot, 1992)

Revised Hierarchical Model. The Revised Hierarchical Model (RHM) (Kroll & Stewart, 1994) is based on both the Word Association and Concept Mediation models. According to this model, conceptual representations are shared but lexical representations are separated and interconnected (see Figure 4[C]). Beginning second language learners access a L2 word through the translation equivalent of the L1 word. The lexical link from L2 words to their L1 translation equivalents is strong while the lexical link from L1 words to their L2 translation equivalents is weak. Also, the strength of connection between L1 words and concepts is stronger than that between L2 words and concepts. However, a direct connection from L2 words to concepts develops and the strength of the lexical link between L1 and L2 becomes stronger with increasing L2 proficiency. This model is supported by studies that found a faster RT translating from L2 to L1 than from L1 to L2 in beginning L2 learners (Kroll & Stewart, 1994; Sholl, Shankaranarayanan, & Kroll, 1995). According to the RHM, the translation asymmetry occurs because translation to L2 is conceptually mediated (e.g., L1 → concepts → L2), but translation to L1 is lexically mediated (e.g., L2 → L1).

Talamas, Kroll, and Dufour (1999) tested the RHM using a translation recognition paradigm. Two groups of English-dominant Spanish learners (the two groups varied in their levels of proficiency in Spanish) were asked to determine whether the second word was the translation equivalent of the first word (e.g., *garlic-ajo* [yes], *garlic-ojo [eye]* [no], *ajo* is the English translation equivalent for the Spanish word *garlic*). The two types of trials that would produce a "no" answer were (1) a form-related neighbor to the translation equivalent (e.g., *garlic-ojo [eye]*), (2) a meaning-related word (e.g., *garlic-cebolla [onion]*). Results indicated that participants with low Spanish proficiency showed more interference from the L2 form related neighbors to the translation equivalent (e.g., *garlic-ojo*) than from the semantically related words (*garlic-cebolla*). However, the more proficient bilinguals showed more interference from the L2 meaning related words than from the form-related neighbors to the translation equivalent. These results supported the RHM which proposes that early in L2 learning, the L2 word is accessed through the L1 translation equivalent. However, with increasing L2 proficiency, L2 learners can access the meaning of the L2 word directly.

Results from cross-language priming studies also support the RHM. If the translation priming effect occurs at the conceptual level, the priming asymmetry (translation priming effect in L1-L2 direction, but not in L2-L1 direction) can be explained by the RHM (Kroll & Stewart, 1994). According to the RHM, L1-L2 priming is effective because the L1 prime activates a concept at the shared conceptual level, and the activated conceptual representation activates an L2 translation-equivalent at the lexical level. However, since the L2 prime cannot activate a concept at the shared conceptual level due to the weaker connection between L2 and concepts, the L1 translation-equivalent is not activated. Therefore, there is no priming effect in the L2-L1 direction.

Heredia (1995, 1996) further modified the RHM by emphasizing the relative language dominance rather than the order of language acquisition. In his Second Revision (R-2) of the RHM, instead of using L1, he used ‘‘the Most Dominant Language’’ (MDL) and L2 was replaced by ‘‘the Least Dominant Language’’ (LDL). In Kroll and Stewart’s (1994) RHM, since the L1 was assumed to be the dominant language, it was difficult to apply the model to the population whose MDL is their L2 rather than their L1. However, since the R-2 of the RHM does not distinguish between order of language acquisition, it allows for the possibility that the bilinguals' L2 has become their more dominant language.

Cross-language priming

The bilingual mental lexicon has been frequently investigated through cross-language priming experiments. In these experiments, prime-target pairs are translation equivalents in L1 and L2 (e.g., *dog-개*, *개* is the translation of *dog* in Korean). In earlier cross-language experiments, a standard priming paradigm begins with a brief presentation (e.g., less than 50 ms) of a prime, followed by the presentation of the target word. However, this design has a potential problem due to the fact that participants could adopt some processing strategies as they become consciously aware of the existence of the prime.

To prevent these strategic effects, a number of recent bilingual studies have adopted the technique of masked priming (e.g., Basnight-Brown & Altarriba, 2007; Brysbaert, Van Dyck, & Van de Poel, 1999; Davis et al., 2000; De Groot & Nas, 1991; Garcíaa-Albea, Sánchez-Casas, & Igoa, 1998; Gollan et al., 1997; Grainger & Frenck-Mestre, 1998; Jiang, 1999; Jiang & Foster, 2001, Williams, 1994). In the masked priming paradigm (Foster & Davis, 1984), the prime is presented for 40-60 ms, and then the target is presented for 500-2000 ms. In addition, the prime is preceded by a forward mask (e.g., ########) for 500-800 ms. Since the prime is preceded by a forward mask and sometimes followed by a backward mask (the mask presented between the prime and the target), participants are usually unaware of the existence of the primes. The primes and targets are usually translation equivalents, semantically related words or orthographically related words across the bilingual's two languages.

Cross-language priming asymmetry. In many masked priming experiments, the significant priming effects in the L1-L2 (or dominant language-less dominant language) direction were robust (De Groot & Nas, 1991; Gollan et al., 1997; Jiang, 1999; Jiang & Forster, 2001; Keatly, Spinks, & De Gelder, 1994; Williams, 1994), but the priming effects in the L2-L1 direction were inconsistent (Gollan et al., 1997; Grainger & Frenck-Mestre, 1998; Jiang, 1999; Jiang & Forster, 2001; Keatly et al., 1994; Sánchez-Casas, Davis, & García-Albea, 1992). Some studies found translation priming effects only in the L1-L2 direction (e.g., Chen & Ng, 1989; Jin, 1990), but other studies have found translation priming effects which occur in both the L1-L2 and L2-L1 directions (e.g., Gollan et al., 1997; Jiang, 1999). However, there is an asymmetry in terms of the magnitude of priming effects, with the magnitude of priming effects in the L1-L2 direction stronger than that in the L2-L1 direction.

One of the reasons for the inconsistent results across studies is methodological differences. Thus, we should take into consideration several methodological issues in interpreting the results from cross-language priming studies. Altarriba and Basnight-Brown (2007) argued that language proficiency, prime duration and prime-target relation (e.g., exclusion/inclusion of cognates and noncognates) are the major methodological issues in cross-language priming experiments.

Language proficiency. One of the accounts of priming asymmetry is that L2 proficiency is an important factor in determining the direction of the priming effect. For example, studies with late bilinguals who are more proficient in their L1 than L2 showed a strong priming effect from L1 to L2, but an inconsistent and weak priming effect from L2 to L1. Jiang (1999) found a stronger priming effect when L2 targets were preceded by their L1 translation primes, compared to when L2 targets were preceded by unrelated L1 words. However, the priming effect was weak when the L1 targets were preceded by their

L2 translation primes. Other studies with participants who are highly proficient in both languages, however, did not show such a priming asymmetry. For example, Basnight-Brown and Altarriba (2007) showed a symmetrical translation priming effect with balanced Spanish-English bilingual speakers. The priming effect occurred in both the L1-L2 and L1-L2 directions, and the magnitude of the priming effect was similar for both directions. In addition, Duñabeitia, Perea, and Carreiras (2010) found a symmetrical translation priming effect in both L1-L2 and L2-L1 directions with highly proficient, simultaneous Basque-Spanish bilinguals.

However, the relative importance between language dominance and age of acquisition (AoA) is still unclear. One of the issues in studying the role of language proficiency is whether age of acquisition could affect the direction of the priming effect regardless of language dominance. In most cross-language priming studies with late bilingual participants, their L1 is consistently their more dominant language. However, early bilingual participants in some studies have various levels of proficiency in their two languages. Gollan et al. (1997) tested the translation priming effect with Hebrew-English bilinguals who acquired the L2 at a very young age. Gollan et al. separated their participants into two groups, the Hebrew-dominant group and the English-dominant group, based on their self-reported proficiency level and their response times and error rates in within-language lexical decision tasks. In both groups, the results showed a priming asymmetry, with the translation priming effect for noncognate pairs existed only in the dominant-less dominant direction but not in the reverse direction.

Kiran and Lebel (2007) also separated the early English-Spanish bilingual speakers into two groups—more balanced and less balanced— in their cross-language priming experiment. The language dominance of the participants shifted from Spanish (L1) to English (L2) as a result of their receiving formal education in the United States. Most of the participants reported that they are more proficient in English than in Spanish in a self-reported proficiency questionnaire. The distinction between the more balanced and less balanced groups was determined by the participants' accuracy in the English and Spanish lexical decision tasks. The priming effect from English (L2: dominant language) to Spanish (L1: less dominant) was greater for the less balanced group than the more balanced group. Taken together, these results suggested that the priming effect is greater in the direction from the more dominant language (MDL; English) to the less dominant language (LDL; Spanish) compared to that from the less dominant language to the more dominant language regardless of the age of acquisition or the chorological order of acquisition of the two languages.

It is worth noting that different language proficiency measures were used in various studies. In some studies language proficiency was reported using self-ratings. In other studies, objective measures were used such as the TOEFL (test of English as a foreign language), the Boston naming test, the C-test, or the reading comprehension test. Each language proficiency test focuses on some aspects of proficiency such as reading or speaking skills but not all aspects. Thus, it is difficult to find bilinguals who are truly balanced between the two languages in all language aspects. For example, late bilinguals tend to be good at L2 reading, but not at speaking because they often learn their L2 in a classroom setting focusing on reading and writing. In contrast, some early bilinguals (e.g., Korean native speakers who immigrated to the United States early in their lives) are proficient in L1 speaking and listening but not in L1 reading and writing because they communicate with their family members using L1, whereas they use their L2 with friends and at school where the language of instruction is their L2.

In summary, language status of the bilingual participants should be assessed by two major constructs – language competence and language history (Marian, Blumenfeld & Kaushanskaya, 2007). Language competence included three distinct constructs – language proficiency, language dominance and language preference. Language proficiency refers to the general language abilities across the language processing domains such as understanding, speaking, reading and writing. Therefore, an objective language proficiency test that relates to the variables under investigation should be used along with language history surveys.

Prime duration. Prime duration is one of the most important factors that influence the cross-language priming asymmetry. Prime duration is related to the issue of prime awareness. Kouider and Dupoux (2004) suggested that prime awareness is not an all-or-none notion, and there is a state of partial awareness in which participants can recognize only part of the prime and at least partial awareness is required for semantic priming. Various prime durations have been used to investigate whether the length of prime duration results in the differential degree of activations on L1 and L2 primes. For the cross-language semantic priming experiment, some experiments used a prime duration of 0 ms (Kirsner et al., 1984; Meyer & Ruddy, 1974) while prime duration in other studies were over 500ms (Grainger & Beauvillain, 1988; Keatley et al., 1994; Tzelgov & Eben-Ezra, 1992; Williams, 1994). The long prime duration is problematic because it may allow participants to utilize strategic processing rather than automatic processing. In earlier cross-language semantic priming experiments, the commonly used prime durations ranged from 200 to 300 ms (Chen & Ng, 1989; Keatley & de Gelder, 1992; Keatley et al., 1994; Larsen et al., 1994; Schwanenflugel & Rey, 1986). However, relatively short prime durations such as 50 ms (Gollan et al., 1997; Jiang, 2001; Williams, 1994) have been used in more recent cross-language translation priming studies.

The short prime duration has been explained as one of the reasons for the absence of the priming effect from L2 to L1. Some studies have suggested that the very short prime duration may not allow enough time for non-native speakers to process the L2 primes (e.g., Gollan et al. 1997; Grainger and Beauvillain, 1988). For example, Grainger et al. (1988) conducted a cross-language semantic priming experiment (e.g., *ROI* [*king* in French]-*QUEEN*) with a short prime duration (100 ms) and a long prime duration (700 ms). When the prime duration was short, the lexical decision of L1 (English) targets was not facilitated by the semantically related L2 (French) primes, while facilitation effects were found at the longer prime duration. To test the hypothesis of insufficient times for the processing of L2 primes, Jiang (1999) inserted a blank interval of 50 ms between the prime and target in his Experiment 3 and inserted a backward mask of 150 ms between the blank interval and target in Experiment 4. However, in both experiments the researcher failed to see a priming effect in the L2 to L1 direction.

Prime-target relationship. Another possible reason for the inconsistent priming effect from the L2-L1 direction is the prime-target relationship. Two major types of prime-target relationships examined in previous studies are cross-linguistic semantically related pairs and translation pairs. The presence of semantic priming effects indicates the association of semantic representations across the two languages. In semantic priming studies (Basnight-Brown & Altarriba, 2007; Grainger & Beauvillain, 1988; Keatley & de

Gelder, 1992; Keatley et al., 1994, Kiran & Lebel, 2007), semantically related and unrelated pairs across languages are presented either from L1-L2 or L2-L1 directions. For example, since the words dog (*개* in Korean) and cat (*고양이* in Korean) are semantically related, the prime-target pairs will be *개 [dog]*-cat, *고양이* [cat]-*dog*, *dog*-*고양이 [cat]* or *cat*-*개 [dog]*.

The stimuli in translation priming studies are translation equivalent pairs across languages (e.g., De Groot & Nas, 1991; García-Albea, Sánchez-Casas, Bradley & Forster, 1985; García-Albea et al., 1998; Grainger & Frenck-Mestre, 1998; Sánchez-Casas et al., 1992; Williams, 1994). For example, the prime word *cat* is followed by the target word *고양이* (the Korean translation equivalent of *cat*). In some translation priming studies, the responses for cognate prime-target pairs were compared to those for noncognate prime-target pairs. Cognates refer to the translation equivalents with the same origin and have similar phonological or orthographic forms across languages (e.g., *rico* in Spanish and *rich* in English), whereas non-cognates are translation equivalents with different origins and have different phonological or orthographical forms (e.g., *mesa* in Spanish, *table* in English).

Studies have consistently shown a priming effect between cognates; however, there is no or weak priming effect between noncognates (De Groot & Nas, 1991; García-Albea et al., 1985; Sánchez-Casas et al., 1992). For example, De Groot and Nas (1991) conducted masked priming experiments with Dutch-English bilinguals. The researchers found that the translation priming effect was larger when the prime-target pairs were cognates, compared to when they were noncognates. Two accounts have been put forth to explain these cognate priming effects (Kim & Davis, 2003). First, the robust priming effect for cognates is due to the overlapped form between the two languages rather than strong links between the representations of cognate translations of the two languages. However, this suggestion is not sufficient to explain the priming effects for cognates since there were no priming effects on form overlapped prime-target pairs (e.g., *coro–corc*, García-Albea et al., 1985) in a monolingual population. Furthermore, no priming effect was obtained in bilingual populations when the prime was different from the nonword target by one letter (e.g., *rict-RICH*; Sanchz-Casas et al., 1992).

An alternative account for the cross-language priming effect in cognate pairs is that the representations of cognate translations are strongly associated in the mental lexicon (Sánchez-Casas et al., 1992). The priming effect of cognates in cross-language priming experiments is similar to the priming effect of morphologically related pairs in within-language priming experiments since both prime-target pairs share similar form and semantic factors. The robust cognate translation priming effect is mostly found across two alphabetic scripts such as English-Dutch (e.g., De Groot & Nas, 1991) and Spanish-English (e.g., Sánchez-Casas et al., 1992). However, studies examining different scripts such as Chinese-English, Hebrew-English and Korean-English showed translation priming effects for noncognate translations that shared semantics only as well as cognates that shared semantics and phonology (Gollan et al., 1997; Jiang, 1999; Kim & Davis, 2003).

Gollan, Forster, and Frost (1997) conducted masked priming experiments with Hebrew-English bilinguals. Since Hebrew and English have different scripts, cognates are phonologically related but orthographically unrelated. Their results were consistent with previous studies in which cognates showed a priming effect from L1-L2 direction, but in contrast with previous studies, noncognate prime-target pairs also showed a translation priming effect. However, the magnitude of the priming effect was greater in the cognate priming condition than that in the noncognate priming condition.

Kim and Davis (2003) also found a translation priming effect in a lexical decision task with both cognate and noncognate prime-target pairs. There were four types of relationships between prime (Korean: L1) and target (English: L2) pairs. These were cognate translations that shared semantics and phonology (e.g., *펜 /pen/-pen*), noncognate translations that shared semantics only (e.g., *곰 /gom/-bear*), homophones that shared phonology only (e.g., *풀/pul/ [grass]-pull*), and control pairs that shared neither phonology nor semantics (e.g., *달/dal/ [moon]-pen*). A significant priming effect was observed for cognate and noncognate pairs, but not for homophones. Since these results are consistent with Gollan et al. (1997), it may be concluded that the noncognate priming effect exists when the scripts of the primes and targets are different. However, Kim and Davis (2003), in contrast with Gollan et al. (1997), did not find a different magnitude of priming effects between the cognate and noncognate translations. Kim and Davis (2003) interpreted this difference between the two studies as being due to the difference in the frequency of the target words. In Gollan et al.'s (1997) study, the frequency of target words was low, whereas in Kim and Davis's (2003) study, it was high. Thus, the participants in Kim and Davis (2003) could rely on orthographic and semantic information for lexical judgment because high frequency English targets were orthographically familiar and semantic information could be accessed rapidly. However, the participants in Gollan et al. (1997) relied on phonological information rather than orthographical and semantic information because in low frequency English targets, orthographical representation was not familiar to the participants and the access of semantic information was slow. Since Gollan et al.'s participants relied more on phonological information, there was a greater priming effect in cognates that shared semantics and phonology than noncognates that shared semantic information only.

In summary, the methodological issues that have been previously discussed were crucial factors in explaining various results of cross-language priming studies. Therefore, by manipulating or controlling these methodological factors, future cross-language priming studies will be able to provide more valuable evidence regarding the nature of bilingual processing.

L2 morphological processing

The major research question in L2 morphological processing is whether L1 morphological processing differs from L2 morphological processing and how the differences between the two can be explained. Some researchers (e.g., McDonald, 2006) have argued that even though L2 processing may be slower and less automatized than L1 processing, L2 learners process the morphologically complex words in their L2 in a similar way as they do in their L1. The differences between L1 and L2 morphological processing could be due to basic cognitive resource limitations (e.g., slower processing or more memory-demanding). In some studies, the priming effects of regularly inflected or derived word forms on stems were not significantly different between L1 and L2 (Basnight-Brown et al., 2007; Dipendaele et al., 2011; Portin, Lehtonen, & Laine, 2007; Portin et al., 2008). For example, Dipendaele et al. (2011) compared the masked priming effects of derived words among native English speakers and two groups of bilinguals (Spanish-English and Dutch-English). There were three types of prime-target pairs:

semantically transparent and morphologically related (e.g., *viewer-view*), semantically opaque (pseudo) and morphological related (e.g., *corner-corn*), and only orthographically related (e.g., *freeze-free*) prime-target pairs. Both native English speakers and the bilingual speakers (regardless of their L1) showed a similar pattern of priming effects: the largest priming effect for the transparent suffixed primes, the smallest priming effect for the form control primes, and intermediate effect for the opaque suffixed primes. Dipendaele et al. (2011) suggested that even late bilinguals process L2 morphologically complex words in a similar way as native speakers.

The differences in L1 and L2 morphological processing may also be accounted for via L1 transfer. For example, Scheutz and Eberhard (2004) showed that when German-English bilinguals process the English agentive noun ending–*er*, they activated the masculine gender feature associated with German agentive noun ending–*er*. However, Silva and Clahsen (2008) suggested that L1 transfer is not a factor in L2 morphological processing. In this study, English morphological processing was compared across native English speakers, German speakers, Chinese speakers and Japanese speakers. Although the German inflectional and derivational systems are more similar to that in English in comparison to that in Chinese or Japanese, the different L2 groups showed the same patterns of results. The lack of L1 transfer implies that all non-native speakers are likely to process complex words in their L2 in a similar way.

Other researchers have argued that L1 and L2 morphological processing are different in a more fundamental way that cannot be accounted for by cognitive resource limitations and L1 transfer (e.g., Babcock, Stowe, Maloof, Brovetto, & Ullman, in press; Clahsen & Neubauer, 2010; Neubauer & Clahsen, 2009; Silva & Clahsen, 2008).

Ullman (2001, 2004) explained L1/L2 morphological processing differences using his dual mechanism model of morphology. According to Ullman (2001, 2004), native language speakers use two different memory systems, declarative memory and procedural memory, to process morphologically complex words. The declarative memory is responsible for handling arbitrary linguistic information (e.g., irregular verb forms) that can be memorized and accessed explicitly. The procedural memory, on the other hand, consists of mental grammar referring to the combination rules of a language. Once the rules have been implicitly learned, native speakers can process morphologically complex words with a combination treatment of inputs rather than with memorization. For example, the past tense suffix -*ed* can be added to any regular verb to form the past tense (*show-showed*) and can also be applied to invented words (*wug* → *wuged*) to indicate the past tense. Ullman (2001, 2004)'s dual route model can be used to explain L2 morphological processing. L2 learners process morphologically complex words with a whole-word form route (declarative memory) rather than the assembly route (procedural memory) of individual constituents of the complex words. Silva and Clahsen (2008) conducted masked priming experiments to compare within-language (English L2) morphological priming effects between the group of native speakers of English and second language learners of English (German speaking, Chinese speaking, and Japanese speaking L2 learners). The regular past-tense suffixed words with -*ed* (e.g., *showed*) were used for the inflected word primes, and the nominalization suffixed words with -*ness* and –*ity* (e.g., *bitterness*, *humidity*) were used for derived word primes. The native speakers exhibited a morphological priming effect for both inflected and derived words, but the nonnative speakers, regardless of their L1, showed no morphological priming effect for the inflected words and a reduced priming effect for the derived words. These results support Ullman's declarative/procedural model of L2 language processing. The reduced priming effects in L2 derived words and no priming effects in L2 inflected words provided the evidence that L2 learners store the inflected forms of verbs as whole word representations in the mental lexicon and rely on declarative memory rather than procedural memory.

Neubauer and Clahsen (2009) compared the processing of morphologically complex verbs in German between Polish learners of German and native speakers of German. The frequency of regular and irregular verbs was manipulated (high regular/low regular/high irregular/low irregular). In the lexical decision task, Polish learners showed significantly shorter RTs for high frequency forms of both regular and irregular participle forms. In contrast, the German native group showed the frequency effect in irregular past participle forms, but not in regular past participle forms. In the masked priming experiment, L2 learners showed full priming effects (similar RTs for irregular/regular primes and identity primes, both of which were significantly shorter than for unrelated primes) for both regular and irregular past participle forms, whereas native speaker exhibited priming effects only for the irregular primes. Clahsen and Neubauer (2010) also conducted the lexical decision tasks and masked priming experiments with the nominalizing derivational suffix *–ung* to compare L1 and L2 morphological processing. In the unmasked lexical decision task, although both German native speakers and L2 learners showed a shorter RT for high-frequency words than low-frequency words, the frequency effect was stronger in L2 learners than in German native speakers. In the masked priming lexical decision task, the morphological priming effect was only significant for the German native group, but not for the L2 group. Taken together, findings from Neubauer & Clahsen (2009) and Clahsen & Neubauer (2010) provide additional support for the claims made in Silva & Clahsen (2008) that adult L2 learners are not as sensitive to morphological structure in the L2 as native speakers of that language, and do not decompose inflectional and derivational affixes from their stems during processing. The researchers (Clahsen & Neubauer, 2010; Neubauer & Clahsen, 2009; Silva & Clahsen, 2008) suggested that the processing of morphologically complex words in L2 relies on direct lexical retrieval rather than grammatical computation.

Note that the aforementioned studies have mainly focused on affixed words such as inflected word forms (e.g., Basnight-Brown, Chen, Hua, Kostic & Feldman, 2007; Portin et al., 2007; Portin, Lehtonen, Harrer, Wande, Niemi, & Laine, 2008) and derived word forms (e.g., Dipendaele, Duñabeitia, Morris, & Keuleers, in press). Furthermore, these studies are limited to within-language morphological processing (L2-L2), and cross-language morphological processing (L1-L2 and L2-L1) has received relatively little attention in the literature.

Kim et al. (2011) examined cross language activation in derived words with Korean-English bilingual readers. In this study, the targets were L2 (English) stem words (e.g., *attract*) and the primes were L1 (Korean) real words (i.e., *매력적, attractive*), interpretable derived pseudowords (i.e., *매력화, attractization*), non-interpretable derived pseudowords (i.e., *매력각, attracticide*), and non-morphological ending pseudowords (i.e., *매력래, attractel*). Results showed that when the primes were real derived words, interpretable derived pseudo words, and non-interpretable derived pseudo words, there were significant priming effects. However, when the primes were non-morphological ending (i.e., illegal combination of a stem and an orthographic ending), there was no significant priming effect. These results demonstrated that cross-language activation of derived words occurs, independent of lexicality and interpretability. However, Kim et al. (2011) only studied priming effects from Korean to English (L1-L2 direction), the cross-language priming asymmetry between L1-L2 and L2-L1 directions were not examined.

Ko et al. (2011) investigated whether Korean-English bilingual readers activate constituents of compound words in one language while processing compound words in the other language via decomposition. Two experiments using a lexical decision paradigm were conducted with adult Korean-English bilingual readers. In Experiment 1, the lexicality of the compound words in the target language (the language being tested) and the lexicality of translated compounds in the nontarget language (the language which is not being tested) were manipulated. There are four conditions in the 2 X 2 factorial design: 1) RR (real word – real word) (e.g., *honeybee-꿀벌*); 2) RN (real word – nonword) (e.g., *bankbook-은행책*); 3) NR (nonword-real word) (e.g., *eyewater-눈물*); and 4) NN (nonword-nonword) (e.g., *babydog-아기개*). The lexical decision of English compound real words was more accurate when the translated compounds (the combination of the translation equivalents of the constituents) in Korean (the nontarget language) were real words than when they were nonwords. In Experiment 2, the frequency of the second constituents of the compound words in the target language and the lexical status of the translated compounds in the nontarget language were manipulated. Results showed that the effect of the lexical status of the translated compounds was greater on the compounds with a high-frequency second constituent than the compounds with a low frequency second constituent in the target language. These results together provided evidence for decomposition and cross-language activation in bilingual reading of compound words.

Directions and method of the dissertation

Previous research regarding morphological processing suggests that morphological decomposition occurs among monolingual populations, but very little is known about how bilingual readers process morphologically complex words. Furthermore, the studies regarding bilingual processing mostly focused on Indo-European languages and two same alphabetic scripts. The present study is one of the first attempts to fill in the gap in the literature and to bridge the two seemingly independent topics of morphological processing and the bilingual lexicon.

This dissertation investigated how morphologically complex words are represented and processed in bilingual readers. The first research question is whether Korean-English bilinguals decompose compound words into their individual constituent morphemes when reading in their L1 (Korean). Although many studies have provided evidence for morphological decomposition of compounds in Indo-European languages, little is known about Korean compound processing. To answer this question, a within-language masked priming experiment with Korean prime-target pairs were conducted in Experiment 1.

The second research question is how Korean-English bilinguals process compounds in their L2 (English). Silva and Clahsen (2008) compared morphological priming effects with English inflected and derived words between native speakers of English and groups of L2 learners of English. However, how English compound words are processed in L2 learners has not been studied extensively. To investigate whether

Korean-English bilinguals decompose compound words into individual constituents when processing in their L2, a within-language masked priming experiment with English prime-target pairs (e.g., *bee-honeybee*) was conducted in Experiment 2. Korean-English bilinguals may rely more on combinatorial processing in their L2 (English) processing than in their L1 (Korean) processing since their L2 (English) lexicon size is smaller than their L1 (Korean) lexicon size. Alternatively, Korean-English bilinguals may rely more on lexical storage and less on combinatorial processing in L2 than in L1 since L2 (English) learners are not proficient enough to employ morphological processing strategies in L2.

The third research question is regarding cross-language activation of the constituents in morphologically complex words. Specifically, I examined whether the translation equivalents of the constituents in morphologically complex words in one language could facilitate the processing of morphologically complex words in the other language via morphological decomposition. One of the essential issues for bilingual processing is that, to what degree the representations from one language are shared/integrated with that from the other language. The RHM argues for a shared semantic representation and a separate but connected representation of lexical information. This model was supported by previous cross-language priming studies (Gollan et al., 1997; Jiang, 1999; Jiang & Forster, 2001). However, most of these previous studies did not specifically examine morphologically complex words. Thus, it is unclear whether cross-language activation occurs in the processing of both monomorphemic and multimorphemic words.

Levy et al. (2006) have suggested that the research questions in bilingual compound processing can be investigated with the experimental techniques used in studies of monolingual readers. Particularly, masked cross-language constituent priming (e.g., the target is a compound word in one language while the prime is the translated constituent of the compound in the other language) can be used in bilingual research. For example, the English compound, *honeybee*, contains two free morphemes, *honey* and *bee*. *Honey* and *bee* can be translated into 꿀*[honey]* and 벌*[bee]*, respectively, in Korean. In a masked priming experiment, the prime can be the Korean translated equivalent of one of the two constituents of the English compound (e.g., 꿀 or 벌), and the target can be the English compound word (e.g., *honeybee*). The RT when the translated constituent is the prime (e.g., 벌 *[bee]-honeybee*) is compared with the Korean unrelated prime (e.g., 달 *[moon]-honeybee*). If the Korean translation equivalents of the constituent morphemes are activated, the RT on the English compounds will be faster for the Korean translated constituent primes in comparison to the Korean unrelated primes. The priming asymmetry shown in previous studies could also be examined by comparing the priming effect from L2 (English) to L1 (Korean) and the priming effect from L1 (Korean) to L2 (English). If there is a priming effect when L1 is the prime and L2 is the target, but no priming effect when L2 is the prime and L1 is the target, the hypothesis of the RHM (Kroll & Stewart, 1994) will be supported. According to the RHM, for non-balanced bilinguals who are less proficient in their L2, the links between L1 words and concepts are stronger than the links between L2 words and concepts. Thus, a L1 prime can activate conceptual information more quickly and accurately than a L2 prime, resulting in the faster processing of the target word L2 word.

The fourth research question is the roles of form, semantic and morphological information in the bilingual processing of compound words. Previous studies of compound processing in monolingual populations have shown an independent role of morphological information (e.g., Marslen-Wilson et al., 2008; Rastle et al., 2000; Rastle et al., 2004; Shoolman & Andrews, 2004). In these studies, when form, semantic and morphological relatedness were manipulated, morphological relatedness was the major factor for priming effects. For example, in Shoolman and Andrews (2004), there was no priming effect when the prime-target pairs were only orthographically related but not morphologically decomposable (e.g., *ham-hammock*). In addition, there was no difference in priming effects between semantically transparent prime-target pairs (e.g., *book-bookshop*) and semantically opaque prime-target pairs (e.g., *jay-jaywalk*). These results suggested that morphological decomposability is independent of semantic transparency and form relatedness in native language compound processing.

When it comes to bilingual processing, the independent role of morphological information can also be examined by manipulating form overlap, morphological decomposability, and semantic transparency. Prior to the cross-language masked priming experiments, the within-language masked priming experiments are conducted to test the role of form, semantic and morphological information in compound processing within L1 (Korean) and L2 (English). It is important to establish that there are indeed priming effects in the within-language conditions before examining the cross-language priming effects. In the cross-language conditions, since Korean and English have different scripts, only phonological information can be manipulated for form related prime-target pairs. In addition, since most Korean compound words are semantically transparent (Choo &

O'Grady, 1996), the semantic transparency variable will not be manipulated in the design for Korean compound targets.

Fifth, the time course of cross-language activation can be examined by manipulating prime durations. Rastle et al. (2000) used three different prime durations (43 ms, 72 ms, and 230 ms) to investigate the time course of morphological decomposition. In this study, semantically transparent derived words showed a priming effect at all three prime durations, but semantically opaque derived words showed a priming effect only at the shortest prime duration (43 ms). These results suggested that the morphological factor is independent of the semantic factor, at least at the early stage of visual word recognition. In bilingual research, the prime duration is an important factor that affects cross-language priming. Some researchers have suggested that a very short prime duration may not allow non-native speakers enough times to process the L2 primes (e.g., Gollan et al., 1997; Grainger & Beauvillain, 1988). The question regarding the time course of cross-language activation in bilinguals can be examined by manipulating the prime durations in both L1 prime-L2 target pairs and L2 prime-L1 target pairs. If we could see the morphological priming effects at a short prime duration as that in native language studies, we can conclude that decomposition occurs at the early stage of processing. Furthermore, we can compare the priming effects from L1 to L2 with that from L2 to L1 to test the asymmetry of priming effects across the two languages.

Finally, the relative contribution of the first and second constituents can be examined in bilingual compound processing. Previous studies in monolingual populations showed inconsistent results for the relative contribution of each constituent. For example, Andrews (1986) suggested an equivalent role of first and second constituents in compound processing whereas Juhasz et al. (2003) suggested that the second constituent is more important. The relative importance of the second constituent may be a result of the position of the head morphemes since the meaning of a compound word is usually determined by its head morpheme, which is the second constituent in English. The relative importance of each constituent in bilingual compound processing can provide novel evidence on this issue. If the first constituent shows a greater priming effect than the second constituent, a serial processing strategy may be employed for compound processing, whereas if the second constituent shows a greater priming effect than the first constituent, the head morpheme that defines the meaning of the whole word may be more important in compound processing

Chapter III: Experiment 1: Priming within Korean (L1)

In Experiment 1, a within-language priming experiment was conducted with Korean prime-target pairs. The within-language priming effect in Korean language is worth studying for three specific reasons. First, the issue of morphological decomposition has not been previously investigated with Korean compound words, it is important to investigate whether morphological decomposition can be generalized to the Korean language. Second, we need to confirm that our bilingual participants could process Korean primes when Korean prime-target pairs are used. Furthermore, the within-language priming data allow us to test whether the head morpheme (the second constituent) is more important than the non-head morpheme (the first constituent) in Korean compound processing. Although semantic transparency was one of the major properties that influence morphological decomposition in English, there are a limited number of semantically opaque compounds in Korean. Thus, the semantic transparency variable will not be studied in this experiment.

There are two research questions in Experiment 1: (1) What information is used to parse Korean compound words into individual constituents and, in particular, does morphological information play a role independent of the orthographic factor? And (2) What is the relative contribution of the first and second constituent to the processing of Korean compound words?

Hypotheses

There are two hypotheses in Experiment 1: First, if the morpho-semantic priming effect dissociates from orthographic overlap, there will be significant constituent priming effects, for both first and second constituent primes, in the morphologically, semantically and orthographically related prime-target pairs (+M+S+O; e.g., *꿀 [honey]-꿀벌 [honeybee]*; *벌 [bee]-꿀벌 [honeybee]*), but not for the only orthographic overlapped (e.g., -M-S+O) prime-target pairs (e.g., *딸 [daughter]-딸기 [strawberry]; 기 [flag]-딸기 [strawberry]*). Alternatively, if the constituent priming effect occurs due to orthographic overlap between the prime and target, there will be significant constituent priming effects for both +M+S+O and -M-S+O. Second, I hypothesize that the priming effect of the second constituent will be greater than the effect of the first constituent since the second constituent is the head morpheme that carries more meaning information in Korean.

Method

Participants. The participants were 36 Korean-English bilingual adults (male = 18, female =18). Due to the difficulty of finding a sufficient number of Korean-English bilinguals in the United States, I recruited the bilingual participants at the Ewha Women's University, Yonsei University and Dongkuk University in South Korea. All the participants have studied English as a second language. The mean age of the participants was 23.8 years (SD = 2.8 years).

Prior to the experimental session, the participants were asked to fill out the Language Experience and Proficiency Questionnaire (Marian, Blumenfeld, & Kaushanskaya, 2007). The LEAP-Q includes questions about the factors that have been identified as important contributors to bilingual status. The main factors are language competence, age of language acquisition, and prior and current language exposure. In assessing language competence, three distinct measures, language proficiency, language dominance and language preference, are used. Consistent with previous bilingual self-assessment studies (Flege et al., 1999, 2002; Grosjean, 2004; Li et al., 2006; Strong-

Krause, 2000; Vaid & Menon, 2000), language proficiency is self-rated in three different domains (speaking, listening, and reading) (Appendix C). According to the LEAP-Q (Marian et al., 2007), all of the participants learned Korean as their L1 and English as their L2. They were currently exposed to Korean 81% of the time and English 19% of the time. Fifty-three percent of the participants had a high school degree, 39% had a college degree, and 6% had a master degree. The participants began to acquire English at the mean age of 9.7 years (*SD* = 2.7 years) and became fluent in English at the mean age of 17.4 years (*SD* = 4.4 years). The average number of years living in a country, in a family and in a school where English is spoken was 1.0 year, 0 years, and 1.5 years, respectively. The participants reported their proficiency levels in both Korean and English, including speaking ability, understanding spoken language, and reading, based on an eleven-point scale (0 = none to 10 = perfect). They were also asked to report their degree of foreign accent on an eleven-point scale (0 = none to 10 = pervasive). Table 1 shows the means and standard deviations of the ratings of each category for English and Korean. Overall, the participants rated their Korean proficiency as almost perfect (greater than 9.3) in all three areas. However, they rated their English proficiency as adequate (5.1) in speaking, slightly more than adequate (6.25) in understanding and good (7.14) in reading. Also, they rated their degree of foreign accent in Korean as none (.42) but in English as considerable (5.75). All of the participants had normal or corrected-to-normal vision and thus had no difficulty with reading words on a computer monitor.

The participants were tested on their English proficiency using the English Boston Naming Test (Kaplan, Goodglass, & Weintraub, 1983) and the English C-test (Babaii & Moghaddam, 2006). The Boston Naming Test contains 60 pictures, arranged in increment levels of difficulty (Appendix A). Participants were asked to say the name of the object in each picture. The English C-test included five passages, and each passage was chosen from *Encyclopedia Britanica*, *Practice and Progress*, *Readers Choice*, and *Developing Reading skills* in which 25 words were incomplete by deleting 2/3 or 1/2 of the words or leaving only the first letter in each passage. Participants were asked to restore the missing letters (Appendix B).

The average scores for the English Boston Naming Test and C-test were 0.71 (*SD* = 0.18) and 0.65 (*SD* = 0.11), respectively.

Table 1. Means and standard deviations of self-rated proficiency in Experiments 1 and 2

	Self-rated proficiency[a]			Self-rating of foreign accent	
	Speaking	Understand spoken language	Reading	Perceived by self[b]	Identified by others[c]
English (L2)	5.11 (2.01)	6.25 (1.61)	7.14 (1.25)	5.75 (2.06)	6.97 (2.54)
Korean (L1)	9.39 (0.73)	9.44 (.65)	9.33 (.83)	.42 (1.79)	.14 (.83)

[a]Range: 0 (none) to 10 (perfect). [b]Range: 0 (none) to 10 (pervasive). [c]Range: 0 (none) to 10 (always).

Design and materials. The design was 3 (condition: +M+S+O [one syllable] vs. +M+S+O [two syllable] vs. -M-S+O) X 4 (prime types: first constituent vs. second constituent vs. first unrelated vs. second unrelated). Originally I had two conditions (+M+S+O [one syllable] and -M-S+O conditions), but in the pilot study data, even in +M+S+O condition, there was a trend indicating inhibitive priming effect. I thought that this inhibition effect is due to a number of homographs in Korean one syllable words. So, I generated another +M+S+O condition with two syllable primes. So, in third condition, primes were two syllable morphemes, and target compound words were four syllable compound words. Condition and prime types were the within-participant factors. In this experiment, prime-target pairs co-varying in morphological decomposability, semantic relatedness and orthographic relatedness were presented. There were three types of Korean prime-target pairs: (1) Morphologically decomposable, semantically transparent and orthographically overlapped one syllable prime- two syllable target pairs (+M+S+O [one syllable], e.g., *꿀 [honey]– 꿀벌 [honeybee]; 벌 [bee]– 꿀벌 [honeybee]*), (2) Morphologically decomposable, semantically transparent and orthographically overlapped two syllable prime-four syllable target pairs (+M+S+O [two syllable], e.g., *전화 [phone]– 전화번호 [phone number]; 번호 [phone]– 전화번호 [phone number]*) and (3) Only orthographically overlapped prime-target pairs (-M-S+O, e.g., *딸 [daughter]–딸기 [strawberry]; 기 [flag]-딸기 [strawberry]*). For the experimental stimuli, a total of 48 words (16 in each condition) were included as target words. The target was preceded by the first or second constituent prime. In addition, two sets of unrelated primes for each target (e.g., *덕 [virtue] – 꿀벌 [honeybee]*) were created as the control condition (See Table 2 for sample items, see Appendix D for a complete list of items). Four experimental lists were constructed so that the participants did not see the same target more than once. Specifically, if the same target was preceded by the first constituent prime in List 1, and it was preceded by the second constituent prime in List 2. For the same target, the prime in List 3 and List 4 were the unrelated words to the first constituent prime, and the second constituent prime, respectively. The participants were randomly assigned to one of the four lists. In addition, 24 unrelated prime-target pairs were generated to match the number of related prime-target pairs to prevent the participants from developing processing strategies. Seventy-two nonword targets were also generated to ensure an equal number of “Yes” and “No” responses. Among the seventy-two nonword targets, 20 nonwords were compound-like nonwords (5 word-word, 5 word-nonword, 5 nonword-word, and 5 nonword-nonword) and the remaining items were monomorphemic nonwords.

Table 2. Sample items of Experiment 1

Condition	1st constituent prime	2nd constituent prime	1st unrelated prime	2nd unrelated prime	Target
-M-S+O	*딸* [*daughter*]	*기* [*flag*]	*밑* [*bottom*]	*층* [*floor*]	*딸기* [*strawberry*]
+M+S+O (1 syl)	*낮* [*day*]	*잠* [*sleep*]	*평* [*comment*]	*선* [*line*]	*낮잠* [*nap*]
+M+S+O (2 syl)	*전화* [*phone*]	*번호* [*number*]	*가슴* [*breast*]	*막내* [*the youngest*]	*전화번호* [*phone number*]

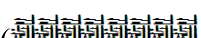
Note. Texts in bold denote the test items. Each English word in [ ] is the translation equivalent of the corresponding test item.

Primes and targets were matched as much as possible across conditions for frequency and the number of letters. However, the number of letters could not be matched due to the constraint from the main design variable (the +M+S+O [two syllable] condition have the two syllable primes and four syllable targets). When the two conditions, +M+S+O (one syllable) and -M-S+O conditions, were compared, there was no significant difference in the number of letters. Furthermore, frequency and the number of letters were matched between the first and second constituent primes, t (93) = -.89, p = .38 for frequency, t (93) = .20, p = .84 for the number of letters, between the first constituent and the control primes, t (93) = -.03, p = .97 for frequency, t (93) = -.73, p = .47 for the number of letters, and between the second constituent and the control primes t (93) = .41, p = .68 for frequency, t (93) = -.68, p = .50 for the number of letters. Frequencies were determined based on a database provided by the National Academy of the Korean Language with a frequency count of 1 per 1.5 million (the database is available on the website, http://www.korean.go.kr). The descriptive statistics of these variables along with the t-test results comparing the two conditions are shown in Table 3.

Table 3. Experiment 1: Averages for stimulus characteristics for items

Property	Conditions			ANOVA/ T-tests between –M-S+O and +M+S+O (1)
	-M-S+O	+M+S+O (1)	+M+S+O (2)	
Number of Letters (T)	5.81	5.94	9.75	*F* (2,45) = 291.44, *p* <. 01 *t* (30) = 1.05, *n.s.*
Number of Letters (P1)	2.94	2.94	4.94	*F* (2,45) = 140.92, *p* <. 01 *t* (30) = .00, *n.s.*
Number of Letters (P2)	2.88	3.06	4.75	*F* (2,45) = 65.66, *p* <. 01 *t* (30) = 1.77, *n.s.*
Frequency (T)	26.06	16.35	16.13	*F* (2,45) = 1.53, *n.s.* *t* (30) = -1.44, *n.s.*
Frequency (P1)	194.13	288.60	236.63	*F* (2,45) = .13, *n.s.* *t* (30) = .35, *n.s.*
Frequency (P2)	227.06	390.77	358.19	*F* (2,45) = .38, *n.s.* *t* (30) = .78, *n.s.*

Note: T = Target, P1 = 1st constituent prime, P2 = 2nd constituent prime, ANOVA with three conditions, T-test with –M-S+O and +M+S+O (1)

Procedure. After the completion of the English proficiency tests and the LEAP-Q, the participants were asked to begin the experiment. A series of letter-strings were presented one at a time on a computer screen controlled by the E-Prime software (Psychology Software Inc. Pittsburgh, PA). The experiment employed a masked priming lexical decision task procedure (Forster & Davis, 1984). In this task, a fixation "+" was presented for 250 ms, followed by a forward mask () for 500 ms. Then the prime word (e.g., 벌 *[honey]*) was presented for 50 ms and immediately followed by a backward mask (XYXYXY) for 150 ms. Finally, the target (e.g., 꿀벌 *[honeybee]*) was presented for 3000 ms. The forward and backward masks were used to minimize prime visibility. The participants were instructed to press the "Yes" key with the right index finger if a real word appears on the screen, and the "No" key with the left index finger if a nonword appears. They were told to respond as accurately and quickly as possible. The target would disappear as soon as a response is made or after 3000 ms from the onset of the target. Before starting the experimental session, each participant performed 12 practice trials to become familiar with the procedure. After the experiment, the participants were asked if they recognize the prime.

Results

Response times (RT) are shown in Table 4 and Mean accuracies are shown in Table 5. The data of 6 participants who could see the primes were deleted. The RT data for incorrect responses were deleted. Responses differing by two standard deviations from the cell mean (4.9 %) were removed from the RT data.

Response time. Planned comparisons showed a significant priming effect of the first (40 ms) and second constituents (35 ms) in the +M+S+O condition (two-syllable), t_1 (29) = 3.102, p = .004; t_2 (30) = 2.885, p = 007 and t_1 (29) = 2.367, p = .025; t_2 (30) = 2.657, p = .013, respectively. When the priming effects of the first and second constituent primes were compared, there was no significant difference, t_1 < 1.

There was no significant priming effect of the first and second constituents in the +M+S+O (one syllable) condition, all *t*s < 1. In addition, there was no significant priming effect of the first and second constituents in the -M-S+O condition, t_1 (29) = -.347, p = .731; t_2 (30) = -.240, p = .812, and t_1 (29) = -1.374, p = .180; t_2 (30) = -.821, p = .418, respectively. Mean RT showed a noticeable trend indicating inhibitive priming effects (-22 ms) of the second constituents in the -M-S+O condition.

3 (conditions: +M+S+O [one syllable] vs. +M+S+O [two syllable] vs. -M-S+O) X 4 (prime types: first constituent vs. second constituent vs. first unrelated vs. second

unrelated) ANOVAs was performed. F_1 (t_1) represents the subject analyses and F_2 (t_2) represents the item analyses. There was a main effect of condition both by participants and items, F_1 (2, 58) = 4.385, p =. 017; F_2 (2, 180) = 4.039, p = .019. RTs were faster in the +M+S+O condition with two-syllable primes (601 ms) than in +M+S+O condition with one-syllable primes (623 ms) and in the –M-S+O condition (618 ms). The interaction between conditions and prime types was significant by participants, but not by items, indicating that the priming effect varied across conditions, F_1 (6, 174) = 2.247, p = .041; F_2 (6,180) = 1.153, p = .334. The main effect of prime types was not significant, F_1 (3, 87) = 1.075, p = .364, F_2 (3,180) = 0.826, p = .481.

Table 4. Experiment 1: Average RT (ms) and priming effect (standard deviation in brackets)

Condition	1st constituent	2nd constituent	1st Unrelated	2nd Unrelated	Priming effect (U1-1st)	Priming effect (U2-2nd)
+M+S+O (one-syllable)	612 (92)	634 (131)	618 (93)	628 (107)	6	-6
-M-S+O	622 (90)	627 (113)	618 (96)	605 (72)	-4	-22
+M+S+O (two-syllable)	578 (72)	587 (74)	618 (92)	622 (92)	40**	35*

Note: U1 refers to the unrelated prime to the first constituent, and U2 refers to the unrelated prime to the second constituent
*p <. 05, **p < .01

Accuracy. Average accuracy was high (greater than .96) in all cells. Planned comparison of accuracy in each condition indicated that there were no significant priming effects of the first constituents in the +M+S+O condition with one syllable primes, the +M+S+O condition with two syllable primes and the -M-S+O conditions, all ts < 1. In addition, there were no significant priming effects of second constituents in +M+S+O with one syllable primes, +M+S+O with two syllable primes, and -M-S+O conditions, t_1

(29) = -.372, p = .712; t_2 (30) = -.293, p = .771, t_1 (29) = 1.439, p = .161; t_2 (30) = 1.464, p = .154 and t_1 (29) = 1.00, p = .326; t_2 (30) = 1.000, p = .325, respectively.

There was a significant main effect of conditions both by participants and items, F_1 (2, 58) = 7.818, p =. 001; F_2 (2, 180) = 5.753, p = .004. Lexical decisions were made more accurately in +M+S+O (the two-syllable condition) than in +M+S+O (the one-syllable condition). However, there was no significant main effect of prime types, F_1 (3, 87) = .407, p = .748, F_2 (3,180) = 0.308 p = .819. The interaction between conditions and prime types was not significant, F_1 (6, 174) = .459, p = .838, F_2 (6,180) = 0.421, p = .865.

Table 5. Experiment 1: Average accuracy (standard deviation in brackets)

Condition	1st constituent	2nd constituent	1st Unrelated	2nd Unrelated	Priming effect (U1-1st)	Priming effect (U2-2nd)
+M+S+O (one-syllable)	.96 (.10)	.97 (.09)	.98 (.08)	.96 (.12)	.02	-.01
-M-S+O	.98 (.06)	.99 (.05)	.98 (.06)	1.00 (.00)	0	.01
+M+S+O (two-syllable)	.99 (.05)	.98 (.06)	1.00 (.00)	1.00 (.00)	.01	.02

Note: U1 refers to the unrelated prime to first constituent, and U2 refers to the unrelated prime to second constituent
* p <. 05, ** p < .01

Discussion

The purpose of Experiment 1 was three folds: (a) to examine whether the morphological decomposition occurs in Korean compound processing, (b) to test whether the morphological priming effect can be dissociated from the orthographic overlapping effect. (c) to test the relative contribution of the first and second constituent to compound processing in Korean.

With respect to the first and second aims, RT results from Experiment 1 showed that there were significant constituent priming effects in the morphologically, semantically and orthographically related prime-target pairs when the primes were two-syllable words, but not in the orthographic overlapped prime-target pairs. This implies that morphological decomposition can be generalized to the processing of Korean compound words. Also, these results indicate that morpho-semantic information plays a role independent of the orthographic information in morphological decomposition.

However, there was no significant priming effect in the +M+S+O condition when primes were monosyllabic words. In Korean, there are a large number of homographs associated with monosyllabic words. In the case of the one-syllable native words (Korean words which can be trace back to Middle and Old Korean, Choo & O'Grady, 1996) in Korean, the amount of monosyllabic words with more than one meaning are 4.39 times larger than those with a single meaning, whereas in the case of two-syllable native words, the words that have only a single meaning are 11.74 times larger than those that have more than one meaning (Cho, 2006). Thus, in the monosyllabic +M+S+O condition the large number of homographs may have eliminated the facilitation effect. For example, the Korean prime, 벌 is a homograph which has three different meanings: *bee, punishment*, and *set*. When a Korean-English bilingual sees the word 벌, three different meanings, *bee*, *punishment* and *set* may be activated and compete with each other. As a result, the response time for target words takes longer time because the target word requires the activation of the *bee* meaning, but there are three possible meanings competing for activation, thus it takes longer to activate the *bee* meaning in the target word of *honeybee*. In comparison, in the disyllabic condition, 전화 can only mean *phone*, there's no other meaning competing for activation, so the RT for the compound target in the disyllabic condition is faster.

With respect to the third aim, there was no difference between the priming effects of the first and second constituents in the +M+S+O condition with two-syllable primes. This result suggests that the priming effects hold across word positions. This result is consistent with the previous studies which showed a similar magnitude of priming effects between the first constituent and the second constituent (Jarema et al., 1999; Sandra, 1990; Zwitserlood, 1994). According to Jarema et al. (1999), the similar magnitude of priming effects between the first and the second constituent in right-headed compounds is possibly a result of the interaction between headedness and position. If the position-in string effect is stronger than the headedness effect, the priming effect should be greater in the first constituent, whereas if the headedness effect is stronger than the position-in string effect, the priming effect should be greater in the second constituent. Therefore, the similar magnitude of the priming effects between the first and second constituent in the current experiment might be a result of the roughly equivalent strength between the position-in string and headedness effects.

Chapter IV: Experiment 2: Priming within English (L2)

In Experiment 2, a within-language priming experiment was conducted using English prime-target pairs. This experiment would provide valuable information regarding morphological processing in bilingual readers' less proficient L2 (English). First, the question whether adult L2 learners of English make use of morphological structure in processing English compound words has rarely been investigated. Thus, it is important to examine whether morphological decomposition of L1 compound words can be generalized to the processing of L2 compound words. Second, it must be established that the nonnative speakers could process the primes in the English prime-target pairs. Furthermore, the within-language data would allow us to compare the relative importance of the non-head morpheme (word-initial position) and with that of the head morpheme (word-final position) in English compound processing.

There are two research questions: (1) What information is used to parse English compound words into the individual constituents and, in particular, does morphological information play a role independent of the orthographic and semantic factors in English compound processing, and (2) What is the relative contribution of the first and second constituents to the processing of English compound words. To investigate these questions, morphological, orthographic and semantic factors were manipulated.

Hypotheses

There are three hypotheses in Experiment 2. First, if morphological decomposition occurs due to morphological structures, not orthographic overlap, there will be constituent priming effects for the semantically transparent and opaque prime-target pairs, but not for the orthographic overlap prime-target pairs. Second, if morphological decomposition occurs independently from the semantic factor, constituent priming effects should be the same between semantically transparent and opaque prime-target pairs. Alternatively, if morphological decomposition is constrained by semantic transparency, constituent priming effects should be greater in the semantically transparent prime-target pairs. Third, I hypothesize that the priming effect of the second constituent will be greater than that of the first constituent since the second constituent is the head morpheme that carries more meaning information in English.

Method

Participants. The same participants who participated in Experiment 1 participated in Experiment 2. The order of Experiments 1 and 2 was counterbalanced. There was a two-week interval between the administration of Experiment 1 and 2. One participant who participated in Experiment 2 did not complete Experiment 1. Therefore, the total number of participants in the current experiment was 37 Korean-English bilingual adults.

Design and materials. A 4 (conditions: +M+S+O vs. +M-S+O vs. -M-S+O vs. -M+S-O) X 4 (prime types: first constituent vs. second constituent vs. first unrelated vs. second unrelated) design was employed. Conditions and prime types were the within-participant factors. Prime-target pairs co-varying in morphological decomposability, semantic transparency, and orthographic relatedness were presented. The experimental stimuli consisted of four types of English prime-target pairs: (1) morphologically decomposable, semantically transparent, and orthographically overlapped (+M+S+O, e.g., *key-keyhole; hole-keyhole*), (2) morphologically decomposable, semantically opaque, and orthographically overlapped (+M-S+O, e.g., *dead-deadline; line-deadline*), (3) only orthographically overlapped (-M-S+O, e.g., *pump- pumpkin; kin-pumpkin*), (4) only semantically related (-M+S-O, e.g., *frigid-cold*). For the experimental stimuli, a total of 64 words (16 in each condition) were included as target words. The targets were preceded by a prime corresponding to the first or second constituent of the target word in the +M+S+O, +M-S+O and -M-S+O conditions. In the -M+S-O condition, a semantically related word was presented as the prime. In addition, two sets of unrelated primes for each target (e.g., *leg-keyhole*) were created as the control condition (See Table 6 for sample items, see Appendix E for a complete list of items). Furthermore, thirty-two unrelated prime-target pairs were generated to balance the proportion of related pairs. Ninty-six word-nonword prime-target pairs were generated as filler items to ensure an equal number of "Yes" and "No" responses in the lexical decision task. Among the ninty-six word-nonward pairs, 40 nonwords were compound-like nonwords (10 word-word, 10 word-nonword, 10 nonword-word, and 10 nonword-nonword) and the remaining items were monomorphemic nonwords.

Table 6. Sample items for Experiment 2

Condition	1st constituent prime	2nd constituent prime	1st unrelated prime	2nd unrelated prime	Target
-M-S+O	*pump*	*kin*	*boom*	*bug*	*pumpkin*
+M-S+O	*dead*	*line*	*baby*	*word*	*deadline*
-M+S+O	*key*	*hole*	*gas*	*trip*	*keyhole*
-M+S-O	*cold*		*deal*		*frigid*

The manipulation of semantic relatedness between pairs of primes and targets was based on both semantic relatedness ratings and the Latent Semantic Analysis (LSA; Landauer & Dumais, 1997). The LSA is a method used to represent the meanings of words based on the co-occurrence of words appearing in the same context, which is usually a sentence or a document. The LSA similarity between pairs was calculated by using the LSA web facility (http://lsa.colorado.edu).

However, the LSA may not reflect the semantic similarity perceived by bilingual speakers. Therefore, 9 Korean-English bilingual speakers who did not participate in Experiment 1 or 2 were asked to indicate how related the first constituent of the word is to the meaning of the whole word on a 7-point Likert scale (1: not related at all in meaning to 7: very related in meaning) and the same procedure was applied to the second constituent. Table 7 shows the results of the semantic relatedness ratings and the LSA. The initial criterion for incorporating the items into the stimulus set was that, for the semantically related conditions (+M+S+O and -M+S-O) the semantic relatedness ratings for both constituents must be 5 or above; for the semantically unrelated conditions (+M-S+O and -M-S+O) the semantic relatedness ratings of one constituent must be 3 or below. However, in order to include a sufficient number of items, it was necessary to include three items that have the rating score between 3.9 and 5 in the -M+S-O condition, and one item with ratings between 3 and 4 for both constituents in the +M-S+O condition. T-test results showed that the semantic relatedness between the first constituent primes and targets and between the second constituent primes and targets from both semantic relatedness ratings and the LSA are significantly higher in the +M+S+O condition than in the +M-S+O condition (*ps* < .01). Although there was no significant difference of semantic relatedness from the LSA between the +M-S+O condition and the -M-S+O condition (t (30) = .24, p =. 81 between the first constituent primes and targets, and t (30) = -.43, p = .67 between the second constituent primes and targets), the semantic rating score was higher in the +M-S+O condition than in the -M-S+O condition (t (30) = 4.60, p

<. 01 between the second constituent primes and targets, and t (30) = 3.15, $p < .01$ between the second constituent primes and targets).

Furthermore, primes and targets were matched as much as possible across the four conditions for the number of letters and frequency. In addition, these variables were matched between the first and second constituent primes, between the first constituent and control primes, and between the second constituent and control primes ($ps > .1$). Frequency was determined from the CELEX corpus. Means for these variables across conditions, along with ANOVA statistical test results, are shown in Table 8. Despite this careful matching procedure, the number of letters for the first constituent primes was slightly smaller in the -M conditions than in the +M conditions due to the constraint from the main design variables. However, when the three conditions except the -M+S-O condition were compared, there was no difference in the number of letters for the first constituent primes, F (2,42) = 1.30, $p > .05$.

Table 7. Experiment 2: Average level of semantic relatedness for four conditions

Conditions	LSA (Latent Semantic Analysis)		Semantic relatedness Rating	
	1st and Whole	2nd and Whole	1st and Whole	2nd and Whole
-M-S+O	.06 (.10)	.09 (.09)	1.39 (.55)	1.49 (.73)
+M-S+O	.07 (.09)	.07 (.08)	2.82 (1.17)	2.57 (1.17)
+M-S+O	.32 (.18)	.27 (.14)	5.67 (.41)	5.64 (.43)
-M+S-O	.28 (.17)		5.69 (.75)	

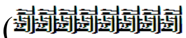
In order to take into account the fact that the frequency information from the CELEX corpus may not truly reflect bilingual speakers' daily exposure, a familiarity rating on a 7-point Likert scale (1: very unfamiliar to 7: very familiar) was collected from 10 Korean-English bilingual speakers who did not participate in Experiment 1 and 2 and matched across the four conditions. The differences in familiarity were not significant across the four conditions for primes and targets. Table 8 shows the means of frequency, the number of letters, and the familiarity ratings.

Targets from each condition were divided at random into three equal lists for counterbalancing purposes. In other words, if the target was preceded by the first constituent prime in List 1, then it was preceded by the second constituent prime in List 2. The prime in List 3 was an unrelated word matched to the first constituent prime, and the prime in List 4 was an unrelated word matched to the second constituent prime. Each participant received only one experimental list and, therefore, each participant saw each target word only once.

Table 8. Experiment 2: Averages for stimulus characteristics for items across the four conditions

Property	Conditions				ANOVA
	-M-S+O	+M-S+O	+M+S+O	-M+S-O	
Number of Letters (T)	7.31	7.94	7.63	6.88	$F(3,60) = 3.19$, $p < .05$
Number of Letters (P1)	3.56	3.94	3.63	4.44	$F(3,60) = 5.78$, $p < .01$
Number of Letters (P2)	3.75	4.00	4.00	4.44	$F(3,60) = 2.01$, *n.s.*
Frequency (T)	9.68	4.16	3.41	7.98	$F(3,60) = 1.33$, *n.s.*
Frequency (P1)	380.28	100.01	156.24	68.87	$F(3,60) = .68$, *n.s.*
Frequency (P2)	110.80	105.15	182.51	68.87	$F(3,60) = .96$, *n.s.*
Familiarity (T)	5.92	6.35	6.12	6.18	$F(3,60) = .51$, *n.s.*
Familiarity (P1)	5.91	6.58	6.75	6.44	$F(3,60) = 2.02$, *n.s.*
Familiarity (P2)	6.46	6.67	6.94	6.44	$F(3,60) = 1.18$, *n.s.*

Note: T = Target, P1 = 1st constituent prime, P2 = 2nd constituent prime

Procedure. The same procedure used in Experiment 1 was used in Experiment 2 except that in Experiment 2, the prime and target words were English words, and the forward mask was two lines of hash marks (######### #########) instead of upside down Korean characters ().

Results

Mean RT are shown in Table 9 and accuracies are shown in Table 10. The data of 3 participants whose English proficiency score (average score of c-test and Boston naming test) was less than 50% were excluded from the analysis. The RT data for incorrect responses were deleted. Responses differing by two standard deviations from the cell mean (4 %) were removed from the RT data. One item (*flea – fleabag*) in the +M-S+O condition was deleted due to its high error rates across participants.

Response time. Planned comparisons showed no significant priming effect of the first and second constituents in the +M+S+O, +M-S+O, and -M-S+O conditions, all *ps* > .1. The semantically related primes in the -M+S-O condition did not show a significant priming effect either, $t < 1$. However, mean RT showed a noticeable trend indicating facilitative priming effects of the first constituents in both the +M-S+O and -M-S+O conditions (15 ms in +M-S+O, and 45 ms in -M-S+O) and inhibitive priming effects of the second constituents (-16 ms in +M-S+O and -39 ms in -M-S+O conditions). In other words, when prime-target pairs are semantically unrelated but orthographically related, the first constituent primes tended to facilitate the lexical decision of the target compounds, whereas the second constituent primes tended to slow down the response times. In addition, there was a trend indicating facilitative priming effects in the semantically related primes (-M+S-O) (20 ms).

4 (condition: +M+S+O vs. +M-S+O vs. -M-S+O vs. -M+S-O) X 4 (prime type: first constituent vs. second constituent vs. first unrelated vs. second unrelated) ANOVAs were carried out the RT data. The main effect of conditions was significant, F_1 (3, 96) = 5.995, p =. 001; F_2 (3, 236) = 3.008, p = .031. However, there was no significant main effect of prime type, F_1 (3, 96) = .400, p = .754, F_2 (3,236) = .129, p = .943, and the interaction between conditions and prime types was not significant, both *Fs* <1.

Table 9. Experiment 2: Average RT (ms) and priming effect (standard deviation in brackets)

Condition	1st constituent	2nd constituent	1st Unrelated	2nd Unrelated	Priming (U1-1st)	Priming (U2-2nd)
+M+S+O	1011 (270)	997 (222)	1024 (248)	1015 (314)	13	18
+M-S+O	914 (187)	943 (210)	929 (229)	927 (193)	15	-16
-M-S+O	924 (226)	986 (247)	969 (244)	946 (211)	45	-39
-M+S-O	967 (242)		987 (284)		20	

Note: U1 refers to the unrelated prime to first constituent, and U2 refers to the unrelated prime to second constituent

Accuracy. Planned comparison of accuracy in each condition indicated that there were no significant priming effects of the first constituents and second constituents in the +M+S+O, +M-S+O, -M-S+O conditions, all *p*s > .1. The semantically related primes in the –M+S-O condition showed significant priming effects (.06) only by participants, t_1 (33) = -2.219, p = .033, t_2 (250) = -1.101, p = .272.

There was a main effect of conditions both by participants and items, F_1 (3, 99) = 12.234, p =. 000; F_2 (2, 180) = 5.753, p = .004. However, there was no significant main effect of prime types, F_1 (3, 99) = .1.257, p = .293, F_2 (3,180) = .308 p = .819. In addition, the interaction between conditions and prime types was not significant, F_1 (9, 297) = 1.047, p = .402, F_2 (6,180) = .421, p = .865.

Table 10. Experiment 2: Average accuracy (standard deviation in brackets)

Condition	1^{st} constituent	2^{nd} constituent	1^{st} Unrelated	2^{nd} Unrelated	Priming effect (U1-1^{st})	Priming effect (U2-2^{nd})
+M+S+O	.95 (.10)	.90 (.18)	.93 (.13)	.87 (.18)	.02	.03
+M-S+O	.95 (.10)	.95 (.12)	.95 (.13)	.93 (.13)	0	.02
-M-S+O	.88 (.19)	.87 (.20)	.86 (.17)	.90 (.19)	.02	-.03
-M+S-O	.87 (.18)		0.81 (.20)		.06*	

Note: U1 refers to the unrelated prime to first constituent, and U2 refers to the unrelated prime to second constituent
* p <. 05

Discussion

The first aim of Experiment 2 was to examine whether morphological decomposition occurs in L2 (English) compound processing. The second aim is to examine whether morphological information plays a role independent of the orthographic and semantic factors. The final aim was to test the relative contribution of the first and second constituent primes to the processing of L2 compound words.

Results from Experiment 2 showed no significant priming effect on RTs in all conditions. Accuracy data showed a facilitative priming effect only in -M+S-O. RT results showed a trend for facilitative priming effects of the first constituents, but inhibitive priming effects of the second constituents in both the +M-S+O and -M-S+O conditions. There are two possible interpretations for the lack of priming effects in the +M+S+O and +M-S+O conditions. The first reason is that non-balanced Korean-English bilinguals are not sensitive to L2 morphological structures when making lexical decision for the L2 compound words. Silva and Clahsen (2008) suggested that adult L2 learners are not as sensitive to morphological structures as native speakers of that language. They compared the within-language morphological priming effects using English inflected and derived words between native speakers of English and groups of second language learners of English (German, Chinese, and Japanese speakers). The native speakers exhibited a morphological priming effect for both the inflected and derived words, but the L2 groups showed no morphological priming effect for the inflected words and a reduced priming effect for the derived words. The second reason for the absence of priming effect is that, non-balanced Korean-English bilinguals may not be able to access the L2 (English) primes during the short prime duration. The participants were exposed to the primes for an extremely short amount of time (48 ms), and there were immediate forward and backward masks to reduce prime visibility. This design might have prevented the L2 primes from being perceived and accessed by the nonnative participants.

Although RT data did not show significant priming effects in all conditions, there were some important trends. When prime and target pairs were orthographically related (+O), but semantically unrelated (-S), the first constituent primes tended to facilitate the lexical decision of the target compounds, whereas the second constituent prime tended to slow down the response times. It seems that the priming effect of the first constituents is related to orthographic information, but that of the second constituents is related to semantic information. In addition, in the -M+S-O condition, RT data showed a trend toward a facilitative effect of the semantically related primes, and accuracy data showed a significant facilitative effects of the semantically related primes. Taken together, these results indicate that Korean-English bilinguals may rely more on the semantic information in the recognition of English words.

Chapter V: Experiment 3: Priming across languages from Korean L1 to English L2

In Experiment 3, a cross-language priming experiment was conducted with Korean primes and English targets. Previous cross-language priming studies with L1 prime and L2 targets have found significant translation priming effects (De Groot & Nas, 1991; Gollan et al., 1997; Jiang, 1999; Jiang & Forster, 2001; Keatly, Spinks, & De Gelder, 1994; Williams, 1994). However, these studies did not specifically examine morphologically complex words. The purpose of this study is to extend previous research on morphological decomposition in the monolingual population to the bilingual population. In the current experiment, phonological information instead of orthographic information was manipulated because Korean and English have different scripts. Cross-language morphological priming effects were investigated by co-varying the morphological, semantic and phonological factors between L1 primes (the second constituent prime) and L2 targets (the compound words). Furthermore, the time course of morphological priming was investigated by varying prime durations which is the duration from the onset of the prime (e.g., Forster & Davis, 1984) to the onset of the backward mask.

There are two research questions in Experiment 3: (1) Does morphological information play a role in cross-language activation of the constituent morphemes independent of the phonological and semantic factors? and (2) How are the effects of morphological, semantic, and phonological factors different across prime durations?

Hypotheses

If morphological information plays an independent role in cross-language activation of the constituent morphemes independent of the phonological factor, the constituent priming effects will be found for both the semantically transparent and opaque compound prime-target pairs, but not for the phonologically overlapped prime-target pairs. Second, if morphological information plays an independent role independent of the semantic factor, the constituent priming effects should be the same between semantically transparent and opaque compound prime-target pairs. Alternatively, if morphological decomposition is constrained by semantic transparency, the constituent priming effects should be greater in the semantically transparent compound prime-target pairs. In addition, it was predicted that phonological priming occurs faster (at the shortest prime duration) than semantic and morphological priming. Activation of semantic and morphological information may occur later in the processing.

Method

Participants. The participants were 122 Korean-English bilingual adults (male = 71, female = 51). I recruited the bilingual participants at the Ewha Women's University, Yonsei University, and Dongkuk University in South Korea from the same participant pool as in Experiments 1 and 2. The mean age of the participants was 22.7 years (SD = 2.96 years).

Prior to the experimental session, participants were asked to fill out the LEAP-Q (Marian et al., 2007). According to the their responses from the LEAP-Q, all of the participants learned Korean as their L1 and English as their L2. They were currently exposed to Korean 78% of the time and English 21% of the time. Seventy-three percent of the participants had a high school degree, and twenty-seven percent of the participants had a college degree. Participants began to acquire English at the mean age of 9.5 years (*SD* = 3.0 years) and became fluent in English at the mean age of 17.4 years (*SD* = 5.1

years). The average number of years living in a country, in a family and in a school where English is spoken was .6 years, .1 years and 1.3 years, respectively. The participants reported their proficiency levels in both Korean and English, including speaking ability, understanding spoken language, and reading, according to an eleven-point scale (0 = none to 10 = perfect). They were also asked to report their degree of foreign accent on an eleven-point scale (0 = none to 10 = pervasive). Table 11 shows the means and standard deviations of the ratings of each category for English and Korean. Overall, participants rated Korean proficiency as almost perfect (greater than 9.5) in all areas. However, they rated English proficiency as adequate (5.3) in speaking, slightly more than adequate (6.5) in understanding and good (7.28) in reading. Also, they rated their degree of foreign accent in Korean as none (.28) but in English as moderate (5.2). All of the participants had normal or corrected-to-normal vision and thus had no difficulty with reading words on a computer monitor.

Table 11. Means and standard deviations of self-rated proficiency in Experiments 3 and 4

	Self-rated proficiency[a]			Self-rating of foreign accent	
	Speaking	Understand spoken language	Reading	Perceived by self[b]	Identified by others[c]
English (L2)	5.32 (2.01)	6.51 (1.66)	7.28 (1.29)	5.19 (2.01)	6.42 (2.64)
Korean (L1)	9.54 (.79)	9.60 (.72)	9.64 (.71)	.28 (1.17)	.24 (1.17)

Note. [a]Range: 0 (none) to 10 (perfect). [b]Range: 0 (none) to 10 (pervasive). [c]Range: 0 (none) to 10 (always).

The participants were tested for their English proficiency using the English Boston Naming Test (Kaplan et al., 1983) and the English C-test (Babaii & Moghaddam, 2006). The participants' average scores for the English Boston Naming Test and C-test were .71 out of 1.0 (*SD* = .11) and .65 out of 1.0 (*SD* = .01), respectively.

Design and materials. The design was 5 (conditions: -M-S+P vs. +M+S+P vs. +M-S+P vs. +M-S-P vs. +M+S-P) X 2 (prime types: related vs. unrelated) X 3 (prime durations: 36 ms vs.48 ms vs.100 ms). Pilot testing was conducted to determine the appropriate prime durations. Eight participants reported whether they could see the primes with four different prime durations (36 ms, 48 ms 72 ms and 100 ms). When the prime was English and the target was Korean, no one could see the primes at 36 ms, 48 ms and 72 ms. However, at 100 ms, all participants could see the primes. When the prime was Korean and the target was English, no one could see the primes at 36 ms and one participant could see the primes at 48 ms. Six participants could see the primes at 72 ms, and all participants could see the primes at 100 ms. Thus, for the two shorter prime durations (36 ms and 48 ms), a visual identification of the primes was not possible. The longest prime duration (100 ms) elicited conscious awareness of the primes, however, it was short enough to minimize strategic processing. Conditions and prime types were within-participant factors, and prime duration was a between-participant factor. The targets were English compound words and the primes were Korean words that are related or unrelated to the English targets. Prime-target pairs co-varying in morphological decomposability, semantic relatedness, and phonological relatedness were presented in this experiment. There were five types of prime (Korean) and target (English) relations: (1) only phonologically related prime-target pairs (-M-S+P, e.g., *비 /bi/ [rain]-honeybee*), (2) morphologically decomposable, semantically and phonologically related (+M+S+P, e.g., *케이크 /keik/ [cake]-cupcake*), (3) morphologically decomposable and phonologically related (+M-S+P, e.g., *라인 /lain/ [line]-deadline*), (4) morphologically decomposable and semantically related (+M+S-P, e.g., 방 */bang/[room]-bedroom*), and (5) only morphologically decomposable (e.g., +M-S-P, e.g., 운*/u:n/ [luck]-potluck*).

Table 12. Sample items of Experiment 3

Condition	Related prime (Korean)	Unrelated prime (Korean)	Target (English)
-M-S+P	*비* */bi/* *[rain]*	*면* */mjʌn/* *[surface]*	***honeybee***
+M+S+P	*케이크* */keik/* *[cake]*	*스피드* */spi:d/* *[speed]*	***cupcake***
+M-S+P	*라인* */lain/* *[line]*	*코치* /kotɕʰi/ *[coach]*	***deadline***
+M+S-P	방 */bang/* *[room]*	곧 */got/* *[soon]*	***bedroom***
+M-S-P	운 */u:n/* *luck*	국 */guk/* *[soup]*	***potluck***

Note. Texts in bold denote the test items. The pronunciations of the Korean items are listed in / /. Each English word in [ ] is the translation equivalent of the corresponding Korean test item.

The experimental stimuli consisted of a total of 60 Korean-English word pairs (12 in each condition). In the critical trials, English target compounds (e.g., *bedroom*) were preceded by the Korean translation equivalents of the second constituent of the target (e.g., 방*/bang/[room]*). In addition, unrelated primes for each target (e.g., 곧 */got/[soon]-bedroom*) were generated for the control condition. These primes were morphologically, semantically, and phonologically unrelated to the targets, but matched with the experimental primes for the number of letters and frequency (see Table 12 for sample items, see Appendix F for a complete list of items). In addition, 30 unrelated prime and non-compound target pairs were generated to balance the proportion of related prime-target pairs as well as for reducing the possibility that participants could guess about the characteristics of the experimental items. Ninety word-nonword pairs were also generated to ensure an equal number of “Yes” and “No” responses.

In order to ensure the translation equivalency between the Korean and English items, four Korean-English bilingual graduate students were asked to translate the constituents from English to Korean. Another four Korean-English bilingual students were asked to back-translate the constituents from Korean to English. All of the translators did not participate in the current experiment All words maintained translation consistency in both directions by all of the translators except four words (*top, fly, trap* and *dew*) whose percentages of translation agreement were on average 75 % in the English-Korean direction and 100 % in the Korean-English direction.

Manipulation of semantic relatedness between Korean primes and English targets was based on the semantic relatedness rating (Table 13). Ten Korean-English bilingual speakers who did not participate in the current experiment were asked to rate semantic relatedness between the Korean primes and the English targets on a 7-point Likert scale (1: not related at all in meaning to 7: very related in meaning). Semantic relatedness ratings for the +M+S+P condition (5.2) was significantly higher than that for the +M-S+P condition (2.7), t (22) = 10.54, $p < .01$, and semantic ratings for the +M+S-P condition (5.0) was significantly higher than that for the +M-S-P condition (2.4), t (22) = 9.63, $p < .01$. Furthermore, there was no significant difference of semantic ratings between the +M+S+P and +M+S-P conditions, t (22) = 1.04, p =. 31 and between the +M-S+P and +M-S-P conditions, t (22) = .84, p = .41.

Phonological similarity ratings for items in phonologically related conditions were also conducted to ensure the phonological relatedness between primes and targets. Ten Korean-English bilinguals who did not participate in the translation task or complete the semantic relatedness ratings were asked to rate the phonological similarity between the second constituents of the English target compounds and the Korean primes (e.g., the similarity between "*bee*" and "*비*" *[bi]*). A seven-point Likert scale was employed, with "1" being "completely different" and "7" being "exactly the same." The rating scores were high in all phonologically related conditions, and there was no significant difference in terms of phonological similarity across the three conditions, F (2, 33) = .26, p =. 77. The results of the rating are listed in Table 14.

Table 13. Experiment 3: Means of semantic relatedness across the five conditions

	Semantically related conditions			Semantically unrelated conditions	
Condition	+M+S+P	+M+S-P	-M-S+P	+M-S+P	+M-S-P
Mean	5.21	5.00	1.88	2.67	2.42
SD	.56	.42	.71	.62	.83

Note: Range: 1 (not related at all in meaning) to 7 (very related at all in meaning)

Table 14. Experiment 3: Means of phonological similarity for phonologically related (+P) conditions

	Phonologically related conditions		
Condition	-M-S+P	+M+S+P	+M-S+P
Mean	6.46	6.47	6.56
SD	.44	.43	.35

Note: Range: 1 (completely different) to 7 (exactly the same)

Primes and targets were matched as much as possible across the five conditions for the number of letters and frequency. Frequencies of the English targets were determined from the CELEX corpus with a frequency count of 1 per million and those of the Korean items were determined based on a database provided by the National Academy of the Korea Language with a frequency count of 1 per 1.5 million. Means for these variables across the conditions, along with ANOVA statistical test results, are shown in Table 15. Despite the careful matching procedure, frequency for primes was slightly different across the five conditions.

In order to take into account the fact that the frequency information from the CELEX corpus may not truly reflect bilingual speakers' daily exposure, familiarity ratings for the English targets (1: very unfamiliar to 7: very familiar) were collected from ten Korean-English bilingual speakers and matched across the four conditions, $F\ (4,55) = 1.63$, $P = .18$.

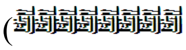
Table 15. Experiment 3: Means of stimulus characteristics for the critical items across the five conditions

Property	Conditions					ANOVA
	-M-S+P	+M+S+P	+M-S+P	+M+S-P	+M-S-P	
Num. of Letters (T)	8.25 (1.29)	7.75 (.97)	8.33 (.89)	8.83 (1.40)	7.83 (.94)	$F\ (4,55) = 1.83$ $P = .14$
Num. of Letters (P)	3.25 (.87)	3.92 (1.00)	4.33 (1.30)	4.25 (1.36)	4.25 (1.22)	$F\ (4.55) = 1.79$ $P = .15$
Frequency (T)	4.12 (7.36)	1.95 (2.38)	3.99 (7.44)	4.94 (16.04)	1.34 (2.31)	$F\ (4,55) = .38$ $P = .82$
Frequency (P)	96.08 (114.93)	24.67 (33.01)	71.58 (139.73)	219.00 (275.46)	201.08 (227.48)	$F\ (4,55) = 2.63$ $P = .04$
Familiarity (T)	6.01 (1.07)	6.62 (.30)	5.71 (1.19)	5.97 (.80)	5.80 (1.16)	$F\ (4,55) = 1.63$ $P = .18$

Note: T = Target, P = Prime

Two lists of prime-target pairs were constructed. In List 1 the target was preceded by the translated second constituent prime (e.g., *방 /bang/[room] – bedroom*), and in List 2 the target was preceded by the unrelated prime (e.g., *곧 /got/[soon]– bedroom*). 122

participants were randomly assigned to one of the three prime durations. In each of the prime durations, half of the subjects saw List 1 while the other half saw List 2

Procedure. Procedure was the same as that in Experiments 1 and 2 except that in Experiment 3, the primes were Korean words and the targets were English words. The forward mask was upside-down Korean characters () to reduce the visibility of the Korean primes. Furthermore, prime durations were 36 ms, 48 ms, and 100 ms with an equal number of participants randomly assigned in one of the three prime durations.

Results

Mean RTs are shown in Table 16 and accuracues are shown in Table 17. The data of 19 participants, including those who could see the primes at 36 ms and 48 ms and those who could not see the primes at 100 ms, and whose English proficiency score was less than 50% in both the Boston Naming Test and the C-test were excluded. The RT data for incorrect responses were deleted. Responses differing by two standard deviations from the cell mean (4 %) were removed from the RT data.

Response time. Planned comparisons were conducted to test the priming effects at each prime duration and each condition. When the prime duration was 36 ms, facilitative priming effects were significant in both the +M+S+P (74 ms) and +M-S+P (99 ms) conditions only by participants, t_1 (34) = 2.684, p = .011; t_2 (22) = .952, p = .352, and t_1 (34) = 2.559, p = .015, t_2 (22) = 1.053, p = .304, respectively, but no priming effects were shown in the other conditions (-M-S+P, +M+S-P, and +M-S-P), ps >.10. Planned comparisons of the priming effects between the +M+S+P and +M-S+P conditions showed no significant difference, t_1 (34) = -.561, p = .578. When the prime duration was 48 ms, there was a facilitative priming effect only in the +M+S+P condition in the participant analysis, t_1 (33) = 2.548, p = .016; t_2 (22) = .688, p = .499. When the prime duration was 100 ms, there was a facilitative priming effect in the +M+S+P condition, and a marginally significant priming effect in the +M+S-P condition, t_1 (33) = 4.075, p < .001; t_2 (22) = 2.148, p = .043, and t_1 (33) = 1.933, p = .062, t_2 (22) = 1.031, p = .314, respectively.

Table 16. Experiment 3: Average RT (ms) and priming effect (standard deviation in brackets)

Condition	Prime type	Prime duration		
		36ms	48ms	100 ms
-M-S+P	Related	1107 (293)	940 (234)	1019 (267)
	Unrelated	1085 (286)	983 (261)	1045 (276)
	Priming	-23	43	26
+M+S+P	Related	1056 (268)	919 (266)	949 (221)
	Unrelated	1130 (297)	970 (258)	1084 (262)
	Priming	74*	51*	135**
+M-S+P	Related	1072 (206)	1000 (264)	1042 (254)
	Unrelated	1171 (322)	1044 (276)	1089 (319)
	Priming	99*	44	47
+M+S-P	Related	1198 (352)	1070 (309)	1098 (242)
	Unrelated	1260 (301)	1097 (347)	1182 (303)
	Priming	62	27	84(*)
+M-S-P	Related	1156 (307)	1004 (298)	1055 (295)
	Unrelated	1177 (329)	1028 (285)	1112 (274)
	Priming	21	24	57

* p <. 05, ** p < .01, (*) p = .06

The omnibus ANOVA yielded a significant main effect of conditions, F_1 (4, 396) = 30.470 p <. 001; F_2 (4, 330) = 7.094, p < .001. The main effect of prime types reached significance with faster RTs for related primes (1046 ms) than unrelated primes (1098 ms), F_1 (1, 99) = 27.404, p =. 001; F_2 (1, 330) = 5.611, p = .018. The main effect of prime durations was marginally significant by participants and statistically significant by items, F_1 (2, 99) = 2.608, p =. 079; F_2 (2, 300) = 14.834, p < .001. However, two-way interactions between conditions and prime durations, prime types and prime durations, and conditions and prime types were all not significant for both participant and item analyses (all *p*s >.1). The three-way interaction of conditions, prime types and prime durations was not significant for both participant and item analyses (both *p*s >.1).

Accuracy. Planned comparisons were conducted to test the priming effects in each prime duration and each condition. When the prime duration was 36 ms, no significant priming effect was shown in all conditions, *p*s >.10. When the prime duration was 48 ms, there was a marginally significant priming effect by participants in the +M+S-P condition, t_1 (33) = -1.977, p = .056; t_2 (22) = -1.032, p = .313. Other conditions did not reach significance, *p*s >.01. When the prime duration was 100 ms, there were facilitative priming effects in the +M+S+P and +M-S+P conditions by participants only, t_1 (33) = -3.438, p < .001; t_2 (22) = -1.811, p = .084 and t_1 (33) = -3.438, p < .001; t_t (22) = -1.574, p = .130, respectively.

The omnibus ANOVA yielded a significant main effect of conditions, F_1 (4, 400) = 14.447 p <. 001; F_2 (4, 330) = 4.730, p = .001. The main effect of prime types reached significance with a higher accuracy on related primes than unrelated primes, F_1 (1, 100) = 12.206, p =. 001; F_2 (1, 330) = 4.397, p = .037. The main effect of prime durations was significant, F_1 (2, 100) = 4.181, p =. 018; F_2 (2, 330) = 8.056, p < .001. A two-way interaction between prime types and prime durations was significant only by participants, F_1 (2, 100) = 3.329, p =. 040; F_2 (2, 300) = 1.208, p = .300. Two-way interactions between conditions and prime durations, and between conditions and prime types were not significant for both participant and item analyses (*p*s >.1). The three-way interaction of condition, prime type and prime duration was not significant, for both participant and item analyses (*p*s >.1). Since the accuracy data did not show any robust effects, and there were similar patterns across the RT and accuracy results, the following discussion will only focus on the RT results.

Table 17. Experiment 3: Average accuracy (standard deviation in brackets)

Condition	Prime type	Prime duration		
		36ms	48ms	100 ms
-M-S+P	Related	.93 (.11)	.93 (.14)	.88 (.15)
	Unrelated	.90 (.14)	.93 (.12)	.87 (.18)
	Priming	.03	0	.01
+M+S+P	Related	.90 (.14)	.92 (.10)	.93 (.12)
	Unrelated	.93 (.12)	.93 (.10)	.81 (.20)
	Priming	-.03	-.01	.12*
+M-S+P	Related	.88 (.16)	.96 (.09)	.91 (.14)
	Unrelated	.88 (.15)	.92 (.15)	.82 (.21)
	Priming	0	.04	.09*
+M+S-P	Related	.86 (.12)	.91 (.11)	.83 (.17)
	Unrelated	.83 (.20)	.85 (.15)	.79 (.20)
	Priming	.03	.06(*)	.04
+M-S-P	Related	.86 (.14)	.87 (.15)	.81 (.19)
	Unrelated	.82 (.20)	.88 (.12)	.77 (.21)
	Priming	.04	-.01	.04

* p <. 05, **p < .01, (*)p = .06

Discussion

The goals of Experiment 3 were: (1) to examine whether the cross-language activation of constituent morphemes occurs when Korean-English bilinguals process compound words in their less-proficient L2, (2) to examine whether morphological information plays a role independent of the phonological and semantic factors in cross-language activation of the constituent morphemes, (3) to examine whether the priming effects of morphological, semantic, and phonological factors are different across prime durations. With respect to the first aim, there were priming effects in the +M+S+P condition across all prime durations and in the +M-S+P condition at the shortest prime duration. Thus, there was a cross-language activation of constituent morphemes when Korean-English bilinguals process English compound words. With respect to the second and third aims, at the shortest prime duration (36 ms), RT data showed priming effects in both the +M+S+P and +M-S+P conditions, and the priming effects between these two conditions were not different in terms of magnitude. In other words, cross-language activation occurs regardless of semantic transparency of the target compounds. Therefore, at 36 ms, morphological information played a role in cross-language activation of constituent morphemes independent of the semantic factor. However, there was no significant priming effect when the primes and targets were morphologically related but phonologically unrelated (+M+S-P and +M-S-P conditions). Phonological information was needed for morphological decomposition at 36 ms. At 48 ms, the priming effect was significant only in the +M+S+P condition. Therefore, morphological decomposition was constrained by semantic transparency and phonological relatedness at 48 ms. At 100 ms, the priming effect was significant in the +M+S+P condition and marginally significant in the +M+S-P condition. There was no significant priming effect in the –S conditions. Thus, morphological decomposition was constrained by semantic transparency at 100 ms because participants made faster lexical judgments when the primes were semantically related to the targets. However, morphological decomposition occurs regardless of phonological relatedness between primes and targets, suggesting the processing of morphological structure is independent of phonological information at the later stage of compound processing (e.g., at 100 ms). These results are consistent with previous masked priming studies with English monolingual speakers (e.g., Rastle et al., 2000). All of these studies have shown an independent role of morphological structure at the early stage of visual word recognition. For example, in Rastle et al. (2000), semantically transparent compounds showed a priming effect at all prime durations (43 ms, 72 ms, 230 ms), but semantically opaque compounds showed a priming effect only at the shorter prime duration (43 ms). The results from the present Experiment 3 suggest that even at the early stage of cross-language activation in L2 compound processing, there is an independent role of the morphological factor that cannot simply be attributed to the semantic factor.

At 36 ms, morphologically and phonologically related prime-target pairs showed priming effects regardless of semantic relatedness; whereas there was no significant priming effect in morphologically related but phonologically unrelated prime-target pairs (+M+S-P and +M-S-P). In addition, there was no priming effect for prime-target pairs that were phonologically related only (-M-S+P). These results suggest that phonological and morphological information jointly facilitate lexical judgment on the L2 target compounds independent of semantic relatedness at the earliest stage of processing.

Chapter VI: Experiment 4: Priming across languages from English L2 to Korean L1

In Experiment 4, a cross-language priming experiment was conducted with English prime-Korean target pairs. Previous cross-language priming studies with L2 primes and L1 targets showed weak or no priming effects while priming effects with L1 primes and L2 targets were robust. Experiment 4 investigated this cross-language priming asymmetry with L2 constituent primes and L1 compound targets. Cross-language morphological priming effects were investigated by co-varying the morphological and phonological factors between L2 prime (the second constituents) and L1 target pairs. Although semantic transparency was one of the major properties that influence morphological decomposition, there are a limited number of semantically opaque compounds in Korean. Thus, semantically opaque compounds are not included in Experiment 4. Some researchers have suggested that the lack of priming effects from the L2 to L1 direction is because bilinguals are unable to effectively process L2 primes within a short period of time. Thus, the time course of morphological priming was investigated by varying the duration of prime exposure.

There are three research questions in Experiment 4: (1) Does morphological information play a role in cross-language activation independent of phonological information? (2) How do the effects of morphological and phonological factors differ across prime durations? and (3) How is the magnitude of the priming effects different between the L1-L2 direction (Experiment 3) and the L2-L1 direction (Experiment 4)?

Hypotheses

If morpho-semantic information plays a role in the cross-language activation of constituent morphemes independent of the phonological factor, there will be constituent priming effects for the transparent compound prime-target pairs, but not for the only phonologically overlapped prime-target pairs. It was also predicted that activation of phonological information occurs earlier (at the shortest prime duration) than morphological information. The magnitude of priming effects will be weaker in the L2 (English)-L1 (Korean) direction (Experiment 4) than the L1 (Korean)-L2 (English) (Experiment 3) direction.

Method

Participants. The same participants who took part in Experiment 3 also participated in Experiment 4. The order of Experiments 3 and 4 was counterbalanced. There was a two-week interval between the administrations of the two experiments. One participant who participated in Experiment 3 did not complete Experiment 4. Therefore, the total number of participants in the current experiment was 121 Korean-English bilingual adults.

Design and materials. The design was 3 (conditions: -M-S+P vs. +M+S+P vs. +M+S-P) X 2 (prime types: related vs. unrelated) X 3 (prime durations: 36 ms vs.48 ms vs.100 ms). The critical stimuli were prime-target pairs co-varying in morphological decomposability and phonological relatedness. The targets were Korean compound words and the primes were the English translated constituents (the second constituent morphemes) of the Korean target compounds or unrelated English words. There were three types of prime and target relations: (1) only phonologically related (-M-S+P, e.g., *balm-가을밤/gaulbam/ [autumn night]*, (2) morphologically, semantically and phonologically related (+M+S+P, e.g., *tie- 넥타이/nektai/ [necktie]* and (3) morphologically and semantically related (+M+S-P, e.g., *candy- 솜사탕/somsatang/ [cotton candy]*).

Table 18. Sample items of Experiment 4

Condition	Related prime (English)	Unrelated prime (English)	Target (Korean)
-M-S+P	***balm***	***font***	**가을밤** */gaulbam/* *[autumn night]*
+M+S+P	***tie***	***bet***	**넥타이** */nektai/* *[necktie]*
+M+S-P	***candy***	***whale***	**솜사탕** */somsatang/* *[cotton candy]*

Note. Texts in bold denote the test items. The pronunciations of the Korean items are listed in / /. Each English word in [ ] is the translation equivalent of the corresponding Korean test item.

Experimental stimuli consisted of a total of 48 target words (16 in each condition). The Korean target compounds were preceded by the English translation equivalents of the second constituent of the target compound word. In addition, unrelated prime for each target (e.g., *whale-솜사탕* [cotton candy]) was created for the control condition (See Table 18 for sample items, see Appendix G for a complete list of items). These were morphologically, semantically, and phonologically unrelated to their targets, but matched with the experimental primes for the number of letters and frequency. Twenty-four word-noncompound pairs were generated to balance the proportion of related and unrelated prime-target pairs as well as to minimize the possibility that participants guess on the characteristics of the experimental items. Seventy-two word-nonword pairs were also generated to ensure an equal number of “Yes” and “No” responses.

In order to ensure the translation equivalency for each Korean-English prime-target pair, four Korean-English bilingual speakers who did not participate in the current experiment were asked to translate the list of English constituents of the target compounds into Korean; another four Korean-English bilingual speakers translated the constituents back from Korean to English. All words maintained translation consistency in both directions by all the translators except three words (*top, fly* and *trap*) whose percentage of translation agreement was an average 75 % in the English-Korean direction and 100 % in the Korean-English direction. These three words were kept in the stimuli list.

Phonological similarity rating for items in the phonologically related conditions was also conducted to ensure phonological relatedness between primes and targets. Ten Korean-English bilinguals who did not participate in the current experiment were asked to rate the phonological similarity between the second constituents of the Korean target compounds and the English primes (e.g., the similarity between 밤 /*bam/* and *balm*) on a seven-point Likert scale (1: completely different to 7: exactly the same). Phonologically similarity was not significantly different between the +M+S+P and -M-S+P conditions, *t* (30) = -.98, *p* =. 34. The results of the ratings are listed in Table 19.

Table 19. Experiment 4: Average level of phonological similarity for phonologically related (+P) conditions

	Phonologically related conditions	
Condition	+M+S+P	-M-S+P
Mean	6.40	6.53
SD	.44	.30

Note: Range: 1 (completely different) to 7 (exactly the same)

Primes and targets were matched as much as possible across the three conditions for the number of letters and frequency. Frequencies of the English primes were collected from the CELEX corpus with a frequency count of 1 per million and those of the Korean targets were collected from a database provided by the National Academy of the Korea Language with a frequency count of 1 per 1.5 million. Means for these variables across conditions, along with the ANOVA statistical test results, are shown in Table 20.

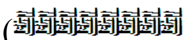
Table 20. Experiment 4: Average of stimulus characteristics for items across the three conditions

Property	Conditions			ANOVA
	+M+S+P	+M+S-P	-M-S+P	
Num. of Letters (T)	8.00 (.97)	8.19 (2.11)	7.50 (1.21)	*F* (2,45) = .89 *P* = .42
Num. of Letters (P)	4.00 (8.74)	7.19 (12.78)	9.00 (11.04)	*F* (2,45) = 2.65 *p* = .08
Frequency (T)	5.44 (7.36)	1.95 (2.38)	3.99 (7.44)	*F* (2,45) = .42 *P* = .66
Frequency (P)	112.82 (110.06)	117.95 (150.64)	105.37 (233.43)	*F* (2,45) = .02 *P* = .98
Familiarity (P)	6.93 (.14)	6.94 (.12)	6.81 (.40)	*F* (2,45) = 1.32 *P* = .28

Note: T: target, P: prime

In order to take into account the fact that the frequency information from the CELEX corpus may not truly reflect bilingual speakers' daily exposure, familiarity ratings for the English primes (1: very unfamiliar to 7: very familiar) were collected from 10 Korean-English bilingual speakers who did not participate in the current experiment and matched across the three conditions, F (2,45) = 1.32, P = .28.

Two lists of prime-target pairs were constructed. In List 1 the targets were preceded by the related primes (e.g., *candy-솜사탕 [cotton candy]*), and in List 2 by the unrelated primes (e.g., *whale-솜사탕 [cotton candy]*). The participants were randomly assigned to one of the three prime durations (e.g., 36 ms, 48 ms, and 100 ms). For each prime duration, half of the participants saw List 1 while the other half saw List 2. Each participant only saw each target once.

Procedure. Procedure was the same as that in Experiment3 except that in Experiment 4, the primes were English words and the targets were Korean words, and the forward mask was two lines of hash marks (######### #########) instead of the upside-down Korean characters ().

Results

Mean RT are shown in Table 21 and accuracies are shown in Table 22. The data of 15 participants including those who could see the primes at 36 ms and 48 ms, and those who could not see the primes at 100 ms, and those whose English proficiency score was less than .5 in the Boston naming task and the C-test were excluded. The RT data for incorrect responses were deleted. Responses differing by two standard deviations from the cell mean (5 %) were removed from the RT data.

Table 21. Experiment 4: Average RT (ms) and priming effects (standard deviation in brackets)

Condition	Prime type	Prime duration		
		36ms	48ms	100 ms
+M+S+P	Related	757 (166)	714 (153)	725 (144)
	Unrelated	743 (160)	722 (134)	737 (151)
	Priming	-14	8	12
+M+S-P	Related	708 (116)	707 (146)	698 (125)
	Unrelated	697 (118)	685 (126)	706 (129)
	Priming	-11	-22 (*)	8
-M-S+P	Related	728 (147)	728 (171)	724 (147)
	Unrelated	716 (139)	704 (148)	708 (139)
	Priming	-12	-24	-16

(*) p = .07

Response time. Planned comparisons were conducted to test the priming effects in each prime duration and each condition. When the prime duration was 36 ms and 100 ms, priming effects were not significant in all conditions, all *p*s >.1. When the prime duration was 48 ms, there was a marginally significant priming effect in the +M+S-P condition by participants, t_1 (36) = -1.876, p = .069; t_2 (22) = -1.351, p = .187, whereas no priming effect was found for the other conditions, *p*s >.1. The omnibus ANOVA yielded a significant main effect of conditions, F_1 (2, 206) = 13.501 p <. 001; F_2 (4, 330) = 7.094, p < .001. However, there was no significant main effect of prime types and prime durations, *p*s > .1. All interactions were not significant, all *p*s >.1.

Table 22. Experiment 4: Average accuracy (standard deviation in brackets)

Condition	Prime type	Prime duration		
		36ms	48ms	100 ms
+M+S+P	Related	.97 (.10)	.92 (.14)	.98 (.05)
	Unrelated	.96 (.07)	.95 (.10)	.98 (.04)
	Priming	.01	-.03	0
+M+S-P	Related	.98 (.05)	.94 (.13)	.98 (.04)
	Unrelated	.97 (.06)	.94 (.10)	.95 (.07)
	Priming	.01	0	.03
-M-S+P	Related	.95 (.09)	.92 (.11)	.94 (.09)
	Unrelated	.95 (.09)	.93 (.14)	.95 (.10)
	Priming	0	-.01	-.01

Accuracy. Planned comparisons showed no priming effects in all conditions and in all prime durations, all *p*s >.1. The omnibus ANOVA yielded a significant main effect of conditions by participants, F_1 (2, 208) = 5.518, p =. 005; F_2 (2, 270) = 2.134, p = .120, and a significant main effect of prime durations, F_1 (2, 104) = 2.676, p =. 074; F_2 (2, 270)

= 4.872, $p = .008$. However, there was no significant main effect of prime types, $p > .1$. All interactions were not significant, all *p*s >.1.

Discussion

The aims of Experiment 4 were (1) to examine whether morphological information plays a role in the cross-language activation (L2-L1 direction) of the constituent morphemes independent of the phonological and semantic factors (2) to examine whether the effects of morphological, semantic, and phonological factors are different across prime durations, (3) to examine whether the magnitude of the priming effects is different between the L1-L2 direction (Experiment 3) and the L2-L1 direction (Experiment 4).

In Experiment 4, there was no significant priming effect in all conditions across all prime durations (except a marginally significant effect in the +M+S-P condition at 48 ms). Non-balanced Korean-English bilinguals showed priming effects in the L1-L2 direction, but no significant priming effect was found in the L2-L1 direction. These results were consistent with other translation priming studies in late bilingual speakers (e.g., Jiang, 1999). These asymmetric priming results are consistent with the RHM which postulates that the lexical link from L2 to L1 is stronger than that from L1 to L2 (Kroll & Stewart, 1994). According to this model, for less proficient L2 learners, the lexical representations in L2 are produced and recognized via translation equivalents in the L1 lexicon while the lexical representations in L1 are connected to their conceptual representations directly.

Chapter VII. General Discussion

The aim of the present study is to investigate how Korean-English bilinguals process compound words in both Korean and English. Experiment 1 investigated whether Korean-English bilinguals decompose L1 (Korean) compound words into their individual constituent morphemes. Experiment 2 investigated whether Korean-English bilinguals apply morphological decomposition to processing L2 (English) compound words. Within-language masked priming experiments were conducted with Korean prime- target pairs in Experiment 1 and with English prime-target pairs in Experiment 2. Experiments 3 and 4 investigated the cross-language activation of constituents in morphologically complex words. Specifically, these two experiments examined whether the translation equivalents of constituents in morphologically complex words in one language facilitate the processing of morphologically complex words in the other language via morphological decomposition and cross-language activation. Cross-language masked priming experiments were conducted with Korean prime-English target pairs in Experiment 3 and with English prime-Korean target pairs in Experiment 4. In the following sections, results of the four experiments are summarized and discussed from three perspectives: L1 morphological processing, L2 morphological processing, and cross language activation. Finally, limitations, directions for future research, and the broader impact of these results are discussed.

L1 Morphological Processing

The question of whether morphologically complex words are decomposed into their constituent morphemes is one of the major issues in the area of L1 morphological processing. Experiment 1 provided evidence for morphological decomposition in the processing of Korean compound words. The results of Experiment 1 showed that there was a significant constituent priming effect in the morphologically, semantically, and orthographically related prime-target pairs when the primes were two-syllable words, but not for the only orthographic overlapped prime-target pairs.

Experiments 1 demonstrated that morphological decomposition can be generalized to the processing of different morphological structures by showing priming effects in compound words. Most of the previous studies that showed morphological priming effects have focused on the affixed word forms (e.g., derived or inflected words). Since the frequency of affixes is normally very high, and the position of affixes in a word is highly predictable, decomposition in affixed word forms could be a result of the characteristics of the affixed words rather than the factors unique to the processing of morphologically complex words. Compound words, however, can be composed of various grammatical forms (e.g., *football*; noun-noun, *sidestep*; noun-verb, *takeout*; verb-preposition), and the position of each constituent is not predictable (e.g., the morpheme *book* is the first constituent in *bookstore*, but it is the second constituent in *bankbook*). Therefore, Experiment 1 supported that there is a general underlying mechanism in processing morphologically complex words independent of frequency and predictability of the position of the constituent morphemes (also see Shoolman & Andrews, 2003).

The results of Experiment 1 provided evidence for compound decomposition in a non-Indo-European alphabetic orthography, Korean. A large number of previous studies have shown evidence for the morphological decomposition independent of orthographic information in Indo-European orthographies (English: Rastle et al. 2004, Fiorentino & Fund-Reznicek, 2009, Basque: Duñabeitia et al, 2009). Yet, little is known about Korean compound processing. The Korean script, Hangul, follows a fundamental alphabetic principle. However, it is written in a nonlinear spatial layout. The graphemes are organized into a square-shaped block, in which the graphemes are arranged left to right and top to bottom. Since there is a clear syllable boundary in a Korean word, the syllable is often considered as the processing unit in Korean (Simpson & Kang, 1994). Furthermore, since a Korean syllable often represents a morpheme by itself (e.g., *밤 /bam/ [night])*, a syllable unit can be considered as a morpheme unit. Nevertheless, our results showed that there was a significant morphological priming effect in the +M+S+O condition but not in the -M-S+O condition, suggesting that Korean compound words are processed based on the morpheme unit rather than the syllable unit. Moreover, since Korean is an agglutinative language which allows the combination of many morphemes in a word, Korean is productive in compound formation. The high productivity in compounding in Korean may also result in morphological sensitivity in Korean speakers.

However, results from Experiment 1 also showed that there was no significant priming effect in the +M+S+O condition when the primes were monosyllabic words. There are two possibilities for this. First, in Korean, a large number of homographs associated with monosyllabic words may have elicited an inhibitory effect, which eliminates the facilitation effect. Monosyllabic words tend to have several homographs (e.g., 벌 */bul/* represents three different morphemes, *punishment, bee, or pair*), three different meanings can possibly be activated and compete with each other. It takes time for the Korean participants to choose the correct semantic representation. Furthermore, if the intended meaning of the morpheme in relation to the target word is not the most frequent meaning, it will be activated slower, resulting in a null priming effect (or even a trend of inhibition) in the +M+S+O condition with one-syllable prime.

Second, the relatively short physical length of the compound targets in the +M+S+O condition (one-syllable prime) may also be responsible for the non-significant priming effect. Since the Korean orthography is written in a non-linear layout in which coda is located at the bottom of the square block (e.g., "ㅇ" in 방 */bang/ [room]* or "ㄱ" in 북 */buk/ [drum]*), Korean syllable has a relatively short physical length compared to other linear alphabetic orthographies such as English or Finnish. An eye movement experiment by Betram and Hyönä (2003) showed that the short complex words elicited one eye fixation (e.g., *eyelid*) while long compounds had more than two eye fixations (e.g., *watercourse*). The researchers suggested that the compound words with shorter physical lengths may be processed via the whole-word route regardless of its morphological structure. The compound words in the +M+S+O condition with one-syllable primes in the present study may be processed via whole-word forms rather than decomposing into individual constituents because of their shorter physical length.

Whether morphological information plays an important role independent of orthographic and semantic information is another key question in the field of morphological processing. It has been suggested by some researchers (Fiorentino & Fund-Reznicek, 2009; Marslen-Wilson et al., 2008; Rastle et al., 2000; Rastle et al., 2004; Shoolman & Andrews, 2003) that the morphological factor plays a role independent of the orthographic factor and semantic factor in the recognition of compound words. Experiment 1examined whether morphological factor is independent of the orthographic factor in Korean compound processing. The semantic factor was not examined given the fact that there are only a limited number of fully opaque compounds (neither constituent contributes to the meaning of the compound, e.g., *hogwash*) in Korean. Consistent with previous research with other languages (English: Rastle et al. 2004; Grainger et al., 1991, Fiorentino & Fund-Reznicek, 2009, Basque: Duñabeitia et al, 2009), orthographically overlapping but morphologically unrelated primes are not sufficient to produce facilitative priming effects. Duñabeitia et al. (2009) showed a priming effect in Basque when primes were compounds that share either the first or second constituents with the target compounds (e.g., *lanordu [working hour]-lanpostu [workplace]*). However, no significant priming effect was found when primes were non-compound words that shared the same initial (e.g., *arrantza [fishing]-arrisku [danger]* or final letters (e.g., *molekula [molecule]-pelikula [film]*). Fiorentino and Fund-Reznicek (2009) also showed a significant constituent priming effect for morphologically and semantically related prime-target pairs but no significant priming for purely orthographic overlapping prime-target pairs. In this study, complex words were used as primes and their constituents as targets, which is the reverse order of the prime-target pairs in the present Experiment 1. The results from Experiment 1 replicated and extended the findings from previous studies by using constituents as primes and compounds as targets, revealing that the morphological priming effect independent of the orthographic factor can also be obtained in constituent primes and compound targets in non-Indo-European alphabetic languages.

The RT data in Experiment 1 showed that there was a similar priming effect size between the first and second constituent primes in the +M+S+O with two-syllable prime condition. This result suggested that the priming effect existed independent of constituent positions, consistent with the previous studies, which showed a similar magnitude of priming effects between the first and the second constituent (Fiorentino & Fund-Reznicek, 2009; Jarema et al., 1999; Sandra, 1990; Shoolman & Andrews, 2003; Zwitserlood, 1994). In Experiment 1 of Fiorention and Fund-Reznicek (2009), compounds were used as primes and the first constituents as targets (e.g., *honeymoon-HONEY*) and in Experiment 2, compounds were used as primes and the second constituent as targets (e.g., *classroom-ROOM*). Both experiments showed a similar pattern of priming effects. According to Jarema et al. (1999), the same magnitude of priming effects between the first and the second constituent in right-headed compounds is possibly a result of the joint effect of headedness and position. In Jarema et al. (1999), the relative importance of the first and second constituents was tested in French, which has both right-headed and left-headed compounds. Since headedness is not fully predictable, it is possible to investigate the independent roles of headedness and position-in-string. The priming effects of the first constituent was significantly greater than that of the second constituent in the left-headed compounds, reflecting the combined effects of position-in-string and headedness, but there was no difference in magnitude between the priming effects of the first and second constituent in the right-headed compounds, suggesting that the effects of position-in-string and headedness compete with each other, resulting in no difference in priming. In the present study, although Korean has right-headed compounds, the script is written from left to right, thus the first constituent has an advantage in terms of position-in-string but the second constituent has an advantage in terms of defining the meaning of the whole word. Korean speakers may take advantage of both types of information, resulting in the similar magnitude priming effect between the first and second constituent.

L2 Morphological Processing

A limited number of studies have investigated L2 morphological processing (e.g., Clahsen & Neubauer, 2010; Neubauer & Clahsen, 2009; Silva & Clahsen, 2008). Experiment 2 investigated whether adult L2 learners of English make use of morphological structures in processing English compound words. Consistent with previous studies with L2 learners (Silva & Clashen, 2008; Clashen & Neubauer, 2010; Feldmam et al., 2010), non-balanced Korean-English bilinguals in the present study did not show significant priming effects in the morphologically related conditions (e.g., +M). Silva and Clahsen (2008) compared between native speakers of English and L2 learners of English (German, Chinese, and Japanese learners of English) on their processing of English inflected and derived words. The native speakers exhibited a morphological priming effect for both inflected and derived words, but all of the L2 groups showed no significant morphological priming effect for inflected words and a reduced priming effect for derived words. Neubauer and Clahsen (2009) also showed no significant priming effect for regular participles in L2 learners of German. Taken together, results from previous studies and Experiment 2 from the current study suggested that in the processing of morphologically complex words, adult L2 learners do not make use of morphological structures and decompose inflectional affixes from their stems or decompose compound words into constituent morphemes. Clahsen and colleagues (Clashen & Neubauer, 2010; Neubauer & Clahsen, 2009; Silva & Clashen, 2008) suggested that the processing of morphologically complex words in L2 relies on direct lexical retrieval rather than grammatical computation. Ullman (2001) argued that the different morphological processing mechanisms between L1 and L2 could be explained using the declarative/procedural memory model. L2 processing relies more on the direct lexical retrieval route (declarative memory) than on the decomposition route (procedural memory). For example, when native Korean speakers process a Korean compound word, they decompose into constituent morphemes, but when Korean learners of English process a compound word in English (such as *honeybee*), they retrieve the lexical representation of the whole word.

However, it is possible that non-balanced Korean-English bilinguals may not be able to access the L2 (English) primes during the short prime duration since there were no significant priming effect even in the orthographically related prime-target pairs and the semantically related prime-target pairs. Participants were exposed to the prime for a short period of time (48 ms) and there were immediate forward and backward masks. The short prime duration combined with the masks might have prevented the L2 primes from being perceived and accessed by non-native participants. This explanation can be examined using identity prime-target pairs (e.g., *honey*-*honey*). Jiang (1999) used the identical English prime-target pairs to test whether the L2 primes are accessed. A priming effect was found in the L2-L2 within-language condition with non-balanced Chinese-English bilinguals. In the present study, it is difficult to conclude whether the participants were able to access and perceive the primes since identity prime-target pairs in L2 were not included. However, accuracy data showed that there was a facilitation effect in the –M+S-O condition and RT data showed that there were trends indicating facilitative effects (20 ms) of semantically related primes in the –M+S-O condition. In addition, when prime and target pairs were orthographically related (+O), but semantically unrelated (-S), the first constituent primes tended to facilitate the RT of the target compounds (15 ms in the +M-S+O condition and 45 ms in the –M-S+O condition), whereas the second constituent primes tended to inhibit RTs (-16 ms in the +M-S+O condition and -39 ms in the -M-S+O condition). These results suggest that the participants could access the L2 primes to some degree. Furthermore, the priming effect of the first constituent appears to be dependent on orthographic information, but that of the second constituent seems to be dependent on semantic information. The facilitative effect of the first constituent primes is because the English orthography is written from left to right, the first constituent is always the first thing that comes into the participants' sight, so the first constituent activates the orthographic representation of the target compound. The second constituent is the head-morpheme and it conveys semantic information, but inhibition only happens in semantically opaque compounds, so probably the second constituent activates the unintended meaning, which leads to competition, resulting in slower RT. In future research, whether the primes in Experiment 2 are accessible could be confirmed by adding identical prime-target pairs in L2.

Cross-language Activation

Cross-language Priming Asymmetry

Experiments 3 and 4 addressed the issue of cross-language activation of constituents in compound processing in Korean-English bilingual speakers. The major research question is whether the translation equivalents of the constituents in morphologically complex words in one language facilitate the processing of morphologically complex words in the other language via morphological decomposition. The results of Experiment 3 demonstrated that cross-language activation occurs when L2 (English) compound words served as targets and L1 (Korean) translated second constituents of the compound words served as primes. The results of Experiment 4, however, did not show significant priming effects when L1 (Korean) compound words served as target and L2 (English) translated second constituents of the compound words served as primes. These results are consistent with previous cross-language priming studies with morphologically less complex words (Gollan et al., 1997; Jiang, 1999; Jiang & Foster, 2001). In these studies, the priming effects in the L1-L2 (or dominant language-less dominant language) direction were robust (De Groot & Nas, 1991; Gollan et al., 1997; Jiang, 1999; Jiang & Forster, 2001; Keatly, Spinks, & De Gelder, 1994; Williams, 1994), however, there were null or reduced priming effects in the L2-L1 direction (Gollan et al., 1997; Grainger & Frenck-Mestre, 1998; Jiang, 1999; Jiang & Forster, 2001; Keatly et al., 1994; Sánchez-Casas, Davis, & García-Albea, 1992). There are two possible explanations for this priming asymmetry. First, the lack of priming effects may be due to the short prime duration. The results from the within-English experiment (Experiment 2) did not show significant priming effects in all conditions at the prime duration of 48 ms. The lack of priming effects in the L2-L2 within-language experiment supports the argument that the level of access in non-balanced Korean-English bilingual participants was not strong enough to show statistically significant L2 priming effect. In Experiment 4, even at the prime duration of 100 ms with a backward mask of 150 ms may not provide enough time for non-native speakers to process the L2 primes. In Grainger et al. (1988), cross-language prime and target pairs (e.g., *ROI* [*king* in French]-*QUEEN*) showed a significant priming effect at the prime duration of 700 ms, but not at 100 ms. Therefore, it is possible that there may be a priming effect in the L2-L1 direction when the prime duration is longer. However, evidence from the current

Experiment 2 and Grainger et al. (1988) are not sufficient to account for the lack of priming effects in Experiment 4. In the current within-English priming experiment, the primes were not completely identical to the targets. Thus, there is a possibility that even though participants could access the primes, the partial primes were not sufficient to produce significant priming effects. Therefore, in future research, a within-language repetition-priming condition can be added to see whether participants could indeed access the L2 primes.

Second, the priming asymmetry can be explained by the RHM (Kroll et al. 1994). According to the RHM, L1-L2 priming is effective because the L1 prime activates a shared conceptual level, and the activated conceptual representation activates an L2 translation-equivalent at the lexical form level. However, since the L2 prime is less likely to activate a shared conceptual level due to the weaker connection between the L2 lexicon and concepts, the recognition of the L1 translation-equivalent form as the target may be less efficient and less likely to be influenced by the L2 prime. Therefore, there is no significant priming effect in the L2-L1 direction. The RHM proposes that L2 proficiency is the important factor in determining masked priming effects. Kiran and Lebel (2007) studied how various levels of proficiency affect the priming asymmetry. The researchers separated their participants into two groups, more balanced and less balanced Spanish-English bilinguals, and found that asymmetric priming from English (L2)-Spanish (L1) was greater for the less balanced group than the more balanced group. Therefore, in future research, a priming symmetry could possibly be obtained if the participants are more balanced in proficiency in their two languages.

The Cross-language Activation of Morphologically Complex Words

Although a number of studies have investigated the cross-language activation of monomorphemic words, only a few numbers of recent studies have investigated the cross-language activation of constituents in morphologically complex words. Kim et al. (2011) examined whether cross-language activation occurs via decomposition during the processing of derived words in Korean-English bilingual readers. In this study, when the targets were L2 (English) stems (e.g., *attract*) and the primes were L1 (Korean) real derived words (i.e., *매력적, attractive*), interpretable derived pseudowords (i.e., *매력화, attractization*), or non-interpretable derived pseudowords (i.e., *매력식, attracticide*), there were significant priming effects for all conditions. However, when the primes were derived pseudowords with non-morphological endings (i.e., illegal combination of a stem and an orthographic ending, *매력래, attratel*), there was no significant priming effect. These results demonstrated that cross-language activation occurs via decomposition because Korean-English bilingual readers are able to decompose morphologically complex words in L1 primes and utilize the constituent morphemes to facilitate lexical judgment of the translated stem words in L2. However, Kim et al. (2011) only focused on derived words. In addition, since only the L1-L2 direction (Korean L1 derived words as primes and English L2 stem words as targets) was examined, the priming asymmetry between the L1-L2 and L2-L1 directions could not be examined. In the present study, morphological decomposition was examined in both Korean and English using English compound words as targets in Experiments 2 and 3 and Korean compound words as targets in Experiments 1 and 4. Ko et al. (2011) also provided evidence for compound decomposition and cross-language activation in Korean-English bilingual readers. In this study, the lexical decision of real English compound words (the target language) was more accurate when the translated compounds (the combination of the translation equivalents of the constituents) in Korean (the nontarget language) were real words than when they were nonwords. However, since the lexical decision task in this study could not tap into the automatic and unconscious processing of morphological structures because the priming paradigm was not employed, it is difficult to test whether L2 learners are sensitive to the morphological structure of compound words during online processing. Moreover, the time course of cross-language activation cannot be tested with the lexical decision task.

In the present study, I extended the findings from previous studies of bilingual morphological processing by investigating the nature of compound decomposition in bilingual readers. Although previous studies have provided evidence supporting morphological decomposition in bilingual readers, it is still not clear what information exactly —morphological, semantic, lexical form information, or a combination of the three types of information—is used to parse a compound word (e.g., *honeybee*) into its constituent morphemes (e.g., *honey* and *bee*) since the morphological, semantic, and form information was not manipulated systematically in previous studies. Furthermore, the time course of cross-language activation and morphological processing is also investigated simultaneously in the current study.

The Time Course of Morphological, Semantic and Form Sensitivity

In Experiments 3 and 4, the independent role of morphological information was examined by manipulating form relatedness, morphological decomposability, and semantic transparency. Moreover, previous studies in L1 processing suggested that the role of morphological, semantic and form information in morphological processing varies across different stages of processing. In the present study, the independent role of morphological information was examined at three different prime durations (36 ms, 48 ms, and 100 ms).

In Experiment 3, when Korean constituents primes and English compound targets were used, at the shortest prime duration (36 ms), the RT data showed significant priming effects in both the +M+S+P and +M-S+P conditions, and the priming effects between these two conditions were not significantly different. Therefore, at the earlier stage of processing, morphological information played a role independent of semantic information in cross-language activation of constituent morphemes (e.g., the +M+S+P and +M-S+P conditions). At 48 ms, only the +M+S+P condition showed a significant priming effect, and at 100 ms, the +M+S+P condition showed a significant priming effect and +M+S-P condition showed a marginally significant priming effect. These results are consistent with previous masked priming studies with English monolingual participants (e.g., Rastle et al., 2000), all of which showed that there is an independent role of morphological information in early visual recognition. For example, in Rastle et al. (2000), semantically transparent derived words showed significant priming effects at all prime durations (43 ms, 72 ms, 230 ms), but semantically opaque derived words showed significant priming effects only at the shorter prime duration (43 ms). Thus, the results from the present Experiment 3 suggest that there is an independent role of the morphological factor that cannot simply be attributed to the semantic factor in early stage of cross-language activation.

In Experiment 3 or 4, when prime and target pairs were phonologically unrelated, but morphologically related (i.e., the +M+S-P and +M-S-P conditions), there was no significant priming effect at the two shorter prime durations (both 36 ms and 48 ms). However, there was a marginally significant priming effect in the +M+S-P condition at the longest prime duration (100 ms) in Experiment 3. Based on the pattern of these results, it seems that at the earlier stage of processing, phonological relatedness was important for morphological processing. Taken together, it seems that the activation of phonological and morphological information occurs earlier than semantic information in morphological processing.

Early activation of phonological and morphological information and late activation of semantic information were also supported in previous cognate priming studies. In previous masked priming studies, a robust cognate priming effect, but no or weak noncognate priming effect, has been found across two alphabetic scripts, such as English-Dutch (e.g., De Groot & Nas, 1991) and Spanish-English (e.g., Sánchez-Casas et al. 1992; Sánchez-Casas & Almagro, 1999). Sánchez-Casas and Almagro (1999) compared the time course of priming effects across Spanish-English cognate translations (e.g., *puno- puny*), noncogate translations (e.g., *pato-anec*) and false cognates (only form-related words; e.g., *coro-corc*) in bilingual word recognition. There were three prime durations, two masked prime durations (30 ms and 60 ms) and one unmasked prime duration (250 ms). At 30 ms, there were significant priming effects in both cognates and false cognates, but not in the noncognates. At 60 ms, there was a significant priming effect only in the cognates and at 250 ms, priming effects were significant in both cognates and noncognates, but not in the false cognates. These results from Sánchez-Casas and Almagro (1999) are similar to those in the current Experiment 3. In both studies, at the shortest masked prime duration, significant priming effect was elicited by morphological and phonological relatedness, but at the longest unmasked prime duration, significant priming effect was based on morphological and semantic relatedness. In other words, the contribution of the form and meaning information in the processing of bilingual word recognition is different across the time course. Form information seems to play a role early on in the processing of bilingual word recognition; however, semantic information seems to play a role later in the recognition process.

Sánchez-Casas and García-Albea (2005) modified the distributed lexical/conceptual model proposed by Kroll and De Groot (1997) to account for the representation of cognate translations and noncognate translations in the bilingual lexicon. In the original distributed lexical/conceptual model (Kroll & De Groot, 1997), there are three levels of representations, a language-independent (shared) lexical feature level of representation, a conceptual feature level, and a level of lemma representations that mediates between the lexical form and conceptual levels. This lemma level contains languge-specific information about the word's syntactic category and morphological structure. According to Sánchez-Casas and García-Albea (2005), the cognate translations across languages can be considered similar to the morphologically related words within languages, since both of them are represented on the basis of the common root. The morphological level is located between the form and lemma levels in the Sánchez-Casas and García-Albea's revised model to help explain the representation and processing of cognate translations.

In order to account for the cross language activation of morphologically complex words in the present study, we modified Sánchez-Casas and García-Albea (2005)'s revised distributed lexical/conceptual model. When an L1 morphologically and phonologically related constituent (+M+S+P and +M-S+P) is presented as a prime (e.g., *케이크, cake*) and an L2 compound word is presented as a target (e.g., *cupcake*), the prime will activate its corresponding lexical feature nodes at the form level (e.g., */k/, /e/, /ɪ/, /k/*). These nodes will then activate the stem (e.g., *케이크 /keɪk/*) at the morphological level. The feature nodes and stem nodes are shared between L1 and L2 because of their phonological relatedness. The already activated shared feature nodes and the stem nodes will speed up the target compound's recognition (e.g., *cupcake /kʌpkeɪk/*). Later in the recognition process, the morphemic units (e.g., *케이크 /keɪk/*) will activate the corresponding lemmas in both L1 (e.g., *케이크* and *컵케이크*) and L2 languages (e.g., *cup*, and *cupcake*) and this will in turn reach activation at the shared conceptual level. For example, in the +M+S+P condition, *케이크* and *cake* share the conceptual features with *컵케이크* and *cupcake*. Therefore, the concept nodes of *케이크* and *cake* will speed up the target compound's recognition (e.g., *cupcake*) (Figure 6). However, in the +M-S+P condition, *라인* and *line* did not share the conceptual feature with *데드라인* and *deadline*. Therefore, the conceptual nodes of *라인* and *line* should not speed up the target compound's recognition, *deadline* (Figure 7). In the present study, at the shortest prime duration, both the primes in the +M+S+P and +M-S+P conditions showed facilitation effects without reaching the conceptual level. However, the priming effect at the longer priming duration still remained significant only in the +M+S+P condition because the shared semantic information is activated only in the +M+S+P condition.

On the other hand, when the L1 primes were morphologically related but phonologically unrelated to the L2 compound targets (+M+S-P and +M-S-P), activation from the feature nodes will only activate the corresponding stem node (i.e., 빛 *[light]*), and no activation will reach the stem of its translation (i.e., *light*). Consequently, there will be no facilitation effects. The facilitation effects obtained in the +M+S-P condition at 100 ms prime duration could be a result of activation at the conceptual level, at which meaning features are shared via the translation equivalents (Figure 8).

Our proposed bilingual morphological processing model (see Figure 6, 7, and 8 expanded the exisiting revised distributed lexical/conceptual feature model by Sánchez-Casas and García-Albea (2005). Since the model by Sánchez-Casas and Gaicia-Albea centers on cognates and noncognates processing, and both cognate translation and noncognate translation pairs are semantically related, the variation of semantic relatedness is not taken into account in their model. Our proposed model takes into consideration the role of semantic factor in the compound processing via differentiating the conceptual links between semantically transparent (+M+S) and semantically opaque compound words (+M-S). Our proposed model would be able to account for the roles of phonological, morphological and semantic information simultaneously in bilingual morphological processing.

Although there was no significant noncognate priming effect with similar script pairs (e.g., *mesa* in Spanish, *table* in English), studies examining different script pairs, such as Hebrew-English and Korean-English pairs, have shown translation priming effects for noncognate translations as well as cognate translations (Gollan et al., 1997; Kim & Davis, 2003) in masked priming tasks. Unlike the Kim and Davis (2003) study which showed the translation priming effects for both noncognate translations and cognate translations with Korean-English script pairs, the present Experiment 3 showed no significant priming effect with phonologically unrelated (noncognate) Korean-English prime-target pairs at 36 ms and 48 ms prime durations. The inconsistent results between the present study and Kim and Davis (2003) may be due to the differences in the properties of the target words. In the present study, the target words were morphologically complex words and the frequency of target words was low. However, the target words in Kim and Davis (2003) were morphologically less complex words, and the frequency of target words was high. With morphologically less complex words of high frequency, it may be easier to access the orthographic and semantic information in a lexical decision task. On the contrary, with morphologically complex words that have low frequency, it may be more difficult for non-balanced bilinguals to access the orthographic and semantic information in their L2. The participants tend to rely more on the phonological information rather than the orthographic and semantic information.

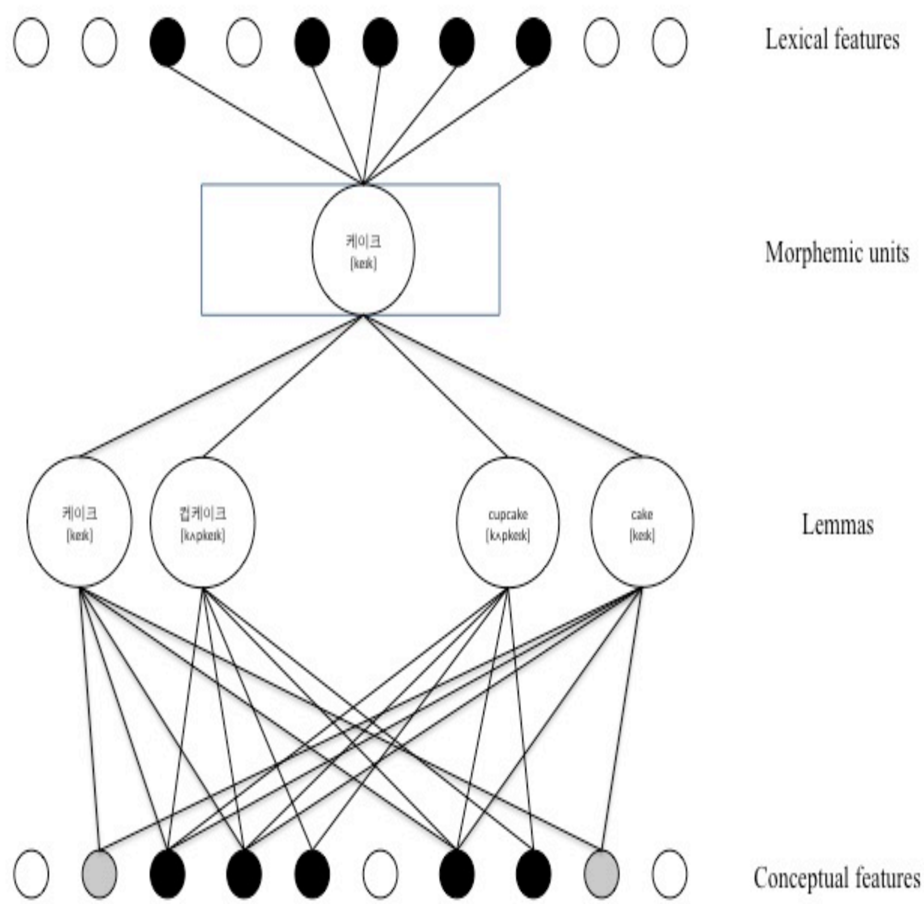


Figure 6. The distributed lexical/conceptual feature model for morphologically, semantically and phonologically related prime-target pairs (+M+S+P condition) (adopted from Kroll and De Groot, 1997, and Sánchez-Casas and García-Albea, 2005).

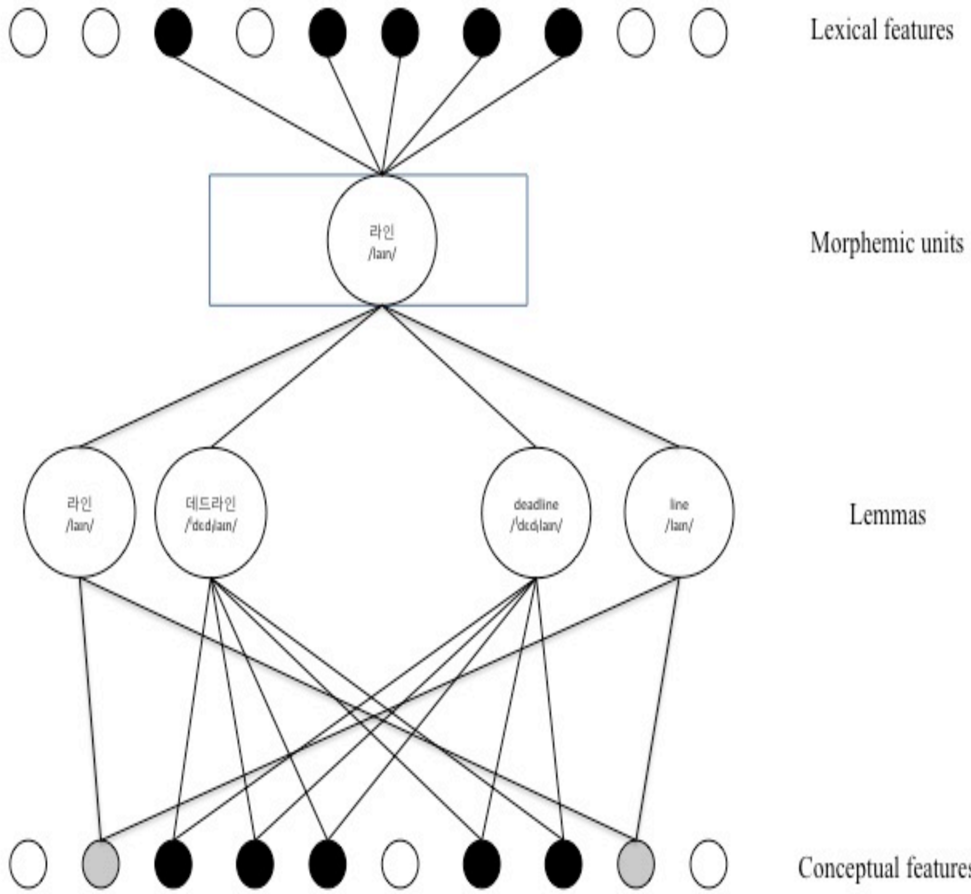


Figure 7. The distributed lexical/conceptual feature model for morphologically and phonologically related but semantically unrelated prime-target pairs (+M-S+P condition) (adopted from Kroll and De Groot, 1997, and Sánchez-Casas and García-Albea, 2005).

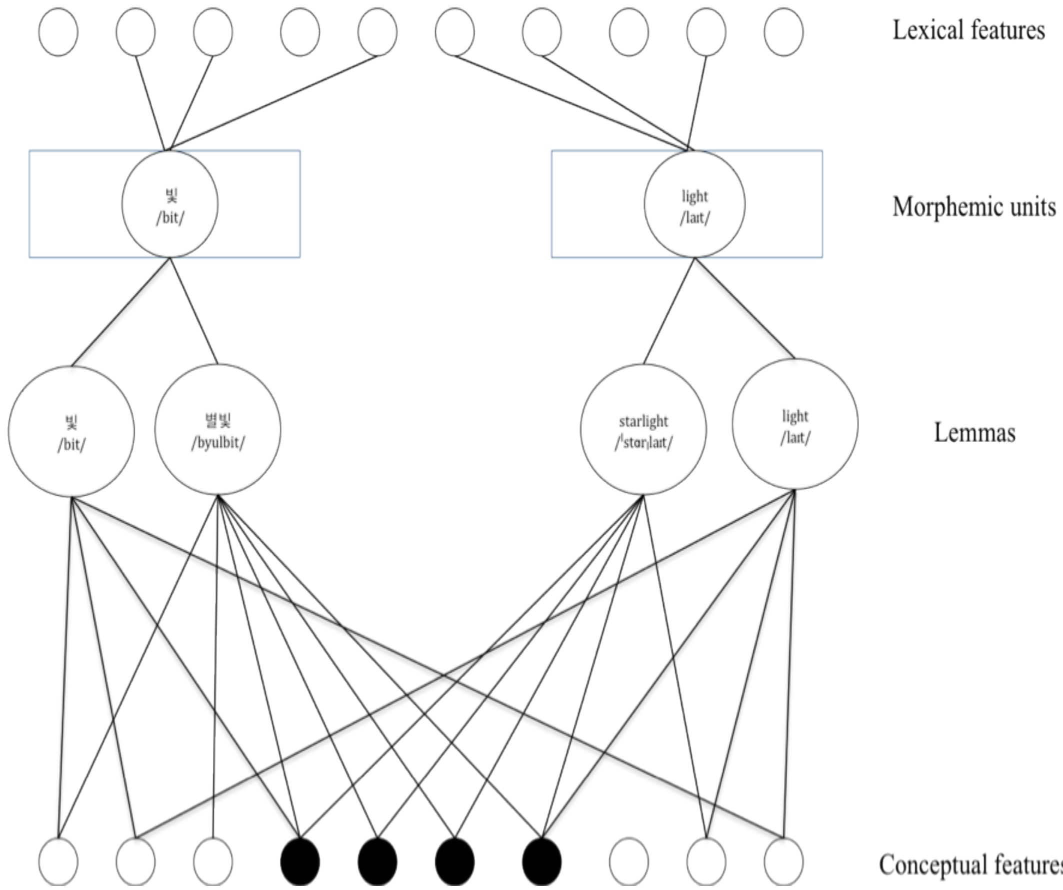


Figure 8. The distributed lexical/conceptual feature model for morphologically and semantically related but phonologically unrelated prime-target pairs (+M+S-P) (adopted from Kroll and De Groot, 1997, and Sánchez-Casas and García-Albea, 2005).

Limitations and Future Research Directions

It is important to acknowledge the limitations of the present study. First, since there were no native English participants in the current study, it was impossible to examine how orthographic, semantic, and morphological information influence native and nonnative speakers differentially in the processing of morphologically complex words. I discussed the results of Experiment 2 based on previous masked priming studies using compound targets among native English speakers (e.g., Fiorentino & Fund-Reznicek, 2009; Shoolman & Andrews, 2003). However, there are differences in the stimuli and designs, limiting a direct comparison between L2 processing in non-native speakers in the current study and L1 processing in native speakers in Shoolman and Andrews (2003). In future research, a direct comparison of performance between non-balanced Korean-English bilinguals and native English speakers need to be made by adding a group of native English speakers.

Second, in the present study, complex words were the targets and their constituents were the primes in order to directly compare the priming effects of the first and second constituents on the target words. Another reason for using constituent as primes and complex words as target is that Korean-English bilinguals might not be able to process complex words as masked primes since most of the complex words have longer length and lower frequency than their constituents. However, with this order of presentation, participants might utilize strategic processing since the compound words were overtly presented as targets. In addition, a significant number of L1 and L2 morphological priming studies (Fiorention & Fund-Reznicek, 2009; Silva & Clahsen, 2008) have used complex words as masked primes and their constituent as targets. Therefore, in future research, the reversed order of presentation (i.e., complex words as primes and their constituents as targets) should be examined to allow a direct comparison to previous studies.

A third limitation is related to prime durations. While the within-language priming experiments used only 48 ms as the prime duration, the cross-language experiments used 36, 48, and 100 ms. Therefore, the time course of activation in within-Korean L1 and English L2 compound processing could not be examined. Moreover, it is not clear whether the relative importance between the non-head morpheme (the first constituent) and the head morpheme (the second constituent) varies in Korean L1 or English L2 compound processing across different time points.

The fourth limitation is the limited number of items in each condition. It was extremely difficult to find items that satisfied all of the matching criteria because of the language-specific characteristics. For example, there are not many English compound words in which constituent morphemes are phonologically and morphologically related but semantically unrelated to the Korean translated constituents (+M-S+P condition in Experiment 3). Moreover, the English stimuli were limited to familiar words for non-balanced Korean-English bilinguals. Future research should increase the numbers of items in each condition. Statistical methods such as ANCOVA may be used to control for possible confounding variables such as familiarity, frequency or semantic similarity. Furthermore, one may argue that some Sino-Korean constituent morphemes (e.g., 학교, *hak-kyo*, "school") in the items are generated via compounding because a Sino-Korean word is usually generated by combining two Chinese characters. However, in many cases, these Chinese characters are not used on their own. Also, since some Sino-Korean words are frequently used in daily life, people do not recognize them as compound words but rather recognizing them as monomorphemic words. The current study only used the Sino-Korean words that are used frequently in daily life and their corresponding Chinese characters are not used independently to minimize the compoundability.

Broader Impact

The present study focused on morphological processing, especially processing of compound words in bilingual readers. Although much research has studied lexical processing in bilinguals, the study of compound processing in bilingual readers is rare.

Furthermore, most of the bilingual studies have centered on bilingual speakers of two European languages. Thus, the investigation of compound processing in Korean-English bilingual readers provides novel evidence in both compound processing and bilingual lexicon and better the understanding of universal and language-specific processes in bilingual acquisition.

In South Korea, young children as well as adults spend a great amount of time learning English as a second language. An increasing number of schools have adopted the "English-only" method to teach English. An increasing number of children and college students are coming to the United States for the purpose of English learning. Furthermore, bilingual and biliteracy education has become one of the most important issues in educational systems across the world. The present study will have important implications for second language instruction and bilingual education. Results from the current study suggest that the translation equivalents of constituents in L1 (Korean) facilitate the processing of compound words in L2 (English). Thus, L2 instruction should be focused on the analysis of constituent morphemes. Furthermore, the results suggest that bilingual speakers' first language is activated during the processing of L2 complex words. Therefore, L2 educators should pay more attention to the morphological structures and linguistics features of the students' L1.

Appendix A. Target answers of the Boston Naming Test

Item	Target word
1	bed
2	tree
3	pencil
4	house
5	whistle
6	scissors
7	comb
8	flower
9	saw
10	toothbrush
11	helicopter
12	broom
13	octopus
14	mushroom
15	hanger
16	wheelchair
17	camel
18	mask
19	pretzel
20	bench
21	racquet
22	snail
23	volcano
24	seahorse
25	dart
26	canoe
27	globe
28	wreath
29	beaver
30	harmonica

Item	Target word
31	rhinoceros
32	acorn
33	igloo
34	stilts
35	dominoes
36	cactus
37	escalator
38	harp
39	hammock
40	knocker
41	pelican
42	stethoscope
43	pyramid
44	muzzle
45	unicorn
46	funnel
47	accordion
48	noose
49	asparagus
50	compass
51	latch
52	tripod
53	scroll
54	tongs
55	sphinx
56	yoke
57	trellis
58	palette
59	protractor
60	abacus

Appendix B. English C-test

Directions

The following tests have been developed by removing the second half of every second word in a text. You are supposed to reconstruct the texts.

Example: My name is Tom. I'm t__ oldest ch__ in m__ family. I ha__ a sister a__ two brot___.

Answer: My name is Tom. I'm the oldest child in my family. I have a sister and two brothers.

Directions

The following tests have been developed by removing the second half of every second word in a text. You are supposed to reconstruct the texts.

Example: My name is Tom. I'm t__ oldest ch__ in m__ family. I ha__ a sister a__ two brot___.

Answer: My name is Tom. I'm the oldest child in my family. I have a sister and two brothers.

Text 1

The representation of thought was achieved by means of oral signs, mutually understood by the group who recognized the same system of representation. This or___ manifestation w___ later o___ preserved i___ the fo___ of draw___ and writ___, so th___ each comm____ left beh___ a record o___ its cul___. But wri___ is n___only a w___ to pres___ memory; i___ is al___ the sym___ of a cul___. This c___ be cle___ observed i___ the sys___ of wri____, which were historically developed. Writing was later developed into artistic and aesthetic forms of knowledge and communication and whether it developed so do calligraphy.

Text 2

Postcards always spoil my holidays. Last sum___, I we___ to It___. I vis___ museums, a___ sat i___ public gar___. A frie___ waiter tau___ me a f___ words o___ Italian. H___ lent m___ a bo___. I re___ a f___ lines, b___ I d___ not under___ a wo___. Every d___ I tho___ about post___. My holi___ passed qui___, but I did not send any cards to my friends. On the last day I made a big decision. I got up early and bought thirty-seven cards. I spend the whole day in my room, but I did not write a single card!

Text 3

Some people believe that cigarette smoking is dangerous and should be considered a health hazard. They wa___ their gover___ to cre___ antismoking prog___. People dif___as t___ how st___these antis___ campaigns sho___ be. So___ of the stro___ campaigns wo___ try t___ completely elim___cigarette smo___. Supporters o___ these prog___ would t___ to b___ cigarette smo___completely i___ public pla___. Others wo___ try on___ to rest___ the number of places where people could smoke. Such restrictions would not try to eliminate public smoking completely, but only to curb smoking by reducing cigarette consumption.

Text 4
Recent studies indicate that grandparents and grandchildren are better off when they spend large amounts of time together. Grandparents gi__ children lo___ of affe___ with n__ strings atta___, and t__ children ma___ the grandp___ feel lo___ and nee___ at a ti___ when t__ society m___ be tel___ ol___ people th___ they a___ a bur___ Grandparents a___ a sou___ of stre___ and wis___ and he___ ease t___ pressure bet___ children and their parents.

Text 5
Is astrology a science? It cert___ claims t___ be o___ . We kn___ that astro___ commit thems___ to predi___ based o___ an all___ connection bet___ the posi___ of t___ stars a___ human li___ . People bo___ under a cer___ sign o___ the zod___ are supp___ to b___ of a cer___ temperament. Wh___ one pla___ is ne___ ano___ this is supposed to mean that the time is favourable for love, or war, or business deals. But does astrology make good its claims to predict the future with reasonably consistent success?

Appendix C. Language Experience and Proficiency Questionnaire (LEAP-Q)

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

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

1	**2**	**3**	**4**	**5**

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

1	**2**	**3**	**4**	**5**

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

List language here:					
List percentage here:					

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

List language here:					
List percentage here:					

(5) When choosing a language to speak with a person who is equally fluent in all your languages, what percentage of time would you choose to speak each language? Please report percent of total time.
(*Your percentages should add up to 100%*):

List language here					
List percentage here:					

(6) Please name the cultures with which you identify. On a scale from zero to ten, please rate the extent to which you identify with each culture. (Examples of possible cultures include US-American, Chinese, Jewish-Orthodox, etc):

List cultures here					
	(click here for sca	(click here for sca	(click here for sca	(click here for sca	(click here for sca

(7) How many years of formal education do you have? ______ ______________________________
Please check your highest education level (or the approximate US equivalent to a degree obtained in another country):

☐ Less than High School	☐ Some College	☐ Masters
☐ High School	☐ College	☐ Ph.D./M.D./J.D.
☐ Professional Training	☐ Some Graduate School	☐ Other:

(8) Date of immigration to the USA, if applicable ___ ______________________________________
If you have ever immigrated to another country, please provide name of country and date of immigration here.
_________________ ____

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

Language:

This is my (please select from pull-down menu) language.

All questions below refer to your knowledge of .

(1) Age when you…:

began acquiring :	*became fluent* in :	*began reading* in :	*became fluent reading* in :

(2) Please list the number of years and months you spent in each language environment:

	Years	Months
A country where is spoken		
A family where is spoken		
A school and/or working environment where is spoken		

(3) On a scale from zero to ten, please select your *level of **proficiency*** in speaking, understanding, and reading from the scroll-down menus:

Speaking	(click here for scale)	Understanding spoken language	(click here for sca	Reading	(click here for sc

(4) On a scale from zero to ten, please select how much the following factors contributed to you learning :

Interacting with friends	(click here for pull-down	Language tapes/self instruction	(click here for pull-down sc
Interacting with family	(click here for pull-down	Watching TV	(click here for pull-down sc
Reading	(click here for pull-down	Listening to the radio	(click here for pull-down sc

(5) Please rate to what extent you are currently exposed to in the following contexts:

Interacting with friends	(click here for pull-dow	Listening to radio/music	(click here for pull-down sc
Interacting with family	(click here for pull-dow	Reading	(click here for pull-down sc
Watching TV	(click here for pull-dow	Language-lab/self-instruction	(click here for pull-down sc

(6) In your perception, how much of a foreign accent do you have in ?

(click here for pull-down scale)

(7) Please rate how frequently others identify you as a non-native speaker based on your <u>accent</u> in :

(click here for pull-down scale)

Appendix D. Experimental Items in Experiment 1

Condition	Korean stimuli					English Gloss				
	1st con prime	2nd con prime	1st un prime	2nd un prime	Target	1st con prime	2nd con prime	1st un prime	2nd un prime	Target
+M+S+O (1)	꿀	벌	굿	흙	꿀벌	honey	bee	exorcism	soil	honeybee
+M+S+O (1)	강	물	백	못	강물	river	water	hundred	nail	river water
+M+S+O (1)	솔	잎	샘	짝	솔잎	pine	leaf	envy	pair	pine needles
+M+S+O (1)	쌀	밥	신	편	쌀밥	rice	rice	shoes	side	boiled rice
+M+S+O (1)	칼	날	볼	몸	칼날	knife	blade	cheek	body	the blade of a knife
+M+S+O (1)	길	벗	삶	뺨	길벗	road	friend	life	cheek	fellow traveler
+M+S+O (1)	꽃	밭	면	땀	꽃밭	flower	garden	cotton	sweat	flower garden
+M+S+O (1)	낮	잠	평	선	낮잠	day	sleep	criticism	line	nap
+M+S+O (1)	낯	빛	팥	값	낯빛	face	light	adzuki beans	price	complexion
+M+S+O (1)	달	밤	급	글	달밤	moon	night	level	writing	moonlight night
+M+S+O (1)	떡	국	폭	향	떡국	rice cake	soup	width	scent	rice-cake soup
+M+S+O (1)	땅	콩	곧	철	땅콩	land	bean	soon	iron	peanut
+M+S+O (1)	벽	돌	탓	종	벽돌	wall	stone	blame	bell	brick
+M+S+O (1)	밀	짚	늪	얼	밀짚	wheat	straw	swamp	spirit	wheat straw
+M+S+O (1)	깃	털	흥	덕	깃털	collar	hair	fun	virtue	feathers
+M+S+O (1)	쥐	덫	칸	귤	쥐덫	mouse	trap	space	mandarin	mousetrap
-M-S+O	실	망	곰	볕	실망	thread	net	bear	sun	disappointment
-M-S+O	입	양	열	불	입양	mouth	sheep	row	fire	adoption
-M-S+O	정	통	극	풀	정통	affection	container	pole	grass	authenticity
-M-S+O	차	별	힘	잔	차별	car	star	force	glass	discrimination
-M-S+O	발	굴	만	흠	발굴	foot	cave	gulf	flaw	excavation
-M-S+O	공	감	놈	욕	공감	ball	persimmon	guy	curse	sympathy
-M-S+O	관	절	답	올	관절	pipe	temple	answer	strand	joint
-M-S+O	총	각	핵	살	총각	gun	angle	nucleus	skin	bachelor
-M-S+O	궁	상	심	숲	궁상	castle	prize	heart	wood	distressed state
-M-S+O	단	독	판	본	단독	bundle	poison	board	model	single
-M-S+O	담	소	쌍	섬	담소	wall	cow	pair	island	chatting
-M-S+O	딸	기	밑	층	딸기	daughter	flag	bottom	floor	strawberry
-M-S+O	당	혹	봄	결	당혹	party	lump	spring	grain	perplex
-M-S+O	혼	돈	염	후	혼돈	soul	money	cleaning of corpse	after	chaos
-M-S+O	천	연	댁	쑥	천연	thousand	kite	you	mugwort	nature
-M-S+O	함	축	뱀	품	함축	case	axis	snake	breast	implication
+M+S+O (2)	가을	바람	판매	정신	가을바람	fall	wind	sale	mind	fall wind
+M+S+O (2)	가정	교사	공간	조건	가정교사	house-hold	teacher	space	condition	private tutor
+M+S+O (2)	기름	종이	정서	폭력	기름종이	oil	paper	emotion	violence	oil paper
+M+S+O (2)	나무	줄기	방송	선택	나무줄기	tree	stem	broad-casting	choice	the trunk of a tree
+M+S+O (2)	단발	머리	부추	아들	단발머리	short hair	head	leek	sun	short hair
+M+S+O (2)	돼지	고기	칭찬	피해	돼지고기	pig	meat	praise	damage	pork
+M+S+O (2)	바늘	구멍	상징	우유	바늘구멍	needle	hole	symbol	milk	needle hole
+M+S+O (2)	비밀	경찰	발달	저녁	비밀경찰	secret	police	development	evening	secret police
+M+S+O (2)	비상	사태	늑대	가격	비상사태	emergency	event	wolf	name	state of emergency

+M+S+O (2)	조개	껍질	이별	낚시	조개껍질	clam	shell	separation	fishing	clamshell
+M+S+O (2)	하늘	나라	필요	의미	하늘나라	sky	nation	need	meaning	heaven
+M+S+O (2)	김치	찌개	독립	비누	김치찌개	kimchi	stew	independenc e	soap	kimchi stew
+M+S+O (2)	전화	번호	가슴	막내	전화번호	phone	number	breast	the youngest child	phone number
+M+S+O (2)	운전	기사	제도	비료	운전기사	driving	driver	system	fertilizer	driver
+M+S+O (2)	자연	법칙	영화	반응	자연법칙	nature	law	movie	contaminat ion	natural law
+M+S+O (2)	시행	착오	꼬마	복습	시행착오	trial	error	kid	review	trial and error

Appendix E. Experimental Items in Experiment 2

Condition	1st constituent prime	2nd constituent prime	1st unrelated prime	2nd unrelated prime	Target
+M+S+O	daylight	day	light	old	sense
+M+S+O	doorbell	door	bell	sort	calm
+M+S+O	sailboat	sail	boat	dame	cool
+M+S+O	cookbook	cook	book	spot	girl
+M+S+O	campsite	camp	site	grey	evil
+M+S+O	sunburn	sun	burn	lay	jail
+M+S+O	birthday	birth	day	smoke	off
+M+S+O	eggshell	egg	shell	ash	hurry
+M+S+O	homemade	home	made	part	good
+M+S+O	teapot	tea	pot	dry	sin
+M+S+O	toolbox	tool	box	zero	sky
+M+S+O	gunshot	gun	shot	leg	gold
+M+S+O	keyhole	key	hole	gas	trip
+M+S+O	jawbone	jaw	bone	ray	rice
+M+S+O	hailstorm	hail	storm	oval	brick
+M+S+O	bookshop	book	shop	name	rock
+M-S+O	deadline	dead	line	baby	word
+M-S+O	fleabag	flea	bag	avid	ill
+M-S+O	hallmark	hall	mark	walk	term
+M-S+O	honeymoon	honey	moon	skirt	fuel
+M-S+O	hotdog	hot	dog	low	fit
+M-S+O	blackjack	black	jack	power	gate
+M-S+O	hamstring	ham	string	fee	garage
+M-S+O	cocktail	cock	tail	plug	wake
+M-S+O	network	net	work	map	come
+M-S+O	jackpot	jack	pot	path	tip
+M-S+O	pineapple	pine	apple	mist	tense
+M-S+O	billboard	bill	board	milk	clean
+M-S+O	joystick	joy	stick	raw	model
+M-S+O	copycat	copy	cat	yard	aim
+M-S+O	nightmare	night	mare	child	numb
+M-S+O	rainbow	rain	bow	iron	pub
-M-S+O	carnation	car	nation	try	beauty
-M-S+O	grammar	gram	mar	fowl	nil
-M-S+O	stubborn	stub	born	hoop	warm
-M-S+O	message	mess	age	hunt	god
-M-S+O	bargain	bar	gain	win	pink
-M-S+O	capsize	cap	size	sum	lady
-M-S+O	sonnet	son	net	art	kid
-M-S+O	pumpkin	pump	kin	boom	bug
-M-S+O	primate	prim	ate	zeal	ben
-M-S+O	confine	con	fine	rag	game
-M-S+O	mushroom	mush	room	yarn	need
-M-S+O	button	but	ton	his	rue
-M-S+O	cashmere	cash	mere	sand	flow
-M-S+O	rampage	ram	page	ego	unit
-M-S+O	cartridge	cart	ridge	peer	heath
-M-S+O	scarlet	scar	let	chip	per
-M+S-O	jeopardy	danger	danger	charge	charge
-M+S-O	fabric	cloth	cloth	solid	solid
-M+S-O	liberate	save	save	task	task
-M+S-O	accuse	blame	blame	clock	clock
-M+S-O	rabbit	bunny	bunny	snore	snore
-M+S-O	aspiration	wish	wish	blue	blue
-M+S-O	frigid	cold	cold	deal	deal
-M+S-O	devout	pious	pious	awoke	awoke
-M+S-O	pitcher	jug	jug	kit	kit
-M+S-O	frighten	scare	scare	whale	whale
-M+S-O	string	cord	cord	exam	exam
-M+S-O	ascend	climb	climb	giant	giant

Appendix F. Experimental Items in Experiment 3

	Experimental stimuli			English Gloss	
Condition	Related prime	Unrelated prime	Target	Related prime	Unrelated prime
-M-S+P	빈	검	soybean	empty	sword
-M-S+P	비	면	honeybee	rain	aspect
-M-S+P	풀	빵	carpool	glue	bread
-M-S+P	북	곰	schoolbook	drum	bear
-M-S+P	독	연	watchdog	poison	kite
-M-S+P	본	꿀	cheekbone	model	honey
-M-S+P	십	통	friendship	ten	case
-M-S+P	내일	차츰	thumbnail	tomorrow	gradually
-M-S+P	밀	깃	oatmill	wheat	feather
-M-S+P	매일	나름	blackmail	everyday	depending on
-M-S+P	팥	낯	flowerpot	red bean	face
-M-S+P	셋	덕	sunset	three	virtue
+M+S+P	케이크	스피드	cupcake	cake	speed
+M+S+P	벨	굽	doorbell	bell	hoof
+M+S+P	펜	궁	ballpen	pen	palace
+M+S+P	백	정	handbag	bag	love
+M+S+P	매트	스릴	doormat	mat	thrill
+M+S+P	홀	금	keyhole	hole	gold
+M+S+P	스푼	제보	teaspoon	spoon	report
+M+S+P	코트	모터	raincoat	coat	motor
+M+S+P	링	짚	earring	ring	straw
+M+S+P	가운	칼슘	nightgown	gown	calcium
+M+S+P	체크	유쾌	paycheck	check	pleasure
+M+S+P	파워	예배	horsepower	power	worship
+M-S+P	라인	코치	deadline	line	coach
+M-S+P	바	맛	crossbar	bar	taste
+M-S+P	박스	샤워	chatterbox	box	shower
+M-S+P	볼	콩	oddball	ball	bean
+M-S+P	케이스	이벤트	staircase	case	event
+M-S+P	보트	슈퍼	dreamboat	boat	super
+M-S+P	백	섬	feedback	back	island
+M-S+P	벨트	지휘	greenbelt	belt	conduct
+M-S+P	스틱	복습	slapstick	stick	review
+M-S+P	레이스	멜로디	necklace	lace	melody
+M-S+P	드럼	억양	eardrum	drum	accent
+M-S+P	폼	귤	platform	form	mandarin
+M+S-P	폭풍	설득	hailstorm	storm	persuasion
+M+S-P	상자	부품	toolbox	box	parts
+M+S-P	방	곧	bedroom	room	soon
+M+S-P	종이	폭력	notepaper	paper	violence
+M+S-P	덫	견	mousetrap	trap	silk
+M+S-P	빛	값	starlight	light	price
+M+S-P	껍질	선택	clamshell	shell	select
+M+S-P	방울	채소	dewdrop	drop	vegetable
+M+S-P	사탕	버선	cottoncandy	candy	socks
+M+S-P	책	힘	pocketbook	book	force
+M+S-P	잠	신	daysleep	sleep	shoe
+M+S-P	칼	들	pocketknife	knife	field
+M-S-P	운	국	potluck	luck	soup
+M-S-P	줄	술	hamstring	string	alcohol
+M-S-P	꼬리	고생	cocktail	tail	pain

+M-S-P	냄비	동굴	jackpot	pot	cave
+M-S-P	걷다	깊다	jaywalk	walk	deep
+M-S-P	파리	척추	firefly	fly	spinal
+M-S-P	판	낮	billboard	board	day
+M-S-P	접다	늦다	blindfold	fold	late
+M-S-P	고양이	카메라	copycat	cat	camera
+M-S-P	사과	순서	pineapple	apple	order
+M-S-P	이슬	퇴근	honeydew	dew	leaving one's office
+M-S-P	불	각	gunfire	fire	angle

Appendix G. Experimental Items in Experiment 4

	Experimental stimuli			English Gloss
Condition	Related prime	Unrelated prime	Target	Target
+M+S+P	letter	happen	팬레터	fan letter
+M+S+P	party	large	가든파티	garden party
+M+S+P	form	week	플랫폼	platform
+M+S+P	car	try	케이블카	cable car
+M+S+P	shop	male	커피숍	coffee shop
+M+S+P	ball	mine	캐치볼	catchball
+M+S+P	mirror	impact	백미러	rearview mirror
+M+S+P	pen	fur	사인펜	sign pen
+M+S+P	pin	fox	헤어핀	hairpin
+M+S+P	tie	bet	넥타이	nacktie
+M+S+P	scene	effort	러브신	love scene
+M+S+P	hole	pale	블랙홀	black hole
+M+S+P	rail	swim	가드레일	guardrail
+M+S+P	line	city	커트라인	cutline
+M+S+P	bag	win	핸드백	handbag
+M+S+P	pan	tin	프라이팬	fry pan
+M+S-P	rabbit	domain	산토끼	hare
+M+S-P	top	run	산꼭대기	mountaintop
+M+S-P	tree	firm	은행나무	gingko tree
+M+S-P	fly	ice	집파리	housefly
+M+S-P	bug	paw	땅벌레	grub
+M+S-P	meat	hill	돼지고기	pork
+M+S-P	cat	aim	도둑고양이	stray cat
+M+S-P	house	under	개집	doghouse
+M+S-P	light	sense	별빛	starlight
+M+S-P	knife	guide	주머니칼	pocketknife
+M+S-P	shell	author	조개껍질	clamshell
+M+S-P	candy	whale	솜사탕	cotton candy
+M+S-P	sleep	drink	낮잠	day sleep
+M+S-P	drop	leg	이슬방울	dewdrop
+M+S-P	book	girl	주머니책	pocketbook
+M+S-P	trap	dish	쥐덫	mousetrap
-M-S+P	bee	gut	이슬비	dew rain
-M-S+P	balm	font	가을밤	fall night
-M-S+P	zip	woo	시골집	country house
-M-S+P	doll	hint	벽돌	wall stone
-M-S+P	bull	chin	장작불	wood fire
-M-S+P	pull	farm	강아지풀	foxtail
-M-S+P	noon	beef	함박눈	large snowflakes
-M-S+P	ill	wet	농사일	farming
-M-S+P	arm	tax	피부암	skin cancer
-M-S+P	beat	vote	달빛	moonlight
-M-S+P	eye	buy	딸아이	daughter
-M-S+P	gym	opt	등짐	pack
-M-S+P	meal	cast	통밀	whole wheat
-M-S+P	sea	law	목화씨	cotton seed
-M-S+P	good	many	마을굿	exorcism
-M-S+P	soup	plot	갈대숲	reed forest

References

Altarriba, J. (1992). The representation of translation equivalents in bilingual memory. In R. J. Harris (Ed.), *Cognitive Processing in Bilinguals* (pp. 157-174). Amsterdam: Elsevier.

Altarriba, J., & Basnight-Brown, D.M. (2007). Methodological considerations in performing semantic and translation-priming experiments across languages. *Behavior Research Methods, Instruments, & Computers, 39,* 1-18.

Andrews, S. (1986). Morphological Influences on Lexical Access: Lexical or Nonlexical Effects? *Journal of Memory and Language, 25,* 726-740.

Andrews, S., Miller, B., & Rayner, K. (2004). Eye movements and morphological segmentation of compound words: There is a mouse in mousetrap. *European Journal of Cognitive Psychology, 16,* 285-311.

Babaii, E., & Moghaddam, M., (2006). On the interplay between test task difficulty and macro-level processing in the C-test. *System, 34*, 586-600.

Babcock, L., Stowe, J., Maloof, C., Brovetto, C., & Ullman, M. T. (in press). Frequency effects, age of arrival and amount of exposure in second language learning: A study of English past-tense production.

Basnight-Brown, D. M., & Altarriba, J. (2007). Differences in semantic and translation priming across languages: The role of language direction, age of acquisition, and language dominance. *Memory and Cognition, 35,* 953-965.

Basnight-Brown, D., Chen, L., Hua, S., Kostic, A., & Feldman, L. (2007). Monolingual and bilingual recognition of regular and irregular English verbs: Sensitivity to form similarity varies with first language experience. *Journal of Memory and Language, 57*, 65–80.

Badecker, W., and Allen, M. (2002). Morphological parsing and the perception of lexical identity: A masked priming study of stem-homographs. *Journal of Memory and Language* 47. 125-144.

Baayen, R. H., Piepenbrock, R., & Gulikers, L. (1995). *The CELEX lexical database (CD-ROM).* Philadelphia, PA: Linguistic Data Consortium, Univ. of Pennsylvania.

Bertram, R., & Hyönä, J. (2003). The length of a complex word modifies the role of morphological structure: Evidence from eye movements when reading short and long Finnish compounds. *Journal of Memory and Language, 48*, 615-634.

Boudelaa, S., & Marslen-Wilson, W. (2005). Discontinuous morphology in time: Incremental masked priming in Arabic. *Language and Cognitive Processes*, *20,* 207-260.

Brysbaert, M., Van Dyck, G., & Van de Poel, M. (1999). Visual word recognition in bilinguals: Evidence from masked phonological priming. *Journal of Experimental Psychology: Human Perception and Performance 25,* 137-148.

Butterworth, B. (1983). Lexical representation. In B. Butterworth (Ed.). *Language production, Vol. II: Development, writing, and other language processes (*pp. 257-294). London: Academic Press.

Caramazza, A., Laudanna, A., & Romani, C. (1988). Lexical access and inflectional morphology. *Cognition, 28*, 287-332.

Chateau, D., Knudsen, E. V., & Jared, D. (2002). Masked priming of prefixes and the influence of spelling-meaning consistency. *Brain and Language, 81,* 587-600.

Chen, H. C., & Ng, M. L. (1989). Semantic facilitation and translation priming effects in Chinese-English bilinguals. *Memory and Cognition, 17,* 454-462.

Cho, H. (2006). *Lexical Statistics of the Korean Language*. Seoul : Pagijong.

Choo, M., & O'Grady, W. (1996). *Handbook of Korean vocabulary: a resource for word recognition and comprehension.* Honolulu : University of Hawai'i Press.

Clahsen, H. & Neubauer, K. (2010). Morphology, frequency, and the processing of derived words in native and non-native speakers. *Lingua 120*, 2627–2637.

Davis, C., Kim, J., & Sánchez-Casas, R. (2003). Masked priming across languages: An insight into bilingual lexical processing. In S. Kinoshita, & S. J. Jupker (Eds.), *Masked priming: The state of the art* (1_{st} ed.) (pp. 309-322). New York: Psychology Press.

De Groot, A. M. B. (1992). Determinants of word translation. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 18,* 1000-1018.

De Groot, A. M. B., Dannenburg, L., & van Hell, J. G. (1994). Forward and backward word translation by bilinguals. *Journal of Memory and Language, 33,* 600-629.

De Groot, A. M. B., & Nas, G. L. J. (1991). Lexical representation of cognates and noncognates in compound bilinguals. *Journal of Memory and Language, 30,* 90-123.

Devlin, J.T., Jamison, H.L., Gonnerman, L.M., & Matthews, P.M. (2006). The role of the posterior fusiform gyrus in reading. *Journal of Cognitive Neuroscience, 18 (6),* 911-922.

Diependaele, K., Duñabeitia, J. A., Morris, J., & Keuleers, E. (2011). Fast morphological effects in first and second language word recognition. *Journal of Memory and Language, 64 (4),* 344-358.

Dijkstra, A.F.J., Timmermans, M.P.H., & Schriefers, H.J. (2000). On being blinded by your other language: Effects of task demands on interlingual homograph recognition. *Journal of Memory and Language, 42* (4), 445-464.

Dijkstra, T., & Van Heuven, W. J. B. (1998). *The BIA model and bilingual word recognition*. Mahwah, NJ, US: Lawrence Erlbaum Associates.

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

Dressler, W. U. (2006). Compound types. In G. Libben. &. G. Jarema (Ed.), *The representation and processing of compound words* (pp. 23-44). Oxford; New York: Oxford University Press.

Duñabeitia, J.A., Laka, I., Perea, M., & Carreiras, M. (2009). Is Milkman a superhero like Batman? Constituent morphological priming in compound words. *European Journal of Cognitive Psychology, 21(4),* 615-640.

Duñabeitia, J., Manuel, P. & Carreiras, C. (2007). The role of the frequency of constituents in compound words: Evidence from Basque and Spanish. *Psychonomic Bulletin & Review, 14(6),* 1171-1176

Duñabeitia, J. A., Marín, A., Avilés, A., Perea, M., & Carreiras, M. (2009). Constituent priming effects: Evidence for preserved morphological processing in healthy old readers. *European Journal of Cognitive Psychology*, *21*, 283-302.

Duñabeitia, J.A., Perea, M., & Carreiras, M. (2010). Masked translation priming effects with highly proficient simultaneous bilinguals. *Experimental Psychology, 57(2),* 98-107

Feldman, L. B. (2000). Are morphological effects distinguishable from the effects of shared meaning and shared form? J*ournal of Experimental Psychology: Learning, Memory, and Cognition, 26,* 1431–1444.

Feldman, L. B. & Prostko, B. (2002). Graded aspects of morphological processing: Task and processing time. *Brain and Language, 81,* 12–27.

Feldman, L. B., & Soltano, E. G. (1999). Morphological priming: The role of prime duration, semantic transparency, and affix position. *Brain and Language, 68*, 33-39.

Finkbeiner, M., Forster, K., Nicol, J., & Nakamura, K. (2004). The role of polysemy in masked semantic and translation priming. *Journal of Memory & Language, 51*(1), 1-22.

Fiorentino, R. and Fund-Reznicek, E. (2009). Masked morphological priming of compound constituents. *The Mental Lexicon, 4(2),* 159-193.

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

Fowler, C. A., Napps, S. E., & Feldman, L. B. (1985). Relations among regular and irregular morphologically related words in the lexicon as revealed by repetition priming. *Memory & Cognition, 13,* 241-255.

Ford, M., Marslen-Wilson, W.D., &Davis, M.H. (2003). Morphologyandfrequency: contrasting methodologies. InR.H. Baayen&R. Schreuder (Eds.), *Morphological structure in language processing*(pp. 89 124). Berlin: MoutondeGruyter.

Forster, K. I., & Davis, C. (1984). Repetition priming and frequency attenuation in lexical access. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 10*, 680-698.

French, R. M., & Jacquet, M. (2004). Understanding bilingual memory: models and data. *Trends in Cognitive Sciences, 8*, 87-93.

Frisson, S., Niswander-Klement, R., & Pollatsek, A. (2008). 3e role of semantic transparency in the processing of English compound words. *British Journal of Psychology, 99*, 87–107.

Fromkin, V., Rodman, R., & Hyams, N. (2007). An introduction to Language (8th ed.). Boston: Thomson/ Heinle.

García-Albea, J. E., Sánchez-Casas, R. M., Bradley, D. C., & Forster, K. I. (1985, November). Cross-language priming effects in bilingual word recognition. Paper presented at the meeting of the Fifth Australian Language Conference, Melbourne.

García-Albea, J.E., Sánchez-Casas, R. & Igoa, J.M. (1998). The contribution of word form and meaning to language processing in Spanish: Some evidence from monolingual and bilingual studies. En D. Hilert (Ed.), *Sentence processing: a cross-linguistic perspective*. New York: Academic Press.

Gleason, J. B. (2009). *The development of language* (7th ed.). Needham Heights, MA: Ally & Bacon.

Gollan, T. H., Forster, K. I., & Frost, R. (1997). Translation priming with different scripts: Masked priming with cognates and non-cognates in Hebrew-English bilinguals. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 23*(5), 1122-1139.

Gonnerman, L. M., Andersen, E. S., & Seidenberg, M. S. (1998). *The emergence of morphological structure: Behavioral experiments and a connectionist model.* Cognitive Neuroscience Society Meeting. San Francisco.

Gonnerman, L.M., Seidenberg, M.S., & Andersen, E.S. (2007). Graded semantic and phonological similarity effects in priming: Evidence for a distributed connectionist approach to morphology. *Journal of Experimental Psychology: General, 136,* 323-345.

Grainger, J., & Beauvillain, C. (1988). Associative priming in bilinguals: Some limits of interlingual facilitation effects. *Canadian Journal of Psychology, 42,* 261-273.

Grainger, J., Colé, P., & Segui, J. (1991). Masked priming in visual word recognition. *Journal of Memory & Language, 30*, 370-384.

Grainger, J., & French-Mestre, C. (1998). Masked priming by translation equivalents in proficient bilinguals. *Language and Cognitive Processes, 13*(6), 601-623.

Grosjean, F. (1982). *Life with Two Languages: An Introduction to Bilingualism*. Cambridge, Mass: Harvard University Press

Grosjean, F. (2004). Studying bilinguals: Methodological and conceptual issues. In T. Bhatia & W. Ritchie (Eds.), *The handbook of bilingualism* (pp. 32–63). Malden, MA: Blackwell.

Heredia, R. R. (1995). *Concreteness effects in high frequency words: A test of the revised hierarchical and the mixed models of bilingual memory representations.* Unpublished Doctoral Dissertation, University of California, Santa Cruz.

Heredia, R. R. (1996). Bilingual Memory: A Re-Revised Version of the Hierarchical Model of Bilingual Memory. The newsletter of the Centre for Research in Language, University of California, San Diego, 10, January.

Jarema, G., Busson, C., Nikolova, R., Tsapkini, K., & Libben, G. (1999). Processing compounds: A cross-linguistic study. *Brain and Language, 68,* 362–369.

Jiang, N. (1999). Testing processing explanations for the asymmetry in masked cross-language priming. *Bilingualism: Language and Cognition, 2*(1), 59-75.

Jiang, N., & Forster, K. I. (2001). Cross-language priming asymmetries in lexical decision and episodic recognition. *Journal of Memory and Language, 44*(1), 32-51.

Jin, Y.-S. (1990). Effects of concreteness on cross-language priming in lexical decisions. *Perceptual and Motor Skills, 70,* 1139–1154.

Juhasz, B., Starr, M., Inhoff, A.W., & Placke, L. (2003). The effects of morphology on the processing of compound words: Evidence from naming, lexical decisions, and eye fixations. *British Journal of Psychology*, *94*, 223-244.

Kaplan, E., Goodglass, H., & Weintraub, S. (1983). *The Boston Naming Test*. Philadelphia: Lea & Febiger.

Keatley, C. W., & de Gelder, B. (1992). The bilingual primed lexical decision task: Cross-language priming disappears with speeded responses. *European Journal of Cognitive Psychology, 4,* 273-292.

Keatley, C. W., Spinks, J. A., & de Gelder, B. (1994). Asymmetrical cross-language priming effects. *Memory & Cognition, 22,* 70-84.

Kehayia, E., Jarema, G., Tsapkini, K., Perlak, D., Ralli, A., & Kadzielawa, D. (1999). The role of morphological structure in the processing of compounds: The interface between linguistics and psycholinguistics. *Brain and Language, 68*, 370-377.

Kim, J., & Davis, C. (2003). Task effects in masked cross-script translation and phonological priming. *Journal of Memory and Language, 49(4)*, 484-499.

Kim, S., Wang, M., & Ko, I. (2011). The processing of derivational morphology in Korean- English bilingual readers. *Bilingualism: Language and Cognition*, *14*, 473-488

Kiran, S., & Lebel, K. (2007). Crosslinguistic semantic and translation priming in normal bilingual individuals and bilingual aphasia, *Clinical Linguistics & Phonetics, 21,* 277-303.

Kirsner, K., Smith, M. C., Lockhart, R. S., King, M. L., & Jain, M. (1984). The bilingual lexicon: Language-specific units in an integrated network. *Journal of Verbal Learning & Verbal Behavior, 23,* 519-539.

Ko, I., Wang, M., & Kim, S. (2011). Bilingual reading of compound words. *Journal of Psycholinguistic Research, 40*, 49-73.

Kouider, S., & Dupoux, E. (2004). Partial awareness creates the 'illusion' of subliminal semantic priming. *Psychological Science, 15*(2), 75-81.

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

Larsen, J. D., Fritsch, T., & Grava, S. (1994). A semantic priming test of bilingual language storage and the compound vs. coordinate bilingual distinction with Latvian–English bilinguals. *Perceptual & Motor Skills, 79,* 459-466.

Landauer, T.K., & Dumais, S. T. (1997). A solution to Plato’s problem: The latent semantic analysis theory of acquisition, induction, and representation of knowledge. *Psychological Review*, 104, 211-240.

Levy, E. S., Goral, M., & Obler, L. K. (2006). Doghouse/ Chien-maison/ Niche: Approaches to the understanding of compound processing in bilinguals. In G. Libben & G. Jarema (Eds.), *The representation and processing of compound words* (pp. 125-144). Oxford; New York: Oxford University Press.

Li, P., Sepanski, S., Zhoa, X. (2006). Language history questionnaire: A web-based interface for bilingual research. *Behavior Research Methods, 38,* 202-210.

Libben, G., Gibson, M., Yoon, Y. B., & Sandra, D. (2003). Compound fracture: The role of semantic transparency and morphological headedness. *Brain and Language, 84*, 50-64.

Longtin, C-M., & Meunier, F. (2005). Morphological decomposition in early visual word processing. *Journal of Memory and Language*, *53*, 26 – 41.

Longtin, C.-M., Segui, J., & Hallé, P. A. (2003). Morphological priming without morphological relationship. *Language and Cognitive Processes, 18,* 313–334.

Marian, V., Blumenfeld, H., & Kaushanskaya, M. (2007). The Language Experience and Proficiency Questionnaire (LEAP-Q): Assessing language profiles in bilinguals and multilinguals. *Journal of Speech Language and Hearing Research, 50* (4), 940-967.

Marslen-Wilson, W. D., Bozic, M., & Randall, B. (2008). Early decomposition in visual word recognition: Dissociating morphology, form, and meaning. *Language and Cognitive Processes, 23*, 394-421.

Marslen-Wilson, W. D., Lorraine, K. T., Rachelle, W., & Lianne, O. (1994). Morphology and meaning in the English mental lexicon. *Psychological Review*, *101*, 3 – 33.

McCormick, S. F., Rastle, K., & Davis, M. H. (2008). Is there a `fete' in `fetish'? Effects of orthographic opacity on morpho-orthographic segmentation in visual word recognition. *Journal of Memory and Language*, *58*(2), 307-326.

McClelland, J. L., & Rumelhart, D. E. (1981). An interactive activation model of context effects in letter perception: Part I. An account of basic findings. *Psychological Review, 88*, 375-407.

McDonald, J. (2006). Beyond the critical period: Processing-based explanations for poor grammaticality judgment performance by late second language learners. *Journal of Memory and Language, 55*, 381–401.

Meyer, D. E., & Ruddy, M. G. (1974, April). *Bilingual word recognition: Organization and retrieval of alternative lexical codes.* Paper presented at the meeting of the Eastern Psychological Association, Philadelphia.

Nefs, H., Assink, E., Knuijt, P. (2003). Effects of sublexical frequency and meaning in prefixed words. In E. Assink, & D. Sandra (Eds.) *Reading complex words: Cross-language studies* (pp.113-137). Amsterdam: Kluwer.

Neubauer, K., & Clahsen, H. (2009). Decomposition of inflected words in a second language: An experimental study of German participles. *Studies in Second Language Acquisition, 31(3)*, 403–435

Perfetti, C. A. (2003). The universal grammar of reading, *Scientific Studies of Reading, 7(1),* 3-24.

Pinker, S., & Ullman, M. T. (2002). The past and future of the past tense. *Trends in Cognitive Sciences, 6*, 456–462.

Plaut, D.C., and Gonnerman, L.M. (2000). Are non-semantic morphological effects incompatible with a distributed connectionist approach to lexical processing? *Language and Cognitive Processes 15*, 445-485.

Pollastek, A., & Hyönä, J. (2005). The role of semantic transparency in the processing of Finnish compound words. *Language and Cognitive Processes, 20*, 261-290.

Portin, M., Lehtonen, M., & Laine, M. (2007). Processing of inflected nouns in late bilinguals. *Applied Psycholinguistics, 28*, 135–156.

Portin, M., Lehtonen, M., Wande, E., Niemi, J., & Laine, M. (2008). L1 effects on the processing of inflected nouns in L2. *Acta Psychologica, 128,* 452–465.

Potter, M. C., So, K.-F., Von Eckardt, B., & Feldman, L. B. (1984). Lexical and conceptual representation in beginning and more proficient bilinguals. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 24*, 539-557.

Rastle,K.,Davis,M.D.,Marslen-Wilson,W.D.,&Tyler,L.K. (2000).Morphological and semantic effects in visual word recognition: A time-course study. *Language and Cognitive Processes, 15*, 407-437.

Rastle, K., Davis, M. H., & New, B. (2004). The broth in my brother's brothel: Morpho-orthographic segmentation in visual word recognition. *Psychonomic Bulletin & Review, 11*, 1090-1098.

Rueckl, J. G., Milkolinski, M., Raveh, M., Miner, C. S., & Mars, F. (1997). Morphological priming, fragment completion, and connectionist networks. *Journal of Memory & Language, 36(3),* 382-405.

Sánchez-Casas, R., & Almagro, Y. (1999, April). Efectos de priming entre lenguas utilizando primes enmascarados y no enmascarados ydiferente asincronı´a estimular. Paper presented at the meeting of the IV Simposium de Psicolingu¨ ı´stica, Madrid, Spain.

Sánchez-Casas, R. M., Davis, C. W., & García-Albea, J. E. (1992). Bilingual lexical processing: Exploring the cognate/non-cognate distinction. *European Journal of Cognitive Psychology*, *4,* 293-310.

Sánchez-Casas, R. García-Albea, J. E. (2005). The representation of cognate and noncognate words on bilingual memory: Can cognate status be characterized as a special kind of morphological relation? In J. F. Kroll y A. M. B. De Groot (Eds.), *Handbook of Bilingualism: Psycholinguistic Approaches (pp. 226-250). New York: Oxford University Press*

Sandra, D. (1990). On the representation and processing of compound words: Automatic access to constituent morphemes does not occur. *Quarterly Journal of Experimental Psychology A: Human Experimental Psychology, 42*, 529-567.

Scheutz, M. J., & Eberhard, K. M. (2004). Effects of morphosyntactic gender features in bilingual language processing. *Cognitive Science, 28,* 559 –588.

Schreuder, R., & Baayen, R. H. (1995). Modeling morphological processing. In L. B. Feldman (Ed.). *Morphological aspects of language processing* (pp. 131-154). Hillsdale. NJ: Erlbaum.

Schreuder, R., & Baayen, R. H. (1997). How complex simplex words can be. *Journal of Memory and Language, 37*, 118–139.

Schwanenflugel, P. J., & Rey, M. (1986). Interlingual semantic facilitation: Evidence for a common representational system in the bilingual lexicon. *Journal of Memory & Language, 25,* 605-618.

Seidenberg, M.S., & Gonnerman, L.M. (2000). Explaining derivational morphology as the convergence of codes. *Trends in cognitive Sciences, 4,* 353-361.

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

Sholl, A., Sankaranarayanan, A., & Kroll, J. F(1995). Transfer between picture naming and translation: A test of asymmetries in bilingual memory. *Psychological Science*, *6*, 45–49.

Shoolman, N., and Andrews, S. (2003). Racehorses, reindeer, and sparrows: Using masked priming to investigate morphological influences on compound word identification. In S.Kinoshita, & S. J. Jupker (Eds.), *Masked priming: The state of the art* (1st ed.) (pp. 241-278). New York: Psychology Press.

Silva, R., & Clahsen, H. (2008). Morphologically complex words in L1 and L2 processing: Evidence from masked priming experiments in English. *Bilingualism: Language and Cognition, 11,* 245-260.

Simpson, G.B. & Kang, H. (1994). Inhibitory process in the recognition of homograph meanings. In D. Dagenbach & T.H. Carr (Eds.). *Inhibitory processes in attention, memory, and language* (pp.359-381). San Diego, CA: Academic Press.

Sohn, H.-M. (1999). *The Korean language.* Cambridge: Cambridge University Press.

Spencer, A., & Zwicky A. M. (1998) *The handbook of Morphology*, Oxford: Blackwell Publishers.

Stoltz, J. A., & Besner, D. (1998). Levels of representation in visual word recognition: A dissociation between morphological and semantic processing. *Journal of Experimental Psychology: Human Perception & Performance, 24,* 1642-1655.

Strong-Krause, D. (2000). Exploring the effectiveness of self-assessment strategies in ESL placement. In G. Ekbatani, & H. Pierson (Eds.), *Learner-directed assessment in ESL* (pp.49-61). Hillsdale, NJ: Lawrence Erlbaum.

Schwanenflugel, P. J., & Rey, M. (1986). Interlingual semantic facilitation: Evidence for a common representational system in the bilingual lexicon. *Journal of Memory and Language, 25*, 605-618.

Taft, M. (1994). Interactive-activation as a framework for understanding morphological processing. *Language and Cognitive Processes, 9*, 271–294.

Taft, M. (2004). Morphological decomposition and the reverse base frequency effect. *The Quarterly Journal of Experimental Psychology*, *57,* 745 – 765.

Taft, M., & Ardasinski, S. (2006). Obligatory decomposition in reading prefixed words. *The Mental Lexicon, 1*, 183 – 199.

Taft, M., & Forster, K. (1975). Lexical storage and retrieval of prefixed words. *Journal of Verbal Learning and Verbal Behavior, 14*, 638-647.

Talamas, A., Kroll, J. F., & Dufour, R. (1999). Form related errors in second language learning: A preliminary stage in the acquisition of L2 vocabulary. *Bilingualism: Language and Cognition, 2,* 45–58.

Tokowicz, N., Kroll, J. F., De Groot, A. M. B., & Van Hell, J. G. (2002). Number-of-translation norms for Dutch-English translation pairs: A new tool for examining language production. *Behavior Research Methods, Instruments, and*

Computers, 34, 435-451.

Tzelgov, J., & Eben-Ezra, S. (1992). Components of the between language semantic priming effect. *European Journal of Cognitive Psychology, 4,* 253-272.

Ullman, M. T. (2001). The neural basis of lexicon and grammar in first and second language: the declarative/procedural model. *Bilingualism: Language and Cognition*, *4*, 105–122.

Ullman, M. T. (2004). Contributions of memory circuits to language: The declarative/procedural model. *Cognition. 92*, 231–270.

Vaid, J., & Menon, R. (2000). Correlates of bilinguals' preferred language for mental computations. *Spanish Applied Linguistics, 4,* 325–342.

Van Hell, J. G. (1998). Cross-language processing and bilingual memory organization. Unpublished doctoral dissertation, University of Amsterdam.

Van Hell, J. G., & de Groot, A. M. B. (1998a). Conceptual representation in bilingual memory: Effect s of concreteness and cognate status in word association. *Bilingualism: Language & Cognition, 1,* 193-211.

Van Heuven, W. J. B., Dijkstra, T., & Grainger, J. (1998). Orthographic neighborhood effects in bilingual word recognition. *Journal of Memory and Language, 39*, 458-483.

Verhoeven, L., & Perfetti, C. A. (2003). Introduction to This Special Issue: The role of morphology in learning to read. S*cientific Studies of Reading*, *7*(3), 209-218.

Viberg, Å. (2001). Age-related and L2-related features in bilingual narrative development in Sweden. In L. Verhoeven & S. Stromqvist (Eds.). *Narrative development in a multilingual context (pp. 87-128)*. Amsterdam: John Benjamins.

Williams, J. N. (1994). The relationship between word meanings in the first and second language: Evidence for a common, but restricted, semantic code. *European Journal of Cognitive Psychology, 6,* 195-220.

Woo, H. (1999). The Principles of Morphs-Writing Methods and Range of Application, *Korean Language, 25,* 261-291.

Zwitserlood, P. (1994). The role of semantic transparency in the processing and representation of Dutch compounds. *Language and Cognitive Processes, 9*, 341-368.