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Experience with code-switching modulates the use of grammatical gender during sentence processing

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Abstract

Using code-switching as a tool to illustrate how language experience modulates comprehension, the visual world paradigm was employed to examine the extent to which gender-marked Spanish determiners facilitate upcoming target nouns in a group of Spanish-English bilingual code-switchers. The first experiment tested target Spanish nouns embedded in a carrier phrase (Experiment 1b) and included a control Spanish monolingual group (Experiment 1a). The second set of experiments included critical trials in which participants heard code-switches from Spanish determiners into English nouns (e.g., la house) either in a fixed carrier phrase (Experiment 2a) or in variable and complex sentences (Experiment 2b). Across the experiments, bilinguals revealed an asymmetric gender effect in processing, showing facilitation only for feminine target items. These results reflect the asymmetric use of gender in the production of code-switched speech. The extension of the asymmetric effect into Spanish (Experiment 1b) underscores the permeability between language modes in bilingual code-switchers.

Keywords

code-switching; sentence processing; grammatical gender

1. Introduction

In many bilingual communities, speakers regularly code-switch, shifting from one language to another (Lipski, 1978; Poplack, 1980). Code-switches are most often spoken without hesitation, pauses, or corrections, suggesting that code-switching is neither random interference from one language to the other nor a manifestation of disfluency. The literature distinguishes between two types of code-switches: between (inter-sentential) and within (intra-sentential) sentence switches, as illustrated in (1–2):

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(1)	Ayer fui al supermercado. *I bought some apples*	[inter-sentential code-switching]
	"Yesterday I went to the supermarket. I bought some apples."	
(2)	El niño está *reading the book*	[intra-sentential code-switching]
	"The boy is reading the book"	

Intra-sentential switches have been a primary focus of research as they require a high degree of sensitivity to the grammatical constraints of both languages (Miccio, Scheffner-Hammer, & Rodríguez, 2009). Quantitative studies on intra-sentential switching involving numerous language pairs have revealed that certain syntactic junctures are more likely to serve as the loci of switching than others. Given that code-switching is most frequently attested in spoken communication, this research is largely based on data from bilingual production. Studies have involved informant-based elicitation (e.g., Toribio, 2004) or have been based on extensive recordings of spontaneous conversation (e.g., Torres-Cacoullos & Travis, *in press*). However, there is comparably little work on code-switching from the perspective of the listener. This is surprising given that the comprehension of code-switching arguably presents the bilingual comprehenders with unique challenges. Specifically, while code-switching is under the control of the speaker in production, for the listener, switches can be unexpected and thus might be more difficult to process than unilingual sentences.

This difficulty can be operationalized in terms of 'processing cost'. Evidence for a cost associated with switching has been reported for switching in lexical decision tasks. Findings (e.g., Grainger & Beauvillain, 1988; Thomas, & Allport, 2000) suggest that recognizing and integrating a linguistic code distinct from the most recently encountered, incurs a processing cost for the comprehenders. However, the implications of these results for real-world code-switching are limited because the vast majority of studies employ decontextualized language switching tasks, while actual code-switching is an inherently discourse-based phenomenon. Thus, the cost triggered by a language change in lexical switch studies may be more analogous to switch costs in non-linguistic domains (e.g., Allport, Styles, & Hsieh, 1994), leaving unanswered whether spontaneous code-switching will incur similar costs.

Some studies have examined the consequences of sentence-level switching for comprehension. In a reading study, Altarriba, Kroll, Sholl, and Rayner (1996) used eyetracking to show that Spanish noun switches are fixated longer than synonymous English words, suggesting a processing cost driven by the language switch. By contrast, Moreno, Federmeier and Kutas (2002) provided electrophysiological evidence that under some conditions, translation equivalent Spanish noun switches are less costly to process than within-language synonym switches. In the auditory domain, studies indicate that the extent to which non-target alternatives are activated is modulated by the phonetic cues available to the listener, such as the phonotactics of the code-switched target item (e.g., Li, 1996; Grosjean, 1988; Soares & Grosjean, 1984).

The experimental literature, then, provides evidence both for switch costs in comparison to unilingual processing but also demonstrates that the comprehension of code-switching can be facilitated under certain conditions. Considering the ubiquitousness of code-switching

among bilingual communities, this complex picture is not surprising. If code-switching were extremely costly to comprehension, its use would not be characterized by researchers as fluid and effortless (e.g., Poplack, 1980; *in press*), nor would we expect code-switching to be commonplace amongst bilinguals (e.g., Backus, 2005; Milroy & Muysken, 1995; Myers-Scotton, 1993; Zentella, 1997).

Consequently, rather than testing for structures that do or do not incur processing costs under variable conditions, our goal here is to build on the spirit of past studies (e.g., Li, 1996; Soares & Grosjean, 1984) by examining how bilingual comprehenders exploit potential cues, rooted in their linguistic experience, to facilitate the processing of upcoming other-language items. Specifically, we examine the extent to which the reliability of the morpho-syntactic context preceding a code-switch facilitates its comprehension. The logic guiding our study is as follows. If bilinguals exposed to code-switching can extract patterns from the many exemplars of utterances in their community, these patterns may provide reliable cues for guiding the comprehension of the speech of their interlocutors. An approach such as this one is congenial with usage-based approaches to language (e.g., Bybee, 2013; Goldberg, 2006). Here, we focus on whether Spanish-English bilinguals exploit grammatical gender information as a cue to facilitate the comprehension of code-switching.

One observation is central to this study: the grammatical gender of prenominal determiners does not pattern in Spanish-English code-switched NPs as in unilingual Spanish (e.g., Otheguy & Lapidus, 2003; Valdés Kroff, *in press*) nor is grammatical gender absent as in English “the”. The particular use of gender on Spanish determiners followed by English nouns is important in that code-switchers must manage three systems: Spanish determiner use; determiner use in Spanish to English code-switching; and English determiner use. We discuss the implications of this in terms of the so-called gender congruency effect.

1.1 The gender congruency effect

A number of studies have investigated how and when gender information affects the processing of nouns (see Friederici & Jacobsen, 1999 for a review), showing across many gendered-languages that the recognition of target nouns is modulated by the gender of prenominal modifiers. When the gender of an article or adjective is congruent with a following noun, noun recognition is enhanced relative to a neutral baseline; when it is incongruent, recognition is slowed down (e.g., Hagoort & Brown, 1999; Dahan, Swingley, Tanenhaus & Magnuson, 2000). This *gender congruency effect* has been reported for monolingual speakers in visual and auditory tasks and observed for highly proficient bilingual populations processing in their second language (L2) during comprehension (Guillelmon & Grosjean, 2001; Weber & Paris, 2004) and production (e.g., Costa, Kovacic, Franck, & Caramazza, 2003; Bordag & Pechmann, 2007). The effect also influences processing across gendered languages — when grammatical gender differs for translation equivalents (e.g., Paolieri et al., 2010). For our purposes, Lew-Williams & Fernald (2007) reveal an important within-language congruency effect. Spanish-speaking children and adults were shown 2-picture displays of common objects while their eye movements were recorded. Paired items were either same-gender (e.g., *pelota* v. *galleta* 'ball.FEM v. cookie.FEM') or different-gender pictures (e.g., *pelota* v. *carro* 'ball.FEM v. car.MASC'). In each

trial, participants heard the target item at the end of a carrier phrase *Encuentra el/la* ____ 'Find the.MASC/FEM _____'. Importantly, on different-gender trials, determiners are a reliable cue for identifying upcoming nouns. Lew-Williams and Fernald found that speakers exploit this cue, which allowed participants to anticipate the identity of the target noun. Both young children and adults capitalized on gender-marked determiners in different-gender trials as informative morphosyntactic cues for upcoming nouns.

Despite the absence of grammatical gender in English, code-switches with a Spanish determiner followed by an English noun (*mixed NPs*) are common in Spanish-English bilingual speech (e.g., Herring, Deuchar, Parafita Couto, & Moro Quintanilla, 2010; Jake, Myers-Scotton & Gross, 2002; Valdés Kroff, *in press*). Interestingly, as illustrated in examples (4)–(5), taken from the Bangor Miami Corpus of oral Spanish-English speech (Deuchar, Davies, Herring, Parafita Couto, & Carter, 2014), bilinguals show an overall preference for masculine articles (e.g., *el*) before switching to an English noun, regardless of the gender of the translation equivalent:

(4) *That he's like* # ah como muerto que se ve como muerto con un tiro en el *glass* (herring7.SEB)
"That he's like, uh, like dead, that he looks dead with a shot through the glass"

(5) Pero no tenían el *flag out there?* (sastre9.fem2)
"But didn't they have the flag out there?"

Thus, both *el glass* (Spanish: *vidrio/cristal*.MASC) and *el flag* (Spanish: *bandera*.FEM) are typical examples of mixed NPs. In contrast, feminine determiners also surface in mixed NPs, as shown in (6) below (also extracted from the Bangor corpus) but are less common and appear before nouns with feminine translation equivalents. Switches such as *una cookie* (Spanish: *galleta*.FEM) are thus attested, while **una juice* (Spanish: *jugo*.MASC) are not[1] (Jake et al., 2002; Valdés Kroff, *in press*):

(6) Qué es lo que ella quiere, qué es una *cookie*? (sastre4.fem1)
"What is it that she wants, what is a cookie?"

Given that gender facilitates processing for both L1 Spanish speakers and even highly proficient L2 speakers (Lew-Williams & Fernald, 2007; Dussias, Valdés Kroff, Guzzardo Tamargo, & Gerfen, 2013), we examine whether gender also modulates comprehension in code-switching. As noted above, if bilinguals use distributional patterns learned through exposure, the gender asymmetry in mixed NP production should be reflected in comprehension. Specifically, code-switchers may asymmetrically show facilitation for feminine gender when processing mixed NPs, because only feminine marked determiners

[1]An anonymous reviewer rightly points out that an unattested form in code-switching is not necessarily evidence that the form is not a part of the code-switching grammar of the bilingual. However, the patterns discussed here have generalized over a large number of different corpus studies on Spanish-English code-switching, providing support for the claim that forms such as *una juice* do not constitute a feature of Spanish-English code-switching grammar.

reliably cue the gender of a following noun, whether in Spanish or in the Spanish translation equivalent in code-switching.

2. The present study

We conducted two experiments, employing the visual world paradigm (Cooper, 1974; Tanenhaus, Spivey-Knowlton, Eberhard, & Sedivy, 1995), using the 2-picture design of Lew-Williams and Fernald (2007). The visual world affords high ecological validity for investigating spoken language processing. This is important given that code-switching is primarily a spoken language phenomenon (c.f. Dorleijn & Nortier, 2009; Montes-Alcalá 2005) that has been notoriously difficult to study experimentally, perhaps due to social stigma. One advantage of the visual world is its use of auditory input, thus providing an experimental context that more closely resembles speech familiar to our participants. Another is that it does not require listeners to provide metalinguistic judgments, which for code-switching may be especially fraught. Independent of debates regarding "grammaticality" in the code-switching literature, our approach can thus tap into processing mechanisms, while circumventing complex issues of metalinguistic reflection.

Experiment 1 assesses grammatical gender as a cue to the identity of an upcoming noun in Spanish-only (unilingual) sentences for two participant groups: monolingual Spanish speakers (Experiment 1a) and Spanish-English code-switchers (Experiment 1b). Our reasoning is that if the bilingual speakers pattern with their monolingual counterparts, the asymmetry found in their overall production in naturalistic corpora is arguably not impacting the processing of Spanish-only sentences. However, if the bilinguals differ from the monolinguals, especially via differentially processing feminine, but not masculine, gender in anticipating the identity of an upcoming noun, we can arguably conclude that the difference lies in the speech communities and not the experimental materials or design.

Experiment 2 tests the bilingual participants in code-switched NPs. Experiment 2a employs the ‘carrier phrase’ design of Experiment 1, while 2b presents target items in a complex and variable sentence context. The rationale behind the two versions is as follows: Experiment 2a most directly follows the design of Experiment 1; however, given that the phrase prior to the code-switch is in Spanish and the context is invariable, one potential critique of the results is that our participants are simply deploying the same strategy as in Experiment 1. We, thus, employ Experiment 2b as an extension to 2a and vary when the code-switch occurs and also present to the participant a code-switch prior to the critical code-switch (explained further below). Due to the increased complexity of the stimuli, Experiment 2a ultimately serves as a link between Experiments 1 and 2b. As a final note, the bilingual participants in 1b,2a, and 2b are all the same individuals.

3. Experiment 1. Spanish-only sentences

3.1 Experiment 1a. Spanish Monolingual Group

Experiment 1a examines whether grammatical gender on determiners facilitates the identity of an upcoming noun for Spanish monolinguals. Given past findings (e.g., Lew-Williams &

Fernald, 2007), we predict that monolinguals will exploit gender marked on a determiner as a facilitatory cue in spoken word recognition.

3.1.1 Method

3.1.1.1 Participants: Twenty-four Spanish monolinguals (12 female) were recruited from the University of Granada, Spain. Participants completed a single, Spanish-only visual world eye-tracking experiment lasting approximately 20 minutes and were paid $10 per hour for their participation.

3.1.1.2 Materials and Design: We selected 224 pictures representing concrete objects (half feminine and half masculine), using EsPal (Duchon, Perea, Sebastián-Gallés, Martí, & Carreiras, 2013; retrieved from www.bcbl.eu/databases/espal/), an online database of Spanish word properties providing frequency and subjective properties of the items. An independent, two-tailed t-test for frequency between feminine and masculine items was not significant ($t(222) = 0.31$, $p = 0.75$). A subset of the items had imageability, concreteness, and familiarity ratings (subjective ratings) available through EsPal (79–82% for feminine items, 74–82% for masculine items). All 3 categories used a scale from 1 to 7, with 7 indicating fully imageable, concrete, or familiar. For imageability and concreteness, there were no significant difference between feminine and masculine items (imageability: feminine items mean rating = 6.04, masculine items mean rating = 6.02, $t(169) = 0.29$, $p = 0.77$; concreteness: feminine items mean rating = 5.81, masculine items mean rating = 5.84, $t(182) = -0.33$, $p = 0.74$). For familiarity, feminine items, though not significantly different, were marginally more familiar (feminine items mean rating = 6.06, masculine items mean rating = 5.89, $t(180) = 1.73$, $p = 0.09$).

The pictures were grouped into quartets, 2 masculine and 2 feminine items, yielding 56 total trials. Each trial consisted of a 2-picture display of pairs with either same (e.g., *bandeja* "tray.FEM" and *taza* "cup.FEM") or different (e.g., *bandeja* "tray.FEM" and *lazo* "ribbon.MASC") gender (Lew-Williams & Fernald, 2007). Items were counterbalanced such that one feminine or masculine item appeared as a target, once with a same gender distractor and once with a different gender distractor. On-screen position was counterbalanced; each target could appear either on the left-hand position or the right-hand position of the monitor. The design yielded 8 experimental lists (see Table 1). Each participant completed one list.

A sound file was created for each trial. Target items were embedded in one of two invariant carrier phrases that included the Spanish definite article marked for gender, *Encuentra el/la* _____ "Find the.MASC/FEM_____". The gender of the determiner always agreed with the target item. Recordings were made in a sound-attenuated chamber with a Shure SM57 microphone on a Marantz PMD670 at a sampling rate of 44.1 kHz with 16-bit quantization. A native female speaker and trained linguist from southern Spain recorded the auditory stimuli. The speaker recorded multiple tokens of the carrier phrase. The duration of the determiner was measured using Praat (Boersma & Weenink, 2012). One phrase was selected from each set and the duration of the determiner was hand-edited to 200 ms. Each target noun was recorded 5 times. One token was selected and concatenated to the invariant carrier phrases following a 50 ms pause between the offset of the determiner and the onset of

the noun. This procedure was implemented to eliminate any coarticulatory information, which might cue the phonetic identity of a following noun independent of cues provided by the determiner's gender (e.g., Magnuson, Dixon, Tanenhaus, & Aslin, 2007). Each noun was produced with sentence-final intonation to maximize the naturalness of the concatenated carrier phrase+noun.

A picture database was compiled for the experimental stimuli. For each item, a color image was selected from Google Images. Selected items appeared in isolation with solid backgrounds. All files were a minimum size of 30 kB and as close as possible to a square size in pixels. Pictures were normed for naming agreement in Spanish and English and only pictures with 100% naming agreement in the two languages were selected.

3.1.1.3 Procedure: Participants were tested in isolation in a lab at the University of Granada (Spain). They were seated before an Eyelink 1000 desk-mounted eyetracker (SR Research) and a 17-inch ViewSonic 17PS monitor. A chin rest provided head stability. A computer mouse was placed on the participant's preferred side. The Eyelink 1000 recorded eye movements from the participant's right eye using corneal reflection sampled at 1000 Hz. Each participant completed a 9-point calibration to reduce eye-tracking error. The experimenter proceeded to the experiment proper when average error was below 0.5°. Participants were instructed that they would hear phrases in Spanish while seeing two pictures on the monitor. They used the mouse to select the picture named on each trial.

3.1.2 Results—We employ a timecourse analysis (e.g., Hopp, 2013) in which we conducted paired-t tests on the mean difference of proportion of fixation to target and distractor items (i.e. target fixation minus distractor fixation) for each condition in 100 ms time regions from determiner onset through 800 ms. This yielded 8 time regions.[2] The timespan is broad to take into account any baseline effects, i.e. significant looks to target or distractor before the grammatical gender of the determiner can impact processing, while also examining whether significant looks to targets are sustained over time. Given that the determiners have a duration of exactly 200 ms, we are interested in identifying the first time region after 200 ms with significantly increased looks towards target items that are then sustained throughout the remainder of the timecourse analysis. If grammatical gender facilitates spoken word processing, different gender trials where the article is informative should result in earlier looks towards target items than in same gender trials.

3.1.2.1 Feminine gender trials: For feminine same gender trials (i.e. where both targets and distractors are feminine), participants first exhibit significantly increased looks to target items in Region 600, mean difference = 0.245 ($t(23) = 3.918$, $p < 0.001$). Throughout the remainder of the time course, participants increasingly and significantly looked more towards target items (Region 700, mean difference = 0.534, $t(23) = 10.32$, $p < 0.001$; Region 800, mean difference = 0.737, $t(23) = 17.766$, $p < 0.001$). For feminine different gender trials, where the target is feminine but the distractor is masculine, there were significantly more looks to distractor items at determiner onset, Region 100 mean difference = −0.152

[2]We report marginal and significant results. Full results and Materials are included in an online supplemental at ufdc.ufl.edu/IR00006197/00001.

($t(23) = -2.553$, $p = 0.018$), indicating the presence of a baseline effect. This effect disappears in the subsequent two time regions, where no difference is found between fixations to target and distractor items ($ps > 0.132$). Participants first show a higher proportion of fixations to target items in Region 400, mean difference = 0.134 ($t(23) = 2.56$, $p = 0.018$). This effect continues throughout the time course, increasing in each region (Region 500 mean difference = 0.296, $t(23) = 5.694$, $p < 0.001$; Region 600 mean difference = 0.438, $t(23) = 8.512$, $p < 0.001$; Region 700 mean difference = 0.606, $t(23) = 12.912$, $p < 0.001$; Region 800 mean difference = 0.736, (23) = 15.93, $p < 0.001$).

The significant divergence towards target items that occurs in the earlier time region on feminine different gender trials (i.e. Region 400) than in feminine same gender trials (i.e. Region 600) suggests that Spanish monolinguals exhibit an anticipatory gender effect for feminine conditions. That is, Spanish monolinguals exploit feminine grammatical gender to speed up spoken language processing when the visual context provides the opportunity to do so (See Figures 1 and 2).

3.1.2.2 Masculine Gender Trials: In masculine same gender trials, both target and distractor items are masculine. Participants first reveal significantly more fixations to target items in Region 600, mean difference = 0.281 ($t(23) = 4.875$, $p < 0.001$). Participants increasingly converge on looks to target items in the subsequent two time regions (Region 700, mean difference = 0.593, $t(23) = 11.679$, $p < 0.001$; Region 800, mean difference = 0.719, mean difference = 0.719, $t(23) = 15.419$, $p < 0.001$). For masculine different gender trials, participants first diverge towards target items in Region 400, mean difference = 0.174 ($t(23) = 3.088$, $p = 0.005$). Significantly increasing looks to targets over distractors continue through the remaining time regions (Region 500 mean difference = 0.353, $t(23) = 5.729$, $p < 0.001$; Region 600 mean difference = 0.448, $t(23) = 8.762$, $p < 0.001$; Region 700 mean difference = 0.639, $t(23) = 13.541$, $p < 0.001$; Region 800 mean difference = 0.8, $t(23) = 18.562$, $p < 0.001$).

As in the feminine conditions, there is earlier significant divergence towards target items in masculine different gender trials (i.e. Region 400) than masculine same gender trials (i.e. Region 600). Furthermore, the timecourse plots (Figures 3 and 4) indicate that monolinguals exhibit a similar timecourse of gender processing effects for both the masculine and feminine trials.

3.1.3 Discussion—The results of Experiment 1a replicate and extend the findings of Lew-Williams & Fernald (2007) with a larger and more variable set of items. Of particular interest, we extend their findings in that we observed the facilitatory effect of gender for masculine and feminine determiners, separately.

3.2 Experiment 1b. Spanish-only sentences, Spanish-English Bilingual Group

In Experiment 1b, we examine Spanish-English bilinguals, for whom Spanish is their first language and who engage in code-switching in daily life. As L1 Spanish speakers performing a Spanish-only task, one prediction is that this group should perform like the monolinguals in Experiment 1a, exploiting both genders in the identification of upcoming nouns when possible. Alternatively, because these bilinguals frequently engage in code-

switching, their richly variable pattern of determiner usage may modulate gender processing, even in a Spanish-only task.

3.2.1 Method

3.2.1.1 Participants: Twenty-five Spanish-English bilinguals (19 female) from New York City participated. This population was chosen for its well-known engagement in code-switching (e.g., Poplack, 1980). Mean age was 22.6 years (SD = 3.96). All participants were born in a Latin American country (Puerto Rico is included) and reported acquiring English after Spanish, English Age of Acquisition = 9.2 years (range: 3–17, SD = 3.56), Spanish Age of Acquisition = 1.04 years (range: 0–5, SD = 1.54),[3] difference = 8.16 years ($t(24) = 10.32$, $p < 0.001$). Participants were paid $10 per hour for their participation in the study.

Participants completed an online language history questionnaire (LHQ) that recorded demographic information (such as age, sex, and place of birth) and self-reported proficiency ratings in English and Spanish in four categories (speaking, listening, reading and writing) on a scale from 1 to 10, with 10 indicating highest proficiency. Similarly, we asked participants to self-report on their exposure to Spanish-English code-switching on a scale of 1 to 5 (1 indicating never, 5 always). The group had a mean rating of 3.48 (SD = 0.71) and no participant indicated that they are never exposed to code-switching.

Additionally, participants completed proficiency tests in Spanish and English for vocabulary and grammatical knowledge. Vocabulary was measured via an adaptation of the Boston Naming Test (BNT, Kaplan, Goodglass, Weintraub, & Segal, 1983), a picture-naming test originally designed as an assessment tool for English speakers that has been normed for Spanish speakers (García-Albea & Sánchez Bernardos, 1986). We split the original item list by language into 2 sets of 30 pictures (e.g., Dussias, Guzzardo Tamargo, Valdés Kroff, & Gerfen, 2014). Items were presented via E-prime (Psychology Software Tools, Inc.). A bilingual experimenter tabulated correct responses.

Participants completed an English grammar test adapted from the *Michigan English Language Institute College English Test* (MELICET) and a Spanish test adapted from the *Diploma de español como lengua extranjera* 'Diploma of Spanish as a Foreign Language' (DELE). The adapted MELICET contained 50 multiple-choice questions in two sections, 30 grammar questions and 20 cloze questions from a reading passage. The adapted DELE had 50 multiple-choice questions in three sections, 20 cloze questions from a reading passage, 10 vocabulary questions, and 20 grammar questions. Both tests were completed on a computer.

Self-ratings are in Table 2. Participants rated themselves higher for listening proficiency in Spanish than English, mean difference = −0.68 ($t(24) = -2.47$, $p = 0.021$), and for speaking in Spanish, although the mean difference is only marginal: −0.33 ($t(24) = -1.89$, $p = 0.071$). There were no differences for reading or writing (reading, $t(24) = 0.77$, $p = 0.45$; writing, $t(24) = 1.05$, $p = 0.306$).

[3]Note that an early English Age of Acquisition is not the same as age of arrival in the U.S. We recognize that we have a varied group of speakers in terms of AoA but they are similar in terms of their speech community.

Participants scored a mean of 18.76 (SD = 4.97) for the English BNT and 18.16 (SD = 3.8) for the Spanish BNT. Performance was not significantly different across languages ($t(24) = 0.458$, $p = 0.651$). For grammar proficiency, participants scored a mean of 40.48 (SD = 5.28) on the MELICET and 40.24 (SD = 5.04) on the DELE. Although not directly comparable, the bilingual group's performance on both 50-question tests was almost identical.

In sum, both self-reported ratings and assessment-based proficiency measures indicate that the Spanish-English group was well balanced across both languages. If anything, the bilingual group may have shown a small bias towards Spanish, as participants self-reported its earlier acquisition and rated themselves higher in Spanish listening and speaking (marginally).

3.2.1.2 Materials and Design: See Experiment 1a.

3.2.1.3 Procedure[4]: Identical to Experiment 1a, except that testing occurred at City College of New York.

3.2.2 Results

3.2.2.1 Feminine Gender Trials: On feminine same gender trials (e.g., *la mesa* "the.FEM table.FEM", *la cama* "the.FEM bed.FEM"), participants first exhibit significantly more fixations to target items in Region 600, mean difference = 0.196 ($t(24) = 4.071$, $p < 0.001$). The final two regions exhibit significantly higher looks to target items (Region 700 mean difference = 0.432, $t(24) = 7.936$, $p < 0.001$; Region 800 mean difference = 0.697, $t(24) = 15.205$, $p < 0.001$). For feminine different gender trials (e.g., la mesa "the.FEM table.FEM", el dinero "the.MASC money.MASC"), in Region 400, bilinguals begin to exhibit non-significant but marginally higher fixations to target items, mean difference = 0.102 ($t(24) = 1.934$, $p = 0.065$). This effect becomes significant in Region 500, mean difference = 0.163 ($t(24) = 3.448$, $p = 0.002$), and continues to be significant with increasingly more looks to target items (Region 600 mean difference = 0.261, $t(24) = 5.733$, $p < 0.001$; Region 700 mean difference = 0.447, $t(24) = 8.29$, $p < 0.001$; Region 800 mean difference = 0.602, $t(24) = 11.641$, $p < 0.001$).

Like Spanish monolinguals, Spanish-English bilinguals exploit feminine grammatical gender to facilitate spoken language processing during comprehension, with earlier looks to feminine target items in different gender contexts (i.e. marginal in Region 400, significant in Region 500) when compared to same gender contexts (i.e. Region 600). Timecourse plots are provided in Figures 5 and 6.

3.2.2.2 Masculine Gender Trials: For masculine same gender trials, participants had non-significant but marginally increased looks to target items in the first 200 ms time regions possibly indicating the presence of baseline effects (Region 100 mean difference = 0.118, $t(24) = 1.87$, $p = 0.074$; Region 200 mean difference = 0.096, $t(24) = 1.725$, $p = 0.097$).

[4]Prior to testing, participants were greeted in both English and Spanish and told that the study was looking at how bilinguals use both of their languages (i.e. no explicit mention of code-switching, although code-switching was used). Before each experimental session, participants were instructed in the language of the experiment, i.e. in Spanish for Experiment 1b, with code-switched speech in Experiments 2a and 2b.

However, subsequent regions through 500 ms reveal no differences between looks to targets and distractors (*ps* > 0.261). Bilinguals first show significantly more fixations to target items in the 600 ms time region, mean difference = 0.151 ($t(24) = 2.667$, $p = 0.013$). This continues throughout the remaining regions with increasingly higher looks to targets (Region 700 mean difference = 0.339, $t(24) = 5.801$, $p < 0.001$; Region 800 mean difference = 0.554, $t(24) = 7.447$, $p < 0.001$).

For the different gender trials, where masculine targets were paired with feminine distractors (e.g., *el libro* 'the.MASC book.MASC', *la cama* 'the.FEM bed.FEM'), bilinguals first show significantly more fixations to target items in Region 600, mean difference = 0.254 ($t(24) = 4.078$, $p < 0.001$). This significant difference continues and increases throughout the remaining two time regions (Region 700 mean difference = 0.466, $t(24) = 8.841$, $p < 0.001$; Region 800 mean difference = 0.626, $t(24) = 14.351$, $p < 0.001$). Timecourse plots are provided in Figures 7 and 8.

Unlike the results reported for the feminine conditions, as well as both conditions for the monolinguals, Spanish-English bilinguals showed an identical timecourse in both same and different gender trials. Importantly, even on masculine different gender trials in which the determiner (*el*) can reliably facilitate the identification of the target noun, bilinguals did not converge on masculine target items at an earlier region over time as compared to trials on which both pictured items were masculine.

3.2.3 Discussion—Experiments 1a and 1b had two primary goals. The first was to establish whether monolinguals would replicate previous findings that Spanish speakers successfully utilize grammatical gender on determiners to facilitate spoken word processing. Experiment 1a replicated Lew-Williams and Fernald (2007) and extended their findings by separately analyzing the masculine and feminine determiners as exploitable cues to the identity of an upcoming noun. Experiment 1b tested Spanish-English bilinguals who are members of a code-switching speech community. The results show that bilinguals exhibit sensitivity to gender as a processing cue, but only in the feminine different gender trials. They do not utilize masculine gender as an informative cue in masculine different gender trials. This result is congenial with an experienced-based view in which the extensive use of *el* as a default article in code-switching may lead bilinguals to ignore it as a cue for a following noun during comprehension, even in a Spanish-only task. To examine this hypothesis further, Experiment 2 examines the processing of mixed NPs.

4. Experiment 2. Code-switching

4.1 Experiment 2a. Mixed NPs in a Fixed Carrier Phrase

Experiment 2a employs the same Spanish carrier phrase as in Experiment 1, but in Experiment 2a the carrier is followed by an English target noun, yielding a mixed NP structure, (e.g., *Encuentra el candy*). Moreover, to provide a strong test of the hypothesis that speakers will exploit feminine, but not masculine, gender cues on determiners, we incorporate an additional manipulation. Critical trials in Experiment 2a contain pairs of items that are phonological competitors in English (e.g., *candle/candy* both share the first syllable [kæn]) but that differ in the grammatical gender of their translation equivalents (e.g.,

vela 'candle.FEM', *dulce* or *caramelo* 'candy.MASC'). This manipulation is predicated on work showing that phonological competition delays fixations to targets (e.g., Allopenna, Magnuson, & Tanenhaus, 1998) but that this delay is modulated by the presence of grammatical gender. Dahan et al. (2000) found that phonological competition between target and competitor items in different gender trials was attenuated by the presence of grammatical gender, allowing participants to circumvent the effect of the non-target phonological competitor item on the basis of the preceding gender cue.

We apply the logic of Dahan et al. (2000) to the experiment here. We hypothesize that overt gender on the determiners and the subsequent presence of phonological competition in the critical item noun pairs will yield asymmetric gender effects if feminine, but not masculine, gender is exploited in the processing of the mixed NPs. Specifically, if masculine gender does not facilitate spoken language processing for mixed NPs, bilinguals should show a competitor effect arising from the phonological competition between the two items in the display, as has been shown for monolinguals (e.g., Allopenna et al., 1998). By contrast, if bilinguals capitalize on feminine gender to facilitate spoken word recognition of code-switched targets, then an anticipatory grammatical gender effect should emerge, despite the presence of phonological competition.

4.1.1 Method

4.1.1.1 Participants: The same Spanish-English bilinguals in Experiment 1b (N = 25).

4.1.1.2 Materials and Design: The design for Experiment 2a is similar to the Spanish-only block with the difference that we introduced a phonological manipulation to enable us to maximize potential asymmetric gender effects. The critical trials include pairs of images with the following two properties: 1) they overlap phonetically in their respective first syllables in English, e.g., [kaen] in *candle* and *candy*, 2) their respective translation equivalents are of different genders in Spanish.

On critical trials, participants were faced with one of two conditions. If the carrier phrase employs the feminine determiner (i.e. *Encuentra la*), the target item is feminine (e.g., target is candle, paired with candy). If the carrier employs the masculine article (i.e.*Encuentra el*), the target item is masculine (e.g., target is candy, paired with candle). Crucially, for all critical trials, the gender of the determiner reliably cues the gender of the pictured target. If bilinguals asymmetrically process the gender information of the determiner, as in Experiment 1b, their looks to masculine items should diverge later due to the presence of phonological competition. By contrast, they should continue to disambiguate towards the feminine target earlier due to the presence of the feminine determiner.

Participants heard 20 critical pairs pseudo-randomly drawn from a master list of 60 pairs of nouns that exhibit phonological competition in English and are of different genders in their Spanish translation equivalents. They heard another 20 pairs that exhibited phonological competition that were included as distractors. Finally, participants heard 80 pairs without phonological competition as fillers. Each participant only heard one target item for each critical pair. Thus, if a participant heard the target “candy” in the candy/candle pair, that participant would not be presented with “candle” as a target. Position of targets was

counterbalanced across lists (*left* or *right*). Participants heard 6 code-switched practice trials to familiarize them to the task.

We conducted independent two-tailed t-tests on the frequency, concreteness, familiarity, and imageability ratings retrieved from the MRC Psycholinguistic Database (Wilson, 1988) for the English nouns with available ratings, split by their masculine and feminine translation equivalents (e.g., *candy* in the masculine translation equivalent list, *candle* in the feminine translation equivalent list). For frequency, concreteness, and imageability, there were no significant difference between feminine and masculine translation equivalents (frequency: $t(100) = 0.633$, $p = 0.528$; concreteness: $t(84) = 0.584$, $p = 0.561$; imageability: $t(84) = 0.356$, $p = 0.723$). For familiarity, the t-test indicated a non-significant but marginal effect for familiarity for English nouns with feminine translation equivalents having a higher familiarity rating ($t(88) = 1.883$, $p = 0.063$).

The critical comparison examined the proportion of looks to target items over time, directly comparing masculine and feminine targets in different gender contexts with the phonological cohort manipulation as presented in examples (7) and (8) (i.e., the distractor item is always a different gender item in the Spanish translation equivalent):

(7) Encuentra el candy.

(8) Encuentra la candle.

The method employed to create the experimental items closely followed that of Experiments 1a and 1b. We recorded stimuli from a speaker whose speech would be recognizable by our participants as produced by a member of their same code-switching community. Therefore, recordings were made by a female, native Spanish-English bilingual from Puerto Rico, who frequently code-switches in her daily life and is a trained linguist. As in the Spanish block, the speaker was instructed to repeat each version of the carrier phrase 5 times, *Encuentra el/la* _____ 'Find the.MASC/FEM _____'. A best exemplar for each version of the carrier phrase was selected and determiner duration was manually edited to 150 ms. Note that the determiner duration is 50 ms. shorter than in Experiments 1a and 1b. This was to maintain the natural speech rate of the speaker, whose determiners were reliably produced at approximately 150 ms. in her five original, recorded repetitions of both the masculine and feminine frames. Recording of the stimulus tokens and concatenation were identical to Experiment 1.

4.1.1.3 Procedure: The same as in Experiment 1b.

4.1.2 Results—In Experiment 2a, analyses were conducted from determiner onset through 800 ms.

4.1.2.1 Critical trials: For feminine target items presented with masculine phonological cohorts (e.g., *candle* Sp. vela.FEM and *candy* Sp. caramelo.MASC), bilinguals show non-significant but marginal differences with increasing looks to feminine target items in the 400 ms region (400 ms time region mean difference = 0.112 ($t(24) = 1.807$, $p = 0.083$). This

difference is significant in the 500 ms region, mean difference = 0.151 ($t(24) = 2.189$, $p = 0.039$) and is sustained throughout, with increasing looks to target items in each subsequent time region (Region 600 mean difference = 0.168, $t(24) = 3.094$, $p = 0.005$; Region 700 mean difference = 0.158, $t(24) = 2.966$, $p = 0.007$; Region 800 mean difference = 0.177, $t(24) = 3.157$, $p = 0.004$).

On masculine target item trials paired with a feminine phonological cohort, bilinguals show a marginal difference with increasing looks to masculine target items in the 700 ms region, mean difference = 0.147 ($t(24) = 1.95$, $p = 0.0631$). This difference is significant in Region 800, mean difference = 0.173 ($t(24) = 2.666$, $p = 0.014$).

On critical trials in which targets were paired with phonological competitors, fixations to target items revealed a timecourse difference between how feminine and masculine targets are processed. Code-switched English target nouns with feminine translation equivalents are facilitated, showing an early divergence towards target items (i.e. marginal in time region 400 ms, significant from time region 500 ms). In striking contrast, code-switched English target nouns with masculine translation equivalents achieve later divergence (i.e. marginal in time region 700 ms, significant from time region 800 ms). Timecourse plots are provided in Figures 9 and 10.

4.1.3 Discussion—As in Experiment 1b, the bilinguals process mixed NPs in a manner that reflects the asymmetric distribution of gender on determiners in naturally attested code-switching. Only the feminine determiner is exploited as a cue to the identity of an upcoming noun. In Experiment 2b, we test whether this effect is observed under more challenging processing conditions.

4.2 Experiment 2b. Intra-sentential Mixed NPs

Experiment 2b embeds target items in diverse code-switched structures, such as "*The man* dijo que el *garlic was in the kitchen*" (The man said that the garlic was in the kitchen) modeled on structures in Spanish-English code-switching corpora (e.g., Poplack, 1980). Thus, the target items are all embedded within varying code-switched sentences in which the location of the switch is not predictable (see Online Supplement).

4.2.1 Method

4.2.1.1 Participants: Same as Experiments 1b and 2a.

4.2.1.2 Materials and Design: As in Experiment 2a, critical trials consisted of English nouns that exhibit phonological competition with Spanish translation equivalents with different grammatical gender. Target items were embedded in variable sentences with a total of 5 critical sentences per condition, yielding 10 experimental sentences. Additionally, participants heard 110 filler code-switched sentences.

Target items were embedded in variable sentences, such as "*The kids* encontraron el *candy while they were cleaning their room*" (The kids found [the.MASC candy] while they were cleaning their room). Each target item was paired with a phonological competitor (e.g., *candy/candle*). Materials were drawn from the Master List described in Experiment 2a.

Pseudo-randomization of the stimuli ensured that no critical target was presented twice to any participant.

Targets varied in syntactic position within the sentences to prevent participants from predicting when target mixed NPs would appear (e.g., target code-switches were not always direct objects of the verb). To foster engagement in code-switching, participants heard a code-switch prior to the region of interest in every critical trial. Finally, to encourage participants to process for meaning and fully engage more natural processing strategies, participants were asked to judge the plausibility of each sentence. Only fillers contained implausible sentences (e.g., "*The woman* compró la *whale for her neighbor*"/The woman bought the whale for her neighbor).

The recordings for Experiment 2b were made by the same speaker used in Experiment 2a. The speaker repeated each sentence 5 times, and a best exemplar was chosen for use in the experiment. The length of the determiner was controlled by hand-editing in Praat to be constant across all trials (150 ms); however, unlike the previous experiments, each target noun was directly recorded in its sentence context (i.e., not spliced into the phrase as in Experiments 1 and 2a).

As in Experiment 2a, the critical comparisons are between nouns whose Spanish translation equivalents have different gender (*candy/candle*, Sp. dulce.MASC v. Sp. vela.FEM). Given the syntactic complexity and variability of the stimuli, we expected the timecourse of looks to targets to be slower than in Experiment 2a. Nevertheless, if the distributional differences in production modulate comprehension, then participants should still asymmetrically exploit the gender cue here, as in Experiment 2a.

4.2.1.3 Procedure: The procedure was identical to that of Experiments 1 and 2a, except that in Experiment 2b participants were also prompted for a plausibility judgment after each trial. For the judgment task, participants were asked to decide whether the meaning of the sentence made sense to them. They responded by clicking the words *lógico* ('logical') or *ilógico* ('illogical') displayed on the screen. Participants familiarized themselves with the task by completing 6 practice trials and were given a short break halfway through the experiment. The experiment lasted approximately 20 minutes.

4.2.2 Results—Eye fixation data was extracted from article onset through 1000 ms to account for slower processing in varying sentence frames.

4.2.2.1 Critical trials: For feminine target trials, participants saw a feminine target item paired with a masculine distractor that was also a phonological competitor. In Region 500, there were non-significant but marginally higher looks to the distractor item, mean difference = −0.167 ($t(24) = -2.055$, $p = 0.051$); however, this effect disappeared in the following time region, Region 600 ($t(24) = -1.424$, $p = 0.167$). Fixations to feminine target items emerged as significantly higher in Region 700, mean difference = 0.151 ($t(24) = 2.145$, $p = 0.042$) and was sustained with more fixations to feminine target items throughout the remaining regions (Region 800, mean difference = 0.233, $t(24) = 2.764$, p 0.011; Region 900, mean difference = 0.356, $t(24) = 4.409$, $p < 0.001$; Region 1000, mean difference =

0.521, $t(24) = 8.731$, $p < 0.001$). For the masculine target items, participants first show significantly more looks target items in Region 900, mean difference = 0.352 ($t(24) = 5.251$, $p < 0.001$), and this effect increases in the final time region, Region 1000 mean difference = 0.515 ($t(24) = 7.893$, $p < 0.001$).

Again, disambiguation towards feminine targets occurs earlier than for masculine target items. It is worth noting that Figures 11 and 12 illustrate that in the feminine cohort condition, bilinguals showed what might be interpreted as a cohort effect yielding early bias towards the masculine distractor item, which reached marginally higher looks in Region 500. Nevertheless despite the possible appearance of a competitor bias in the more complex syntactic processing task, that bias is absent in Region 600, and the proportion of fixations towards the correct feminine target is significant from Region 700 onwards. By contrast, competition between masculine targets and feminine distractors persists over time, with the masculine targets only showing significant divergence from Region 900 onwards.

4.2.3 Discussion—We tested the hypothesis that an asymmetric pattern of determiner use in the production of code-switching modulates how bilingual code-switchers will exploit gender as a cue in comprehension. Our design arguably balances experimental control with more naturalistic stimuli that are more likely to engage the processes recruited by our participants during their natural discourse interactions.

While the Spanish-English participants were overall slower to converge on target items than in the carrier phrase experiments--an expected finding given the more varied level of syntactic complexity--the results confirm the patterns exhibited in Experiment 1b and Experiment 2a. Target items with feminine Spanish translation equivalents continue to show earlier significant divergence than target items with masculine translation equivalents.

A final point of interest in Experiment 2b is the timecourse data for the feminine translation equivalent critical targets. As we note above, the timecourse of the feminine target trials revealed what might be an indication of phonological competition (i.e. the marginally higher looks in Region 500 towards the distractor). This putative effect was ephemeral in that it was absent at Region 600 before significant looks to feminine targets began at Region 700. The possibility of a competitor effect in the feminine condition in Experiment 2b is interesting if we bear in mind that nothing resembling a competitor effect was seen for the feminine condition in Experiment 2a. A possible brief competitor effect here may reflect the recruitment of multiple processing strategies in this more difficult task. Perhaps participants, when they cannot simply process for a target item presented in a semantically empty carrier phrase, may engage processing strategies at multiple linguistic levels. A short-lived trend towards the masculine distractor may indicate that grammatical gender does not fully override phonological competition (cf. Dahan et al., 2000). Alternatively, in more predictable switching contexts (e.g., after a determiner in the carrier phrase *Encuentra el/la* _____) bilinguals can more easily ignore subsequent phonological competition for feminine targets. Future research is needed to explore the extent to which task demands and competing cues modulate processing in code-switching.

5. General Discussion

We tested the hypothesis that bilinguals who are exposed to and engage in code-switching exploit distributional patterns present in speech production during comprehension. We focused on grammatical gender in mixed NPs containing Spanish determiners and English nouns (e.g., *el house, el juice*), because these structures are commonly attested in corpora, and linguists have long observed an asymmetry in gender use in mixed NPs. In particular, masculine prenominal determiners can and most often precede English nouns, regardless of the grammatical gender of the Spanish translation equivalent (e.g., Otheguy & Lapidus, 2003; Jake et al., 2002). Despite this preference for the masculine, mixed NPs with a feminine determiner are also attested. Importantly, however, the English noun invariably has a feminine Spanish translation equivalent, e.g., *la house* but not **la juice*. The comprehension experiments above are designed to test the hypothesis that the asymmetry in the distributional patterns of the two determiners will modulate comprehension if speakers' processing strategies are sensitive to their extensive exposure to mixed language use.

As expected, Experiment 1a revealed that Spanish monolinguals exploited the gender of both masculine and feminine determiners to facilitate identification of upcoming nouns. In Experiment 1b, the bilinguals exhibited perhaps the most surprising results of the study; they exploited the feminine, but not the masculine, determiner as a cue to facilitate the processing of an upcoming noun. Given that Experiment 1b involved Spanish-only sentences and that our bilingual participants were all fluent, native speakers of Spanish, we hypothesized that their performance would be identical to that of the monolinguals.

A question that arises is whether the results in Experiment 1b (and Experiment 2) are best attributable to participants' extensive experience with the asymmetrical use of gender in code-switched speech. An alternative explanation, for example, might be that the bilinguals are showing the effects of attrition (e.g., Schmitt, 2010) with attrition first manifesting itself on masculine gender. There are compelling reasons to argue against an attrition-based interpretation of our results. First, participants' proficiency levels are comparable across their languages. On both of the assessment-based measures (BNT and grammar tests), the bilingual group scored similarly in English and Spanish. Additionally, their self-ratings on the LHQ confirm their balanced proficiency, and if anything, suggest a slight Spanish dominance in two areas (speaking and listening), both particularly relevant to code-switching. In addition, we conducted a follow-up task with nine randomly selected bilingual participants a month after the eye-tracking experiments. Participants were presented with the images used in the experiments and asked to name them in Spanish with the determiner (e.g., *el martillo* 'hammer.MASC'). By leaving a month between the experimental session and the post-testing for confirmation of gender knowledge, we controlled for the possible confound of priming from the experimental session. Not surprisingly, participants were highly accurate, indicating that they knew the lexically specified gender of the nouns in Spanish and thus paired them with the correct determiner. Participants had a mean correct gender assignment of 105.89 out of 120 (SD = 7.15). Critically, the nature of these errors did not involve gender agreement errors but rather arose because participants named a handful of objects incorrectly.

Additionally, an attrition-based account would imply a weakening of the grammatical gender representation of Spanish nouns for this group. That is, bilinguals should have delayed access to gender information in general--a requisite component of attrition. However, they consistently show facilitated processing for the feminine gender.[5] Especially noteworthy is that feminine-gendered determiners facilitate the identification of target nouns that are heard in English in the code-switching experiments. If gender were attriting, it would be difficult to explain how the feminine gender of the *Spanish translation equivalents* of the English targets nouns is impacting processing. In this regard, the results of Experiment 2b are all-the-more striking, since the target mixed NPs were embedded in variable sentential contexts, were not predictable by syntactic position, and were accompanied by a task that required participants to process for plausibility. In short, our results across Experiments 1b,2a, and 2b are better understood from experience-based views of the intimate connection between language production and comprehension (e.g., Gennari & MacDonald, 2009; Garnsey, Pearlmutter, Myers, & Lotocky, 1997).

Alternatively, one possible contributing factor[6] that can give rise to the asymmetric gender pattern is exposure to other speakers of Spanish (i.e. heritage speakers) who may overproduce masculine gender assignment in Spanish, especially with opaque nouns (e.g. *pared* 'wall.FEM'). Under this alternative, our balanced bilinguals may shift their use of masculine in online processing because some speakers with whom they engage do not reliably use masculine with masculine nouns in Spanish (and presumably may do the same in Spanish- English code-switching). Here the locus for our results shifts from exposure to the distributional patterns of code-switching to an accommodation strategy on the part of our bilingual participants. An in-depth social network analysis would be necessary to explore this alternative.

One question that we have not addressed involves why an asymmetric pattern of determiner use has arisen in the first place in Spanish-English code-switching. The Spanish lexicon itself has roughly a 50/50 split between masculine and feminine nouns (Eddington, 2002; Otheguy & Lapidus, 2003), so the distributional difference in code-switching is not driven simply by an asymmetry in masculine versus feminine nouns in Spanish. Nevertheless, masculine gender appears to function in Spanish as the unmarked gender (Corbett, 1991; Eddington, 2002; Harris, 1991; Natalicio, 1983). Thus, it is not altogether surprising that in mixed NPs, speakers often deploy the masculine determiner as a default article before a following English noun (e.g., *el house*). At the same time, the availability but less common use of the feminine article before English nouns with feminine translation equivalents (e.g., *la house*) attests to the complex array of factors at play (in this case default gender versus lexical gender activation of the translation equivalent) in mixed language use. Despite this default status, such an outcome in code-switching reflects a choice made by the speech community. For example, other researchers have noted that Spanish in contact with Basque — a language that, like English, lacks grammatical gender — settles on the use of the

[5]A reviewer points out that the bilinguals are slower to disambiguate towards feminine targets in the different gender contexts when compared to the monolinguals, which may support an attrition account. Our study does not have sufficient power to test for timing differences between groups.

[6]We thank an anonymous reviewer for highlighting this possible alternative.

feminine determiner as the preferred, default article in Spanish-Basque code-switching (Parafita Couto, Munarriz, Epelde, Deuchar, & Oyharçabal, 2015). Given the findings here, we would predict that for Basque-Spanish bilingual communities, gender would also be processed in an asymmetric manner in code-switched sentences, but now with the masculine determiner reliably affording opportunities for facilitated processing.[7]

Returning to the results of Experiment 1b, a particularly interesting aspect of our findings involves the issue of language permeability. As we note, the results were somewhat surprising in that we predicted that in the Spanish-only experiment, the participants (all native Spanish speakers who learned Spanish before English and were born in Spanish speaking countries) would perform analogously to their monolingual counterparts. While we were aware of their varied experience with multiple modes of exposure to and participation in language use — ranging from Spanish-only use, to mixed (i.e. code-switched) language use with other bilinguals, to English-only use with non-Spanish speakers — we nevertheless expected that if there were to emerge a clear differential processing of gender cues, it would more likely manifest in the code-switching blocks. How, then, can we best understand the Spanish-only results Experiment 1b?

We argue that they provide a striking example of the openness of bilinguals' two linguistic systems to the continuously variable patterns of multiple language use in their global experience. In many, if not most, of the language scenarios that these bilinguals find themselves, their languages cannot be fully encapsulated from each other. Rather, to optimally navigate between languages, bilingual code-switchers must be prepared to integrate other language information into comprehension as the need arises, while also staying within language when necessary, as per the demands of the discourse context. Thus, rather than viewing the results of Experiment 1b as arising from a loss of sensitivity to masculine gender, they are better understood as an exemplification of the adaptation that bilingual code-switchers make in order to be prepared to integrate code-switched speech at any given time. For bilingual code-switchers, nouns following a masculine-marked Spanish determiner can be Spanish masculine nouns (in continuing Spanish discourse) or English nouns (in code-switched discourse) whose Spanish translation equivalent are either masculine or feminine. If bilingual code-switchers commit to the expectation that a masculine noun will follow the masculine-marked determiner, they will experience difficulty in integrating code-switched nouns that are feminine in their Spanish translation equivalent. On the other hand, if they do not form strong expectations regarding the gender or language of upcoming nouns after the masculine determiner, they will be open to upcoming code-switches, regardless of the gender of their translation equivalent while still never making incorrect predictions regarding the gender of an upcoming within-language (i.e. Spanish) noun.

This situation bears some resemblance to the well-known cases in which bilingualism can effect changes in each of the bilingual's languages (e.g., Dussias & Piñar, 2010; Hopp, 2010;

[7]We can also comment that pilot studies from our group confirm that Spanish-English bilingual speakers from a non code-switching community (Granada, Spain) do not show the gender asymmetry we report here (Guzzardo Tamargo, Valdés Kroff, & Dussias, 2015; Valdés Kroff et al., 2011). Similarly, a group of English-Spanish bilinguals (i.e. L2 speakers of Spanish) neutralize the use of gender when processing Spanish-English code-switching (*unpublished data*).

Jackson & Dussias, 2009; Williams, 2006). Dussias and Sagarra (2007) provide a striking example of the permeability of the L1 to exposure to an L2. They examined attachment preferences for relative clauses in structures such as "An armed robber shot the sister of the actor who was on the balcony." In English, low attachment predominates, so that the relative clause describes a scene in which the actor is on the balcony. In Spanish, the default interpretation involves high attachment, yielding a reading in which the sister is on the balcony. Crucially for our purposes, Dussias and Sagarra found that for Spanish speakers immersed in an English environment, the processing routines of the L1 (Spanish) were influenced by the L2 (English).

While our results arguably provide another example of the openness, rather than the encapsulation, of the bilingual's languages, the situation is also distinct. For these bilinguals, their two languages are not only interacting, but rather, they engage in a third language mode, namely code-switching, which has evolved its own community-driven patterns of usage — patterns which are neither completely Spanish nor English based. In this sense, our results suggest that the non-exploitation of the masculine gender cue reflects the emergence of a repertoire of processing strategies that allows code-switchers to efficiently navigate the varying patterns of language use to which they are exposed. More simply, the results here are not an example of English affecting Spanish (or Spanish affecting English) processing preferences, but rather are an example of the development of processing strategies optimized for the linguistic landscape of the code-switching community. In short, our view entails the position that these participants have not lost sensitivity to masculine gender on determiners (or masculine agreement more broadly). Rather, our explanation suggests that given an appropriate context (experimental or natural), we predict that these bilinguals would be able to exploit masculine gender as a processing cue. This is an area for future research.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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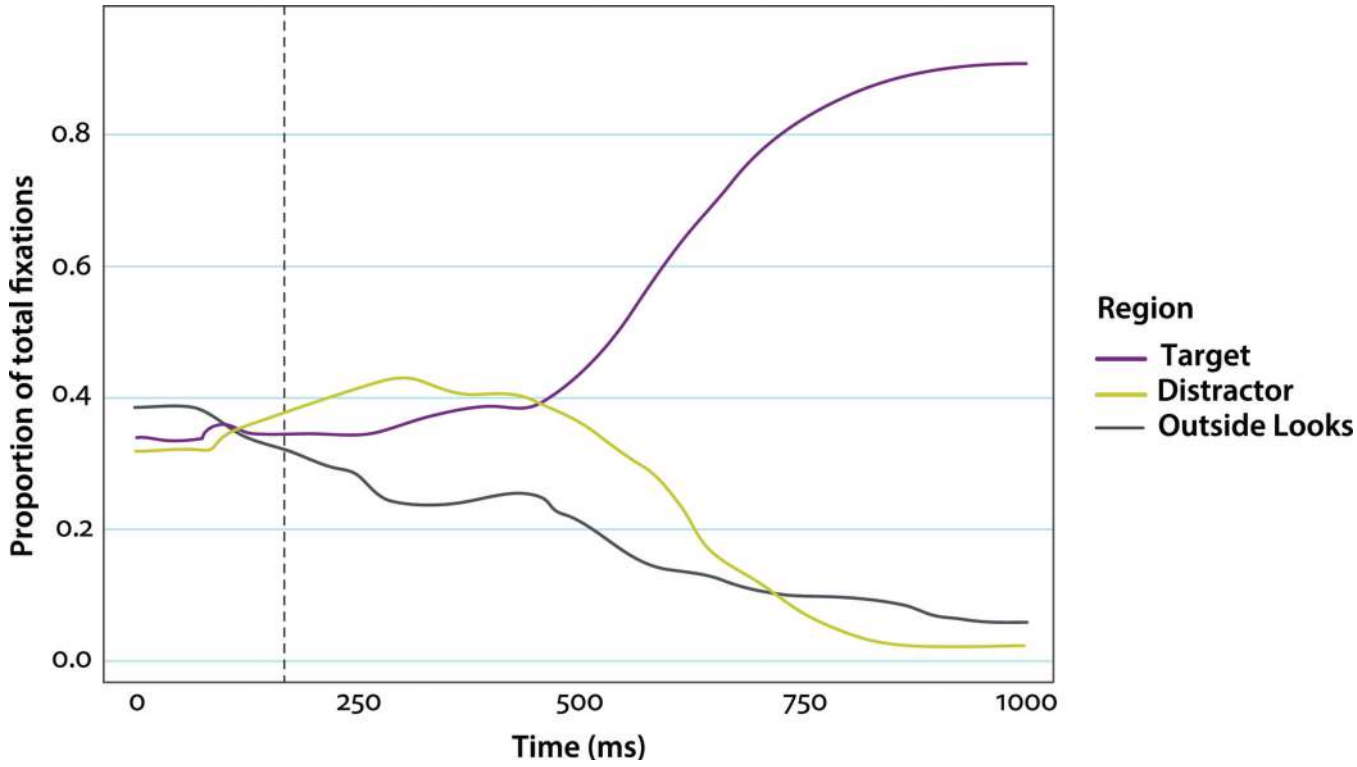

Figure 1.

The proportion of total fixations plotted towards targets, distractors, and neither image from determiner onset on feminine target items. Determiner offset is represented by a vertical dashed line.

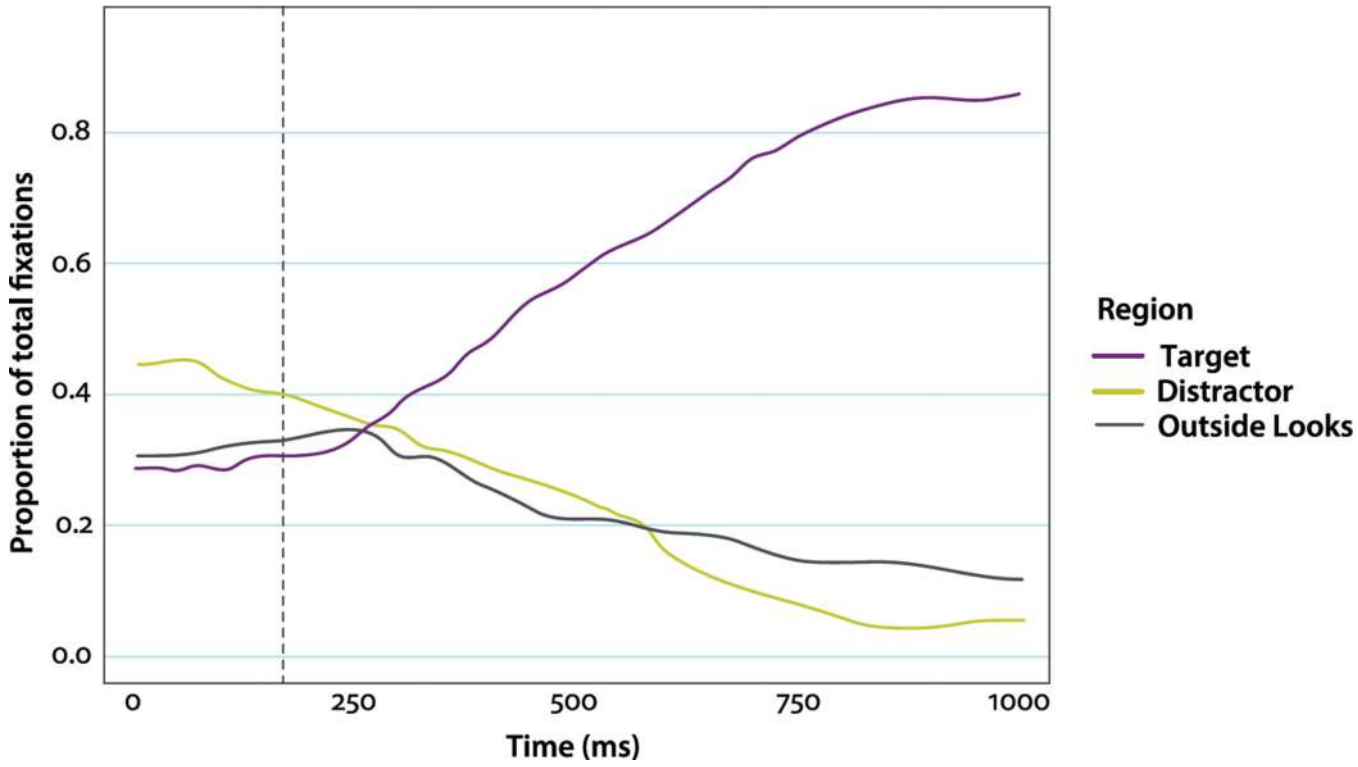

Figure 2.

The proportion of total fixations plotted towards targets, distractors, and neither image from determiner onset on feminine target items. Determiner offset is represented by a vertical dashed line.

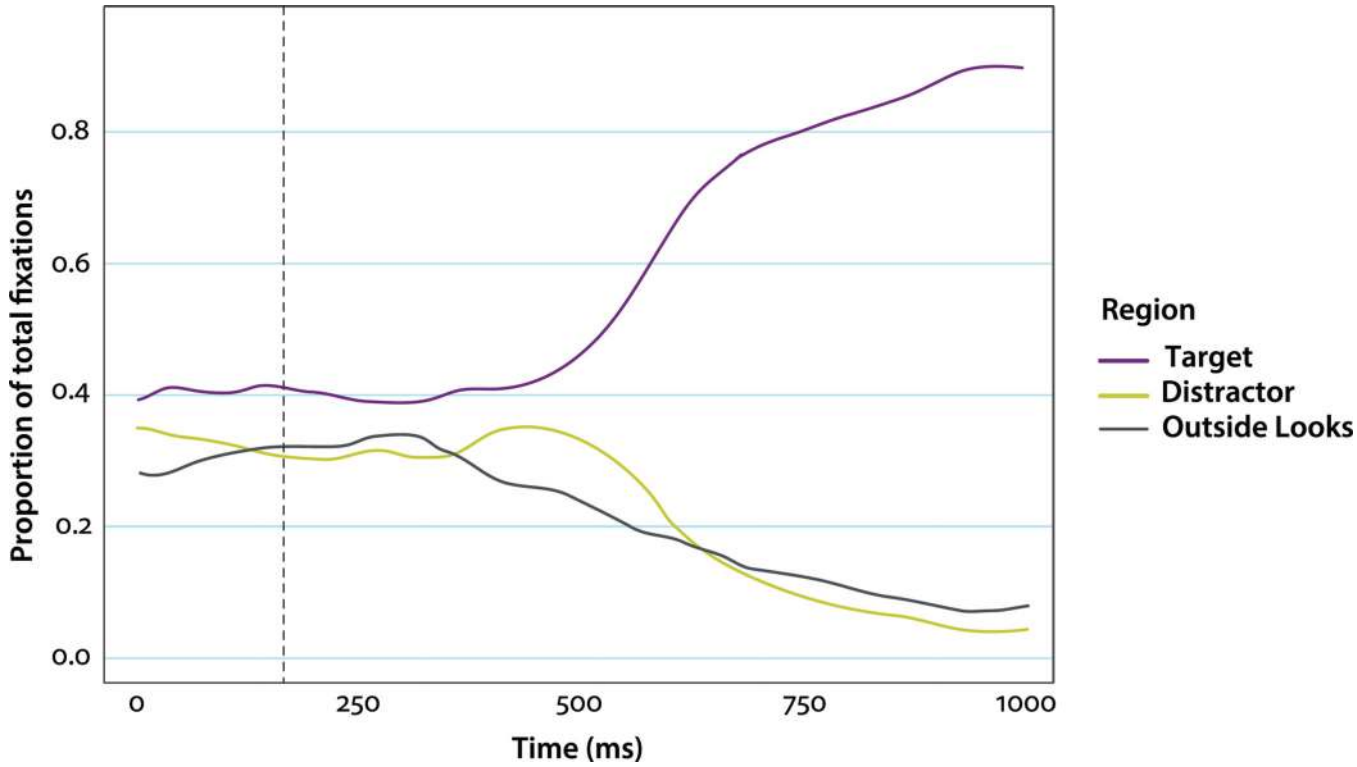

Figure 3.
The proportion of total fixations plotted over time towards targets, distractors, and neither image from determiner onset on masculine target trials. Determiner offset is represented by a vertical dashed line.

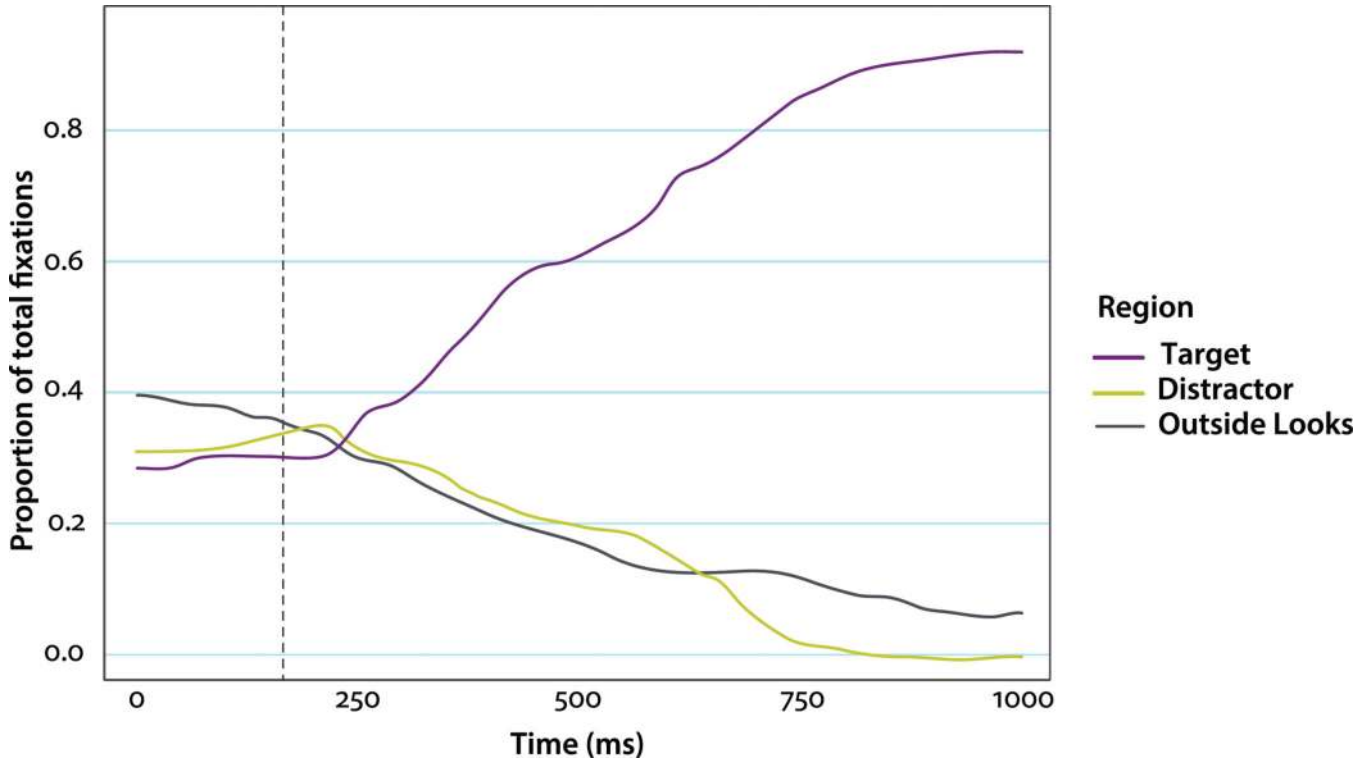

Figure 4.

The proportion of total fixations plotted over time towards targets, distractors, and neither image from determiner onset on masculine target trials. Determiner offset is represented by a vertical dashed line.

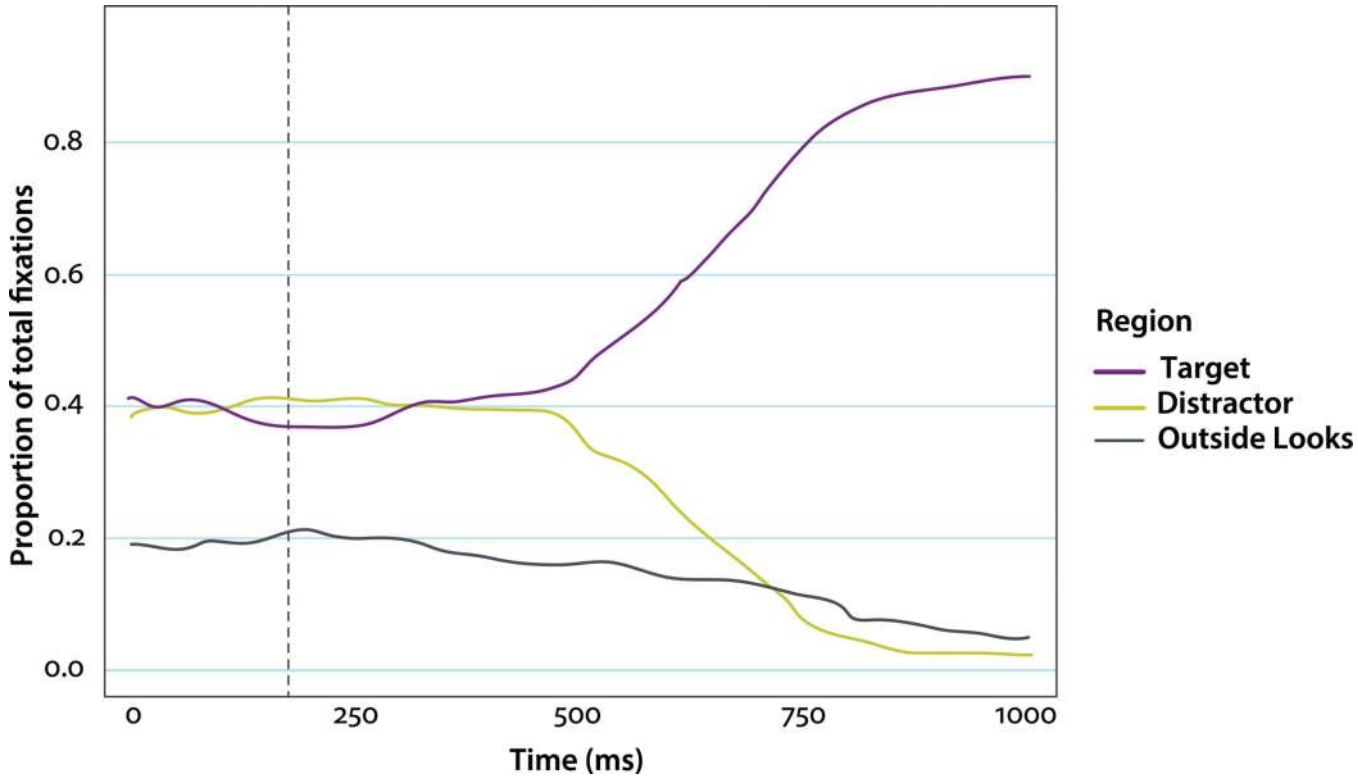

Figure 5.
The proportion of total fixations plotted over time towards targets, distractors, and neither image from determiner onset on feminine target trials. Determiner offset is represted by a vertical dashed line.

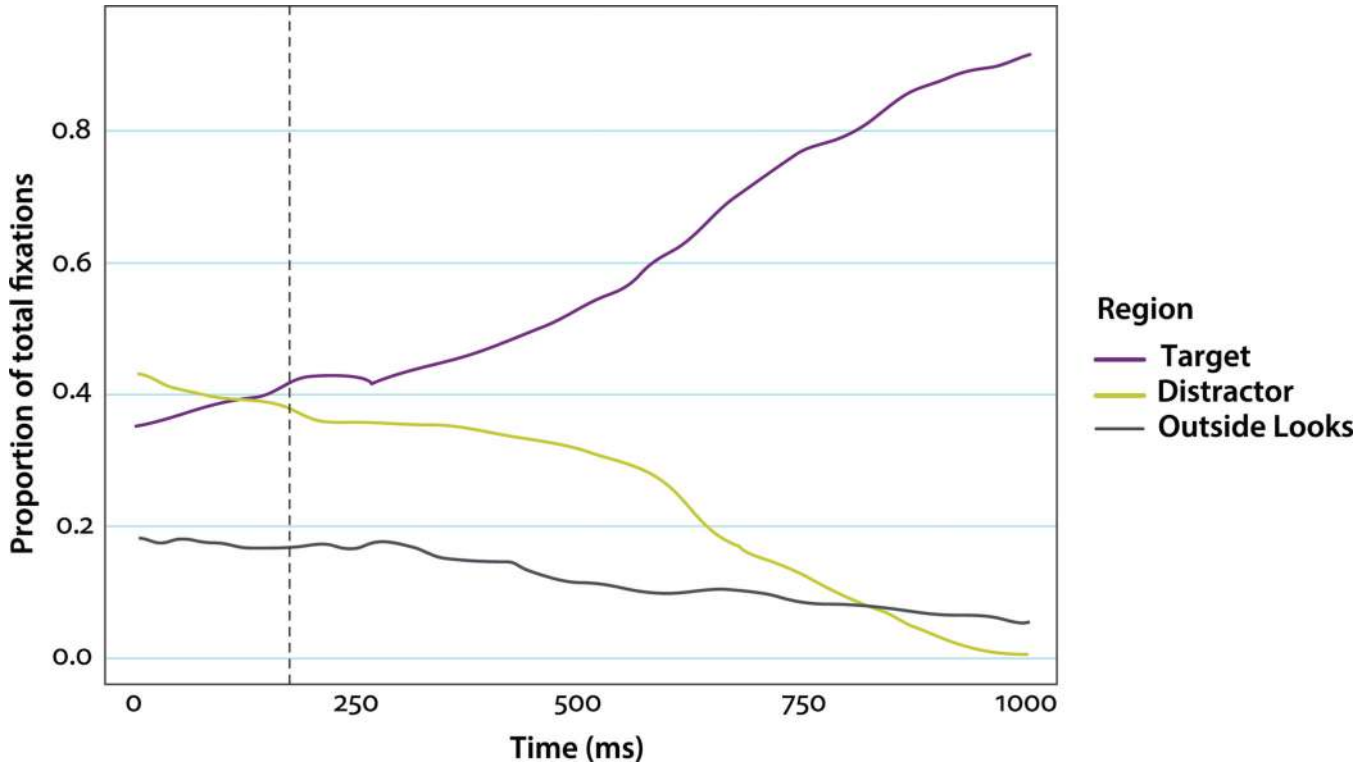

Figure 6.

The proportion of total fixations plotted over time towards targets, distractors, and neither image from determiner onset on feminine target trials. Determiner offset is represted by a vertical dashed line.

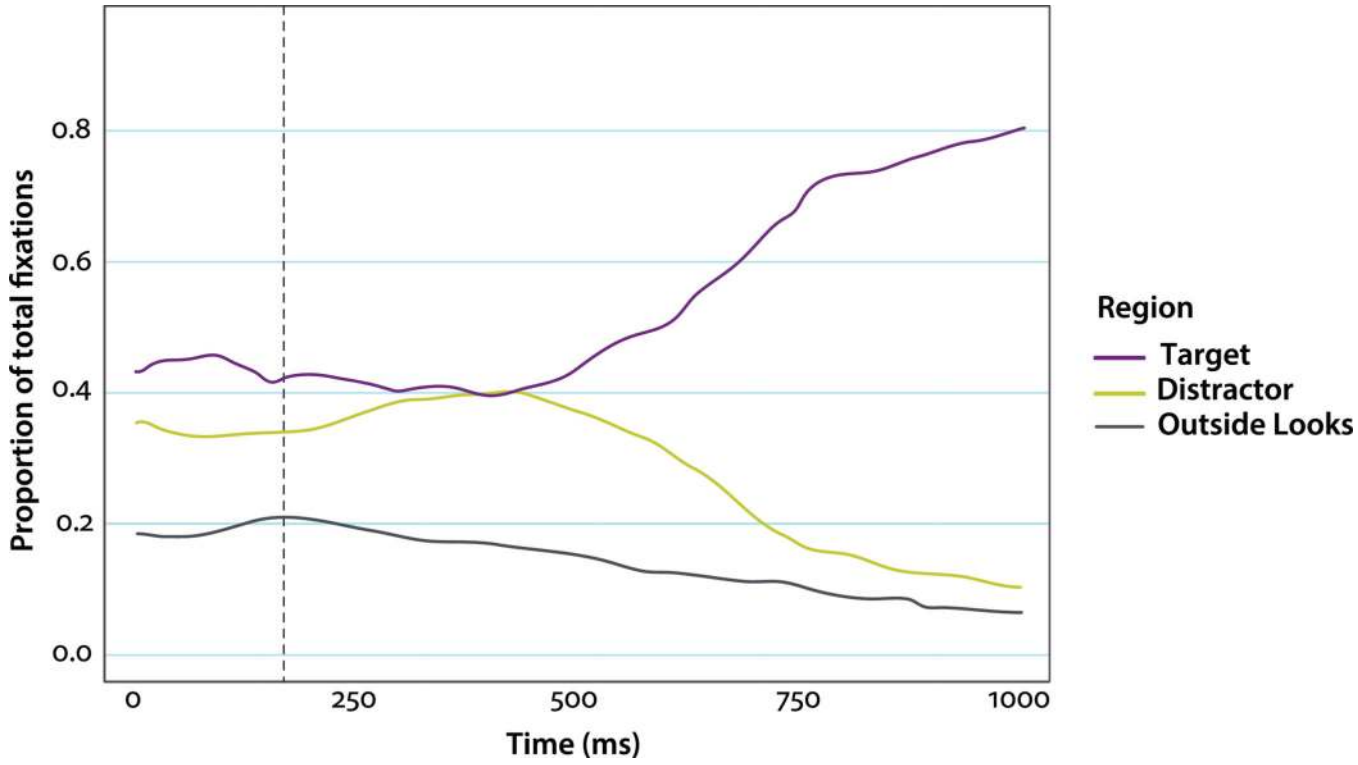

Figure 7.

The proportion of total fixations plotted over time towards targets, distractors, and neither image from determiner onset on masculine target trials. Determiner offset is represented by a vertical dashed line.

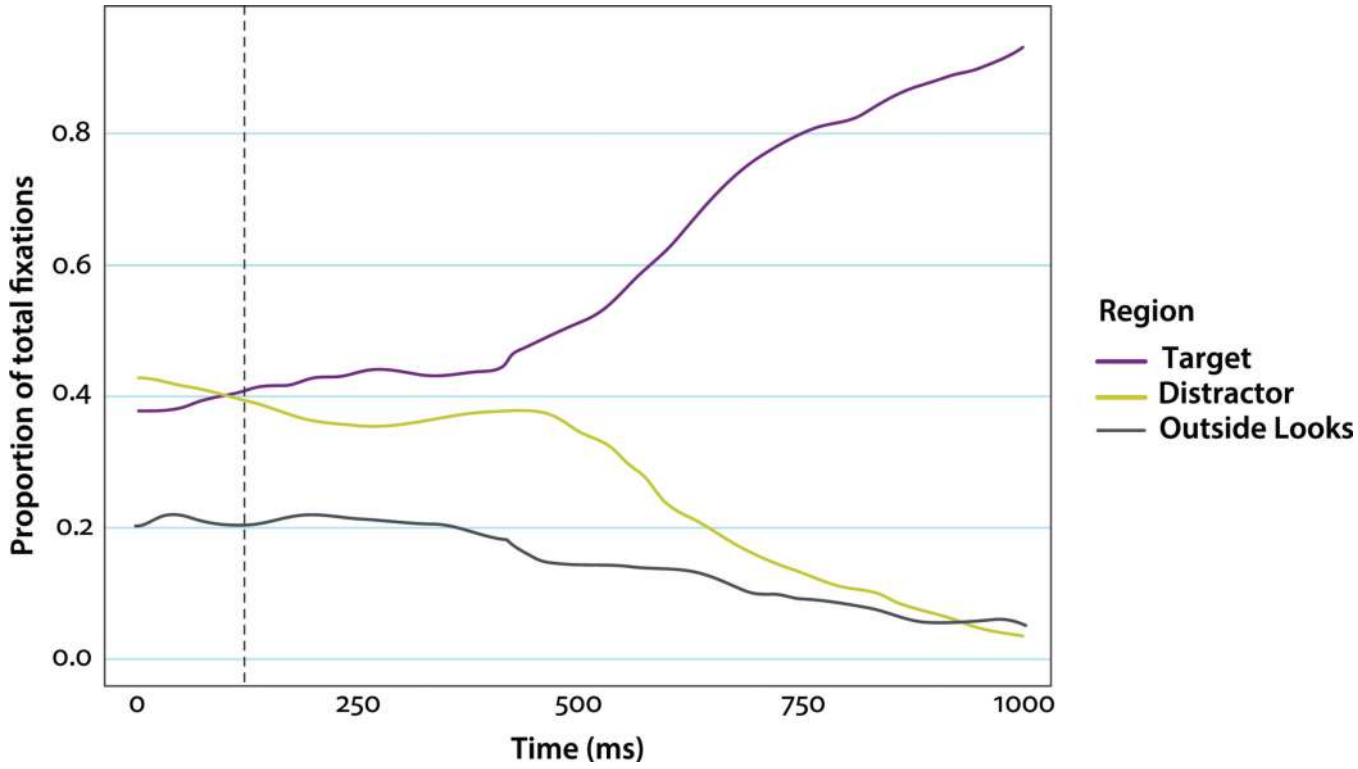

Figure 8.

The proportion of total fixations plotted over time towards targets, distractors, and neither image from determiner onset on masculine target trials. Determiner offset is represented by a vertical dashed line.

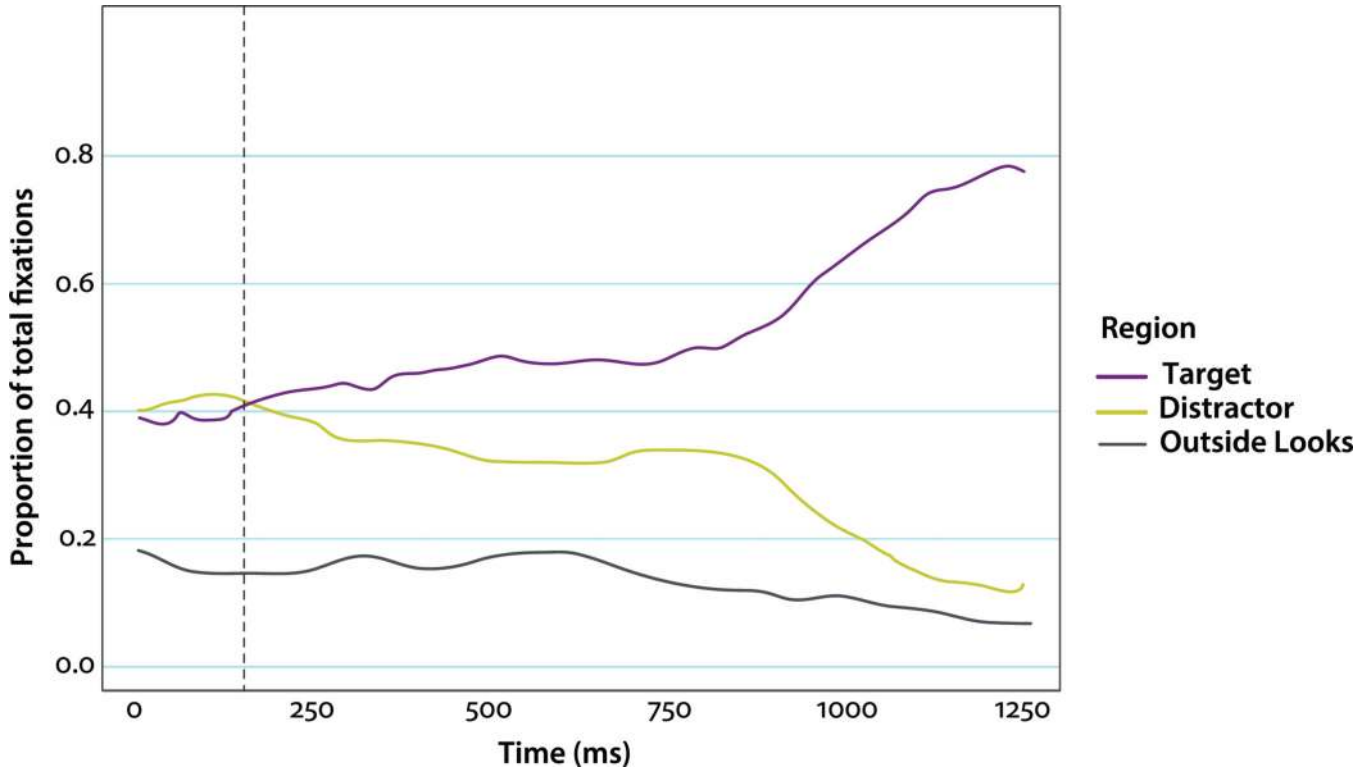

Figure 9.

The proportion of total fixatons plotted over time towards targets, distractors, and neither image from determiner onset on fixed carrier code-switched trials. Determiner offset is represented by a vertical dashed line.

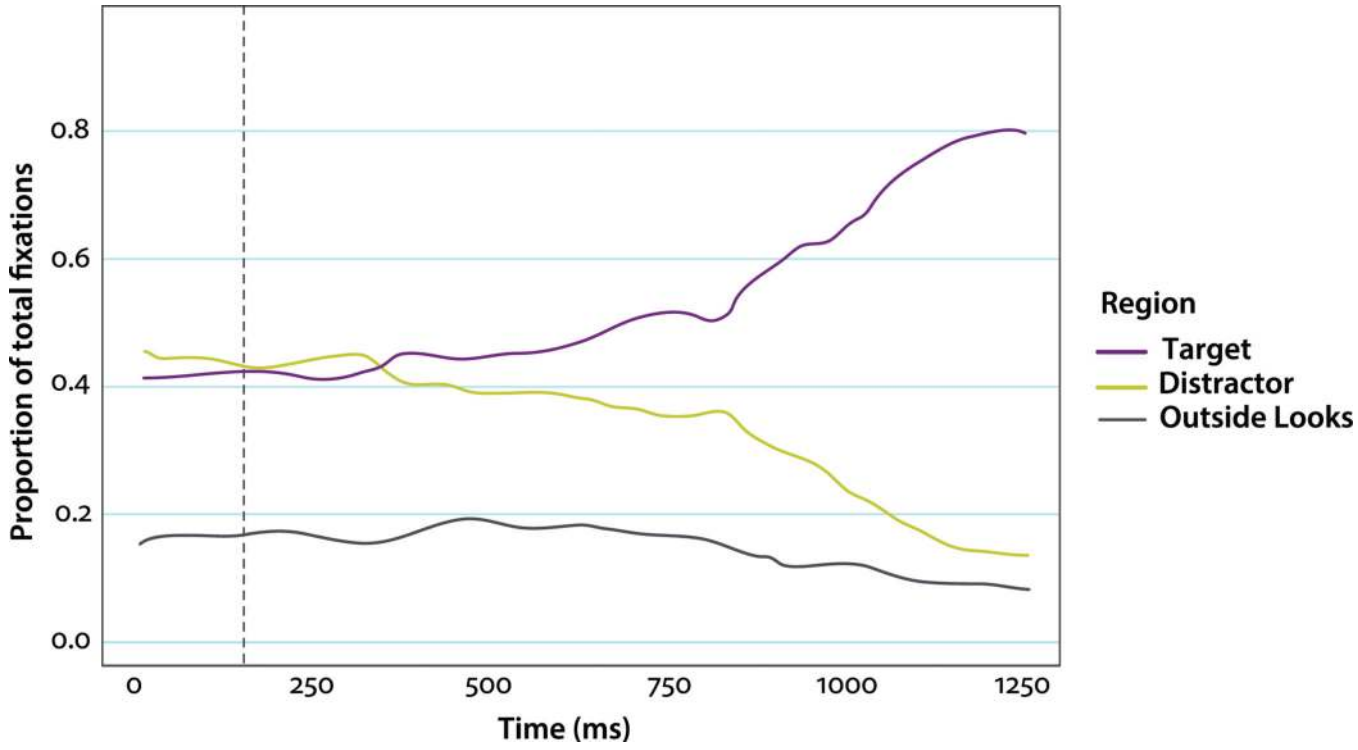

Figure 10.

The proportion of total fixatons plotted over time towards targets, distractors, and neither image from determiner onset on fixed carrier code-switched trials. Determiner offset is represented by a vertical dashed line.

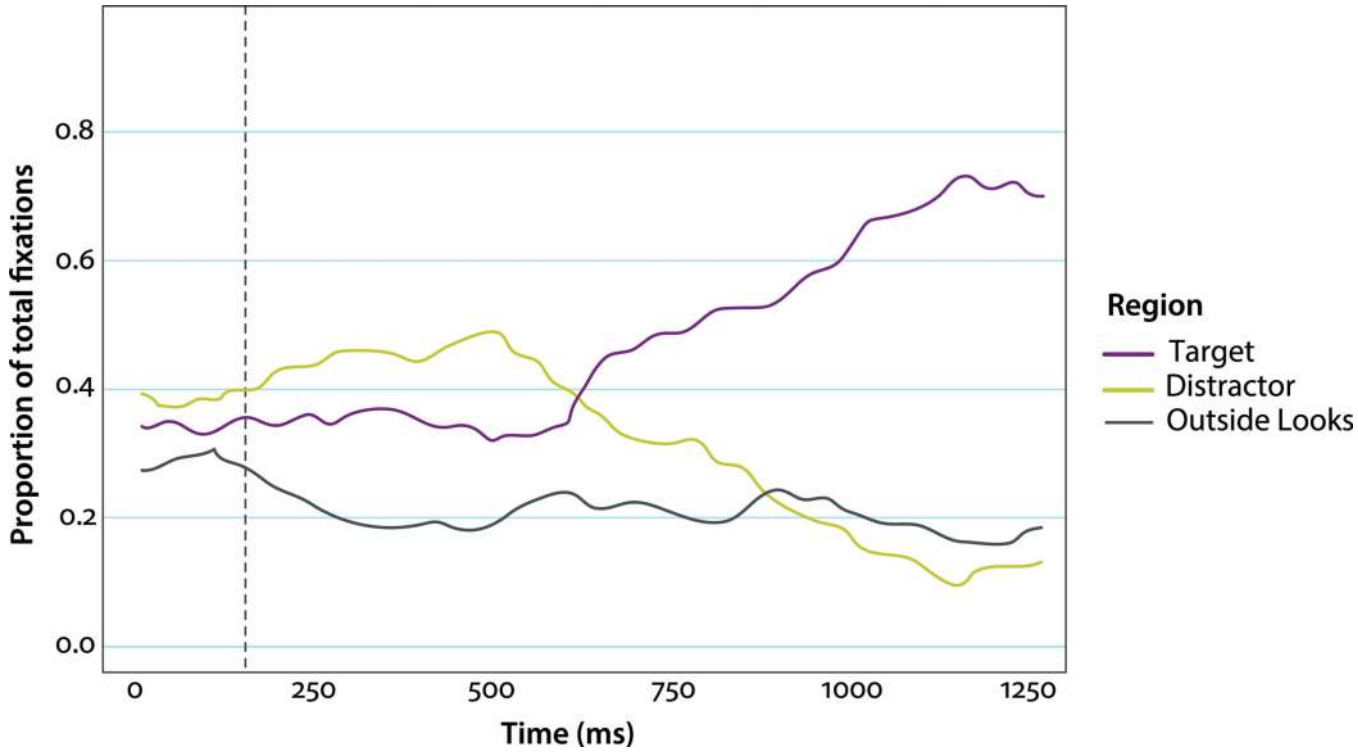

Figure 11.

The proportion of total fixations plotted over time towards targets, distractors, and neither image from determiner onset on intra-sentential code-switched trials. Determiner offset is represented by a vertical dashed line.

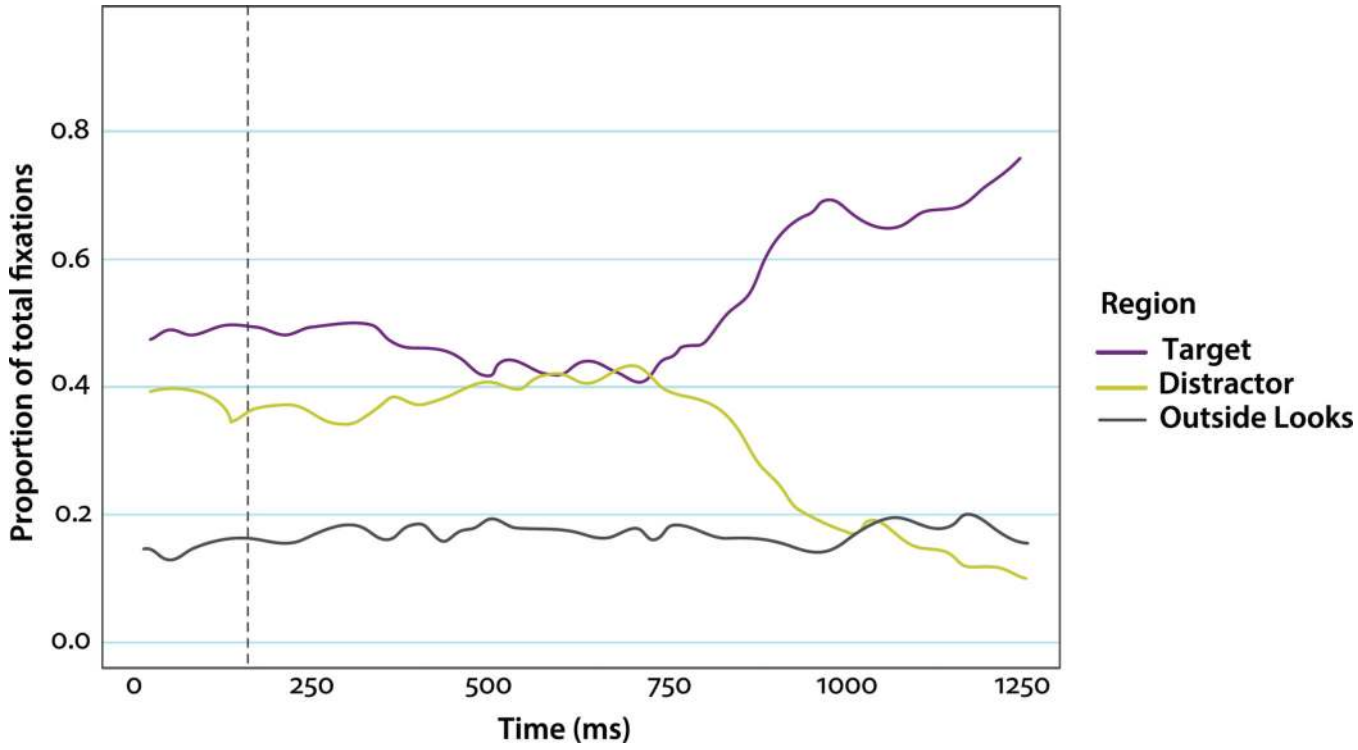

Figure 12.

The proportion of total fixations plotted over time towards targets, distractors, and neither image from determiner onset on intra-sentential code-switched trials. Determiner offset is represented by a vertical dashed line.

Table 1

Experimental Conditions for Spanish-only Experiments 1a and 1b

Condition	Article	Target	Distractor
Feminine Same Gender	la	mesa "table$_{fem}$"	cama "bed$_{fem}$"
Feminine Different Gender	la	mesa "table$_{fem}$"	dinero "money$_{masc}$"
Masculine Same Gender	el	libro "book$_{masc}$"	dinero "money$_{masc}$"
Masculine Different Gender	el	libro "book$_{masc}$"	cama "bed$_{fem}$"

Carrier Phrase: *Encuentra el/la* _____ "Find the$_{masculine/feminine}$_____"

Table 2

Experimental Conditions for Spanish-only Experiments 1a and 1b

Category	Spanish	English	Difference
Speaking	9.24 (0.88)	8.56 (1.19)	*
Listening	9.48 (0.65)	9.15 (0.3)	marginal
Reading	8.72 (1.7)	9.08 (1.38)	n.s.
Writing	8.16 (1.89)	8.68 (1.35)	n.s.