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Looking into the Comprehension of Spanish-English Code-switched Sentences: Evidence from Eye Movements

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We present the findings of a study that examines a predominant view in the sentence comprehension literature that attributes comprehension difficulty to particular distributional patterns in speaker's production choices (e.g. MacDonald & Thornton 2009). The purpose is to ask whether the correspondence between production patterns and comprehension difficulty observed in monolingual sentence processing extends to bilingual code-switching. We focus on Spanish-English code-switches involving two types of auxiliary phrases because of their distribution in naturalistic code-switching data. Switches between the Spanish auxiliary *estar* 'to be' and an English present participle are attested in bilingual production corpora (Pfaff 1979; Poplack 1980), whereas switches between the Spanish auxiliary *haber* 'to have' and an English past participle are rare.

We recorded the eye movements of 18 native Spanish speakers who learned English during adulthood and who reported code-switching. Participants read sentences containing code-switches between the Spanish auxiliary *estar* and the English present participle and between the Spanish auxiliary *haber* and the English past participle. After each sentence, participants answered a comprehension question or performed an acceptability judgment task. Results indicate that participants experienced more difficulty reading *haber*+participle switches than *estar*+participle switches, evidenced by longer fixation durations. The findings are discussed in terms of models of language processing that emphasize the close relationship between comprehension and production (Gennari & MacDonald 2009).

Key words: code-switching, psycholinguistics, comprehension

1. Introduction

In many bilingual communities, speakers regularly *codeswitch*, changing from one language to another, often several times in a single utterance. One characteristic of code-switched utterances is that they are often spoken without hesitation, pauses, or corrections, suggesting that code-switching is not random interference of one language with the other, but rather a natural process that reflects a systematic and exquisitely controlled integration of two linguistic systems which comprises an integral part of the competence of many bilingual

speakers (Myers-Scotton 1993). One important distinction in the code-switching literature is the division between inter-sentential and intra-sentential switches. In the former, language switching takes place at sentence boundaries, as illustrated in the following Spanish-English example:

(1) Acaba de llegar un paquete. *Let's open it.*
'A package has just arrived. Let's open it.'

In the latter, the alternation from one language to the other occurs within a single sentence:

(2) The teacher said *que los niños están* playing outside.
'The teacher said that the kids are playing outside.'

Because intra-sentential switches require greater simultaneous control of both languages, they have been used by many as the testing ground for putative constraints licensing allowable or grammatical switches. It is only at the intra-sentential level that the interaction between two grammatical systems can be observed, and these interactions, to the extent that they can be systematically characterized, provide a unique opportunity for investigating processing issues from the perspective of both sentence generation and comprehension.

Quantitative studies on intra-sentential switching involving numerous language pairs have revealed that certain types of syntactic junctures are more likely to undergo language switching than others. Some studies propose that these asymmetries in code-switching are constrained by formal principles of grammar (e.g. Belazi, Rubin & Toribio 1994; MacSwan 2000; Mahootian & Santorini 1996). Others attribute such asymmetries to a general constraint on the switchability of closed-class items (e.g. determiners, prepositions, complementizers; see Joshi 1985; Myers-Scotton & Jake 2000, 2001) or to a lack of 'equivalence' of functional elements across languages (Muysken 2000). In all of these studies, code-switching research has focused almost exclusively on production, with markedly less work being conducted on the comprehension of code-switched sentences. This gap is significant given that code-switching is not a production phenomenon alone. All code-switched utterances produced by a speaker must, in turn, be processed by a comprehender.

In production, code-switching is often motivated by a word or phrase in the other language that better conveys pragmatic intentions (Myers-Scotton 2005). For bilingual listeners or readers, however, code-switches can be unexpected and thus potentially more costly to process than within-language sentences. Indeed, a few studies investigating code-switching from the perspective of the comprehender suggest that recognizing and integrating a linguistic code different from the one most recently encountered entails a processing cost and that these costs are modulated by a number of linguistic variables. The few studies that have examined the processing of switched words during reading report that when the uncertainty associated with a switch is decreased by creating more natural contexts for code-switching, the cost associated with switching is diminished or eliminated (Amrhein 1999; Chan, Chau & Hoosain 1983). To

illustrate, using event related potentials (ERPs), Moreno, Federmeier and Kutas (2002) showed that processing semantically expected lexical code-switches disrupted reading less than unexpected within-language lexical switches. Although these studies provide important insights, they nevertheless remain narrowly focused on switching at the level of lexical processing. A deeper understanding of the processing of code-switched language requires investigation of structures involving more than single lexical switches and manipulations of the syntactic locus of the switch point.

The goal of the work reported here is to begin to study the comprehension of code-switched language when bilinguals read code-switched sentences. Our primary aim is to systematically examine the variables that modulate processing costs during the comprehension of code-switches. The remainder of this paper is structured as follows. First, we motivate the study of code-switching from the perspective of bilingual readers. This is important given the general view that, because code-switching is primarily a production phenomenon, the study of the processes engaged while bilinguals comprehend code-switched language should begin not with an examination of how they process code-switched text, but rather how they understand code-switched speech. We achieve this by focusing on how reading processes relate to auditory sentence comprehension and by arguing that the study of written code-switches is not only possible but informative given the close correspondence that exists between written and oral code-switches. We then present the theoretical framework that guides our hypothesis, a framework that focuses on the close relationship between comprehension and production mechanisms. Next, we present the preliminary findings from a pilot study with Spanish-English bilinguals that investigates the processing costs as they read code-switches at the auxiliary phrase. We conclude with directions for further research.

2. Code-switching from a comprehension standpoint

As noted, we advocate an approach that looks into the comprehension of code-switching not only from the perspective of the bilingual hearer, but also from the point of view of the bilingual reader. Like most monolingual communication, interactions involving code-switch speech among bilinguals occur in the spoken domain. Nevertheless, there is broad consensus that reading activates the system employed in auditory language processing (e.g. Perfetti 1999). In the parsing literature, for example, Fodor (1998) proposes that syntactic processing during reading proceeds through subvocal phonological encoding of the prosody that guides auditory comprehension. Steinhauer and Friederici (2001) provided confirming evidence for this, showing that the processing of phrasing in both reading and auditory comprehension is reflected in the same ERP component. We focus on reading because reading data linked with speed of performance have long been used in psycholinguistics to identify the cognitive processes associated with—and to develop theories of—language comprehension. In this way, our results will be interpretable in the context of the vast general literature on reading and

comprehension processes. In addition, it is important to note that for the language pair under investigation here, Spanish-English code-switching is increasingly common in text and in the bilingual's reading experience as well. This is particularly true of email and chat environments, as seen in the extensive written code-switching corpus of Montes-Alcalá (2005a, 2005b, 2005c). In fact, code-switching is also long attested in literary contexts, as in the work of Latino writers such as Alurista and Ricardo Sánchez.

2.1 Relating reading and auditory sentence comprehension

In the sentence parsing literature, reading tasks have been used largely to adjudicate between sentence processing models (e.g. Clifton, Speer & Abney 1991; MacDonald, Pearlmutter & Seidenberg 1994; MacDonald & Seidenberg 2006) and the results are frequently cited as evidence that specific sources of information are applied with broad generality during sentence comprehension (e.g. Frazier & Rayner 1982). In reading and auditory modalities, sentence comprehension unfolds rapidly over the course of perception, and structure-building is influenced by similar phonological, syntactic, semantic, and referential factors. Written language and spoken language also display important differences. While processing written language, readers are able to move freely along the text and can regress to earlier points to re-process information (Hinrichs 2006). Conversely, during auditory processing, language unfolds over time as a sequence of brief acoustic events, requiring moment-by-moment comprehension via careful signal monitoring. Also, word boundaries are signaled by blank spaces in written text, while spoken language processing lacks reliable word boundary cues (Tanenhaus & Trueswell 2007). An important question is whether the processing characteristics uncovered to date are specific to reading or are general to both modes of comprehension. In an ERP study, Osterhout and Holcomb (1993) found that hearing words in a sentence that were inconsistent with the preferred syntactic structure produced a P600 effect, similar to that elicited during reading (Osterhout & Holcomb 1992), suggesting that processing decisions during sentence comprehension are (at least in some circumstances) the same across both modalities. Recent work in the visual world paradigm (e.g. Allopenna, Magnuson & Tanenhaus 1998) also provides converging results for similarities between written and auditory processing. Using this task, Snedeker and Trueswell (2004) found that, despite the presence of potent visual cues to the visual referential context, participants remained sensitive to verb bias information during auditory processing, a result consistent with the ambiguity resolution findings in reading studies (e.g. Britt 1994; Garnsey, Pearlmutter, Myers & Lotocky 1997; Trueswell, Tanenhaus & Kello 1993). Similarly, a self-paced reading study by Trueswell and Kim (1998) and a spoken-language comprehension experiment by Novick, Kim and Trueswell (2003) tested how the fast priming of verbs affected readers' and listeners' processing of sentences with direct-object/sentential complement ambiguity, respectively. In both cases, the syntactic preferences of a briefly presented prime word modulated parsing preferences. For our purposes, the results

are important in that they indicate a strong link between general reading and listening comprehension processes (Snedeker & Trueswell 2004).

2.2 Do written code-switches in existing Spanish-English corpora mirror oral code-switches?

Reading code-switched sentences is now a common experience among Spanish-English bilinguals. The following email illustrates the point clearly (code-switched material appears in bold, capital letters for ease of presentation; translation appears in square brackets).

> On Mon, 9 Jul 2007 17:50:33 -0400 (name omitted to respect anonymity) wrote:
> Tuesdays at 6:30 pm **SUENA BIEN**. If there's enough people interested in playing, maybe **PODEMOS EMPEZAR** tomorrow **MARTES**. **¿QUÉ PIENSAN?** We could play in the IM building. The place **TIENE** three volleyball courts **QUE ESTÁN** available most of the time. **COMO DIRÍAN LOS** commentators of the Puerto Rican Volleyball Federation…
>
> 'Tuesdays at 6:30 pm **SOUNDS GOOD**. If there's enough people interested in playing, maybe **WE CAN START** tomorrow **TUESDAY**. **WHAT DO YOU THINK?** We could play in the IM building. The place **HAS** three volleyball courts **THAT ARE** available most of the time. **AS THE** commentators of the Puerto Rican Volleyball Federation **WOULD SAY**…'

There are, of course, numerous differences between speech and writing, pertaining to the universality of speech over writing systems, to differences in the acquisition of each, and to issues dealing with retrievability of the message, prestige, and standardization. Unlike speech, the conditions under which written language is generally taught also promote the belief that it represents the "*correct*" language. In studies of code-switching, there has been a tendency to regard code-switching as almost exclusively an oral phenomenon and to discount written code-switching as artificial or qualitatively different from oral discourse. However, recent research shows that written code-switch data correspond closely to both the syntactic and discourse patterns reported for spoken code-switching.

Callahan (2002) analyzed a written corpus of 30 texts (totaling 2954 pages) of short stories and novels containing Spanish-English and English-Spanish code-switches and found little or no variance in the syntactic patterns of code-switching between the written texts and patterns in oral production. Our own comparison of Montes-Alcalá's (2005a, 2005b, 2005c) Spanish-English code-switching data, gathered from email messages between bilinguals, with published oral data (taken from Klavans 1985; Lance 1975; Lipski 1985; Pfaff 1979; and Poplack 1980), shows extensive overlap in both modes of communication. Illustrative examples are provided in Table 1.

Table 1: A comparison between written and oral code-switch types

Code-switch types	E-mail interactions	Oral production data
At clausal boundaries	I am sure he'll appreciate it, **AUNQUE LE DUELA**	**AQUÍ CON HOPE**, I am trying to figure out what's wrong…
At the verb-object boundary	Laura está escondiendo **EVERYONE'S DRINKS!**	Los hombre comieron **THE SANDWICHES**
Following a preposition	Yo estoy de acuerdo **con THE GROUP NOMINATION**	Ben viene **con THE SPORTS NEWS**
At the adjective	Pues aquí estoy **muy BORED**	Mi papá es **muy PROTECTIVE**
At adverbial phrases	Y además, me llamaron para una entrevista **AT THAT PLACE**	Uno no podía comer carne **EVERY DAY**
Tag phrases	**WELL,** resulta que Isabel necesitaba a alguien para su clase y le contó todo el problema.	Yo estaba aburrecido, durmiéndome, **YOU KNOW?**
NP insertions	Bueno, espero que no trabajes demasiado, es **un THREE DAY WEEKEND…**	Me lo dijo **el SAME NIGHT**
Following a complemetizer	Después me quedé pensado por lo que dijiste **que THAT WOULD MAKE THE OTHER GUY MAD**	Se me hace **que I HAVE TO RESPECT HER PORQUE…**

Thus, despite obvious differences between spoken and written language, the patterns of code-switching in both literary and email corpora exhibit properties strikingly analogous to those found in natural speech.

3. Theoretical framework

Psycholinguistic studies examining monolingual linguistic behavior have shown that comprehension and production involve many of the same representations and processes (Treiman, Clifton, Meyer & Wurm 2003). In comprehension, listeners quickly map the signal onto lexical entries, whose semantic and syntactic information becomes available for constructing the syntactic structure and meaning of utterances. Similarly, in production, speakers select lexical items, each carrying syntactic and morphological features affecting the selection of additional words (Treiman et al. 2003). Given this connection, studies have investigated how comprehension and production interact. One model that argues for the existence of a close correspondence between comprehension difficulty and production patterns is the Production-Distribution-Comprehension (PDC) framework (MacDonald & Thornton 2009 and related work). The premise of the model rests on the idea that sentence complexity effects observed during reading comprehension derive from particular distributional patterns in production, which in turn create distributional regularities that shape comprehenders' interpretations. For

instance, it has been well-documented in the psycholinguistic literature that when English speakers read the sentence "Mary said that John left yesterday," they typically interpret it to mean that the 'leaving' event took place yesterday, even though the adverb could plausibly refer to the 'saying' event instead. According to the PCD, this is not because of hardwired constraints on the comprehension system (e.g. expressions like 'yesterday' initially modify the verb that is nearest). Instead, the preferences observed during comprehension are learned from patterns in the input which arise from constraints on production.

The PDC framework grants a major role to frequency: frequent constructions are more readily activated by appropriate information sources than less common constructions. For example, studies show that comprehension difficulty is influenced by the match between syntactic structure and the frequency with which verbs appear in that structure. Thus, transitive verbs (e.g. *believe*) most often used by speakers with sentential complements cause less comprehension difficulty when followed by a sentential complement than by a noun phrase (NP) complement (Garnsey, Pearlmutter, Myers & Lotocky 1997; Spivey-Knowlton & Sedivy 1995; Tanenhaus & Trueswell 1995; Trueswell & Kim 1998). Further evidence for the strong dependency between production and comprehension has been supplied by Gennari and MacDonald (2009), who found that relative clauses that speakers do not produce frequently were difficult to comprehend. That is, the verb and noun types that speakers tend to produce in active or passive relative clause constructions were easier to process when they, in fact, occurred in those syntactic structures. Based on this evidence, we expect ease of comprehension of codeswitched language to reflect production patterns. Of course, while construction frequency may not always predict comprehension preferences (cf. Gibson, Schütze & Salomon 1996; Kennison 2001; Pickering, Traxler & Crocker 2000), growing evidence from experience-based studies of sentence processing indicates that frequency of exposure to certain constructions modulates comprehension difficulty. Whether such correspondences between comprehension and production extend to code-switching is an empirical question, but the results from the monolingual research lead us to predict that frequently produced code-switched structures should be easier to process by the comprehension system. We test this hypothesis in a pilot study in which eye tracking is used to examine whether reading Spanish-English switches at the auxiliary juncture incur processing costs. We have chosen to examine this structure because of interesting code-switching asymmetries involving the auxiliaries ESTAR and HABER reported in the production literature, which provides us with a means to test the premises of the PDC framework.

4. The present study: processing code-switched verb phrases during reading

In Spanish-English code-switching production data, there is evidence that certain types of syntactic junctures are more likely to undergo language switching than others. With respect to alternations involving the auxiliary phrase, switches between *estar*, the Spanish auxiliary

be, and the English present participle are more common than switches between *haber*, the Spanish auxiliary *have*, and the English past participle. For instance, switches, such as those displayed in examples (3) through (6), have been reported in naturalistic code-switching data.

(3) *Mi marido está* working on his Master's (Lipski 1978:252)
'My husband is working on his Master's'

(4) *Los están* bussing *pa otra escuela* (Pfaff 1979:296)
'(They) are bussing them to another school'

(5) *Estaba* training *para pelear* (Pfaff 1979:296)
'(He) was training to fight'

(6) *Siempre está* promising *cosas.* (Poplack 1980:596)
'(He) is always promising things.'

Conversely, switches between *haber* and the English past participle are vanishingly rare in Spanish-English code-switching corpora. One of the few cases found in production data is shown in example (7).

(7) *Yo creo que apenas se había* washed out. (Pfaff 1979:300)
'I think that it had just washed out.'

Generally, the code-switch in (7) is referred to in the literature to highlight its unaccepted status. Belazi et al. (1994) and Toribio (2001) state that examples (8) and (9) were judged as unacceptable code-switches by Spanish-English speakers and advanced English-Spanish participants, respectively.

(8) *The students had *visto la película italiana.* (Belazi et al. 1994:225)
'The students had seen the Italian movie.'

(9) **Los estudiantes han* elected a new representative. (Toribio 2001:220)
'The students have elected a new representative.'

The predominance of switches involving the progressive construction over those involving the perfect construction is revealing of the differential behavior of these two Spanish auxiliaries. Although they represent the same type of construction in structural terms, they do not seem to be used with the same frequency during bilingual interactions. This may give rise to differences in the way the two types of switches are processed by the comprehension system. Specifically, the PDC framework would lead us to predict that the more frequently produced code-switches should be easier to process by the comprehension system.

To test this prediction, we recorded the eye movements of 18 native Spanish speakers who learned English during adulthood and who code-switched daily. Participants read sentences that contained switches between the Spanish auxiliary *estar* and the English present participle

and between the Spanish auxiliary *haber* and the English past participle. A second goal of the study was to determine if and how different tasks affected the way these two groups of bilinguals processed the *estar*+participle and the *haber*+participle switches. This was important because some tasks that participants are normally engaged in during sentence processing may reflect distributional patterns in production better than others. Two tasks were compared: a comprehension task and an acceptability judgment task. The first task is widely used in psycholinguistic studies that examine linguistic processing whereas the second task has been the preferred task used in code-switching studies that aim to model bilingual competency. To summarize, the two research questions addressed in this pilot study are:

1) Are more frequently produced types of code-switches easier to process by the comprehension system than less frequent types of code-switches?
2) Do different tasks display distinct processing patterns during the comprehension of these code-switches?

4.1 Methods

4.1.1 Participants

The participants were born in Spanish-speaking countries and had arrived in the United States during adulthood. At the time of data collection, most were undergraduate and graduate students at a large U.S. institution. The average age of the participant group was 21.77 years (range 18-31). All received monetary compensation for their participation.

To assess knowledge of their first and second language, participants completed a language history questionnaire designed to tap into several aspects of language proficiency and use by self-report (e.g. language dominance, level of proficiency in the four language areas, number of years that the second language was studied, length of stay in a country where the second language was spoken). Participants reported using Spanish and English in their daily lives and in a variety of contexts, including professional and academic contexts as well as during informal interactions with family and friends. Participants reported valuing their maintenance of Spanish because of close ties with Spanish-speaking family members and friends. At the same time, high proficiency in English was considered important in facilitating professional and academic growth as well as in nurturing friendships with English-speaking individuals. Critically for our purposes, all participants reported being exposed to Spanish-English code-switched speech and used code-switching often with bilingual family members and friends.

Participants' responses to the language history questionnaire indicated that they had been immersed in an English-speaking environment for an average of 5.7 years. The self-rated proficiency measure was a ten-point scale with 1 being the lowest score and 10 being the highest score. The mean self-reported score for overall proficiency in the L1 was 9.38 (range 7.5-10) and for proficiency in the L2 was 8.67 (range 6.75-9). A paired-samples *t*-test revealed

that the mean self-reported score for Spanish was significantly different from English ($t(17) = 3.22$, $p = .005$).

In addition to the language history questionnaire, overall knowledge of Spanish and English was assessed by administering a section of the Diploma de Español como Lengua Extranjera (Diploma of Spanish as a Foreign Language, DELE) and a section of the Michigan Test of English Language Proficiency (MTELP). The DELE is a standardized test of Spanish issued by the Ministry of Education, Culture and Sport of Spain, which tests proficiency in Spanish at seven levels. Here, we administered the *Nivel Superior C2*, the highest level of accreditation. The test had a maximum score of 50 points and was composed of three sections: a cloze section, a vocabulary section (including highly specialized uses of the language), and a multiple-choice grammar section. The MTELP was also based on 50 points and was composed of a multiple-choice grammar section and a cloze section. Participants were given 1 point for each correct answer and 0 points for incorrect answers. A paired-sample t-test on the scores for the DELE ($M = 42.05$, $SD = 3.65$) and the MTELP ($M = 40.44$, $SD = 4.61$) revealed no significant differences between the two test scores ($t(17) = 1.20$, $p = .244$). This indicates that the participants were highly proficient in the two languages.

4.1.2 Materials and procedure

The experimental materials included 96 item sets. An item set consisted of four different versions of the same sentence, corresponding to four experimental conditions (Table 2). Conditions 1 and 2 were code-switched conditions involving the progressive construction. In Condition 1, the switch occurred at the phrasal boundary, that is, right at the auxiliary. Condition 2 contained a switch between the Spanish auxiliary *estar* and the English present participle. Conditions 3 and 4 were analogous to Conditions 1 and 2. However, these code-switched conditions involved the perfect construction.

Table 2: Sample of experimental stimuli

Condition type	Sample stimuli
(1) *Estar*-Switch at auxiliary	*El director confirmó que los actores* are rehearsing their lines for the movie.
(2) *Estar*-Switch at participle	*El director confirmó que los actores están* rehearsing their lines for the movie.
(3) *Haber*-Switch at auxiliary	*El director confirmó que los actores* have rehearsed their lines for the movie.
(4) *Haber*-Switch at participle	*El director confirmó que los actores han* rehearsed their lines for the movie.

To ensure that all conditions were formally similar to each other, all item sets were controlled as much as possible for total word length. The average sentence length was 13 words (range

11-14). Total character length at the critical region was 9 characters for the present participle (e.g. approving; range 6-11) and 8 characters for the past participle (e.g. approved; range 5-10).

In addition to the experimental items, 64 filler code-switched sentences were added to serve as distractors. Experimental and filler sentences were pseudo-randomly interleaved to mitigate order effects.

Stimuli were presented on a color monitor using an EyeLink 1000 desktop-mounted eye-tracker, interfaced with an IBM-compatible PC. A chinrest was used to prevent head movement. Participants were instructed to read the sentences silently at their own pace. After reading each sentence, participants were asked to complete one of two tasks: an acceptability judgment task or a comprehension question task. The tasks were added to ensure that participants remained attentive while reading the sentences. The acceptability judgment task was chosen as it provides an additional way of comparing our results to linguistic theoretic claims that rely on grammaticality judgments to model competency. The comprehension question task was used because it more closely resembles what speakers do in everyday interactions, that is, to comprehend the interlocutor's message. Task was blocked such that, for half of the experimental and filler items, participants performed the grammaticality judgment task and, for the remaining half, they completed the comprehension question task. In the acceptability judgment task, participants were asked to indicate their judgment by pressing a "yes" or a "no" button on a game pad. In the comprehension task, participants were asked to answer a 'yes/no' question related to the content of the sentence they had just read.

4.2 Results

The results correspond to the critical region under examination, that is, the auxiliary+ participle area. Following standard procedure in eye movement studies (Rayner 1998; Rayner, Sereno, Morris, Schmauder & Clifton 1989) several measures of eye movements were analyzed. *Gaze Duration* is the total duration of all fixations in a target region until the eyes fixated on a region of text that was either progressive or regressive to the target region, provided that the first fixation on the target region did not occur after any fixations on words further along in the text. *Regression Path Duration* is the total duration of all fixations that occurred from the first fixation on a target region until the target region was exited in a progressive manner (including fixations on the target region and fixations on words regressive to the target region), provided that the first fixation on the target region did not occur after any fixations on words further along in the text. *Total Duration* is the duration of all fixations in a target region. We will first report the eye-tracking results when participants were reading the code-switched sentences for comprehension, followed by the eye-tracking results in which they were reading the code-switched sentences to provide acceptability judgments.

A two-way repeated measures analysis of variance (ANOVA) was conducted to evaluate the effect of auxiliary type and switch site on the three extracted reading measures, gaze duration, regression path time, and total time. Auxiliary type (*estar* 'be' versus *haber* 'have')

and switch site (switch at the auxiliary versus switch at the participle) were treated as the within-subject factors.

4.2.1 Reading for comprehension

The mean gaze duration, regression path time, and total time by condition for the group of Spanish-English speakers is displayed in Table 3. Standard deviations for the means are shown in parentheses.

Table 3: Mean gaze duration, regression path time, and total time by condition for the Spanish-English codeswitchers during the comprehension task

Condition	Gaze duration	Regression path time	Total time
(1) *Estar*-Switch at auxiliary	343.58 (*SD* = 116.53)	531.04 (*SD* = 227.19)	722.92 (*SD* = 379.29)
(2) *Estar*-Switch at participle	364.27 (*SD* = 122.06)	521.87 (*SD* = 258.36)	685.65 (*SD* = 254.33)
(3) *Haber*-Switch at auxiliary	316.72 (*SD* = 94.86)	469.88 (*SD* = 312.39)	668.52 (*SD* = 320.68)
(4) *Haber*-Switch at participle	383.50 (*SD* = 131.24)	623.14 (*SD* = 303.93)	886.51 (*SD* = 276.23)

4.2.1.1 Gaze duration

For gaze duration, the results indicated no main effect of auxiliary type, $F(1,17) = .24$, $p = .877$, no main effect of switch site, $F(1,17) = .24$, $p = .628$, and no by-participant interaction of auxiliary type and switch site, $F(1,17) = 1.30$, $p = .270$. Participants displayed no significant participle reading time differences between sentences that included the progressive structure and those that included the perfect structure, nor between sentences that included a switch at the auxiliary and those that included a switch at the participle.

4.2.1.2 Regression path time

The regression path time results did not display a main effect of auxiliary type, $F(1,17) = .24$, $p = .628$, but they displayed a main effect of switch site, $F(1,17) = 11.80$, $p = .003$. There was also a significant by-participant interaction of auxiliary and switch site, $F(1,17) = 4.78$, $p = .043$. Subsequent pairwise contrasts indicated significant mean differences between Conditions 3 and 4, $t(17) = 4.44$, $p < .001$, but not between Conditions 1 and 2, $t(17) = 1.85$, $p = .855$. For this reading measure, participants read perfect structures in which the switch occurred at the auxiliary significantly more quickly than perfect structures in which the switch occurred at the participle. They did not, however, read the two types of switches involving the

progressive structure at significantly different reading speeds.

4.2.1.3 Total time

For total time, the results of the ANOVAs indicated no main effect of auxiliary type, $F(1,17) = 2.49$, $p = .133$, as well as no main effect of switch site, $F(1,17) = 3.63$, $p = .074$. There was, however, a significant by-participant interaction of auxiliary and switch site, $F(1,17) = 9.29$, $p = .007$. Follow-up paired-samples t tests exhibited again significant mean differences between Conditions 3 and 4, $t(17) = 4.02$, $p = .001$), but not between Conditions 1 and 2, $t(17) = .52$, $p = .607$). In other words, in sentences with the perfect structure, participants read the participles significantly more slowly when the switch occurred at the participle than when it occurred at the auxiliary. Nonetheless, they read the participles at a similar speed in both types of experimental sentences with the progressive structure.

4.2.2 Reading for acceptability

The mean gaze duration, regression path time, and total time by condition for the group of Spanish-English code-switchers is displayed in Table 4, with the standard deviations for the means shown in parentheses.

Table 4: Mean gaze duration, regression path time, and total time by condition for the Spanish-English codeswitchers during the acceptability judgment task

Condition	Gaze duration	Regression path time	Total time
(1) *Estar*-Switch at auxiliary	417.61 (*SD* = 170.33)	615.33 (*SD* = 304.41)	955.88 (*SD* = 523.71)
(2) *Estar*-Switch at participle	425.8 (*SD* = 110.84)	586.91 (*SD* = 238.32)	940.4 (*SD* = 405.07)
(3) *Haber*-Switch at auxiliary	421.06 (*SD* = 127.53)	680.51 (*SD* = 373.50)	1015.28 (*SD* = 639.87)
(4) *Haber*-Switch at participle	475.1 (*SD* = 180.57)	920.44 (*SD* = 559.80)	1424.81 (*SD* = 646.03)

4.2.2.1 Gaze duration

For gaze duration, the results displayed no main effect of auxiliary type, $F(1,17) = 1.72$, $p = .208$, no main effect of switch site, $F(1,17) = 1.82$, $p = .195$, and no by-participant interaction of auxiliary type and switch site, $F(1,17) = .85$, $p = .370$. These results show that during this early reading measure there were no significant participle reading time differences among any of the four experimental conditions.

4.2.2.2 Regression path time

For regression path time, there was only a main effect of auxiliary type, $F(1,17) = 11.34$, $p = .004$. There was no main effect of switch site, $F(1,17) = 3.86$, $p = .066$, nor was there a by-participant interaction of auxiliary type and switch site, $F(1,17) = 3.72$, $p = .071$. Therefore, overall participants read participles more quickly when they were part of a progressive structure than when they were part of a perfect structure. However, there were no significant differences between conditions with respect to the particular point at which a switch occurred.

4.2.2.3 Total time

For total time, the results indicated a main effect of auxiliary type, $F(1,17) = 5.41$, $p = .033$, a main effect of switch site, $F(1,17) = 10.14$, $p = .005$, and a by-participant interaction of auxiliary and switch site, $F(1,17) = 7.44$, $p = .014$. Follow-up paired-samples t tests indicated significant mean differences between Conditions 3 and 4 ($t(17) = 3.65$, $p = .002$), but not between Conditions 1 and 2, $t(17) = .18$, $p = .857$. Therefore, these Spanish-English codeswitchers' total reading time of the perfect participles was significantly slower when the switch occurred at the participle than when it occurred at the auxiliary, but no significant differences for total reading time of the present participles were found between Conditions 1 and 2.

5. Discussion

The results will be discussed in the context of the two research questions. The first question asked whether more frequently produced types of code-switches (i.e. *estar*+English participle switches) were easier to process during reading comprehension than less frequent types of code-switches (i.e. *haber*+participle code-switches). This question can be addressed by comparing the mean differences between the two conditions in which the switch occurs at the participle with their respective baseline conditions, in which the switch occurs at the auxiliary. In other words, on the one hand, the means of Conditions 1 (*Estar*-Switch at auxiliary) and 2 (*Estar*-Switch at participle) were compared, and on the other, the means of Conditions 3 (*Haber*-Switch at auxiliary) and 4 (*Haber*-Switch at participle) were compared. In the comprehension task, participants' fixation durations on the participle were significantly longer for Condition 4 than for Condition 3. However, there were no significant differences between the fixation durations on the participle for Condition 1 and Condition 2. This was the case in measures of early processing (i.e. regression path time) and measures of later processing (i.e. total time). This suggests that during reading comprehension, it was easier for participants to process the more frequent *estar*+English participle switches than the less frequent *haber*+English participle switches, when each of these was compared to their counterparts in

which the switch occurred at the auxiliary.

The second research question asked whether different tasks influenced the way participants processed the two types of code-switches. This question is answered by examining the differences in processing costs that participants exhibited between the two tasks. For these participants, the interaction of auxiliary type and switch site was present in both the comprehension task and the acceptability judgment task. The interaction arose in an earlier reading measure (i.e. regression path time) in the comprehension task, but it was present during the measure of total time in the acceptability judgment task. In other words, in the acceptability judgment task, it took participants a little longer to display the differential processing of *estar*+Engish participle switches and *haber*+English participle switches, but it surfaced, nevertheless. This result suggests that task effects did not influence processing. What might these results mean? A possible explanation may have to do with awareness of the social stigma that is often attached to the linguistic act of code-switching. We know that bilinguals who have been exposed to code-switching from an early age (e.g. early bilinguals) often believe that code-switching is something that should be avoided because it is ultimately "wrong" to mix languages. For these bilinguals, code-switching may be attached to negative views and social stigma. In contrast, the bilinguals who participated in the presented study were late bilinguals (i.e. bilinguals who acquired the second language during adulthood). By virtue of being late bilinguals, these participants may not be completely aware of the stigma that is generally attached to code-switching. Therefore, when asked to judge the acceptability of the code-switches, their processing is probably more neutral and unbiased; that is, less informed by the social rejection of code-switching and simply influenced by what they have been exposed to from the time they acquired their second language and began codeswitching with other bilinguals. In theoretical terms, the results appear to suggest that the readers are sensitive to the distributional patterns found in production, regardless of how this is tested. If so, we would predict that the same effect would show up in tasks other than the two employed here as well as with other types of bilinguals. This is a question that remains for future work.

6. Concluding remarks

Despite the fact that more than half of the world's population is bi- or multi-lingual, models of sentence comprehension have been developed on the basis of work conducted primarily on monolingual data. Only recently has research involving bilingual speakers begun to test and, more broadly, to inform processing models in ways that would be impossible in studies limited to monolinguals. Interestingly, the work on language comprehension that has been conducted with bilinguals has limited itself to testing participants in one or the other of their languages. Bilinguals, however, do not always operate in a single language. Rather, in numerous bilingual communities around the world, speakers regularly code-switch between their languages during single stretches of discourse. In the work presented here, we argue that

research on the comprehension processes engaged while bilinguals read code-switched language add crucial data to our understanding of the architecture underlying human language processing, both in terms of the testing of model-driven predictions—such as those advanced by the PDC framework—and in terms of the expansion of the types of populations tested. In the pilot study discussed here, our intention was to show that research involving the study of code-switching from the perspective of the reader provides a fundamental context in which to examine comprehension models of reading processes, as it affords a unique view of the dynamically changing strategies available to listeners, who must process mixed language and multiple language systems in real time. From the perspective of the study of code-switching as a field of linguistic inquiry in its own right, our approach adds processing data to the growing body of evidence which indicates that code-switching is closely grammatically controlled, and that speakers employ processing strategies particular to the comprehension of code-switching that are not simply derived from the morpho-syntactic properties of either of their languages. More broadly, future studies should continue to articulate a carefully constrained experimental approach to the comprehension of code-switches, with cross-disciplinary contributions for theories of language processing and formal linguistic theorizing.

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