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 (; for review, see Declerck, 2020; 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). 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 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 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 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 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 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. 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 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 3a. Interference effects relative to unrelated distractors are illustrated in Figure 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 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 3a. Interference effects relative to unrelated distractors are illustrated in Figure 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 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 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 3a. Interference effects relative to unrelated distractors are illustrated in Figure 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 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 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 3b. Interference effects relative to unrelated distractors are illustrated in Figure 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.

Acknowledgements

This research was supported by grants from the National Science Foundation (1923065), National Institute on Deafness and Other Communication Disorders (011492), and the National Institute of Child Health and Human Development (051030, 079426). The results were presented at the Psychonomic Society's 60th Annual Meeting in Montréal, Québec, Canada, and Psychonomic Society's 61st Virtual Annual Meeting. We thank Dan Kleinman, Shota Momma, and Alena Stasenko for helpful discussions, Annie Chai and Kenner Johnson for assistance with data collection, Hyeree Choo and Koh Eyetacking lab at Seoul National University for participant recruitment and providing laboratory space for Experiment 2, and Heesun (Jenny) Jung for assistance with data collection and data coding.

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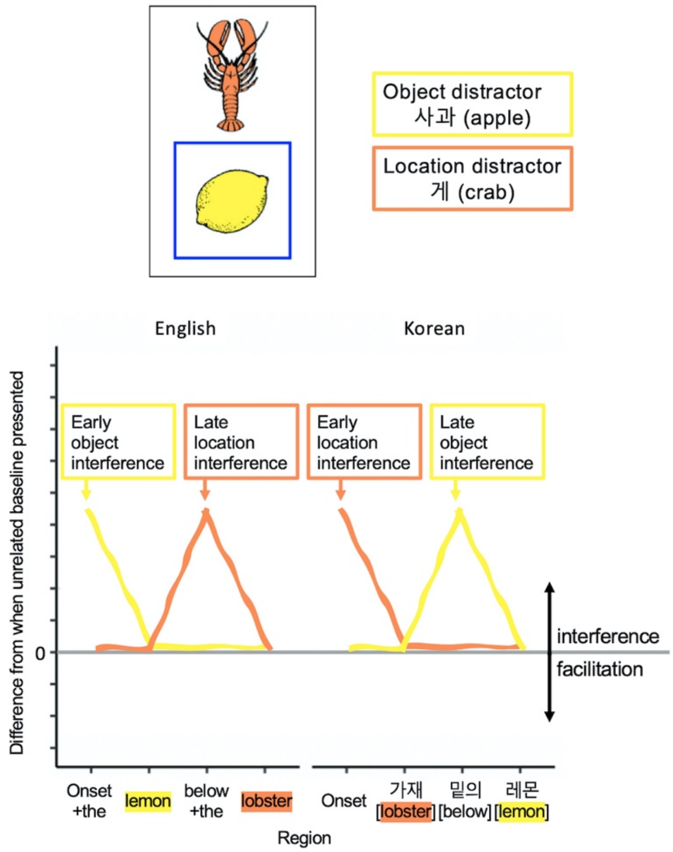


Figure 1. An illustration of the expected timing of semantic interference from object and location distractors for English vs. Korean sentences if speakers plan each noun in a noun phrase "just in time." Participants were asked to describe the picture in the blue square (lemon) using the other picture (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.

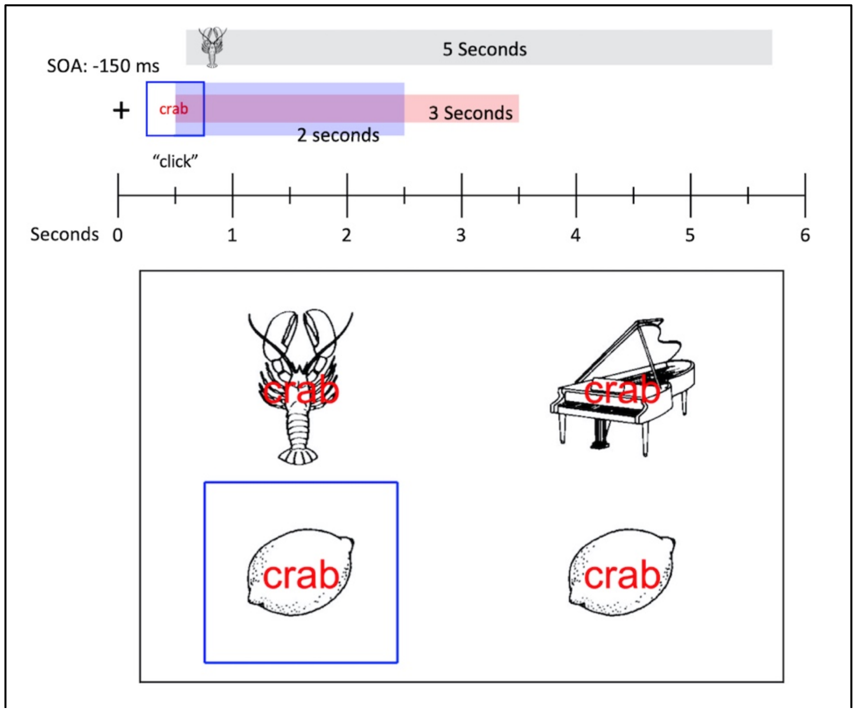


*Figure 2***.** A schematic of an experimental trial. In this example, the target utterance is "the lemon below the lobster." Each experimental trial lasted for 6 seconds. At the beginning of the trial, a fixation cross appeared for 500 ms, which was replaced by the distractor word ("crab" in this example) 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.

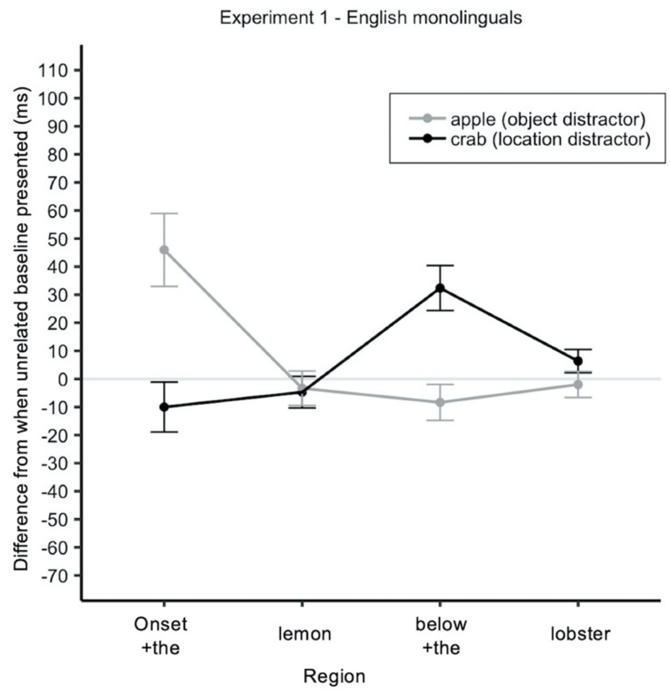


Figure 3. Interference effects relative to when unrelated baselines were presented. Error bars represent standard errors.

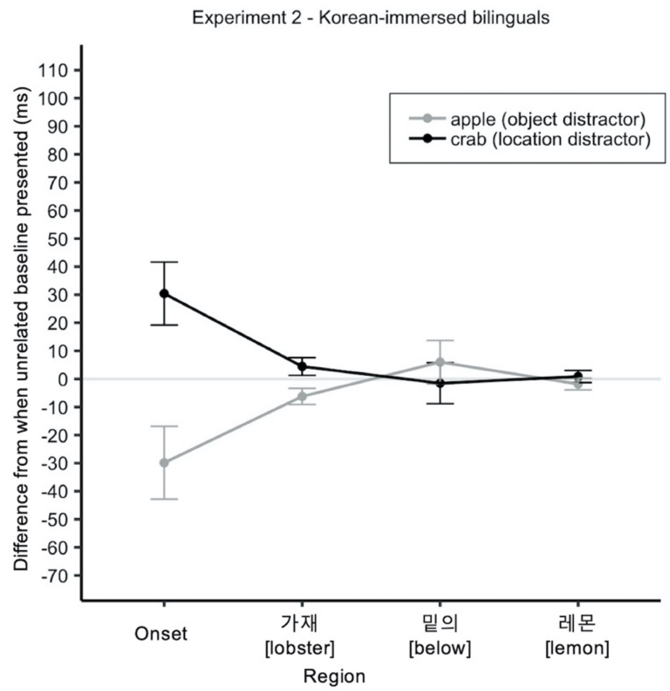


Figure 4. Interference effects relative to when unrelated baselines were presented. Error bars represent standard errors.

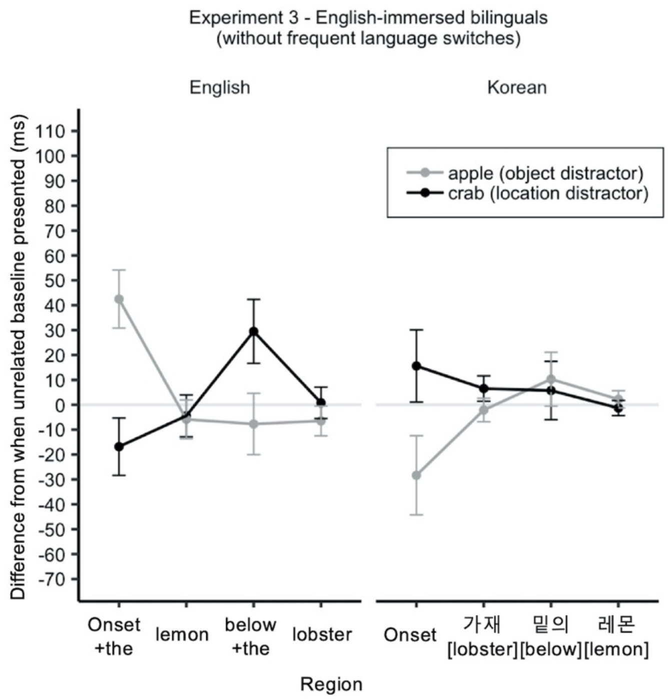


Figure 5. Interference effects relative to when unrelated baselines were presented. Error bars represent standard errors.

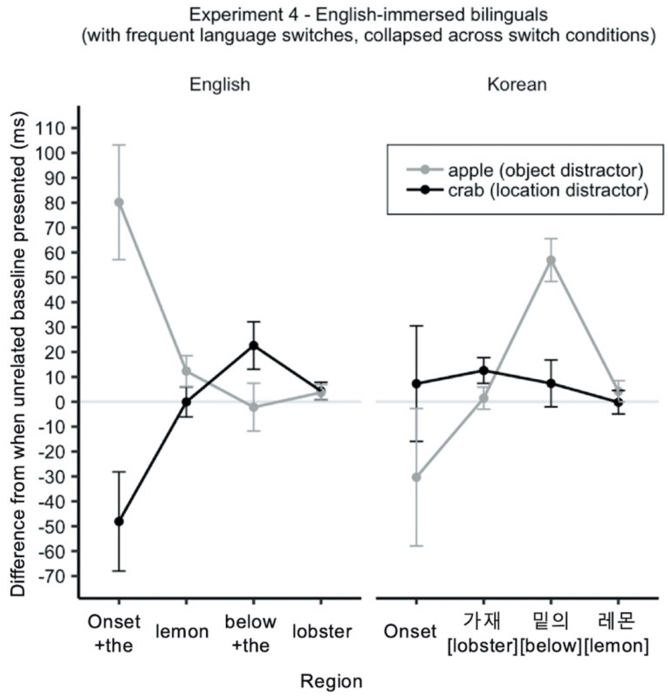


Figure 6a. Interference effects relative to when unrelated baselines were presented, collapsed across switch conditions. Error bars represent standard errors.

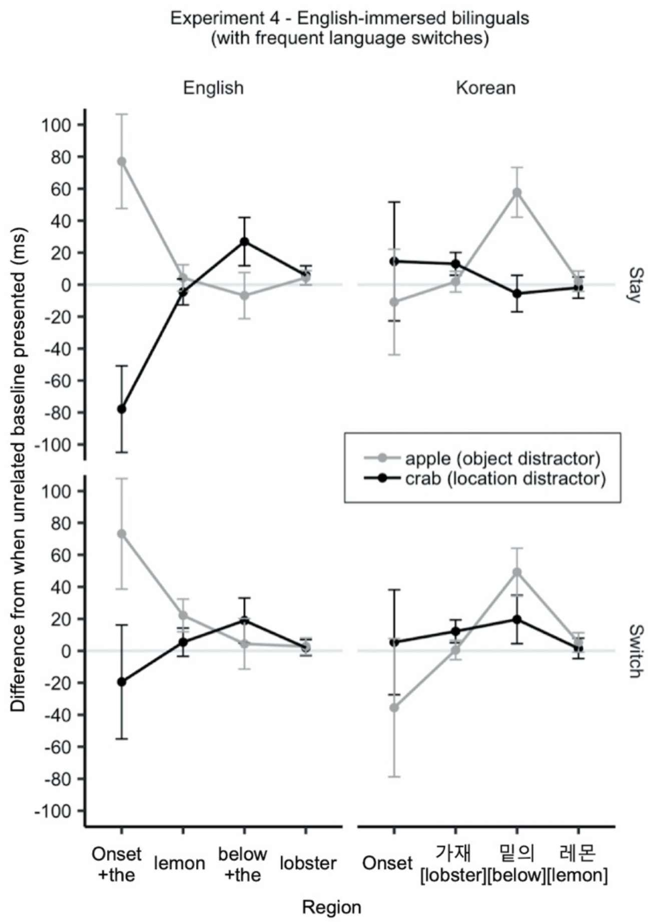


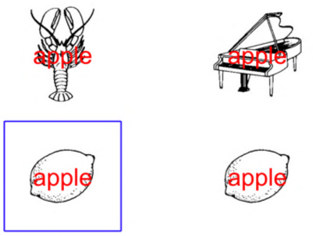
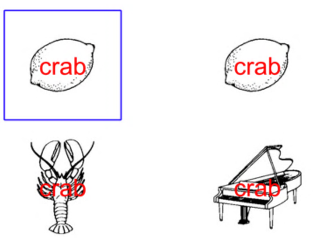
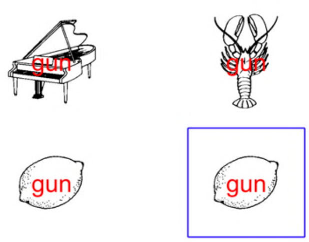
Figure 6b. Interference effects relative to when unrelated baselines were presented. Error bars represent standard errors.

Table 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. 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 3a. The mean and standard deviations of production durations for Experiment 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 3b. The mean 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.