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Disentangling grammar and experience: On the role of environmental exposure to Spanish-English code-switching

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Abstract

Code-switching (CS) processing is subject to modulation by language-internal properties and extralinguistic factors, including the distributional patterns of bilingual language production specific to a given bilingual community. To tease apart the roles of grammar and experience in CS processing, a group of advanced L1 English, L2 Spanish learners (*n*=39) immersed in an environment with ubiquitous code-switching (U.S. east coast) participated in a reading-while-eye-tracking experimental task. Spanish-English CS asymmetries present in the production of bilingual compound verbs and determiner-noun switches that differ in their regional use and frequency were tested. Results reveal that L2 learners are sensitive to the distributional

production frequencies of CS present in their interactive context during online processing. However, the onset of these effects is somewhat delayed, indicating that the impact of environmental production frequencies may surface during later stage processing for L2 learners. Results are discussed in the context of experience-based frameworks of sentence processing.

Keywords: code-switching, experience-based processing, Spanish-English, L2 learners, eye-tracking.

1. Introduction

Code-switching (CS), the alternating employment of two languages in a single conversational event, is a linguistic phenomenon observed in the naturalistic language production of many bilingual communities (Poplack, 1980, Gardner-Chloros, 2009). Bilingual code-switches are typically classified as pertaining to one of two subcategories: between-sentence (i.e., intersentential) switches (1a) and within-sentence (i.e., intrasentential) switches (1b), as demonstrated by the below examples from the Bangor Miami Corpus of oral Spanish-English speech (Deuchar et al., 2014).

(1) a. Spanish-English, Deuchar et al. (2014:Herring7, Lines 18–19)
They don't kill. *Ellos no mataban a su propia gente.*
'They don't kill. They didn't kill their own people.'
b. Spanish-English, Deuchar et al. (2014:Herring6, Line 627)
...tú sabes que ella te da full credit for just doing it.
'...you know that she gives you full credit for just doing it.'

Intrasentential switches are informed by restrictions on their construction, rendering them systematic and governed by higher-order grammatical processes (Poplack, 1980; Deuchar, 2020); as such, their implementation in fluid production and their decoding in comprehension require an advanced command of the grammars of both languages (Miccio et al., 2009). Such switches have witnessed many attempted syntactic explanations, consisting of constraint-reliant proposals (e.g., Poplack, 1981; Joshi, 1985; Di Sciullo et al., 1986; Belazi et al., 1994); constraint-free frameworks, either operating within the assumptions of the Minimalist Program (Mahootian, 1996; MacSwan 1999, 2005, 2014) or with applications to exoskeleton and Distributed Morphology frameworks (Lohndal & Putnam, 2024; López, 2020); and models informed by psycholinguistic theories of speech production like the Matrix Language Framework, which proposes a dynamic, asymmetric relationship between the roles of matrix and embedded languages in switched utterances (Myers-Scotton, 1993; Myers-Scotton & Jake, 2000, 2001).

While valuable, these structural accounts of CS neglect to address the adaptive role of the experiential dimensions of bilingual language use on real-time CS parsing, operationalized as interactional context (Green & Abutalebi, 2013), sociolinguistic context (Titone & Tiv, 2023; Wigdorowitz, 2024), perceived language knowledge of fellow interlocutors (Kaan et al., 2020), and distributional patterns of language production (Gennari & MacDonald, 2009; MacDonald, 2013; Dell & Chang, 2014; Guzzardo Tamargo et al., 2016). These extrastructural factors are modulatory of CS

processing and cognitive mechanism recruitment (Valdés Kroff & Dussias, 2023), sometimes in ways that do not align with predictive or descriptive syntactic models; that is, a switched construction's structural plausibility does not necessarily bring about facilitated processing for said construction. By adopting an experience-based approach, such as the Production-Distribution-Comprehension Model (PDC) (Gennari & MacDonald, 2009; MacDonald, 2013), cases that deviate from syntactic predictions can be understood as reflecting bilinguals' sensitivity to the probabilistic patterns of CS production in their environment. Under such a view, CS comprehension is guided by learned probabilistic distributions of switched constructions produced in one's speech community. A framework that accounts for bilinguals' dynamic updating of structural expectations as a function of (degree of exposure to) local CS patterns thus emerges (Valdés Kroff & Dussias, 2023). Such a framework can also be productively applied to recent efforts to characterize the role of passive exposure to or incidental engagement with ambient linguistic input in shaping sensitivity to its features (Wigdorowitz, 2024). If passive exposure constitutes implicit learning of production patterns (e.g., Bice & Kroll, 2019), a sensitivity to CS norms attested for one's linguistic environment might be expected to surface independently of a bilingual's own CS production. It stands to reason that the interplay between the domains of structural constraint and language experience in CS processing merits further investigation.

To this point, efforts to disentangle these competing formal and experience-based explanations of CS constraints are thwarted by the (un)availability of experimental populations for which structure and context are entities which may be reliably separated. Habitual code-switchers are experts at navigating switched linguistic input owing to the *interaction* of their structural knowledge in both languages and their sensitivity to statistical production regularities of CS (Guzzardo Tamargo et al., 2016); it is therefore uncertain whether the use of certain structures is constrained by syntactic impermissibility and then reflected in regional production norms, or vice versa. In an effort to tease apart, and potentially reconcile, these contending accounts, the present study seeks to isolate the variables of structural permissibility and (regional) experiential constraints in an eye-tracking-while-reading paradigm using a novel participant sample for whom grammatical and experience-based knowledge may be better controlled: English-speaking second-language (L2) learners of Spanish.

In the following sections, structural and experiential understandings of two switch types of interest, namely Spanish-English compound verb and determiner-noun switches, are detailed. Existing studies of CS processing at these sites are evaluated in an effort to inform hypotheses of their anticipated behavior in L2 processing.

1.1. Spanish-English bilingual compound verb switches

Subject-predicate switches between a lexical DP and its predicate have been widely documented in Spanish-English CS (Poplack, 1981), whereas switches at the auxiliary-VP boundary show more irregular and asymmetric production patterns. In Spanish-English bilingual corpora, there is a marked difference in distributional probability between switches involving the Spanish auxiliary *estar* 'be' and an English progressive participle and those involving the Spanish auxiliary *haber* 'have' and an English past participle. Progressive structure switches equally occur at the participle

(e.g., *los maestros* ***están*** **grading** the exams 'the teachers are ...') and the auxiliary (e.g., *los maestros* **are grading** the exams) in both written and oral corpora. In contrast, perfect structure switches are more constrained in their production, predominantly occurring at the auxiliary (e.g., *los maestros* **have graded** the essays) with significantly fewer appearances within the auxiliary-VP complex (e.g., *los maestros* ***han*** **graded** the essays 'the teachers have ...'; Guzzardo Tamargo et al., 2016). These findings are consistent with the long-reported distributional asymmetries between *estar* + V_{Prog} and *haber* + V_{Perf} switches at the auxiliary-VP switch site (e.g., Lipski, 1978; Lipski, 1985; Pfaff, 1979; Poplack, 1980).

Despite the ample attestation of the diverging differential production frequencies of these two bilingual compound verbs, its root cause remains contested. If this disparity is owing to formal and not experiential factors, there are several competing explanations which could account for this productional asymmetry. Some early constraint-based proposals assert that switches at a participial boundary should be universally impermissible, if only for modal auxiliaries (Joshi, 1985; Belazi et al., 1994), while other government-reliant accounts contrarily maintain that all such switches are indeed licensed (Di Sciullo et al., 1986). These proposals were promptly followed by the Matrix Language Framework and 4-M model which characterize *estar* as an optionally early system morpheme depending on whether it takes on a main or auxiliary verb function and *haber* as a late system morpheme, affecting their respective salience at different points in the retrieval process and thus differentially predisposing their participation in CS (Myers-Scotton, 1993; Myers-Scotton & Jake, 2001; Myers-Scotton & Jake, 2017). More recent endeavors informed by the Minimalist Program have attributed CS violations at this switch site to conflicts at Phonetic Form (PF) due to head restructuring (MacSwan 2005, 2014) and to within-phase switching (López et al., 2017).

Independent of the specific syntactic factors driving this asymmetry, experimental data reveal that bilingual code-switchers capitalize on the distributional production frequencies of these two bilingual compound verbs in order to attenuate processing costs during CS processing, as postulated by experience-based frameworks of sentence processing (Dell & Chang, 2013; MacDonald, 2013). In online tasks of CS reading comprehension, switches at the participle are more easily integrated when rendered using the progressive structure in early Spanish-English bilinguals (Dussias, 2003; Guzzardo Tamargo et al., 2016; Valdés Kroff et al., 2018), late, Spanish-dominant Spanish-English bilinguals (Guzzardo Tamargo & Dussias, 2013; Guzzardo Tamargo et al., 2016), and, most recently, late, English-dominant Spanish L2 learners (Valdés Kroff et al., forthcoming). To this point, Spanish L2 learners' sensitivity to the asymmetric acceptability of these structures has primarily been investigated in offline judgment tasks, in which L2 learners have reliably been able to intuit the distinct acceptability of these switches (Toribio, 2001; Giancaspro, 2015; Koronkiewicz, 2018). Importantly, learners' felicitous performance on said tasks was independent of exposure to and/or use of CS but rather was found to occur as a function of L2 proficiency. Thus, these findings point towards internal factors constraining the asymmetric production distribution of these switches.

Nevertheless, experiential factors such as interactional context may additionally inform the distribution of bilingual compound verbs in Spanish-English bilingual speech. For bilinguals in Puerto Rico, a preference is found for switches occurring between the auxiliary *estar* and an English present participle (*estar* + V_{Prog}), while CS occurring between the light verb *hacer* ('do') and an English lexical infinitive (*hacer* + V_{Inf}) is rejected, despite the structures' equivalent acceptability in syntactic models (González-Vilbazo & López, 2011; López et al., 2020) and frequency of use in Spanish-English CS from other regions, such as northern Belize (Fuller Medina, 2005; Balam, 2015) and the southwestern U.S. (Reyes, 1982; Jenkins, 2003; Vergara Wilson & Dumont, 2015; Balam et al., 2020; see also Olson, 2024). This regional distinction is potentially due to the (ongoing) grammaticalization and increased productivity of *hacer* in the switched light verb structure (Vergara Wilson, 2013) which does not extend or has not yet extended to all Spanish-English bilingual communities. In this way, bilingual compound verb implementation may be understood as being *community-specific*; that is, the distributional frequencies of bilingual compound verbs may be influenced by regional preferences for one or another structure regardless of the admissibility of said structure in the syntactic domain. The syntactic plausibility of a structure does not equate to its being processed as such by the bilingual parser, owing to more dynamic questions of linguistic *experience* (e.g., Wigdorowitz, 2024).

Given prior work that demonstrates that habitual code-switchers use production statistics to attenuate CS processing costs (Dussias, 2003; Guzzardo Tamargo et al., 2016; Valdés Kroff et al., 2018) and that the production of the light verb switch is regionally constrained (Balam et al., 2020), we utilize late Spanish-English bilinguals who acquire Spanish as a second language as young adults to test the respective roles of grammaticality and experience in CS processing. In testing the online CS comprehension of advanced L2 learners of Spanish who are immersed in an environment where CS use is present but where the light verb switch is not attested, we can begin to directly compare the impacts of grammaticality and (passive) environmental exposure to community-specific differential production patterns of bilingual compound verbs in the real-time processing of switched structures. If L2 learners are reliant on grammar alone in their processing of bilingual compound verbs, then the light verb switch should pose no additional processing cost, as the switch is structurally licit (González-Vilbazo & López, 2011; López et al., 2020). However, if passive linguistic exposure is modulatory of processing mechanisms in L2 learners (e.g., Bice & Kroll, 2019; Wigdorowitz, 2024), the lack of attestation of the light verb switch in their linguistic environment should make its real-time integration more effortful.

1.2. Spanish-English determiner-noun switches

Spanish boasts a binary grammatical gender system; that is, all inanimate nominal lexical units are either masculine or feminine. This grammatical gender system exhibits some preference for specific form classes. For instance, nouns ending in '-a' (e.g. *la botella* 'the bottle') are favorably associated with feminine lexical gender assignment, while nouns ending in '-o' (e.g. *el vaso* 'the glass') often possess

masculine gender; however, these patterns do show notable exceptions (e.g. *el programa* 'the program'; *la mano* 'the hand') and do not apply to nouns which lack transparent gendered morphology (e.g. *la noche* 'the night'; *el restaurante* 'the restaurant') (Harris, 1991). Despite these irregularities, L1 Spanish speakers and highly proficient L2 speakers of Spanish rely on gendered prenominal determiners as predictive cues in processing.

Language processing is a bidirectional phenomenon in which expectations for upcoming visual or auditory (bottom-up) information are modulated by linguistic schema (top-down information) unique to the parser at a given moment, whether it be recent activation of a specific semantic context or experience with differential patterns of lexical gender assignment in a language. This top-down constraint-induced preparedness for or pre-activation of information prior to the onset of critical bottom-up linguistic information is understood as predictive processing when its effects are facilitatory, as manifested by decreased reaction times or faster fixation convergence (Kuperberg & Jaeger, 2016). When this facilitatory pre-activation occurs between a prenominal determiner and a noun which share grammatical gender, it is known as the gender congruency effect; that is, noun recognition is enhanced by the presence of a prenominal determiner that has congruent grammatical gender (e.g., Hagoort & Brown, 1999; Dahan et al., 2000). While early studies on L2 processing were unsuccessful in documenting L2 learners' use of grammatical gender as a predictive cue (e.g. Grüter et al., 2012), more recent studies show that advanced L2 learners exhibit a target-like gender congruency effect, at least under certain contexts such as when gender cues are transparent (Dussias et al., 2013) or when L2 speakers demonstrate knowledge of the gender category of the noun (Hopp, 2016).

Though English does not have its own grammatical gender system, CS between a Spanish gendered determiner and an English noun is common in mixed-language corpora. However, these mixed DPs experience asymmetric production. In the Spanish-English CS commonly utilized in the U.S., Belize, and Puerto Rico, feminine determiners are restricted in their use, appearing almost categorically before an English noun whose Spanish counterpart is feminine; masculine determiners, however, are permitted to precede an English noun whose equivalent is either masculine or feminine in Spanish (e.g., Valdés Kroff et al., 2017). As a result, the "gender congruency effect" that emerges for habitual code-switchers when processing mixed DPs is distinct from that experienced when processing unilingual DPs. That is, Spanish-English code-switchers suspend the predictive use of masculine gender-marked Spanish determiners, coinciding with the asymmetric production of gendered determiners in contexts of CS use.

In one demonstrative study, Spanish-English bilinguals participated in an eye-tracking-while-listening visual world paradigm in which they heard both Spanish unilingual and Spanish-English code-switched noun phrase stimuli while looking at a display of two images that differed in their Spanish grammatical gender. In the code-switched condition, facilitative processing was only observed for feminine target items (i.e. English translation equivalents of feminine Spanish nouns) preceded by feminine Spanish determiners. This finding was ascribed to the predictive integrity of the feminine determiner type in the bilingual participants' linguistic environment (Valdés Kroff et al., 2017). These results were replicated when comparing predictive fixation patterns for mixed determiner-noun phrases of Spanish-English bilinguals from a

dense CS context (i.e., a bilingual context in which CS is among the modes of communication attested for bilingual interlocutors) to those of their equivalents from a sparse CS environment (i.e., a context in which languages are kept functionally separate and CS is sparingly used). Bilinguals hailing from a dense CS context were more successful at integrating determiner-noun switches than their counterparts from regions with sparse CS use (Valdés Kroff et al., 2018), reiterating the salient role of variability of environmental exposure in the utilization of prenominal gendered determiners in anticipatory processing, aligning with experience-based models (e.g. Dell & Chang, 2013).

It is conceivable that such environmental variability may also extend to L2 learners, impacting their (anticipatory) processing strategies for determiner-noun complexes in Spanish-English as a function of the presence of CS in their linguistic context. L2 predictive processing, like L1 predictive processing, is subject to adaptation by cue reliability (Kaan & Grüter, 2021). For L2 learners with regular exposure to CS, the integrity of the congruence-based grammatical gender cues exploited during unilingual Spanish comprehension would be compromised. This may make such predictive cues unreliable and, consequently, no longer useful during CS processing (Kuperberg & Jaeger, 2016). If utility frameworks of prediction are borne out, consistent exposure to asymmetric Spanish-English determiner-noun switches would render canonical grammatical congruence prediction ineffectual during CS processing, outweighed by the cues in line with differential production frequencies of CS.

2. The present study

To guide our investigation of the effects of environmental exposure to CS on L2 learners' online processing of Spanish-English CS, we asked the following investigative question: How does passive exposure to differential production frequencies of (1) bilingual compound verb switches and (2) determiner-noun switches modulate the processing of these structures?

We hypothesized that, in online processing, L2 learners would exhibit sensitivity to the differential production frequencies of bilingual compound verbs attested in their immersive environment (i.e. the southeastern U.S.). Specifically, we predicted that sensitivity to bilingual compound verb switches would vary as a function of their regional attestation. Thus, CS involving the light verb *hacer* and an English lexical infinitive should induce greater processing costs in the participants because its use is *exclusive* to other regions (i.e., New Mexico and Belize). In contrast, CS involving *estar* and an English present participle should incur shorter reading times as compared to CS involving *hacer* due to its widespread usage and attestation in participants' environment. We also predicted that CS occurring at the auxiliary should be less costly to process than switches occurring at the participle/lexical infinitive, particularly for *hacer* switches. This prediction is based on subject-predicate switches being relatively more frequent in production than switches within a verbal complex for other low attestation bilingual compound verb types, such as the perfect switch, while progressive switches are equally likely to occur at both auxiliary and participle switch sites (Guzzardo Tamargo et al., 2016).

With regards to determiner-noun switches, we predicted that L2 learners would be similarly sensitive to the distributional frequencies of determiner-noun CS in their online processing of mixed DPs. L2 learners were predicted to be sensitive to the fact that the feminine determiner type (i.e., *la*) maintains predictive validity in mixed DPs, given that the feminine determiner only occurs naturalistically with English nouns that are translation equivalents of *feminine Spanish nouns*. Therefore, we predicted L2 learners would demonstrate shorter reading times for congruent determiner-noun switches containing feminine determiners (la_{FEM} $house_{FEM}$) relative to incongruent determiner-noun switches containing feminine determiners (la_{FEM} $pencil_{MASC}$), given that only the former conforms to CS production patterns. These findings would be predicted under utility frameworks of prediction. Determiner-noun switches containing the masculine determiner (i.e., *el*), however, do not boast the same predictive validity given that the masculine determiner can occur with both masculine and feminine English translation equivalents. For this reason, we did not predict shorter reading times for congruent determiner-noun CS containing the masculine determiner (el_{MASC} $pencil_{MASC}$) relative to incongruent determiner-noun CSs containing the masculine determiner (el_{MASC} $house_{MASC}$). Pre-registration of predictions, sample, and experimental design can be found at the following link: https://doi.org/10.17605/OSF.IO/7BZXE.

2.1. Participants

Forty-five subjects participated in the present study and were recruited primarily from upper-level Spanish courses and via word of mouth. Five participants were excluded for being heritage speakers of other languages, and one participant was excluded because of poor eye-tracking data quality, resulting in less than 60% of trials with fixations to words in the critical interest period. After exclusions, 39 participants were included. All participants were undergraduate (n = 38) or graduate (n = 1) students attending a large, public university in the southeastern United States. Approximately 24% of the undergraduate population of the university identifies as Hispanic and come from areas with high incidence of Spanish use (e.g., south Florida); as such, naturalistic Spanish-English CS is abundant on campus at this university. Given that the early bilingual code-switchers at this university tend to come from central and south Florida, the distribution of CS structures reported for the Bangor Miami Corpus of oral Spanish-English speech align well with that produced on campus (Deuchar et al., 2014; Guzzardo Tamargo et al., 2016). Participants' environmental exposure to CS is corroborated in participants' scores on the Bilingual Code-Switching Profile (BCSP) (M = 42.2, SD = 12.0, range = 11.5–68.9) (Olson et al., 2022). The BCSP ranges from 0–100, with a score closer to 100 signifying active participation in CS and a score closer to 0 signifying a lack of exposure to or engagement with CS. The mean score of the sample coupled with the large variability in scores suggest that although participants are all, at minimum, exposed to Spanish-English CS, they may not all be active participants in Spanish-English CS; importantly, the above descriptive statistics do not preclude members of the sample from being active CS participants, but they do confirm that no member of the sample participates in CS at ceiling.

All participants were L2 Spanish learners who began acquiring Spanish relatively late (M = 11.9 years, SD= 2.2 years, range = 10–16 years) and had substantial formal exposure to Spanish (M = 7 previous Spanish classes, SD = 3.9, range = 0–18). Some participants seem to have misunderstood the question about formal exposure to mean content courses only (i.e. courses with a focus beyond the Spanish language incidentally taught in Spanish), thereby underestimating their formal exposure (e.g., mistakenly reporting having taken no Spanish courses, as reflected by the lower end of the reported range) while others report all Spanish courses, including those taken concurrently, thereby potentially inflating their formal exposure to Spanish. Nevertheless, given participants were recruited from upper-level Spanish courses and/or self-reported having taken those courses previously, all participants had enough formal Spanish training to complete advanced coursework.

Crucially, all participants were English-Spanish bilinguals and were not heritage speakers of other languages. Participants were more dominant in English, as shown in their scores on the Bilingual Language Profile (BLP) (M = 113.8, SD = 17.6, range = 72.5-149.9) (Birdsong et al., 2012). On this assessment, positive scores approaching 218 indicate relative English dominance, while negative scores approaching -218 indicate relative Spanish dominance. As an additional measure of proficiency, participants completed the LexTALE, a lexical decision task, in Spanish (Izura et al., 2014) and English (Lemhöfer & Broersma, 2012). Accuracy on the Spanish LexTALE reveals an intermediate to advanced proficiency in Spanish (M = 56.1%, SD = 6.8%, range = 45.0%–75.8%). Participants' accuracy on the English LexTALE reflect their high proficiency in their first language (M = 91.4%, SD = 11.6%, range = 78.8%-100%). While accuracy for English and Spanish LexTALE scores are presented as percentages, these scores are not directly comparable, in part due to the different number of words and non-words in each task; the English LexTALE consists of 40 words and 20 nonwords, while the Spanish LexTALE contains 30 words and 60 nonwords.

2.2. Materials and design

The present study consisted of two concurrent 2x2 factorial designs. For both factorial designs, each level of each factor contained six items, resulting in 24 experimental stimuli for each factorial design. All stimuli contained intrasentential Spanish-English CS that targeted either bilingual compound verb CSs or determiner-noun CSs.

The factorial design examining bilingual compound verbs contained stimuli adapted from Guzzardo Tamargo et al. (2016), which were manipulated to include switches involving the light verb. The first factor was auxiliary type; stimuli contained either the attested progressive structure (e.g., *está* testing 'is testing') or the regionally unattested, syntactically plausible light verb structure (e.g., *hizo* test 'did test'). The second factor manipulated was switch location; switches either occurred at the auxiliary (e.g., *el científico* did test 'the scientist...') or the participle/lexical infinitive (e.g., *el científico hizo* test 'the scientist did...') (Table 1).

The factorial design examining determiner-noun switches contained stimuli adapted from Johns et al. (2019). The first factor of this factorial was the gender of the

target noun, either masculine (e.g., *el*$_{MASC}$ pencil$_{MASC}$) or feminine *(la*$_{FEM}$ house$_{FEM}$). The second factor for the determiner-noun stimuli was determiner-noun congruence; stimuli were either congruent (e.g., *la*$_{FEM}$ house$_{FEM}$) or incongruent *(la*$_{FEM}$ pencil$_{MASC}$) in grammatical gender (Table 1; refer to Appendix A for a comprehensive list of critical experimental stimuli).

Table 1. Experimental item conditions by switch type.

Bilingual compound verb switches		
Condition	**Sample sentence**	**Translation**
Progressive – Switch at auxiliary	*La reportera afirmó que el científico* is **testing** the vaccine on rats.	'The reporter confirmed that the scientist...'
Progressive – Switch at participle	*La reportera afirmó que el científico está* **testing** the vaccine on rats.	'The reporter confirmed that the scientist is...'
Light verb – Switch at auxiliary (light verb)	*La reportera afirmó que el científico* did **test** the vaccine on rats.	'The reporter confirmed that the scientist...'
Light verb – Switch at lexical infinitive	*La reportera afirmó que el científico hizo* **test** the vaccine on rats.	'The reporter confirmed that the scientist did...'
Determiner-noun switches		
Condition	**Sample sentence**	**Translation**
Masculine target noun – Congruent	*La traductora perdió el* **pencil** before the exam.	'The translator lost the...'
Masculine target noun – Incongruent	*La traductora perdió la* **pencil** before the exam.	'The translator lost the...'
Feminine target noun – Congruent	*El joven exploró la* **house** with his friends.	'The teenager explored...'
Feminine target noun – Incongruent	*El joven exploró el* **house** with his friends.	'The teenager explored...'

Critical regions are presented in bold and spillover regions are underlined. Further discussion can be found in sections 3.1 and 3.2, respectively.

2.3. Procedure

Participants sat approximately 60 cm away from the 27 in display monitor and used a chin rest to minimize head movement. Eye movements were recorded using an EyeLink 1000 Plus desktop-mounted eye-tracker (SR Research Ltd.) interfaced with an IBM-compatible PC. Monocular tracking of the right pupil and corneal reflection was performed at a sampling rate of 1000 Hz. At the start of the experiment, participants completed a nine-point calibration and validation procedure to ensure capture of both horizontal and vertical eye movements. Following calibration, eye position errors were less than 0.5°. Calibration and validation were repeated only if necessary during the experimental block.

Instructions were presented in Spanish-English CS. Participants were instructed to read each sentence silently at their own pace and to pay attention, as some

sentences would be followed by a comprehension question. At the beginning of each trial, a fixation point appeared on the left side of the screen. When a fixation was detected at this point, it was replaced by the experimental sentence. Sentences never exceeded one line in length and were presented in 20-point Consolas font. Participants pressed a button when they were ready to proceed to the next screen. After one-third of experimental trials, participants were asked to respond to a comprehension question having to do with the content of the sentence just read. Comprehension questions were chosen as a secondary task to avoid inducing metalinguistic processes that have been found to modulate attentional resources during (CS) reading (Valdés Kroff et al., 2018; Valdés Kroff et al., forthcoming). Answers of "yes" or "no" were indicated by pressing one of two buttons on dual handheld button boxes. Trials that were not followed by a comprehension question immediately proceeded to the next trial. After the conclusion of the eye-tracking experiment, participants completed the BLP, BCSP, English LexTALE, and Spanish LexTALE on a separate behavioral computer.

3. Analyses

For both critical item sets, two eye-tracking reading measures were extracted for analysis: first-pass reading time and total reading time. First-pass reading time is the sum of all fixations within a given interest area beginning with the first fixation into an interest area until the participant's gaze leaves that interest area for the first time either to the left or to the right. This measure was chosen over first fixation duration because both first-pass reading time and first fixation duration bring about similar results in analysis (Rayner, 1998) and because first-pass reading time better captures cognitive processing in multi-word interest areas (Guzzardo Tamargo et al., 2016). Total reading time is the sum of all fixation durations, including regressive fixation durations, in a given interest area (Rayner & Duffy, 1986). Total reading time reflects more later stage processing than first-pass reading time, which may include such mechanisms as syntactic reanalysis (Clifton et al., 2007). Taken together, these reading time measures were employed to quantify processing, with longer fixation durations or reading times being associated with more costly processing for a particular interest area. These two reading measures were analyzed using generalized linear mixed-effects models as operationalized by the lme4 package version 1.1-7 (Bates et al., 2014) in the R Environment for Statistical Computing program, version 4.2.2 (R Core Team, 2022).

Prior to data cleaning, each conducted analysis contained 936 data points (24 stimuli by 39 participants). All fixations below 150 ms were excluded, as these are not reflective of higher order processing mechanisms (Rayner, 1998). Similarly, fixations which are +/- 3 SD of a given participant's mean fixation time during reading were excluded as outliers. The proportion of critical trials removed owing to the above exclusion criteria was 40.1% for the bilingual compound verb critical region, 35.5% for the bilingual compound verb spillover region, 38.5% for the determiner-noun critical region, and 25.4% for the determiner-noun spillover region, exclusion proportions which are in line with comparable CS reading paradigms conducted with L2 learners of Spanish (Valdés Kroff et al., forthcoming). Trials for which participants

incorrectly answered the comprehension question were also excluded from statistical analysis. Only 1.8% of trials for the bilingual compound verb critical region and spillover region and a mere 0.8% of trials for the determiner-noun critical region and spillover region were excluded for incorrect responses.

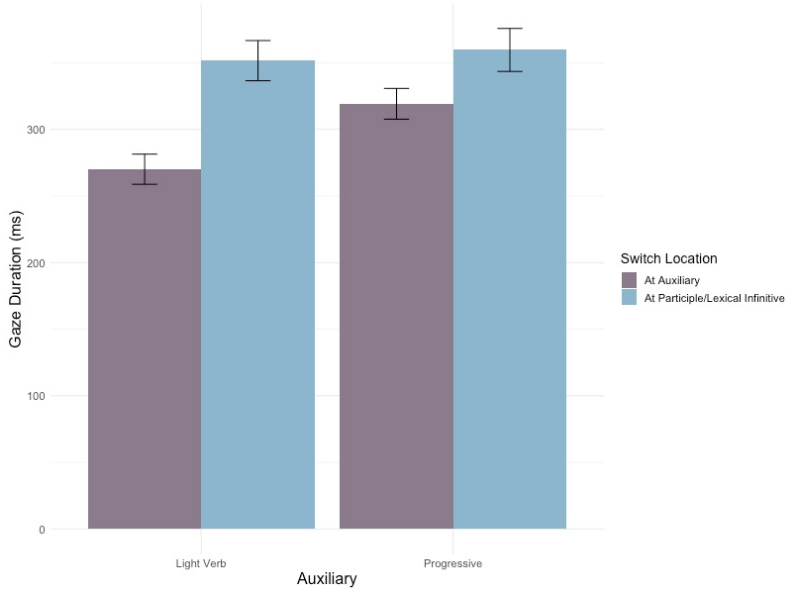
3.1. Results: Bilingual compound verb switches

Consistent with Guzzardo Tamargo and colleagues (2016), the critical region for bilingual compound verb switches is operationally defined as the progressive participle or the lexical infinitive, as it is the point by which participants will have processed the entire verb complex. The two words immediately following the critical region (determiner + noun) were analyzed for spillover effects; because the eyes sometimes move before processing of the subject of a given fixation has been completed (Rayner & Duffy, 1986), analyses of these regions are conducted to discern whether processing costs engendered by the verb complex persist beyond the boundaries of the critical region.

Compound Verb Type (progressive, light verb) and Switch Location (at the auxiliary/light verb, at the participle/lexical infinitive) and their interaction were included as fixed effects in the linear mixed-effects models. Each binary factor was deviation coded (-0.5, +0.5) such that results for said factors could be interpreted as main effects. All models began with a maximal random effects structure with random intercepts for Items and Participants, with by-participant random slopes Compound Verb Type, Switch Location, and their interaction, as informed by experimental design (Barr et al., 2013). Non-convergence of models resulted in the inclusion of an optimizer, followed by the elimination of interactions between random slopes and, if need be, removal of random slopes (followed by removal of random intercepts) by order of lowest to highest variance.

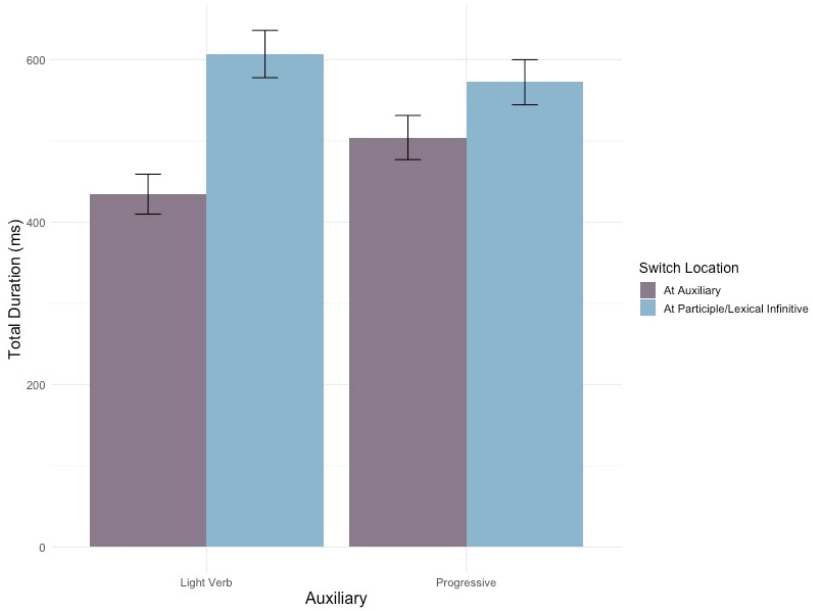
The linear mixed effects regression model that converged for first-pass reading time in the critical region had random intercepts for Participants and Items and a by-participant random slope of Switch Location. This model revealed a main effect of Switch Location, such that switches occurring at the participle/lexical infinitive had significantly longer reading times than switches at the auxiliary [b=64.9, SE=18.2, p=0.001] (Figure 1). There is a marginal main effect of Compound Verb Type [b=29.1, SE=14.5, p=0.05], such that switches using the progressive structure had longer first-pass reading times than those using the light verb structure. There was no significant interaction between the two fixed effects [b=-45.1, SE=29.0, p=0.13]. The random effects structure of the model fit for total reading time of the critical region was the same as that for first-pass reading time. This model similarly revealed a main effect of Switch Location in the same direction [b=121.0, SE=34.2, p=0.001]. In this later-stage measure, no main effect of Compound Verb Type emerged [b=-14.5, SE=28.0, p=0.61]; however, the interaction between Switch Location and Compound Verb Type approached significance [b=101.1, SE=56.1, p=0.08], such that light verb switches occurring at the lexical infinitive were trending towards having longer reading times than the other three bilingual compound verb conditions (Figure 2).

Figure 1. Mean first-pass reading time on the critical region (participle/lexical infinitive) for bilingual compound verb switches.



Mean reading times in milliseconds are presented for the first-pass reading times on the lexical infinitive for switches involving the light verb (did/*hizo*) and on the participle for switches involving the progressive (is/*está*). For each auxiliary type, switches at the auxiliary (*el estudiante* did check/is checking) are presented on the left. Error bars represent standard error of the mean.

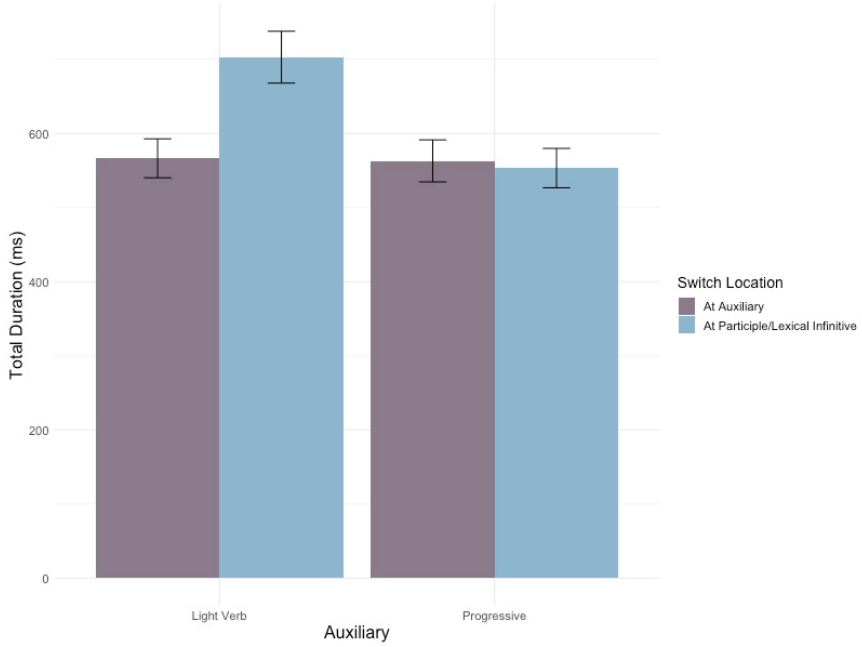
Figure 2. Mean total reading time on the critical region (participle/lexical infinitive) for bilingual compound verb switches.



Mean reading times in milliseconds are presented for the total reading times on the lexical infinitive for switches involving the light verb (did/*hizo*) and on the participle for switches involving the progressive (is/*está*). For each auxiliary type, switches at the auxiliary (*el estudiante* did check/is checking) are presented on the left. Error bars represent standard error of the mean.

The model that converged for first-pass reading time in the spillover region had random intercepts of Participants and Items. The model output showed no main effect of Switch Location [b=25.8, SE=20.3, p=0.21]; while there was similarly no significant main effect of Compound Verb Type, it approached significance [b=34.7, SE=20.3, p=0.09] such that light verb switches were trending towards having longer reading times than progressive switches. The interaction between the two fixed effects was not significant [b=42.3, SE=40.6, p=0.3]. The model fit for total reading time in the spillover region had the same random effects structure as that for first-pass reading time of the same region. Here, a significant interaction between Switch Location and Compound Verb Type surfaces [b= 156.6, SE=72.5, p=0.04]; light verb switches occurring at the lexical infinitive were significantly more costly to process than the other bilingual compound verb conditions (Figure 3). Fixed effects of Switch Location [b=63.8, SE=36.2, p=0.08] and Compound Verb Type [b=67.5, SE=36.2, p=0.07] approached significance, reinforcing trends that switches at the participle/lexical infinitive were more costly to process than switches at the auxiliary/light verb and that light verb switches were more costly than progressive switches.

Figure 3. Mean total reading time on the spillover region (determiner + noun post-switch) for bilingual compound verb switches.



Mean reading times in milliseconds are presented for the total reading times on the two words post-switch for switches involving the light verb (did/*hizo*) and for switches involving the progressive (is/*está*). For each auxiliary type, switches at the auxiliary (*el estudiante* did check/is checking) are presented on the left. Error bars represent standard error of the mean.

3.2. Results: Determiner-noun switches

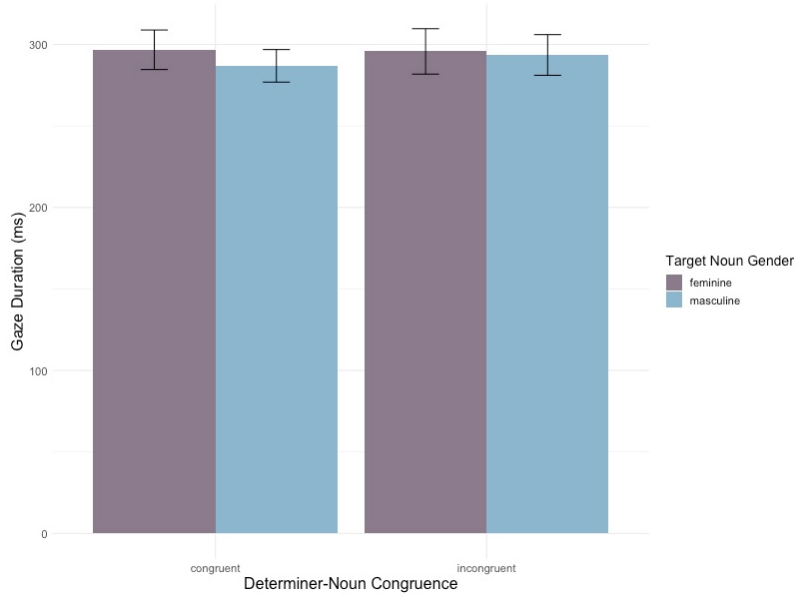
The critical region for determiner-noun switches is operationally defined as the noun in the mixed DP, as it is the point by which participants will have processed the entire switched determiner-noun complex. Again, a spillover region has been included should processing effects from the code-switch be observed beyond the critical region (Rayner & Duffy, 1986); this region will be understood as the three words immediately following the critical region, whether that be a complete prepositional phrase or another comparable structure.

The fixed ffectts of Target Noun Gender (masculine, feminine) and Determiner-Noun Congruence (congruent, incongruent), as well as their interaction, were included in the linear mixed-effects models. Again, all binary factors were deviation coded (-0.5, +0.5) so that any significant results for these factors may be explained as main effects. As described above, a maximal random effects structure as warranted by experimental design was included (Barr et al., 2013); non-convergence of models resulted in the inclusion of an optimizer, incremental reduction of random effects structure through the exclusion of interactions between random slopes and, if necessary, removal of random slopes and intercepts in order of increasing variance.

In the critical region, the linear mixed-effects regression model fit for gaze duration or first-pass reading time included a random effects structure with random intercepts on Participants and Items with a by-participant random slope of Target Noun Gender. This model revealed no main effects of Target Noun Gender [b=-4.9, SE=16.9, p=0.76] or Determiner-Noun Congruence [b=-1.2, SE=15.4, p=0.94] (Figure 4). Similarly, there was no significant interaction between fixed effects [b=-4.9, SE=30.9, p=0.87]. The model fit for total duration of the critical region similarly had random intercepts on Participants and Items, but with a by-participant random slope of Determiner-Noun Congruence. The results for this model are analogous to those elicited in the analysis of first-pass reading time for the same region: no main effects of Target Noun Gender [b=5.6, SE=24.4, p=0.82] or Determiner-Noun Congruence [b=-12.6, SE=26.1, p=0.66] are observed, nor is any interaction between these fixed effects [b=31.8, SE=48.8, p=0.52].

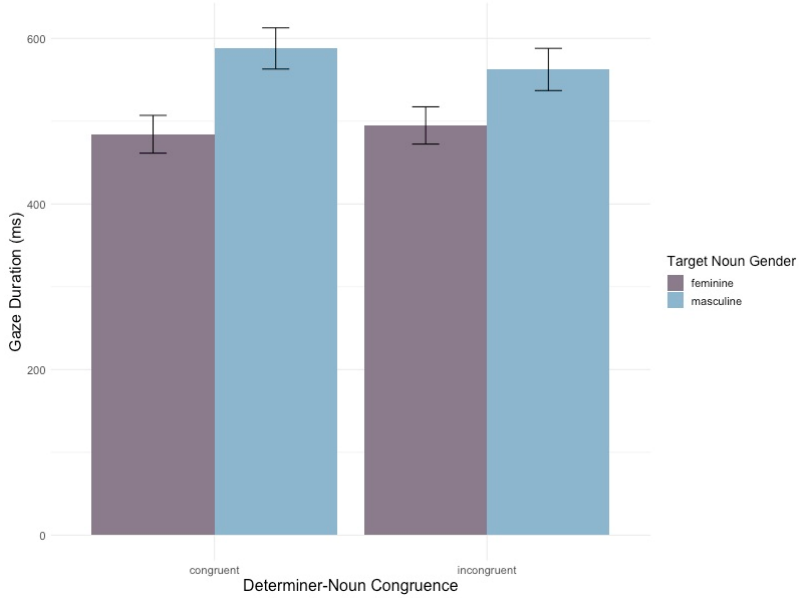
The model that converged for first-pass reading time of the spillover region had a random intercept on Participants. A significant main effect of Target Noun Gender emerged [b=84.6, SE=21.4, p<0.001] (Figure 5) such that masculine target nouns had significantly longer reading times than feminine target nouns; however, there was no main effect of Determiner-Noun Congruence [b=-10.62, SE= 21.4, p=0.62] nor a significant interaction between the two fixed effects [b=-36.2, SE=42.7, p=0.4]. In the analysis of total reading time for the spillover region, the model that was fit had a random intercept on Participants with a random slope of Target Noun Gender. The significant main effect of Target Noun Gender was maintained [b=99.4, SE=36.6, p=0.01], and a significant interaction of fixed effects was obtained [b=131.8, SE=60.0, p=0.03], indicating that masculine target nouns incongruently paired with feminine determiners had the longest reading time of all determiner-noun conditions (Figure 6). However, there was no main effect of Determiner-Noun Congruence [b=-3.0, SE=30.1, p=0.92].

Figure 4. Mean first-pass reading time on the critical region (noun) for determiner-noun switches.



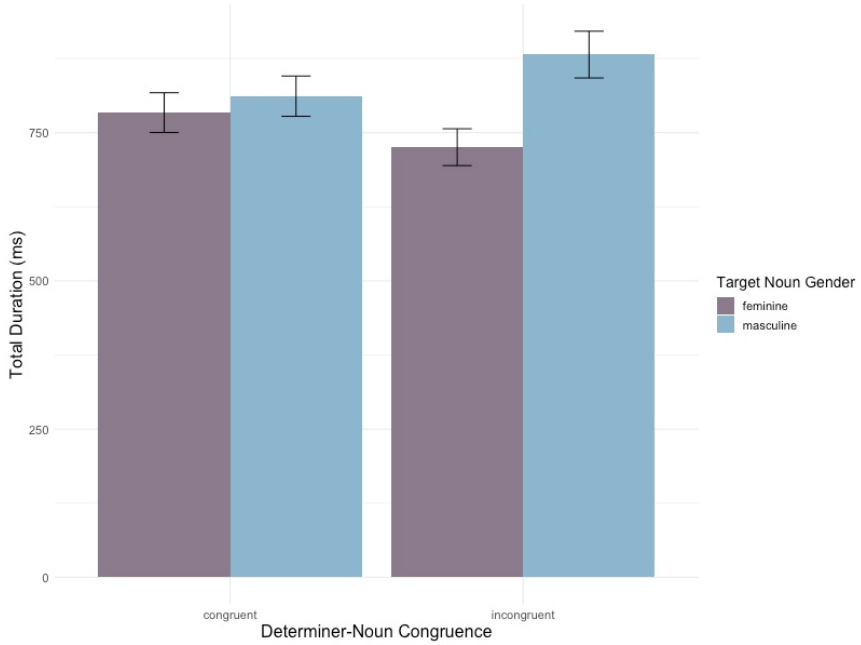
Mean reading times in milliseconds are presented for the first-pass reading times for congruent (*la* house$_{FEM}$; *el* pencil$_{MASC}$) and incongruent (*el* house$_{FEM}$; *la* pencil$_{MASC}$) determiner-noun switches. For each level of determiner-noun congruence, switches to a feminine target noun (*el*/*la* house$_{FEM}$) are presented on the left. Error bars represent standard error of the mean.

Figure 5. Mean first-pass reading time on the spillover region (three words post-switch) for determiner-noun switches.



Mean reading times in milliseconds are presented for the first-pass reading times for congruent (*la* house$_{FEM}$; *el* pencil$_{MASC}$) and incongruent (*el* house$_{FEM}$; *la* pencil$_{MASC}$) determiner-noun switches. For each level of determiner-noun congruence, switches to a feminine target noun (*el*/*la* house$_{FEM}$) are presented on the left. Error bars represent standard error of the mean.

Figure 6. Mean total reading time on the spillover region (three words post-switch) for determiner-noun switches.



Mean reading times in milliseconds are presented for the total reading times for congruent (*la* house$_{FEM}$; *el* pencil$_{MASC}$) and incongruent (*el* house$_{FEM}$; *la* pencil$_{MASC}$) determiner-noun switches. For each level of determiner-noun congruence, switches to a feminine target noun (*el*/*la* house$_{FEM}$) are presented on the left. Error bars represent standard error of the mean.

4. Discussion

In the present study, the interacting roles of grammaticality and exposure to (community-specific) distributional production frequencies of CS in real-time CS processing were explored. To tease apart these inherently interrelated modulating factors, two novel manipulations were introduced. Firstly, L2 learners of Spanish, whose level of L2 grammatical knowledge and exposure to (regional) CS patterns could be independently controlled, acted as the experimental sample. Secondly, the design capitalized on known CS production asymmetries of determiner-noun and bilingual compound verb switches. More specifically, the light verb switch, which is syntactically plausible but unattested in the CS environment of the participants, was presented as a means by which to distinguish the individual contributions of structure and exposure in CS processing. Results revealed that L2 learners were sensitive to the distributional production frequencies specific to their bilingual speech community during an online comprehension task, regardless of the grammatical status of the unattested structure. This sensitivity was most robust in measures of later-stage processing.

In measures of early-stage processing, bilingual compound verb switches rendered in both the progressive and light verb structures were processed as comparably grammatical; indeed, descriptively, the progressive structure initially induced longer reading times than did the unattested light verb switch (Figure 1). However, the unavailability of the light verb switch at the lexical infinitive emerged

during later-stage processing, including an emergent trend in the total reading time of the critical region (Figure 2) and a significant interaction in the total reading time of the spillover region (Figure 3). These results pattern with previous work on L2 learners' processing of bilingual compound verb switches during reading, where it is argued that this departure from latency trends seen for early Spanish-English bilinguals (e.g. Guzzardo Tamargo et al., 2016) may be reflective of sensitivity to environmental CS patterns not yet being automatized for L2 participants (Valdés Kroff et al., forthcoming). It is yet unclear whether this delayed onset of processing costs would be modulated with increased L2 proficiency or CS exposure, among the language experience factors that have demonstrated impacts on offline judgments of CS (Giancaspro, 2015; Olson, 2024). Scores on the BCSP (Olson, 2022) established participants as at least passively exposed to CS, while not necessarily all active participants in CS themselves. With increased CS participation, the time course of processing costs may be accelerated, instead surfacing more resolutely in measures of early-stage processing. To investigate this hypothesis, a follow-up study is being conducted with early Spanish-English bilingual code-switchers immersed in the same CS environment as the participants in the present study to further characterize how varying degrees of engagement with CS modulate the real-time processing of structurally plausible but unattested switched constructions. Similarly, testing a sample of L2 learners with a broader range of L2 proficiency would help determine whether earlier stage sensitivity to CS patterns strengthens with greater L2 proficiency.

Equivalently, the asymmetric production patterns of Spanish-English determiner-noun switches were registered in the real-time comprehension of CS by L2 learners. That is, for the spillover region of mixed DPs boasting an English translation equivalent of a masculine Spanish noun, reading times were significantly longer than for mixed DPs containing an English translation equivalent of a feminine Spanish noun (Figures 5 and 6); this was particularly the case when such nouns were preceded by a feminine Spanish determiner (Figure 6), pointing to the potential application of learned production asymmetries to CS comprehension to mitigate processing costs (Valdés Kroff et al., 2017, 2018). These results fall in line with a utility framework of prediction. The costs of a masculine translation equivalent preceded by an illicit feminine determiner were maintained, while those of a feminine translation equivalent preceded by a masculine determiner that might be expected unilingually were withheld. Under a utility framework, this asymmetrical attenuation of processing costs has its root in the reliability of each determiner type as a predictive cue for a given gendered noun class in CS. Because the feminine determiner retains its reliability as a predictor of only feminine nouns in Spanish-English CS, violations of this expectation result in a slowdown in reading time. However, masculine determiners in Spanish-English CS are not comparably constraining of a singular gendered category and are therefore no longer exploited as a stable predictor (Kuperberg & Jaeger, 2016; Kaan & Grüter, 2021). It merits noting that once again, the above-mentioned online sensitivity principally surfaced in measures of later-stage processing, only appearing in the spillover region. While participants' CS exposure and L2 proficiency were certainly also of interest here, it is more likely that determiner-noun switches may not be suitable for reading-while-eye-tracking paradigms. Function words such as

determiners tend to have high skipping rates during reading, especially when their appearance is highly constrained by their sentential context (Rayner, 1998); as such, it is reasonable to assume that, particularly in first-pass reading, participants skipped the manipulated prenominal determiner before reading and processing the target noun. Indeed, the majority of investigations on (mixed) DP processing are conducted with auditory presentation for this reason (e.g., Lew-Williams & Fernald, 2010; Grüter et al., 2012; Dussias et al., 2013; Valdés Kroff et al., 2017; Valdés Kroff et al., 2018).

The results presently reported are in accordance with experience-based models of processing. One such model, the Production-Distribution-Comprehension (PDC) model, holds that the constraints of the production system predispose individuals to produce certain structural and/or lexical items in tandem. These production pressures, collapsed over many speakers, lead to the creation of distributional patterns in the input of the comprehending system. These patterns, in turn, inform real-time comprehension. Under such a framework, the L2 learners in this study would have had sufficient exposure to the distributional production frequencies of CS in their immersive environment to learn and adapt their comprehension systems in preparation for likely upcoming bilingual input. This outcome is also predicted by the P-chain framework (Dell & Chang, 2014) and the Adaptive Predictability hypothesis (Valdés Kroff & Dussias, 2023), both of which rely on the notion of the comprehending system being trained on production-biased patterns. As a result, this study foregrounds the critical role of sociolinguistic context in the constraint of bilingual processing patterns (Titone & Tiv, 2023; Wigdorowitz, 2024); while this multidimensional variable has been historically avoided or considered unnecessary noise in psycholinguistic research, when asking questions that center the role of a gradient bilingual experience, the field stands to gain a more fine-grained understanding of bilingual language processing.

Several limitations of the present study warrant further discussion. The present study included no post-test evaluation of L2 participants' knowledge of critical lexical items. This is particularly consequential for the interpretation of results for determiner-noun switches, especially given that past work indicates L2 learners' knowledge of nouns' gender category modulates their predictive use of gendered determiners (Hopp, 2016). Future work may also consider including a behavioral measure, such as an acceptability judgment task, to complement online results. Such an approach would permit an assessment of whether explicit intuitions regarding CS map onto real-time processing trends and would be one way to discourage the skipping of functional words, such as the determiners in mixed DPs. However, it is important to underscore that results of an explicit judgment task are not necessarily reflective of the CS norms of a community; the metalinguistic mechanisms engaged to complete such a task (Valdés Kroff et al., 2018; Valdés Kroff et al., forthcoming), as well as variables such as attitudes toward CS (e.g., Giancaspro, 2015), may distort responses.

Further, it is not possible to attribute the processing costs associated with the light verb switch at the lexical infinitive solely to questions of (non-)exposure without first characterizing Spanish L2 learners' online comprehension of a switch that is unattested and grammatically disallowed (i.e. the perfect switch at the past participle). An ongoing study seeks to differentiate between the processing costs for grammatical,

unattested and ungrammatical, unattested bilingual compound verbs both in size and time course. Efforts to formally quantify the distributional production frequency of the light verb switch in Spanish-English bilingual communities outside of the southwestern U.S. and northern Belize, as conducted for progressive and perfect switched structures (Guzzardo Tamargo, 2016), would also strengthen present arguments. Additionally, to bolster the experience-based account of the present results, this experimental design should be replicated in contexts for which CS is equally as prevalent, but features distinct distributional production patterns (e.g. New Mexico), and also in contexts in which CS is less ubiquitous; if experiential explanations of the present results are to be believed, processing costs should be modulated as a function of the bilingual practices and CS patterns of participants' immersive linguistic environment (e.g., Green & Abutalebi, 2013; Green & Wei, 2014).

Finally, because this proposed line of research continues to rely on participants' primary linguistic environment at the time of testing as a proxy for CS exposure, more thorough measures of prior or concurrent exposure to CS varieties with distributional production frequencies that do not align with that of the primary speech community should be included. Any sustained passive exposure could lead to implicit learning of ambient linguistic features (Wigdorowitz, 2024); thus, a more granular characterization of that exposure by individual is merited. Another facet that is fundamental to supporting the narrative of experiential modulation to bilingual processing is the contribution of personal CS profile to real-time comprehension adaptation. While the participant sample in this study was likely too homogeneous to capture the impact of individual differences of CS profile in CS processing, future studies should continue to explore the modulatory effects of bilingual language practices, networks, and attitudes on CS processing to further define the experiential dimensions of bilingualism which are most crucial to bilingual language processing.

5. Conclusions

The present study made use of (regional) productional asymmetries in Spanish-English CS to tease apart the roles of intralinguistic and extralinguistic factors in real-time CS processing. To this end, L2 learners of Spanish, for whom L2 grammatical knowledge and CS immersion context may be independently manipulated, were utilized as an experimental sample. L2 learners exhibited online sensitivity to the distributional production frequencies of CS in their environment of exposure, even when the switched construction unattested in their environment was syntactically plausible (i.e. light verb switches). This suggests that L2 learners, like early Spanish-English bilinguals, exploit experiential knowledge about CS production patterns of their linguistic community to attenuate processing costs of CS, and are not solely reliant on expectations generated by (the interaction of) the participating languages' grammars. The findings of the present study garnered support for experience-based accounts of CS comprehension (MacDonald, 2013; Dell & Chang, 2014; Valdés Kroff & Dussias, 2023). As a result, this research underlines the importance of the consideration of sociolinguistic context and notions of linguistic experience in studies of (bilingual)

sentence processing. Born out of this work is a case for the continued investigation of passive linguistic exposure (Wigdorowitz, 2024) as a systematic modulator of language processing.

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References

Balam, Osmer. 2015. Code-switching and Linguistic Evolution: The case of '*Hacer* + V' in Orange Walk, Northern Belize. *Lengua y Migración* 7(1): 83–109. http://www.redalyc.org/articulo.oa?id=519551619004.

Balam, Osmer, Parafita Couto, M. Carmen, & Hans Stadthagen-González. 2020. Bilingual verbs in three Spanish/English code-switching communities. *International Journal of Bilingualism* 24(5-6): 952–967. https://doi.org/10.1177/1367006920911449.

Barr, Dale J., Levy, Roger, Scheepers, Christoph, & Harry J Tily. 2013. Random effects structure for confirmatory hypothesis testing: Keep it maximal. *Journal of Memory and Language* 68(3): 255-278. https://doi.org/10.1016/j.jml.2012.11.001.

Bates, Douglas, Maechler, Martin, Bolker, Ben, & Steve Walker. 2014. *lme4: Linear mixed-effects models using Eigen and S4. R package version 1.1-7*. http://CRAN.R-project.org/ package=lme4.

Belazi, Heidi M., Rubin, Edward J., & Almeida Jacqueline Toribio. 1994. Code Switching and X-Bar Theory: The Functional Head Constraint. *Linguistic Inquiry* 25(2): 221–237. https://www.jstor.org/stable/4178859.

Bice, Kinsey, & Judith F. Kroll. 2019. English only? Monolinguals in linguistically diverse contexts have an edge in language learning. *Brain and Language* 196: 104644. https://doi.org/10.1016/j.bandl.2019.104644.

Birdsong, David, Gertken, Libby, & Mark Amengual. 2012. *Bilingual Language Profile: An Easy-to-Use Instrument to Assess Bilingualism.* Austin: COERLL, University of Texas at Austin.

Clifton, Charles, Staub, Adrian, & Keith Rayner. 2007. Eye movements in reading words and sentences. In R. van Gompel (ed.), *Eye movements: A window on mind and brain,* 341–372. Washington, D.C.: American Psychological Association. https://doi.org/10.1016/B978-008044980-7/50017-3.

Dahan, Delphine, Swingley, Daniel, Tanenhaus, Michael K., & James S. Magnuson. 2000. Linguistic gender and spoken-word recognition in French. *Journal of Memory and Language* 42(4): 465–480. https://doi.org/10.1006/jmla.1999.2688.

Dell, Gary S., & Franklin Chang. 2013. The P-chain: Relating sentence production and its disorders to comprehension and acquisition. *Philosophical Transactions of the Royal Society B*, 369. https://doi.org/10.1098/rstb.2012.0394.

Deuchar, Margaret. 2020. Code-switching in linguistics: A position paper. *Languages* 5: 22. https://doi.org/10.3390/languages5020022.

Deuchar, Margaret, Davies, Peredur, Herring, Jon, Parafita Couto, M. Carmen, & Diana Carter. 2014. Code-switching corpora: A state of the art. In E. Thomas, & Mennen, I. (eds), *Unraveling Bilingualism: A Cross-Disciplinary Perspective*, 93–110. Bristol: Multilingual Matters.

Di Sciullo, Anne-Marie, Muysken, Pieter, & Rajendra Singh. 1986. Government and code-mixing. *Journal of Linguistics* 22: 1–24. https://doi.org/10.1017/S0022226700010537.

Dussias, Paola E. 2003. Spanish-English code mixing at the Auxiliary Phrase: Evidence from eye-movement data. *Revista Internacional de Lingüística Iberoamericana* 1(2): 7–34. http://www.jstor.org/stable/41678169.

Dussias, Paola E., Valdés Kroff, Jorge R., Guzzardo Tamargo, Rosa E., & Chip Gerfen. 2013. When gender and looking go hand in hand: Grammatical gender processing in L2 Spanish. *Studies in Second Language Acquisition* 35: 353–387. https://doi.org/10.1017/S0272263112000915.

Fuller Medina, Nicté. 2005. Spanish-English contact in Belize: The case of "hacer+V." In C. Gurski (ed.), *Proceedings of the 2005 Annual Conference of the Canadian Linguistic Association*, 1–9. Ontario: Canadian Linguistics Association. https://cla-acl.ca/pdfs/actes-2005/FullerMedina.pdf.

Gardner-Chloros, Penelope. 2009. *Code-switching.* Cambridge: Cambridge University Press. https://doi.org/10.1017/CBO9780511609787.

Gennari, Silvia P., & Maryellen C. MacDonald. 2009. Linking production and comprehension processes: The case of relative clauses. *Cognition* 111(1): 1–23. https://doi.org/10.1016/j.cognition.2008.12.006.

Giancaspro, David. 2015. Code-switching at the auxiliary-VP boundary: A comparison of heritage speakers and L2 learners. *Linguistic Approaches to Bilingualism* 5(3): 379–407. https://doi.org/10.1075/lab.5.3.04gia.

González-Vilbazo, Kay, & Luis López. 2011. Some properties of light verbs in code-switching. *Lingua* 121(5): 832–850. https://doi.org/10.1016/j.lingua.2010.11.011.

Green, David W., & Jubin Abutalebi. 2013. Language control in bilinguals: The Adaptive Control Hypothesis. *Journal of Cognitive Psychology* 25(5): 515–530. https://doi.org/10.1080/20445911.2013.796377.

Green, David W., & Li Wei. 2014. A control process model of code-switching. *Language, Cognition and Neuroscience* 29(4): 499-511. https://doi.org/10.1080/23273798.2014.882515.

Grüter, Theres, Lew-Williams, Casey, & Anne Fernald. 2012. Grammatical gender in L2: A production or a real-time processing problem? *Second Language Research* 28(2): 191–215. https://doi.org/10.1177/0267658312437990.

Guzzardo Tamargo, Rosa E., & Paola E. Dussias. 2013. Processing of Spanish-English code-switches by late bilinguals. In S. Baiz, N. Goldman, & R. Hawkes (eds), *BUCLD 37: Proceedings of the 37th Annual Boston University Conference on Language Development*, 134–146). Cascadilla, MS: Cascadilla Press. https://www.cascadilla.com/bucld37toc.html.

Guzzardo Tamargo, Rosa E., Valdés Kroff, Jorge R., & Paola E. Dussias. 2016. Examining the relationship between comprehension and production processes in code-switched language. *Journal of Memory and Language* 89: 138–161. https://doi.org/10.1016/j.jml.2015.12.002.

Hagoort, Peter, & Colin M. Brown. 1999. Gender electrified: ERP evidence on the syntactic nature of gender processing. *Journal of Psycholinguistic Research* 28: 715–728. https://doi.org/10.1023/A:1023277213129.

Harris, James. 1991. The exponence of gender in Spanish. *Linguistic Inquiry* 22(1): 27–62. https://www.jstor.org/stable/4178707.

Hopp, Holger. 2016. Learning (not) to predict: Grammatical gender processing in second language acquisition. *Second Language Research* 32(2): 277–307. https://doi.org/10.1177/0267658315624960.

Izura, Cristina, Cuetos, Fernando, & Marc Brysbaert. 2014. Lextale-Esp: A test to rapidly and efficiently assess the Spanish vocabulary size. *Psicologica* 35: 49–66. http://hdl.handle.net/1854/LU-5774107.

Johns, Michael A., Valdés Kroff, Jorge R., & Paola E. Dussias. 2018. Mixing things up: How blocking and mixing affect the processing of codemixed sentences. *International Journal of Bilingualism* 23(2): 584–611. https://doi.org/10.1177/1367006917752570.

Joshi, Aravind. (1985). Processing of sentences with intrasentential code switching. In D. Dowty, L. Karttunen, & A. Zwicky (eds), *Natural language parsing: Psychological, computational and theoretical perspectives*, 190–205. Cambridge: Cambridge University Press.

Kaan, Edith, & Theres Grüter. 2021. Prediction in L2 processing and learning: Advances and directions. In E. Kaan, & T. Grüter (eds), *Prediction in second language processing and learning*, 1–24. John Benjamins Publishing Company. https://benjamins.com/catalog/bpa.12.01kaa.

Kaan, Edith, Kheder, Souad, Kreidler, Ann, Tomić, Aleksandra, & Jorge R. Valdés Kroff. 2020. Processing code-switches in the presence of others: An ERP study. *Frontiers in Psychology* 11. https://doi.org/10.3389/fpsyg.2020.01288.

Koronkiewicz, Bryan. 2018. Acquiring L1-English L2-Spanish Code-Switching: The Role of Exposure to Language Mixing. *Languages* 3(26). https://doi.org/10.3390/languages3030026.

Kuperberg, Gina R., & T. Florian Jaeger. 2016. What do we mean by prediction in language comprehension? *Language, Cognition and Neuroscience* 31(1): 32–59. https://doi.org/10.1080/23273798.2015.1102299.

Lemhöfer, Kristin, & Mirijam Broersma. 2012. Introducing LexTALE: A quick and valid Lexical Test for Advanced Learners of English. *Behavior Research Methods* 44: 325–343. https://doi.org/10.3758/s13428-011-0146-0.

Lew-Williams, Casey, & Anne Fernald. 2010. Real-time processing of gender-marked articles by native and non-native Spanish speakers. *Journal of Memory and Language* 63(4): 447–464. https://doi.org/10.1016/j.jml.2010.07.003.

Lipski, John. 1978. Code switching and the problem of bilingual competence. In M. Paradis (ed.), *Aspects of bilingualism*, 250–264. Columbia, SC: Hornbeam Press.

Lipski, John. 1985. *Linguistic aspects of Spanish-English language switching*. Tempe, AZ: Center for Latin American Studies, Arizona State University.

Lohndal, Terje, & Michael T. Putnam. 2024. The importance of features and exponents: Dissolving feature reassembly. *Linguistic Approaches to Bilingualism* 14(1): 1–36. https://doi.org/10.1075/lab.23023.loh.

López, Luis, Alexiadou, Artemis, & Tonjes Veenstra. 2017. Code-switching by phase. *Languages* 2(3). https://doi.org/10.3390/languages2030009.

López, Luis. 2020. *Bilingual grammar: Toward an integrated model*. Cambridge: Cambridge University Press.

MacDonald, Maryellen C. 2013. How language production shapes language form and comprehension. *Frontiers in Psychology* 4. https://doi.org/10.3389/fpsyg.2013.00226.

MacSwan, Jeff. 1999. *A Minimalist approach to intrasentential code switching*. Garland, TX: Garland Press. https://doi.org/10.4324/9781315053158.

MacSwan, Jeff. 2014. Programs and proposals in codeswitching research: Unconstraining theories of bilingual language mixing. In J. MacSwan (ed.), *Grammatical Theory and Bilingual Codeswitching*, 1–33. Boston: MIT Press. https://doi.org/10.7551/mitpress/9780262027892.001.0001.

Mahootian, Shahrzad. 1996. Code-switching and universal constraints: Evidence from Farsi/English. *World Englishes* 15(3): 377–384. https://doi.org/10.1111/j.1467-971X.1996.tb00124.x.

Miccio, Adele W., Scheffner Hammer, Carol, & Bárbara Rodríguez. 2009. Code-switching and language disorders in bilingual children. In B. E. Bullock & A. J. Toribio (eds), *The Cambridge Handbook of Linguistic Code-Switching*, 241–252. Cambridge: Cambridge University Press. https://psycnet.apa.org/doi/10.1017/CBO9780511576331.015.

Myers-Scotton, Carol. 1993. Common and uncommon ground: Social and structural factors in codeswitching. *Language in Society* 22(4): 475-503. https://doi.org/10.1017/S0047404500017449.

Myers-Scotton, Carol, & Janice L. Jake. 2000. Testing the 4-M model: An introduction. *International Journal of Bilingualism* 4(1): 1–8. https://doi.org/10.1177/13670069000040010101.

Myers-Scotton, Carol, & Janice L. Jake. 2001. Explaining aspects of code-switching and their implications. In J. Nicol (ed.), *One mind, two languages: Bilingual language processing*, 84–116. Hoboken, NJ: Wiley-Blackwell.

Myers-Scotton, Carol, & Janice L. Jake. 2017. Revisiting the 4-M model: Codeswitching and morpheme election at the abstract level. *International Journal of Bilingualism* 21*:* 340–366. https://doi.org/10.1177/1367006915626588.

Olson, Daniel J. 2022. The Bilingual Code-Switching Profile (BCSP): Assessing the reliability and validity of the BCSP questionnaire. *Linguistic Approaches to Bilingualism*: 1–34. https://doi.org/10.1075/lab.21039.ols.

Olson, Daniel J. 2024. Bilingual language experience and code-switching acceptability judgments: A constructive replication of the work by Stadthagen-González et al. (2019), Balam et al. (2020), and Stadthagen-González et al. (2018). *International Journal of Bilingualism*: 13670069241298766. https://doi.org/10.1177/13670069241298766.

Pfaff, Carol W. 1979. Constraints on language mixing: Intrasentential code-switching and borrowing in Spanish/English. *Language* 55: 581–618. https://doi.org/10.2307/412586.

Poplack, Shana. 1980. Sometimes I'll start a sentence in Spanish y termino en español: toward a typology of code-switching. *Linguistics* 18(7/8): 581–618. https://doi.org/10.1515/ling.1980.18.7-8.581.

Poplack, Shana. 1981. Syntactic structure and social function of codeswitching. In R. Durán (ed.), *Latino language and communicative behavior*, 169–184. Norwood, N.J.: Ablex.

R Core Team. 2022. *R: A language and environment for statistical computing.* [Computer software]. Retrieved https://www.R-project.org/.

Rayner, Keith, & Susan A. Duffy. 1986. Lexical complexity and fixation times in reading: Effects of word frequency, verb complexity, and lexical ambiguity. *Memory & Cognition* 14(3): 191–201. https://doi.org/10.3758/BF03197692.

Rayner, Keith. 1998. Eye movements in reading and information processing: 20 years of research. *Psychological Bulletin* 124(3): 372. https://psycnet.apa.org/doi/10.1037/0033-2909.85.3.618.

Reyes, Rogelio. 1982. Language mixing in Chicano Spanish. In J. Amastae, & L. Elías-Olivares (eds), *Spanish in the United States: Sociolinguistic aspects*, 154–165. Cambridge: Cambridge University Press.

Titone, Debra A., & Mehrgol Tiv. 2023. Rethinking multilingual experience through a Systems Framework of Bilingualism. *Bilingualism: Language and Cognition* 26(1): 1–16. https://doi.org/10.1017/S1366728921001127.

Toribio, Almeida Jacqueline. 2001. On the emergence of bilingual code-switching competence. *Bilingualism: Language and Cognition* 4(3): 203–231. https://doi.org/10.1017/S1366728901000414.

Valdés Kroff, Jorge R., Dussias, Paola E., Gerfen, Chip, Perrotti, Lauren, & María Teresa Bajo. 2017. Experience with code-switching modulates the use of grammmatical gender during sentence processing. *Linguistic Approaches to Bilingualism* 7(2): 163–198. https://doi.org/10.1075/lab.15010.val.

Valdés Kroff, Jorge R., Guzzardo Tamargo, Rosa E., & Paola E. Dussias. 2018. Experimental contributions of eye-tracking to the understanding of comprehension processes while hearing and reading code-switches. *Linguistic Approaches to Bilingualism* 8(1): 98–133. https://doi.org/10.1075/lab.16011.val.

Valdés Kroff, Jorge R., & Paola E. Dussias. 2023. Production, processing, and prediction in bilingual codeswitching. In K. Federmeier, & J. Montag (eds), *The psychology of learning and motivation, Volume 78: Speaking, writing, and communicating*, 195–237. Cambridge: Academic Press. https://doi.org/10.1016/bs.plm.2023.02.004.

Valdés Kroff, Jorge R., Treadway, Hannah G., Guzzardo Tamargo, Rosa E., & Paola E. Dussias. Forthcoming. Sensitivity to codeswitching asymmetries in second language sentence processing. In D. Kascelan, M. C. Parafita Couto, P. Webb Davies, & R. Pérez Tottam (eds), *Current insights into code-switching*. Language Science Press.

Vergara Wilson, Damián, & Jenny Dumont. 2015. The emergent grammar of bilinguals: The Spanish verb *hacer* 'do' with a bare English infinitive. *International Journal of Bilingualism* 19(4): 444–458. https://doi.org/10.1177/1367006913516047.

Vergara Wilson, Damián. 2013. One construction, two source languages: *Hacer* with an English infinitive in bilingual discourse. In A. Carvalho, & S. Beadrie (eds), *Proceedings from the 6th International Workshop on Spanish Sociolinguistics*, 123–134. Somerville, MA: Cascadilla Proceedings Project. https://www.lingref.com/cpp/wss/6/paper2862.pdf.

Wigdorowitz, Mandy. 2024. The case for Contextual Linguistic Diversity in bilingualism research. *Journal of Multilingual Theories and Practices*: e24140. https://doi.org/10.17863/CAM.104798.