

Changing pronoun interpretations across-languages: discourse priming in Spanish–English bilingual speakers

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Abstract

Are bilingual speakers' representations of pronominal expressions completely independent in the two languages, or is there sharing of discourse-level representations cross-linguistically? In the present study, we address this question by using a sentence comprehension task that implements the cross-linguistic priming technique at the discourse-level.

In two experiments conducted with Spanish–English bilinguals, we prime dis-preferred interpretations for ambiguous pronouns in the second language (English) by using first language (Spanish) pronoun interpretation primes. In experiment 1, Spanish null pronouns prime second-mentioned/object interpretations in English, showing an effect of priming. In experiment 2, Spanish explicit pronouns prime second-mentioned/object interpretations in English, indicating that an effect of priming approaches significance.

The results demonstrate that bilinguals' inferences about probability distributions and coherence relations are susceptible to cross-linguistic influence. The strength of the priming effect is discussed within models of cross-language abstract representations.

1. Introduction

Different languages have different referential expressions and interpretation biases. For example, in English, referents that are more accessible are usually expressed as pronouns. In comprehension, speakers of English tend to refer pronouns to a first-mentioned/subject referent, which is often the most salient in the previous discourse, as shown in example (1).

(1) John_i saw Mark while he_i was at the coffee shop

Differently than English, in a null subject language like Spanish, reference to previously mentioned entities can be expressed using full noun phrases, null pronouns and overt pronouns. Null and overt pronouns have different (and complementary) interpretation biases in Spanish; more specifically, comprehenders tend to interpret null pronouns as referring to a previously mentioned subject antecedent, while overt pronouns are more often interpreted as referring to a non-subject antecedent, as exemplified in (2) (for Mexican Spanish, the variety tested here: Contemori & Di Domenico, 2021; Keating, VanPatten & Jegerski, 2011; Keating, Jegerski & VanPatten, 2016).

(2) Pedro_i saludó a Carlos_j cuando él_i/ø_i cruzaba la calle
Pedro greeted Carlos when he crossed the street

Notice that individual variability in the interpretation of pronouns may exist among comprehenders (e.g., Arnold, 2015). Recent research has shown that some of the variability can be explained by comprehenders' print exposure, demonstrating that language experience has an important role on the use of anaphora resolution in monolingual English-speaking adults (e.g., Arnold, Strangmann, Hwang, Zerkle & Nappa, 2018; Arnold, Castro-Schilo, Zerkle & Rao, 2019; Langlois & Arnold, 2020). For example, in a series of experiments, Arnold et al. (2018) measured subject pronoun interpretation in monolingual English speakers and found that among a number of individual differences (i.e., print exposure, *theory of mind*, working memory, socioeconomic status) only print exposure predicted the strength of the subject/first-mentioned bias. In the case of English, speakers with higher reading exposure become more familiar with the high frequency of subjects being re-mentioned in discourse and referred to using a pronoun, a result that supports theoretical accounts of reference based on probabilistic inferences (e.g., Arnold, 1998; Kehler, Kertz, Rohde & Elman, 2008).

In addition, previous research has demonstrated that comprehension preferences are variable, and that they may change based on the referential probability of pronouns presented in the statistical environment (e.g., Contemori, 2019; Kaiser, 2009). A question that remains open

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is how permeable are the statistics that bilingual speakers calculate in their languages. In the present study, we aim to fill this gap by investigating cross-linguistic discourse representations in Spanish–English bilingual speakers.

Bilingual individuals that speak a null and a non-null subject language, like English and Spanish, must choose between two languages' competing strategies to interpret pronouns. While monolinguals make inferences about the probability of occurrence of pronominal forms and referents in one language, bilinguals must track probabilities in two languages. Does bilinguals' probabilistic inference in tracking referents in one language affect the other language? We address this question by looking at pronoun resolution biases in Spanish–English bilinguals using the comprehension priming technique.

1.1 Discourse priming

We know that comprehenders can adapt their pronoun resolution biases to the likelihood of occurrence of specific type of pronouns in the input. For example, in a study by Fernandes, Luegi, Correa Soares, de la Fuente, and Hemforth (2018), speakers of European and Brazilian Portuguese were tested on their interpretation preferences for null and explicit pronouns. While European Portuguese speakers present similar interpretation strategies as Spanish speakers, Brazilian Portuguese speakers interpret explicit pronouns as referring to a second-mentioned/object antecedent less often than European Portuguese speakers (European Portuguese: 75%; Brazilian Portuguese: 46%). This pattern has been linked to the high production of explicit pronouns in Brazilian Portuguese (e.g., Brazilian Portuguese: 56%, European Portuguese: 22%, i.e., Barbosa, Duarte & Kato, 2005). Fernandes et al. manipulated the number of null and explicit pronouns presented in a sentence comprehension task, where pronouns could refer either to a first-mentioned/subject antecedent or a second-mentioned/object antecedent. The results showed that by decreasing the number of overt pronouns presented in the task, comprehenders' preference for interpreting explicit pronouns towards a second-mentioned/object antecedent increased. This pattern of interpretation was stronger for Brazilian Portuguese speakers in comparison to European Portuguese speakers, due to the weaker second-mentioned/object antecedent preference for explicit pronouns in Brazilian Portuguese, suggesting that adaptation took place between the existing statistical knowledge about pronouns distribution and the statistical information obtained in the experiment. The findings by Fernandes et al. demonstrate that comprehenders actively calculate distributional probabilities of pronouns in a given environment.

Previous research has also demonstrated that comprehenders are sensitive to the frequency of occurrence of specific pronoun interpretations presented in a task (e.g., Contemori, 2019; Kaiser, 2009). For example, using a sentence comprehension task that included novel verbs, Kaiser (2009) found that English monolinguals' pronoun interpretation preferences in a sentence like "Stephen tulvered Peter and Diane churbited him" where "him" can refer to either Stephen or Peter, was modulated by the type of prime presented before the target (subject or object pronoun interpretation: William swooked Betty and Kevin brucked him/her). The results of the comprehension task demonstrated that during pronoun resolution there is activation of an abstract level of representation and that after encountering an anaphoric configuration, the processing of the same configuration can be facilitated, i.e., an effect of immediate priming. With two

additional experiments, Kaiser (2009) showed that the priming effect results from the combination of two factors: (i) the activation of an anaphoric dependency and (ii) the activation of coherence relations between clauses (i.e., intersentential semantic relations), an effect that is not specifically linguistic, but rather domain-general (i.e., pronoun interpretation was primed by coherence relations presented either linguistically or visually). Kaiser (2009) is the first study to address the nature of abstract representations associated with pronoun resolution by using the priming technique. The author concluded that the abstract representations activated during pronoun resolution are shared between (non-pronominal) coherence relations inference and pronoun resolution processes.

In a study looking at English monolingual speakers and unbalanced bilinguals (i.e., adult second language learners of English whose first language is Mexican Spanish), Contemori (2019) used the priming technique in a comprehension study including prime sentences like "Emily liked *Brian* because *he* was a good person". The aim of the prime sentences was to attenuate first-mentioned/subject pronoun interpretations in English sentences that contained a potentially ambiguous pronoun, like "*Mary* met *Linda* while *she* was travelling". Contemori (2019) found an effect of immediate priming in both groups, demonstrating that unbalanced bilinguals and monolingual speakers were more likely to interpret an ambiguous pronoun as referring to the second-mentioned/object antecedent (i.e., *Linda*) after a prime sentence, than after encountering a non-prime sentence. The study by Contemori (2019) showed that priming can change bilingual and monolingual speakers' pronoun interpretation preferences in English as a result of exposure. In a follow up study, Contemori, Mossman and Ramos (2021) tested the comprehension of English pronouns in more complex discourse contexts showing that exposure through priming can be effective in changing within-language interpretations up to 7–10 days, potentially aiding in the successful acquisition of pronoun resolution biases in the non-dominant language (English) of bilingual speakers¹. While pronoun interpretations can be primed in bilingual speakers using a single-language priming task (e.g., Contemori, 2019; Contemori et al., 2021), it is not clear if pronoun interpretations can be primed cross-linguistically. The present study addresses this open question, by investigating cross-linguistic abstract representation associated with pronoun resolution in bilingual speakers.

1.2 Cross-linguistic priming

Cross-linguistic priming is a technique adopted to investigate the interaction of two languages during bilingual language processing (e.g., Altarriba & Basnight-Brown, 2007 for a review). Cross-linguistic priming has been interpreted to indicate cross-language activation and shared abstract representations, which has been shown at the phonological, word-level and syntactic level in bilingual individuals (e.g., Kootstra & Muysken, 2017; for a review). For instance, word-level priming has demonstrated that processing primed words in one language can activate the stored links to the target words in the other language (e.g., Altarriba & Basnight-Brown, 2007 for a review). At the syntactic

¹In the present study, we test more balanced Spanish–English bilinguals than in Contemori (2019) and Contemori et al. (2021). Participants in previous studies are Spanish dominant late learners of English, recruited from an English as a second language program.

level, cross-linguistic priming has been observed when the production/comprehension of a syntactic structure in one language facilitates the production/comprehension of the same syntactic structure in the other language, leading researchers to hypothesize that syntactic representations are shared between languages (the shared-syntax model, Hartsuiker, Pickering & Veltkamp, 2004). Hartsuiker et al. (2004) hypothesize that lexical and syntactic representations are interconnected so that a unit (lemma) for translation equivalents in two languages is linked to combinatorial nodes and a shared conceptual representation in the underlying system of a bilingual speaker. Cross-linguistic effects of structural priming are typically weaker than within-language priming effects in bilinguals (e.g., Bernolet, Hartsuiker & Pickering, 2013; Van Gompel & Arai, 2017, for a review). In addition, while structural priming across-languages has been observed even when the syntactic structures in the two languages are not fully identical (e.g., when syntactic structures have different word orders; e.g., Song & Do, 2016), priming may be stronger when the two structures fully overlap (e.g., Jacob, Katsika, Family & Allen, 2017; Chen, Jia, Wang, Dunlap & Shin, 2013). This evidence has been taken to suggest that non-identical syntactic structures in two languages may be connected but not fully shared in the underlying grammar of bilingual speakers (e.g., Kantola & Van Gompel, 2011; Van Gompel & Arai, 2017).

Notice that while many structural cross-linguistic priming studies have analyzed production, only a few published studies have looked at comprehension priming (e.g., Kidd, Tennant & Nitschke, 2015). In addition, while research on structural cross-linguistic priming has focused on syntax, only one published study has analyzed discourse persistence in bilinguals' production, by analyzing a corpus of Spanish–English bilingual speech (Travis, Torres Cacoullos & Kidd, 2017). Travis et al. (2017) investigated the production of first person pronouns in Spanish–English bilinguals, looking at within-language (Spanish to Spanish) and between-language (English to Spanish) priming. While the first person pronoun is explicit in English, it can be either explicit or null in Spanish. Travis et al. observed that the spontaneous use of the first person singular pronoun *I* primes the use of the explicit first person singular pronoun *yo* in Spanish in mixed-language utterances. The cross-linguistic persistence in the use of the explicit first person pronoun observed by Travis et al. was limited to specific verb configurations and topic-continuity contexts. Additionally, while the persistence of use of the explicit pronoun occurred within-language (Spanish-only) and between-language (from English), the between-language priming effect was weaker than the within-language effect, a result analogous to structural cross-linguistic priming effects (e.g., Van Gompel & Arai, 2017). Existing research has not yet investigated discourse level representations cross-linguistically using comprehension priming. In addition, while priming has been shown in production from English to Spanish (explicit pronoun in English priming an explicit pronoun in Spanish), it is unclear how the two pronominal forms available in Spanish (null and explicit) map onto the representation of explicit pronouns in English, a question that we address here by investigating Spanish to English priming.

Previous evidence from discourse priming demonstrated that abstraction of discourse structures can be observed (Kaiser, 2009; Contemori, 2019). However, discourse priming in comprehension involves multiple layers of activation, including the priming of an abstract anaphoric dependency representation and the priming of the event structure, as shown by Kaiser (2009). Because an anaphoric dependency and sentence coherence

relations are intrinsically connected in discourse, it may be difficult to isolate effects deriving purely from the activation of the (structural) anaphoric dependency. In this respect, discourse priming may be fundamentally different from structural priming, where only the abstract structure of a sentence/phrase can be activated (e.g., Van Gompel & Arai, 2017). Nonetheless, the activation of an anaphoric dependency may be reminiscent of structural ambiguities resolution, such as relative clause attachment. For example, in the sentence “the servant of the actress who was on the balcony”, the relative clause “who was on the balcony” can attach high, to first noun phrase (the servant) or low, to the second noun phrase (the actress), creating global ambiguity². Previous research has shown that by exposing monolingual German speakers to an unambiguous high attached relative clause increased the speakers' likelihood of producing a high-attached relative clause in a following sentence. On the other hand, when participants were exposed to an unambiguous low-attached relative clause, the probability of producing a low-attached relative clause increased in a subsequent stimulus (e.g., Scheepers, 2003). Recent studies on the priming of relative clause attachment have suggested that linguistic structural knowledge may be shared across other domains such as mathematics, so that the structure that underlies (high and low) relative clause attachment can be primed by mathematical equations that have similar hierarchical structures (e.g., Scheepers, Sturt, Martin, Myachykov, Teevan & Viskupova, 2011). In addition, relative clause attachment can be primed cross-linguistically, as shown by Desmet and Declercq (2006) in a study with Dutch–English bilinguals. Similarly to the formation of a dependency in relative clause attachment, pronoun resolution requires establishing a dependency between a referent and the pronominal expression, which we hypothesize may lead to cross-linguistic priming.

2. Aims and predictions

In the present study, using a sentence comprehension experiment that implements the cross-linguistic priming technique, unambiguous null pronouns (indicated as \emptyset) referring to a second mentioned-referent are presented in Spanish (3) with the aim of decreasing first noun phrase/subject interpretations in English in sentences containing a potentially ambiguous pronoun like (4).

- (3) Spanish priming sentence (experiment 1):
Ana invitó a Alvaro al cine porque \emptyset era un buen chavo.
Ana invited Alvaro to the movies because (he) was a good (masc) kid(masc).
- (4) Target English sentence with ambiguous pronoun:
John met Paul while he was in high school

The prime sentence provides evidence against the comprehender's statistics that first-mentioned/subject antecedent re-mention is frequent, with the L1 (Spanish) distribution being experimentally skewed towards second-mentioned/object antecedent re-mention. Grammatical gender in the prime sentences provides disambiguation that the Spanish pronoun (a null pronoun in (3)) refers to the second-mentioned/object referent (buen chavo in the masculine = Alvaro). In addition, the prime sentence includes an implicit causality verb (invitar/to invite in (2)) followed by the connector *because*. Implicit causality is a feature of certain

²We would like to thank an anonymous Reviewer for this suggestion.

psychological verbs where the verb elicits re-mention of either a first-mentioned or a second-mentioned referent. In our prime sentences, second-mentioned/object biased verbs are used to create high expectation that a second-mentioned referent should be re-mentioned³. The grammatical and discourse coherence features of the Spanish priming sentences aim to attenuate the strength of the first-mention bias used to interpret L2 (English) sentences like (4) that contain a potentially ambiguous pronoun. We test L1 to L2 priming (Spanish to English) using two sentence comprehension experiments. In one experiment, we test cross-linguistic priming using Spanish null pronouns, as exemplified in (3) and in a second experiment, the Spanish prime sentence contains a gender unambiguous explicit pronoun, as shown in (5).

(5) Spanish priming sentence (experiment 2):

Ana invitó a Alvaro al cine porque él era un buen chavo.

Ana invited Alvaro to the movies because he was a good kid.

In experiment 2, it is possible that if priming is found, the strength of the effect may differ in comparison to experiment 1. While cross-linguistic structural priming research has assumed shared representations between corresponding syntactic structures (e.g., Hartsuiker et al., 2004), it is unclear if the representations of two different pronouns in one language (null and explicit in Spanish) can map onto the representation of one pronominal form in the other language (explicit pronouns in English). Thus, it is an open question if and how the use of Spanish null and explicit pronouns may affect priming in English, and if the use of either pronoun in the Spanish primes may affect the size of the priming effect. The present study is the first to address these questions.

3. Experiment 1

3.1 Participants

Fifty-eight Spanish–English bilinguals were recruited at the University of Texas at El Paso (USA) (15 males, 43 females; mean age = 21.5; SD: 5). Informed consent was obtained and participants received credits for their participation.

Participants completed a language background questionnaire (Kaushanskaya, Blumenfeld & Marian, 2007) and two proficiency tests, one in English and one in Spanish (Diplomas de Español como Lengua Extranjera/DELE and the Michigan English Language Institute College English Test/MELICET). The MELICET assesses English proficiency and consists of 50 multiple-choice questions organized in two sections (30 grammar questions, and 20 cloze questions from a reading passage). The DELE is a test for Spanish proficiency that contains 20 cloze questions from a reading passage, 10 vocabulary questions and 20 grammar questions. The self-reported measures and proficiency scores in Spanish and English are reported in Table 1.

A one-sample t-test was used to compare bilingual speaker's proficiency in English and a one-sample t-test was used to

compare bilingual speaker's proficiency in Spanish, based on the MELICET and DELE scores. The t-test showed that bilingual speakers were significantly different in terms of proficiency in English ($t(57) = 42.209$, $p < 0.0001$) and Spanish ($t(57) = 38.128$, $p < 0.0001$), demonstrating that proficiency in the two languages was not homogenous. Since in the present study we measure pronoun comprehension in English, we used the MELICET scores as a continuous variable in our statistical analysis to observe if English proficiency modulates the cross-linguistic priming effect.

3.2 Materials

In a sentence comprehension task adapted from Contemori (2019), participants read sentences in English and Spanish and answered a comprehension question. Thirty sentences in English contained either two stereotypical male or two stereotypical female proper nouns and a transitive verb in a main clause followed by the connector “while”, as shown in (4), repeated here as (6). In the subordinate clause, a potentially ambiguous third person pronoun was presented, and pronoun gender was counterbalanced across-items. The verbs in the main clause did not include an implicit causality bias and the use of the connector “while” ensured a more semantically neutral context than the prime sentences. The English sentences were the same as the target sentences used in Contemori (2019) and were normed to ensure that the preferred interpretation for the pronoun is toward the first mentioned/subject referent. The norming task was conducted with twenty monolingual speakers of English using Amazon Mechanical Turk. We selected target sentences that had a minimum of 75% first mentioned/subject referent interpretations, an average preference that has been shown in previous studies investigating the first mentioned/subject bias in intra-sentential English anaphora resolution (e.g. for a corpus study, see Arnold, 1998; for a comprehension study see Contemori, Asiri & Perea Irigoyen, 2019).

(6) John met Paul while he was in high school

Participants answered a three-choice comprehension question about the referent of the pronoun, and could choose between the subject referent (John), the object referent (Paul) or an external referent (Someone else), as exemplified in (7). The position of the referents in the multiple-choice question was counterbalanced across the experiment. While the external referent is not a possible interpretation for the pronoun in English, we included this option as a distractor.

(7) Who was in high school?

- (a) John
- (b) Paul
- (c) Someone else

Half of the target sentences were preceded by a Spanish prime sentence that included a male and a female stereotypical proper name and a second-mentioned/object-biased implicit causality verb, as shown in (5), repeated here as (8). The implicit causality verbs were selected from a previous normative study on Spanish by Goikoetxea, Pascual and Acha (2008). The connector “because” introduced a subordinate clause that included a null pronoun, indicated in (8) as \emptyset . The subordinate sentence was semantically biased to include information about the second-mentioned/object antecedent and included a gender-inflected

³Previous research on the interpretation of Spanish null/explicit pronouns in Spanish–English bilinguals has shown that bilinguals do not always display the subject-object asymmetry observed in Spanish monolingual speakers (e.g., Keating et al., 2011; Contemori, Mossman, Armendariz, & Perea-Irigoyen, submitted). Because bilinguals' pronominal interpretations in Spanish are more variable than in monolingual speakers, we added implicit causality and gender information in our task to make obvious that the Spanish pronoun should be interpreted as the second-mentioned referent in the prime sentences.

Table 1. Experiment 1 and 2: Participants' information based on the language history questionnaire and proficiency tests: Mean (SD).

Experiment 1	Self-reported measures	Spanish - L1	English - L2
	Age of exposure (age in years)	1(1)	7 (4)
	Became fluent (age in years)	4(2)	11 (5.5)
	Length of residence in a country where the language is spoken (in years)	12 (8)	14 (8.5)
	Average Speaking (%)	56(22)	44(22)
	Average Reading (%)	32(20)	68(20)
	Average daily exposure (%)	53(20.5)	47(19)
	Dominance	34/58	24/58
<i>Language proficiency</i>	Score (out of 50)	35.6 (7)	35.6 (6.3)
Experiment 2	Self-reported measures	Spanish - L1	English - L2
	Age of exposure (age in years)	2.4(3.1)	4.5 (2.5)
	Became fluent (age in years)	5.6(4.6)	7.9 (3.4)
	Length of residence in a country where the language is spoken (in years)	13.5 (8.4)	16.7 (6.9)
	Average Speaking (%)	47(25)	53(25)
	Average Reading (%)	25(22)	75(20)
	Average daily exposure (%)	49(21)	51(20)
	Dominance	18/60	42/60
<i>Language proficiency</i>	Score (out of 50)	32.7 (7.9)	38.5 (5.4)

noun or adjective that identifies the second-mentioned/object antecedent as the referent of the null pronoun. For example, in (8), “buen chavo” is inflected in the masculine and refers unambiguously to the second-mentioned/object masculine antecedent “Alvaro”. In half of the prime sentences, the second-mentioned/object antecedent was masculine and in half of the prime sentences, it was feminine. Prime sentences were followed by comprehension questions that probed the second-mentioned/object antecedent interpretation, as shown in (9).

(8) Spanish prime sentence:

Ana invitó a Alvaro al cine porque \emptyset era un buen chavo.
Ana invited Alvaro to the movies because (he) was a good-masculine kid-masculine.

(9) ¿Quién era un buen chavo?

Who was a good kid?

- (a) Ana
- (b) Alvaro
- (c) Alguien más (Someone else)

Half of the target English sentences were preceded by a Spanish sentence that did not contain a pronoun (baseline condition), as exemplified in (10).

(10) Kathy le dio un regalo a Sheila por su cumpleaños la semana pasada. Sheila regresó el regalo porque no le gustó.

Kathy gave a present to Sheila for her birthday. Sheila returned the present because she did not like it.

¿ Quién regresó el regalo?

Who returned the present?

- (a) Kathy
- (b) Sheila
- (c) Alguien más (Someone else)

Thirty filler sentences (15 in English and 15 in Spanish) were included that had a variable number of referents. The fillers had similar structure as the baseline sentences.

The structure of the task and the materials are exemplified in the Supplementary Materials. Two lists were created, so that each English target sentence with an ambiguous pronoun followed a baseline sentence in one list, and a priming sentence in the other list.

3.3 Procedure and Coding

The task was presented as an online Question Pro survey. Participants were instructed to read the sentences and answer the comprehension questions. There was no time limit to complete the survey. The survey was presented in one session, without breaks. In addition to the sentence comprehension task, participants completed an online version of the language history questionnaire, the DELE and MELICET.

Participants whose proficiency was lower than 0.95 on unambiguous sentences were discarded (two participants not included in the participants' section). Overall, participants demonstrated high accuracy on the task, scoring 0.96 (SD = 0.19) on English fillers and 0.99 (SD = 0.09) on Spanish fillers. Participants' accuracy on Spanish baseline (mean = 0.98; SD = 0.11) and Spanish priming sentences (mean = 0.99; SD = 0.08) was also at ceiling.

In the analysis, we compared the likelihood of choosing a first-mentioned/subject antecedent for the English pronoun in the baseline and prime conditions. We used mixed-effects logistic regression (Jaeger, 2008), coding number of interpretations per each subject and item as 1 or 0. The independent variable is Prime condition (baseline vs. prime). We also included English proficiency as a continuous factor in the analysis, measured with the MELICET scores. A stepwise backward inclusion procedure was used to test both first-level effects and the interactions

Table 2. Experiment 1: Proportion of first-mentioned/subject choices (he = John) for the English sentences with ambiguous pronouns by priming type (SD in parenthesis)

	First-mentioned/subject choices
Baseline condition	0.7 (0.46)
Priming condition	0.65 (0.47)
Total average first-mentioned/subject choices	0.68 (0.46)

between the fixed-effect factors. The analysis was conducted using *glmer* (*lme4* library, Bates & Sarkar, 2007).

3.4 Results

Table 2 shows the proportions of first-mentioned/subject interpretations produced by bilingual speakers after the Spanish prime sentences and after the Spanish baseline sentences.

Table 3 summarizes the full model. The maximal random effect structure leading to convergence includes by subject and by item random intercepts and slopes for the effect of Priming condition.

In the analysis, we found a main effect of Priming condition and English proficiency. The main effect of Priming condition indicates that participants produced significantly fewer first-mentioned/subject interpretations for ambiguous English pronouns after encountering a prime sentence (0.65) than after encountering a baseline sentence (0.70). A main effect of English proficiency emerged, revealing that the first-mentioned/subject bias is weaker for bilinguals with lower English proficiency than participants with higher English proficiency. We chose a MELICET cut-off score of 38 to split lower and higher proficiency participants (see Contemori & Dussias, 2016, for similar criteria to determine proficiency levels). The main effect of English proficiency indicates that participants with lower proficiency score an average of 0.63 first-mentioned/subject choices, while higher proficiency participants chose the first-mentioned/subject on average 0.70 of the times.

3.5 Interim discussion

In experiment 1, we measured bilinguals' interpretations of English pronouns that are potentially ambiguous. The English sentences were preceded by Spanish primes where a null pronoun unambiguously refers to a second-mentioned/object. Interpretation of English pronouns presented after prime sentences was compared to English pronouns presented after baseline sentences. A main effect of prime condition indicated that participants' first-mentioned/subject interpretations significantly decreased after a Spanish prime in comparison to English pronouns encountered after a Spanish baseline sentence. This effect suggests that the first-mention bias in English can be attenuated by null pronoun interpretations in Spanish, when gender and semantic bias point to an object interpretation of the null pronoun. Although from the present experiment we cannot disentangle the priming of coherence relations from the priming of the anaphoric dependency (e.g., Kaiser, 2009), this result is the first to show that inferences about probability distributions and coherence relations in one language (L1, Spanish) can affect the other language (L2, English). As

Table 3. Experiment 1: Full model statistics

	Estimate	Std. Error	z value	Pr(> z)
(Intercept)	1.08	0.26	4.121	0.0001
Priming condition	-0.29	0.14	-2.092	0.03
English proficiency	0.09	0.03	2.607	0.009
Priming condition*English proficiency	-0.02	0.02	-0.899	0.3

bilingual speakers can be primed to establish a dependency in relative clause attachment cross-linguistically (e.g., Desmet & Declercq, 2006), our results demonstrate that a dependency between a referent and a pronominal expression can also be activated across the two languages of bilingual speakers.

From the analysis, a main effect of English proficiency emerged suggesting that participants with higher English proficiency have a stronger first-mentioned/subject bias than participants with lower proficiency. As the first-mentioned/subject bias is a language-specific interpretation strategy, it is expected that participants with more English experience would show an increased preference for comprehending the pronoun as referring to the first-mentioned/subject antecedent. Previous research has demonstrated that bilingual speakers do not always show monolingual patterns of pronoun comprehension and production in the L1/L2 (e.g., Montrul, 2004, 2018; Sorace & Filiaci, 2006), and effects of language dominance have recently been shown (Contemori, Tsuboi & Armendariz, submitted; Contemori, Mossman, Armendariz, Perea-Irigoyen, submitted). Studies on monolingual English-speaking adults have also demonstrated that variability in the strength of the first-mention bias exists, with monolinguals that have higher reading exposure displaying a more robust first-mentioned/subject bias (Arnold et al., 2018, 2019). Arnold et al. (2018) point out that while written language can be an ideal source of evidence for frequently occurring discourse patterns (i.e., in English, subjects are the entities more often referred to), spoken language can also provide supporting evidence. Our results demonstrate that in bilingual speakers who divide their time between two languages (and who are naturally more variable than monolinguals on their language proficiency), individual language experience, measured as proficiency, can account for some of the variability in the strength of the first-mentioned/subject bias. This result adds to the literature highlighting that language experience plays a role in the development of discourse patterns comprehension (e.g., Arnold et al., 2018, 2019).

In experiment 2, we use similar materials as in experiment 1, to verify if L1 to L2 cross-linguistic priming is found when the explicit pronominal form is used in Spanish to refer to a second-mentioned/object antecedent.

4. Experiment 2

4.1. Participants

Sixty Spanish–English bilinguals participated in experiment 2 (8 males, 50 females; two participants did not answer the gender question; mean age = 20.8; SD: 2.8). They were recruited at the University of Texas at El Paso (USA). Informed consent was obtained and participants received credits for their participation.

Table 4. Experiment 2: Proportion of first-mentioned/subject choices (he = John) for the English sentences with ambiguous pronouns by priming type (SD in parenthesis)

	First-mentioned/subject choices
Baseline condition	0.71 (0.45)
Priming condition	0.67 (0.47)
Total average first-mentioned/subject choices	0.69 (0.46)

Participants completed a language background questionnaire (Kaushanskaya et al., 2007) and the MELICET and DELE proficiency tests. The self-reported measures and proficiency scores measured with the MELICET and DELE tests are reported in Table 1. Concerning within-group proficiency, a one-sample t-test showed that participants in experiment 2 are not homogeneous in terms of proficiency in English ($t(59) = 53.840$, $p < 0.0001$) and Spanish ($t(59) = 31.560$, $p < 0.0001$). As in experiment 1, we used MELICET scores as a continuous variable in the analysis of experiment 2's results: to observe if proficiency modulates cross-linguistic priming effects. In addition, we compared the MELICET and DELE scores of participants in experiment 1 and 2 to verify if the groups have comparable proficiency in the two languages. An independent sample t-test showed that participants in experiment 2 score significantly higher on the MELICET (38.5) than participants in experiment 1 (35.6) ($t(116) = 2.621$, $p < 0.01$). Concerning the Spanish proficiency measure, participants in experiment 2 (32.7) score significantly lower on the DELE than participants in experiment 1 (35.5): ($t(116) = 2.029$, $p < 0.04$). Therefore, we can assume that while the bilingual group in experiment 1 is more Spanish dominant, the group tested in experiment 2 is more English dominant, as also confirmed by the self-reported dominance in Table 1.

4. 2. Materials

The materials in experiment 2 are the same as in experiment 1, except that the Spanish prime sentences included an explicit pronoun, as illustrated in (11). In experiment 2, besides the semantic bias and the adjective/noun gender disambiguation, the gender of the pronoun unambiguously identifies the second-mentioned object referent (él = Alvaro). Half of the prime sentences contained the feminine third person pronoun *ella*, and half of the sentences included the masculine third person pronoun *él*.

(11) Spanish priming sentence:

Ana invitó a Alvaro al cine porque él era un buen chavo.
Ana invited Alvaro to the movies because he was a good kid.

4. 3. Procedure and Coding

The procedure and statistical analysis were the same as in experiment 1.

Participants who scored lower than 0.90 on unambiguous sentences were discarded (three participants not included in the participants' section). Overall, bilingual participants demonstrated high accuracy on the task, scoring 0.97 (SD = 0.15) on English fillers and 0.98 (SD = 0.12) on Spanish fillers. Participants' accuracy on Spanish baseline (mean = 0.98; SD = 0.13) and priming sentences (mean = 0.99; SD = 0.05) was also at ceiling.

Table 5. Experiment 2: Full model statistics

	Estimate	Std. Error	z value	Pr(> z)
(Intercept)	1.13	0.23	4.814	0.0001
Priming condition	-0.24	0.12	-1.961	0.05
English proficiency	0.07	0.03	2.403	0.01
Priming condition*English proficiency	-0.00	0.02	-0.143	0.8

4. 4. Results

Table 4 shows the proportions of first-mentioned/subject interpretations produced by bilingual speakers after the Spanish prime sentences and after the Spanish baseline sentences.

Table 5 summarizes the full model. The maximal random effect structure leading to convergence includes by-subject and by-item random intercepts and by-subject random slopes for the effects of Priming Condition.

As in experiment 1, the analysis revealed a main effect of English proficiency. Using the same median split as in experiment 1 for the MELICET scores, we found that bilinguals with higher proficiency in English have a stronger first-mention bias (0.71) than bilinguals with lower English proficiency (0.62).

An effect of Priming condition is marginally significant, showing a decrease in first-mentioned/subject interpretations after a prime sentence in comparison to baseline. We conducted an additional exploratory analysis where we compared the results of study 1 and 2 with existing within-language priming data by Contemori (2019) (see Supplementary Materials). In Contemori (2019), English primes (e.g., Emily liked *Brian* because *he* was a good person) preceded English sentences containing a potentially ambiguous pronoun (*Mary met Linda while she was travelling*). The study by Contemori (2019) found discourse within-language priming with a group of adult L2 English learners (intermediate L2 proficiency; L1 Spanish), demonstrating that L2 speakers' interpretation of the ambiguous pronoun was affected by the prime. The aim of the exploratory analysis is to investigate if the size of the priming effect differs within and across-language (cross-linguistic priming: Spanish to English vs. within-language priming: English to English). The comparison did not show any differences in the size of the priming effect between the present study and Contemori (2019).

5. Discussion and conclusions

In experiment 2, we found that an effect of priming condition approached significance, showing a tendency for bilingual participants' first mention bias in English to be attenuated after a Spanish prime sentence was encountered. The effect confirms the results of experiment 1, demonstrating that the statistics about likely referents of a pronoun in one language can affect pronoun resolution in the other language, when gender and semantic disambiguation favor an object interpretation of the explicit pronoun. The effect of priming that we found in experiment 2 approached significance in comparison to the fully significant effect observed in experiment 1. A possible explanation to account for the difference in the strength of the effect is that the difference between the priming effect in experiment 1 and 2 is analogous to the findings that cross-linguistic structural priming is weaker when the surface and hierarchical structures tested in the two

languages are similar but not identical (e.g., Bernolet, Hartsuiker & Pickering, 2009; Kidd et al., 2015; Jacob et al., 2017). Previous research has shown that for balanced bilinguals, cross-linguistic priming is strong when the syntactic structures tested are identical in their surface and hierarchical structure in the two languages (e.g., Hartsuiker, Beerts, Loncke, Desmet & Bernolet, 2016). This evidence has been taken to suggest that the underlying representations of these structures are fully shared across languages. On the other hand, when the surface and hierarchical structure are similar but not identical, cross-linguistic priming can be observed, but it may be weaker than in structures with identical surface constituent and hierarchical configuration (e.g., Bernolet, Hartsuiker & Pickering, 2007). These results have been interpreted to indicate that the underlying representations of syntactic structures that do not fully overlap could be connected rather than shared across-languages (Van Gompel & Arai, 2017). We tentatively speculate that this may be the case for the representations of explicit pronouns in Spanish and explicit pronouns in English. Null pronouns (the default form in Spanish) and English explicit pronouns (the default form in English) are used to refer to topic/prominent antecedents in the two languages (Arnold, 1998; Contemori & Di Domenico, 2021). The similarity in the use of the two referential expressions may suggest that the two forms have fully shared representations, as indicated by the fully significant effect of priming. On the other hand, explicit pronouns in English and Spanish have different uses (in Spanish the explicit pronoun tends to refer to a non-topic antecedent; Contemori & Di Domenico, 2021). As a result, the underlying representations of the explicit pronouns in the two languages may be connected but not fully overlapping, leading to a weaker priming effect that approaches significance. Notice that Spanish explicit pronouns are usually stressed or strong pronouns as opposed to weak null pronouns, a distinction that may parallel that of overt subject pronouns in English that are typically unstressed but can receive contrastive or emphatic stress (e.g., Lipski, 2008; Otheguy, 2004; Toribio, 2004). We do not exclude that a distinction may be made in the underlying representations of bilingual speakers between the stressed/unstressed pronouns in English and the null/explicit Spanish pronouns. Further research should address this open question using a priming comprehension task in the auditory modality to uncover what is the degree of sharing between pronoun representations that include emphasis across the two languages.

We conducted an exploratory analysis to investigate within-language and cross-language priming effects, by comparing the results of the present study to the results by Contemori (2019). The analysis suggests that the within and cross-language priming experiments lead to similar effects of discourse priming. This result is not in line with previous studies indicating that within-language priming leads to stronger priming effects than cross-language priming (e.g., Travis et al., 2017). However, notice that the group of bilinguals tested in Contemori (2019) is very different from the participants tested here. Contemori (2019) recruited a group of adult second language learners (L1 Spanish) with intermediate English proficiency who attended English as a Second Language courses at a large American university. Future research should compare within and cross-language discourse priming in the same group of participants using a within-subject design.

The present study demonstrates that some degree of sharing exists between the representations of anaphoric dependencies in the two languages of a bilingual speaker. The present results are relevant for research on bilingual discourse acquisition. The

interpretation and use of referential expression is a domain where differences can be observed between monolinguals and various bilingual populations even at the highest levels of proficiency (e.g., native speakers in situation of attrition: Tsimpli, Sorace, Heycock & Filiaci, 2004; adult learners: Sorace & Filiaci, 2006; Rothman, 2008; heritage speakers: Keating et al., 2011, 2016). One of the factors that previous research has identified to explain the (sometimes-persistent) optionality at the discourse level is cross-linguistic interference (e.g., Sorace, 2011, for a review). However, to determine the degree of cross-linguistic interference that might occur in pronoun resolution among bilinguals, previous research has relied on the comparison between groups that speak different L1s or L2s. While this method provides informative results, it also has some limitations, due to the nuanced differences in the use of referring expressions among languages (e.g., for Spanish dialects: Carvalho, Orozco & Shin, 2015) and differences among different populations of bilingual speakers (e.g., learning context, socio-economic status, age, immigrant status).

The current study provides evidence of cross-language interaction at the discourse level within the same population of bilingual speakers, a strong indication that cross-linguistic interference may exist in bilingual discourse for speakers with varying degrees of L1 and L2 proficiency. To conclude, we stress the importance of studying cross-linguistic priming as a process that could inform other research domains such as contact-induced language change at the discourse level in bilingual populations (e.g., Torres Cacoullos & Travis, 2011, 2015; Kootstra & Muysken, 2017).

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