CHAPTER 7

Code-switching

A processing burden, or a valuable resource for prediction?

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Monolinguals use various linguistic phenomena to guide prediction while comprehending. For bilinguals, the richer linguistic landscape provides additional resources. Code-switches (CS) are a particularly salient event, which could play a role in bilingual prediction. Despite the ubiquity and diverse functions of code-switching, experimental research has focused on CS processing costs, largely in comprehension (Litcofsky & Van Hell, 2017). Despite apparent integration costs, code-switching can facilitate subsequent language processing, due to natural code-switching patterns. We illustrate this approach with two eye-tracking studies suggesting that code-switches are used as a cue that a less frequent or negative word follows. These studies underscore the need to integrate socio-pragmatic and corpus-modeling observations with experimentation to reach a comprehensive understanding of CS processing (Myers-Scotton, 2006).

Introduction

Among certain bilingual communities, bilinguals amongst themselves will engage in sentential code-switching, a skillful speech act where bilinguals intentionally switch between languages within the same conversation. Theoretical linguists and sociolinguists have studied the structural and social constraints of code-switching for decades (see Deuchar, 2020; Gardner-Chloros, 2009, for overviews). This rich line of research has uncovered that code-switching is systematic (i.e., rule-governed) and is subject to the influence of various linguistic and extralinguistic factors such as grammatical category, congruency across the two languages, frequency of use, bilingual proficiency, and community use. Psycholinguists have more recently begun to explore the cognitive and neural mechanisms involved in mixed language use. This literature can be divided into two general approaches. Researchers primarily interested in bilingual language control and lexical access have resorted

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to studying mixed language input in cued language switching paradigms (e.g., Meuter & Allport, 1999; Gollan & Ferreira, 2009) or by including artificial (i.e., unattested) switches in "connected speech" (e.g., Gollan & Goldrick, 2018; Schotter et al., 2019). Other researchers focus on successful production and comprehension of code-switching as reflective of bilingual language use (see Beatty-Martínez et al., 2018; Valdés Kroff et al., 2018; Van Hell et al., 2018 for overviews). Code-switching is speaker-generated in production, embedded within sentential contexts, and can occur at various syntactic junctures. In contrast, language switching is externally cued (via background color or auditory cue) and most typically studied with single lexical items, which come from a single grammatical category (i.e., nouns). In this chapter, we will focus on sentence processing in sentential code-switching as we are principally concerned with how bilingual comprehenders integrate code-switches in real-time processing. Our goal is to unravel how what on the surface appears "costly" may in fact, show processing benefits in certain contexts.

In broad terms, psycholinguistic approaches to code-switching demonstrate that bilinguals experience greater processing costs when encountering a code-switch as compared to non-switched utterances (e.g., Altarriba et al., 1996), a phenomenon referred to as "switch costs." However, a distinction should be made between switch costs in production and integration costs in comprehension. Within the cued language switching literature, switch costs typically refer to greater naming latencies when switching between languages at a trial-by-trial basis. Bilinguals experience switch costs in production (e.g., Meuter & Allport, 1999) likely due to the exogenously cued locus of the experimental paradigm but show reduced to no integration costs in comprehension (Declerck et al., 2019). In contrast, in studies that focus on sentential code-switching, bilinguals may benefit and show reduced switch costs in production (Beatty-Martínez et al., 2020), likely due to speakers exploiting speech planning mechanisms, but instead show costs to integration in certain contexts (Altarriba et al., 1996).

While sentential code-switch integration costs have been robustly documented in the prior literature, recent approaches have attempted to find contexts in which these can be reduced. These studies demonstrate that integration costs are attenuated by linguistic factors such as syntactic distribution or phonetic cues (Beatty-Martínez & Dussias, 2017; Fricke et al., 2016; Guzzardo Tamargo et al., 2016), phonotactic constraints (Li, 1996), cognitive mechanisms such as syntactic priming (e.g., Kootstra et al., 2010, 2012) or lexical triggering (Broersma & de Bot, 2006), individual-level and task factors such as proficiency, switch direction, proportion of code-switches (Johns et al., 2019; Litcofsky & Van Hell, 2017), social cues (Kaan et al., 2020; Valdés Kroff et al., 2018), or the frequency of switching within a community (Adamou & Shen, 2017). These approaches have in some cases documented diminished costs to varying degrees, but do not find evidence for

eliminated integration costs. On the surface, these robust processing costs (even if diminished) present an unusual paradox for bilingual language use and prediction (Altmann & Kamide, 1999). For one, bilingual code-switching is ubiquitous within bilingual communities, yet these lab-based results would suggest that bilinguals are engaging in effortful processing. This paradox may be the result of the artificial setting and decontextualized stimuli in which lab-based studies on code-switching are carried out, essentially turning psycholinguistic studies on code-switching into investigations on how bilinguals process unexpected input (Gullberg et al., 2009; Moreno et al., 2002; Valdés Kroff et al., 2018). Here, we will propose an alternative approach as it relates to predictive processing by shifting our focus towards potential benefits the code-switch provides to downstream processing.

Prediction, in our view, consists of the probabilistic activation of upcoming lexical, semantic, and grammatical information (Kuperberg & Jaeger, 2016). In unilingual processing, incremental, predictive processing leads listeners and readers to probabilistically anticipate upcoming information by continuously updating their expectations for upcoming information based on prior context (e.g., Altmann & Kamide, 1999). Thus, individuals are anticipating grammatical structure, semantic concepts, and potentially lexical forms. In appropriate pragmatic contexts (i.e., in the presence of other known bilinguals), the bilingual is additionally attempting to anticipate possible code-switches, as shown by studies demonstrating bilinguals' sensitivity to cues preceding code-switches (Beatty-Martinez & Dussias, 2017; Shen et al., 2020). So why do bilinguals code-switch if it is costly or difficult to predict? This paradox leads us to argue for a different approach to investigate prediction in code-switching. Our proposal is to shift focus from the integration costs at the site of the code-switch itself and ask how code-switches affect processing and prediction downstream. In other words, even if bilinguals experience measurable integration costs when they first encounter a code-switch, these costs may later turn into processing benefits because the code-switch serves as a contextual signal to the bilingual comprehender. This proposal is based on socio-pragmatic and information-distribution functions that have been linked to the production of code-switching. For example, bilinguals produce code-switches before more difficult or less expected content (Myslín & Levy, 2015; Example (1)) and before the introduction of socially negative, taboo topics (Bentahila, 1983; Tomić, 2015; Example (2)).

(1) a. Tady vidiš že ona je *in need*.
'Here you see that she is *in need*.'
b. A potřebuje *entertainment*.
'And she needs *entertainment*.' (Myslín & Levy, 2015, p. 872)

In two consecutive utterances in Example (1), adapted from Myslín & Levy (2015), the authors argue that newly introduced concepts, such as the concept of NEED, italicized in a., are expressed in English. When the concepts become discourse-old, they are expressed in Czech, such as *potřebuje* ('needs') in b.

(2) J: neću da mi to radiš
'I don't want you to do that to me'
L: dobro, za početak ću da podrigujem
'ok, for starters I'll burp'
J: you know I'm gonna start *farting* as a {trails off}
L: exactly, that was my goal all along (Tomić, 2015, p. 353)

In Example (2), adapted from Tomić (2015), the author observes a speaker of Serbian switching to their second language (L2) English, the language of power and global majority, to discuss taboo concepts (italicized).

These socio-pragmatic choices may signal a trade-off between immediate integration costs and downstream facilitated processing. Our experimental framework taps into this facilitative function for the bilingual comprehender by explicitly designing psycholinguistic experiments that manipulate the language that bilingual comprehenders encounter and examining whether processing a code-switch leads to better prediction or facilitated processing of upcoming linguistic input. In this chapter, we illustrate this approach with two studies where we summarize the basic concept, methods and design, and the primary results of interest. These illustrations are necessarily brief, and we include references to more detailed reports. We conclude our chapter by discussing new insights on prediction in bilingual sentence processing with the goal of shifting focus from integration costs into processing benefits. This shift starts from the premise that bilingual code-switching is a common bilingual language practice that underscores the highly adaptive bilingual comprehension system.

Illustrative Study 1: Can code-switching signal less expected upcoming lexical information?

Our first illustrative study tests the effects of processing code-switches in the auditory modality on the prediction of upcoming words based on their lexical frequency (Tomić & Valdés Kroff, 2020). This study builds on Myslín and Levy (2015), who found that US Czech-English bilinguals switch to English on less predictable words, presumably to improve listeners' comprehension. This preferred switch direction to the language of power is found commonly in contact settings with a power asymmetry between languages (Blokzijl et al., 2017). The authors created a corpus

of Czech-English bilingual discourse, containing Czech-only utterances and Czech to English code-switched sentences, where the code-switch occurred on the final word. They calculated a range of lexical accessibility and syntactic dependency factors for code-switched vs. unilingual final words in the utterances to ascertain the factors which most affect code-switching behavior. The main factor of interest was predictability of meaning in context, which was calculated using a Shannon guessing game, in which a separate pool of participants guessed the meaning of the utterance-final word. The predictability of meaning was defined as the percentage of correct guesses. Statistical modeling of how CS behavior was affected by these factors showed that less predictable words were frequent code-switch sites from the minority language, Czech, to the majority, more salient or marked language, English (Myslín & Levy, 2015, p. 878). The authors reason that this practice is due to audience design, i.e., speakers are aware of which language is considered more salient by their listeners and use it to encode more difficult meaning to ensure it is comprehended. Simply put, in the context of this study, the older Czech-English bilinguals are likelier to stay in Czech when talking to other bilinguals, unless signaling harder to process content. Czech is thus the less marked or salient language and English the more marked or salient language. If this information-theoretic function is indeed a general function in the pragmatics of code-switching, then switch direction and the salience of the languages involved in switching are likely agreed upon as a community practice and not based on the individual proficiency and language dominance of bilingual speakers (e.g., Bhatt & Bolonyai, 2011).

Our study uses the visual world paradigm, a common eye-tracking paradigm in which participants view a visual scene while listening to audio instructions (Tanenhaus et al., 1995), to test whether bilingual listeners exploit this code-switch distribution pattern during online processing. If so, then bilinguals should be able to predict less predictable words after a code-switch. We operationalized predictability through the correlated measure of lexical frequency (Calvillo et al., 2020). The study design took inspiration from visual world studies testing the effect of disfluent speech on prediction. Disfluent fillers, such as 'uhm', 'uh', are also found to precede unexpected, discourse-new words (Arnold et al., 2000; Barr, 2001). Consequently, listeners use this distributional information to adjust their expectations for upcoming information. In the case of disfluent vs. fluent speech, listeners expected less frequent or discourse-new targets (Arnold et al., 2003, 2004, 2007).

For the experimental design, we extracted a set of images illustrating more and less frequent words from the International Picture Naming Project (IPNP, Bates et al., 2003; Szekely et al., 2003, 2004, 2005). Each experimental panel contained two images, corresponding to a lower and a higher frequency noun respectively (Figure 1A), which could vary in their location on a computer screen (Figure 1B). We controlled for the frequency of the object label equivalents in Spanish and

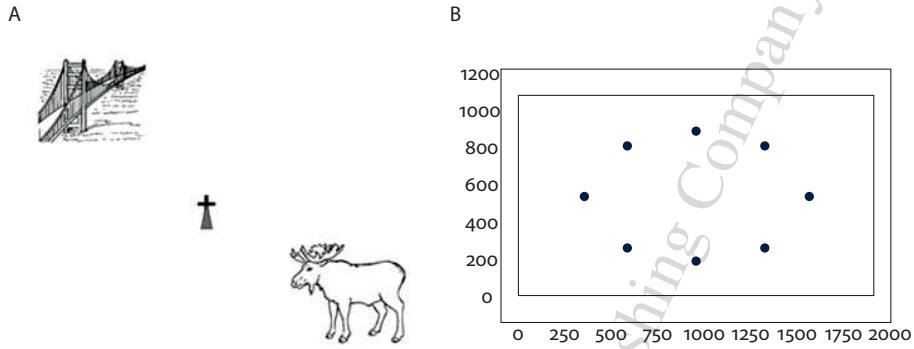

Figure 1. A. The illustration of an experimental picture panel for the "bridge" and "moose" high- and low-frequency label image pair. B. Possible positions for images

English and for the gender of the low- and high-frequency counterparts in Spanish. At the same time, we made sure to create significant frequency differences for each experimental pair as confirmed by a one-tailed paired *t*-test on experimental lists (see Tomić & Valdés Kroff, 2020).

A highly proficient Puerto Rican Spanish-English bilingual recorded Spanish unilingual (Sp) and Spanish-English code-switched (CS) instructions to click on an image:

(3) Sp: *Encuentra el dibujo de un/una/Ø* _____
CS: *Encuentra el* drawing of a/an/Ø _____
'Find the drawing of a/an/Ø _____'
Sp: *Elige el dibujo de un/una/Ø* _____
CS: *Elige el* drawing of a/an/Ø _____
'Select the drawing of a/an/Ø _____' (Tomić & Valdés Kroff, 2020)

We offset the code-switch away from the target by several words to avoid immediate effects of integration costs on the target word and test whether code-switching serves as a predictive cue for upcoming linguistic content. The code-switched instructions were naturally pronounced with a slight prolongation before the CS onset compared to the Spanish version (mean difference = 22 ms). We left this delay unchanged, as slight delays have been found to precede code-switches in bilingual discourse and aid the processing of a CS (Fricke et al., 2016). Taking these cues out can make CS processing more difficult (Shen et al., 2020). We chose only the Spanish-English code-switching direction as it is the most frequent code-switching direction among Spanish-English bilinguals in the US (Blokzijl et al., 2017; Moreno et al., 2002; Valdés Kroff et al. 2018). This preferred switch direction tracks with Myslín and Levy's (2015) attested switches from a minority language (in this case

Spanish) into the majority language (i.e., English). Using the switch direction which is not attested to co-occur with less expected items would have likely introduced confounds. Similarly, to create the ecological context of bilingual code-switching, English unilingual sentences were not included, which also follows the experimental design of Myslín and Levy (2015).

Thirty Spanish-English bilinguals who regularly code-switch listened to auditory instructions and clicked on correct images via computer mouse. They were exposed to 8 pairs of images in each condition (frequency [low, high] × language of instructions [Spanish, code-switches]) in 32 experimental visual scenes, as well as ~~additional~~ 64 filler visual scenes (accessible through Open Science Framework [OSF] repository https://osf.io/azcn4). Filler visual scenes had the exact same structure as experimental trials, yet they included mostly mid-range frequency items. Also, the filler pairs of images did not significantly differ in frequency and the instructions accompanying them were always in Spanish. The task was preceded by experiment procedure instructions containing code-switches to promote a bilingual language mode and the global expectation that code-switches may occur during the experimental session. Language proficiency tests, questionnaires, and self-reported proficiency measures showed that these bilinguals overall acquired Spanish first but were currently dominant in English (full details in Tomić & Valdés Kroff, 2020). We conducted a Growth Curve Analysis (Mirman, 2014) on the proportion of looks to images in the time period from 200 ms before to 200 ms after the target onset. Eye-movements in this time span reflect predictive processing, before the participants' eye movements are affected by the target word processing, as planned eye movements generally take 150–200 ms to launch (Allopenna et al., 1998; Travis, 1936). Thus, we are focusing on the impact that listening to a code-switch has on predictive processing of upcoming lexical information. In the remainder of this section, we summarize the main findings from this study. For full model results, see Tomić & Valdés Kroff (2020) and the associated OSF repository <https://osf.io/azcn4>.

The statistical model reveals two important interactions: language of instructions × frequency and language of instructions × frequency × language dominance. The critical, first interaction indicates that bilinguals looked at low frequency images significantly more in the code-switched condition than in the non-switched Spanish condition (Figure 2), suggesting that bilinguals interpreted the code-switch as a contextual signal for upcoming, less expected lexical content.

The second interaction further reveals that eye-movement patterns were modulated by language dominance, such that participants more dominant in Spanish exhibited the typical frequency bias towards high frequency nouns in the non-switched Spanish condition, i.e. they looked more at objects representing higher frequency words (Dahan et al., 2001). In contrast, the less Spanish-dominant participants did not show a clear frequency bias in Spanish-only conditions. Nevertheless, Spanish

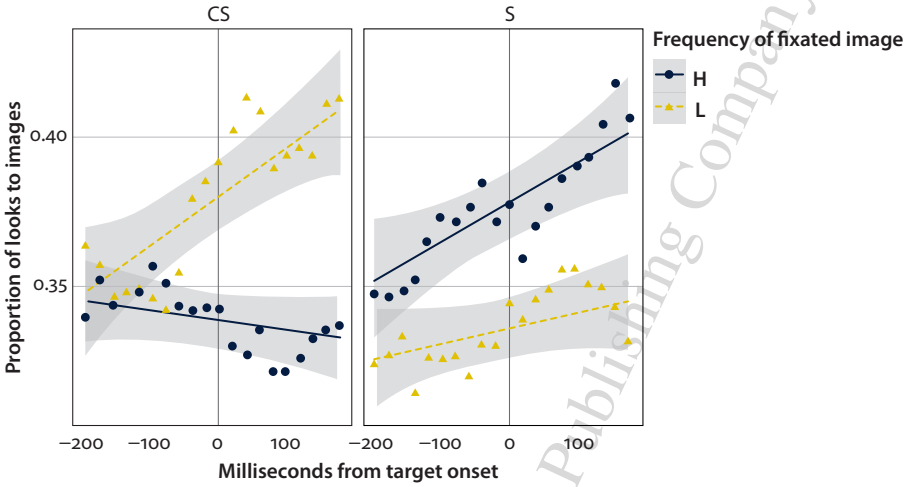

Figure 2. Proportion of looks to images with Low (L) and High (H) frequency labels 200 ms before and after the target word onset (vertical line), split by language condition: Code-switched (CS) and Spanish (S); adapted from Tomić & Valdés Kroff (2020)

dominance did not affect the increased looks to low-frequency items in the CS condition, indicating that participants interpreted code-switches as contextual and predictive cues in sentence processing. These results suggest that Spanish-English bilingual listeners are exposed and sensitive to the distribution pattern of code-switches to the language of power as a pragmatic function of encoding less expected upcoming information, regardless of their own individual language dominance (Tomić & Valdés Kroff, 2020). The results thus corroborate the audience-design interpretation that Myslín and Levy (2015) propose for code-switching.

This study is the first to experimentally test and confirm the influence of code-switches on the predictive processing of upcoming linguistic content. Specifically, processing a code-switch helps bilinguals anticipate upcoming less expected information, operationalized using lower frequency items, due to bilinguals being exposed to the pattern of code-switches preceding or occurring on less expected items in production (Myslín & Levy, 2015). Unlike foreign accent (Romero-Rivas et al., 2016), or foreign accent combined with filled pauses (Bosker et al., 2014), which cause prediction to halt likely due to the lack of exposure to such linguistic contexts, we show that code-switches are interpretable as beneficial cues to lower-frequency information. Processing a code-switch steers bilingual prediction patterns away from a general, high-frequency heuristic to preactivate lower-frequency information (Dahan et al., 2001) and helps bilingual comprehenders predictively attend to lower-frequency words. We discuss possible mechanisms and the scope of this effect in the Discussion section.

Illustrative Study 2: Can code-switching ease the processing of taboo or negative information?

Having initial evidence of bilingual listeners interpreting code-switching as a facilitatory cue for upcoming speech, we turn to other co-occurrences of code-switches with different linguistic content in production to investigate whether code-switches lead to reduced integration costs for socially negative, taboo content (Tomić & Valdés Kroff, 2021). Sociolinguists have observed that code-switches often precede embarrassing, taboo, negative content (Bentahila, 1983; Bond & Lai, 1986; Tomić, 2015; Example (4)):

(4) waɦed lli ʕandu *la diarrhée* tajSwb šwija
'someone who has diarrhea can take a bit of it'
(Arabic-French, Bentahila, 1983, p. 236)

Following the logic of Study 1, this socio-pragmatic function of code-switching in production led us to hypothesize that code-switches can serve as a facilitatory cue of upcoming emotional taboo words in comprehension.

Emotional reactivity or emotionality to words and other stimuli has been captured by two main dimensions, *arousal*, how exciting the stimulus is, and *valence*, how positive or negative it is perceived to be (Bradley et al., 2001; Osgood et al., 1957). In monolingual studies, positive words are processed faster and/or responded to more accurately than neutral words and often negative words (Kissler & Koessler, 2011; Schacht & Sommer, 2009). The positive word behavioral advantage has been termed "positivity bias" (Herbert et al., 2009). Negative words sometimes also show facilitation (Knickerbocker et al., 2015), but often only in early processing or modulated by other factors, such as arousal (Hofmann et al., 2009) and lexical frequency (Scott et al., 2012; Scott et al., 2014). Consequently, negative and taboo words have been hypothesized to grab attention more intensely, due to negative stimuli being more pertinent to survival than positive ones (Baumeister et al., 2001; Mackay et al., 2004; Pratto & John, 1991), even when the task does not require attending to valence or tabooness (Eilola & Havelka, 2011; Pratto & John, 1991). This increased attentional demand has been interpreted as the locus for slowdowns in behavioral measures (negative: Eilola & Havelka, 2011; Pratto & John, 1991; Schacht & Sommer, 2009; taboo: Eilola & Havelka, 2011; Raizen et al., 2015), often in later processing measures reflective of integration (Lüdtke & Jacobs, 2015).

As for bilinguals, initial evidence indicated that they do not develop emotional reactivity in their L2 to the extent of their first language (L1; e.g. Anooshian & Hertel, 1994). Nevertheless, recent evidence using different experimental techniques, including eye-tracking (Sheikh & Titone, 2016) and event-related potentials (ERPs, Opitz & Degner, 2012), confirm that bilinguals do develop emotional

reactivity in their L2 at a similar level to their L1, modulated by individual-level factors such as increased proficiency and naturalistic exposure to and use of the language (Altarriba & Basnight-Brown, 2011; Ayçiçeği & Harris, 2004; Conrad et al., 2011; Opitz & Degner, 2012; Ponari et al., 2015). However, none of these prior bilingual emotionality studies directly examines the emotional reactivity of bilinguals in code-switched discourse, despite the relative frequency of CS in bilingual discourse (~20%, Beatty-Martinez & Dussias, 2017) and the aforementioned socio-pragmatic function of CS to encode upcoming negative or taboo topics.

Oganian et al. (2016) tested the extent of decision bias, a supposed consequence of emotional reactivity, when a problem was presented in L1, L2, and in code-switched passages. One type of decision bias is the framing effect, referring to the tendency to choose a particular option based on the positive (gains) vs. negative (loss) framing of the problem (Oganian et al., 2016). The authors found that the framing effect was significantly reduced in the code-switched condition but not in the L2, in line with prior sociolinguistic work suggesting that CS could modulate emotional reactivity. Our study tests this hypothesis using eye-tracking-while-reading measures as direct correlates of emotional reactivity. Emotionality has been shown to affect both early and late eye-tracking measures, such that more emotional words, especially positive words, are processed faster (Knickerbocker et al., 2015; Scott et al., 2012; Sheikh & Titone, 2013). The emotionality effects for words in general, including in eye-tracking studies, have been explained by the motivational salience of emotional words, which promotes their accessibility and/or recruits additional resources to enhance their processing (Mackay et al., 2004). As a signature of emotional reactivity, we can expect that positive words are read faster than neutral words. Negative and taboo words could be initially read faster, but cause delays in processing in later eye-tracking measures, due to additional resources deployed to attend to their processing (Eilola & Havelka, 2011; Pratto & John, 1991; Schacht & Sommer, 2009; Raizen et al., 2015).

We designed an eye-tracking-while-reading experiment to examine the effects of code-switches on the processing of taboo words in an initial 2 × 3 experiment design: tabooness (taboo, neutral) × language (English, Spanish, code-switched). We embedded taboo and neutral words in unilingual Spanish and English sentences and Spanish-English code-switched sentences (Table 1; materials available through the OSF repository: https://osf.io/du7ay/). As in the case of Study 1, we chose the Spanish to English code-switch direction since switches to the language of power, usually the local and/or global majority language, are more frequently attested in bilingual communities (e.g., Nicaraguan English Creole to Spanish in Nicaragua: Blokzijl et al., 2017; Bhatt on languages in India, 2013, as cited in Blokzijl et al., 2017; Spanish to English in the US: Blokzijl et al., 2017; Poplack, 2000; Zentella, 1997). Also, sociolinguistic studies indicate that switches prior to or on taboo words are

from the L1 to the L2 or from the less to the more situationally marked language (Bentahila, 1983; Bond & Lai, 1986; Tomić, 2015). English, in US Spanish-English bilingual communities, is both the local and the global majority language, as well as the language of power, thus making it the situationally marked language during minority language use.

Table 1. Experimental design for Illustrative Study 2

Lang	Status	Item
CS	Taboo	A principios de este verano, they found a *turd* in the showers at the waterpark.
CS	Neut	A principios de este verano, they found a *tooth* in the showers at the waterpark.
Eng	Taboo	Earlier this summer, they found a *turd* in the showers at the waterpark.
Eng	Neut	Earlier this summer, they found a *tooth* in the showers at the waterpark.
Sp	Taboo	A principios de este verano, encontraron una *cagada* en las duchas del parque acuático.
Sp	Neut	A principios de este verano, encontraron un *diente* en las duchas del parque acuático.

Target words italicized. Sp = Spanish, Eng = English, CS = code-switched

We devised 48 target neutral-taboo word pairs, (46 noun pairs and 2 adjective pairs), in English and Spanish, e.g. 'cocksucker' – *chupapollas*, 'airplane' – *avión*. The taboo words denoted body parts used for copulation and excretion, excrement matter, and sexual acts. Neutral words represented non-taboo words which could semantically and syntactically fit the same sentence frame. We pre-normed the target words on the dimensions of use and exposure to words, arousal and valence, as defined above, offensiveness (how offensive the word is to the person), tabooness (how taboo the word is in society), and imagery, following Janschewitz (2008). Taboo words were rated significantly lower on exposure, use, valence, and higher on offensiveness, tabooness, and arousal (full report in Tomić & Valdés Kroff, 2021).

To maximize ecological validity, the sentences were conversation-like and featured code-switches deemed natural by two proficient Spanish-English bilinguals. Two to three words intervened between the CS and target word, as in Study 1, to avoid immediate integration costs and to investigate whether the CS leads to subsequent predictive processing. We additionally conducted cloze probability and plausibility pre-norming studies on the sentence frames and combinations of the sentence frames and target words (Sheikh & Titone, 2013). With the cloze probability pre-norming task, we confirmed the unpredictability of target words based on pre-target sentential context. The Plausibility pre-norming task included participants judging how likely it would be for the taboo and neutral versions of Spanish and English sentences to be uttered in daily life. The linear mixed effects

models for Spanish and English separately showed that taboo versions of sentences were less likely in daily conversations. The low plausibility of taboo words is an intrinsic property of taboo words. Therefore, we did not control for this variable.

We created 6 experimental lists with 48 experimental sentences and 8 items per condition. The study was split into a Spanish and CS block (32 experimental sentences) and an English monolingual block (16 experimental sentences) to mimic the language contexts in which bilinguals find themselves during their daily lives in the US (Zentella, 1990). We included additional 96 neutral filler sentences. The filler sentences for the Spanish and CS block included 56 Spanish and 8 code-switched sentences, to keep the ratio of CS utterances close to their attested distribution in production (Beatty-Martinez & Dussias, 2017).

Thirty Spanish-English bilinguals, who acquired both languages before the age of 12 and reported regular code-switching, participated in the experiment. Participants completed several measures to establish a more encompassing language and emotionality profile: adapted standardized tests for Spanish (Diplomas of Spanish as a Foreign Language, DELE, Ministry of Education, Culture, and Sport of Spain, 2006) and English (Michigan English Language Institute College English Test, MELICET, University of Michigan English Language Institute, 2006), Language History Questionnaire (LHQ, Guzzardo Tamargo et al., 2016), the Autism Quotient (Baron-Cohen et al., 2001), and the Emotionality Questionnaire (EQ, Janschewitz, 2008) at the end of the experiment. The EQ required participants to rate the experimental words they read as in the pre-norming study, on exposure, use, valence, arousal, tabooness, offensiveness, and imagery. These ratings were used as measures of emotionality in the final statistical analysis, to control for the language variant and individual rating variability.

The participants overall acquired Spanish first. Nevertheless, as in Study 1, the bilinguals were more dominant in English, as demonstrated by their proficiency scores and self-reports (full report in Tomić & Valdés Kroff, 2021). Additionally, the participants were overall more exposed to English in everyday life, and they reported that they would address a fellow bilingual in English most of the time. Order and age of acquisition (Pavlenko, 2012), proficiency, language dominance, and naturalistic exposure (Altarriba & Basnight-Brown, 2011; Degner et al., 2012) are important factors for the development of emotionality. In our study sample, Spanish had a slight advantage in terms of order and age of acquisition, yet English had the advantage due to increased exposure and dominance. Importantly, 28 participants out of 30 confirmed they code-switch in the LHQ questionnaire. No participants scored higher than 32 points on the AQ questionnaire, the cut-off for the clinical diagnosis of autistic traits (Baron-Cohen et al., 2001). The models with the AQ scores as predictors did not provide a significant improvement, so we do not report them here.

Participants completed the experiment in two blocks on separate days. The instructions were presented in code-switched speech for the Spanish and Code-switched block, and only in English for the English block, to activate the appropriate language schemas. Participants read the sentences and responded to comprehension questions.

We fit linear mixed-effects models using the lme4 package (Bates et al., 2015) in R (R Core Team, 2017) to Gaze Duration (GD) and Total Duration (TD) eye-tracking measures for the target and post-target regions. GD is the sum of all fixations within a region before eyes move out of the region. TD is the sum of all fixations on the region, including regressions. The post-target region consisted of two words following the target word in order to capture any spillover effects.

The study was designed to investigate the interaction of tabooness and language. Nevertheless, initial models with tabooness as the only emotionality variable did not show any significant effects. We suspected that this was due to the target words not being well controlled for valence, i.e., experimental word pairs were not matched for valence and both neutral and taboo target words could be positive or negative. Valence and arousal primarily and separately contribute to emotional reactivity (see for a review Citron, 2012), and there is evidence that positive and negative words exhibit different behavioral effects (Kissler & Koessler, 2011). Since the experimental words, including neutral and taboo words, included an approximately equal number of positive and negative words as judged by participants and since arousal and valence were not correlated for the target region, we added valence and arousal ratings provided by the participants in the final statistical models. Tabooness was not included in the final models, as it was heavily correlated with both arousal and valence.

As the measure of significance, we compared the base linear mixed effects models for each measure and region to models including incrementally added emotionality variables of valence and arousal. The base linear mixed effects models included language (English, Spanish, CS [reference level]), Spanish dominance (DELE divided by MELICET scores), Word Length (character length of the target or the post-target region), and their interactions as fixed effects, and minimally Participant and Item random intercepts. To this base model, we added emotionality factors as fixed effects, as well as interactions with other variables, to determine the scope of emotionality effects. All continuous variables were normalized and the dependent variables were trimmed and transformed following adapted standard procedures (e.g. Sheikh & Titone, 2013). For GD, the addition of emotionality variables either did not improve the model fits, or it did not produce any significant language × emotionality interactions. In the remainder of this section, we discuss the relevant language × emotionality (arousal and valence) interactions from the TD models for the target and spillover region. Full model

reports, including additional analyses, can be found in the associated OSF repository <https://osf.io/du7ay>.

In the summarized models, there was a main effect of language (Spanish), such that target words in Spanish were read slower than the words in the CS condition. This is likely due to the fact that the CS condition contained words in English, most participants' dominant language. Heritage bilinguals also might not have developed reading skills in Spanish to the same degree as in English. The language (English) × valence interaction was trending in the TD model for the target region, such that more positive words were read faster in English than in the CS condition. This trending interaction suggests facilitation in English for positive words due to emotional reactivity, as well as emotionality reduction in the CS condition. Increasing Spanish dominance led to a smaller TD difference between negative and positive words for unilingual conditions (flattened slopes for English and Spanish in Figure 3, right panel, compared to left panel). For these more Spanish-dominant participants, more negative words were read slower and more positive words faster in the CS condition (solid line, Figure 3, right), resembling the slopes of the emotionality effect in unilingual conditions for the less Spanish dominant speakers (dashed and dotted lines, Figure 3, left). This was corroborated by the negative-coefficient two-way interaction of valence and Spanish dominance, with CS as the language

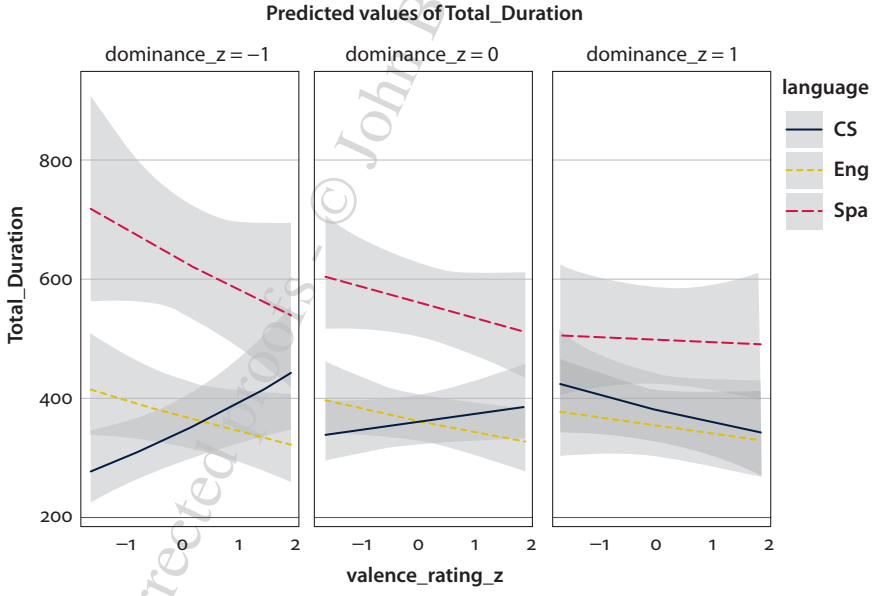

Figure 3. Predicted marginal effects plot for the language x valence x dominance interaction for the reported TD model for the target region. Dominance rating of $z = -1$ corresponds to more English-dominant speakers. Valence rating of $z = -1$ corresponds to negative valence words

baseline, indicating that positive words were read faster in the CS condition for more Spanish dominant participants. These two interactions suggest that more Spanish-dominant participants do not experience the same emotionality reduction in the CS condition compared to the less Spanish-dominant speakers (compare solid lines across Figure 3). This and subsequent predicted marginal effects plots were constructed using the ggeffects R package (Lüdecke, 2018).

With an increase in word length, more Spanish dominant participants read more arousing words slower in the English vs. CS condition. Predicted marginal effects for this interaction while keeping Spanish dominance at maximum suggests that Spanish dominant participants do not experience facilitation for arousing words in English, particularly when the words are long.

The most parsimonious model for the TD measure in the spillover region included arousal and valence, and their interactions with other variables. For the relevant language and emotionality interactions, spillover words were read faster in English the more positive the target words were, whereas this reading pattern was reversed in the CS condition (Figure 4), suggesting that code-switches reversed the emotionality signature from the English unilingual condition. This interaction mirrors the trending interaction in the TD model for the target region. With increasing

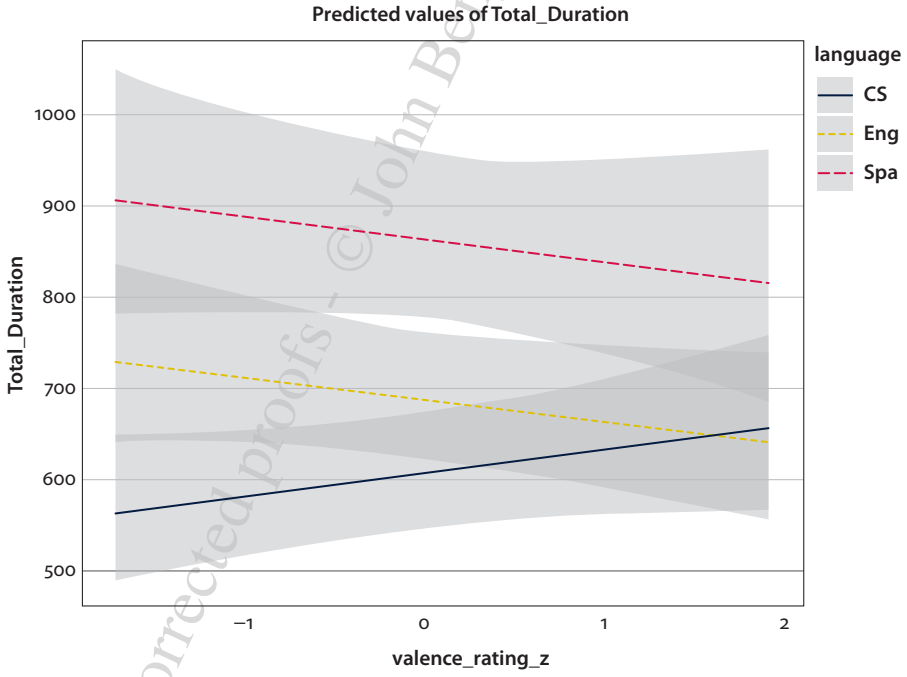

Figure 4. Predicted marginal effects plot for the language x valence interaction for the reported TD model for the post-target region. Valence rating of $z = -1$ corresponds to negative valence words

Spanish dominance, the spillover words after more positive and more arousing target words were read slower in English as opposed to CS sentences.

Research on emotionality shows that emotional words exhibit facilitated processing, at least definitively so for positive words (Kissler & Koessler, 2011; Schacht & Sommer, 2009). Negative words provide mixed results, behaving similarly as neutral words, or causing processing slowdowns (Kissler & Koessler, 2011; Pratto & John, 1991; Schacht & Sommer, 2009). Taboo words consistently cause slowdowns in processing in behavioral studies (e.g. Raizen et al., 2015). Therefore, the facilitation we see for positive words in the English condition compared to the CS condition is likely the manifestation of strong emotional reactivity in English and its significant reduction after a code-switch, despite the fact that the CS and English language conditions feature exactly the same English words. We did not, however, find a strong emotionality effect in Spanish. This asymmetry is likely due to more variable Spanish proficiency and emotionality, caused by the groups' status as heritage speakers of Spanish. In the case of code-switched trials, the negative coefficient of the language (English) × valence interaction, trending in the target region and significant in the post-target region, suggests that preceding CS facilitates the processing of linguistic input following negative words, unlike in English unilingual processing. This is likely caused by the pre-activation or facilitated integration of negative content, a specific valence value, after a code-switch, due to the attested pattern of code-switches preceding negative words. When these expectations are not met, the participant likely experiences prediction error and adjusts their expectations on the type of content likely to follow a CS. More generally, the results show that bilinguals build expectations for upcoming linguistic input based on encountering a code-switch.

The type of information which is pre-activated in Study 2 might be related to Study 1. Negative emotional words are generally more informative and less frequent than positive words in discourse (e.g. Boucher & Osgood, 1969). Therefore, participants might expect generally more informative, less frequent content after a CS, including low frequency words *and* negative words as a subset of low frequency words. Interestingly, Example (1), which Myslín & Levy (2015) give as an illustration of less predictable words being switched to English, could also be analyzed in terms of the CS pattern of preceding or occuring on negative social concepts. From the authors' explanation, both code-switched expressions, *in need* and *entertainment,* are related to the behavior the speaker finds promiscuous and socially negative.

As in Study 1, (Spanish) dominance played a role in this overall emotionality effect. Nevertheless, in Study 2 increased Spanish dominance or more balanced proficiency attenuated the CS emotionality reduction effect. We discuss reasons for this modulation in the General Discussion section.

General discussion

With two recent studies, we have illustrated a novel approach in CS processing research, involving the investigation of the effects of bilingual CS on the (predictive) processing of upcoming linguistic content in terms of lexical frequency and emotional valence. These studies contribute to research on prediction, i.e. predictive pre-activation and/or facilitation (Kuperberg & Jaeger, 2016) of specific lexical input by adding another useful predictive cue, formerly characterized as a processing burden. We show that a code-switch could cause pre-activation of lower-level lexical features such as lexical frequency and emotional valence, which can be observed prior to target word onset (Study 1), or facilitate the processing of predicted information, even in the absence of an effect in early processing measures (GD; Study 2). Our studies do not speak directly to whether CS preactivates particular words, as the actual targets were unpredictable in both studies. Rather, the CS seems to be preactivating low-frequency information and negative valence, thus probabilistically constraining the pool of possible upcoming words to those that share these features and aiding their processing (DeLong et al., 2005).

The two purported types of preactivated information, lower lexical frequency and negative emotional valence, are related in several ways. There is a documented positivity bias in discourse, making positive words more frequent and negative valence or negative social concepts in general less frequent (Dodds et al., 2015). The negative valence could thus be a subcategory of low frequency information. The positivity bias in bilingual discourse in terms of frequency of positive concepts could be underlying the facilitative effects of positive words, also termed positivity bias, similar to the effects of the high-frequency bias (Dahan et al., 2001). Therefore, in both cases, documented and potentially related biases, positivity bias and high-frequency bias, are overturned by encountering a code-switch.

It remains an open question as to which aspect of CS is responsible for adjusting prediction in such a way, i.e. at which level of representation the information on the CS is encoded. The CS as a predictive cue could be richly represented as a language alternation, with potential information on the syntactic locus and/or specific direction of the language switch. If so, unattested or infrequent switches, e.g. from English to Spanish, could have caused the bilingual comprehender to stop predicting or adjust prediction in a different way. Nevertheless, the CS itself is a discrete salient point in the communicative stream not necessarily tied to linguistic information. Thus, the CS could also be represented as a manifestation of a sudden change in the intensity or type of linguistic or even paralinguistic information at some level of representation, acting like an attention signal to redirect the comprehender's expectations. Along similar lines, switches in register, genre, intonation,

pace, brightness or boldness in writing could produce a similar effect on predictive pre-activation.

Additionally, we could expect CS to exert the same beneficial effect on the predictive processing of cognitively demanding linguistic information at other levels of representation. Some examples include helping bilinguals adjust their expectations to preactivate morphological complexity, length, discourse-newness, or unpredictability, in the service of facilitating the processing of morphologically complex vs. simple words, long vs. short words, discourse-new vs. -old concepts, or less predictable vs. more predictable words in certain contexts. These other means of organizing discourse content may have been at play in the studies we describe here. Further studies delineating or controlling for these variables, especially predictability in context, should test different levels of representation at which the linguistic material is pre-activated due to the presence of a CS, to further elucidate the scope and nature of the effect.

Devising experiments taking other CS functions and patterns into account would be especially useful for understanding the scope of this facilitatory effect, both in production and comprehension. Sociolinguists enumerate a slew of functions underlying CS, such as topic shift, quotation, addressee specification, reiteration, message qualification, clarification, emphasis, and interjections (Gumperz, 1982, pp. 75–84). Similar to the functions which inspired the illustrative studies, these socio-pragmatic functions suggest that CS precedes important junctions in speech and/or difficult or unexpected linguistic elements. Consequently, code-switches preceding addressee specification might help comprehenders anticipate and prepare for their turn, streamlining the conversation (De Ruiter et al., 2006). Code-switches used for topic shifts, reiteration, clarification, or emphasis might draw comprehender's attention and adjust predictive processing biases, thus potentially improving the processing and retention of new information or the information the speaker deems important.

Potential mechanisms underlying the CS effect

Several alternative or complementary mechanisms may underlie the CS effect that leads to facilitated processing of upcoming linguistic information. In terms of production, these CS co-occurrence patterns could be grounded in production difficulty: The "difficult" planned message might be momentarily more available in one language vs. the other. CS may be associated with production biases such as "easy first" in which harder elements of speech are produced later in utterances. Johns and Steucke (2020) recently presented evidence in support of this hypothesis by finding that code-switches are more likely to occur towards the end of intonational phrases and that normalized speech rate becomes faster after code-switches by analyzing a

New Mexican Spanish-English bilingual corpus of spontaneous speech. The faster speech rate after the code-switch likely signifies that bilingual speakers implement a code-switch when speech becomes difficult, thus proactively relieving production pressures, or that the code-switch occurs as a consequence of impending difficulty and serves to reactively alleviate speech planning difficulties. To some extent, this account parallels a similar underlying interpretation of disfluencies (Arnold et al., 2003, 2004, 2007). In other words, speakers are more likely to produce disfluencies before upcoming more "difficult" concepts. Comprehenders in turn might be sensitive to these production pressures.

The comprehender's sensitivity to the CS signal might be relatively automatic, through language processing mechanisms proposed in models such as the P-chain (Dell & Chang, 2014) or other integrated accounts of production and comprehension (Pickering & Garrod, 2013; see also Ito & Pickering, this volume). According to these models, comprehension entails constant prediction and modeling of the speaker's production either as a means to guide error-based learning or through simulation.

Alternatively, there may be no such automatic connection between comprehension and prediction. The bilingual comprehender could separately infer that a CS is related to the speaker's production difficulty, which is not necessarily something they personally experience. Here, the bilingual comprehender would use top-down information to make inferences on the speaker's perceived state of mind. Studies have shown that bilinguals can similarly pre-activate particular languages or bilingual language context on the basis of top-down information on the speaker's language habits or knowledge (Kaan et al., 2020; Molnar et al., 2015).

Another account is based on the use of the accumulated statistical distributions of how CS is produced. Whatever the cause of CS patterns in production may be, bilingual comprehenders may be tracking these statistical distribution patterns to guide comprehension (Production-Distribution-Comprehension model; MacDonald, 2013). These explanations have also been proposed for the effect of certain disfluencies on prediction (Arnold et al., 2003, 2004, 2007).

Ultimately, code-switching in production may serve several functions, including as a repair strategy for production difficulties or as a somewhat unlikely intentional speech event to direct the attention of the comprehender to upcoming salient points in speech. The contributions of these different CS functions in production could change with more frequent code-switching use or proficiency. Exposure to code-switching patterns and practices, proficiency, and other factors could also modulate bilingual comprehenders' use of code-switches for prediction. Future studies varying the social context (e.g. comprehender's knowledge on speaker's language use preferences or state of mind), production pressures, and methods (e.g. including ERPs) should be conducted to determine the potential role of these production and comprehension mechanisms in predictive CS effects.

Factors modulating how CS affects prediction

The degree to which a code-switch pre-activates upcoming lexical form likely depends on a number of factors tied to individual differences in language experience and cognition, the current socio-pragmatic context, and perceptual differences such as word length. Both studies demonstrate that language dominance plays a strong role, either relatively enhancing (Study 1) or diminishing (Study 2) the effects of code-switches on the prediction of low frequency and negative content, respectively. This effect could be directly related to proficiency and different pressures on processing in more and less dominant languages or how these individual-level factors interact with aspects of code-switching such as switch direction (Litcofsky & Van Hell, 2017). Predictive processing and emotional processing may be differentially affected by proficiency/dominance in each language, with emotionality potentially being more dependent on global emotionality levels in each language.

Finally, it is important to highlight that not all bilinguals code-switch or are exposed to code-switching in a uniform way. The apparent effect of dominance may simply be a manifestation of the linguistic knowledge of a bilingual due to use and/or exposure, where the more balanced or more Spanish-dominant participants in our study could also be less exposed to code-switching or this particular switching function. Such bilinguals might thus have difficulties integrating the switch itself and stop predicting, similar to the effects of foreign accent on prediction (Bosker et al., 2014). Due to the relatively uniform CS frequency of use and exposure measures in our participant samples, we could not investigate further how these factors affect the interpretation of CS as a predictive cue. Moreover, the ability to interpret CS as a predictive cue likely depends heavily on the comprehender's knowledge of the CS habits/patterns of a specific community or interlocutor (e.g., Adamou & Shen, 2019). Consequently, a bilingual listener may fail to interpret CS as a predictive cue in situations in which code-switches were not expected. Moreover, the typology of code-switching may affect bilingual comprehenders' ability to interpret a CS a predictive cue. For example, code-switches may be classified as insertional, alternational, or as congruent lexicalizations according to Muysken (2000). The dominant CS types that emerge in a community are subject to socio-historical factors, which in turn, likely affect bilingual comprehension. Such outcomes are captured by recent models of bilingualism that incorporate the variability of bilingual interactional contexts (e.g., Green & Abutalebi, 2013; Green & Wei, 2014). Our studies show that investigating CS in relatively meaningful sentences is sufficient to provide the appropriate context to affect prediction. Nevertheless, these studies only represent a beginning in understanding how to incorporate additional sociolinguistic variables to determine the scope of predictive processing in code-switching.

Conclusions

Despite the challenge of studying code-switch processing in more ecologically valid paradigms, incorporating sociolinguistically-informed observations into the experimental study of CS is paramount for constructing a sound psycholinguistic theory of bilingual sentence processing (Myers-Scotton, 2006). One means for accomplishing this goal is to shift focus from purely examining integration costs found at the moment of processing code-switches to investigating whether bilinguals infer the code-switch as a meaningful and beneficial signal. As the results from the illustrative studies described in this chapter suggest, bilinguals can do so, indicating that processing costs (i.e., integration costs) can turn into processing benefits (i.e., predictive processing). This approach represents a novel lens through which we can study the linguistic resources that bilinguals deploy in both production and comprehension and which cannot be studied in monolingual or unilingual contexts alone. Our approach here is promissory with room for additional discoveries that relate to prediction, emotionality, production planning, and comprehension.

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