CHAPTER SIX

Production, processing, and prediction in bilingual codeswitching

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Abstract

Bilinguals in the presence of other bilinguals engage in codeswitching, the fluid and intentional alternation between languages during bilingual speech or text. Codeswitching has most prominently been studied from a theoretical and sociolinguistic perspective, but over the last 20 years, psycholinguists have increasingly turned their attention to understanding the cognitive and neural underpinnings of codeswitching. Despite its common use among bilinguals, understanding the production and comprehension of codeswitching presents unique challenges to current theories of sentence processing. We overview the planning, production, and comprehension of codeswitching, discussing the complex interaction between linguistic, cognitive, and social factors that modulate its use and its comprehension. This overview brings to the forefront an apparent paradox between measurable processing costs and the ease with which bilinguals engage in codeswitching, namely, that codeswitching introduces greater ambiguity into the linguistic signal yet does not lead to disruptive

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processing delays. To account for this contradiction, we propose the Adaptive Predictability hypothesis with two premises: bilinguals adapt predictive cues in sentence processing as a consequence of exposure to distributional regularities in production, and they recruit greater cognitive control in the service of rapidly integrating codeswitches in real time. We end the chapter by illustrating recent findings that support the Adaptive Predictability hypothesis and areas for future directions.

1. Introduction

Speaker A. …And that's going to include the message, o sea… quién lo vendió, el combo… todo eso.

Speaker A. Después, I'm going to have a spreadsheet para… keep track of nada ehm cuántos combos tenemos ehm who do we give it to porque el takeoff va a ser así. Like, tú pusiste nombre, yo tengo la lista, ah ok, tú pediste un combo, toma. ¿Entiendes? It's gonna be like that so…

Speaker B. [overlapping with prior turn] Básicamente… como que

Speaker A. Uh huh, in order to have todo de esta información, pues la mamá… la esposa del papá de C. me va a pasar todos esos datos, and I'm just gonna organize it in a spreadsheet. If you guys want, I can eh send it to you when it's… done.

Caption: Transcript of a segment of bilingual conversation happening between Puerto Rican middle school students during a meeting for a school fundraising event.

Examine the bilingual exchange above,[a] which involves several middle school-aged Spanish-English bilingual children at an after-school meeting to discuss logistics for a fundraising event. We have transcribed just under a minute of the recording. To visually aid the reader, we have color-coded the transcription to highlight the use of both languages. Sections that appear

[a] A colleague who works at a private English-medium middle school in Puerto Rico personally shared the recording of the conversation and provided permission to use it for illustrative purposes of bilingual speech.

in red are identifiably Spanish elements, and sections in black are identifiably English elements; elements that appear in blue are filler words and arguably language neutral; and purple indicates lexical items that potentially may be considered established borrowings. Just this short example underscores the complexities that can arise in bilingual speech and shows the nature of bilingual exchanges: common, grammatical, and nondisruptive to conversational exchanges.

One characteristic of bilingual speech that features prominently above is *codeswitching*, which we functionally define as the *fluid* and *intentional* switching between languages in bilingual speech and text[b] (e.g., Lipski, 1978; Poplack, 1980). Other researchers have offered broader definitions of codeswitching, including any instances in which the two languages may appear. The extent to which codeswitches include other bilingual language phenomena such as borrowings, loanwords, and calques remains highly debatable within the field (Bullock & Toribio, 2009). For us, "fluid" and "intentional" are key features of our definition. By fluid, we refer to the grammatical and phonological integration that seemingly occurs at the moment of the codeswitch. While there may be phonetic cues that subtly and reliably change before codeswitches (Fricke et al., 2016; Johns & Steuck, 2021), the phonologies of the two languages are respected in codeswitching. In other words, in the exchange above, the Spanish elements are not an imposition of English phonology on Spanish (aside from individual differences in one's own accent). We further specify intentionality. Codeswitching occurs in pragmatic contexts in which bilingual speakers dialogue with other bilingual speakers. One strong piece of evidence underlying this intentionality is that bilinguals can shift to speaking in one language alone when necessary and do not uncontrollably produce codeswitches in the presence of monolingual speakers. This intentionality also separates codeswitching from other bilingual phenomena such as lexical gap switches, in which a speaker may switch into a single word because they cannot access the lexical item in the target language in the moment.

The most widely-cited classification of codeswitches appeared in Muysken's (2000) classic monograph *Bilingual Speech*, which outlines a

[b] One important note: throughout the remainder of the paper, we will use the term "speech" to refer to both written and spoken modalities in oral languages. If a distinction needs to be made, we will distinguish between spoken modality and written modality. This terminological choice is in part motivated by the observation that there are minor structural differences in codeswitching when comparing spoken language and written language corpora (Callahan 2004; Guzzardo Tamargo et al., 2016; Montes-Alcalá 2000,2001).

typology of codeswitches that is linked to linguistic, psycholinguistic, and sociolinguistic factors. Built from analyses of bilingual corpora, Muysken proposes that codeswitches be classified into three possible categories: insertional, alternational, and congruent lexicalization. Insertional codeswitches involve the embedding of single phrases or words into an otherwise unilingual stretch of speech. Alternational codeswitches occur when speech starts in one language and continues into another. Congruent lexicalization is a special case of codeswitching that most obviously occurs when the two languages are structurally similar, and thus permits freer and more copious switching between languages (see examples 1–3 from Spanish-English bilingual codeswitching cited in Muysken, 1997):

1. *Yo anduve* in a state of shock *pa' dos días (Pfaff, 1979) [Insertion]*
   "I walked in a state of shock for two days"
2. *Ándale pues* and do come again *(Peñalosa, 1980) [Alternation]*
   "That's all right then and do come again"
3. *Bueno,* in other words, *el* flight *que sale de Chicago* around three o'clock *(Pfaff, 1976) [Congruent Lexicalization]*
   "Good, in other words, the flight that leaves Chicago around three o'clock"

Muysken's typology promotes that several factors can affect the incidence and type of codeswitching. A sociolinguistic study comparing two bilingual communities, French-English bilinguals in the Ottawa-Hull region of Canada and Spanish-English bilinguals in New York City, illustrates this point (Poplack, 1987). The language pairings represent an interesting comparison between English and a romance language in two regions that are economically comparable. Despite these similarities, Poplack documented differences across the two bilingual groups. The Spanish-English bilingual group engaged in more frequent and intricate codeswitching, demonstrating high flexibility in the syntactic junctures where codeswitching could occur. In contrast, the French-English bilinguals codeswitched less frequently and were more limited in the types of codeswitching that they produced. Poplack explains the difference as deriving from socio-political differences between the two communities. The Ottawa-Hull region exerted a greater social dispreference to codeswitching, likely reflecting the political tension that exists between French and English, especially in a border region between English-majority Ontario (Ottawa) and French-majority Quebec (Hull). This study demonstrates that beyond the linguistic factors that may contribute to codeswitching, a powerful social component must additionally be taken into account.

The complexities underlying bilingual speech that are reflected in Muysken's typology, and that can be surmised in the Ottawa-Hull/New York City example, lead to several questions. Why does the speaker choose to codeswitch, and what factors affect when codeswitches will be produced? Is there a communicative benefit to the listener or the speaker when bilinguals purposefully codeswitch? How does the listener anticipate or prepare for a codeswitch? Our goal is to provide a psycholinguistically plausible account, which we term adaptive predictability, for how bilinguals attune their production and comprehension systems for bilingual exchanges. We do not claim that this mechanism is specific to bilingual speakers who codeswitch; rather, codeswitching is a unique window that affords language scientists the opportunity to investigate connections between production and comprehension due to the heightened ambiguity that occurs during bilingual exchanges. We begin with a brief overview of theoretical models of codeswitching, followed by a closer look at speech planning and production of codeswitches. We then turn to the comprehension system and examine past studies that have focused on the real-time processing of codeswitched speech or text. The next section introduces the Adaptive Predictability hypothesis, which we illustrate with two recent studies. We then offer concluding remarks and future directions.

2. Theoretical accounts of codeswitching

Over the past four decades, linguists have proposed theoretical accounts for grammatical and ungrammatical instances of codeswitching. Researchers have used a variety of methods, including acceptability judgments (e.g., Liceras et al., 2008; González-Vilbazo et al., 2013), corpus-based analyses (e.g., Deuchar, 2020; Poplack, 1980, Torres Cacoullos & Travis, 2018), and production-based elicitation tasks (e.g., Gullberg et al., 2009; Munarriz-Ibarrola et al., 2022; Sarkis & Montag, 2021). Because it is uncontroversial that codeswitches are not random but are instead systematic and grammatical, these theoretical accounts have as a primary goal to propose unified accounts of codeswitching. However, the common ground stops there. Two primary issues have dominated theoretical debates. One is the contribution of each of the participating languages in codeswitching. Another issue is whether grammatical constraints are specific to bilingual grammars or not.

On the first issue, we have termed the distinction as symmetric and asymmetric approaches to codeswitching (Valdés Kroff, 2012). This distinction

centers on the theoretical stance of the researcher as to whether both languages neutrally contribute to the grammatical properties of code-switching or if one language "controls" the grammatical frame whereas the other language plays a more limited role. Symmetric approaches include early descriptive accounts most famously embodied by Poplack's (1980) Equivalence Constraint, which claims that codeswitches are only permissible if the two grammars are congruent or equivalent at the point of the codeswitch. Spanish and English differ in word order in the placement of object pronouns that are complements to the verb (4).

4a. *I bought it at the store yesterday.*
4b. *(Yo) lo compré en la tienda ayer.*
(I)it bought at the store yesterday

The placement of the object pronoun 'it' is post-verbal in English (4a) but pre-verbal in Spanish (4b). The Equivalence Constraint thus posits that a codeswitch before or after the verb is not licensed in Spanish-English codeswitching, i.e., **Yo lo bought at the store yesterday* or **I bought lo en la tienda ayer*. Symmetric approaches remain agnostic to the participatory role of the two languages or take a stance that they can equally contribute.

Asymmetric approaches are most clearly represented by Myers-Scotton's Matrix Language Framework (MLF, Myers-Scotton, 1993; Myers-Scotton & Jake, 2000). This framework takes direction from psycholinguistic models of production, in particular the separation between grammatical and lexical morpheme selection (Levelt, 1989). This approach is partially inspired by well-known speech error phenomena showing that lexical elements are swapped systematically but often leave their grammatical elements (inflectional morphology) in place, e.g., *the moving company lamped the ships* instead of *the moving company shipped the lamps*. The MLF attributes a single matrix language that sets the grammatical frame for codeswitched speech. Consequently, grammatical elements (e.g., conjunctions, complementizers, inflectional morphology, determiners) should come from one language alone. The embedded language plays a more limited role, contributing lexical items into a matrix language frame. In (5), for example, the matrix language, Acholi (underlined below), sets the grammatical frame while the embedded language, English, only contributes lexical items.

5. *chances me accident pol ka i- boarding taxi (Myers-Scotton & Jake, 2009)*
chances ASSOC accident many if 2SG-boarding taxi
"[The] chances of [an] accident [are] many if you board [a] taxi"

The second issue concerns how specific the constraints are to bilingual grammars. Theoretical constraints proposed in the 1980s and 1990s, such as the Functional Head Constraint (Belazi et al., 1994), relied upon language-specific mechanisms such as a language feature checking mechanism or a language node (Sankoff & Poplack, 1981) to account for codeswitched utterances. To illustrate, the Functional Head Constraint extended Abney's (1987) proposal that functional heads such as determiners and complementizers are generally required to select the features of their complement (a process that Abney refers to as f-selection) to include language index in bilingual speech as one of the features being checked. However, proponents of constraint-free accounts (Mahootian & Santorini, 1996; MacSwan, 1999) criticized these approaches as introducing bilingual-specific machinery, thus questioning its universality within the language faculty. Constraint-free approaches instead propose that bilingual codeswitching should be fully accountable simply by the grammatical properties of the participating languages. Constraint-free approaches now dominate theoretical accounts of bilingual codeswitching, and include minimalist approaches to codeswitching (e.g., González-Vilbazo & López, 2011) and approaches working within Distributed Morphology (López, 2020; Cruz, 2021).

3. Planning and production of codeswitched speech

Bilingual speech corpora (e.g., the New Mexico Spanish-English Bilingual corpus or NMSEB, Torres Cacoullos & Travis, 2018; the Bangor Miami corpus of Spanish-English bilingual speech, Deuchar et al., 2014) demonstrate that when bilinguals interact with other bilinguals, they use stretches of unilingual discourse, alongside fluid alternations between their two languages, adapting their linguistic demands on the fly according to their patterns of language use, their communicative intentions, and the immediate spoken context (Green, 2018:1). What is remarkable about this feat is that bilinguals seldom make language selection errors. One important question, then, is what mechanism bilinguals engage to move effortlessly in and out of their two languages.

Green and Abutalebi (2013) argue that eight domain-general control processes—*goal maintenance*, *interference suppression*, *salient cue detention*, *selective response inhibition*, *task engagement*, *task disengagement* and *opportunistic planning*—are recruited to different degrees by bilinguals to regulate their

two languages in everyday interactions (Green & Abutalebi, 2013:518-528). In their Adaptive Control hypothesis, three distinct interactional contexts, reflecting everyday conversational use of language, will require the differential recruitment of these control processes. In *dual language contexts*, where codeswitching is expected because both languages are used, the demands placed on control processes will be the greatest due to the need to engage and disengage the two linguistic systems. Control processes such as goal maintenance and interference control will be more pertinent in the *single-language contexts*, where only one language is used exclusively in a particular environment (e.g., speaking one language at home and another one at work), and where codeswitching would be viewed as an instance of a language intrusion error (Gollan et al., 2014). Finally, in *dense-codeswitching contexts*, where bilinguals routinely mix freely between their two languages within a single utterance, the demands are expected to be the smallest. The Adaptive Control Hypothesis also recognizes that bilinguals may find themselves predominantly in only one of these three contexts or may shift from context to context, requiring cognitive control mechanisms to adapt accordingly. More recently, Green (2018:12) has argued that changes in bilinguals' language use specifically—not just the greater social context itself—may also differentially engage cognitive control mechanisms. To illustrate, whereas dense codeswitching may instantiate an open control state, where monitoring and interference suppression at a local (i.e., lexical) level would be required, insertional codeswitching would necessitate the engagement and disengagement of the participating languages, therefore requiring global inhibition. As such, dense codeswitching would promote a broader attentional state relative to insertional switching, which would require a narrow attentional state. Importantly, these control mechanisms are argued to be domain general rather than language specific (Green & Abutalebi, 2013), with the implication that the process of adapting to different task demands during the production of codeswitched language may have ramifications not only for language-related processes but also for non-linguistic tasks.

Although studies testing the Adaptive Control Hypothesis have been difficult to carry out given the methodological challenges that come with recording brain activity while participants speak to other bilinguals, comprehension studies that simulate bilingual discourse and naturalistic interactions are beginning to provide the first pieces of evidence that bilinguals' interactional contexts modulate the engagement of language control networks. Kaan et al. (2020) examined whether bilinguals could dynamically shift

between attentional control states depending on whether another bilingual speaker or a monolingual speaker was present during a reading task involving unilingual and codeswitched sentences. The EEG findings showed an early frontal positivity effect that was largest when bilinguals read codeswitched sentences in the presence of a known monolingual interlocutor. Because past research had shown that the prefrontal cortex and anterior cingulate cortex are primarily involved in language control and cognitive control, the finding provided evidence that knowledge of the interlocutor's language modulates the engagement of language control in bilinguals. A second piece of particularly strong evidence comes from a study by Blanco-Elorrieta and Pylkkänen (2017), who recorded MEG responses in a study investigating cued language switching and natural language switching in a setting that simulated (or not) naturalistic interactions. In production, participants' language choice (Arabic or English) was determined by a color cue or was socially-conditioned by a facial cue of an individual introduced as a monolingual or bilingual speaker. In the comprehension study, the processing of isolated word switches was compared to the comprehension of language switches in natural Arabic-English conversations. Blanco-Elorrieta and Pylkkänen found that in production, voluntary switching did not engage the prefrontal cortex or elicit behavioral switch costs. The comprehension study showed that the anterior cingulate and prefrontal cortex regions were more involved when language switching was externally-cued by a color stimulus relative to listening to naturalistic codeswitched conversations. The evidence stemming from these comprehension studies only provides indirect support for the differential recruitment of different control processes during the production of codeswitched language. Notwithstanding, support from related fields of study (e.g., motor control) have demonstrated that imagery engages a network of cortical, subcortical, and cerebellar regions that largely overlaps with the network for actual execution (see, for example, Hardwick et al., 2018; Jeannerod, 2001). In this sense, these results described here support the hypothesis that the diversity of bilingual experiences differentially modulates the engagement of cognitive processes (see also Beatty-Martínez & Dussias, 2017 for related findings).

The premises of the Adaptive Control Hypothesis highlight the fact that being bilingual does not, in and of itself, require the engagement of a unique pattern of cognitive control. An important future line of research is to explicitly test the prediction of the hypothesis against different types of codeswitches. This is a point raised by Treffers-Daller et al. (2020), who discuss that Green and Abutalebi's (2013) reference to "dense

codeswitching" remains rather underspecified: whereas in some cases it refers to insertional codeswitching (example (3) above), other times its reference includes alternations such as those shown in example (4). Correlational results reported in Hofweber, Marinis, and Treffers-Daller (2016) suggest that bilinguals' performance on executive control tasks (measured in their study by a Flanker task) is affected by the frequency with which bilinguals engage in codeswitching, along with the specific type of intrasentential codeswitching they use within their social network. A next step would be to find direct evidence by capitalizing on the method with high temporal resolution to track the unfolding of neural activity as it occurs millisecond by millisecond.

3.1 Why do bilinguals codeswitch?

One approach to answer this question has been to ask codeswitching bilinguals why they codeswitch. As with most metalinguistic reflections, the answers are after-the-fact explanations that are unreliable. Bilinguals often surmise that they codeswitch to fill linguistic gaps (Heredia & Altarriba, 2001). Fueling this assumption is the persistent, yet mistaken, belief among parents, educators, and healthcare providers that codeswitching reflects mental laziness and is a sign of alingualism or an inability to maintain the two languages separate. As critical linguistic, psycholinguistic, and neurolinguistic attention has been directed to the study of codeswitching, one unsurprising result has been that only those bilinguals who are linguistically competent in their two languages produce fluid and rule-governed language alternations (Lipski, 1982; Myers-Scotton, 1993; Poplack, 1980), thus directly challenging these ill-formed perceptions of bilingual language use. Instead, bilingual codeswitching should be seen as a complex and skillful speech act that requires a high degree of proficiency and coordination across a bilingual's languages. Below we discuss several bottom-up processes that may partially explain why bilinguals codeswitch.

3.1.1 Lexical accessibility

An oft-cited reason for engaging in codeswitching relies on the notion of *lexical accessibility*—codeswitching takes place when bilinguals experience difficulty retrieving a word in the current language that best conveys the intended meaning. Bilinguals, like monolinguals, also experience *tip-of the-tongue* (TOT) word retrieval failures, which they might resolve by resorting to codeswitching. And indeed, lab research has shown that bilinguals experience more TOTs than monolinguals. Several reasons have been

proposed to explain this difference: competition for selection between translation equivalents (Kroll et al., 2006; Sarkis & Montag, 2021), reduced frequency of use of words in each language (Gollan et al., 2011; Pyers et al., 2009), and interference with the accessibility of one of the languages due to immersion in the other one (Linck et al., 2009). While the evidence that bilingual speakers experience word retrieval difficulties is undisputed, the notion that bilinguals predominantly switch as a strategy to make up for word finding difficulties faces substantial challenges. First, inspection of naturally produced bilingual speech (e.g., Torres Cacoullos & Travis, 2018; Chapters 2 and 3) has documented that single other-language noun insertions are the most frequent type of language switch (Poplack, 1980; Torres Cacoullos & Travis, 2018). If switching exclusively fills in lexical gaps, it would mean that bilinguals are "in a constant TOT state"—a proposition that would be at odds with the observation that codeswitching is fluid and intentional. Second, the lexical accessibility account predicts that only words that are subject to frequency effects (e.g., nouns, verbs, etc.) should participate in codeswitching; however, evidence from bilingual corpora suggests that closed-class words are also switched, as shown in (6) below (switched closed class lexical item in italics):

6. *I could understand* que *(that) you don't know how to speak Spanish, ¿verdad? (Poplack, 1980: 596).*

Third, in balanced bilingual communities such as the Spanish-English bilingual community living in northern New Mexico where codeswitching is remarkably balanced with respect to switch direction and the nearly even distribution of unilingual English and unilingual Spanish clauses, we would expect similar rates of noun insertions in mixed noun phrases (e.g., *el shoe*, *the zapato*). However, analyses of these bilinguals' spontaneous speech reveal that they disproportionately opt for inserting English nouns when speaking Spanish over inserting Spanish nouns when speaking English (Torres Cacoullos et al., 2022). Furthermore, English noun insertions into Spanish include high frequency words such as kinship terms, suggesting that language-use norms, coupled with the control demands of bilinguals' interactional context also play an important role (Green & Abutalebi, 2013; Green &Wei, 2014; Beatty-Martínez et al., 2020b).

3.1.2 The Triggering Hypothesis

The *Triggering Hypothesis,* introduced in Clyne (1967), proposes that when bilinguals using one language access a word whose language-specific

membership is ambiguous, such as homophones (e.g., *fin* meaning *end* in Spanish; or *pan* meaning *bread* in Spanish), proper nouns (e.g., *Walmart*; *Target*), borrowed words (*taco, tortilla, queso*), or lexical transfers, the raised level of activation of the language not in use sometimes precipitates (i.e., triggers) a switch into that language. Cognate words are thought to be predilect triggers due to their overlapping phonology, orthography, and meaning in the bilinguals' languages. In the trilingual Spanish-Italian-English example below, *disprezzare*, an Italian cognate with Spanish (*despreciar*) and English (*despise*—although the valence in English is more negative than in Italian or Spanish) is interpreted as triggering the codeswitch into English in (7):

7. *no porque quiero* disprezzare *a mi language, Italian*
not because (I) want to despise (to) my language Italian
"Not because I want to belittle my language, Italian"
Clyne (1997:109)

Testing the predictions of the triggering hypothesis has been the object of many recent studies (Broersma, 2009, 2011; Broersma et al., 2009, 2020; Broersma & De Bot, 2006; Bultena et al., 2015; Fricke & Kootstra, 2016; Gullifer & Titone, 2019; Li & Gollan, 2018; Neveu et al., 2022), with corpus data generally confirming the privileged status of cognate words as triggers to codeswitches. For example, Broersma and De Bot (2006) report that codeswitches occur more frequently directly after a cognate or a proper name, and Broersma et al. (2020) found that codeswitches occur more frequently in clauses containing cognates than in clauses without cognates. These authors also found that the number of cognate words within a clause increases the likelihood of codeswitches downstream (see Van Hell, 2023, for a review). These findings suggest that language switches are more likely to occur when the target word is relatively more accessible to the speaker. However, recent evidence has challenged the conclusion that certain words serve as triggers for codeswitches. At stake is the role of single-word insertions in mixed speech. Past studies that have classified single word insertions as codeswitches have found support for the triggering hypothesis. However, some researchers argue for the need to distinguish between single word insertions and multi-word codeswitches (e.g., Poplack et al.,1988). When this distinction is made, rates of codeswitching do not vary according to the presence or absence of trigger words; instead, codeswitches co-occur with codeswitches more than with trigger words (Trawick, 2021), leading to the hypothesis that perhaps priming promotes codeswitching.

3.1.3 Priming effects

Within a dominant language, some sentence structures are more frequent than others. For example, dominant English-speaking adults are more likely to use the active sentence 'The chairman is suggesting a compromise' over the passive sentence 'A compromise is being suggested by the chairman' (examples taken from Bock, 1986: 383). In a classic study, Bock (1986) showed that it was possible to override the bias for active sentences if a speaker first heard and then repeated a sentence spoken in passive voice. This syntactic repetition effect, referred to as *syntactic priming*, is thought to serve several cognitive and social functions, among which are promoting fluent language production (MacDonald, 2013) and coherence during social interactions (Pickering & Garrod, 2004), supporting the learning of syntax (Dell & Chang, 2014), and promoting and guiding predictive language processing (e.g., Dell & Chang, 2014, Pickering & Gambi, 2018).

In the bilingual literature, scholars have asked whether languages that share syntactic structures lead to cross-linguistic priming. To illustrate, Hartsuiker, Pickering and Veltkamp (2004) examined whether English passive sentences were produced more frequently following a Spanish passive than a Spanish intransitive or active sentence. The results showed that cross-language priming effects were similar to the within-language priming effects, leading Hartsuiker et al. to the proposal that the syntactic computations for each of the bilingual's two languages make use of the same abstract syntactic-level information. This finding begs the question of whether priming might be a mechanism that helps explain why codeswitching occurs.

In their analysis of naturally produced speech from the Bangor Miami corpus (Deuchar et al., 2014), Fricke and Kootstra (2016) found that signature priming effects first described in studies with monolingual speakers were present in bilingual codeswitched discourse. Of note in their study, they found that bilingual speakers were more likely to codeswitch when the immediately preceding utterance also contained a codeswitch. They also observed that lexical overlap boosted the tendency to codeswitch, consistent with past experimental work showing that cross-language priming effects are generally stronger when there is lexical overlap and shared word order across languages (Kootstra et al., 2010). In addition, a speaker's tendency to codeswitch is primed more by their own speech (within-speaker priming) than by the speech of others (between-speaker priming or comprehension-to-production priming). In a recent lab-based

study, Kootstra, Dijkstra, and Van Hell (2020) used the confederate-scripted priming task, where a naïve participant engages in a referential communication task with a lab member who presents as another participant, to investigate codeswitching behavior in a group of Dutch-English bilingual speakers. Analyses of a picture description task showed codeswitching was more common when the confederate had codeswitched in the preceding trial; in addition, the likelihood of a codeswitch was even greater when a cognate was also present, demonstrating the impact of cross-language priming on codeswitching (see also Torres Cacoullos & Travis, 2018).

While the studies reviewed in this section underscore the impact that bottom-up processes have on codeswitching behavior, it is also important to recognize bilinguals most often produce unilingual speech. The estimated rate of codeswitches in the New Mexico Spanish-English bilingual corpus is 11% (Trawick, 2021: 82), and Fricke and Kootstra (2016) note that only about 5.8% of the utterances in the Bangor Miami corpus contains intrasentential codeswitches. Leaving aside the specifics of how the percentages were calculated (a matter that is not trivial), these figures strongly indicate that despite high levels of cross-language activation, priming effects—no matter how robust they might be—are insufficient to account for how bilinguals use their two languages. Instead, a speaker's communicative intentions exert top-down control over codeswitching practices to achieve communicative objectives, "opportunistically threading together words and phrases from each language in order to convey the intended meaning" (Beatty-Martínez et al., 2020a: 2; cf. Fricke & Kootstra, 2016: 195).

Studies examining speech articulation in bilingual speakers provide some evidence of a certain degree of cross-language effects adjacent to a codeswitch. When English and Spanish have been the languages under investigation, voice onset time has been the preferred target of study, given obvious differences between the two languages. Voice onset time (VOT) refers to the temporal lag of vocal fold vibration (voicing) following the occlusion produced in a stop consonant (e.g., /p/, /t/, /k/). Spanish VOT of voiceless stops is characterized by a short lag of approximately 0-30 milliseconds (Lisker & Abramson, 1964; Abramson & Lisker, 1973), whereas English VOT has a lag duration between 30 and 90 milliseconds. In this respect, Spanish is considered a 0-lag language because voicing begins shortly after the release of the voiceless stop, whereas English is considered a positive-lag language because in certain phonological contexts some time passes between the release of the stop and voicing, often realized as a puff of air (e.g., Spanish *pata* [pata], English *pot* [p^{ha}t]).

Examining spontaneously produced speech, Balukas and Koops (2015) found interesting asymmetries in VOT values between English and Spanish for words in close proximity of a codeswitch. Whereas Spanish words near a codeswitch did not result in a significant increase in Spanish VOT values in the direction of English, the converse was true such that the VOT of English words in the vicinity of a codeswitch into Spanish were significantly reduced (i.e., more Spanish-like). Fricke, Kroll, and Dussias (2016) similarly found that words in the proximity of codeswitches showed slower speech rate and exhibited cross-language phonological influence on consonant VOT (Bullock, 2009; Olsen 2013).

These changes in the properties of acoustic features in bilingual speech could be viewed either as a consequence of the cognitive demands associated with codeswitching, which result in the unintended activation of the non-target languages, or as processes related to opportunistic planning in anticipation of producing an intended codeswitch (Beatty-Martínez et al., 2020a; Beatty-Martínez et al., 2020b). To shed light on this question, Johns and Steuck (2021) conducted analyses of the codeswitched speech in the New Mexico Spanish-English bilingual corpus, couching their hypothesis on the premises of MacDonald's (2013) Production-Distribution-Comprehension (PDC) model. The PDC model proposes that production is shaped by a combination of an individual's linguistic experience and by cognitive limitations on production: production is difficult, but our own experiences as a language user, along with the cognitive strategies speakers employ, can alleviate this difficulty. One such strategy is the *easy first bias:* easier-to-produce features of language will tend to occur before harder-to-produce ones in a production episode. The goal is to 'buy time' for the production system to plan the more difficult elements without disrupting the fluidity characteristic of spontaneous speech. Johns and Steuck reasoned that if switching languages is cognitively more demanding than staying in one language, then it should occur later in a production episode, which they confirmed in their analysis. Importantly, while this may suggest that codeswitching is difficult to plan and produce, an alternative interpretation is that codeswitching could serve as one of several strategies that bilinguals use to alleviate difficulties when they arise. To test this, they further examined speech rates in the codeswitched utterances and compared them to carefully matched Spanish- and English-only production from the same speakers. They found that speech rates surrounding a codeswitch were significantly *faster* compared to unilingual production. Thus, codeswitching may be more likely to occur when production gets

difficult, however, not as the source of the difficulty but as a mechanism to alleviate it. In other words, codeswitching is one of various tools that bilingual speakers employ to facilitate effortful speech planning and production (cf. Sarkis & Montag, 2021).

This section has focused on discussing findings that shed light on a question that has been of great interest to scholars, parents, and teachers alike: why do bilinguals codeswitch? We have provided a cursory overview of the research that contributes to our understanding of the bottom-up factors that contribute to the production of a codeswitch and have also presented arguments to show that these factors are insufficient to explain the overall pattern of data available to date. Ultimately, bilinguals codeswitch "because they can."

3.2 What do naturally produced codeswitches look like?

One important finding in the codeswitching literature is the presence of asymmetries in the production of codeswitched speech. Earlier we discussed asymmetries in the phonetic realization of VOT when voiceless stop consonants in Spanish and English are in the vicinity of a codeswitch. Here, the focus will be on different a type of asymmetry: one that arises from bilinguals' syntactic choices at particular codeswitching sites. We will limit our discussion to two examples often cited in the literature of Spanish-English codeswitching, a pair of languages that has been examined extensively in codeswitching studies.

Several studies examining the production of Spanish-English intrasentential codeswitches (e.g., Lipski, 1978; Poplack, 1980) have alluded to an asymmetry involving alternations within the auxiliary phrase. Specifically, when the direction of the codeswitch is from Spanish into English, switches in which the Spanish auxiliary verb *estar* (English *be*) is followed by an English present progressive verb (examples (8) through (11) below) are produced with similar frequency as switches at the verb phrase boundary (e.g., example (12) below):

8. *Mi marido está working on his Master's (Lipski, 1978: 252)*
"my husband is working on his Master's"

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

10. *Estaba training para pelear (Pfaff, 1979: 296)*
"(He) was training to fight"

11. *Siempre está promising cosas. (Poplack, 1980: 596)*
"(He) is always promising things."

12. *El niño is trying to catch mariquitas. (Rodrigo & Dussias, in prep)*
"The boy is trying to catch ladybugs."

In contrast to *estar/be* + English verb switches, switches in which the Spanish auxiliary *haber* (*to have*) is followed by an English participle verb form are rare in Spanish-English codeswitching corpora. One of the few cases found in production data is shown in (13):

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

Guzzardo Tamargo, Valdés Kroff, and Dussias (2016) examined available oral and written Spanish-English codeswitching corpora to confirm the distributional patterns involving switches at these two syntactic sites. The oral corpus was the Bangor Miami Corpus of Spanish-English bilingual speech mentioned earlier (Deuchar et al., 2014). Twenty-six transcriptions (approximately 390,000 words) were analyzed. The written corpus was extracted from a weekly editorial column of a bilingual newspaper published in Gibraltar. Eighty-eight editorial codeswitched column entries (approximately 25,300 words) were examined. Despite differences in modality between written and spoken language, the data extracted from the two corpora confirmed the existence of asymmetric patterns.

A second well-documented asymmetry observed in virtually every corpus that has been examined to date concerns mixed noun phrases (or mixed NPs). Corpus analyses have reported the systematic and widespread use of gender-marked masculine determiners (*el*/the$_{MASC}$; *este*/this$_{MASC}$; *muchos*/many$_{MASC}$) with English nouns whose Spanish translation equivalents are marked with masculine or feminine grammatical gender (See (14) and (15) below). However, codeswitches involving gender-marked feminine determiners (*la*/the$_{FEM}$; *esta*/this$_{FEM}$; *muchas*/many$_{FEM}$) have been observed to occur less frequently and are restricted to English nouns whose translation equivalents are marked with feminine grammatical gender (see (16) and (17) below). This asymmetry differs from that in unilingual contexts, where masculine and feminine nouns are evenly distributed (Eddington, 2002), suggesting a codeswitching strategy that results from the interaction between the two languages.

14. *En el* winter
"In the winter"

15. *El* flag
"the flag"
16. *con la* flashlight *en una mano*
"with the flashflight in one hand"
17. *We went to that floating garden*
que hay muchas *flowers*
"that there are many flowers"

Why are asymmetries important? First, as discussed in Beatty-Martínez et al. (2020a), bilingual speakers use their languages in different ways; not all syntactic sites participate equally in codeswitching, just like not all contexts of language use incur the same cognitive demands during the production of codeswitched language. The task at hand is to uncover "… of the places where bilinguals can switch, where they prefer to do so" (Torres Cacoullos & Travis, 2018: 175). Second, mounting evidence has shown an intimate connection between production patterns and comprehension difficulty. One influential model of monolingual language processing that has sought to capture this link is MacDonald's (2013) PDC model, mentioned earlier. Briefly, the PDC proposes that cognitive limits on language planning and production, such as those related to memory and retrieval, shape the distributional properties of language. If indeed comprehension skill is tied to individuals' production preferences, documenting codeswitching asymmetries in production choices is important because distributional patterns in the production of code-switches lead to the clear prediction that codeswitching bilinguals should demonstrate asymmetric processing patterns that do not match unilingual processing. We take up this issue again in Section 5.1 below.

4. The real-time processing of codeswitched speech

A cornerstone finding in sentence processing is that the human sentence parser is incremental and predictive, continuously and dynamically updating interpretations as new linguistic input unfolds. The parser builds interpretations guided by phonological, lexical, syntactic, and semantic information, as well as extra-linguistic information such as speaker, setting, or pragmatic context (e.g., Altmann & Kamide, 1999; Garnsey et al., 1997; Trueswell et al., 1999). The field continues to hold important debates in terms of when linguistic and extra-linguistic information come online to aid parsing, as well as whether prediction is lexically specific or more probabilistic (Kuperberg & Jaeger, 2016). Nevertheless, there is strong evidence for the observation that speakers of a first or dominant language can

anticipate speech under certain conditions. Meanwhile whether the same characteristics are observable in speakers of a second, late acquired language remains more debatable, but recent work reveals the capacity to efficiently anticipate upcoming linguistic input under certain constraints and with sufficient proficiency in the second language (Kaan & Grüter, 2022).

To demonstrate incremental parsing, we discuss a classic study on verb bias (i.e., a verb's preferential subcategorization frame) by Garnsey et al. (1997). Verbs such as "discover" and "believe," as in examples (18) and (19) below, appear in different structural configurations. Both verbs can optionally select a direct object complement (18a, 19a) or sentence complement (18b, 19b). Yet examination of different production corpora coupled with sentence completion studies indicate that some verbs are more likely to co-occur with specific structures. Thus, in English, "discover" is often followed by a direct object (18a) but "believe" is more often followed by an embedded sentential complement (19b; examples taken from Garnsey et al., 1997):

18a. *The scuba diver discovered the wreck behind the hidden coral reef.*
18b. *The scuba diver discovered the wreck was caused by a collision.*
19a. *The job applicant believed the interviewer despite her pointed questions.*
19b. *The job applicant believed the interviewer was dishonest with her.*

Of note, this frequency difference is, in part, language-specific (i.e., translation equivalents across languages may show different frequency co-occurrences, Cuetos & Mitchell, 1988; Dussias et al., 2010).

According to constraint-based or experiential theories of sentence processing, such distributional differences affect online sentence processing at the earliest moment. Such theories predict that L1 speakers of English will demonstrate differential processing speeds based on whether the structural configuration matches the speaker's expected verb bias. In line with such predictions, Garnsey et al. (1997) showed that in 18b, participants initially *garden path* (Bever, 1970) interpreting "the wreck" as a direct object, leading in turn to slower reading times when encountering the embedded verb "was caused." In contrast, participants did not encounter this slowdown in (19b), presumably because the post-verbal noun phrase was assigned the role of sentential subject. This finding has subsequently been confirmed using other methodologies such as EEG (Román et al., 2022) and for L2 readers who have familiarity with a verb's distributional bias (Dussias & Cramer Scaltz, 2008).

This line of research demonstrates two important points. First, during sentence processing, humans exploit probabilistic information from their linguistic input and use it to generate expectations about upcoming input

(e.g., Gahl & Garnsey, 2006; MacDonald, 2013). Second, the observation that humans experience delayed processing or garden-path effects strongly suggests that comprehenders do not wait to reach the end of a clause to begin to build interpretations, instead making commitments incrementally while new information becomes available. When comprehenders encounter incorrect initial interpretations, they revise them based on later-arriving information.

The fundamental characteristic of incremental parsing in human sentence processing raises further issues when considering codeswitching. As codeswitching involves alternations from one language into another at variable syntactic positions, its use entails the constant coordination of two grammars at multiple linguistic levels (e.g., phonology, morphology, syntax, semantics). This coordination across grammars potentially introduces greater ambiguity into the linguistic signal. It may also momentarily lead to representational conflict if the produced codeswitching structure differs from unilingual structures (we discuss this point in more detail below). Moreover, the psycholinguistics of bilingualism robustly finds that bilingual lexical access and processing is non-selective; even when bilinguals intend to stay in one language alone, their non-target language remains co-active to varying degrees, and only under very limited circumstances is it possible to completely "shut off" the other language (Kroll & Gollan, 2014; Kroll et al., 2015). Consider the logical alternative: for comprehension, it should be simpler to remain in the same language within a conversation than to introduce additional ambiguity into the speech signal by codeswitching. Nevertheless, we know that bilinguals choose to ubiquitously codeswitch under the right pragmatic contexts and that such practice does not visibly result in confusion or a breakdown to comprehension. The question, then, is how?

Codeswitching is presumably under the speech planning control of the speaker, as discussed in Section 2; however, there are potentially no clear, explicit signals to the comprehender that a codeswitch may occur, nor that the switch may potentially induce conflict across the two languages. We demonstrate this potential conflict in example (20), taken from the Bangor Miami Corpus (Deuchar et al., 2014):

20. pero no tenían el *flag out there? [sastre 09]*[c]
but NEG have-3PL.IMP the-MASC flag out there
"but didn't they have the flag out there?"

[c] The name in brackets is the corresponding file in the Bangor Miami corpus from which the example is extracted, see https://biling.talkbank.org/access/Bangor/Miami.html.

The utterance was made without any apparent pauses or hesitations by the speaker; the switch occurred at the Spanish definite masculine article *el* and then continued into English. This example highlights the potential challenges for the comprehender. One well-known cross-linguistic difference between Spanish and English is the presence of grammatical gender in Spanish and its absence in English. All Spanish nouns are classified in a binary grammatical gender category (feminine, masculine), and modifying elements such as determiners and adjectives must agree in grammatical gender with the corresponding noun. Psycholinguistic studies have demonstrated consequential effects of this characteristic of gendered languages for sentence processing. When processing a gender-marked pre-nominal word such as an article, listeners anticipate the gender of the upcoming noun (Dussias et al., 2013; Hopp, 2016; Lew-Williams & Fernald, 2007, Morales et al., 2016; Paolieri et al., 2020). This effect, known as the grammatical gender congruency effect (see Beatty-Martínez & Dussias, 2019 for review), leads to bilinguals experiencing significant delays in processing when encountering a noun that does not agree in gender with the preceding element (Barber & Carreiras, 2005). Consequently, pre-nominal elements that overtly mark grammatical gender serve as predictive or facilitatory cues in sentence processing.

Returning to Example (20), there are two reasons to assume that switching at this site ought to give rise to processing difficulties. First, the robustness of the gender congruency effect presupposes a strong dependency between Spanish articles and Spanish nouns. Therefore, an English noun after a Spanish article should be an unexpected event. A second, more complex observation is that the Spanish translation equivalent of *flag* is a feminine noun, *bandera*. Consequently, it conflicts with the preceding gender-marked definite article, *el*, which is masculine. This and other similar examples should be problematic during online processing for Spanish-English bilinguals. Essentially, if Spanish-speaking individuals commit to Spanish-like processing, then they should expect Spanish masculine nouns to follow masculine articles. Nevertheless, this specific type of switch is highly frequent among Spanish-English bilingual speakers and within certain bilingual communities (e.g., Poplack, 1980; Torres Cacoullos & Travis, 2018) and does not saliently appear to disrupt communication.

As will be discussed in greater detail below, experience with codeswitching can lead to changes in the time course of how these structures are processed (e.g., Valdés Kroff et al., 2017). This specific example illustrates the need for bilinguals to avoid costly garden paths in codeswitching

contexts, especially when these contexts differ in numerous ways from unilingual contexts. Our claim is that bilinguals adapt and shift the cues that they rely upon during sentence processing, a phenomenon that we term *adaptive predictability*. Adaptive predictability stems from the same mechanisms operant under constraint satisfaction accounts, thus extending these notions into bilingual contexts.

To further underscore the seemingly challenging demands that face the bilingual comprehender, lab-based studies on sentential codeswitching find apparent switch costs to comprehension. Using time-based measures such as reaction times (e.g., self-paced reading), fixations and regressions (eye-tracking), pupil dilation (pupillometry), and neurocognitive measures (e.g., event-related potentials, ERPs), encountering a switch into another language can lead to a slowdown or an unexpectancy in processing (e.g., Altarriba et al., 1996; Moreno et al., 2002; Bultena et al., 2015; Johns & Dussias, 2022; Litcofsky & Van Hell, 2017). However, some studies show that these switch costs can be attenuated under certain circumstances, such as when the codeswitch is more frequent (e.g., Beatty-Martínez & Dussias, 2017; Guzzardo Tamargo et al., 2016; Kheder & Kaan, 2019; Salig et al., under review; Valdés Kroff et al., 2017, 2020), when taking into account language dominance and direction of the switch (e.g., Litcofsky & Van Hell, 2017; Fernández et al., 2019), or when considering the ecological validity or the pragmatic context underlying the experimentally presented codeswitch (Blanco-Elorrieta & Pylkkänen, 2017; Johns et al., 2019; Kaan et al., 2020; Tomić & Valdés Kroff, 2022; Tomić & Kaan, 2022. See Beatty-Martínez et al., 2018; Blanco-Elorrieta & Pylkkänen, 2017; Valdés Kroff et al., 2018 for extended discussions on these issues and why they may arise). These findings more broadly align with how humans engage with general switching phenomena. In cued language switching tasks where participants are asked to name a picture or digit in which a language is externally signaled via a visual or auditory cue (e.g., color of background screen), bilinguals are slower to name on switch trials as compared to same-language trials (e.g., Meuter & Allport, 1999). Similarly, in studies where participants are asked to indicate a response that switches between two dimensions, such as indicating the color or shape of a figure, participants are slower to respond on trials that switch between tasks relative to responding to the same task (e.g., Monsell, 2003). Yet there are also appreciable differences between these highly controlled externally cued languages switching paradigms and the naturalistic switching that occurs within bilingual speech. For one, switch costs in cued language switching are robust

in production but are weak or non-existent in comprehension (Declerk et al., 2019; Declerck, 2020), while the opposite appears true for sentential codeswitching (Altarriba et al., 1996; Moreno et al., 2002; Beatty-Martínez et al., 2020a). Second, cued language switching studies are mostly focused on lexical switching and overwhelmingly represent one grammatical category, nouns, while sentential code-switching occurs at a variety of syntactic switch junctures and can involve multiple words. Thus, even though we can draw certain inferences between cued language switching and sentential codeswitching paradigms, the extent to which the same cognitive and neural processes are involved in both phenomena is not yet well-understood.

In this section, we have discussed how incremental parsing and codeswitching highlight an apparent paradox in that it should be costly for comprehension, yet its ubiquity in bilingual and multilingual speakers suggests that it is not. We argue that these contrasting findings require a different approach to how we consider these issues, one that focuses on how bilinguals better prepare the comprehension system for bilingual language use. In the next section we outline the Adaptive Predictability hypothesis.

5. Adaptive prediction in codeswitching

We propose the Adaptive Predictability hypothesis to account for the real-time integration of codeswitched speech in online comprehension. The hypothesis is composed of two core premises. First, bilinguals adapt the way in which they process bilingual speech, especially how they predict upcoming linguistic information, because of accumulated experience with codeswitched speech (i.e., adaptability). Second, cognitive control is the primary domain-general cognitive mechanism that supports rapid integration of other-language information in online comprehension. Underlying the hypothesis is the assumption that codeswitching is a highly skilled speech act that one acquires through experience that is not immediately accessible to all bilinguals in online processing. Our hypothesis is an extension of experience-based accounts that considers ways in which ongoing language experience shifts the cues that comprehenders rely upon to not only guide prediction but also actively not to predict in circumstances that would otherwise lead to non-optimal processing of bilingual input.

5.1 Adaptive prediction

Bilinguals demonstrate adaptability in codeswitching by shifting the weighting of different sentence processing cues. For prediction in sentence processing, this shifting entails adapting when to predict and when not to predict, even in contexts that are predictive in monolingual processing. This adaptive behavior, which results from cumulative experience, best prepares the comprehension system for a *possible but not guaranteed* codeswitch in upcoming speech. In other words, the bilingual listener must consider a trade-off between actively predicting or holding off on predicting upcoming information. The intention to delay active prediction becomes an optimal and efficient strategy for the bilingual comprehender if it aids in avoiding disruptions arising from predictive commitments that ultimately are wrong (i.e., predicting Spanish-like processing when instead, a codeswitch into English occurs). This adaptation will require dynamic changes from those cues that facilitate monolingual sentence processing, thus fundamentally making bilingual sentence processing qualitatively different on the surface, even when comparing the dominant language of the bilingual. Yet, the mechanisms that bilinguals rely upon are the same as those that monolinguals recruit; simply put, the language input bilinguals encounter blurs the line between languages, speakers, and contexts thus leading to varied experiences from monolinguals and even from other bilinguals.

At the phonological level, we see evidence for facilitated processing arising thanks to the existence of cross-linguistic phonetic differences that can signal to the listener an impending codeswitch on the part of the speaker. Corpus and experimental studies have demonstrated that subtle shifts in VOT can occur before a codeswitch (Balukas & Koops, 2015; Bullock, 2009). Recent research has shown that these shifts are used by bilingual listeners, along with a host of other cues (e.g., slower speech rate, disfluencies, cross-linguistic differences in the permissibility of complex consonant clusters) to anticipate an upcoming codeswitch (Fricke, et al., 2016; Li, 1996; Olson 2013; Shen et al. 2020). Whether these sub-phonemic and speech rate differences are the result of articulatory pressures or are a pragmatic means of signaling to the listener an impending codeswitch remains an open question; however, because these physical properties can uniquely differentiate between unilingual and bilingual speech, listeners are able to exploit them to aid comprehension. We find similar patterns in monolinguals and the inferences that they make when speakers are disfluent. Listeners interpret disfluencies such as "uh" and "uhm" as signals that new or less frequent

information is upcoming (Arnold et al., 2003, 2004, 2007) but only do so when the speaker is a dominant speaker and not when an L2-accented speaker produces similar disfluencies (Bosker et al., 2014).

At the morphosyntactic level, bilingual speakers capitalize on codeswitching asymmetries that surface in production (see Section 3.2). Grammatical notions of constituency, clause boundary, and congruence are likely to play a role in determining common versus less common codeswitches. For example, both children and adults are sensitive to the processing cost of inter- v. intra-sentential codeswitching, as reflected by pupillometry (Byers-Heinlein et al., 2017), an implicit measure of the diameter of the pupil that serves as an index of cognitive or processing effort. On the other hand, in structurally similar constructions (such as within the noun phrase in Spanish and English), community practices may instead lead to distributional asymmetries, which in turn, should lead to differential processing of these structures (Beatty-Martínez & Dussias, 2017; Valdés Kroff et al., 2017). To further uncover these grammatical asymmetries, additional work triangulating between corpus analyses, speaker intuition and production, and experimental-based tasks will be necessary (Beatty-Martínez et al. 2018; Valdés Kroff et al. 2018). Here, we claim that morphosyntactic cues tune the bilingual parser to delaying active prediction because likelier or more frequent codeswitch junctures lead to increased ambiguity as to whether an utterance will continue in the same language or codeswitch. In essence, experience with codeswitching can guide listeners to optimally reweight processing cues that lead to actively predicting or not under appropriate contexts.

Other extra-linguistic factors such as speaker and context are also probable cues for the listener. Individual- and community-level factors such as proficiency, codeswitching habits, and community practices can affect the frequency and type of codeswitching, which in turn contribute to adaptive prediction. Bilinguals who are less proficient in a second language are more likely to produce single word or inter-sentential codeswitches (Poplack, 1980; Zentella 1996). Similarly, the extent to which codeswitching is accepted by a community of speakers will further affect codeswitching production (Poplack, 1987). Listeners are guided by this same information, adapting to the environmental and pragmatic context of the setting and/or interlocutor (Blanco-Elorrieta & Pylkännen, 2017; Kaan et al., 2020). Using the visual world eye-tracking paradigm and ERPs respectively, Valdés Kroff et al. (2018) and Beatty-Martínez and Dussias

(2017) demonstrated group differences in the online comprehension of Spanish-English codeswitches involving mixed determiner phrases, showing that only bilinguals who had been exposed to community-specific codeswitching patterns (in this case, overwhelming preference for Spanish masculine articles in mixed noun phrases) also exhibited asymmetric processing patterns that reflected these production biases.

Altogether, we take these varied and intricate linguistic cues as indication that codeswitching is a skillful, interactive speech act. Although bilinguals have strong intuitions for major codeswitch violations occurring at clear, grammatical boundaries (e.g., codeswitches between subject pronouns and predicates are dispreferred; González-Vilbázo & Koronkiewicz, 2016; Koronkiewicz, 2020), only bilinguals who are exposed to more intricate forms of codeswitching (and their resulting asymmetries) will be able to rapidly process these same asymmetries in comprehension. Consequently, one further extension of the Adaptive Predictability hypothesis is that the acquisition of codeswitching constraints does not go hand in hand with bilingual acquisition. The development of sensitivities to preferred codeswitching structures will occur on a different trajectory relative to the development of either language and will be cumulative with experience. This means that the type of language mixing that bilingual children may demonstrate is not necessarily the same type of codeswitching that bilingual adults engage in (e.g., Ribot & Hoff, 2014). Consequently, codeswitching structures produced in bilingual adult speech may not be easily processed in child sentence processing. Initial indications support these claims, at least in the case of bilingualism in North America (Byers-Heinlein, 2013; Gross & Kaushanskaya, 2015; Quick et al., 2021; Smolak, de Anda, Enriquez, Poulin-Dubois, & Friend, 2020). Nevertheless, whether bilingual children acquiring both languages are also sensitive to adult bilingual codeswitching most likely depends on the extent to which codeswitching has broad community support (Myers-Scotton 1993) and where direct transmission from older to younger generations occurs (e.g., Aboh, 2020; Yow et al., 2016, 2018). Within such multilingual communities, children will develop sensitivity to asymmetric codeswitching patterns at a younger age, as their language mixing patterns are also more likely to mirror adult codeswitching within their community. More work directly comparing the processing of codeswitched speech between children and adults is a necessary path to continue to uncover similarities and differences and understand acquisition of codeswitching constraints.

5.2 Cognitive control

The prior section illuminates the multiple moving pieces and possible cues that could potentially signal the listener to impending codeswitches. However, the occurrence of a codeswitch is, of course, not guaranteed. In other words, these linguistic and extra-linguistic cues probabilistically signal an increased likelihood of a codeswitch, but the utterance may continue in the same language. Additionally, bilingual speakers may vary in their scope of planning an upcoming codeswitch, thus leading to moments when codeswitches are planned in advance or occur on the fly and at later stages of speech planning (Valdés Kroff, 2016; Johns & Steuck, 2021). Therefore, a second component to the Adaptive Predictability hypothesis is the upregulation of cognitive control to aid rapid integration of codeswitches in online processing.

Cognitive control is a domain-general executive function that is deployed to resolve representational conflict or to override prepotent biases or responses (Botvinick et al., 2001; Braver 2012). One model of sentence processing proposes that cognitive control deploys in contexts in which conflict resolution is necessary to override dominant interpretations that ultimately are not correct (Novick et al., 2005). Empirically, this framework has been supported by behavioral and neuroimaging work (e.g., Humphreys & Gennari, 2014; January et al., 2009; Zirnstein et al., 2018; Hsu & Novick, 2016) as well as by demonstrating that patients with left inferior frontal damage (a neural area involved in cognitive control) have greater difficulties in resolving garden-path syntactic ambiguities (Novick et al., 2009).

In parallel, we interpret the comprehension of bilingual codeswitching as linguistic contexts that bring bilingual grammars into competition to varying degrees. This competition can occur at multiple levels, with the most basic level being language membership. This competition means that barring any explicit signal, bilingual listeners need to override biases that utterances will continue in the same language. Many of the cues outlined in Section 5.1 make this task easier but may not eliminate it completely. At more complex levels, codeswitches can occur at syntactic sites that result in cross-linguistic conflict that needs to be resolved between the two grammars, as in the case of mixed NPs in Spanish-English codeswitching (Example 20). Consequently, cognitive control is the primary mechanism that helps to overcome same-language lexical and grammatical constraint biases, which aids listeners to shift to processing in the other language after

encountering a codeswitch. The upregulation of cognitive control is likely to be gradient due to the varying degrees of conflict induced by code-switching (cf. Green, 2018). Less cognitive control should be required for inter-sentential codeswitches as compared to intra-sentential codeswitches and especially in environmental contexts that highly support bilingual speech. More complex intra-sentential codeswitches or codeswitches that occur under pragmatically odd or unexpected contexts should require greater cognitive control for comprehension.

Initial evidence in support of this prediction comes from behavioral and neuroimaging work. For example, neural regions implicated in the cognitive control network such as the left inferior frontal gyrus and the dorsal anterior cingulate cortex are reliably recruited when bilinguals are engaged in language switching tasks or when processing auditory codeswitches (Abutalebi et al., 2008; Abutalebi & Green, 2008; Hernandez, et al., 2001; cf. Blanco-Elorrieta & Pylkkänen, 2017; Luk, Green, Abutalebi, & Grady, 2011). Additionally, in between-group designs directly comparing monolinguals and bilinguals or bilinguals with different linguistic profiles—those who are more likely to switch between their languages throughout the day or who engage in more intricate "dense" codeswitching—show reduced conflict effects on non-linguistic tasks requiring cognitive control such as the Stroop and Flanker tasks (Hofweber et al., 2016; Prior & Gollan, 2011).

5.3 Empirical illustrations of the adaptive predictability hypothesis

In this section, we describe two research studies in support of our hypothesis. Our descriptions will summarize overall findings and provide a brief discussion on how these studies illustrate the two central premises of the Adaptive Predictability hypothesis. For further technical details on the studies, readers should consult the original studies (Valdés Kroff, 2016; Valdés Kroff et al., 2017, 2018 for adaptation in predictive processing; Adler et al., 2020 for upregulation of cognitive control while reading codeswitched sentences).

Valdés Kroff et al. (2017) investigated how the purported asymmetry in mixed noun phrase production in east coast US and Puerto Rican Spanish-English bilingual communities affects online processing. Aside from the greater preference for mixed noun phrases to surface with a Spanish determiner and an English noun phrase (*el house* v. *the casa*), these bilinguals overwhelmingly produce Spanish masculine gender-marked determiners in

mixed noun phrases (i.e., preferring *el house* v. *la house*, Sp. *la casa, feminine;* Beatty-Martínez & Dussias, 2017; Otheguy & Lapidus, 2003; Valdés Kroff, 2016). Infrequently, feminine-marked mixed noun phrases also are produced but are prohibitively restricted to English nouns whose Spanish translation equivalents are feminine (i.e., *la house* but **la juice*, Sp. jugo/zumo, masculine). These distributional patterns mean that the gender concord system in Spanish-English codeswitching does not simply follow the constraints in place for Spanish or fully neutralize grammatical gender agreement due to English contact. Yet despite its arbitrary assignment, the presence of obligatory grammatical gender in Spanish leads to consequences for the human parser; namely, it serves as a predictive cue for upcoming nouns. Subsequently, any shifts in how grammatical gender is used in codeswitching should have consequences for online processing.

The study employed the visual world paradigm (Tanenhaus, Spivey-Knowlton, Eberhard, & Sedivy, 1995) in eye-tracking to test for asymmetric effects in online processing. Twenty-five bilingual participants were shown a visual scene consisting of two concrete objects while listening to auditory instructions indicating which object to select via computer mouse. Instructions were presented in Spanish only, single word codeswitches, or multi-word codeswitches. Crucially, critical trials consisted of pairs of items that are different gender in Spanish (e.g., *el carro/coche* "the car, masculine" v. *la galleta* "the cookie, feminine") because these trials provide linguistic contexts in which prenominal Spanish articles can be informative. In other words, participants can look towards target items more quickly due to the facilitatory information carried by the Spanish article on different gender trials (Lew-Williams & Fernald, 2007; Dussias et al., 2013). This anticipatory effect was symmetrically found in a control group of 24 Spanish monolinguals, thus confirming the experimental manipulation. The critical test came in the case of Spanish-English bilinguals, since in codeswitched speech masculine articles no longer uniquely signal the upcoming presence of masculine items either in Spanish or in the translation equivalent of the corresponding English target item. Consequently, we predicted an asymmetric processing pattern for the codeswitched trials, whereby bilinguals would continue to exhibit predictive processing towards feminine translation equivalent English target items when hearing the feminine article but would wait until after the onset of target nouns after hearing the masculine article. The results confirmed this prediction, thus indicating that online processing had changed adaptively due to how grammatical gender is used in production.

However, we also had an at-the-time unexpected finding: bilinguals exhibited the same asymmetric processing pattern in the Spanish-only session. Because the monolingual group had shown a symmetric anticipatory effect for both masculine- and feminine-marked articles, we isolated this unexpected finding to the bilingual group. We conducted a post-hoc naming test on the experimental materials by a subset of the participants about 6 weeks after the experiment which confirmed that the asymmetric processing pattern observed in the Spanish-only session was not due to overuse of the masculine gender in production (i.e., due to loss of grammatical gender representation; Montrul et al., 2008). Therefore, we reasoned the adaptation that occurs in the bilingual comprehension system is one that reflects a trade-off between predictive processing and intentional delay in the service of avoiding a costly garden path. In the case of the Spanish grammatical gender system, this means that Spanish masculine gender on prenominal agreement elements will no longer be predictive globally including in Spanish-only contexts because this trade-off best serves the bilingual comprehension system. While Spanish masculine articles continue to uniquely signal upcoming masculine Spanish nouns in Spanish, they may additionally be linked to switches into English and may include English nouns whose translation equivalents are feminine. Rather than having to calculate at any given moment whether an upcoming noun will continue in Spanish, adapting to an intentional delay leads the bilingual comprehension system to be better prepared for a possible codeswitch that may ultimately conflict with Spanish grammatical gender agreement constraints. In contrast, feminine articles continue to uniquely signal upcoming feminine nouns, whether in Spanish or as English translation equivalents; consequently, participants continue to utilize feminine gender as a facilitatory cue. The critical point is that what on the surface may seem like a failure to predict is instead a global shift to actively not predict as an optimal processing strategy.

Adler et al. (2020) directly tested the hypothesis that reading codeswitched language leads to upregulation of cognitive control. The study takes direction from recent work by Novick and colleagues demonstrating cross-modal conflict adaptation in monolingual speakers (Hsu & Novick, 2016; Kan et al., 2013). The basic idea behind conflict adaptation is that participants are more efficient on "harder" trials that require cognitive control after having just triggered cognitive control mechanisms, a phenomenon known as conflict adaptation (Botvinick et al., 2001). For example,

Kan et al. (2013) demonstrated that after monolingual readers encountered a garden path from processing temporarily ambiguous sentences (e.g., *Put the frog on the napkin in the box* where *on the napkin* is a modifying prepositional phrase instead of an intended location), they were more efficient (i.e., faster) on an immediately following incongruent Stroop trial. This logic was used to test whether reading codeswitched sentences similarly led to conflict adaptation on an immediately following Flanker task; such a finding would lend support to the hypothesis that encountering codeswitches in comprehension engages cognitive control.

Forty-eight Spanish-English bilingual participants either read Spanish or English unilingual sentences or Spanish-English codeswitched sentences via a non-cumulative moving window self-paced reading paradigm (Just et al., 1982). The sentences were embedded in pseudorandom sequences with a classic Flanker task where participants were instructed to indicate the direction of a central arrow flanked by two arrows on each side. On congruent Flanker trials, the central arrow points in the same direction as the other arrows, whereas on incongruent trials the central arrow points in the opposite direction. Participants respond more slowly and less accurately on incongruent trials in classic Flanker tasks.

Pseudorandomization led to critical trial sequences in which sentence reading was immediately followed by Flanker trials. If participants were indeed upregulating cognitive control while reading codeswitched sentences, then immediately following incongruent but not congruent Flanker trials should show a reduced interference cost as compared to reading unilingual sentences. The results indeed showed an interaction on reaction times between language (unilingual, codeswitched) and Flanker trial type (congruent, incongruent). Importantly, the interaction was not driven by language dominance. Additionally, the effects of conflict adaptation were stronger in the second half of the experimental session, indicating that recruitment of cognitive control while processing codeswitched text does not diminish over time.

While these studies are only illustrative, and more work needs to be carried out to test the two key predictions of the Adaptive Predictability hypothesis, the hypothesis is a first attempt to make sense of the apparent contradiction that results from increasing ambiguity in bilingual codeswitching not leading to massive disruption to comprehension. This hypothesis extends experience-based accounts in sentence processing to bilingual contexts by globally considering the diverse linguistic experiences of

bilinguals. Taken together, the adaptive behavior that bilinguals demonstrate during sentence processing and the upregulation of cognitive control suggest that switch costs that are found during comprehension may simply reflect an optimal strategy deployed by bilinguals to avoid disruptive garden paths. This framing moves away from the deficit framing that is prevalent in bilingualism and L2 studies and invites researchers to turn their focus from interpreting switch costs in comprehension as indices of integration difficulty to being an indication of a complex and skillful trade-off between prediction and garden path avoidance.

6. Conclusions

We have provided a broad examination of bilingual codeswitching, reviewing its planning and production and its comprehension in sentence processing; further, we have proposed the Adaptive Predictability hypothesis—an extension of experience-based or constraint-satisfaction approaches in bilingual contexts. Our goal has been to argue that codeswitching is a skillful speech act that bilinguals frequently engage in and to demonstrate how its careful investigation in production and comprehension can reveal the highly dynamic and adaptive mind of humans in language processing and use. There are a myriad of reasons and constraints underlying a speaker's choice to codeswitch. These constraints often conspire to lead to likelier codeswitch junctures in speech, which in turn comprehenders can capitalize on. Nevertheless, codeswitching does not occur in a vacuum, and both speakers and listeners must be prepared for codeswitches to be embedded within larger stretches of speech that continue in a single language.

Our goal in outlining the Adaptive Predictability hypothesis is to provide a psycholinguistically plausible framework for how comprehenders rapidly integrate codeswitched speech without suffering from delayed processing or disruptions to comprehension. Bilinguals learn to adapt how they predict in sentence processing guided by distributional regularities that arise in bilingual language use. Exposure to bilingual language use thus leads bilinguals to shift and reorder the weighting of the cues that they rely upon to facilitate comprehension. This results in a more optimized system, and in some cases leads codeswitching bilinguals to no longer rely upon predictive cues that are typically used during monolingual processing. While this adaptive behavior can help comprehenders avoid costly garden paths,

codeswitching heightens conflict between the two languages to varying degrees. Subsequently, the upregulation of cognitive control further supports the rapid integration of codeswitched speech in comprehension.

Why propose a seemingly new hypothesis that appears to be subsumed by constraint-satisfaction approaches that already account for monolingual processing? Our observation is that the monolingual and second language literatures on sentence processing have been primarily focused on what prediction is (e.g., Kuperburg & Jaeger, 2016), debates about whether prediction is necessary (e.g., Huettig & Mani, 2016), and on the cues and contexts that could trigger prediction (Kaan & Grüter, 2022). Indications of failure to predict are often attributed to traits at the participant level, whether it be due to literacy, proficiency, or availability of domain-general cognitive resources. Codeswitching and other instances of bilingual language use open new avenues of interpretation—with implications for monolingual sentence processing—by revealing instances in which not predicting is, in fact, an optimal and more efficient choice. Rather than being tied to individual traits, adaptive prediction is a reflection of humans' susceptibility to shifting linguistic contexts and how these contexts trigger changes in the comprehension system. Codeswitching brings these changes to the surface and demonstrates that our experiences do not just trigger predictive mechanisms but highly affect how sentence processing mechanisms come into play.

Several issues remain to be addressed that will help (dis)confirm the validity of the Adaptive Predictability hypothesis. For one, given the highly experiential basis of the hypothesis, we need a clearer understanding of the transmission of codeswitching between adults and children. Are children sensitive to the same distributional asymmetries as adults are? Will such sensitivities depend on community-level support for bilingual codeswitching? Second, we need to disentangle the apparent tension between phonetic and phonological cues that facilitate a comprehender's expectation for codeswitching with morphosyntactic cues that instead push comprehenders to delay active prediction. Studies that can pit these two cue classes against each other will help elucidate on this question. Finally, taking as a given that bilinguals engage in language practices that vary from monolingual language use, we believe that an important future direction is to investigate whether the codeswitch itself serves as a predictive cue for signaling upcoming content. This line of research would help tie the processing of codeswitching to the functions of codeswitching. Indeed, initial work suggests that this future research area could be fruitful, as recent work demonstrates that bilinguals anticipate harder or less frequent words and experience reduced

negative reactivity after processing a codeswitch (Tomić & Valdés Kroff, 2021, 2022). Ultimately, by shining a spotlight on bilingual codeswitching, we hope to highlight how codeswitching is a natural testbed to investigate language processing under heightened uncertainty.

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