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(Not) Keeping another language in mind: Structural representations in bilinguals

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(Not) Keeping another language in mind: Structural representations in bilinguals

A dissertation submitted in partial satisfaction of the requirements for
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in

Experimental Psychology

by

Danbi Ahn

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2021

The dissertation of Danbi Ahn is approved, and it is acceptable in quality and form for publication on microfilm and electronically.

University of California San Diego

2021

DEDICATION

For Mom

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Chapter 2, in full, is a reprint of the material as it appears in Ahn, D., Ferreira, V. S., & Gollan, T. H. (2021). Selective activation of language specific structural representations: Evidence from extended picture-word interference. *Journal of Memory and Language*, *120*, 104249. The dissertation author was the primary investigator and author of this paper.

Chapter 3, in full, is currently being prepared for submission for publication of the material. Ahn, Danbi; Ferreira, Victor. S.; Gollan, Tamar. H. The dissertation author was the primary investigator and author of this material.

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ABSTRACT OF THE DISSERTATION

(Not) Keeping another language in mind: Structural representations in bilinguals

by

Danbi Ahn

Doctor of Philosophy in Experimental Psychology

University of California San Diego, 2021

Professor Victor Ferreira, Co-Chair
Professor Tamar Gollan, Co-Chair

Different languages have different *sentence structures*—i.e., rules and information that guide the assembly of words into sentences. How are the sentence structures from two languages with very different word orders organized in a bilingual's mind? Chapter 1 aimed to disentangle whether structural representations are shared or separate-and-connected by using cumulative cross-language structural priming, which does not involve frequent language switching (unlike standard cross-language structural priming). Contra the rich evidence from standard cross-language structure priming, results from Chapter 1 suggest separate-and-connected representations of sentence structures from two languages with different word orders. By measuring production time of each word in a phrase using an extended picture-word interference paradigm, Chapter 2 examined whether bilinguals access sentence structures from both languages even when only speaking one. Results suggest language-specific structural activation for phrases that have different linear word order across languages, even when there are frequent language switches. Finally, using acceptability judgment and memory-recall paradigms, Chapter 3 investigated whether the word order information from a second language (L2) influences the representation and use of the first language (L1). Results suggest that L1 structural representations can change after L2 immersion, but not such that L1 sentences resemble L2 structures. Instead, the L2 immersion seems to be associated with "noisier" L1 representations. Together, this dissertation demonstrates the mostly separate structural representations of two languages that use different word orders.

INTRODUCTION

Speakers have the information that guides the assembly of words into sentences (i.e., *sentence structures)* in the languages that they know. Knowing more than one language, bilinguals need to represent highly related structural information about their two languages. For example, Dutch-English bilinguals know that they can describe an event by using a prepositional dative (PD) (e.g., *the knitter gives the sweater to* ***her sister***)*,* or a direct object dative (DO) sentence structure in English (e.g., *the knitter gives* ***her sister*** *the sweater*). Similarly, they also know that they can use the comparable PD structure (e.g., *de breister geeft de trui aan* ***haar zus***) or DO structure (e.g., *de breister geeft* ***haar zus*** *de trui*) in Dutch. While there are language pairs such as Dutch and English that are similar to each other in sentence structure, especially in word order, there are also language pairs such as Korean and English that are very different in word orders even for a comparable sentence structure. For example, Korean-English bilinguals know that they should use the verb in the middle of the sentences in English (e.g., *the knitter* **gives** *the sweater to her sister*), while they should use the verb at the end of the sentences in Korean (e.g., *[knitter][sweater][sister][****give****]*). How are these sentence structures from different languages organized in a bilingual's mind?

Studies in bilingualism have been investigating this question mostly by using *cross-language structural priming* paradigm. In monolingual studies, *structural priming* refers to the phenomenon in which speakers tend to repeat the same sentence structure that they previously processed or produced (Bock, 1986; for reviews, see Mahowald, James, Futrell, & Gibson, 2016; Pickering & Ferreira, 2008). For example, speakers are more likely to say *the clown throws* ***the cook*** *the ball* (a DO structure) after saying *the knitter gives* ***her sister*** *the sweater* (another DO structure) compared to after saying *the knitter gives the sweater to* ***her sister*** (a PD structure).

The idea is that for alternative sentence structures such as PD vs. DO, using one of the structures allows that structure to remain accessible so that speakers are more likely to use the same structure in a subsequent production rather than selecting an alternative, less accessible sentence structure.

Critically, bilinguals also show cross-language priming, such that they tend to repeat the same sentence structure even when the previously processed or produced sentence is in a different language than the language that they are actively speaking (e.g., Hartsuiker, Pickering, & Veltkamp, 2004; Loebell & Bock, 2003; see Gries & Kootstra, 2017; Hartsuiker & Bernolet, 2017; Hartsuiker & Pickering, 2008; Kootstra & Muysken, 2017; Van Gompel & Arai, 2018). For example, Dutch-English bilinguals are more likely to say *de clown gooit* ***de kok*** *de bal* (*the clown throws* ***the cook*** *the ball*; a DO structure in Dutch) after saying *the knitter gives* ***her sister*** *the sweater* (another DO structure, but in English) compared to after saying *the knitter gives the sweater to* ***her sister*** (a PD structure in English). Such cross-language structural priming has been widely observed using different sentence structures and language pairs, and even using language pairs with different word orders (e.g., Bernolet, Hartsuiker, & Pickering, 2009; Chen, Jia, Wang, Dunlap, & Shin, 2013; Desmet & Declercq, 2006; Hwang, Shin, & Hartsuiker, 2018; Muylle, Bernolet, & Hartsuiker, 2020, 2021; Shin & Christianson, 2009; Weber & Indefrey, 2009). For example, similar to Dutch-English bilinguals, Korean-English bilinguals are also more likely to say *the knitter gives* ***her sister*** *the sweater* (a DO structure) in English after saying *[clown]**[cook]**[ball][throw]* (a DO structure, but in Korean) compared to after saying *[clown][ball]**[cook]**[throw]* (a PD structure in Korean) despite the word order differences in Korean and English. Cross-language structural priming studies have argued that comparable sentence structures across languages are organized in a bilingual's mind in a single, shared representation rather than separate representations. That is, accessing a DO sentence structure in one language facilitates the production of a DO sentence structure in another language only because the representation of a DO sentence structure is one and the same for the two languages. If there are two separate representations of a DO structure per language, accessing a DO sentence structure in one language should not lead to increased accessibility and production of a DO structure in another language.

Although experiments using cross-language structural priming have been useful for better understanding bilingual structural representation, they do have several limitations. The current dissertation aims to extend the current understanding of bilingual structural organization by using novel methods other than standard cross-language structural priming. Furthermore, this dissertation focuses on structural representations of relatively less investigated Korean-English bilinguals, whose languages are typologically very different from each other.

Chapter 1 fills the gap in the existing literature by disentangling whether the structural representations of a bilingual are completely shared, or if they are separate-and-connected across languages. Some studies have reported equivalent levels of structural priming within- vs. cross-languages, arguing for a completely shared structural representation in bilinguals (Kantola & van Gompel, 2011; Schoonbaert, Hartsuiker, & Pickering, 2007). Nevertheless, in a standard cross-language structural priming paradigm, participants switch between languages trial-by-trial. This experimental property of standard cross-language priming could have led to equivalent levels of within- vs. cross-language structural priming even if the representations are separate and connected rather than completely shared. Thus, we investigated whether the magnitude of within- vs. cross-language structural priming still remains equivalent in a cumulative structural priming (i.e., structural priming across blocks rather than trial-by-trial), where switches between languages are minimized compared to standard cross-language structural priming. Experiment 1 revealed that while there was significant within-language structural priming for English-to-English priming, there was no cross-language structural priming observed across Korean and English, suggesting completely separate representations across Korean and English. However, when Korean was the priming language, the priming effects were unreliable. We suspected that it might be because of the way the priming sentences were presented to participants, which introduced some differences in English and Korean priming sentences. Experiment 2 directly tested this by better matching the English and Korean priming sentences. Still, we found that priming effects were unreliable when priming language was in Korean. However, together with a combined post-hoc analysis, we suggest that the data are most consistent with the claim of separate-and-connected structural representation across languages.

Chapter 2 investigates whether Korean-English bilinguals access the sentence structures of both their languages while speaking in only one, when the sentence structures across languages are very different in word orders. To do so, we examined when speakers plan each noun in a noun phrase, such as *the lemon below the lobster*. Critically, the same event in Korean is described as *[lobster][below][lemon]*, saying the location (*lobster*) first, unlike English which describes the object (*lemon*) first. We first established how English monolinguals speaking English and Korean-immersed speakers speaking Korean plan each noun in the phrase by using an extended picture-word interference paradigm, measuring articulation times for each word in the phrase. Experiment 1 revealed that English monolinguals speaking English plan each noun in the phrase "just in time," right before saying each noun. Experiment 2 showed that Korean-immersed speakers speaking Korean do not plan the speech of the noun phrase "just in time" like English monolinguals do, but the planning of their Korean speech differs from the English monolinguals' English speech planning. Using the same paradigm on English-immersed Korean-English bilinguals, Experiment 3 showed that, when not expecting frequent language switches, English-immersed speakers' English speech planning resembles that of English monolinguals' while their Korean speech planning resembles Korean-immersed speakers', suggesting that their representations of English and Korean noun phrases are separate and do not influence the speech of each other. Experiment 4 replicated the pattern observed in Experiment 3 even when English-immersed speakers did expect frequent language switches, suggesting that the language-specific activation of noun phrases persists even with the recent activation of another language.

Finally, Chapter 3 examines the long-term effect of second language (L2) immersion on the first language (L1) for late Korean-English bilinguals. In three experiments, we compared Korean-immersed speakers (who had little exposure to English) and English-immersed speakers (who had extensive exposure to English) in their Korean sentence processing and production. Experiment 1 showed acceptability judgment patterns of Korean sentences that were opposite from what we would expect if L1 sentence processing becomes more like L2 after L2 immersion. That is, compared to English-immersed speakers, Korean-immersed speakers rated the Korean sentences in Korean-canonical word orders and Korean sentences in English-canonical word orders higher. Experiments 2 and 3 compared the Korean sentence production of the two groups, in Korean- vs. English-canonical word orders (Experiment 2) and Korean-canonical word order vs. a word order that is non-canonical in both Korean and English (Experiment 3). Again, we did not observe evidence that English-immersed Korean native speakers' Korean sentence production resembles English sentence structures. Instead, it seems that Korean speakers' Korean production becomes "noisier" after English immersion.

Together, the goal of this dissertation is to provide a more comprehensive understanding of how structural information from two languages is organized in a bilingual's mind and how that organization influences speech production, especially when the bilingual's two languages differ in word order. Across nine experiments, I examine whether structural representations are shared, or are separate-and-connected across two languages (Chapter 1), whether bilinguals access the structural information of both their languages even when speaking in only one (Chapter 2), and whether L2 immersion influences the L1 in a way that L1 processing and production becomes to resemble the L2 structures (Chapter 3). The results suggest that that structural representations of Korean and English are mostly separate and have limited influence on production of one another. In all, these lines of experiments illuminate how bilinguals represent and use the sentence structures from the two languages that are typologically very different.

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CHAPTER ONE

Shared vs. Separate Structural Representations:

Evidence From Cumulative Cross-Language Structural Priming

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Abstract

How do bilingual speakers represent the information that guides the assembly of words into sentences for their two languages? The shared-syntax account (Hartsuiker, Pickering, & Veltkamp, 2004) argues that bilinguals have a single, shared representation of the sentence structures that exist in both languages. Structural priming has been shown to be equal within- and across-languages, providing support for the shared-syntax account. However, equivalent levels of structural priming within- and across-languages could be observed even if structural representations are separate and connected, due to frequent switches between languages, which is an experimental property of standard structural priming paradigms. Here, we investigated whether cumulative structural priming (i.e., structural priming across blocks rather than trial-by-trial), which does not involve frequent switches between languages, also shows equivalent levels of structural priming within- and across-languages. Results suggest that cumulative structural priming appears be more persistent within- compared to across-languages, suggesting a separate-and-connected account of bilingual structural representations.

Keywords: Bilingualism, Sentence production, Cumulative structural priming, Bilingual syntax

1. Introduction

Because any pair of languages will have differences as well as similarities, bilinguals need to represent different but highly related knowledge about the two languages they speak. Even so, proficient bilinguals are nearly flawless at using only their intended language and they do so nearly always correctly. This issue leads to a central topic in bilingualism: How is the knowledge of two languages organized in the one cognitive system of a bilingual speaker?

Studies have revealed that even when bilinguals speak in one language, linguistic representations (e.g., words and sounds) from both of their languages are accessed (for reviews, see Costa, 2005; Dijkstra & van Heuven, 2002; Kroll & Gollan, 2014; Kroll, Gullifer, & Rossi, 2017; Runnqvist, Strijkers, & Costa, 2014). Recently, the field of bilingualism extended this topic to structural organization in bilinguals, to investigate how comparable constructions in two languages are organized in a bilingual's cognitive system. That is, both English and Spanish have comparable active (e.g., *the dog chases the cat; el perro persigue al gato)* and passive (e.g., *the cat is chased by the dog*; *el gato es perseguido por el perro*) constructions. For such comparable constructions, are structural representations in bilinguals' two languages shared or separate?

One way that structural knowledge could be organized in bilinguals' cognitive systems is that constructions could be completely separately represented. It may be helpful to have English and Spanish constructions fully separate, particularly when bilinguals are in a setting that requires them to use only one language (e.g., conversing with a monolingual friend). Given that there are still subtle differences in comparable constructions in English and Spanish (e.g., the word-to-word English translation of Spanish active *El perro persigue* ***a****l gato* is approximately *the dog chases* ***at-him*** *the cat*, having a preposition before the patient), separate Spanish and English active constructions would be helpful in avoiding grammatical mistakes that resemble correct sentences of the non-target language, thereby aiding bilinguals when they want to speak in one language. On the other hand, having separate constructions for two languages is not the most economical way to represent sentence structures because some information is represented twice, leading to notable redundancy. Having separate structural representations for different languages might also present some inefficiency when switching between two languages often (e.g., during online language interpretation).

Alternatively, bilinguals might represent the analogous sentence structure across languages only once, which introduces the advantages and disadvantages that are opposite from those of having separate representations of sentence structures across languages. Specifically, although having the analogous construction represented only once reduces redundancy and might be useful when having to switch back and forth between languages often (e.g., translating from one language to another), it might be difficult to keep subtle differences straight which could lead to more grammatical errors when trying to speak in only one language.

This question of whether structural representations in the two languages bilinguals know are shared or separate has been investigated using cross-language structural priming methods. Structural priming (Bock, 1986; see Mahowald, James, Futrell, & Gibson, 2016; Pickering & Ferreira, 2008) refers to the phenomena in which speakers are more likely to repeat a sentence structure that they previously used or processed when describing another event that could be described using the same structure. For example, English speakers are more likely to say *the ball is hit by the bat* after saying *the cat is chased by the dog* compared to after saying *the dog chases the cat*. The underlying idea is that after accessing one of the alternative constructions, speakers are more likely to use the same construction to describe another event rather than trying to access the other construction. The same idea applies to cross-language structural priming. If there is only one structure shared across languages, then speakers would be more likely to use the same construction that is already accessed in one language even when describing an event in another language. Crosslinguistic priming would not be observed if there are completely separate structural constructions for different languages, as eliciting one construction in one language would not necessarily elicit the similar construction in the other language.

Cross-language structural priming has been observed in multiple studies using different languages, providing evidence for shared structural organization in bilinguals (e.g., Hartsuiker, Pickering, & Veltkamp, 2004; Loebell & Bock, 2003; see Gries & Kootstra, 2017; Hartsuiker & Bernolet, 2017; Hartsuiker & Pickering, 2008; Kootstra & Muysken, 2017; Van Gompel & Arai, 2018). In these studies, bilinguals were given a priming sentence in one language and were asked to immediately produce a target sentence in another language. Bilinguals often used target sentence structures that matched the structure from the priming sentences, supporting an integrated (shared lexicon, shared syntax) account of bilingual language representation (Hartsuiker et al., 2004). This model claims that verbs in each language are connected to a *combinatorial node* (representing sentence structures that the verbs can take) that is shared between languages. Cross-language structural priming occurs because the combinatorial node remains accessible after processing a sentence structure in one language, which then leads it to be reused during production of the analogous structure in another language.

Although experiments using cross-language structural priming have been useful for better understanding bilingual structural representation, they do have several limitations. One is that models that assume separate and interacting structural representations between two languages could also explain the presence of structural priming across languages. That is, separate structural representations from different languages might be connected to each other when they represent the same or corresponding sentence structures (much like translation equivalent lexical representations might be linked directly; Kroll & Stewart, 1994). Some studies have attempted to disentangle a shared syntax model from a separate but closely connected model by comparing the strength of structural priming for within- versus cross-languages (Bernolet, Hartsuiker, & Pickering, 2013; Cai, Pickering, Yan, & Branigan, 2011; Hartsuiker, Beerts, Loncke, Desmet, & Bernolet, 2016; Kantola & van Gompel, 2011; Schoonbaert, Hartsuiker, & Pickering, 2007). A shared syntax account predicts no difference in the size of structural priming across languages vs. within a single language, because it claims that the representation of a given structure in a bilingual's two languages are one and the same. In contrast, a separate but connected or interacting account of bilingual syntax predicts weaker structural priming across languages compared to within a single language, because activation must cross the extra connection between a combinatorial node for one language and a combinatorial node for a different language (see Figure 1.1).

Supporting a shared syntax account, several studies found equivalent levels of structural priming within and across languages (Hartsuiker et al., 2016; Kantola & van Gompel, 2011; Schoonbaert et al., 2007). However, it is not completely conclusive that structural representations must be shared between bilinguals' two languages in part because such evidence is based on null effects (i.e., the lack of difference between the size of the two priming effects). For instance, it is possible that the separate structural representations from the two languages are so closely connected that the difference between within- and cross-language structural priming strength is hard to detect. Furthermore, in contrast to these studies, other studies reported stronger within-compared to cross-language priming (Bernolet et al., 2013; Cai et al., 2011; Travis, Torres Cacoullos, & Kidd, 2017). Bernolet et al. (2013) attributed these discrepancies to their participants' low proficiency in the second language (L2), and argued that the development of shared structural representations with first language (L1) might require high proficiency in both languages.

Another possible reason why some studies have observed equivalent levels of structural priming within and across languages is that using standard prime-target structural priming to investigate the organization of sentence structures in bilinguals naturally involves using two languages at the same time. That is, in the same experimental session, participants need to switch between the two languages frequently (indeed, from prime to target). Although bilinguals can frequently switch between languages when speaking to another bilingual, doing so may require maintaining high accessibility of two languages even if they have separate representations. Thus, to disentangle whether structural representations are shared or are separate-and-connected across two languages, examining bilingual speech during production of just one language will be valuable.

To do so, we adapted the cumulative structural priming method (Kaschak, 2007; Kaschak, Kutta, & Coyle, 2014; Kaschak, Kutta, & Schatschneider, 2011; Kaschak, Loney, & Borreggine, 2006) which allows more separation between prime and target experimental trials and thus could provide an environment in which only one language is used without an expectation of frequent language switches. In a series of experiments with English monolingual speakers, Kaschak and colleagues found that patterns of experience with dative constructions affected the base rates of production of those constructions in a subsequent production block. For example, participants were asked to complete multiple sentence fragments that were designed to induce production of prepositional dative (PD) constructions (e.g., *Meghan gave the doll…*) in a block. Then, when asked to complete sentence fragments that could be completed as either PD or double object dative (DO) constructions (e.g., *The soldier gave…*) in a subsequent block, they were more likely to complete these sentences using PD constructions. In contrast, when participants were initially asked to complete sentence fragments that were designed to induce production of DO constructions (e.g., *Meghan gave her mother…*), they were more likely to complete the sentence fragments in the subsequent block using DO constructions. This suggests that structural priming might reflect the operation of the long-term implicit learning of the use of sentence structures (e.g., Bock & Griffin, 2000; Chang, Dell, & Bock, 2006). If sentence structures are shared across languages, we should see a similar pattern of cumulative structural priming across languages as within. Alternatively, if structural representations from bilinguals' two languages are separate (even if they are tightly connected), it is reasonable to assume that implicit learning in one language would not transfer to the other. If structural representations are separate across languages, we should not observe cross-language structural priming. If structural representations are separate-and-connected across languages, we should observe less priming across languages than within.

To test this hypothesis, we adapted the method from Kaschak's studies and examined cumulative structural priming across languages in Korean-English bilinguals. Although Korean and English have different canonical word orders, the dative alternation is analogous across the two languages. That is, both English and Korean construct the different forms within the dative alternation by changing the positions of the theme and the goal of the sentences (e.g., *the doll* and *the mother* in the sentence *Meghan gave the doll to the mother*). Furthermore, using a standard cross-language structural priming paradigm, Shin and Christianson (2009) observed structural priming between English and Korean dative structures. If the representation of Korean and English dative constructions are completely shared, we should see that bilinguals are equally likely to use the constructions presented in a previous block regardless of whether the two blocks include the same or different languages. If the constructions are completely separate, we should only observe priming when the two languages are the same. If the constructions are separate but connected, we should observe structural priming both when the two blocks are the same language and when they are different languages, but less priming across languages.

2. Experiment 1

2.1. Method

2.1.1. Participants

Forty-eight Korean-English bilinguals from the UC San Diego Department of Psychology subject pool volunteered for course credit or monetary compensation. The number of participants was decided based upon Kaschak et al. (2011) which found significant priming effects with 20 participants per condition. As we describe in materials and design below, each of our participants were given four of the eight possible conditions, therefore allowing 24 participants per condition. All participants indicated that they were born and raised in Korea at least until the age of 11. All participants learned Korean as a first language and English as a second language, and all but 6 participants were dominant in Korean according to their ability to name pictures in each language (see below). All 6 participants who were dominant in English were highly proficient in both English and Korean [88.5% (1.5%) correct in English vs. 83.6% (3.1%) correct in Korean on the picture-naming task, respectively]. Detailed information about the participants' language proficiency and language history is presented in Table 1.1.

2.1.2. Materials and Design

Seven ditransitive action verbs (e.g., *read*) were selected. For each action, 14 stock photos (98 photos total) depicting ditransitive actions with various agents, themes, and goals were selected from Shutterstock.com. To minimize bias towards theme-goal or goal-theme word order, whether the theme was on the left or right of the goal in the photos was counterbalanced.

Each picture was included only once. However, given the availability of pictures found on Shutterstock.com, many pictures depicted the same event (e.g., a woman reading a book to a girl). Sentences describing events in the pictures were created. Repetition of the same sentence was minimized using family relationships or synonyms that were reasonable given the photos. For example, photos depicting an event of a woman reading a book to a girl were described using different sentences such as "The woman is reading the book to the girl," "the mother is reading the bedtime story to her daughter," or "the aunt is reading the fairy tale to her niece." All items were translated into Korean.

Items were divided into 42 priming items and 56 target items. For each priming item, two sentence fragments that force the sentence completion to theme-goal (e.g., The woman is reading ______ to the girl.) or goal-theme (e.g., The woman is reading ______ the book) word orders were created. For each target item, one sentence fragment that could be completed using either theme-goal or goal-theme word orders was created (e.g., The man is giving ______).

Four lists were created. Each list included 6 blocks (2 priming blocks and 4 target blocks). The priming items were presented in the first and the fourth blocks, and the target items were presented in second, third, fifth, and sixth blocks. Each priming block included 21 items, and each target block included 14 items. Each list involved one Korean priming block, one English priming block, two Korean target blocks, and two English target blocks. The priming sentence structures (theme-goal vs. goal-theme) were different for the two priming blocks. The target blocks that were next to each other were always in different languages. Thus, each list involved both priming sentence structures (theme-goal vs. goal-theme), both priming languages

(Korean vs. English), and both types of structural priming (cross-language vs within-language). The orders in which these were presented were counterbalanced across four lists (see the counterbalanced lists available at tinyurl.com/2uj4zy29).

An additional 104 pictures depicting intransitive (e.g., sleep) or transitive (e.g., eat) events were selected for filler items. Sentences describing the events in the pictures were created using similar procedures as the critical items. However, the sentence fragments were created in a way that English sentence fragments involved blanks in the middle of the sentences when possible. This was to compensate for where the blanks appeared in the sentence fragments in the critical sentences. Because Korean is a verb-final language and all target sentences were given with the agents and verbs, all Korean critical target sentences had the blanks in the middle of the sentence fragments and all English critical target sentences had the blanks at the end of the sentence fragments. The filler items were inserted between critical items so that neither the critical items nor the filler items were presented more than twice in a row. Example materials are presented in Figure 1.2. All sentence materials are available at tinyurl.com/2uj4zy29.

2.1.3. Procedure

The experiment was presented on an iMac (21.5-inch, Mid 2014) using PsychoPy2 (Version 1.81.03; Peirce et al., 2019). Spoken responses were recorded via a Marantz PMD661 Solid State Recorder. Voice recordings were transcribed for later analyses.

Each trial was presented with a photo and a corresponding sentence fragment. Participants were asked to describe the photos (e.g., *a child drinking a green drink in a glass using a straw*) by filling in the blanks in the sentence fragments (e.g., *The child is drinking* ______.) using the language that the sentence fragments are presented in. During a pilot study, some participants had difficulty coming up with any words to complete sentences under time pressure, and claimed that they felt as though they had to come up with the "correct words" that fit in the blanks and could not think of them under time pressure. Such pilot participants were able to complete sentences in time when they were encouraged to start speaking as soon as they saw the pictures by saying anything. Thus, to support more sentence completions and to conceal the real purpose of the study, participants were assured that there was no one correct answer (e.g., *the drink* can be described as *the drink*, *the smoothie*, or *the juice*) and encouraged to use more than one word to fill in the blank using information present (e.g., *green, using a straw, from a glass*) or not present (e.g., *in the morning, delicious, healthy*) in the photo. To minimize possible goal drops, participants were encouraged to use all characters in their description of the photos when there was more than one character in the photo. Participants were told that the sentence fragments may be in English or Korean, but all trials in one block were in the same language.

Each experimental trial lasted for 8 seconds, with a countdown timer at the bottom of the screen. At the beginning of a trial, a photo and the sentence fragment appeared on the screen with a short click sound; the photo stayed on the screen for 8 seconds. At the end of the trial, a blank screen appeared for 200 milliseconds. Trials in each block automatically advanced without a break. Participants were allowed a short break between each block. At the end of the experiment, participants completed an adapted version of Multilingual Naming Test (MINT; Gollan, Weissberger, Runnqvist, Montoya, & Cera, 2012) and a language history questionnaire. To adapt the MINT for use in Korean, 7 items that are Korean-English cognates were excluded; thus, participants were tested on 61 items, first in English, and then in Korean. Note that the MINT was developed for use with speakers of Spanish, Chinese, Hebrew, and English, and the Korean adaptation was not validated against a Korean proficiency interview (as was done for the languages for which the MINT was originally developed). Thus, although it is not clear to what extent the scores accurately reflect degree of dominance in Korean versus in English, the scores are still useful for matching bilinguals within each language.

2.1.4. Coding and Analysis

Only the responses from the target phase were used for analysis. Participants' responses on critical items were coded into theme-goal, goal-theme, or other. "Other" responses were removed prior to analysis (15% of the total data). Theme-goal responses were coded as 1 and goal-theme responses were coded as 0. GLMMs were fit using the 'glmer' function from the lme4 package (Version 1.1-20; Bates, Mächler, Bolker, & Walker, 2015) in R: A Language and Environment for Statistical Computing (Version 3.5.1; R Core Team, 2014). We used sum–to–zero contrasts (i.e., the intercept of the model was the grand mean of the dependent measure) to code the categorical predictors, language (English vs. Korean), prime structure (goal-theme vs. theme-goal) and prime type (across languages vs. within languages). We first attempted to fit GLMMs incorporating the maximal random effects structure given the experimental design (Barr, Levy, Scheepers, & Tily, 2013). For maximal models that did not converge, random effects accounting for the least variance were gradually removed until a model successfully converged. Using the R function 'Anova' from the car package (Version 3.0-2; Fox & Weisberg, 2019), type III Wald Chi square tests were conducted in order to calculate main effects and interactions. When significant or marginally significant interactions were found, the emmeans package (Version 1.3.2; Lenth, 2019) was used to compute and compare estimated marginal means and standard errors for each treatment level. The data and R code are available at tinyurl.com/2uj4zy29.

2.2. Results

Figure 1.3 illustrates the proportion of theme-goal responses depending on target response language and conditions. Means are presented along with statistics, and standard deviations are reported in parentheses next to means.

Participants produced significantly more theme-goal responses in English compared to in Korean [.91 (.17) vs. .47 (.31), χ^2 (1) = 67.47, p < .001]. Prime structure (theme-goal vs. goal-theme) did not influence the response rates of theme-goal structure [.69 (.22) vs. .69 (.23), χ^2 (1) = 1.71, p = .19]. Prime type (within-language priming vs. cross-language priming) did not influence the rates of theme-goal structure [.69 (.18) vs. .65 (.16)%, χ^2 (1) < 1, p = .75].

None of the two-way interactions, between prime structure and prime type, prime structure and language, and prime type and language, were significant (all χ^2s < 1).

However, the 3-way interaction between prime structure, prime type, and language was marginally significant, hinting that the extent of difference of within-language vs. cross-language priming effects are different for English and Korean (χ^2 (1) = 3.71, p = .054). Comparing estimated marginal means revealed that only English showed different within- vs. cross-language priming effects. That is, when speaking English and the priming language was in English, participants produced significantly more theme-goal responses when given theme-goal primes compared to when given goal-theme primes, showing a classic within-language structural priming effect in English [.95 (.14) vs. .84 (.25), b = -2.23, SE = 1.13, z = -1.98, p = .048; transformed means as shown in Figure 1.1 = .98 vs. .95]. In contrast, when speaking English but the priming language was in Korean, the rate of theme-goal responses was not influenced by theme-goal vs. goal-theme primes, showing a lack of cross-language structural priming effect when the response language is English [.88 (.20) vs. .97 (.06), b = 1.01, SE = .98, z = 1.03, p = .30; transformed means as shown in Figure 1.1 = .96 vs .99]. Note that unexpectedly, not only we did not observe cross-language structural priming, but also the direction of priming was reversed such that the rate of theme-goal responses was numerically (but not statistically) higher when given goal-theme primes compared to given theme-goal primes. When speaking Korean and the priming language was in Korean, the rate of theme-goal responses was not influenced by theme-goal vs. goal-theme primes, showing lack of within-language structural priming when the response language is Korean [.43 (.32) vs. .52 (.36), b = .63, SE = .77, z = .81, p = .42; transformed means as shown in Figure 1.1 = .34 vs. .51]. Similarly to the pattern of cross-language structural priming when English is the response language, note that the direction of priming was reversed. When speaking Korean and the priming language was in English, the rate of theme-goal responses was not influenced by theme-goal vs. goal-theme primes, showing lack of cross-language structural priming when the response language is Korean [.54 (32) vs. .38 (.32), b = -1.05, SE = .66, z = -1.59, p = .11; transformed means as shown in Figure 1.1 = .51 vs. .29].

2.3. Discussion

Using a cumulative structural priming paradigm, we did not observe consistent cross-language or within-language structural priming. That is, we observed the expected structural priming effects in the English within-language condition, in which both prime and targets were in English. In all other conditions, we failed to find robust structural priming. Thus, taken at face-value, these results are consistent only with fully separate structural representations between languages, though under such an account, it is unclear why we why we failed to observe Korean-to-Korean structural priming.

When Korean was the prime language, we observed a numerical differences in the direction opposite to an expected priming effect, which is curious. This suggests that some aspect of our task setup might have worked against finding structural priming from Korean, for example, the way participants completed sentences. In particular, the priming and target items were created such that the blanks in the sentences were placed at about the same linear position across English and Korean. Although this was done to minimize the discrepancies in the English and Korean priming sentences, it may have had unintended effects. Recall that English theme-goal priming sentences involved participants filling in the theme of the sentence in order to complete the sentence (e.g., *The woman is reading ______ to the girl*). Because Korean is a verb final language, having the blanks at approximately the same position across the two languages involved participants filling in the goal of the sentence in order to complete the Korean theme-goal priming sentences (e.g., *[woman] [book] _____ [is reading].).* This also happened in goal-theme priming sentences, such that participants had to come up with the goal of the sentence for English priming sentences (e.g., *The woman is reading _______ the book*), but had to come up with the theme of the sentence for Korean sentences (e.g., *[woman] [girl] _____ [is reading]*). Coming up with material for the blank might have driven the structural priming in this fill-in-the-blank paradigm rather than the entire sentence. For the Korean theme-goal priming conditions, having to come up with the goal of the sentence repeatedly might have put participants in "goal generating mode", encouraging participants to come up with the goal of the sentence as soon as possible during the target phase, leading to more common goal-theme word order, accounting for the backward numerical differences.

To test this hypothesis, we conducted a follow-up experiment in which materials were designed to elicit the theme for theme-goal priming conditions and the goal for goal-theme priming conditions for both the English and the Korean bias phases.

3. Experiment 2

3.1. Method

3.1.1. Participants

Forty Korean-English bilinguals were recruited in the same way as in Experiment 1[1]. All participants indicated that they were born and raised in Korea at least until the age of 11, except three participants who moved to the US at the age of 4, 5, and 10, respectively. Most participants were dominant in Korean based on the scores on the modified MINT. Nine participants were highly proficient in both languages [85.1% (5.9%) correct in English vs. 80.7% (7.1%) correct in Korean on the modified MINT, respectively]. Detailed participant characteristics are provided in Table 1.1.

3.1.2. Materials and Procedure

Materials and procedure were identical to Experiment 1, except the Korean and English sentence fragments from the bias phase encouraged sentence completions using the same thematic roles. For both the English and Korean theme-goal bias sentence fragments, blanks were presented where participants could complete the sentence by describing the theme of the sentence (e.g., *the woman is reading ______ to the girl*; *[woman] [girl] ________ [is reading]*). For both English and Korean goal-theme bias sentence fragments, blanks were presented where participants could complete the sentence by describing the goal of the sentence (e.g., *the woman is reading ______ the book*; *[woman] ______ [book] [is reading]*).

3.1.3. Coding and Analysis

The coding and analysis procedures were identical to Experiment 1. In total, 87% of the data were analyzed.

[1] We planned to recruit 48 participants as we did in Experiment 1. However, the data collection was terminated early due to the COVID-19 lockdown. Forty participants still allowed an even number of participants across the lists.

3.2. Results

Figure 1.3 illustrates the proportion of theme-goal responses depending on target response language and conditions. Means are presented along with statistics, and standard deviations are reported in parentheses next to the means.

Participants produced more theme-goal responses in English compared to in Korean [.95 (.09) vs. .39 (.28), χ^2 (1) = 93.40, p < .001], and the same rate of theme-goal responses for within- vs. cross-language priming [.69 (.18) vs. .65 (.16), χ^2 (1) < 1, p = .68]. In contrast to Experiment 1, participants produced more theme-goal responses when given theme-goal primes compared to when given goal-theme primes [.69 (.19) vs. .65 (.17), χ^2 (1) = 5.50, p = .02], replicating classic cumulative structural priming. The structural priming effect was marginally affected by prime type [i.e., the interaction between prime structure and prime type was marginally significant; χ^2 (1) = 2.74, p = .10], such that collapsed across language, there were structural priming effects for within-language priming [.73 (.34) vs. .64 (.37), b = -1.42, SE = .59, z = -2.40, p = .02], but not for cross-language priming [.66 (.36) vs. .64 (.38), b = .14, SE = .49, z = .28, p = .78].

In contrast to Experiment 1, the statistically marginal interaction between prime structure and prime type was not influenced by language [i.e., the 3-way interaction between prime structure, prime type, and language was not significant; χ^2 (1) = 1.07, p = .30]. However, comparing estimated marginal means revealed that only English showed different within- vs. cross-language priming effects, and in different directions from Experiment 1. That is, when speaking English and the priming language was in English, participants produced more theme-goal responses when given theme-goal primes compared to when given goal-theme primes, showing the expected within-language structural priming effect in English [.96 (.12) vs. .92

(.10), b = -2.04, SE = .98, z = -2.09, p = .04; transformed means as shown in Figure 1.3 = .99 vs .96]. In contrast, when speaking English but the priming language was in Korean, the rate of theme-goal responses was not influenced by theme-goal vs. goal-theme primes, showing a lack of cross-language structural priming effect when the response language is English [.95 (.08) vs. .97 (.08), b = .62, SE = .93, z = .66, p = .51; transformed means as shown in Figure 1.3 = .98 vs. .99]. When speaking Korean and the priming language was in Korean, the rate of theme-goal responses was not influenced by theme-goal vs. goal-theme primes, showing lack of within-language structural priming when the response language is Korean [.51 (.33) vs. .37 (.34), b = -.79, SE = .69, z = -1.14, p = .26; transformed means as shown in Figure 1.3 = .48 vs. .26]. When speaking Korean and the priming language was in English, the rate of theme-goal responses was not influenced by theme-goal vs. goal-theme primes, showing lack of cross-language structural priming when the response language is Korean [.37 (.30) vs. .31 (.26), b = -.34, SE = .50, z = -.68, p = .50; transformed means as shown in Figure 1.3 = .32 vs. .24].

The 2-way interactions between prime structure and language, and prime type and language, were not significant (both $\chi^2 < 1$).

3.3. Discussion

Experiment 2 demonstrated that bilinguals are more likely to produce theme-goal sentences after producing theme-goal primes compared to after producing goal-theme primes, replicating the expected structural priming effect. A marginally significant interaction between prime structure and prime type (within- vs. cross-language) suggests that the structural priming effect was observed in within-language priming, but not in cross-language priming. Furthermore, although the 3-way interaction between prime structure, prime type, and language was not statistically significant, comparing estimated marginal means revealed that the structural priming was observed only when both the prime and target languages were in English. In other words, only when the target language was in English, the extent of structural priming was stronger for within-language compared to cross-language priming. In contrast, when the target language was in Korean, not only was the extent of structural priming not different for within-language versus cross-language priming, but also we did not observe a standard within-language structural priming effect. From this, we might infer that although it is less clear how structural representations are accessed when Korean is the target language, structural representations in English and Korean are organized separately. Overall, it seems that structural priming from Korean, for both within-language and across-languages, was weak and unreliable.

One reason why structural priming effects were inconsistent might be that the priming effects from the first priming phase (priming from Block 1 to Blocks 2 and 3) interfered with the priming efficacy of the second priming phase (priming from Block 4 to Blocks 5 and 6), especially given that cumulative within-language structural priming can persist as long as for a week between prime and target phases (Kaschak et al., 2011). That is, all participants received different types of priming structures in Block 1 vs. Block 4 (e.g., all participants who received theme-goal priming structures in Block 1 received goal-theme priming structure in Block 4). In our analyses, we considered the effects in Blocks 5 and 6 to be structural priming only as a function of the priming structure in Block 4. If potential long-lasting priming effects from Block 1 interfered with the alternative structural priming in Block 4, priming effects in Blocks 5 and 6 would have been lost. If so, we might observe more consistent structural priming effects in Blocks 2 and 3 compared to when collapsing the results across all production blocks (as in Experiments 1 and 2). To test this, we conducted a post-hoc analysis.

3.3.1. Combined analysis of Blocks 2 and 3 from Experiments 1 and 2

The post-hoc analysis was conducted only using the target phase trials following the first bias phase (Blocks 2 & 3). Data from Experiments 1 and 2 were combined to provide maximal power. GLMMs were fit following the same procedures as Experiments 1 and 2.

Figure 1.4 illustrates the proportion of theme-goal responses depending on prime structure and prime type, presented in log-odds space to match statistical analysis.

Participants produced more theme-goal responses in English compared to in Korean [.92 (.17) vs. .40 (.31), χ^2 (1) = 158.09, p < .001], and the same rate of theme-goal responses for within- vs. cross-language priming [.64 (.36) vs. .67 (.36), χ^2 (1) < 1, p = .49]. Participants produced more theme-goal responses when given theme-goal primes compared to when given goal-theme primes [.70 (.20) vs. .61 (.20), χ^2 (1) = 5.85, p = .02], replicating classic cumulative structural priming. The structural priming effect was significantly affected by prime type [i.e., the interaction between prime structure and prime type was significant; χ^2 (1) = 6.74, p = .009], such that collapsed across language, there were structural priming effects for within-language priming [.70 (.34) vs. .59 (.37), b = -1.93, SE = .67, z = -2.87, p = .004], but not for cross-language priming [.73 (.32) vs. .62 (.40), b = -.28, SE = .41, z = -.68, p = .50].

The interaction between prime structure and prime type was significantly influenced by language [i.e., the 3-way interaction between prime structure, prime type, and language was significant; χ^2 (1) = 7.28, p = .007]. Comparing estimated marginal means revealed that English and Korean showed different patterns of within- vs. cross-language priming effects. That is, when speaking English and the priming language was in English, participants produced more theme-goal responses when given theme-goal primes compared to when given goal-theme primes, showing the expected within-language structural priming effect in English [.94 (.18) vs. 82 (.24), b = -3.26, SE = 1.17, z = -2.78, p = .005; transformed means as shown in Figure 1.4

= .98 vs .92]. In contrast, when speaking English but the priming language was in Korean, the rate of theme-goal responses was not influenced by theme-goal vs. goal-theme primes, showing a lack of cross-language structural priming effect when the response language is English [.94 (.10) vs. .97 (.06), b = .84, SE = .63, z = 1.34, p = .18; transformed means as shown in Figure 1.4 = .97 vs. .98]. When speaking Korean and the priming language was in Korean, the rate of theme-goal responses was not influenced by theme-goal vs. goal-theme primes, showing lack of within-language structural priming when the response language is Korean [.45 (.30) vs. .36 (.33), b = -.59, SE = .65, z = -.91, p = .36; transformed means as shown in Figure 1.4 = .40 vs. .25] (because statistical significance was determined in log-odds space, and so the differences close to proportional extremes (0% and 100%) are statistically more prominent than differences around 50%; Jaeger, 2008). When speaking Korean and the priming language was in English, the rate of theme-goal responses was significantly influenced by theme-goal vs. goal-theme primes, showing the expected cross-language structural priming effect from English to Korean [.52 (.33) vs. .27 (.25), b = -1.39, SE = .53, z = -2.62, p = .009; transformed means as shown in Figure 1.4 = .57 vs. .20].

The 2-way interactions between prime structure and language, and prime type and language, were not significant (both $\chi^2 < 1$).

Overall, the results from the post-hoc analysis with only the first half of the experiments were similar to Experiment 2 results. However, we observed a few key differences. First, unlike in Experiment 2, where the interaction between prime structure and prime type was marginally significant, the post-hoc analysis showed a significant interaction between prime structure and prime type, with significant within-language priming but non-significant cross-language priming. Moreover, unlike in Experiment 2, this post-hoc analysis showed significant cross-language priming when the priming language was in English, and the target language was in Korean. The 2-way interaction of a subset of the data (with English-to-English vs. English-to-Korean structural priming) was marginally significant [$\chi^2(1) = 3.19$, $p = .07$]. Although we should be cautious about interpreting this marginally significant interaction, the English-to-English within-language priming trended towards a stronger structural priming effect compared to English-to-Korean cross-language priming. Thus, overall, the significant interaction in this post-hoc analysis between prime type (within- vs. across-languages) and prime structure suggests at the very least that English and Korean structural representations are separate; but the significant priming from English to Korean (along with the marginally stronger priming effect from English-to-Korean compared to from English-to-English) points to separate-but-connected representations of English and Korean structure, such that within-language priming will tend to be more robust than cross-language priming.

4. General Discussion

Using a cumulative structural priming paradigm, two experiments examined the extent of within- vs. cross-language structural priming effects when bilinguals do not switch between languages frequently. The same degree of structural priming for within- vs. cross-language, even when there are no frequent language switches, would have provided strong support for the claims in the current literature that structural representations are shared between the two languages in bilinguals.

Experiment 1 showed that only when both the priming and target languages were English (i.e., only in English within-language structural priming), bilinguals produced more theme-goal sentences after theme-goal primes, showing the classic structural priming effect. Similar to Experiment 1, Experiment 2 showed that only when both the priming and target languages are in

English (i.e., only for English within-language structural priming), bilinguals produced more theme-goal sentences after theme-goal primes, showing the expected structural priming effect. When the priming language was Korean and the target language was English, bilinguals did not show significant structural priming effects, showing the different extent of structural priming effect for cross-language compared to within-language. When the target language was in Korean, we did not observe significant within- or cross-language priming effects. Post-hoc combined analysis of Experiments 1 and 2 with only the priming blocks from the first half of the two experiments was consistent with the possibility that the priming effects from the first priming phase are long-lasting and may have influenced the priming effects into the second half of the experiments. Furthermore, the 2-way interaction between prime structure and prime type from this post-hoc analysis was statistically significant, suggesting that the structural priming effect was stronger for within-language structural priming compared to cross-language structural priming. Altogether, on balance, these experiments and analyses support the claim of separate-and-connected structural representations in bilinguals.

The long-term nature of the priming assessed in this paradigm implies that any cumulative structural priming effect that is revealed relies on implicit learning. If the structural representations in the two languages are completely shared, this implicit learning in one language should be fully transferred to another language. Given that we replicated Kaschak and colleagues' findings of within-language structural priming in English, we might infer that English and Korean structural representations are separate rather than shared. Our results contrast with standard prime-target structural priming studies that showed the same extent of within- vs. cross-language structural priming and argued shared structural representations across languages in bilinguals (e.g., Hartsuiker et al., 2016; Kantola & van Gompel, 2011; Schoonbaert et al., 2007). Instead, our results are more consistent with the findings of stronger within- compared to cross-language structural priming, which support the separate and connected structural representations in bilinguals (e.g., Cai et al., 2011; Travis et al., 2017). Additionally, our results suggest that shared structural representations do not automatically arise from high L2 proficiency (see Bernolet et al., 2013), given that our participants were highly proficient in English (their L2) – structural differences between languages may modulate proficiency effects.

One reason why we observed hints of evidence for separate structural representations might be the word order differences between Korean and English. As we have discussed, although there are some similarities in Korean and English, there are structural differences between English and Korean as well. Most notably for the current sentences, the main verb is at different linear positions in English and Korean sentences, and articles are absent in Korean (e.g., for the PD, *Meghan gave the doll to the mother* vs. *[Meghan][doll][mother][gave]*). Thus, although it may be possible for more typologically similar languages such as Dutch and English to have shared structural representations, languages with structural differences such as Korean and English might develop separate and connected structural representations instead. In fact, the current evidence for languages with different word orders is mixed. Using the same methods as the cross-language structural priming studies with languages with the same linear word order, several studies showed cross-language structural priming using structures with different linear word orders (e.g., Bernolet et al., 2013; Chen, Jia, Wang, Dunlap, & Shin, 2013; Desmet & Declercq, 2006; Hwang, Shin, & Hartsuiker, 2018; Muylle, Bernolet, & Hartsuiker, 2020, 2021; Shin & Christianson, 2009; Weber & Indefrey, 2009), whereas other studies found cross-language structural priming only when the linear word order was the same across languages (Loebell & Bock, 2003; although they also did not observe a statistically significant within-language priming in German passive constructions). In an attempt to disentangle this mixed evidence, Ahn, Ferreira, and Gollan (2021) pointed at possible limitations of standard structural priming methods. That is, the cross-language structural priming effect in some studies for languages with different linear word orders might have been driven by the task properties of standard structural priming methods, rather than sharedness of structural representation. Bilinguals might simultaneously access both languages when expecting frequent language switches, either in anticipation of a language switch or as a result of a recent language switch. Cross-language priming effects could occur because both languages are active to support interleaved production of two languages, not because structural representations are shared across languages. Using a different method other than cross-language structural priming, Ahn et al. argued for separate representations of sentence structures in bilinguals. They tested Korean-English bilinguals while they produced noun phrases ("the cat above the piano"), which have different word orders in English and Korean (the Korean word order is [piano][above][cat]). Then, they examined the planning of each noun in a noun phrase by measuring articulation time of each word within an extended picture-word interference paradigm. They found that bilinguals plan English and Korean speech differently when describing events using noun phrases, suggesting that the representation of noun phrases are separate for English and Korean. In sum, there are discrepancies in the current literature on cross-language structural priming and evidence from a different paradigm that supports separateness of structural organization for languages with different linear word orders. Importantly, our current study was designed to investigate bilingual structural representations with a paradigm that reduces the need to switch between languages often (unlike the standard structural priming methods). Thus, we might infer that our results provide additional insight to structural representation for languages with different linear word orders, such that Korean and English sentence structures are separately represented and that this pattern emerges more clearly when bilinguals do not expect frequent switches between languages.

Finally, it should be noted that the significant interaction between prime structure and prime type might have been driven at least partially by a weaker priming from Korean than from English. This was unexpected, especially given that other studies such as Shin and Christianson (2009) showed an equivalent degree of structural priming for English-to-English and Korean-to-English. We might speculate that Korean dative sentences are represented differently from English dative sentences, and that this difference may not be prevalent in a standard structural priming method but is exaggerated in a cumulative structural priming paradigm. Furthermore, even though comparing estimated marginal means revealed that the within-language structural priming effect was statistically significant while the cross-language structural priming effect was not (and possibly stronger within- compared to cross-language structural priming when any English-to-Korean cross-language priming was observed), the higher order interaction between prime structure and prime type was only marginally significant. One reason might be that when speaking English, participants showed a strong bias for PD compared to DO structures such that it might have been difficult to observe robust priming effects, and even more difficult to observe differences in priming effects for within- versus cross-language conditions. Future research might use different sentence structures that show less bias for one construction over the other. Another possibility is that although we attempted to separate the production of each language by having separate prime and target blocks, the separation was not sufficient to counter possible dual-language activation similar to that in standard structural priming paradigms with two languages interleaved throughout an experimental session. Thus, even with some separation between the two languages, some lingering dual-language activation might have been enough to cause some cross-language structural priming. If so, we might expect that having the two languages further apart should dampen such cross-language structural priming if structural representations are separate. Given that cumulative within-language structural priming can last as long as a week between prime and target phases (Kaschak et al., 2011), a weakened structural priming effect for only cross-language priming should provide stronger support for separate structural representations of two languages.

In all, we suggest separate-and-connected structural representation for Korean and English, and that this separateness may not be evident in standard cross-language structural priming methods.

Chapter 1, in full, is currently being prepared for submission for publication of the material. Ahn, Danbi; Ferreira, Victor. S.; Gollan, Tamar. H. The dissertation author was the primary investigator and author of this material.

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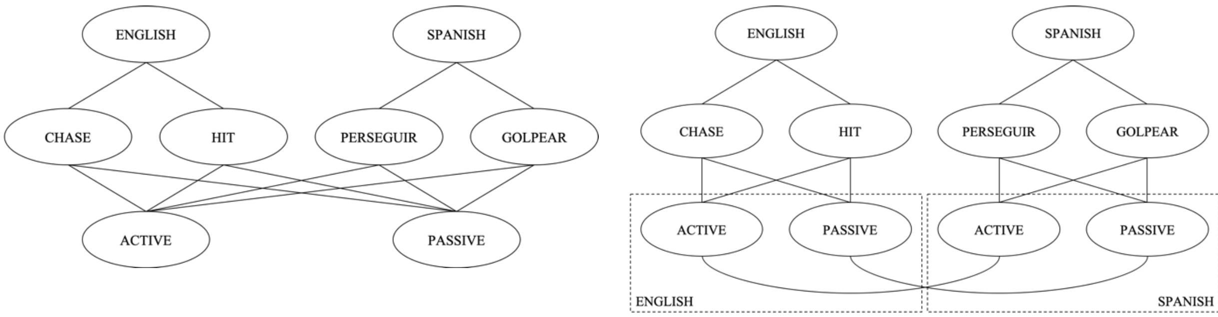

Figure 1.1. Shared (left) versus separate and connected (right) models of bilingual structural representation (adapted from Kantola & van Gompel, 2011). *Perseguir* is Spanish translation for *to chase*. *Golpear* is Spanish translation for *to hit*. In both models, each lemma node (*chase*, *hit*, *perseguir*, or *golpear*) is connected to a relevant language node (English or Spanish) and both combinatorial nodes (active and passive). In the shared model, only one combinatorial node exists per sentence structure for both English and Spanish. In the separate but connected model, combinatorial nodes for the same sentence structure are represented twice, separately per language, but the combinatorial nodes that are analogous across languages are linked.

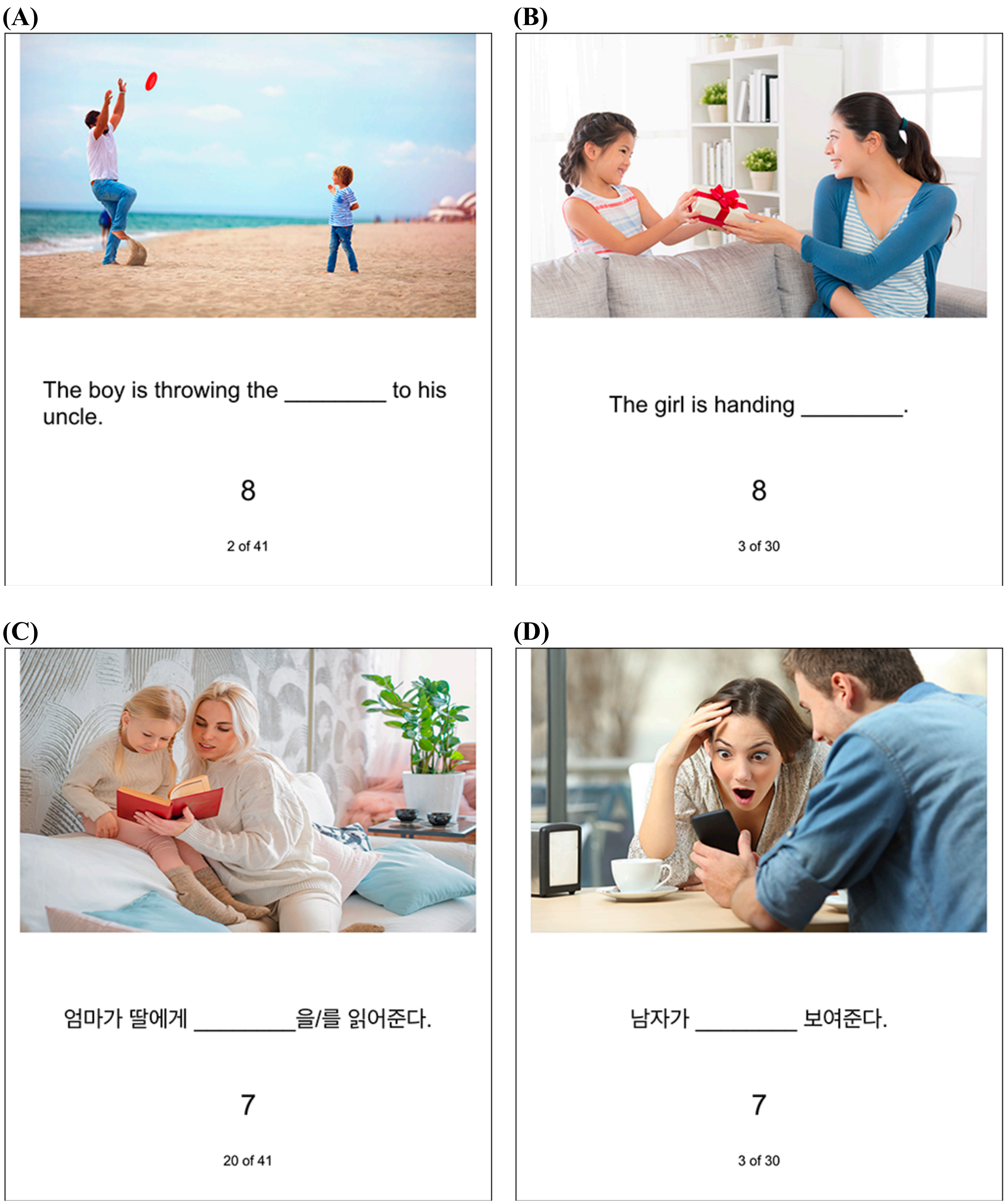

Figure 1.2. Example critical trials. Complete sentence materials for List 1 are available at tinyurl.com/2uj4zy29. (A) English theme-goal priming trial. (B) English target trial. (C) Korean goal-theme priming trial (mother-NOM daughter-DAT ________-ACC read-PRES-DECL). (D) Korean target trial (man-NOM ________ show- PRES-DECL). NOM = nominative, DAT = dative, ACC = accusative, PRES = present tense, DECL = declarative.

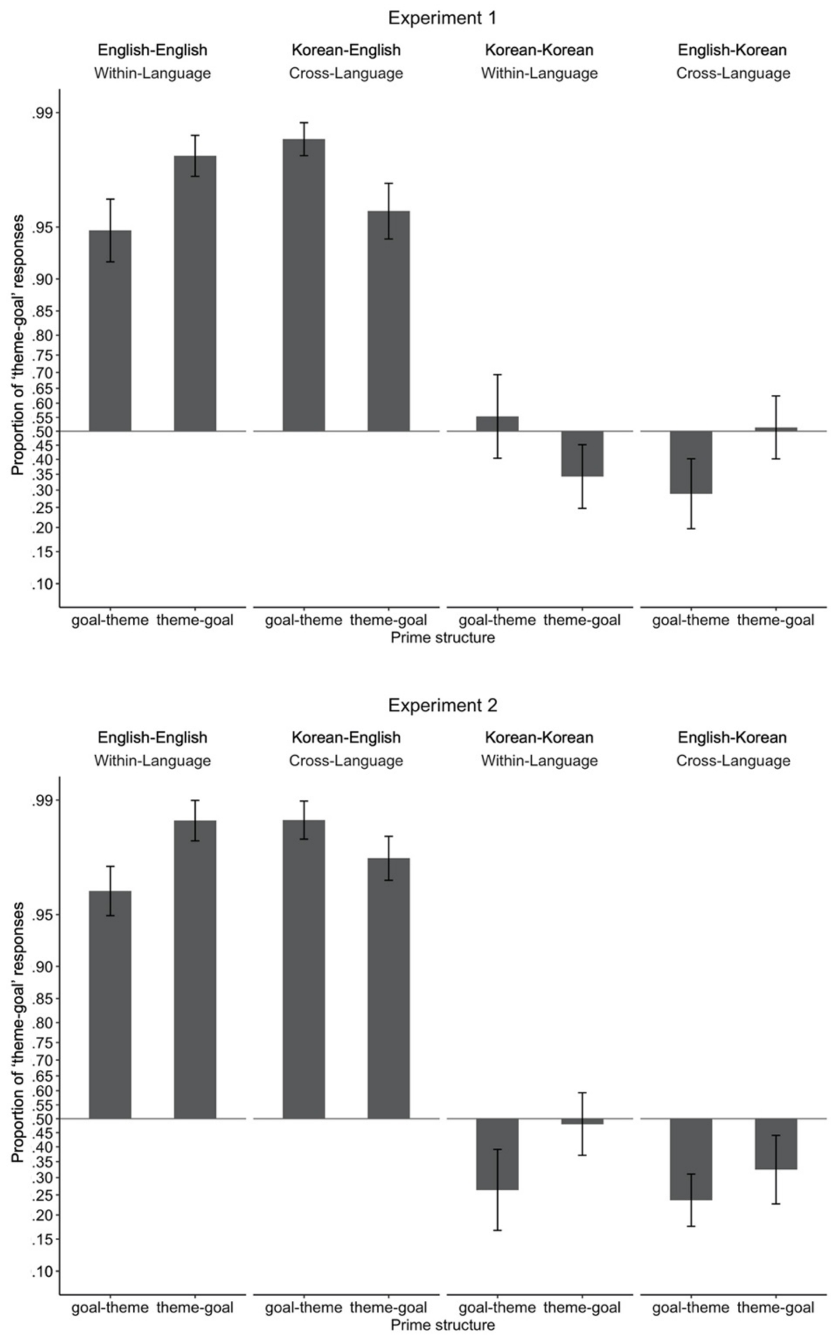

Figure 1.3. Proportion of "theme-goal" responses in Experiments 1 and 2. Proportions were transformed and presented in log-odds space to match statistical analyses, such that the vertical distances between proportions along the y-axis represents the magnitude of differences in log-odds space. Proportions for each participant were transformed to log-odds and then averaged. To allow the log-odds transformation, participants who had proportions of 0 or 1 were assigned a one-tenth of a proportion if they were to produce a single trial of another sentence structure (e.g., a participant who produced 0 theme-goal structures and 10 goal-theme structure was assigned a proportion of .01; a participant who produced 10 theme-goal structures and 0 goal-theme structure was assigned a proportion of .99). Error bars represent standard errors.

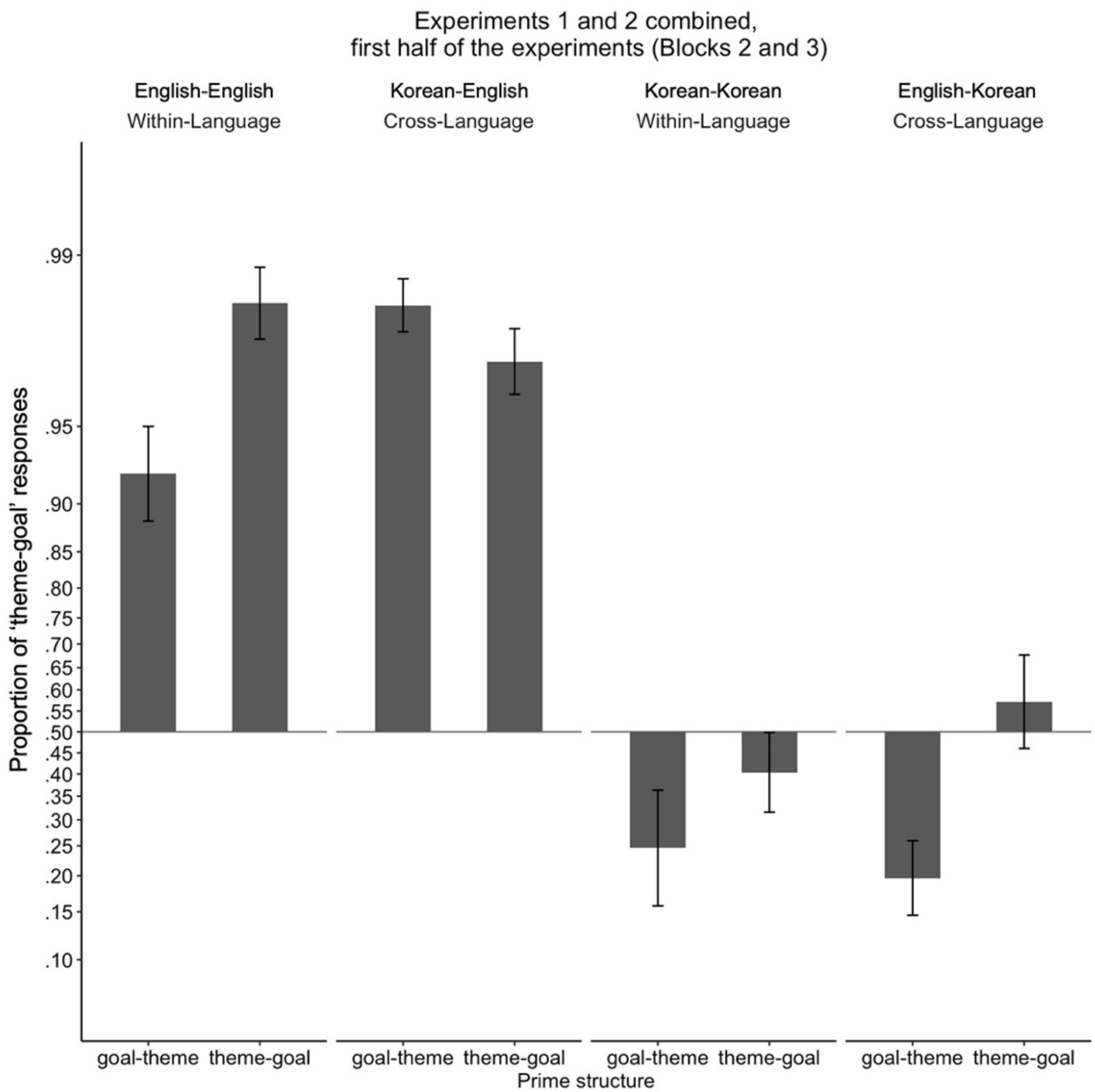

Figure 1.4. Proportion of "theme-goal" responses for Experiments 1 and 2 combined, for the first half of the experiments (Blocks 2 and 3). Proportions were transformed and presented in log-odds space to match statistical analyses, such that the vertical distances between proportions along the y-axis represents the magnitude of differences in log-odds space. Proportions for each participant were transformed to log-odds and then averaged. To allow the log-odds transformation, participants who had proportions of 0 or 1 were assigned a one-tenth of a proportion if they were to produce a single trial of another sentence structure (e.g., a participant who produced 0 theme-goal structures and 10 goal-theme structure was assigned a proportion of .01; a participant who produced 10 theme-goal structures and 0 goal-theme structure was assigned a proportion of .99). Error bars represent standard errors.

Table 1.1. Participant characteristics and language proficiency based on self-report and modified MINT.

	Experiment 1 (n = 48)		Experiment 2 (n = 40)	
Current Age	24.1 (4.4)		23.4 (3.8)	
Lived in the US (years)	5.3 (3.2)		7.2 (3.8)	
	English	Korean	English	Korean
Age of Acquisition (year)	8.8 (3.0)	0.1 (0.6)	8.0 (3.8)	0.2 (0.9)
Approximate percentage of daily use				
Current	49.9 (23.6)	49.0 (24.1)	54.7 (20.5)	44.0 (20.9)
Growing up	20.6 (16.5)	78.3 (17.6)	28.8 (18.9)	70.3 (19.5)
Proficiency self-rating (1 – 7)				
Listen	5.3 (1.2)	6.9 (0.3)	5.6 (1.2)	6.8 (0.6)
Read	5.3 (0.8)	6.8 (0.6)	5.5 (0.9)	6.7 (0.9)
Write	5.0 (0.9)	6.8 (0.7)	5.0 (1.1)	6.4 (1.2)
Speak	4.9 (1.2)	6.9 (0.4)	5.4 (1.2)	6.8 (0.6)
MINT (% correct)	78.1 (8.4)	86.8 (3.7)	79.5 (7.4)	84.9 (5.5)

Note. All numbers represent means across participants. Standard deviations are indicated in parentheses.

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CHAPTER TWO

Selective Activation of Language Specific Structural Representations: Evidence from Extended Picture-Word Interference

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Abstract

How do bilingual speakers represent and use information that guides the assembly of the words into phrases and sentences (i.e., *sentence structures*) for languages that have different word orders? Cross-language syntactic priming effects provide mixed evidence on whether bilinguals access sentence structures from both languages even when speaking just one. Here, we compared English monolinguals, Korean-immersed Korean-English bilinguals, and English-immersed Korean-English bilinguals while they produced noun phrases ("the lemon below the lobster"), which have different word orders in English and Korean (the Korean translation word order is [lobster][below][lemon]). We examined when speakers plan each noun using an extended picture-word interference paradigm, by measuring articulation times for each word in the phrase with either the distractor word "apple" (which slows the planning of "lemon") or "crab" (which slows the planning of "lobster"). Results suggest that for phrases that are different in linear word order across languages, bilinguals only access the sentence structure of the one language they are actively speaking at the time, even when switching languages between trials.

Keywords: Bilingualism, Sentence production, Extended picture-word interference, Bilingual syntax

1. Introduction

How does a speaker represent and access information that guides the assembly of the words into phrases and sentences (i.e., *sentence structures*) when there is more than one way to describe the same event? For example, to describe a particular event, English speakers can use an active construction (e.g., *the dog chases the cat*) or a passive construction (e.g., *the cat is chased by the dog*). These choices become even more complicated for bilinguals, as there can be similar multiple options available for the other language that they also know. For example, a Spanish-English bilingual, on top of the English active and passive constructions, also has the Spanish active (e.g., *el perro persigue al gato*) and passive (e.g., *el gato es perseguido por el perro*) constructions available. How is this information organized in a bilingual's cognitive system?

One way might be that these constructions in the different languages are represented completely separately. Having English and Spanish constructions represented separately could be useful especially when bilinguals are in an environment that forces them to use only one language (e.g., conversing with a monolingual friend). This might also be especially useful when trying to keep straight subtle differences between the languages they know. For example, even though there are comparable active sentence structures in both English and Spanish, there are still subtle differences in Spanish such that the word-to-word direct English translation of the Spanish active construction is approximately *the dog chases* ***at-him*** *the cat* (*El perro persigue* ***al*** *gato*). Having separate Spanish and English active constructions will be helpful for bilinguals when they want to speak in one language, especially to avoid grammatical mistakes that resemble correct sentences of the non-target language. On the other hand, having separate constructions for two languages is not the most economical way to represent sentence structures because many aspects of structural translations are very similar, so that some information ends up represented twice. This might also be inefficient when having to switch between two languages often (e.g., during online language interpretation).

Another way to have constructions from different languages organized is to have the same sentence structure represented only once and shared across the languages. In this case, the advantages and disadvantages are the opposite of the advantages and disadvantages of having separate representations of sentence structures across languages. That is, having the same information represented only once reduces redundancy. This might be useful when having to switch back and forth between languages often such as when talking to two monolingual friends who know different languages, or translating from one language to another. However, it might be difficult to keep subtle differences straight and so could lead to more grammatical errors and might be inefficient when trying to speak in only one language.

This question, whether structural representations in two languages are shared or separate, has been investigated mainly using cross-language structural priming methods. Structural priming (Bock, 1986; see Mahowald, James, Futrell, & Gibson, 2016; Pickering & Ferreira, 2008) refers to the phenomenon in which after describing or hearing an event described with one construction, speakers are more likely to describe another event with that same construction. For example, English speakers are more likely to say *the truck is chased by the taxi* (a passive) after saying *the cat is chased by the dog* (another passive) compared to after saying *the dog chases the cat* (an active).

Critically, such standard priming is observed from one language to another—*cross-language structural priming*. Cross-language structural priming has been observed in multiple studies using different languages (e.g., Hartsuiker, Pickering, & Veltkamp, 2004; Loebell & Bock, 2003; see Gries & Kootstra, 2017; Hartsuiker & Bernolet, 2017; Hartsuiker & Pickering, 2008; Kootstra & Muysken, 2017; Van Gompel & Arai, 2018). For example, in Hartsuiker et al. (2004), bilinguals were given a prime sentence in Spanish and were asked to immediately produce a target sentence in English. Crucially, bilinguals were more likely to produce English passive constructions (e.g., *the bottle is hit by the bullet*) after being given Spanish passive constructions (e.g., *el camión es perseguido por el taxi; the truck is chased by the taxi*) compared to after being given Spanish active constructions (e.g., *el taxi persigue el camión; the taxi chases the truck*). Such observations of cross-linguistic structural priming support the claim of shared structural organization in bilinguals. That is, one explanation is that cross-language structural priming occurs because a sentence structure in one language subsequently remains accessible, which then leads it to be reused during production of the similar structure in another language—something that should happen if representations are shared.

While there are languages that have the same word order, such as English and Spanish active and passive constructions, there are languages that have different word orders. For example, to say *the dog chases the cat*, the Korean word order is *[dog][cat][chase]*, placing the verb at the end of the sentence. The evidence for shared sentence structure for languages with different word orders has been mixed, although most cross-language structural priming studies point towards a shared representation even for languages with different word orders. That is, several studies showed cross-language structural priming using structures with different linear word orders, using the same methods as the studies with languages with the same linear word order described above (e.g., Bernolet, Hartsuiker, & Pickering, 2009; Chen, Jia, Wang, Dunlap, & Shin, 2013; Desmet & Declercq, 2006; Hwang, Shin, & Hartsuiker, 2018; Muylle, Bernolet, & Hartsuiker, 2020, 2021; Shin & Christianson, 2009; Weber & Indefrey, 2009). However, other studies did not find cross-language structural priming for sentence structures with different linear word orders. In particular, Loebell and Bock (2003) found that German-English bilinguals showed structural priming from both German to English and English to German only in dative constructions, which share word order in German and English, but not with passive constructions, which have different word order in German and English (for a passive sentence *the cat is chased by the dog*, the word-to-word German translation is *the cat is by the dog chased*). They attributed this to the word order difference between German and English passive constructions (but note that they also did not observe a statistically significant within-language priming of German passive constructions). Similarly, Bernolet, Hartsuiker, and Pickering (2007) found priming in relative clauses between languages that share the same word order (Dutch and German) but not between languages that have different word orders in relative clauses (Dutch and English).

In an attempt to explain these discrepancies in the literature, Jacob, Katsika, Family, and Allen (2017) proposed a *hierarchical syntactic tree account*, raising the possibility that cross-language priming might be more constrained than within-language priming, such that cross-language priming might require more prerequisites to be fulfilled for it to occur. On this account, not all levels of the syntactic tree must match between the two languages in order to share a structural representation. For example, some studies (Chen et al., 2013; Hwang et al., 2018; Shin & Christianson, 2009) showed structural priming between English and other languages that lack articles in their noun phrases. The hierarchical syntactic tree account can still account for these results by having flexibility in which levels of representations must match for priming to occur. The exact match of constituent orders at low levels of the tree may not be necessary for shared syntactic organization. It may be that which levels of the syntactic tree are sensitive to priming might depend on language typology, such that more typologically different languages could still have shared representations for sentence structures without exact matches at every level of the syntactic tree. According to this account, some studies that showed cross-language structural priming despite their differences in constituent order might be more typologically different compared to studies that did not show priming for sentences with different constituent orders across languages.

Although there are several studies that showed cross-language structural priming across languages with different word orders and claimed shared structural representations, understanding the mechanisms underlying shared representation of structures with different word orders can be complex. Supplementing the current experimental evidence, current models of language production could also help us understand arguments for or against shared representations for languages with different linear word orders. A one-stage model of language production (e.g., Pickering, Branigan, & McLean, 2002) argues that grammatical functions and linear order relations are computed simultaneously. Thus, for two languages to share structural representations, both the grammatical functions and the linear order relations must match between the two languages. Thus, this account can readily explain results showing no priming between languages that have different word orders for a structure, but has difficulty explaining results showing priming between languages that have different word orders for a structure.

However, cross-linguistic priming effects in constructions with different word order could also be explained by some one-stage models, such as Chang, Dell, Bock, and Griffin (2000). In Chang et al. (2000)'s account, structural priming arises by implicit learning, as the linguistic procedures for creating sentence structures become strengthened for subsequent use. This implicit learning from structural priming is not necessarily domain-specific in nature, and so such implicit learning can occur even between comprehension and production (Bock, Dell, Chang, & Onishi, 2007; Branigan, Pickering, & Cleland, 2000; Potter & Lombardi, 1998). Thus, even for languages with different linear word orders, some structural representations could be shared as long as the languages share some common procedures for building sentence structures. For example, even though the word orders of dative constructions of English and Korean are different (the verb comes at the end of the sentence in Korean), some procedures of assembling those constructions can be similar. In particular, for both English and Korean, the difference between a prepositional dative sentence *the knitter gave the sweater to her sister* and a double object dative sentence *the knitter gave her sister the sweater* involves switching the order of *the sweater* and *her sister*. Because of these similarities, the representation for prepositional dative and double object dative constructions could have some components shared between English and Korean, despite their different word orders and so show priming across languages (see Shin & Christianson, 2009).

Furthermore, other models of language production (e.g., Bock & Levelt, 1994; Garrett, 1975) argue that there are two stages in grammatical encoding. At one stage, the functional stage, grammatical roles such as subject and object are assigned. At a separate stage, the positional stage, the linear order relations that determine constituent order are assembled. Thus, sentence structures with different word orders across languages can still be the same at the functional stage. Accordingly, aspects of the representation or processing of syntactic structures could still be shared or connected even though the linear order of words is different across languages, because they can still overlap at the order-independent functional stage of representation. (Note that in the current experiments, we investigate the production of phrases such as *the lemon below the lobster*, which do not include traditional functional-stage roles like subject and object; even so, it is reasonable to assume that they include functional-stage roles such as *head* and *modifier*, and such roles could serve as the locus of shared representations for languages with different word orders.)

Overall then, although there are some inconsistencies for languages with different word orders, evidence from most cross-language priming studies strongly points towards the possibility of shared structural representation across languages. However, it is important to note that there are critical limitations to the standard structural priming method. For instance, structural priming reflects cognitive processes beyond structural representations alone. At the very least, semantic structures can influence structural priming in addition to surface syntactic structures (e.g, Chang, Bock, & Goldberg, 2003; see also Yi & Koenig, 2016; Ziegler & Snedeker, 2018; Ziegler, Snedeker, & Wittenberg, 2018). For example, Chang et al. (2003) reported that participants were more likely to produce location-theme locative sentences (e.g., *The farmer heaped the wagon with straw*) after another location-theme locative sentence (e.g., *The maid rubbed the table with polish*) compared to after a theme-location locative sentence (e.g., *The maid rubbed polish onto the table*). This occurred despite the fact that the two locative types have the same syntactic structure (both NP-V-NP-PP), suggesting that structural priming is sensitive to something beyond syntactic structure (here, likely order of thematic roles). Given that there are linguistic factors other than sentence structure that can influence structural priming, the remaining discrepancies in the current literature might reflect these properties of the standard structural priming methodology rather than the nature of structural representations in bilinguals. Thus, a different methodology other than structural priming could be beneficial for investigating how sentence structures of the two languages are organized in bilinguals.

Another limitation of standard structural priming methods involves the task setting, which requires bilinguals to frequently switch between two languages on many trials throughout the experiment. When anticipating frequent language switches, bilinguals might simultaneously access both languages, either in anticipation of a language switch or as a result of a recent language switch (analogous to task-mixing costs in which responses are slower—even on non-switch trials—in task-mixing blocks relative to single-task blocks; Gollan, Kleinman, & Wierenga, 2014; for review, see Declerck, 2020). Thus, cross-language priming effects might arise because the two languages are both active to support interleaved production, and not because structural representations are shared. Showing that bilinguals access sentence structures from another language while speaking in only one language would be a first step to provide stronger support for shared structural representations across languages.

To examine whether bilinguals access the sentence construction of the non-target language while speaking in one language, we used the *extended picture-word interference paradigm*, in which participants produce phrases or sentences while production onset and production durations of each word in a sentence are measured (e.g., Momma & Ferreira, 2019; Momma, Slevc, & Phillips, 2016). In a standard picture-word interference paradigm (e.g., Glaser & Düngelhoff, 1984; Lupker, 1979; Rosinski, Golinkoff, & Kukish, 1975), speakers are presented with a target picture (e.g., a picture of a *lemon*) along with a distractor word. Compared to when a conceptually unrelated distractor word is presented (e.g., *gun*), participants are slower to name the target picture when presented with a conceptually related distractor word (e.g., *apple*), showing the classic *semantic interference effect* (Lupker, 1979; Rayner & Springer, 1986). Momma and Ferreira (2019) extended this paradigm (following other extensions such as Momma et al., 2016) to measure when monolingual speakers plan to say words in sentences. In this experiment, participants were asked to describe pictures that elicited *the octopus below the lemon is swimming*, while a noun distractor (e.g., *peach*) or a verb distractor (e.g., *run*) were presented with the picture. Interestingly, when a noun distractor (*peach*) was presented, participants' speech rate slowed down immediately before "lemon." On the other hand, when a verb distractor (*run*) was presented, the speech rate slowed down immediately before "is swimming." The slowed speech rates show the interference from distractor words, and so reveal the respective timing of lexical retrieval in sentence production. Based on the classic semantic interference effect, we can infer that the timing of speech slowing during sentence production reveals when the word ("lemon") related to the distractor word ("peach") was planned (note that Momma & Ferreira also revealed more complex patterns depending on the type of verb that speakers produced; these effects are beyond the scope of this paper). In sum, results from Momma and Ferreira (2019) suggest that speakers plan the noun and the verb of sentences such as these "just in time," immediately before producing them.

Using this extended picture-word interference paradigm, we can investigate whether Korean-English bilinguals access both languages at the same time even when speaking in only one. To describe the spatial relationship of two items, Korean and English use different linear word orders. For example, to describe "the lemon below the lobster" in Korean, speakers have to say the location ("lobster") first; that is, the Korean word order to describe "the lemon below the lobster" is "[lobster][below][lemon]." We first aimed to examine monolingual speech planning scope during the production of these phrases. For English, we tested monolingual English speakers with virtually no exposure to Korean (Experiment 1). But because some English proficiency is required for high school graduation and college admission in Korea, we tested Korean-immersed participants living in Korea who are Korean-English bilinguals (Experiment 2). We expected to observe a pattern of a planning scope similar to what we would have observed from Korean monolinguals, given their limited active use of English, and that even highly proficient bilinguals with limited immersion experience in their second language exhibit similar linguistic behaviors in their native language as monolingual speakers of this language (e.g., Dussias & Sagarra, 2007). Then, we compared English versus Korean speech of English-immersed Korean-English bilinguals (Experiments 3-4).

If English monolinguals (speaking English) and Korean-immersed bilinguals (speaking Korean) plan each noun in a noun phrase right before producing it, we should see the semantic-interference pattern of the same distractor word at linearly different locations for English monolinguals versus Korean-immersed bilinguals. That is, when a picture that elicits *the lemon below the lobster* is presented with a distractor word related to the head-noun object (e.g., *apple*), English monolinguals' speech should slow down immediately before the object ("lemon"), the first noun of the phrase. In contrast, for the same picture and distractor word, Korean-immersed bilinguals' speech should slow down also immediately before the object (also "[lemon]"), which instead is the second noun of the phrase in Korean. Similarly, when a location distractor word (e.g., *crab*) is presented, English monolinguals' speech should slow down immediately before the second noun of the phrase ("lobster"), whereas Korean-immersed bilinguals' speech should slow down immediately before the first noun of the phrase (also "[lobster]"). See Figure 2.1 for an illustration of the expected timing of semantic interference from object and location distractors for English vs. Korean sentences if speakers plan each noun in a noun phrase "just in time."

This difference between the two languages gives us the opportunity to test whether English-immersed Korean-English bilinguals (living in the U.S.) access only the intended sentence structure when describing a spatial relationship. That is, even though the linear word orders of noun phrases are different in Korean and English, both the object and the location descriptions of the phrase are nouns, allowing the possibility of some overlap in the process of constructing these phrases (Chang et al., 2000). Also, both Korean and English descriptions have the same functional structure, raising the possibility that this shared functional structure will activate both word orders from the respective languages (e.g., Bock & Levelt, 1994; Garrett, 1975). And so, if sentence structures are shared across languages and bilinguals access both languages even when speaking only in English, both word orders—object-location in English, and location-object in Korean—should be accessed. Lexical items will be selected for both of these structural frames; because both structures with different word orders have been (by hypothesis) accessed, this should lead to simultaneous activation of the English object noun ("lemon") and Korean location noun ("[lobster]") at the beginning of the phrase, when trying to say "the lemon below the lobster" in English. Thus, the English location distractor (*crab*) should slow down the processing of the Korean lemma ("[lobster]") and its integration with the Korean structural frame (location-object), introducing a burden on the language production system that should slow down the speech right before the English object word "lemon" at the beginning of the phrase. An English object distractor (*apple*) should still slow down speech right before the English object word "lemon" in the beginning of the phrase, as we observed in English monolinguals.

Additionally, if speakers plan each noun of the noun phrase "just in time," we should observe similar interference patterns right before each noun. Thus, similarly to what happens at the beginning of the phrase, when planning the second noun of the noun phrase, the English location ("lobster") and Korean object ("[lemon]") should be accessed simultaneously when trying to say "the lemon below the lobster" in English. Thus, while an English location distractor (*crab*) should slow down speech right before the English location word "lobster" right before the second noun of the phrase, also the English object distractor (*apple*) should slow down speech right before the English location word "lobster," reflecting the simultaneous activation of Korean object word "[lemon]" at the same linear position of the phrase.

From this, we predict specific patterns of data. Both Korean and English should show semantic interference, but the timing of the semantic interference effects (rather than whether or not semantic interference effects happen) should reveal whether structures are shared or separate. If sentence structures are shared across languages and bilinguals access both languages even when speaking in only one, we should observe evidence that when speaking English, English-immersed bilinguals' semantic-interference effects include the effects observed in Korean-immersed bilinguals in Korean, and their Korean speech patterns include the effects observed in English monolinguals speaking English. That is, both when speaking English and when speaking Korean, English-immersed bilinguals should show interference effects from both object and location distractors immediately before the first and second noun of the phrase. As a result, their English and Korean interference patterns should not differ from each other. In contrast, if Korean and English structures are represented separately and bilinguals access structural representations only for the one language that they are actively speaking at the time, we should observe that the English-immersed bilinguals' interference pattern during English production is the same as English monolinguals', and their interference pattern during Korean production is the same as Korean-immersed speakers'. That is, when speaking English, English-immersed bilinguals should show interference effects from object distractors only before the first noun, and interference effects from location distractors only before the second noun. This pattern should be opposite when the same speakers speak Korean—interference effects from object distractors should only show before the second noun (instead of the first noun when speaking English), and interference effects from location distractors should only show before the first noun (instead of the second noun when speaking English). As a result, their English and Korean interference patterns should differ from each other.

2. Experiment 1

2.1. Method

2.1.1. Participants

Forty-eight English monolinguals from the UC San Diego Department of Psychology subject pool volunteered for course credit. Instead of a-priori power analysis, our choice of 48 participants was based on Momma and Ferreira (2019), which found significant 2-way interaction with 60 participants in 2 x 3 design with 48 trials. Thus, 48 participants (with 60 trials as we describe below) should allow us to observe an effect of a single factor with 3 levels. Based on a language history questionnaire, eight participants were replaced for one of the following reasons: exposure to the Korean language (n = 1), not born in the United States (n = 1), heard other languages at home growing up and self-rated their comprehension on those languages as "proficient" (n = 3), more than thirty percent of their data unusable (n = 3). Detailed information about participants' language history is presented in Table 2.1.

2.1.2. Apparatus

The experiment was presented on an iMac (21.5-inch, Mid 2014) using PsychoPy2 (Version 1.81.03; Peirce et al., 2019). Spoken responses were recorded via a Marantz PMD661 Solid State Recorder. Voice recordings were transcribed for later analyses.

2.1.3. Materials and Design

Table 2.2 illustrates example trials with detailed information about all experimental items. Each trial involved line drawings presented at each of the four corners of the screen. One line-drawing (e.g., *the lemon*) was presented twice, side-by-side, in the bottom two corners or the top two corners. One of these line-drawings was outlined with a blue square, to indicate that this was the target object. In the other two corners, two different line-drawings (e.g., *lobster* and *piano*) were presented side-by-side as two alternative locations (target location and non-target location) for the target object. An English distractor word was presented superimposed on all four line-drawings. The participants' task was to ignore the written distractor words and describe the target object line-drawing enclosed by the blue square, using one of the two line-drawings as the target location (e.g., *the lemon below the lobster*, or *the lemon above the lobster*).

The materials and lists were created using the following procedure. First, 20 semantically related word pairs were chosen (e.g., *lemon-apple, lobster-crab, piano-violin*). The semantic relatedness of the words was first judged based on intuition and was confirmed with the cosine similarity measure from Latent Semantic Analysis database (LSA; Landauer & Dumais, 1997; Landauer, Foltz, & Laham, 1998; see Table 2.2 for detailed LSA information about experimental items). Forty line-drawings depicting the chosen words were selected.

Then, two lists were created using the selected items. For the first list, the target-objects and object-distractors were created using the first half of the word pairs (e.g., *lemon, lobster, piano*) as the target-objects, and the second half of the word pairs as the object-distractors (e.g., *apple, crab, violin*). The two alternative locations were created by pseudo-randomizing the target-objects (e.g., *lemon* was target-object in the trial *the lemon below the lobster*, but was one of the two alternative locations for other trials such as *the windmill below the lemon*). The same object-distractors used for the target-objects were used also as location-distractors for the target-locations. For example, the word *apple* (semantically related to *lemon*) was used as an object-distractor when the target utterance is "the lemon below the lobster," and used as a location-distractor when the target utterance was “the windmill below the lemon.” The distractor words were pseudo-randomized to create unrelated-distractors. Thus, each target (a target-object and target-location, with a non-target location) had three possible distractor words—object-distractor, location-distractor, and unrelated-distractor. We ensured that target-object, target-location, and the non-target location were minimally semantically related, quantified as less than .3 of cosine similarity measures in LSA (see Table 2.2 for mean cosine similarity measures across items). Moreover, object-distractors (e.g., *apple*) were highly related to target-objects (e.g., *lemon*) but minimally related to target-locations (e.g., *lobster*; and location-distractor, *crab*) or the non-target locations (e.g., *piano*). Location-distractors (e.g., *crab*) were highly related to target-locations (e.g., *lobster*) but minimally related to target-objects (e.g., *lemon*; and object-distractor, *apple*) or the non-target locations (e.g., *piano*). Unrelated-distractors (e.g., *gun*) were minimally related to target-objects (e.g., *lemon*; and object-distractor, *apple*), target-locations (e.g., *lobster*; and location-distractor, *crab*), or the non-target locations (e.g., *piano*).

Throughout the list, each target was presented three times with three different distractor words. Thus, the list involved sixty trials in total. The trials were presented in pseudo-randomized order. The same target object was never presented twice in a row. Whether the target object was below or above the location object was not repeated more than twice in a row. The same distractor condition was never presented more than four times in a row. The materials are available at OSF.IO/7GHBK.

2.1.4. Procedure

Participants were familiarized with the stimuli prior to the experimental session to minimize lexical retrieval delay unrelated to the distractor conditions. During the familiarization stage, participants were presented with static trial screens without the distractor words presented.

Participants were asked to name the object in the blue square with its location. At their own pace, participants pressed the spacebar to see the next trial screen. Each trial screen was presented twice, once with the target-object above the target-location and once below the target-location. An experimenter corrected responses when participants said unexpected words (e.g., *the glue gun* instead of *the drill*). However, participants were not corrected for synonyms (e.g., *the bunny* instead of *the rabbit*) to minimize lexical retrieval delay. Similarly, participants were allowed to use any prepositions as long as the location was accurate (e.g., above, over, below, under, underneath).

After the familiarization phase, participants were given six practice trials with line-drawings that were different from experimental trials. Each participant completed one of the experimental lists during the session.

A schematic of each experimental trial is illustrated in Figure 2.2. Each experimental trial lasted for 6 seconds. At the beginning of the trial, a fixation cross appeared for 500 ms, which was replaced by the distractor word and the blue square, together as a short click sounded. The line-drawings appeared 150 ms after the onset of the distractor word and the blue square. The blue square disappeared 2 seconds after its presentation, and the distractor words disappeared 3 seconds after their presentation. The target line-drawings stayed on the screen for 5 seconds. At the end of each trial, a blank screen was presented for 350 ms. All trials advanced automatically, without any break. Our choice of -150 ms as stimulus-onset asynchrony (SOA) was based upon Momma and Ferreira (2019), which directly tested the influence of SOA and replicated the pattern of effects from their Experiment 1 (which used -150 ms as SOA) by using SOAs of 0 ms and 300 ms in their Experiments 2a and 2b. The total experimental block lasted for 6 minutes. At the end of the experiment session, participants completed a language history questionnaire (see Table 2.1 for detailed information).

2.1.5. Analysis

The audio files and the transcription were first aligned using a text-to-speech automatic forced alignment technique (Montreal Forced Aligner; McAuliffe, Socolof, Mihuc, Wagner, & Sonderegger, 2017). Then, using Praat: doing phonetics by computer (Version 6.0.46; Boersma & Weenink, 2019), experimenters naive to individual trial conditions corrected errors on text-to-speech alignments. From the output, the production onset relative to the picture presentation and the production durations for each word were extracted. Durations of each word were measured from the onset of the target word until the onset of the next target word. Overt hesitations (e.g., *um*) were counted towards the duration of a previous word. For example, in an utterance "…below the, um, lobster," the "um" was counted towards "the." Any trials with errors, with a production onset of more than 5000 ms or production time of 1500 ms in any region, or onset latencies or durations more than three standard deviations away from each participant's mean were excluded from the analysis. In total, 95.5% of the data were analyzed.

Four regions were defined in a way that allowed us to directly compare the planning time for the nouns in the same linear position across English and Korean, accounting for the lack of articles in Korean. To do this, the speech duration of the articles in English were combined with the regions immediately prior to each article, under the assumption that articles in English, if anything, allow for additional planning of the immediately following noun (see Clark & Wasow, 1998). That is, for English, Region 1 included both the production onset from the presentation of the picture and the production duration of the first "the" in the noun phrase. Region 3 in English included both the production duration of "below" and the second "the" in the noun phrase.

Consequently, Region 1 tested for the planning time of the first noun ("lemon" in the "the lemon below the lobster" in English), and Region 3 tested for the planning time of the second noun ("lobster" in the "the lemon below the lobster" in English).

Each region was tested for interference effects. LMMs were fit using the "lmer" function from the lme4 package (Version 1.1–20; Bates, Mächler, Bolker, & Walker, 2015) in R: A Language and Environment for Statistical Computing (Version 3.5.1; R Core Team, 2014). We used sum-to-zero contrasts (i.e., the intercept of the model was the grand mean of the dependent measure) to code the distractor condition (object distractor vs. unrelated distractor vs. location distractor), a categorical predictor. We first attempted to fit LMMs incorporating the maximal random effects structure given the experimental design (Barr, Levy, Scheepers, & Tily, 2013). For maximal models that did not converge, random effects accounting for the least variance were gradually removed until a model successfully converged. Using the "Anova" function from the car package (Version 3.0–2; Fox & Weisberg, 2019), type III Wald Chi-square tests were conducted in order to calculate main effects. For the regions where significant main effects were found, the emmeans package (Version 1.3.2; Lenth, 2019) with Satterthwaite approximation was used to compute estimated marginal means and standard errors for each treatment level and to compare each treatment level. Note that our theoretical arguments are based upon the results of Chi-square tests, and estimated marginal means were computed only to describe the pattern of results. The data and R code are available at OSF.IO/7GHBK.

2.2. Results

The means and standard deviations of the production durations are presented in Table 2.3a. Interference effects relative to unrelated distractors are illustrated in Figure 2.3. Effect sizes are reported with Cohen's *d*. Throughout the results of Experiment 1, it is important to note that the object (e.g., *lemon* in the phrase *the lemon below the lobster*) was the first produced noun in the noun phrase in English.

Region 1 (the onset latency of *lemon* in the phrase *the lemon below the lobster*) was influenced by the type of distractor word presented with the pictures ($\chi^2(2) = 11.29$, $p = .004$). As predicted, the onset latency was significantly slower when the object distractor was presented compared to when the unrelated distractor was presented (972 ms vs. 926 ms; $b = 45.5$, $SE = 16.4$, $t(40) = 2.78$, $p = .008$, $d = .88$), whereas there was no statistical difference between when the location distractor was presented compared to when the unrelated distractor was presented (916 ms vs. 926 ms; $b = 10.4$, $SE = 15.2$, $t(39) = 0.68$, $p = .498$, $d = .22$).

Region 2 (e.g., *lemon* in the phrase *the lemon below the lobster*) was not statistically different depending on the type of distractor words presented with the pictures ($\chi^2(2) < 1$, $p = .617$).

Region 3 (e.g., the speech duration from the onset of *below* until the onset of lobster in the phrase *the lemon below the lobster*) was influenced by the type of distractor words presented with the pictures ($\chi^2(2) = 10.51$, $p = .005$). As predicted, the Region 3 duration was significantly slower when the location distractor was presented compared to when the unrelated distractor was presented (530 ms vs. 498 ms; $b = -32.14$, $SE = 13.54$, $t(39) = -2.37$, $p = .023$, $d = .76$), whereas there was no statistical difference between when the object distractor was presented and the unrelated distractor was presented (490 ms vs. 498 ms; $b = -8.38$, $SE = 8.02$, $t(39) = -1.05$, $p = .302$, $d = .33$).

Region 4 (e.g., *lobster* in the phrase *the lemon below the lobster*) was not statistically different depending on the type of distractor words ($\chi^2(2) < 1$, $p = .753$).

2.3. Discussion

Experiment 1 demonstrated that when asked to produce noun phrases such as "the lemon below the lobster," English monolinguals' speech slowed at the onset of the phrase (just before "lemon") when given object distractors (*apple*), and slowed at the "the" before the word "lobster" when given location distractors (*crab*). This suggests that when producing noun phrases, English monolinguals plan to say each noun in the phrase just before producing it, replicating Momma and Ferreira (2019), among others.

Critical to our experimental design, recall that the word order of a noun phrase is different in Korean than in English for the same target utterance. For example, for the same experimental item "the lemon below the lobster", the Korean word order is [lobster][below][lemon]. Thus, we predict the opposite pattern in Korean-immersed speakers on regions right before each noun in the noun phrase.

3. Experiment 2

Experiment 2 was designed to establish when Korean-immersed speakers plan each noun in a noun phrase. If speakers plan each noun of the noun phrase incrementally, we should observe the semantic interference effect from location distractors on onset latency, and the semantic interference effect from object distractors later in the phrase immediately prior to the object.

3.1. Method

3.1.1. Participants

Forty-eight Korean-immersed speakers from Seoul National University community volunteered for monetary compensation. Even though these participants had some English knowledge, most participants never traveled or lived outside Korea for more than six months (two participants responded that they lived outside Korea for 10 months and 12 months, respectively). All participants responded that they only spoke Korean growing up, learned English only through formal studies, and were highly Korean dominant based on our proficiency measures described in the procedure below. Given that our extended picture-word interference tasks were fast-paced and difficult even in the native, dominant language, the tasks in English were unrealistic with participants from Experiment 2. Thus, Korean-immersed speakers were only tested in Korean. Detailed information about the participants' language proficiency and language history is presented on Table 2.1.

3.1.2. Apparatus

The experiment was presented on MacBook Air 2013 using PsychoPy2 (Version 1.81.03; Peirce et al., 2019). The spoken responses were recorded via a Sony PX Series Digital Voice Recorder ICDPX370.

3.1.3. Materials and Design

Materials and design were identical to Experiment 1, except all target utterances and distractor words were Korean translation equivalents of materials used in Experiment 1.

3.1.4. Procedure

The procedure was identical to Experiment 1. At the end of the experiment, participants completed an adapted version of Multilingual Naming Test (MINT; Gollan, Weissberger, Runnqvist, Montoya, & Cera, 2012) and a language history questionnaire. To adapt the MINT for use in Korean, 7 items that are Korean-English cognates were excluded; thus, participants were tested on 61 items, first in English, and then in Korean. Note that the MINT was developed for use with speakers of Spanish, Chinese, Hebrew, and English, and the Korean adaptation was not validated against a Korean proficiency interview (as was done for the languages for which the MINT was originally developed). Thus, although it is not clear to what extent the scores accurately reflect degree of dominance in Korean versus in English, the scores are still useful for matching bilinguals within each language across Experiments 2-4.

3.1.5. Analysis

The analysis procedure was identical to Experiment 1, except the regions were defined differently from Experiment 1 because of the absence of articles in Korean. Region 1 included only the production onset (whereas Region 1 in Experiment 1 included the production onset and the production duration of the first "the"). Region 3 in Korean included only the production duration of “[below] (whereas Region 3 in Experiment 1 included both the production duration of “below” and the second “the” in the noun phrase).” Consequently, in parallel to Experiment 1, Region 1 tested for the planning time of the first noun (“[lobster]” in “[lobster][below][lemon]” in Korean), and Region 3 tested for the planning time of the second noun (“[lemon]” in “[lobster][below][lemon]” in Korean). In total, 97.0% of the data were analyzed for Experiment 2.

3.2. Results

The means and standard deviations of the production durations are presented in Table 2.3a. Interference effects relative to unrelated distractors are illustrated in Figure 2.4. Throughout the results of Experiment 2, it is important to note that the object (e.g., *[lemon]* in the phrase *[lobster][below][lemon]*, which would be *the lemon below the lobster* in properly translated English) was the second noun in the noun phrase in Korean (as compared to the first noun in the noun phrase in English).

Region 1 was influenced by the type of distractor words presented with the pictures ($\chi^2(2) = 8.01$, $p = .018$), but in a different way from what it was for English monolinguals (who showed slower onset latency when object distractors were presented compared to when unrelated distractors were presented). This effect of distractor word type was driven by the difference between when the object distractor or location distractor was presented. That is, compared to when unrelated distractors were presented, Region 1 was not statistically different depending on the presentation of object distractors (927 vs. 957; *b* = -28.0, *SE* = 18.3, *t*(40) = -1.53, *p* = .135, *d* = .48) or location distractors (987 vs. 957; *b* = -29.3, *SE* = 19.0, *t*(39) = -1.54, *p* = .131, *d* = .49). However, Region 1 was significantly faster when the object distractor was presented compared to when the location distractor was presented (927 ms vs. 987 ms; *b* = -57.3, *SE* = 20.3, *t*(41) = -2.83, *p* = .007, *d* = .89).

Unlike for English monolinguals, whose Region 2 did not show a statistical difference depending on distractor conditions, the duration of Region 2 (e.g., *[lobster]* in the phrase *[lobster][below][lemon]*) was influenced by the type of distractor words presented with the pictures ($\chi^2(2) = 8.45$, *p* = .015). Similarly to the onset latency, this effect of distractor word type was driven by the difference between when the object distractor versus when the location distractor was presented. That is, compared to when unrelated distractors were presented, Region 2 was not statistically different depending on the presentation of object distractors (393 vs. 399; *b* = -7.34, *SE* = 3.65, *t*(39) = -2.01, *p* = .052, *d* = .64) or location distractors (403 vs. 399; *b* = -3.61, *SE* = 4.42, *t*(39) = -0.82, *p* = .419, *d* = .26). However, Region 2 was significantly faster when the object distractor was presented compared to when the location distractor was presented (393 ms vs. 403 ms; *b* = -10.95, *SE* = 4.09, *t*(39) = -2.68, *p* = .011, *d* = .85). Note that although the effect of object distractors is very close to statistical significance, the direction of the effect is the opposite from the effect of object distractors shown in English monolinguals. That is, while English monolinguals showed a significant interference effect from object distractors, Korean-immersed speakers did not show the same interference effect but rather showed facilitation (although statistically non-significant), which was different from English monolinguals.

The production durations in the Regions 3 (e.g., *[below]* in the phrase *[lobster][below][lemon]*) and 4 (e.g., *[lemon]* in the phrase *[lobster][below][lemon]*) were not statistically different depending on the type of distractor words (both χ^2s < 1). The lack of statistical difference depending on distractor condition on Region 3 was also different from what English monolinguals showed, in which the production duration of the word right before the second noun of the phrase (e.g., *the* before the location, *lobster*, in the phrase *the lemon below the lobster*) was slowed by the location distractor.

3.3. Discussion

In English monolinguals in Experiment 1, we observed evidence of "just in time" planning—slowed production duration from object distractors right before the object (the first noun of the English noun phrase), and slowed production duration from location distractors right before the location (the second noun of the English noun phrase). In Korean-immersed speakers speaking Korean, we predicted slowed production durations from location distractors right before the location (the first noun of the Korean noun phrase), and slowed production durations from object distractors right before the object (the second noun of the Korean noun phrase). Contrary to patterns found for English and our predictions for Korean, Experiment 2 showed that when Korean-immersed speakers produce noun phrases, location distractors led to slower onset latencies and first-word durations compared only to when object distractors were presented, but not compared to when unrelated distractors were presented. Furthermore, location distractors led to only numerically slower and not statistically significant onset latency differences compared to unrelated distractors. This might hint at a small semantic interference effect and "just in time" planning for location in Korean-immersed speakers at the beginning of the phrase, a different timing pattern from English monolinguals who showed evidence of planning location right before the second noun of the phrase. In all, these patterns suggest that Korean-immersed speakers do not plan each noun of the noun phrase incrementally in a similar way that English monolinguals do.

It is unclear why the planning processes appear to differ between English monolinguals and Korean-immersed speakers speaking Korean, in a different way from our prediction based on the linear word order differences. That is, based on the results of Experiment 2, Korean speakers do not seem to be doing "just in time" planning, like English speakers did in Experiment 1. This unexpected pattern in Korean might be explained by some experimental properties that we intentionally kept consistent across experiments influencing Korean and English differently. For example, the SOA of -150 ms might have had different effect on interference effects in Korean compared to in English. Because Korean is orthographically shallower than English, speakers might be able to repair interference effects from distractor words faster in Korean than in English, leading to the numerical trend towards significant interference observed in Experiment 2. Future research would be needed to determine whether a shorter SOA in Korean leads to a clearer evidence of "just in time" planning in Korean.

Another experimental property we should note is the way we used blue squares around the object of the phrase for both languages, when the object is the first noun in the phrase in English while it is the second noun in the phrase in Korean. It is possible that the blue square around the object introduced a tendency for Korean speakers to attend to the object first, even though they should say the location first in Korean. Having an object distractor such as *apple* superimposed when speakers are trying to say *[lobster][below][lemon]* (*the lemon below the* *lobster* in English) might have helped speakers to resolve their urge to say *[lemon]* first, leading to the numerical pattern (but not statistically significant) of facilitation from object distractors at the beginning of the phrase[1].

However, importantly for present purposes, Experiment 2 demonstrated that when producing noun phrases, Korean-immersed speakers' semantic interference pattern differed from that of English monolinguals. For instance, Korean-immersed speakers did not show the semantic interference effect from object distractors at the beginning of the phrase, which English monolinguals did. Instead, when object distractors were presented, Korean-immersed speakers' onset latency and speech duration for the first word were *faster* than when location distractors were presented (but not compared to when unrelated distractors were presented). Critically, the interference pattern on the onset latency was the opposite pattern from what English monolinguals showed, which was slower when object distractors were presented compared to when unrelated or location distractors were presented. Together, Experiment 1 and 2 revealed that English monolinguals and Korean-immersed speakers plan their speech differently for the same event that has different word orders depending on their languages.

4. Experiment 3

Experiment 3 was designed to examine whether English-immersed Korean-English bilinguals speaking in each of their languages (one at a time) access the sentence structure of the language they are not speaking, when participants had a clear expectation that there will not be any language switches (i.e., differing from previous structural priming studies).

If English-immersed bilinguals access both languages even when speaking only one, their English and Korean interference patterns should look like a combination of the English

[1] We thank an anonymous reviewer for suggesting this possibility.

monolingual and Korean-immersed speaker patterns, and should not differ from each other. Namely, both when speakers speak English and Korean, we should observe slowed speech duration from both types of distractors right before the first noun—reflecting the interference effect from object distractors observed in English monolinguals and the interference effect (although statistically non-significant) from location distractors observed in Korean-immersed speakers. Moreover, for both when speakers speak English and Korean, we should observe slowed speech durations from location distractors right before the second noun—reflecting the interference effect from location distractors observed in English monolinguals.

In contrast, if English-immersed bilinguals represent Korean and English structures separately and access only the one language that they are actively speaking at the time, their English and Korean interference pattern should look like the separate English monolingual and Korean-immersed speaker patterns observed in Experiments 1 and 2, and so should differ from each other. Namely, only when speakers speak English should we observe slowed speech durations from object distractors right before the first noun, and slowed speech durations from location distractors right before the second noun. Moreover, only when speakers speak Korean should we observe slowed speech durations from location distractors right before the first noun.

4.1. Method

4.1.1. Participants

Forty-eight Korean bilinguals from the UC San Diego Department of Psychology subject pool volunteered for course credit or monetary compensation. All participants indicated that they were born and raised in Korea at least until the age of 11. All participants learned Korean as a first language and English as a second language, and were dominant in Korean according to both self-report and MINT scores (except one participant who scored 82% in both Korean and English

MINT). Detailed information about the participants' language proficiency and language history is presented in Table 2.1.

4.1.2. Apparatus

The experiment was presented on an iMac (21.5-inch, Mid 2014) using PsychoPy2 (Version 1.81.03; Peirce et al., 2019). Spoken responses were recorded via a Marantz PMD661 Solid State Recorder. Voice recordings were transcribed for later analyses.

4.1.3. Materials and Design

These were identical to Experiments 1 and 2.

4.1.4. Procedure

The procedure was identical to Experiments 1 and 2, except that participants completed both lists instead of one. All participants completed one list in Korean, and the other list in English. Familiarization phases and practice trials were given separately for the two lists prior to each list, in the language of the following list. The presentation orders of the lists and languages were counterbalanced across participants. At the end of the experiment session, participants completed the Korean modified version of the MINT and the language history questionnaire (see *Table 2.1* for detailed information).

4.1.5. Analysis

The pre-analysis data cleaning procedure was identical to Experiment 1 and 2. In total, 94.5% of the data were analyzed for Experiment 3. Each region was tested for interference effects following the identical procedure as Experiments 1 and 2, except that language (English vs. Korean) was also included as a categorical predictor, using sum-to-zero contrasts. The data and R code are available at OSF.IO/7GHBK.

4.2. Results

The means and standard deviations of the production durations are presented in Table 2.3a. Interference effects relative to unrelated distractors are illustrated in Figure 2.5. Throughout the results of Experiment 3, it is important to note that the object was the first noun in the noun phrase in English (e.g., *lemon* in the phrase *the lemon below the lobster*), whereas it was the second noun in the noun phrase in Korean (e.g., *[lemon]* in the phrase *[lobster][below][lemon]*, which would be *the lemon below the lobster* in properly translated English; note that participants never had to name the same picture in both English and Korean). We present Regions 1 and 3 first, as our predictions were only on these regions.

Region 1 (the onset latency of the first noun) was influenced by language, such that Region 1 was faster for English compared to Korean (975 ms vs. 1064 ms; $\chi^2(1) = 16.29$, $p < .001$). As we describe below, speech durations were slower in English compared to in Korean for all other regions, which may reflect language dominance effect—that participants were slower to describe the pictures in their non-dominant language. This unexpected slower durations of Region 1 for Korean compared to English may reflect the fact that Korean content words in our material tend to be longer [2.3 (1.1) syllables vs. 1.6 (0.8) syllables]. Collapsed across language, Region 1 was not statistically different depending on the type of distractor words presented with the pictures ($\chi^2(2) < 1$, $p = 0.857$). However, the influence of distractor words differed depending on the language (i.e., the interaction between distractor condition and language was significant; $\chi^2(2) = 19.73$, $p < .001$). Compared to when unrelated distractors were presented, Region 1 was significantly slower when object distractors were presented in English (966 ms vs. 1009 ms; $b = 43.6$, $SE = 18.2$, $t(43) = 2.40$, $p = .021$, $d = .73$) but not statistically different in Korean (1068 ms vs. 1039 ms; $b = -28.2$, $SE = 20.4$, $t(41) = -1.38$, $p = .174$, $d = .43$), resembling the separate English monolingual and Korean-immersed speaker patterns. Compared to when unrelated distractors were presented, Region 1 did not statistically differ when location distractors were presented in English (966 ms vs. 949 ms; b = 18.2, SE = 16.5, $t(51)$ = 1.11, p = .275, d = .31) or in Korean (1068 ms vs. 1083 ms; b = -17.1, SE = 21.5, $t(40)$ = -0.80, p = .431, d = .25), also resembling the patterns we observed in English monolinguals and Korean-immersed speakers. Note that even though some statistically non-significant effects (e.g., the comparison between unrelated distractors vs. object distractors in Korean) might seem numerically comparable to the significant difference between unrelated distractors vs. object distractors in English (29 ms difference vs. 43 ms difference), the direction of the effect is opposite from the significant effect in English; the general pattern of results is opposite in English vs. Korean, which is supported by the significant 2-way interaction between distractor condition and language.

Region 3 (the speech duration from the onset of "below" until the onset of the second noun) was influenced by language, such that Region 3 was significantly slower for English compared to Korean (628 ms vs. 431 ms; $\chi^2(1) = 163.94$, $p < .001$). Collapsed across language, Region 3 mean durations were not statistically different depending on the type of distractor word presented with the pictures ($\chi^2(2) = 4.07$, $p = 0.131$). However, the influence of the distractor word differed depending on language (i.e., the interaction between distractor condition and language was significant; $\chi^2(2) = 8.02$, $p = .018$). Compared to when unrelated distractors were presented, Region 3 did not statistically differ when object distractors were presented in English (620 ms vs. 613 ms; b = -7.30, SE = 13.2, $t(42)$ = -0.55, p = .585, d = .17) or in Korean (426 ms vs. 436 ms; b = 12.29, SE = 12.9, $t(46)$ = 0.95, p =.346, d = .28), resembling the patterns we observed in English monolinguals and Korean-immersed speakers. Compared to when unrelated distractors were presented, Region 3 was significantly slower when location distractors were presented in English (620 ms vs. 650 ms; $b = -29.95$, $SE = 14.0$, $t(46) = -2.14$, $p = .038$, $d = .63$) but not statistically different in Korean (426 ms vs. 431 ms; $b = -4.42$, $SE = 13.7$, $t(44) = -0.32$, $p = .749$, $d = .10$), also resembling the separate English monolingual and Korean-immersed speaker patterns.

Region 2 (the speech duration of the first noun) was influenced by language, such that Region 2 was significantly slower for English compared to Korean (543 ms vs. 450 ms; $\chi^2(2) = 18.14$, $p < .001$). On average, Region 2 was not statistically different depending on the type of distractor word presented with the pictures ($\chi^2(2) = 1.23$, $p = .539$), and this was not statistically different depending on depending on the language (i.e., the interaction between distractor condition and language was not significant; $\chi^2(2) = 1.00$, $p = .606$).

Region 4 (the speech duration of the second noun) was influenced by language, such that it was slower for English compared to Korean (535 ms vs. 466 ms; $\chi^2(1) = 8.18$, $p = .004$). Region 4 mean durations were not statistically different depending on the type of distractor word presented with the pictures ($\chi^2(2) < 1$, $p = .820$), and this was not statistically different depending on depending on the language (i.e., the interaction between distractor condition and language was not significant; $\chi^2(2) < 1$; $p = .723$).

4.3. Discussion

Experiment 3 examined whether English-immersed Korean-English bilinguals access both languages when they speak in only one. We observed a pattern of interference that resembled the separate English monolingual and Korean-immersed speaker patterns. That is, when producing noun phrases such as “the lemon below the lobster” in English, compared to when given an unrelated distractor, bilinguals showed slower speech at the onset of the phrase (just before “lemon”) when given object distractors (*apple*), and slower speech just before the word “lobster” when given location distractors (*crab*) — as was observed in English monolinguals in Experiment 1. Critically, this pattern was not found when the same bilinguals described the same pictures in Korean. The different pattern of interference across Korean and English suggests that rather than accessing sentence structures of both languages that they know, bilinguals only access the sentence structure of the language that they are actively speaking at the time.

These results suggest that English-immersed Korean bilinguals access structures in their two languages separately when not expecting frequent switches between languages. However, it remains possible that when English-immersed bilinguals are in a context with frequent language switches (which would increase the extent of dual-language activation), that they might then exhibit greater evidence of shared structural processing mechanisms (for reviews, see Declerck, 2020; Kroll, Bobb, Misra, & Guo, 2008). If so, English-immersed bilinguals should show more similar patterns in English versus Korean when having to frequently switching between languages.

5. Experiment 4

Experiment 4 was designed to examine whether English-immersed bilinguals access the sentence structure of the other language when speaking in one language, when frequently switching between the two languages. If English-immersed bilinguals maintain access to non-target languages because of frequent language switches, we should observe similar interference patterns across English and Korean, as we initially predicted in Experiment 3. Namely, both when speakers speak English and Korean, we should observe slowed speech duration from object distractors right before the first noun (Region 1) and from location distractors right before the second noun (Region 3)—reflecting the interference effects observed in English monolinguals. Moreover, both when speakers speak English and Korean, we should observe slowed speech duration from location distractors right before the first noun (Region 1)—reflecting the interference effect (although statistically non-significant) from location distractors observed in Korean-immersed speakers.

5.1. Method

5.1.1. Participants

Forty-eight additional English-immersed bilinguals from the UC San Diego Department of Psychology subject pool volunteered for course credit or monetary compensation. All participants indicated that they were born and raised in Korea at least until the age of 11. All participants learned Korean as a first language and English as a second language, and all but 6 participants were dominant in Korean according to the modified MINT. All 6 participants who were dominant in English were highly proficient in both English and Korean [88.5 (1.5) % correct in English vs. 83.6 (3.1) % correct in Korean on the MINT, respectively] and none self-reported that they were more proficient in English compared to Korean in speaking, listening, reading or writing. Detailed information about the participants' language proficiency and language history is presented in Table 2.1.

5.1.2. Apparatus

The experiment was presented on an iMac (21.5-inch, Mid 2014) using PsychoPy2 (Version 1.81.03; Peirce et al., 2019). Spoken responses were recorded via a Marantz PMD661 Solid State Recorder. Voice recordings were transcribed for later analyses.

5.1.3. Materials and Design

Materials were identical to Experiment 3. Additional lists with 120 trials with both English and Korean trials were created by combining the two lists from previous experiments.

Within each new list, materials from List 1 and List 2 from previous experiments appeared in different languages, counterbalancing which list appeared in which language across participants. For example, one participant named “the lemon below the lobster” with distractor words *apple* or *crab* in English, and named “[crab][below][apple]” with distractor words *lemon* or *lobster* in Korean. Thus, one participant never had to name the same picture in both English and Korean. English and Korean trials were interleaved such that half of the trials were *stay* trials (i.e., the response language of the current trial was the same as the response language of the previous trial), and the other half of the trials were *switch* trials (i.e., the response language of the current trial was different from the response language of the previous trial). Stay or switch trials never appeared more than twice in a row. Korean or English trials never appeared more than three times in a row. The same distractor condition never appeared more than five times in a row. To account for order effects, additional lists were created by counterbalancing the order of the first and the second half trials of each list.

Pilot-testing revealed that introducing language switches greatly increased the difficulty of the task. To make the task more manageable for participants, we kept the spatial relationships of the object and the location consistent throughout the experiment for each participant. That is, one participant only saw “the lemon **below** the lobster” throughout the experiment, while another participant only saw “the lemon **above** the lobster.” Different languages were cued using American vs. Korean flags and colored boxes (blue vs. red) for indicating target objects. Language cues were presented at the same time as the fixation cross in the beginning of each trial.

5.1.4. Procedure

The procedure was very similar to previous experiments. Familiarization phases and practice trials were given with the language cues. Each participant completed the entire experimental block without a break, which lasted for 12 minutes. At the end of the experiment session, participants completed the Korean modified version of the MINT and the language history questionnaire (see Table 2.1 for detailed information).

5.1.5. Analysis

The pre-analysis data-cleaning procedure was identical to previous experiments. In total, 87.4% of the data were analyzed for Experiment 4. Four regions were defined using the same procedure as Experiment 3. Each region was tested for interference effects following the same procedure as Experiment 3, except that trial type (stay vs. switch) was also included as a categorical predictor, using sum-to-zero contrasts. The data and R code are available at OSF.IO/7GHBK.

5.2. Results

The means and standard deviations of the production durations are presented in Table 2.3b. Interference effects relative to unrelated distractors are illustrated in Figure 2.6a-b. Throughout the results of Experiment 4, it is important to note that the object was the first noun in the noun phrase in English (e.g., *lemon* in the phrase *the lemon below the lobster*), whereas it was the second noun in the noun phrase in Korean (e.g., *[lemon]* in the phrase *[lobster][below][lemon]*, which would be *the lemon below the lobster* in properly translated English; participants never had to name the same picture in both English and Korean). We present Regions 1 and 3 first, as our predictions were only on these regions.

On average, Region 1 (the onset latency of the first noun) was not statistically different depending on the language of the current trial (1368 ms vs. 1407 ms; $\chi^2(1) = 1.77$, $p = .183$) or the distractor condition (1409 ms vs. 1385 ms vs. 1366 ms; $\chi^2(2) = 2.78$, $p = .249$). However, the influence of the distractor word differed depending on language (i.e., the interaction between distractor condition and language was significant; $\chi^2(2) = 16.88$, $p < .001$). Compared to when unrelated distractors were presented, Region 1 was significantly slower when object distractors were presented in English (1435 ms vs. 1355 ms; $b = 77.0$, $SE = 25.1$, $t(67) = 3.06$, $p = .003$, $d = .75$) but not statistically different in Korean (1386 ms vs. 1416 ms; $b = -34.7$, $SE = 32.3$, $t(39) = -1.07$, $p = .289$, $d = .35$). Compared to when unrelated distractors were presented, Region 1 was not statistically different when location distractors were presented in English (1307 ms vs. 1355 ms; $b = 41.7$, $SE = 26.6$, $t(65) = 1.57$, $p = .122$, $d = .39$) nor in Korean (1423 ms vs. 1416 ms; $b = -13.4$, $SE = 36.5$, $t(39) = -0.37$, $p = .714$, $d = .12$). This interaction between distractor condition and language was not modulated by trial type (i.e., stay vs. switch trials; the 3-way interaction between distractor condition, language, and trial type was not significant; $\chi^2(2) = 1.47$, $p = .478$).

Region 1 was significantly influenced by language-switch, such that Region 1 was significantly faster when the language of the previous trial was the same compared to when it was different from the current trial (1319 ms vs. 1459 ms; $\chi^2(1) = 33.41$, $p < .001$). This effect of language switch was not statistically different depending on the language of the current trial (i.e., the interaction between trial type and language was not significant; $\chi^2(1) = 1.40$, $p = .236$) or by the distractor condition (i.e., the interaction between trial type and distractor condition was not significant; $\chi^2(2) = 1.40$, $p = .497$).

Region 3 (the speech duration from the onset of "below" until the onset of the second noun) was influenced by language, such that it was slower for English compared to Korean (607 ms vs. 472 ms, $\chi^2(1) = 54.67$, $p < .001$). Furthermore, Region 3 was influenced by distractor condition ($\chi^2(2) = 9.26$, $p = .009$)—collapsed across language, Region 3 was significantly slower in both the object distractor condition (552 ms vs. 524 ms; $b = 28.4$, $SE = 9.96$, $t(45) = 2.85$, $p = .007$, $d = .87$) and the location distractor condition compared to the unrelated distractor condition (539 ms vs. 524 ms; $b = -17.4$, $SE = 8.43$, $t(42) = -2.07$, $p = .045$, $d = .64$). However, this effect of distractor condition differed depending on language, as suggested by the interaction between the distractor condition and language ($\chi^2(2) = 16.36$, $p < .001$). Compared to when unrelated distractors were presented, Region 3 was significantly slower when object distractors were presented in Korean (508 ms vs. 451 ms; $b = 59.4$, $SE = 14.5$, $t(44) = 4.11$, $p < .001$, $d = 1.25$) but not statistically different in English (598 ms vs. 600 ms; $b = -2.6$, $SE = 12.4$, $t(49) = -0.21$, $p = .834$, $d = .06$). Compared to when unrelated distractors were presented, Region 3 was not statistically different when location distractors were presented in Korean (458 ms vs. 451 ms; $b = -8.1$, $SE = 12.7$, $t(42) = -0.64$, $p = .53$, $d = .20$) or in English (623 ms vs. 600 ms; $b = -26.8$, $SE = 15.1$, $t(42) = -1.78$, $p = .08$, $d = .55$). Furthermore, this interaction between the distractor condition and language did not show statistical difference depending on stay vs. switch trials (i.e., the 3-way interaction between distractor condition, language, and trial type was not significant; $\chi^2(2) = 2.20$, $p = .332$).

Region 3 was not statistically different depending on the trial type ($\chi^2(1) = 2.37$, $p = .124$), and this lack of trial type effect did not differ depending on language (i.e., the interaction between trial type and language was not significant; $\chi^2(1) = 1.96$, $p = .163$) or distractor conditions (i.e., the interaction between trial type and distractor condition was not significant; $\chi^2(2) < 1$, $p = .800$).

Region 2 (the speech duration of the first noun) was not statistically different depending on the language ($\chi^2(1) < 1$, $p = .715$), distractor condition ($\chi^2(2) = 2.63$, $p = .268$), or trial type

($\chi^2(1) < 1$, $p = .955$). None of the higher order interactions were significant—the lack of language effect did not show statistical difference depending on distractor condition ($\chi^2(2) = 4.10$, $p = .129$) or trial type ($\chi^2(1) < 1$, $p = .476$); the effect of distractor condition did not show statistical difference depending on trial type ($\chi^2(2) < 1$, $p = .817$); the lack of interaction between language and distractor condition did not show statistical difference depending on trial type (i.e., the 3-way interaction between distractor condition, language, and trial type was not significant; $\chi^2(2) < 1$, $p = .643$).

Region 4 (the speech duration of the second noun) was significantly influenced by trial type, such that Region 4 was significantly slower when the language of the previous trial was the same as the current trial compared to when it was different (494 ms vs. 487 ms; $\chi^2(1) = 4.14$, $p = .042$). This effect of trial type did not show a statistical difference depending on the language of the current trial (i.e., the interaction between trial type and language was not significant; $\chi^2(1) < 1$, $p = .670$) or the distractor condition (i.e., the interaction between trial type and distractor condition was not significant; $\chi^2(2) < 1$, $p = .944$). Region 4 was not statistically different depending on the language ($\chi^2(1) < 1$, $p = .819$), or distractor condition ($\chi^2(2) = 1.56$, $p = .448$). The lack of language effect did not show a statistical difference depending on distractor condition (i.e., the interaction between language and distractor condition was not significant; $\chi^2(2) < 1$, $p = .963$), and the lack of interaction between language and distractor condition did not show statistical difference depending on trial type (i.e., the 3-way interaction between distractor condition, language, and trial type was not significant; $\chi^2(2) < 1$, $p = .876$).

5.3. Discussion

Experiment 4 demonstrated that when English-immersed bilinguals produce one language in the context of frequent language switches, interference from object distractors (*apple*) appeared at the beginning of the phrase for English (right before saying the word "lemon" in the phrase "the lemon below the lobster"), and later in the phrase for Korean (right before saying the word "lemon" in the phrase "[lobster][below][lemon]"). This different pattern of interference depending on language was not influenced by whether the language of the previous trial was the same or different as the current trial. From these results, we suggest that when bilinguals speak one language, they plan the linear word order of their speech only based on the language that they are actively using at the time, even when they are frequently switching languages which should substantially increase the extent of dual-language activation.

Interestingly, although Experiment 4 showed that language switching (stay vs. switch trials) did not influence the interference effects, the interference effects we observed in Experiment 4 seemed as though they were stronger than the interference effects from Experiment 3 (see Figures 5 vs. 6a), indicating that there may be overall more robust interference effects when being in an environment that requires frequent language switching. To test if the interference effects were in fact stronger in Experiment 4 than in Experiment 3, we conducted two post-hoc analyses comparing the two experiments on interference effects from object distractors on Region 1 when bilinguals were speaking English, and on Region 3 when bilinguals were speaking in Korean. To account for overall slowing when frequently switching between languages (*language-mixing cost*; see Declerck, 2020; Declerck, Philipp, & Koch, 2013), we calculated proportional interference effects by dividing the RTs from object distractor condition by RTs from the unrelated distractor condition. RT means were then submitted to an ANOVA with experiment (Experiment 3 vs. Experiment 4) as a between-subject variable. After making this adjustment for overall response speed, when bilinguals spoke in English, interference from object distractors was equivalent across experiments; i.e., was not different when bilinguals did versus did not switch languages from trial to trial [$F(1, 94) = 1.54$, $p = .218$]. In contrast, when bilinguals spoke in Korean, their dominant language, interference from object distractors was significantly stronger when frequently switching languages compared when there were no language switches [$F(1, 94) = 6.02$, $p = .016$]. From this, we might infer that bilinguals not only keep their language separate while speaking one, but that they do so even more when they speak in their dominant language in a block of trials that requires frequent language switches (compared to when they are not expecting frequent language switches).

6. General Discussion

Four experiments examined when speakers plan each noun in a noun phrase using an extended picture-word interference paradigm, to investigate whether English-immersed bilinguals access the sentence structure of a non-target language when speaking a target language. Evidence of dual language activation during the production of one language would have provided the first step in expanding the current literature on whether structural representations of two languages with different linear word orders are shared or separate.

Experiment 1 showed that English monolinguals plan each noun in a noun phrase just before producing it. Experiment 2 showed that, although it is less clear when Korean-immersed speakers plan nouns in a noun phrase, planning of nouns in a noun phrase is different for Korean-immersed speakers speaking Korean versus English monolinguals speaking English, i.e., revealing a different time-course of planning nouns in different orders depending on the language. Experiment 3 showed that when English-immersed bilinguals speak in one language without expecting frequent language switches, English and Korean interference patterns differ from each other, suggesting that English-immersed bilinguals only access the language that they are actively using at the time. Such patterns were replicated in Experiment 4, where English-immersed bilinguals frequently switched between languages, and this was not influenced by whether the language of the previous trial was the same or different as the current trial. Post-hoc analyses indicated that the interference patterns in the dominant language (Korean) observed in Experiment 3 might be amplified in Experiment 4, suggesting that bilinguals might access the non-target language even less when expending more effort to maintain separation between languages, in a context that demands frequent switching between languages compared to in a context that does not demand frequent switching between languages.

Before considering the implications of our results, it is important to note that we did not observe the expected pattern in Korean-immersed speakers speaking in Korean. That is, although we replicated Momma and colleagues' observation of "just in time" planning with English monolinguals, we did not observe a clear evidence of "just in time" planning with Korean-immersed bilinguals speaking Korean. "Just in time" planning would predict an interference effect from location distractors at the beginning of the Korean phrase (rather than later in the phrase), where the location is uttered. Instead, Korean-immersed bilinguals showed slower onset latencies and first-word durations when location distractors were presented only compared to when object distractors were presented, but not compared to when unrelated distractors were presented. Location distractors led to numerically slower onset latencies than unrelated distractors, but this was statistically non-significant. It seemed as though the same unrelated distractors that served as baseline for English monolinguals did not serve as baseline for Korean-immersed bilinguals. It is unclear why Korean-immersed speakers did not exhibit the same "just in time" planning as English monolinguals, although it is unlikely that it was because they were not monolingual Korean speakers, given that English-immersed bilinguals speaking Korean in Experiment 4 did show some expected patterns of "just in time" planning. As mentioned in the discussion of Experiment 2, the different pattern in Korean may be because the -150 SOA operates differently when participants are speaking Korean compared to English, or because the blue squares indicating the object pictures drew attention and advanced processing of the object lexical representation, a process that was interfered with by the object-related distractors. However, for the purpose of the current study, it was evident that Korean-immersed bilinguals plan their Korean speech differently from English monolinguals planning their English, allowing us to compare English and Korean speech of English-immersed bilinguals.

Comparing English and Korean speech of English-immersed bilinguals, our data do not support the idea that sentence structures with different linear word orders across languages have shared representations at the functional stage of two-stage models of production (e.g., Bock & Levelt, 1994; Garrett, 1975), or if they do, these shared functional-stage representations lead to dual-language activation at the positional stage. Although Korean and English noun phrases should be the same at the functional stage, we observed no evidence of dual-language activation, suggesting that Korean and English noun phrases are represented separately at both functional and positional stages, or that if they are represented together at the functional stage, these shared functional-stage representations do not lead to dual-language activation at the positional stage.

Our data are consistent with one-stage models of language production (e.g., Pickering et al., 2002), which claim that grammatical functions and linear order relations are computed simultaneously. Because noun phrases with prepositional phrases have different linear word orders across Korean and English, according to one-stage accounts, they cannot share structural representations. Although some structures with different linear word orders could share structural representations as long as they share some common procedures for building sentence structure (Chang et al., 2000), at least some overlap of linear word orders might be necessary. That is, for example, although the Korean and English dative constructions that showed priming across languages (Shin & Christianson, 2009) have different linear word orders in terms of the position of the verb (e.g., for the prepositional dative, *the knitter* ***gave*** *the sweater to her sister* vs. *[knitter][sweater][sister]****[gave]***), they still share the same linear word orders in part of the construction (e.g., for the prepositional dative, *the knitter gave* ***the sweater to her sister*** vs. *[knitter]****[sweater][sister]****[gave]*). Given that Korean and English noun phrases have very different linear word orders, they might be procedurally so different that it is difficult to have a shared representation. Additionally, we should note that our choice of noun phrases for our experiment might have introduced different ways of constructing sentence structures from standard structural priming. That is, while speakers often have to choose between alternative sentence structures that are comparable in meaning (e.g., dative alternations; such as *the knitter gave the sweater to her sister* vs. *the knitter gave her sister the sweater*) in a structural priming paradigm, speakers in our experiment only produced noun phrases in single, non-alternative sentence structure throughout the experiment. This suggests that perhaps one way that structural representations are shared across languages is by having the same language-independent process of selecting one sentence structure over the other. To examine these issues, future research should examine Korean and English dative structures using the extended picture-word interference paradigm. If some points of overlap and the process of selecting between alternative sentence structures allow a shared representation of Korean and English dative structures despite their different word orders, we should observe evidence of dual-language activation also in extended picture-word interference paradigm.

Our conclusion contrasts with previous studies that argued for shared representation of sentence structures with different linear word orders across languages (e.g., Bernolet et al., 2009;

Chen et al., 2013; Desmet & Declercq, 2006; Hwang et al., 2018; Muylle et al., 2020, 2021; Shin & Christianson, 2009; Weber & Indefrey, 2009). The discrepancies between our results and the previous literature cannot be explained by properties of standard structural priming alone, namely, frequent language switches within the experimental session. We observed that even when bilinguals frequently switch between languages, they still did not show sentence production patterns that suggest dual-language activation. Instead, if anything, exploratory comparisons suggested that bilinguals' production patterns in their dominant Korean resembled the expected patterns of Korean-immersed speakers even more strongly. Although speculative, we might infer that at least when word orders are very different across languages, inhibition of the non-target language can be even stronger when frequently switching between languages (see Declerck & Philipp, 2015). In all, although different from the direction we predicted, we observed that the expectation of frequent language switching can influence the extent of dual language activation. Given that current cross-language structural priming studies only involve experimental settings with frequent language switches, future research investigating sharedness of sentence structures across languages should take into consideration whether or not the tasks involve frequent language switches.

Overall, we found that the sentence production patterns of bilinguals differ depending on the language that they are actively speaking, suggesting mainly separate representations and language-specific activation of sentence structures with very different linear word orders. Language-specific activation seems to persist even with recent activation (i.e., language switching) of another language.

Chapter 2, in full, is a reprint of the material as it appears in Ahn, D., Ferreira, V. S., & Gollan, T. H. (2021). Selective activation of language specific structural representations:

Evidence from extended picture-word interference. *Journal of Memory and Language*, *120*, 104249. The dissertation author was the primary investigator and author of this paper.

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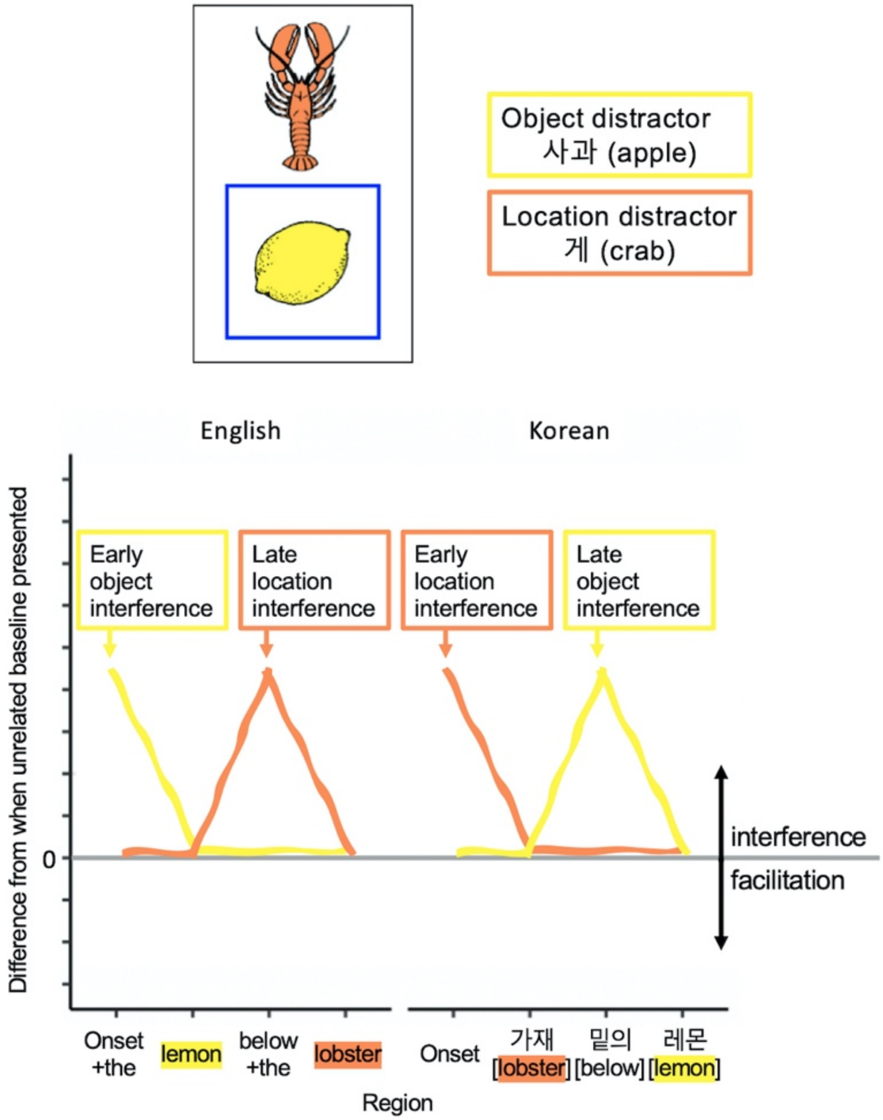


Figure 2.1. An illustration of the expected timing of semantic interference from object and location distractors for English vs. Korean sentences if speakers plan each noun in a noun phrase "just in time." Participants were asked to describe the picture in the blue square (lemon) using the other picture (lobster) as the location. In this example, the target utterance is "the lemon below the lobster" in English with the object stated first, and "[lobster][below][lemon]" in Korean with the location stated first. Pictures are colored in this figure for illustrative purposes; pictures were presented as black and white line drawings in the experiments. The grey horizontal bar represents when unrelated distractors are presented. Lines above the grey bar represent expected semantic interference effects.

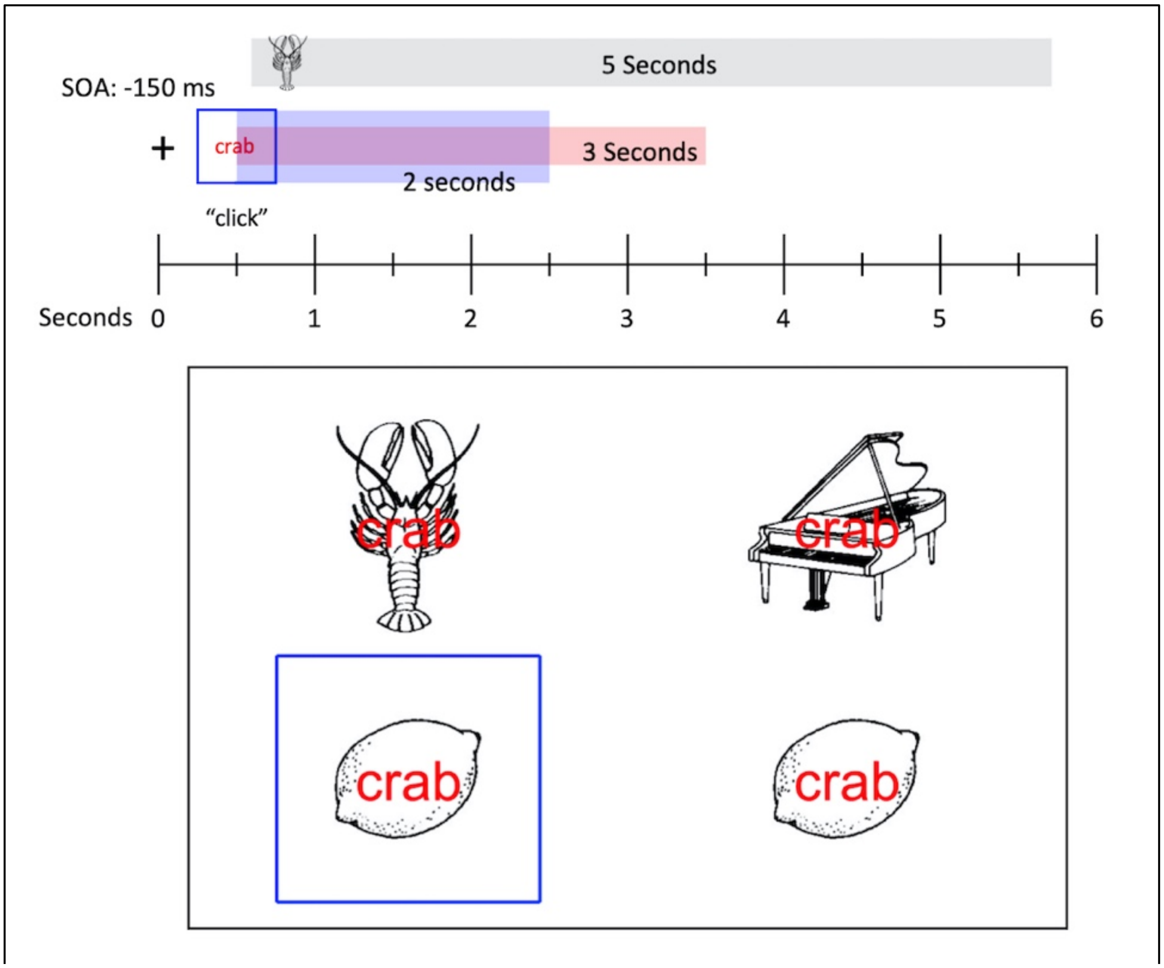


*Figure 2.2***.** A schematic of an experimental trial. In this example, the target utterance is "the lemon below the lobster." Each experimental trial lasted for 6 seconds. At the beginning of the trial, a fixation cross appeared for 500 ms, which was replaced by the distractor word ("crab" in this example) and the blue square, together as a short click sounded. The line-drawings appeared 150 ms after the onset of the distractor word and the blue square. The blue square disappeared 2 seconds after its presentation, and the distractor words disappeared 3 seconds after their presentation. The target line-drawings stayed on the screen for 5 seconds.

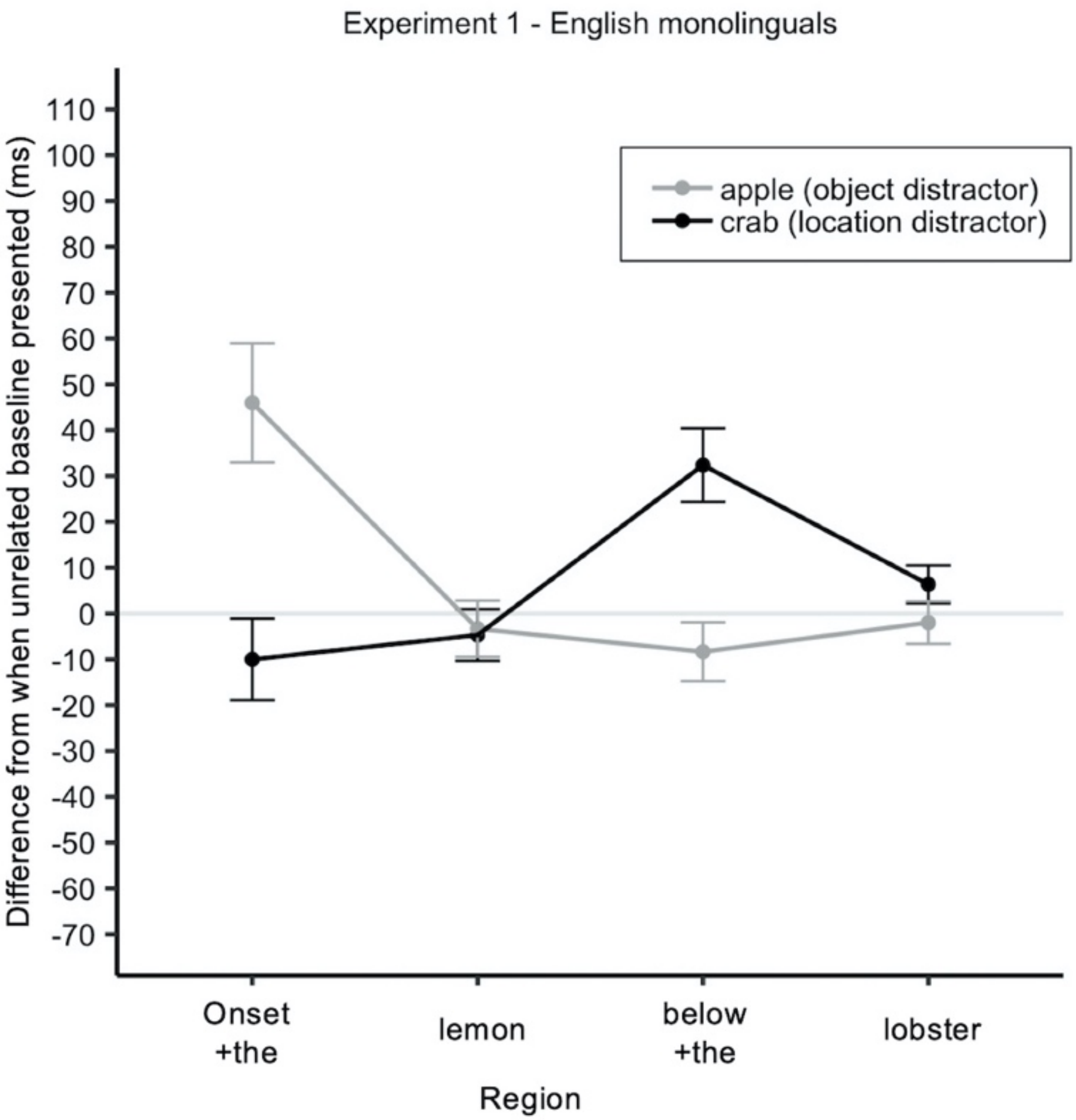


Figure 2.3. Interference effects relative to when unrelated baselines were presented. Error bars represent standard errors.

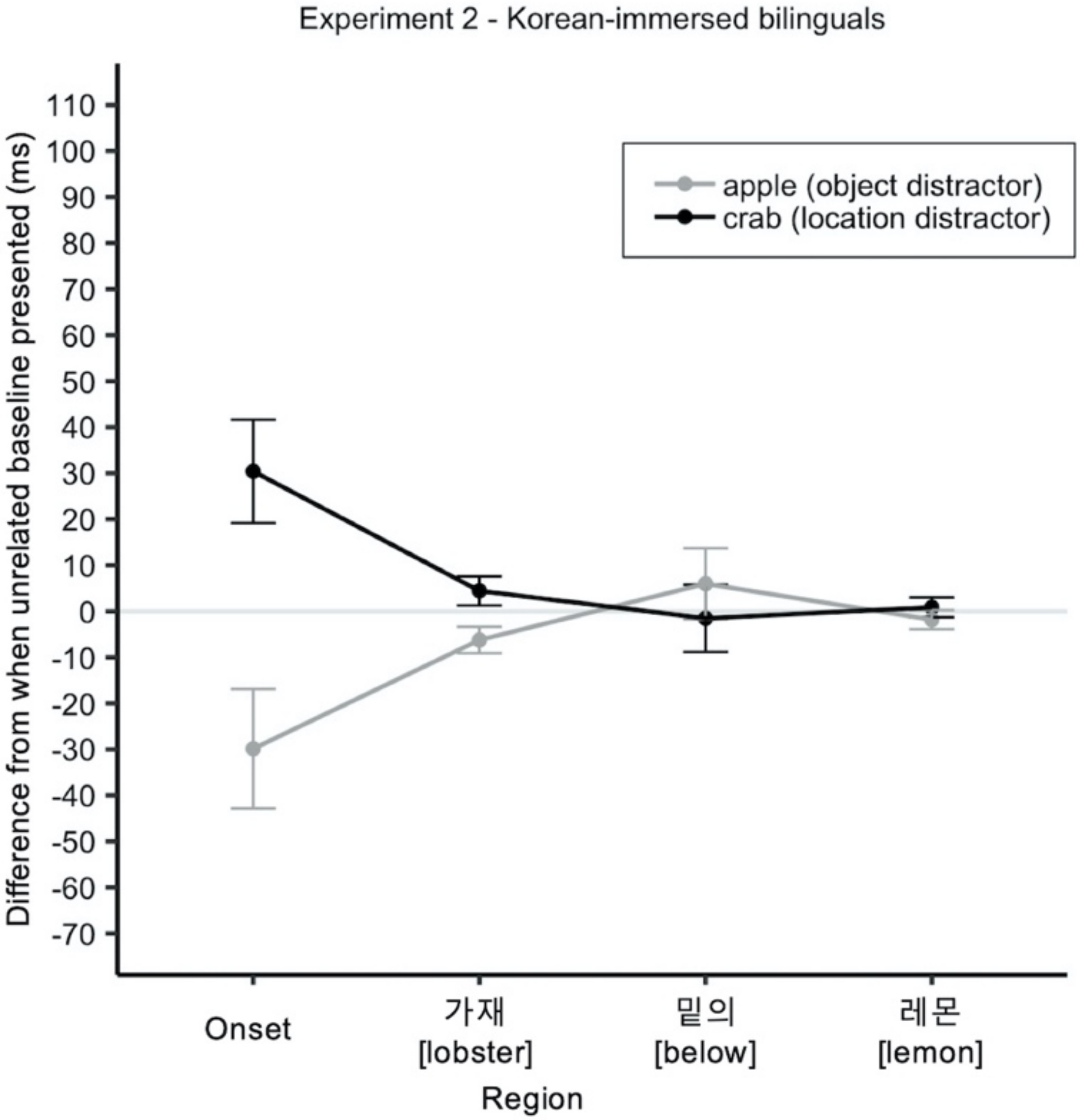


Figure 2.4. Interference effects relative to when unrelated baselines were presented. Error bars represent standard errors.

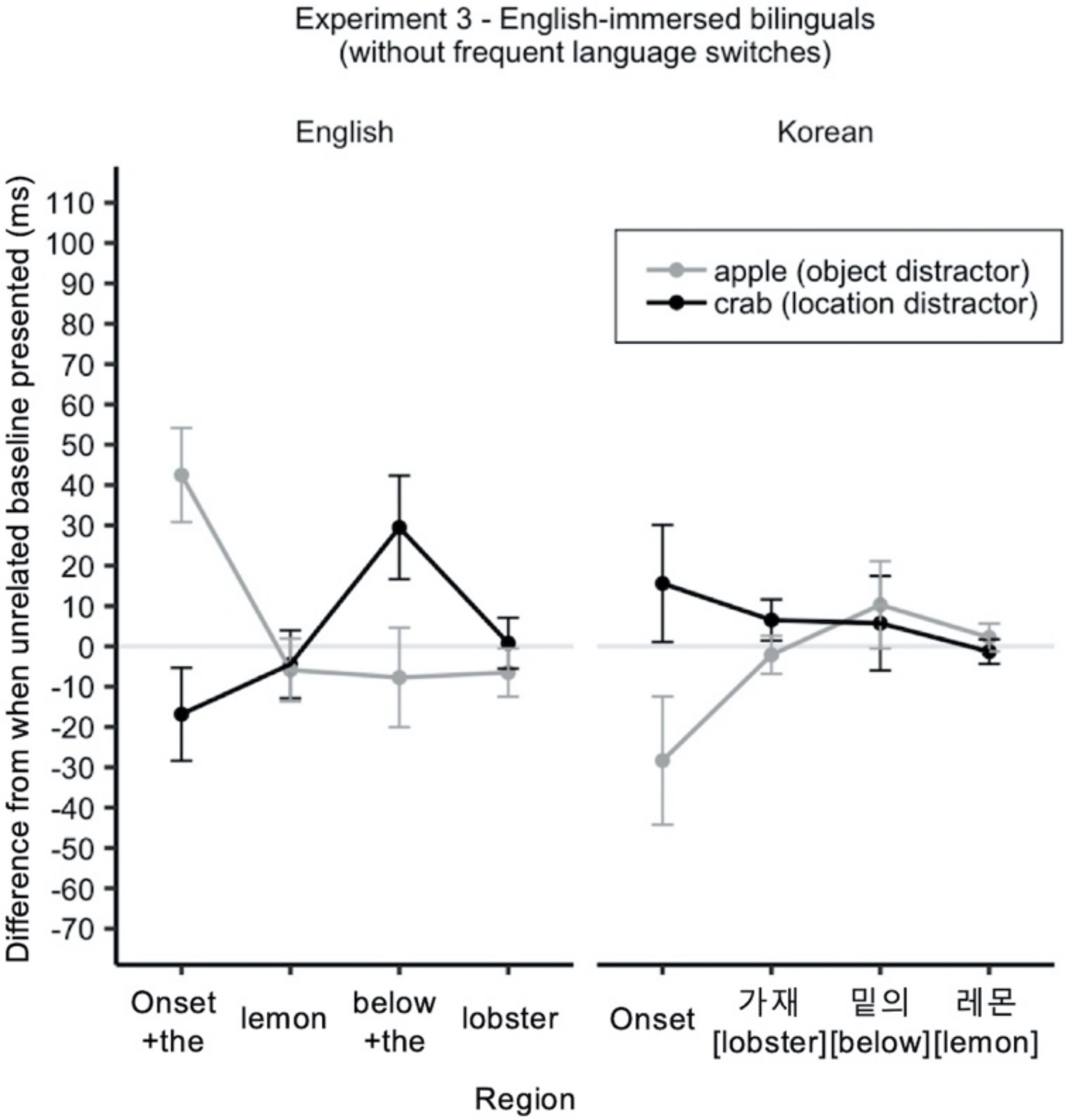


Figure 2.5. Interference effects relative to when unrelated baselines were presented. Error bars represent standard errors.

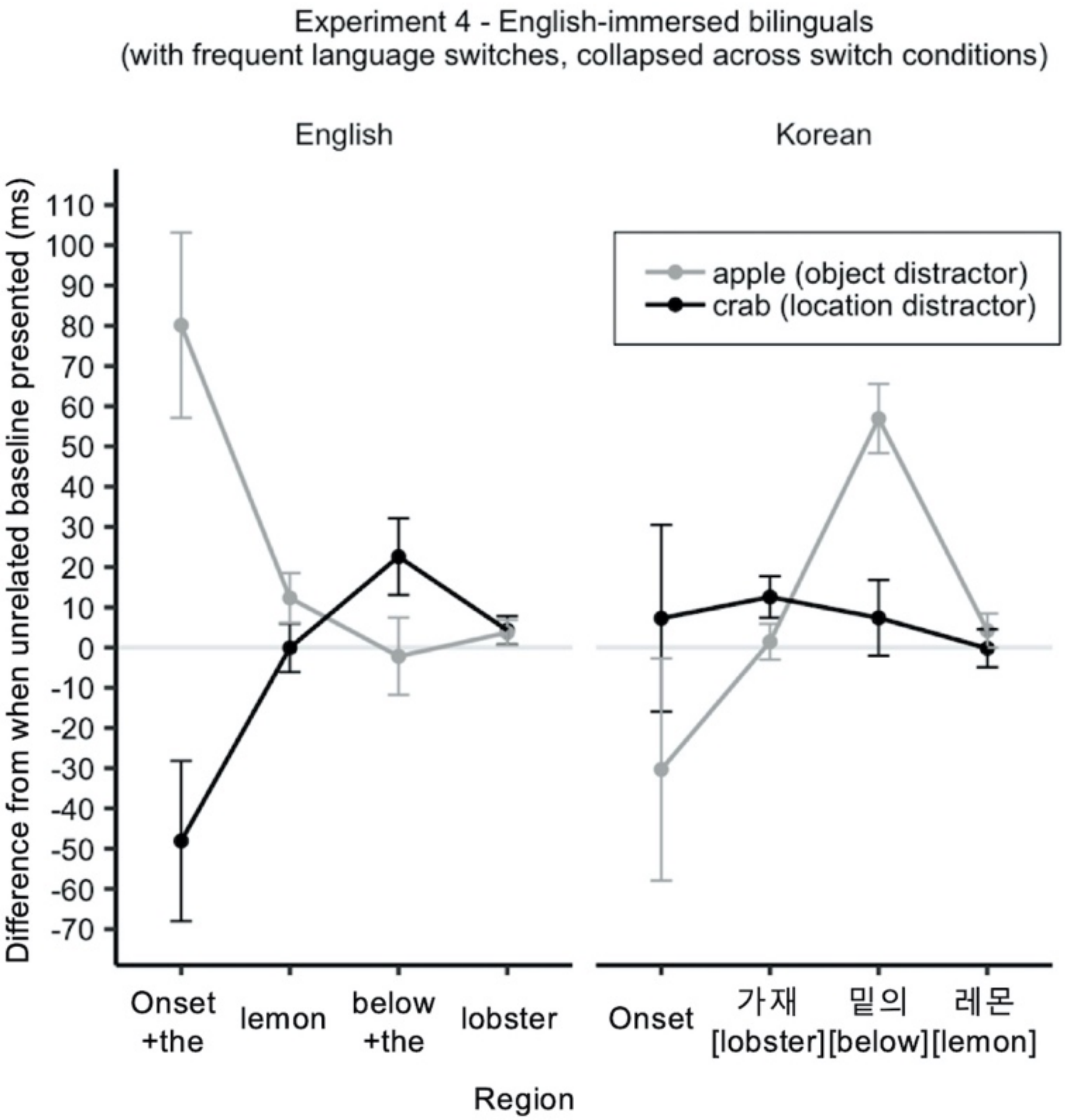


Figure 2.6a. Interference effects relative to when unrelated baselines were presented, collapsed across switch conditions. Error bars represent standard errors.

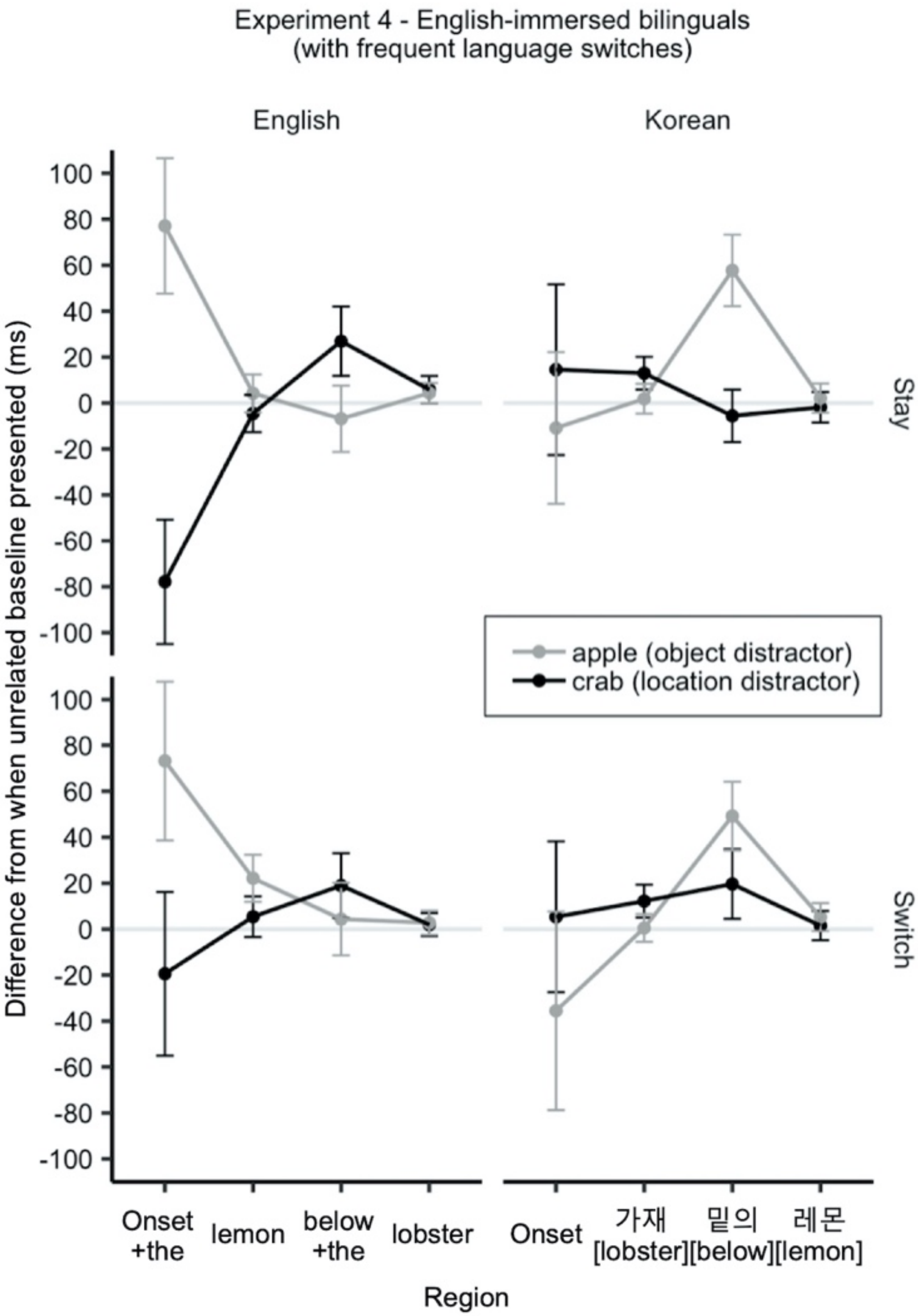


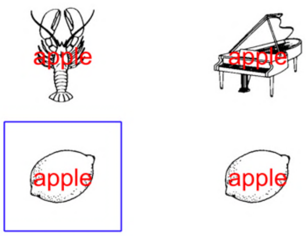
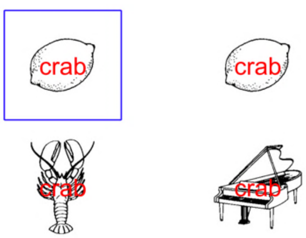
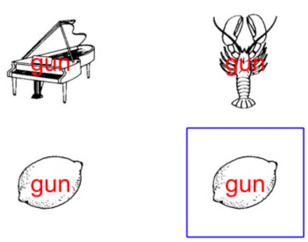
Figure 2.6b. Interference effects relative to when unrelated baselines were presented. Error bars represent standard errors.

Table 2.1. Participant characteristics and language proficiency based on self-report and pictures from the Multilingual Naming Test (MINT).

	English Monolinguals (Experiment 1)		Korean-immersed Korean-English Bilinguals (Experiment 2)		English-immersed Korean-English bilinguals (Experiment 3)		English-immersed Korean-English bilinguals (Experiment 4)	
Current Age	21.4 (3.2)		24.0 (3.4)		22.1 (3.8)		24.1 (4.4)	
Lived in the US (years)	21.4 (3.2)		0.1 (0.2)		5.9 (2.7)		5.3 (3.2)	
	English	Korean	English	Korean	English	Korean	English	Korean
Age of Acquisition (year)	0 (0)		8.6 (3.2)	0 (0)	8.5 (4.0)	0 (0)	8.8 (3.0)	0.1 (0.6)
Approximate percentage of daily use								
Current			9.6 (9.2)	89.4 (9.5)	54.5 (19.2)	44.2 (19.5)	49.9 (23.6)	49.0 (24.1)
Growing up			10.3 (7.4)	88.7 (8.5)	27.4 (16.2)	70.1 (18.7)	20.6 (16.5)	78.3 (17.6)
Proficiency self-rating								
Listen	6.9 (0.4)		3.9 (1.0)	6.9 (0.6)	5.5 (1.1)	6.9 (0.4)	5.3 (1.2)	6.9 (0.3)
Read	7.0 (0.0)		4.3 (1.2)	6.8 (0.6)	5.3 (1.1)	6.8 (0.6)	5.3 (0.8)	6.8 (0.6)
Write	7.0 (0.0)		3.2 (1.1)	6.8 (0.7)	4.9 (1.1)	6.5 (1.0)	5.0 (0.9)	6.8 (0.7)
Speak			3.2 (0.9)	6.8 (0.7)	5.3 (1.2)	6.9 (0.5)	4.9 (1.2)	6.9 (0.4)
Fluent	7.0 (0.0)							
Pronunciation	6.9 (0.4)							
MINT (% correct)			66.1 (9.3)	90.1 (3.0)	77.1 (5.8)	85.5 (4.8)	78.1 (8.4)	86.8 (3.7)

Note. All numbers represent means across participants. Standard deviations are indicated in parentheses.

Table 2.2. Example trials for one item and mean cosine similarity measure (in Latent Semantic Analysis database) across all items.

			Target Object	Target Location	Other Location
Object distractor condition			Lemon	Lobster	Piano
	Target Object	Lemon	-	-	0.08 (0.05)
	Target Location	Lobster	0.06 (0.06)	-	-
	Other Location	Piano	0.08 (0.05)	0.07 (0.10)	-
	Object Distractor Word	Apple	**0.43 (0.17)**	0.06 (0.06)	0.08 (0.07)
Location distractor condition			Lemon	Lobster	Piano
	Location Distractor Word	Crab	0.08 (0.07)	**0.43 (0.17)**	0.10 (0.11)
Unrelated distractor condition			Lemon	Lobster	Piano
	Unrelated Distractor Word	Gun	0.13 (0.19)	0.08 (0.08)	0.12 (0.21)

Note. In this example, the target utterance is always "the lemon below (above) the lobster." Absolute values were used to compute means and standard deviations for negative cosine similarity values. Standard deviations of the cosine similarity measures across pairs are indicated in parentheses. The mean and standard deviations of cosine similarity measures for the word pairs that should be highly semantically related in our experimental design are boldfaced. Unrelated words were quantified as less than .3 of cosine similarity measures in LSA.

Table 2.3a. The means and standard deviations of production durations for Experiments 1-3.

English monolinguals (Experiment 1)				
Condition	Region 1 Onset + *the*	Region 2 *lemon*	Region 3 *below + the*	Region 4 *lobster*
Location Distractor	916 (173)	446 (82)	530 (108)	546 (75)
Object Distractor	972 (198)	447 (79)	490 (93)	538 (62)
Unrelated Distractor	926 (179)	450 (85)	498 (92)	540 (70)

Korean-immersed Korean-English Bilinguals (Experiment 2)				
Condition	Region 1 Onset	Region 2 *[lobster]*	Region 3 *[below]*	Region 4 *[lemon]*
Location Distractor	987 (196)	403 (54)	380 (86)	411 (46)
Object Distractor	927 (221)	393 (51)	388 (89)	408 (49)
Unrelated Distractor	957 (206)	399 (52)	382 (79)	410 (45)

English-immersed Korean-English bilinguals, English (Experiment 3)				
Condition	Region 1 Onset + *the*	Region 2 *lemon*	Region 3 *below + the*	Region 4 *lobster*
Location Distractor	949 (194)	542 (105)	650 (114)	533 (63)
Object Distractor	1009 (228)	540 (111)	613 (112)	526 (72)
Unrelated Distractor	966 (193)	546 (110)	620 (109)	532 (79)

English-immersed Korean-English bilinguals, Korean (Experiment 3)				
Condition	Region 1 Onset	Region 2 *[lobster]*	Region 3 *[below]*	Region 4 *[lemon]*
Location Distractor	1083 (270)	455 (69)	431 (102)	464 (55)
Object Distractor	1039 (278)	447 (68)	436 (101)	468 (57)
Unrelated Distractor	1068 (281)	449 (65)	426 (120)	465 (56)

Note. Means are calculated by first collapsing across items per participant and then averaging across participants. Standard deviations (indicated in parentheses) are across participants. An example of target word for each region is italicized.

Table 2.3b. The means and standard deviations of production durations for Experiment 4.

English-immersed Korean-English bilinguals, English, stay				
Condition	Region 1 Onset + *the*	Region 2 *lemon*	Region 3 *below + the*	Region 4 *lobster*
Location Distractor	1209 (394)	455 (79)	627 (147)	492 (63)
Object Distractor	1364 (455)	464 (79)	594 (136)	490 (64)
Unrelated Distractor	1287 (423)	459 (86)	600 (125)	486 (64)

English-immersed Korean-English bilinguals, English, switch				
Condition	Region 1 Onset + *the*	Region 2 *lemon*	Region 3 *below + the*	Region 4 *lobster*
Location Distractor	1407 (414)	458 (92)	617 (115)	483 (80)
Object Distractor	1500 (428)	475 (105)	602 (140)	484 (78)
Unrelated Distractor	1426 (437)	453 (81)	598 (136)	481 (78)

English-immersed Korean-English bilinguals, Korean, stay				
Condition	Region 1 Onset	Region 2 *[lobster]*	Region 3 *[below]*	Region 4 *[lemon]*
Location Distractor	1361 (415)	466 (73)	460 (111)	494 (89)
Object Distractor	1336 (425)	455 (74)	523 (136)	498 (84)
Unrelated Distractor	1347 (504)	453 (71)	465 (114)	496 (79)

English-immersed Korean-English bilinguals, Korean, switch				
Condition	Region 1 Onset	Region 2 *[lobster]*	Region 3 *[below]*	Region 4 *[lemon]*
Location Distractor	1491 (491)	462 (85)	457 (128)	488 (73)
Object Distractor	1450 (545)	450 (77)	486 (120)	492 (78)
Unrelated Distractor	1486 (481)	449 (74)	437 (107)	486 (72)

Note. Means are calculated by first collapsing across items per participant and then averaging across participants. Standard deviations (indicated in parentheses) are across participants. An example of target word for each region is italicized.

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CHAPTER THREE

Structural Representation in the Native Language After Extended Second-Language Immersion: Evidence from Acceptability Judgment and Memory-Recall

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Abstract

People represent the structures of sentences (i.e., information that guides the assembly of words into sentences) in the languages that they know. This knowledge must be stable for successful communication. But, when learning another language that uses different structures, speakers must adjust their structural knowledge to fit the newly learned language. Does this also influence first language (L1) structural knowledge? Here, we examine whether newly acquired second language (L2) knowledge can influence L1 structure knowledge. To do this, we compared Korean-immersed speakers living in Korea (who had little English exposure) with English-immersed speakers who acquired English late and were living in the US (and so had more English exposure) using acceptability judgment and sentence production tasks on Korean sentences in three word orders: the canonical word order in Korean (subject-object-verb; SOV), the canonical word order in English (subject-verb-object; SVO), or scrambled but grammatical word order in Korean (object-subject-verb; OSV). Results suggest that acceptability and structural usage in L1 change after exposure to L2, but not in a way that matches L2 structures. Instead, L2 exposure appears to be associated with overall "noisier" L1 representations.

Keywords: Bilingualism, Sentence production, Bilingual syntax, L2 immersion, Word order

1. Introduction

Speakers know how to describe an event in the language they speak, using acceptable *sentence structures* (i.e., information that guides the assembly of words into sentences). For example, Korean speakers know that the canonical word order in Korean is subject-object-verb (SOV), so that they can describe an event of a dog chasing a cat by saying *[**dog**][cat][chase]* in Korean. In contrast, English speakers know that the canonical word order in English is subject-verb-object (SVO), so that they can describe the same event of a dog chasing a cat by saying ***the dog*** *chases* *the cat* in English. This knowledge of which word orders speakers can use in their languages must be stable to communicate successfully with other speakers of the same languages. However, sometimes speakers learn a second language (L2) which can introduce different word order, while (almost) always keeping their first language (L1). For example, for the same event that a Korean speaker describes using SOV word order, in English they should use SVO word order. How does adding structural knowledge of the L2 influence structural knowledge of the L1?

Although L1 might feel stable and resistant to change, the current bilingualism literature suggests that L1 might be subject to changes in response to acquiring an L2, and bilinguals are not identical to monolinguals even in their L1 (for reviews, see Kroll, Dussias, & Bajo, 2018; Kroll & Gollan, 2014). In particular, abundant evidence supports that bilinguals access linguistic information such as sounds and words from both of their languages even when speaking only one (for reviews, see Costa, 2005; Dijkstra & van Heuven, 2002; Kroll & Gollan, 2014; Kroll, Gullifer, & Rossi, 2017; Runnqvist, Strijkers, & Costa, 2014). To modulate this co-activation, bilinguals use domain-general control mechanisms such as inhibitory control (for review, see Declerck, 2020), and this inhibition helps to modulate language competition by inhibiting the dominant language (typically L1; e.g., Guo, Liu, Misra, & Kroll, 2011; Kroll, Bobb, Misra, & Guo, 2008; Linck, Kroll, & Sunderman, 2009; Philipp, Gade, & Koch, 2007). Furthermore, the dominant language seems to require more inhibition than the non-dominant language, as switching to the dominant language takes longer than switching to non-dominant language (e.g., Christoffels, Firk, & Schiller, 2007; Christoffels, Ganushchak, & La Heij, 2016; Costa & Santesteban, 2004; Gollan & Ferreira, 2009; Heikoop, Declerck, Los, & Koch, 2016; Meuter & Allport, 1999; Verhoef, Roelofs, & Chwilla, 2009, 2010). Thus, it seems that L1 goes through repetitive inhibition for bilinguals in a way that does not happen for monolinguals' L1. From this, it may be that bilinguals' L1 is subject to long-lasting consequences in which their L1 representation becomes different from that of monolinguals.

Studies of bilingual structural representations also point to possibilities of changes in L1 following L2 acquisition. In English, speakers can describe an event of a dog chasing a cat by using an active sentence structure (e.g., ***the dog*** *chases* *the cat*) or a passive sentence structure (e.g., *the cat* *is chased by* ***the dog***). Similar active (***el perro*** *persigue* *al gato*; *the dog* is boldfaced and *the cat* is underlined for the ease of interpretation) and passive (*el gato* *es perseguido por* ***el perro***) sentence structures also exist in Spanish. These sentence structures could be organized in a bilingual’s mind separately or together. For example, there could be two separate representations for English (*the cat* *is chased by* ***the dog***) and Spanish (*el gato* *es perseguido por* ***el perro***) passive sentence structures. Alternatively, there could be a single, shared abstract representation that applies to both English and Spanish passive structures, such as *the cat* or *el gato* comes first in the sentence, and the verb is modified differently from the active sentences (-*ed* for English; -*ido* for Spanish).

Several studies investigated whether bilinguals have shared or separate representations for sentence structures in the languages that they know by using a *cross-language structural priming* paradigm. In monolingual studies, structural priming refers to the phenomenon in which speakers are more likely to repeat the structure that they accessed in subsequent production (Bock, 1986; see Mahowald, James, Futrell, & Gibson, 2016; Pickering & Ferreira, 2008). For example, speakers are more likely to say *the cat is chased by the dog* (a passive) after hearing *the truck is chased by the taxi* (another passive) compared to after hearing *the taxi chases the truck* (an active). Critically, structural priming has also been observed across languages, such that bilinguals were more likely to say *the cat is chased by the dog* (a passive) after hearing *el camión es perseguido por el taxi* (*the truck is chased by the taxi*; another passive) compared to after hearing *el taxi persigue el camion* (*the taxi chases the truck*; an active). The idea is that if Spanish and English passive structures are completely separate, accessing a passive structure in one language should not influence the access of a passive structure in another language. Cross-language structural priming effects thus provide evidence for a shared structural representation between two languages for bilinguals (e.g., Hartsuiker, Pickering, & Veltkamp, 2004; Loebell & Bock, 2003; see Gries & Kootstra, 2017; Hartsuiker & Bernolet, 2017; Hartsuiker & Pickering, 2008; Kootstra & Muysken, 2017; Van Gompel & Arai, 2018).

Such cross-language priming effects were also observed across languages that have different word orders, suggesting that the sharedness of structural representation is independent of word order (e.g., Bernolet, Hartsuiker, & Pickering, 2009; Chen, Jia, Wang, Dunlap, & Shin, 2013; Desmet & Declercq, 2006; Hwang, Shin, & Hartsuiker, 2018; Muylle, Bernolet, & Hartsuiker, 2020, 2021; Shin & Christianson, 2009; Weber & Indefrey, 2009; but see Bernolet, Hartsuiker, & Pickering, 2007; Jacob, Katsika, Family, & Allen, 2017; also see Ahn, Ferreira, &

Gollan, 2021 for evidence against shared structural information using a different paradigm). For example, Shin and Christianson (2009) examined cross-language structural priming in Korean L1 speakers who learned English as their L2. They used dative sentences, which have different linear word orders across English and Korean in terms of the position of the verb (e.g., for the prepositional dative, or PD, *the knitter* ***gave*** *the sweater to her sister* vs. *[knitter][sweater][sister]****[gave]***), although they still share the same linear word orders in part of the sentences (e.g., for the PD, *the knitter gave* ***the sweater to her sister*** vs. *[knitter]****[sweater][sister]****[gave]*). Shin and Christianson asked participants to memorize English prepositional dative (PD; *the lawyer handed the gift to the child*) or double object dative (DO; *The lawyer handed the child the gift*) target sentences. Then, after listening to Korean PD (*[knitter][sweater][sister][gave]*) or DO (*[knitter][sister][sweater][gave]*) priming sentences, participants were asked to recall the English target sentences that they had memorized before listening to the Korean priming sentences (although it is unclear whether these word-order variants in Korean are closely analogous to PD and DO forms in English, for simplicity, we adopt the PD and DO terminology here). Despite the different linear word orders, participants were more likely to recall the English target sentences as PD sentence structures after listening to Korean PD sentences compared to after listening to Korean DO sentences. This suggested that word order differences do not limit the extent to which sentence structures can have shared representations across languages. Even though the word orders are different across languages, some structural information, such as the selection process between the two alternative choices (PD vs. DO), could be represented together in a bilingual's cognitive system. If bilinguals have a single, shared representation for a sentence structure across languages, we might expect that some structural information from L2 could alter the representation of sentence structures in L1.

Indeed, some evidence from bilingual language comprehension suggests that L1 comprehension is influenced by L2 structural information (Dussias, 2003, 2004; Dussias & Sagarra, 2007). Monolingual Spanish speakers and monolingual English speakers show different preferences for structural interpretations of sentences with relative clauses (RC; e.g., Carreiras & Clifton, 1999; Cuetos & Mitchell, 1988). For example, when reading an ambiguous sentence such as *someone shot the servant of the actress [who was on the balcony]*, monolingual English speakers tend to interpret the sentence so that the actress was on the balcony (a low-attachment interpretation). In contrast, monolingual Spanish speakers tend to interpret the sentence so that the servant was on the balcony (a high-attachment interpretation).

Importantly, this interpretation preference seems to change for Spanish native speakers after learning English as an L2 (Dussias, 2003, 2004; Dussias & Sagarra, 2007). In a series of experiments, Spanish native speakers who were proficient in English preferred the relative clause attachment that is comparable to what English native speakers prefer. For example, eye movement recordings revealed that Spanish-English bilinguals took longer to read Spanish sentences that forced high attachment (e.g., *The police arrested* ***the sister*** *of the (male) servant who had been* ***ill (fem)*** *for a while*), compared to sentences that force low attachment (e.g., *The police arrested the brother of the* ***(female) baby-sitter*** *who had been* ***ill (fem)*** *for a while*). In other words, Spanish native speakers who learned English as their second language showed faster reading times for L1 sentences that were biased towards interpretations preferred in their L2 rather than their L1. This result suggests that Spanish-English bilinguals might have developed a shared structural representation in their two languages such that their comprehension of L1 was influenced by structural information from their L2.

A similar influence of L2 could be found for languages with different word orders, such as Korean and English. For example, the word order representation of a Korean native speaker (who grew up using SOV canonical word order in Korean) might adapt when exposed to English (which is a language with SVO canonical word order), such that Korean sentences in SVO word order becomes more natural. To test this, we compared Korean-immersed speakers with little exposure to English to English-immersed Korean speakers with extensive exposure to English. Experiment 1 tested their acceptability judgments of Korean sentences in Korean canonical word order (SOV), English canonical word order (SVO), and Korean scrambled word order (OSV). Experiments 2 and 3 tested the production of Korean sentences in these word orders. We selected English-immersed speakers who moved to the US after at least the age of 11, to investigate the change of representation of a well-established L1 after L2 exposure. Korean-immersed speakers should rate Korean sentences in Korean-canonical word order as most acceptable, and Korean sentences in English-canonical word order as least acceptable. Given that Korean has a relatively flexible word order and OSV can be used, the acceptability rating of Korean sentences in OSV (a Korean-scrambled) word order should be in between Korean sentences in Korean-canonical or English-canonical word orders. If English exposure influences the representation of Korean word orders to become more English-like, the acceptability rating and production of Korean sentences in English-canonical word order should be higher for English-immersed speakers compared to Korean-immersed speakers. Given that our English-immersed speakers were late learners of English, the representation of L1 canonical word order should be intact and thus acceptability ratings and production for Korean-canonical and Korean-scrambled word orders should not necessarily differ between English-immersed speakers and Korean-immersed speakers.

2. Experiment 1

2.1. Method

2.1.1. Participants

Forty-eight Korean-immersed speakers and forty-eight English-immersed speakers were recruited from Amazon's Mechanical Turk, the UC San Diego Psychology Department subject pool, and by word of mouth. All Korean-immersed speakers responded that they never lived in the US (or any other English-speaking country) for more than 2 years (*M* = 0.1 years; *SD* = 0.3 years). All English-immersed speakers indicated that they were born and raised in Korea, learned Korean as their first language, only used Korean until they moved to the United States age eleven, and Korean was their dominant language. At the time of participation, English-immersed participants lived in the US for an average of 12.3 years (*SD* = 8.6). See Table 3.1 for detailed participant information.

2.1.2. Materials and Design

Ninety-six Korean sentences were created. Each sentence was written in three word orders: the Korean-canonical word order (subject-object-verb; SOV; e.g., *composer-NOM*[1] *several notes-ACC evenly drew*), the English-canonical word order (subject-verb-object; SVO; e.g., *composer-NOM evenly drew several notes-ACC*), or Korean-scrambled—but grammatical—word order (object-subject-verb; OSV; e.g., *several notes-ACC composer-NOM evenly drew*). To provide more context for sentences, modifiers for verbs and objects (e.g., *evenly*, *several*) were included.

Six lists were created. Each list included all ninety-six experimental sentences once, with equal numbers of Korean-canonical, Korean-scrambled, and English-canonical word orders. Word orders were counterbalanced across lists.

[1] The abbreviations used are as following: NOM = nominative, ACC = accusative.

2.1.3. Procedure

The experiment was built, and responses were recorded using Qualtrics (Qualtrics, Provo, UT). Participants completed the survey on their personal computers or cellphones on their own time. Each participant was presented with 96 sentences from one list in random order, one sentence at a time. Participants were asked to judge each sentence on its grammatical acceptability and naturalness on a scale of 1-7, 1 being "very unnatural" and 7 being "very natural." Participants were asked to complete a language history questionnaire at the end of the experiment.

2.1.4. Analysis

Linear mixed effects models (LMMs; Baayen, Davidson, & Bates, 2008) were constructed with participants' ratings on the sentences as a continuous dependent variable. LMMs were fit using the lmer function from the lme4 package (Version 1.1-18-1; Bates, Mächler, Bolker, & Walker, 2015) in R: A Language and Environment for Statistical Computing (Version 3.5.1; R Core Team, 2014). We coded the categorical predictors using sum-to-zero contrasts (i.e., the intercept of the model was the grand mean of the dependent measure) for language background (Korean-immersed speakers vs. English-immersed speakers) and given sentence (Given Korean-canonical, Given Korean-scrambled, or Given English-canonical).

LMMs were fit incorporating the maximal random effects structure given the experimental design (Barr, Levy, Scheepers, & Tily, 2013). For significance testing, Type III Wald chi-square tests were performed on fitted LMM models using the "Anova" function from the car package (Version 3.0-3 Fox & Weisberg, 2011). Additionally, we computed estimated marginal means and standard errors using the emmeans package (Version 1.2.4; Lenth, 2019) to compare each treatment level.

2.2. Results

Figure 3.1 illustrates acceptability judgments. Throughout the results, it is important to note that all sentences were given in Korean.

Collapsed across given word orders, Korean- and English-immersed speakers were not different in their acceptability judgment of given sentences [4.3 (0.6) vs. 4.4 (0.6); χ^2 (1) < 1, $p = .43$].

Collapsed across Korean- and English-immersed speakers, participants rated the sentences differently based on the given word orders (χ^2 (2) = 1071.19, $p < .001$). In particular, participants rated sentences with Korean-canonical word order as more acceptable than sentences with Korean-scrambled word order [6.2 (0.7) vs. 4.7 (1.1); $b = 1.42$, $SE = .11$, $t = 13.37$, $p < .001$], sentences with Korean-canonical word order as more acceptable than sentences with English-canonical word order [6.2 (0.7) vs. 2.1 (0.9); $b = 4.00$, $SE = .12$, $t = 32.67$, $p < .001$], and sentences with Korean-scrambled word order as more acceptable than sentences with English-canonical word order [4.7 (1.1) vs. 2.1 (0.9); $b = 2.58$, $SE = .13$, $t = 19.70$, $p < .001$]. Given that all sentences were in Korean, these results were as predicted.

Korean- and English-immersed speakers rated the sentences differently based on the given word order (i.e., the 2-way interaction between group and given word order was significant; χ^2 (2) = 10.01, $p = .007$). That is, opposite to what we predicted, Korean-immersed speakers gave lower acceptability ratings compared to English-immersed speakers for sentences with Korean-canonical word order [6.0 (0.8) vs. 6.3 (0.6); $b = -.36$, $SE = .14$, $t = -2.52$, $p = .01$], whereas Korean-immersed speakers gave higher acceptability ratings than English-immersed speakers for sentences with English-canonical word order [2.3 (1.0) vs. 2.0 (0.8); $b = .37$, $SE = .18$, $t = 2.07$, $p = .04$]. Korean- and English-immersed speakers were not different in their acceptability rating for sentences with Korean-scrambled word order [4.6 (1.1) vs. 4.9 (1.0); b = -.30, SE = .22, t = -1.39, p = .17].

2.3. Discussion

Based on the acceptability judgments of Korean sentences, as predicted, we found that Korean-immersed and English-immersed speakers are not different in their ratings of Korean sentences in Korean-scrambled word order (OSV). However, for Korean sentences in Korean-canonical word order (SOV) and English-canonical word order (SVO), we found an opposite pattern from our prediction. Compared to how Korean-immersed speakers rated the sentences, English-immersed speakers rated Korean sentences in Korean-canonical word orders as more acceptable and Korean sentences in English-canonical word orders as less acceptable.

Given that acceptability judgment tasks allowed participants to spend as much time as they wanted, these results might be driven by the meta-linguistic knowledge that English-canonical (SVO) word order is non-canonical in Korean. Such use of meta-linguistic knowledge could be exaggerated in English-immersed speakers, as part of overcompensating for their L1 attrition (which late English learners who immigrate to English-immersed environments can experience; e.g., Schmid, 2010, 2013). Although an overcompensation for L1 attrition and the meta-linguistic knowledge that English-canonical (SVO) word order is non-canonical in Korean could drive acceptability judgments. more implicit language knowledge might drive the choice of word orders in Korean. If structural information is shared between a bilingual's two languages and if this structural sharedness drives production, L1 sentence production should be influenced by L2 word order knowledge so that the produced L1 sentences might resemble word orders from L2. To test this, we used a memory-recall paradigm adapted from Ferreira and Dell (2000). In their study, participants were asked to memorize temporarily ambiguous sentences such as *the* *coach knew (that) you missed practice* with or without the optional *that*. When asked to recall the sentences later, participants did not always exactly repeat the given sentence. Instead, participants did or did not include the optional “that” in a way that suggested that they produced the sentence structure that was most available to them as they spoke (i.e., even though participants were given the “that” in half of sentences, they produced it back in nearly three-quarters of sentences). Similarly, if bilinguals were asked to memorize and recall a sentence, they might produce the sentence using the sentence structure that is most available to them. If so, bilinguals should sometimes produce L1 sentences using L2 word order, showing that L2 structural information can influence L1 sentence production. Thus, English-immersed Korean native speakers who learned English as a second language should produce Korean (with a canonical word order of SOV) using English-canonical word order (SVO) more often than Korean-immersed speakers.

3. Experiment 2

3.1. Method

3.1.1. Participants

Detailed participant characteristics are provided in Table 3.1.

3.1.1.1. Korean-immersed speakers

Forty-eight Korean-immersed speakers from the Seoul National University (Seoul, Republic of Korea) community volunteered for monetary compensation. All participants were born and raised in Korea. Because the English language is a part of the high school curriculum in Korea, no participant was truly monolingual. However, all participants responded that they were functionally Korean monolinguals and never lived in the US (or any other English-speaking countries) for more than 12 months (M = 0.1 years; SD = 0.2 years).

3.1.1.2. English-immersed speakers

Forty-eight English-immersed speakers from the UC San Diego Psychology Department subject pool volunteered for course credit. All participants indicated that they were born and raised in Korea, learned Korean as their first language, moved to the United States after eleven years of age, and Korean is their dominant language. At the time of participation, participants lived in the US for an average of 5.6 years (*SD* = 2.5).

3.1.2. Materials and design

Materials and Design were identical to Experiment 1, except the order of sentences was kept identical for all participants who were given the same list. Order of sentences in each list was individually randomized, with a restriction that a single word order never repeated more than twice.

Four additional Korean sentences were included for instruction and training.

3.1.3. Procedure

The experiment was presented on a Macbook Air (13-inch, Mid 2013) for Korean-immersed speakers and an iMac (21.5-inch, Mid 2014) for English-immersed speakers using PsychoPy2 Version 1.81.03. Responses were recorded using the Voice Memos App on an iPhone 6 (Korean-immersed speakers) or a Marantz Solid State Recorder PMD661 (English-immersed speakers) for coding and analyses.

Each trial included three experimental sentences and involved an encoding phase and a recall phase. In the encoding phase, each sentence was shown in the middle of the screen for six seconds with one second of blank screen in between. Participants were asked to carefully read and memorize the given sentences, as they were to recall those sentences in the next phase. In the recall phase, participants were given an adverb and verb as cues to recall the respective sentences. The order of cues in the recall phase was different from the order of sentences in the encoding phase, with the restriction that the last memorized sentence was never the first recalled sentence. The recall cue stayed on the screen for two seconds, before the cues disappeared and participants were given three seconds to say the sentence out loud. The next recall cue appeared on the screen after one second of blank screen. Participants continued to the next trial by pressing the space bar at their own pace. Participants were encouraged to recall the sentences as much as possible and to guess if they did not remember the exact details of the memorized sentences. Example stimuli for one trial are shown in Table 3.2.

Participants completed a language history questionnaire at the end of the experiment.

3.1.4. Coding and Analysis

Participants' responses were transcribed and coded by native speakers of Korean, into Korean-canonical (SOV), Korean-scrambled (OSV), English-canonical (SVO), Other, or Forgot. "Other" responses included responses that included any two of S, O, and V in any order, and responses that included all three parts but were not in the order of Korean-canonical (SOV), Korean-scrambled (OSV), or English-canonical (SVO). "Forgot" responses included instances where the participant explicitly said that they forgot the response or did not say anything, and responses that included only one of S, O, or V.

GLMMs were fit using the glmer function from the lme4 package (Version 1.1-20; Bates et al., 2015) in R: A Language and Environment for Statistical Computing (Version 3.5.1; R Core Team, 2014). We fitted five separate binomial logistic regressions to predict proportions of utterances in Korean-canonical (SOV), Korean-scrambled (OSV), English-canonical (SVO), Other, and Forgot by assigning each of the possible word order as 1 and all the rest of the word orders as 0 (e.g., for the analysis of Korean-canonical word order, SOV was assigned as 1 and

OSV, SVO, Other, and Forgot were assigned as 0). Participant language background (Korean- vs. English-immersed) and given word order (Given Korean-canonical, Given Korean-scrambled, or Given English-canonical) were entered as categorial predictors using sum–to–zero contrasts (i.e., the intercept of the model was the grand mean of the dependent measure). Using the "Anova" function from the car package (Version 3.0-2; Fox & Weisberg, 2011), Type III Wald Chi square tests were conducted in order to calculate main effects and interactions. On the fitted GLMMs, the emmeans package (Version 1.3.2; Lenth, 2019) was used to compute estimated marginal means and standard errors for each treatment level. The data and R code are available at tinyurl.com/65se6nfb.

3.2. Results

Figure 3.2 illustrates proportions of produced word orders, split by given word orders. Throughout the results, it is important to note that all sentences were given in Korean.

3.2.1. Proportions of utterances with Korean-canonical word order (SOV)

Collapsed across given word orders, Korean- and English-immersed speakers were statistically equally likely to produce sentences using Korean-canonical word order [58% (17%) vs. 52% (22%); χ^2 (1) = 1.80, p = .18]. Collapsed across Korean- and English-immersed speakers, the proportions of utterances in Korean-canonical word order were influenced by given word order [χ^2 (2) = 111.81, $p < .001$]. Specifically, participants were more likely to produce Korean-canonical word order when given Korean-canonical compared to when given Korean-scrambled word orders [73% (22%) vs. 46% (23%); b = 1.44, SE = .14, z = 10.13, $p < .001$] and when given Korean-canonical compared to when given English-canonical [73% (22%) vs. 45% (26%); b = 1.48, SE = 0.15, z = 9.65, $p < .001$], and statistically equally likely to produce Korean-canonical word order when given Korean-scrambled compared to when given English-canonical word order [46% (23%) vs. 45% (26%); *b* = .04*, SE* = 0.10*, z* = .42*, p* = .91]. The interaction between participant language background and given sentence was significant [χ^2 (2) = 8.20, *p* = .02]. Specifically, Korean-immersed speakers were more likely to produce Korean-canonical word order than English-immersed speakers when given Korean-canonical [78% (17%) vs. 68% (25%); *b* = .58*, SE* = .28*, z* = 2.04*, p* = .04] and marginally more likely to produce Korean-canonical word order than English-immersed speakers when given Korean-scrambled [51% (23%) vs. 42% (23%); *b* = .44*, SE* = .24*, z* = 1.79*, p* = .07], but not when given English-canonical word order [45% (25%) vs. 46% (28%); *b* = -.06*, SE* = .30*, z* = -.20*, p* = .84].

3.2.2. Proportions of utterances with Korean-scrambled word order (OSV).

Collapsed across given word orders, Korean- and English-immersed speakers were statistically equally likely to produce sentences using Korean-scrambled word order [10% (8%) vs. 10% (9%); χ^2 (1) = .90, *p* = .34], and this was not different depending on given word orders [i.e., the interaction between language background and given word order was not significant; χ^2 (2) = 3.55, *p* = .17]. Collapsed across Korean- and English-immersed speakers, the proportions of utterances with Korean-scrambled word order were influenced by given word order [χ^2 (2) = 231.07, *p* < .001]. Specifically, participants were more likely to produce Korean-scrambled word order when given Korean-scrambled word-order compared to when given Korean-canonical word order [27% (23%) vs. 2% (4%); *b* = -3.59*, SE* = .25*, z* = -14.26*, p* < .001], when given Korean-scrambled word order compared to when given English-canonical word order [27% (23%) vs. 1% (3%); *b* = 4.23*, SE* = .33*, z* = 12.95*, p* < .001], and when given Korean-canonical word order compared to when given English-canonical word order [2% (4%) vs. 1% (3%); *b* = .63*, SE* = .26*, z* = 2.43*, p* = .04].

3.2.3. Proportions of utterances with English-canonical word order (SVO).

Collapsed across given word orders, Korean- and English-immersed speakers were statistically equally likely to produce sentences using English-canonical word order [14% (11%) vs. 10% (11%); χ^2 (1) = 2.36, p = .12]. Collapsed across Korean- and English-immersed speakers, the proportions of utterances with English-canonical word order were influenced by given word order [χ^2 (2) = 281.62, p < .001]. Specifically, participants were equally very unlikely to produce English-canonical word order when given Korean-canonical or Korean-scrambled word orders [3% (6%) vs. 2% (4%); b = .00, SE = .20, z = .00, p = 1.00], but more likely to produce English-canonical word orders when given English-canonical compared to when given Korean-canonical [30% (27%) vs. 3% (6%); b = -3.40, SE = .22, z = -15.45, p < .001], and compared to when given Korean-scrambled [30% (27%) vs. 2% (4%); b = -3.40, SE = .23, z = -14.64, p < .001]. The interaction between participant language background and given sentence was not significant based on the chi square test [χ^2 (2) = .76, p = .68]. However, comparisons in estimated marginal means revealed that although Korean- and English-immersed speakers were equally unlikely to produce English-canonical word order when given Korean-canonical [3% (6%) vs. 2% (7%); b = .52, SE = .53, z = .99, p = .32] and when given Korean-scrambled word orders [2% (4%) vs. 2% (4%); b = .54, SE = .48, z = 1.15, p = .25], contrary to what we predicted, Korean-immersed speakers were significantly more likely to produce English-canonical word orders compared to English-immersed speakers when given English-canonical word order [36% (28%) vs. 25% (26%); b = .87, SE = .44, z = 1.98, p = .048].

3.2.4. Proportions of utterances in "other" word orders

On average, English-immersed speakers were more likely to produce "other" word orders compared to Korean-immersed speakers [19% (22%) vs. 12% (14%); χ^2 (1) = 4.59, p = .03], and this was not different depending on the given word order [i.e., the interaction between language background and given word order was not significant; χ^2 (2) < 1, p = .78]. Furthermore, speakers' production of "other" word orders was not statistically different depending on given word orders [χ^2 (2) = 3.58, p = .17].

3.2.5. Proportions of "forgot" responses

On average, English-immersed and Korean-immersed speakers were equally likely to provide "forgot" responses [9% (11%) vs. 7% (6%); χ^2 (1) < 1, p = .35], and this was not different depending on the given word order [i.e., the interaction between language background and given word order was not significant; χ^2 (2) = 1.60, p = .45]. Furthermore, speakers' production of "other" word orders was not statistically different depending on given word orders [χ^2 (2) = 1.54, p = .46].

3.3. Discussion

Contrary to our prediction, collapsed across given word orders, we found that Korean- and English-immersed speakers were not different in their production of Korean sentences using Korean-canonical (SOV) word order, and Korean- and English-immersed speakers were not different in their production of Korean sentences using English-canonical (SVO) word order. If anything, although the higher order interactions were statistically non-significant, comparing marginal means suggested that Korean-immersed speakers were more likely to produce English-canonical word order when given English-canonical word order. Moreover, unlike what we would predict from Experiment 1 where English-immersed speakers rated the Korean canonical word order higher than Korean-immersed speakers did, Korean-immersed speakers were more likely to produce Korean-canonical word orders when given Korean-canonical word order (and marginally more likely to produce Korean-canonical word order when given Korean-scrambled) compared to English-immersed speakers. In other words, it seemed that English-immersed speakers' Korean (L1) production did not resemble English (L2) structures. This might suggest that English-immersed speakers represent L1 and L2 structural information separately for L1-canonical vs. L2-canonical word orders.

Interestingly, however, it seemed that English-immersed speakers produced more "other" word orders compared to Korean-immersed speakers. This is unlikely to be driven by English-immersed speakers being more forgetful, given that the two groups were equivalent in their "forgot" responses. Instead, the higher proportion of "other" responses from English-immersed speakers might suggest that L1 production is more random for English-immersed speakers than Korean-immersed speakers. Incorporated with our main analysis, these results might still support the shared structural representation across L1 and L2. Our task was to memorize sentences and recall them, and participants were likely to try also to remember the word order that the given sentences were in (although the instructions were not explicit that they should remember the given word orders). If speakers develop shared representations between L1 and L2 after L2 immersion, because SOV from L1 and SVO from L2 are the canonical word orders in their respective languages, the distinction between these word orders might become murkier for English-immersed speakers—on the assumption that structural representations are somehow shared. Thus, trying to remember Korean-canonical and English-canonical word orders separately might be more difficult for English-immersed speakers. In contrast, for Korean-immersed speakers, Korean-canonical and English-canonical word orders are so distinctive that it is easier for them to remember the sentences in given word orders than for English-immersed speakers. This might lead to the production pattern that we observed, in which Korean-immersed speakers can memorize and produce more English-canonical word orders than English-immersed speakers can.

If English-immersed speakers produce fewer English-canonical word order and more "other" word orders because of the murkier distinction between Korean-canonical and English-canonical word orders from their shared representation of L1 and L2, then we should observe a more similar production pattern between Korean-immersed and English-immersed speakers with word orders that are non-canonical in both Korean and English, such as VSO. To test this, we conducted Experiment 3 with an identical design as Experiment 2, except the word orders given were Korean-canonical (SOV), Korean-scrambled (OSV), and non-canonical (VSO) word orders.

4. Experiment 3

4.1. Method

4.1.1. Participants

Detailed participant characteristics are provided in Table 3.1.

4.1.1.1. Korean-immersed speakers.

Forty-eight Korean-immersed speakers from the Seoul National University (Seoul, Republic of Korea) community volunteered for monetary compensation. All participants responded that they were born and raised in Korea, were functionally Korean monolinguals, and never lived in the US (or any other English-speaking countries) for more than 24 months (M = 0.1 years; SD = 0.3 years).

4.1.1.2. English-immersed speakers. Forty-eight English-immersed speakers from the UC San Diego Psychology Department subject pool volunteered for course credit. All participants indicated that they were born and raised in Korea, learned Korean as their first language, moved to the United States after eleven years of age, and that Korean is their dominant language. At the time of participation, participants lived in the US for an average of 6.5 years (SD = 3.3).

4.1.2. Materials and Design

The materials and design were identical to Experiment 2, except English-canonical (SVO) sentences from Experiment 2 were presented in non-canonical (VSO) order.

4.1.3. Procedure

The procedure was identical to Experiment 2, except participants were additionally asked to complete an adapted version of Multilingual Naming Test (MINT; Gollan, Weissberger, Runnqvist, Montoya, & Cera, 2012) at the end of the experiment (see Table 3.1 for more information).

4.1.4. Coding and Analysis

Coding and Analysis were identical to Experiment 2, except non-canonical (VSO) word order replaced the English-canonical (SVO) word order from Experiment 2.

4.2. Results

Figure 3.3 illustrates proportions of produced word orders, split by given word orders. Throughout the results, it is important to note that all sentences were given in Korean.

4.2.1. Proportions of utterances with Korean-canonical word order (SOV)

Unlike in Experiment 2 where Korean- and English-immersed speakers were not statistically different in their production of Korean-canonical word order, collapsed across given word orders, Korean-immersed speakers were more likely to produce sentences using Korean-canonical word order [48% (18%) vs. 35% (18%); χ^2 (1) = 11.30, $p < .001$]. Collapsed across Korean- and English-immersed speakers, the proportions of utterances in Korean-canonical word order were influenced by given word order [χ^2 (2) = 67.48, $p < .001$]. Specifically, participants were statistically more likely to produce Korean-canonical word order when given Korean-canonical compared to when given Korean-scrambled word orders [55% (22%) vs. 38% (21%); $b = .84$, $SE = .11$, $z = 7.77$, $p < .001$], when given Korean-canonical compared to when given non-canonical [55% (22%) vs. 33% (24%); $b = 1.16$, $SE = .16$, $z = 7.51$, $p < .001$], and when given Korean-scrambled compared to when given non-canonical [38% (21%) vs. 33% (24%); $b = .32$, $SE = .11$, $z = 3.06$, $p = .006$]. The interaction between participant language background and given sentence was not significant [χ^2 (2) = 3.00, $p = .22$]. That is, Korean-immersed speakers were more likely to produce Korean-canonical word orders compared to English-immersed speakers regardless of given word orders—when given Korean-canonical [63% (19%) vs. 46% (21%); $b = .85$, $SE = .22$, $z = 3.96$, $p < .001$], given Korean-scrambled [43% (21%) vs. 32% (20%); $b = .55$, $SE = .22$, $z = 2.46$, $p = .01$], and when given non-canonical [39% (24%) vs. 27% (23%); $b = .71$, $SE = .30$, $z = 2.33$, $p = .02$].

4.2.2. Proportions of utterances in Korean-scrambled word order (OSV)

Collapsed across given word orders, Korean-immersed speakers were marginally more likely to produce sentences using Korean-scrambled word order compared to English-immersed speakers [9% (7%) vs. 6% (6%); χ^2 (1) = 3.22, $p = .07$], and this was not different depending on given word orders [i.e., the interaction between language background and given word order was not significant; χ^2 (2) < 1, $p = .89$]. Collapsed across Korean- and English-immersed speakers, the proportions of utterances with Korean-scrambled word order were influenced by given word order [χ^2 (2) = 188.91, $p < .001$]. Specifically, participants were more likely to produce Korean-scrambled word order when given Korean-scrambled word-order compared to when given Korean-canonical word order [18% (16%) vs. 2% (4%); $b = -3.00$, $SE = .25$, $z = -12.17$, $p < .001$], when given Korean-scrambled word order compared to when given non-canonical word order [18% (16%) vs. 3% (5%); *b* = 2.18, *SE* = .19, *z* = 11.54, *p* < .001], and when given non-canonical word order compared to when given Korean-canonical word order [3% (5%) vs. 2% (4%); *b* = -.82, *SE* = .23, *z* = -3.64, *p* < .001].

4.2.3. Proportions of utterances in non-canonical word order (VSO)

Collapsed across given word orders, Korean-immersed speakers were marginally more likely to produce sentences using non-canonical word order [7% (9%) vs. 5% (7%); χ^2 (1) = 2.80, *p* =.09]. Collapsed across Korean- and English-immersed speakers, the proportions of utterances in non-canonical word order were influenced by given word order [χ^2 (2) = 314.98, *p* < .001]. Specifically, participants were less likely to produce non-canonical word order when given Korean-canonical compared to given Korean-scrambled [0% (2%) vs. 2% (3%); *b* = -1.18, *SE* = .46, *z* = -2.55, *p* = .03], when given Korean-canonical compared to when given non-canonical [0% (2%) vs. 17% (22%); *b* = -3.89, *SE* = .44, *z* = -8.79, *p* < .001], and when given Korean-scrambled compared to when given non-canonical word order [2% (3%) vs. 17% (22%); *b* = -2.71, *SE* = .17, *z* = -16.09, *p* < .001]. However, it should be noted that the statistically significant difference between when given Korean-canonical vs. Korean-scrambled word orders arises from extremely unlikely non-canonical sentence production. Thus, it is reasonable to argue that collapsed across Korean- and English-immersed speakers, participants nearly only produced non-canonical word order when given non-canonical word order. The interaction between participant language background and given sentence was significant [χ^2 (2) = 8.63, *p* = .01]. That is, Korean-immersed speakers were more likely to produce non-canonical word order compared to English-immersed speakers when given Korean-canonical [1% (3%) vs. 0% (1%); *b* = 2.51, *SE* = .95, *z* = 2.63, *p* = .01], but not when given Korean-scrambled [2% (3%) vs. 2% (3%); *b* = .01, *SE* = .64, *z* = .01, *p* = .99] or when given non-canonical [20% (24%) vs. 14% (19%); *b*

= .53*,* *SE* = .61*,* *z* = .87*,* *p* = .38]. Similarly to the comparisons collapsed across Korean- and English-immersed speakers, this statistically significant difference between Korean- and English-immersed speakers when given Korean-canonical word order arises from the extremely unlikely production of non-canonical word order. Thus, it is reasonable to assume that Korean- and English-immersed speakers were equally likely to produce non-canonical word order, regardless of given word orders.

4.2.4. Proportions of utterances in "other" word orders

Replicating Experiment 2, English-immersed speakers were more likely to produce "other" word orders compared to Korean-immersed speakers [31% (17%) vs. 24% (14%); χ^2 (1) = 5.53, *p* = .02], and this was not different depending on the given word order [i.e., the interaction between language background and given word order was not significant; χ^2 (2) < 1, *p* = .64]. Furthermore, speakers' production of "other" word orders differed depending on given word orders [χ^2 (2) = 15.71, *p* < .001]. That is, participants were less likely to produce "other" word order when given Korean-canonical compared to when given non-canonical [26% (17%) vs. 30% (18%); *b* = -.27*,* *SE* = .07*,* *z* = -3.86*,* *p* < .001], and when given Korean-scrambled compared to when given non-canonical word order [26% (17%) vs. 30% (18%); *b* = -.21*,* *SE* = .08*,* *z* = -2.72*,* *p* = .02], but did not show a statistical difference between when given Korean-canonical compared to when given Korean-scrambled word order [26% (17%) vs. 26% (17%); *b* = -.06, *SE* = .07, *z* = -.81, *p* = .70].

3.2.5. Proportions of "forgot" responses

On average, English-immersed were more likely to provide "forgot" responses compared to Korean-immersed speakers [22% (16%) vs. 12% (8%); χ^2 (1) = 17.55, *p* < .001], and this was not different depending on the given word order [i.e., the interaction between language background and given word order was not significant; χ^2 (2) < 1, p = .66]. Furthermore, speakers' production of "other" word orders was not statistically different depending on given word orders [χ^2 (2) < 1, p = .75].

4.3. Discussion

Experiment 3 was designed to test whether the effect we found in Experiment 2 was associated with a shared representation across English and Korean in English-immersed speakers. Namely, we hypothesized that English-immersed speakers in Experiment 2 might have produced more "other" word orders compared to Korean-immersed speakers because English-canonical word order (SVO) is less distinctive due to the (hypothetical) shared representation of canonical word orders across Korean and English. This predicts that Korean- and English-immersed speakers should not differ in their perception of distinctiveness of a word order that is non-canonical in both Korean and English (VSO), and thus they should not differ in their production tasks when given non-canonical word order instead of English-canonical word order. Contrary to this prediction, we found that English-immersed speakers were still more likely to produce "other" word orders compared to Korean-immersed speakers even when given non-canonical instead of English-canonical word order. Furthermore, Korean-immersed speakers were more likely to produce Korean-canonical word order, more likely to produce (although statistically marginally so) non-canonical word order, less likely to provide "forgot" responses. Thus, while Korean-immersed speakers were sensitive to the given word orders, English-immersed speakers were overall more random with which word orders they use and were more impacted by the given non-canonical word order in their ability to recall given sentences compared to Korean-immersed speakers. From this, we might infer that instead of developing shared representations for different word orders leading speakers to produce their L1 in a way that its sentence structures resemble L2, English-immersed speakers' L1 become "noisier" in their word order production after L2 immersion.

4. General Discussion

Three experiments tested whether Korean (L1) sentence processing and production can be influenced by English (L2) structural information for Korean speakers in an English-immersive environment. Experiment 1, where we tested acceptability judgment of Korean sentences in different word orders, showed an opposite pattern of what we predicted if L2 straightforwardly influences L1 sentence processing. That is, while Korean-immersed speakers rated Korean sentences in English canonical word order (SVO) higher than English-immersed speakers, English-immersed speakers rated Korean sentences in Korean-canonical word order (SOV) higher than Korean-immersed speakers did. Experiment 2 also did not show a pattern that we would expect if L2 straightforwardly influences L1 production. Namely, Korean- and English-immersed speakers were not statistically different in their production of Korean- or English-canonical word orders. If anything, although the higher-order interactions were not statistically significant, Korean-immersed speakers produced both Korean- and English-canonical word orders more than English-immersed speakers did. Interestingly, instead of producing more English canonical word orders as we predicted, English-immersed speakers tended to produce more "other" word orders than Korean-immersed speakers did even though they were not necessarily different in their "forgot" responses. Experiment 3 tested whether the effects we found in Experiment 2 were associated with the increased perceived naturalness of English-canonical word orders for English-immersed speakers, which might have made our task more difficult and thus resulting in producing more "other" word orders. Testing a word order that is non-canonical in both Korean and English (VSO), Experiment 3 revealed that Korean-immersed speakers were again more likely to produce Korean-canonical word order, while English-immersed speakers were more likely to produce "other" word orders. Moreover, English-immersed speakers seemed to be overall more impacted by the given non-canonical word orders than Korean-immersed speakers and exhibited more "forgot" responses. Together, it appears that Korean-immersed speakers can recall and produce Korean sentences in given word orders more systematically than English-immersed speakers can. Thus, instead of resembling L2 structures, the L1 representation of English-immersed speakers might be somewhat noisier.

These results contradict what we would predict if Korean native speakers' representations of Korean word orders become more English-like after acquiring English. Instead, our results partially resemble the word order acceptability patterns that were reported by Namboodiripad, Kim, and Kim (2019), who tested English-dominant Korean-English bilinguals. In their study, Namboodiripad et al. compared Korean-immersed speakers and English-dominant Korean bilinguals in their acceptability judgment of Korean sentences in all possible word orders (SOV, OSV, SVO, OVS, VSO, VOS; SOV is the Korean-canonical word order; SVO is the English-canonical word order). Unlike the participants in our study (who grew up in Korea only using Korean until at least the age of 11 and were Korean-dominant), English-dominant speakers in Namboodiripad et al. were Korean heritage speakers who grew up in the US and learned Korean primarily through informal exposure at home. They found that although the two groups were not different in their preference of English-canonical word order and other word orders that are neither Korean- nor English-canonical word orders), English-dominant speakers were more likely to rate the Korean-canonical word order higher than the other word orders that are non-canonical in Korean. From this, they suggested that English contact reduces word order flexibility in Korean. Alternatively, they suggested that the frequency of input for English-dominant speakers led to their higher preference for Korean canonical word order. That is, in a corpus study, Cho (1982) found that the Korean canonical word order is predominant in Korean-speaking mothers' infant-directed speech. Because Korean input for the English-dominant speakers in Namboodiripad et al. mainly was from home, it was possible that their early exposure to Korean mainly consisted of Korean canonical word order, which might have led to a higher preference of Korean canonical word order.

The frequency of input during early exposure cannot explain our results. Given that our English-immersed speakers moved to the US after the age of 11 at the youngest, their early Korean exposure should have been very similar to Korean-immersed speakers. Reduced L1 flexibility could explain part of our results in which English-immersed speakers rated the Korean canonical word orders higher than Korean-immersed speakers, but does not explain why Korean-immersed speakers produced more Korean canonical word order sentences than English-immersed speakers did in some conditions. Moreover, it is unclear why we observed that English-immersed speakers both rated the English canonical word orders lower and produced the English canonical word order less frequently in some conditions than Korean-immersed speakers, which is a pattern that was not observed in Namboodiripad et al. We might speculate that our participants, who were late learners of English, were more likely to overcompensate than speakers who grew up speaking both English and Korean during the acceptability judgment task. Unlike Korean heritage speakers who are English dominant (and likely to be English dominant throughout their language learning experience), late English learners who immigrate to English-immersed environments can undergo L1 attrition (e.g., Schmid, 2010, 2013). Consequently, these late English learners might become more likely to give low ratings on non-canonical Korean sentences as part of overcompensating for the L1 attrition.

Our results also contrast with what we would predict from the previous literature that showed structural priming across Korean and English dative sentences, despite the different word orders across Korean and English (e.g., Hwang et al., 2018; Shin & Christianson, 2009). Cross-language structural priming across Korean and English suggested that dative constructions could have a shared representation across Korean and English. Relevant to our hypotheses, this cross-language structural priming raised a possibility that Korean-canonical vs. English-canonical representations could also be shared for English-immersed speakers, and thus sentences that could be represented only using Korean-canonical word order for Korean-immersed speakers could also be represented using English-canonical word order for English-immersed speakers. Our results opposing the prediction might have been driven by the difference between the representation of dative constructions and Korean- vs. English-canonical constructions. That is, producing dative sentences involves selecting between two alternative choices that are comparable in meaning (e.g., *the knitter gave the sweater to her sister* vs. *the knitter gave her sister the sweater*). In contrast, Korean- vs. English-canonical constructions may not involve such selection process between the two alternative constructions. If such a selection process is necessary for developing a shared representation across languages, representation for Korean- vs. English-canonical constructions might not develop a shared representation even after extensive L2 immersion.

Furthermore, our results also contrast with studies that suggested an L2 influence on L1 sentence parsing (Dussias, 2003, 2004; Dussias & Sagarra, 2007). This discrepancy might be due to the difference between comprehension and production. Given that language control mechanisms are not necessarily shared across production and comprehension (e.g., Ahn, Abbott, Rayner, Ferreira, & Gollan, 2020; Blanco-Elorrieta & Pylkkanen, 2016; Blanco–Elorrieta &

Pylkkänen, 2017; Mosca & de Bot, 2017; but see Dussias, 2001; Gambi & Hartsuiker, 2016; Guzzardo Tamargo, Valdés Kroff, & Dussias, 2016; Peeters, Runnqvist, Bertrand, & Grainger, 2014), it is correspondingly possible that the influence of L2 on L1 is different for comprehension versus production.

However, not only did we not observe an L2 influence on L1 in production, but we also did not observe an L2 influence on L1 acceptability judgments. We might suggest a few reasons for this discrepancy between our results and studies that suggested an L2 influence on L1 sentence parsing (e.g., Chen et al., 2013; Hwang et al., 2018; Shin & Christianson, 2009). First, the greater typological difference between Korean and English, compared to Spanish and English, might hinder the influence of L2 on L1. Although there are studies that found cross-language structural priming across more typologically different languages (e.g., Chen et al., 2013; Hwang et al., 2018; Shin & Christianson, 2009), a stronger connection from closer typological proximity might be necessary for the influence of L2 on L1 representation to occur. Second, similarly to our speculations on why we found different results from what we would expect from reported cross-language priming in Korean and English dative sentences, the relative clause attachment representations from Dussias and colleagues' studies might be fundamentally different from SOV vs. SVO representation from our studies. That is, relative clause attachments are represented mostly covertly, such that sentences with different relative clause attachments are still indistinguishable on the surface (e.g., for both the interpretation of *the servant* or *the actress* who is on the balcony, the sentence is equally *someone shot the servant of the actress [who was on the balcony]*). In contrast, Korean- vs. English-canonical constructions differ from the surface (e.g., *[dog][cat][chase]* vs. *[dog][chase][cat]*). Perhaps an influence of L2 information on L1 structural representation is subtle and only can arise in sentence structures such as relative clause attachments. Future research should test more different sentence structures and diverse language pairs to investigate the L2 influence on L1 representation.

In sum, we did not find evidence that native Korean speakers' L1 structural processing and production resemble their L2 English after English immersion. Instead, we suggest that L2 immersion is associated with overall "noisier" L1 representation.

Chapter 3, in full, is currently being prepared for submission for publication of the material. Ahn, Danbi; Ferreira, Victor. S.; Gollan, Tamar. H. The dissertation author was the primary investigator and author of this material.

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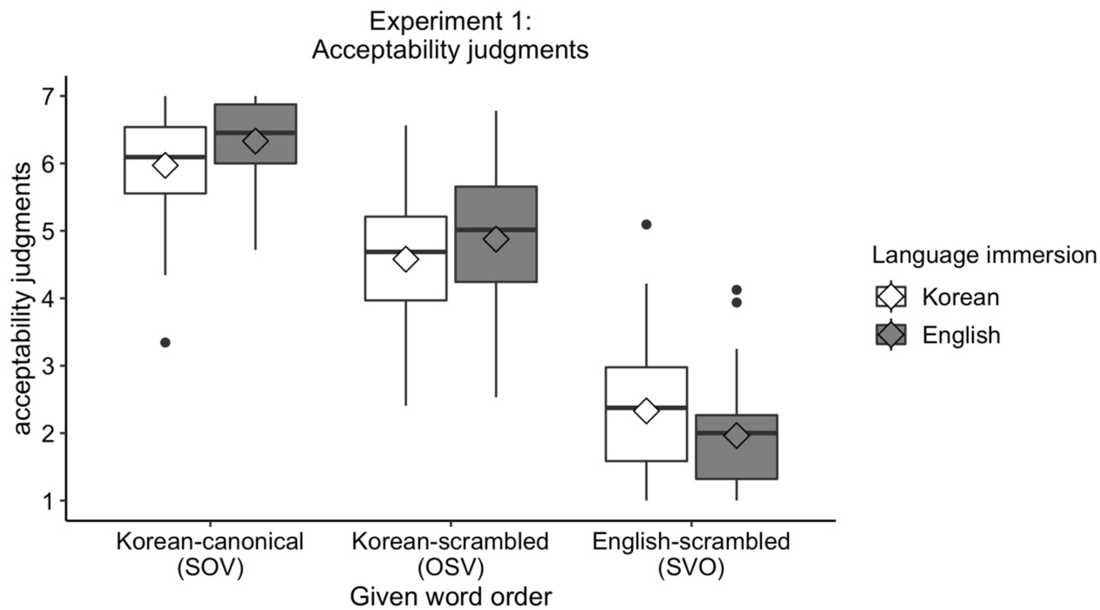

Figure 3.1. Acceptability judgments split by given word orders. The boxes represent inter-quartile ranges, with the thick horizontal bars representing condition medians. Dots represent outliers defined as >1.5 times the inter-quartile range away from the edge of the box. Whiskers extend to the furthest non-outlier. Diamonds represent condition means.

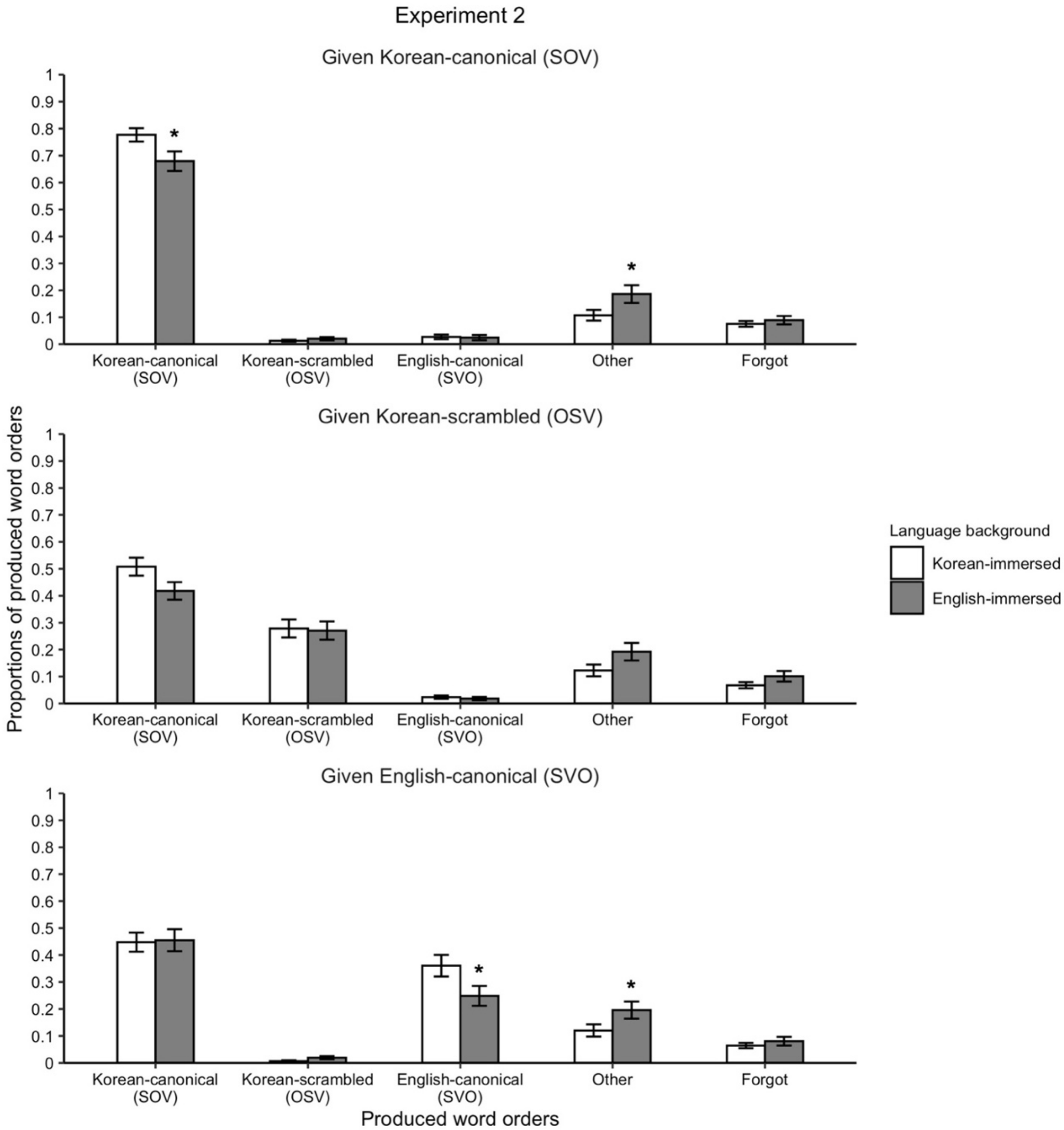

Figure 3.2. Proportions of produced word orders in Experiment 2, split by given word orders. "Other" responses included responses that included any two of S, O, and V in any order, and responses that included all three parts but were not in the order of Korean-canonical (SOV), Korean-scrambled (OSV), or English-canonical (SVO). "Forgot" responses included instances where the participant explicitly said that they forgot the response or did not say anything, and responses that included only one of S, O, or V. The means that were statistically different between Korean-immersed vs. English-immersed speakers are labeled with asterisk above English-immersed speakers (* = < .05; ** = < .01; *** = <.001). Error bars represent standard errors.

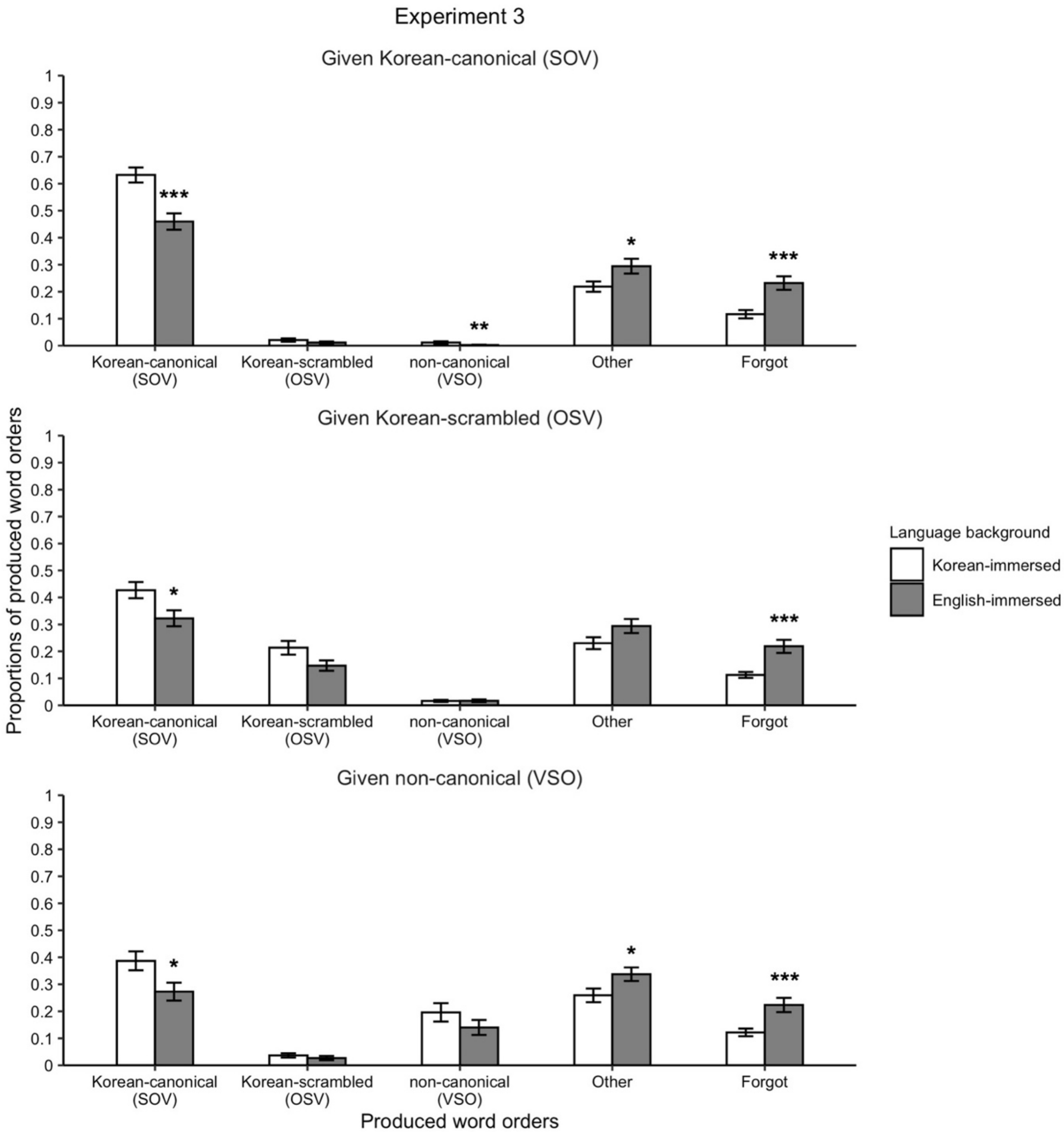

Figure 3.3. Proportions of produced word orders in Experiment 3, split by given word orders. Note that unlike participants in Experiment 2 who were given SVO, an English-canonical word order, participants in Experiment 3 were given VSO, which is a non-canonical word order in both Korean and English. "Other" responses included responses that included any two of S, O, and V in any order, and responses that included all three parts but were not in the order of Korean-canonical (SOV), Korean-scrambled (OSV), or non-canonical (VSO). "Forgot" responses included instances where the participant explicitly said that they forgot the response or did not say anything, and responses that included only one of S, O, or V. The means that were statistically different between Korean-immersed vs. English-immersed speakers are labeled with asterisk above English-immersed speakers (* = < .05; ** = < .01; *** = <.001). Error bars represent standard errors.

Table 3.1. Participant characteristics and language proficiency based on self-report and modified MINT.

	Experiment 1		Experiment 2		Experiment 3	
	Korean-immersed	English-immersed	Korean-immersed	English-immersed	Korean-immersed	English-immersed
Current Age	26.7 (7.2)	30.0 (11.1)	23.2 (2.7)	21.8 (3.2)	24.0 (3.4)	21.9 (3.6)
Lived in the US (years)	0.1 (0.3)	12.3 (8.6)	0.1 (0.2)	5.6 (2.5)	0.1 (0.3)	6.5 (3.3)
Age moved to the US	NA	17.6 (5.8)	NA	14.8 (2.1)	NA	15.0 (2.8)
Age at first exposure						
Korean	0.0 (0.0)	0.0 (0.2)	0.0 (0.0)	0.0 (0.0)	0.1 (1.0)	0.0 (0.1)
English	9.4 (2.7)	11.4 (3.3)	8.1 (3.1)	10.0 (4.6)	8.6 (3.2)	9.3 (4.4)
Proficiency self-ratings						
Korean						
Speak	6.9 (0.3)	6.8 (0.7)	7.0 (0.1)	6.8 (0.6)	6.8 (0.7)	6.7 (0.8)
Listen	7.0 (0.2)	6.7 (0.8)	6.9 (0.4)	6.9 (0.4)	6.9 (0.6)	6.5 (1.0)
Write	6.9 (0.5)	6.5 (1.1)	6.9 (0.5)	6.6 (0.8)	6.8 (0.7)	6.0 (1.6)
Read	7.0 (0.2)	6.7 (0.7)	6.9 (0.3)	6.7 (0.7)	6.8 (0.6)	6.4 (1.1)
English						
Speak	3.2 (1.0)	5.1 (1.2)	3.2 (1.2)	4.9 (1.1)	3.2 (0.9)	5.5 (1.1)
Listen	4.0 (1.2)	5.1 (1.3)	3.9 (1.1)	5.1 (1.1)	3.9 (1.0)	5.6 (1.1)
Write	3.2 (1.0)	5.0 (1.3)	3.3 (1.3)	4.6 (1.1)	3.1 (1.1)	5.2 (1.3)
Read	4.2 (1.2)	5.3 (1.3)	4.6 (1.0)	5.0 (1.0)	4.3 (1.2)	5.5 (1.1)
Approximate percentage of daily use						
Current						
English	8.7 (7.0)	56.9 (24.0)	5.8 (5.7)	49.5 (25.8)	9.6 (9.2)	52.7 (24.8)
Korean	89.8 (8.5)	41.3 (24.4)	93.7 (6.3)	49.9 (26.1)	89.4 (9.5)	45.3 (24.5)
Other	1.5 (3.4)	1.8 (3.4)	0.5 (1.7)	0.6 (1.6)	0.9 (1.8)	1.9 (5.6)
Growing up						
English	10.2 (7.8)	29.2 (16.0)	7.6 (8.0)	23.3 (18.5)	10.3 (7.4)	33.7 (18.8)
Korean	88.4 (9.4)	68.6 (16.8)	91.5 (8.8)	75.2 (19.9)	88.7 (8.5)	64.6 (18.7)
Other	1.4 (3.0)	2.1 (4.1)	1.0 (2.3)	1.5 (5.0)	1.0 (2.4)	1.8 (3.3)
MINT (% correct)						
English					66.1 (9.3)	79.6 (7.4)
Korean					90.1 (3.0)	82.5 (7.0)

Note. Proficiency self-ratings were on the scale of 1-7 (1= almost none, 2= very poor, 3 = fair, 4= functional, 5= good, 6= very good, 7= like native speaker). All numbers represent means across participants. Standard deviations are indicated in parentheses. MINT refers to a Korean modified version of Multilingual Naming Test (Gollan, Weissberger, Runnqvist, Montoya, & Cera, 2012). To adapt the MINT for use in Korean, 7 items that are Korean-English cognates were excluded; thus, participants were tested on 61 items, first in English, and then in Korean.

Table 3.2. An example trial.

Phase	Stimuli
Encoding Phase	Composer-NOM several notes-ACC evenly drew Expensive pen-ACC writer-NOM tightly held Hyunji-NOM birthday gift-ACC carefully wrapped
Recall Phase	tightly held carefully wrapped evenly drew

Note. Case markers are indicated in capital letters (NOM, nominative; ACC, accusative).

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CONCLUSION

This dissertation examined how bilinguals who know two languages with very different word orders represent and use sentence structures from those languages.

Chapter 1 aimed to disentangle whether the structural representations of bilinguals' two languages are shared or separate-and-connected by using a cumulative cross-language structural priming paradigm (which, unlike standard cross-language structural priming, does not require frequent language switches). We found that without frequent language switches, bilinguals show more reliable and a stronger degree of within-language priming than cross-language priming, suggesting a separate-and-connected rather than a shared structural representation.

By measuring the scope of planning of each word in noun phrases (e.g., *the lemon below the lobster* in English vs. *[lobster][below][lemon]* in Korean translation equivalent) using an extended picture-word interference paradigm, Chapter 2 examined whether English-immersed bilinguals access sentence structures from both languages even when speaking in only one. We demonstrated that when bilinguals speak in one language, the pattern of sentence planning differs for English and Korean. This difference between English and Korean persisted even when there were frequent language switches. We suggest that the structural information of one language does not influence the production of the other language and that Korean and English structural information are represented separately rather than together.

Finally, comparing Korean-immersed speakers and English-immersed Korean speakers in acceptability judgment and memory-recall tasks in Korean (their L1), Chapter 3 investigated whether L2 (English) immersion is associated with L1 representations that resemble L2 sentence structures. In both tasks, we found that L1 representations differ for Korean- vs. English-immersed Korean speakers, supporting the claim that L1 representation can change after L2 exposure (for reviews, see Kroll, Dussias, & Bajo, 2018; Kroll & Gollan, 2014). However, we did not find an evidence that English-immersed speakers represent their L1 structures in a way that resembles L2 structures. Thus, we suggest that English (L2) immersion is associated with "noisier" structural representations of Korean (L1).

Our results contrast with the abundant evidence from standard cross-language structural priming that supports the idea of shared structural representations for structures and languages with the same word orders (e.g., Hartsuiker, Pickering, & Veltkamp, 2004; Loebell & Bock, 2003; for reviews, see Gries & Kootstra, 2017; Hartsuiker & Bernolet, 2017; Hartsuiker & Pickering, 2008; Kootstra & Muysken, 2017; Van Gompel & Arai, 2018) and different word orders (e.g., Bernolet, Hartsuiker, & Pickering, 2009; Chen, Jia, Wang, Dunlap, & Shin, 2013; Desmet & Declercq, 2006; Hwang, Shin, & Hartsuiker, 2018; Muylle, Bernolet, & Hartsuiker, 2020, 2021; Shin & Christianson, 2009; Weber & Indefrey, 2009). Across nine experiments using various behavioral tasks and different sentence structures, we repeatedly observed evidence supporting that Korean-English bilinguals must represent Korean and English separately rather than together. Any possible cross-linguistic connection we observed was when the Korean and English structures had at least some overlap (Chapter 1). Namely, although Korean and English dative structures are different in where the verbs are placed in the sentences, (e.g., for the PD, *the knitter* ***gives*** *the sweater to her sister* vs. *[knitter][sweater][sister][****give****]*), they are similar in the way that PD vs. DO alternate—both English and Korean PD vs. DO structures involve changing the order of the theme and the goal of the sentences (e.g., *the sweater* and *her sister* in the sentence *the knitter gives the sweater to her sister*). Overall, we suspect that the connection between the structural representations of two typologically very different languages is possible only when there is at least some overlap in the structures.

Alternatively, the possible connection we observed across Korean and English dative structural representations might be driven by the selection process between two alternative sentence structures that are comparable in meaning (e.g., *the knitter gave the sweater to her sister* vs. *the knitter gave her sister the sweater*). It is possible that one way that structural representations are shared across languages is by having the same language-independent process of selecting one sentence structure over the other. However, it is unclear from our results that this possible connection across languages is only observable when said selection process is actively involved in the experimental setting (i.e., structural priming), or if evidence of shared or connected structural representations could be observed even in different experimental settings where the selection process is not required. That is, in both standard and cumulative cross-language structural priming, participants need to select one structure over the other throughout the experimental session, because which structure is selected is the dependent variable in structural priming methods. On the other hand, in methods such as extended picture-word interference paradigm (Chapter 2), participants do not necessarily have to select one structure over the other and instead repeat the same structure throughout the experimental session. If the structural representations for dative constructions are truly shared or connected between Korean and English despite the word order differences, we should observe evidence of dual-language activation even when participants repeat the same structure throughout the experimental session. For example, we might observe that Korean-English bilinguals access the verb of the dative sentence both early (following English word order) and late (following Korean word order), even when repeating the English PD throughout the experiment (instead of having a choice of alternating between English PD and English DO). Such evidence would provide stronger support for a truly shared or connected representations of dative constructions across Korean and English, beyond the experimental properties of structural priming.

Bilinguals need to represent highly related but different structural information from the two languages that they know. This dissertation adds to the current literature of bilingual structural representations by illuminating the cognitive processes that underlie how bilinguals represent and produce sentences that are very different across languages when they intend to speak in only one language. Evidently, standard structural priming alone is not sufficient in elucidating the complex cognitive processes behind the use of bilingual structural representations and more different kinds of paradigms (such as the ones used in this dissertation) are necessary. In all, we suggest primarily separate structural representations for very different sentence structures from typologically different languages.

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