THE PRODUCTION-PROCESSING PARADOX:

EXAMINING THE COGNITIVE EFFECTS OF CODE-SWITCHING VIA FEBLOC, A NOVEL ECOLOGICALLY VALID SWITCHING CORPUS

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To my great-grandfather, who was a gold miner,

my grandfather, who was a gold miner,

and my parents, who both worked in the mines.

I am here because you were there.

Cette famille, la mienne, habitait le nord. Un nord triste. Un nord froid. Pourtant, le nord n'était pas que misère. De la fenêtre, j'observais les corneilles qui, elles, semblaient s'amuser follement. Elles déployaient leurs ailes sur la neige. Elles faisaient l'ange. Feignaient l'humilité. Quelles charmantes petites sorcières! J'enviais leur liberté.

À l'ombre du silence, Marie-Andrée Donovan

A speaker who is made ashamed of his own language habits suffers a basic injury as a human being.

Halliday, 1968 (p.165)

Abstract

Many fluent bilinguals pass from one language to the another in a single conversation, seemingly without effort. However, in-lab experiments show that reading or hearing code-switching elicits cognitive costs (e.g., longer reaction times, distinct brain responses, etc.). The present dissertation teases apart this production-processing paradox and examines the cognitive consequences of code-switching according to modality.

First, nineteen in-group pairs of French-English bilinguals (i.e., siblings, couples, parent-child, etc.) completed a series of speech elicitation activities in a private room. Their conversations were recorded, transcribed, and coded for language membership (English, French, code-switched). This speech data—coined the French-English Bilingual Loved Ones Corpus (FEBLOC)—resulted in a dataset of 36,000 utterances (18% code-switches). Exploratory analyses revealed that i) the amount of within-speaker code-switching did not impact performance on the speech elicitation activities; ii) between-speaker switching was related to decreased proficiency and performance; iii) members from the same testing pair tended to match each other's language usage, with no effect of relationship type (e.g., couples vs. relatives); iv) women tended to code-switch more often than men; and v) participants were inaccurate in self-evaluating their code-switching habits.

Second, since FEBLOC contains multiparty speech (pairs of bilinguals), it was possible to compute proportions of produced switches (i.e., what partner-A said themselves) and heard switches (i.e., what partner-A heard from partner-B) for each participant. These indices were then examined in relation to the bilinguals' performance on a subsequent

behavioural Flanker task. The findings revealed a dissociation in the cognitive consequences of code-switching according to modality. Producing and hearing code-switches were both linked to ameliorated interference suppression (quicker responses to conflict trials), but interference disengagement was uniquely negatively associated to producing switches (slower responses to non-conflict trials). I speculated that producing dense code-switches engages proactive control (which impedes task disengagement), but that hearing inter-utterance code-switches engages reactive control (which does not hinder task disengagement). This difference reflects the inherent nature of producing vs. processing: speech output can be biased according to a speaker's own internal state (e.g., the accessibility of a given lexical item). By contrast, the listener is 'at the mercy' of the speaker's internal state and must process input as it arrives.

Finally, FEBLOC was utilized in a pilot EEG experiment. Ten new French-English participants listened to forty excerpts of genuine conversations from the corpus (half bilingual, half unilingual); they also completed a Flanker task, and five minutes of resting-state EEGs. The passive listening EEGs for each excerpt were split into equal-sized segments. Spectral components were then extracted and averaged across conditions, giving a measure of 'global' processing in the frequency domain. During both resting state and passive listening, language background characteristics (e.g., entropy) modulated gamma oscillations. Equivalent global neural responses were observed for densely code-switched excerpts and unilingual excerpts during the passive listening task. However, participants with larger N2 Flanker effects exhibited *decreased* code-switching listening costs, while participants with larger LPC Flanker effects exhibited *increased* code-switching listening costs. Under the assumption that early ERP components reflect bottom-up mechanisms and later components reflect top-down mechanisms, I speculated that processing code-switches is positively associated to (top-down) reactive control abilities. Nevertheless, the absence of global costs corresponds well with bilinguals' feelings about code-switching: though bilingualism doubtlessly shapes cognition (even at rest), code-switching costs are probably functionally inconsequential outside of the lab.

Overall, the present dissertation demonstrates that bilingual production and bilingual processing involve distinct mechanisms: producing (dense) code-switches engages (and therefore potentially trains) bottom-up proactive control, while processing switching is modulated by top-down reactive control. The original data included in the present dissertation circumvents many of the pre-existing issues in the code-switching literature (e.g., stigmatization, ecological validity, subjectivity), since (naive) in-group bilinguals were tested in a private room, and switching habits were operationalized objectively. With any luck, the corpus can continue to instruct future bilingualism research.

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Writing a dissertation may seem like a solitary experience. I suppose it often is. However, this thesis would not exist without a village of mentors, colleagues, friends, family, and other supporters—both active and passive. This is *your* place in my dissertation!

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When I first moved away from home and started university, my parents decided that they would contribute to my education by taking over my cell phone bill until I was no longer a student. They got a little more than they bargained for: ten years of post-secondary education! My father often teased me about how I pursued a doctorate just so that I could avoid my phone bill. I guess the jig is up: C'est finalement le temps, dad… You're free!

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LIST OF ABBREVIATIONS

***FIR**	first speaker of the pair (Partner-A)
***INV**	investigator
***SEC**	second speaker of the pair (Partner-B)
ACC	anterior cingulate cortex
ACH	Adaptive Control Hypothesis (Green & Abutalebi, 2013)
ACSES	Assessment of Code-Switching Experience Survey (Blackburn, 2013)
AD(H)D	attention deficit (hyperactive) disorder
AoE	age of exposure
ANT	attention network task
APH	Adaptive Predictability Hypothesis (Valdés Kroff & Dussias, 2023)
BAH	Bilingual Advantage Hypothesis
BBE	Bilingualism-based effects
BIA+	Bilingual Interactive Activation Plus model (Dijkstra & Heuven, 2002)
BInConQ	Bilingual Interactional Contexts Questionnaire (Hartanto & Yang, 2016)
BOR	borrowing
BSwQ	Bilingual Switching Questionnaire (Rodriguez-Fornells et al., 2012)
CHAT	Codes for the Human Analysis of Transcripts (MacWhinney, 2014)
CI(s)	confidence interval(s)
CLAN	Computerized Language ANalysis program (MacWhinney, 2014)
CPM	Control Process Model (Green & Wei, 2014)
CS	code-switching
DB	degree of balance
EF(s)	executive function(s), executive functioning
EEG(s)	electroencephalography
EMA	Ecological Momentary Assessment (Jylkkä et al., 2020)
EN-to-FR	English-to-French switching
ERP(s)	Event-Related (brain) Potential(s)

Est.	estimate
FEBLOC	French-English Bilingual Loved Ones Corpus
FFT	fast Fourier transform(ation)
FJT	frequency judgement task
(f)MRI	(functional) magnetic resonance imaging
FR-to-EN	French-to-English switching
ICC(s)	intra-class correlation coefficient(s)
ICM	Inhibitory Control Model (Green, 1998)
IPL	inferior parietal lobe
ISPR	Integrated System of Participation in Research
L1/L2/L3…	first/second/third language
LOLI(s)	lone other-language item(s)
LPC	late positive component
LSBQ	Language Social Background Questionnaire (Anderson et al., 2018)
NMSEB	New Mexico Spanish-English Bilingual corpus
OSF	Open Science Framework
PDC	Production-Distribution-Comprehension model (MacDonald, 2013)
PF	phonological form
PFC	prefrontal cortex
pre-SMA	pre-supplementary motor area
rEEG(s)	resting-state electroencephalography
RT(s)	reaction time(s)
SD	standard deviation
SE	standard error
SG	speaker-grouped coding
TFR(s)	Time-Frequency Representation(s)
TL	time-linear coding
VIF	variance inflation factor

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CHAPTER 1: *L*'introduction

Bilinguals and multilinguals around the world often switch between their languages within a single conversation, or even, a single utterance. In-lab psycholinguistic research has quite robustly shown that this linguistic phenomenon, known as CODE-SWITCHING, engenders some sort of processing cost (i.e., longer reaction/response times, differential electrophysiological and neural activation signatures, etc.; e.g., Gosselin & Sabourin, 2021, 2023, 2024). This 'code-switching cost' has puzzled researchers, who regularly cite the apparent ease with which bilinguals pass from one language to the other: if code-switching is indeed cognitively effortful, why would bilinguals produce it so fluidly (or produce it at all)? Thus, the production-processing paradox was born.

The goal of the current dissertation is to unify two prominent subfields in the study of code-switching. The first pertinent subfield concerns the production and processing of code-switching; the second pertains to the potential consequences of code-switching on bilingual cognition. I rationalize that the above lines of questioning are inherently related: If code-switching is cognitively effortful, perhaps it is precisely this 'cost' that shapes bilingual cognition. Importantly, we do not yet understand which aspects of code-switching are 'costly', and what types of cognitive mechanisms they engender. I bring together the experimental code-switching literature and the bilingual neurocognitive literature by examining the modality-specific effects (i.e., producing vs. processing) of code-switching. The following questions are of interest:

(1) **Research questions:**

RQ1) Does the frequent *production* and/or *processing* of code-switching lead to increased cognitive functioning?

RQ2) Is code-switching more difficult to produce and/or process than unilingual language, even in the most ecologically valid contexts?

The dissertation starts by reviewing key previous research examining the production and processing of code-switches (**Chapter 2**) and the effects of code-switching on cognition (**Chapter 3**). I highlight several methodological and conceptual gaps in the literature. First, producing and processing are often seen as symbiotic in code-switching studies (the modality conflation issue). Second, the vast majority of existing analyses rely on subjective measures of code-switching (the subjectivity issue). Third, participants are almost always tasked with producing and/or processing lab-made (i.e., artificial) code-switches (the ecological validity issue). The caveats are the focus of the following experiments.

Chapter 4 details the construction and composition of the French-English Bilingual Loved Ones Corpus (FEBLOC). During a first experiment, 19 pairs of French-English bilinguals performed a series of speech elicitation activities in a private room (ranging from structured games to naturalistic discussions), while their conversations were recorded. Crucially, the pairs of bilinguals were part of the same in-group (i.e., "Loved Ones": couples, friends, siblings, parent-child, etc.). A corpus containing 18 hours of speech was thus transcribed using the CHAT method (MacWhinney, 2022). This allowed for the coding of the speakers' interactions, notably their proportion of intra-utterance switching, inter-utterance switching, and between-speaker switching. In total, 35,800 utterances were coded, 18% of which are code-switches.

The corpus was utilized as a tool in the subsequent chapters. First, in **Chapter 5**, a series of exploratory analyses were conducted on the data from FEBLOC. Code-switching behaviours were examined in relation to pair characteristics (type of relationship, years known, etc.) and speaker traits (age, sex, language proficiency, etc.). The relationship between objective code-switching behaviours and subjective self-reports (code-switching, language entropy questionnaires) was also examined. Finally, the pairs' scores during the structured speech elicitation games were examined in relation to their code-switching proportions. Did more code-switching lead to increased task/conversational efficiency?

The exploratory analyses in Chapter 5 hone-in on the modality of production. As such, **Chapter 6** disentangles the cognitive consequences of producing vs. hearing (processing) code-switches. Immediately following the recorded speech elicitation activities, the speakers from FEBLOC completed an individual Flanker task. As FEBLOC is composed of speech from pairs of bilinguals, it was possible to compute proportions of produced switches (i.e., what partner-A said themselves) and heard switches (i.e., what partner-A heard partner-B say). These indices were then examined in relation to the bilinguals' subsequent Flanker performance, thereby testing the modality-specific consequences of code-switching on cognitive control.

A final experiment focused on the modality of *processing* is described in **Chapter 7**. In this pilot experiment, ten new French-English bilinguals listened to forty conversation excerpts while their electroencephalograms (EEGs) were recorded. Crucially, the materials were selected from FEBLOC and thus represent completely genuine instances of code-switched (and unilingual) speech. Analyses compare the power density of bands across the frequency spectrum when bilinguals listened to code-switched excerpts and unilingual excerpts. The participants additionally completed an online Flanker task and five minutes of resting-state (i.e., sitting quietly without performing a task), allowing for i) the examination of by-subject traits modulating baseline cognition, and ii) the association between domain-general EEGs and the processing of naturalistic code-switches.

Chapter 8 concludes the dissertation by discussing key findings, methodological limitations, and avenues for future research. Altogether, the thesis provides novel corpus data, behavioural data, and online electrophysiological data to support the dissociation between producing and processing code-switches.

CHAPTER 2: *Un* condensed overview *du* code-switching

One needs only to wander into bilingual pockets of Canada, such as the capital region, in order to be exposed to mixed-language sentences. The curious phenomenon of bilingual CODE-SWITCHING involves the practice of alternating between more than one language during a single speech event (Poplack, 1980). Code-switching is found in every corner of the world (2a-f). In the francophone Canadian context, mixed sentences are colloquially known as 'Frenglish' or '*franglais*' utterances (1g).

(1) **Instances of code-switching from around the world:**

a. **Spanish/*English*** in Miami, Florida (taken from Valdés Kroff et al., 2017):
   i. Qué es lo que ella quiere, qué es una *cookie*?
      'What is it that she wants, what is a cookie?'

b. **Cantonese/*Standard Chinese*/English** in Hong Kong (Chan, 2019):
   i. Next time when you come to Hong Kong, *wǒ dài nǐ qù chī* 菠蘿油.
      Next time when you come to Hong Kong, I will bring you to have pineapple bun with butter.'

c. **French/*Dutch*** in Brussels, Belgium (Treffers-Daller, 1994):
   i. *d'r zit me hier* une femme qui n'est pas drôle
      'here we have a woman who is not funny.'

d. **Swahili/*English*** in Nairobi, Kenya (Myers-Scotton, 1993):
   i. Mimi siku hizi ni-ko *used* ku-amka *very early* ili niende shule *in time*. Hata wakati wa *holidays* mimi huamka *just the same*.
      'These days I'm used to waking up very early so that I get to school in time. Even during the holiday time I usually get up [at] just the same time.'

e. **Arabic/*French*** in Morocco (Lahlou,1998; as reported in Aabi, 2020):
   i. *Regarde la montagne*! la hadi lli 'la š-šmal šefti šḥāl kbira.
      'Look at the mountain! No this one, the left. Did you see how big it is?'

f. **Burarra/*English*** in Maningrida, Australia (Vaughan, 2021):
   i. *Collecting* jiny-ni *stories pictures* mu-manga [...] so grow up aburr-ni barra mbi-na barra who they family.
   'She collected stories, and took pictures [...] so when they grow up they will see that book, who their family is.'

g. **French / *English*** in Ottawa, Canada (pair02, FEBLO-Corpus, see CHAPTER 4):
   i. Une autre question *I guess. Well not* 'question'. *But like something that you have to consider?* Quand tu dis ça.
   Another question I guess. Well not 'question', but like something that you have to consider when you say that.
   ii. Pas les libéraux. *Mostly repub(lican) [/] republicans*.
   'Not the liberals. Mostly Republicans.'

Code-switching can occur within sentences (intra-sentential: 1g-i) or between sentences (inter-sentential: 1e, g-ii). Originally proposed by Muysken (2000), many authors (e.g., Green & Wei, 2014; Hofweber et al., 2020b, 2023; Ng & Yang, 2022; Paap et al., 2021; Treffers-Daller et al., 2020) also distinguish between insertions, alternations, and congruent lexicalisation (or dense code-switching). Insertions occur when an item from a given language is embedded into a sentence from a different matrix-language (1a). Alternations involve the juxtaposition of two independent segments of speech from different languages (1c). Finally, congruent lexicalisation occurs when two (or more) languages are integrated grammatically and lexically within a single structure (e.g., 1d, f).

Early research criticized code-switching, stating that this linguistic behaviour reflected a speaker’s lack of competence or their “linguistic laziness” (see Heredia & Altarriba, 2001). Fortunately, the bulk of linguistic research from the past several decades refutes this early viewpoint. Children exposed to code-switching do not appear to display delayed language acquisition (Bail et al., 2015; Yow et al., 2018; cf. Byers-Heinlein, 2013), though this may depend on their underlying cognitive abilities (Kaushanskaya & Crespo, 2019). Adults who code-switch (particularly within sentences) are generally found to be highly proficient in both of their languages (Dewaele & Li, 2014; Poplack, 1980), and quite balanced (e.g., Gollan & Ferreira, 2009; Yow & Li, 2015). From a structural standpoint, code-switching is highly rule-governed and systematic (e.g., Belazi et al., 1994; Di Sciullo et al., 1986; MacSwan, 2000; Myers-Scotton, 1993) and code-switchers possess intuitive acceptability judgements about mixed sentences. Children typically follow the code-switching patterns of the adults around them (Phillips & Deuchar, 2021; Sun et al., 2020; cf. Tulloch & Hoff, 2023), yielding community-specific code-switching norms. Thus, recent evidence clearly illustrates that code-switching is a high-level skill that can be honed through in-the-field experience.

The fact that code-switching is so widespread globally suggests that the phenomena imparts some sort of positive outcome, be it conversational, social, emotional, or otherwise. Interdisciplinary research indeed demonstrates that bilinguals can code-switch for a variety of reasons. Some of these reasons are reviewed below.

2.1 Why do bilinguals code-switch?

2.1.1 Switching to fill lexical gaps and maximize expressive power

First, code-switching can be used as a mechanism to help fill lexical gaps. For instance, a French-dominant child may use a French word while speaking English if they have not yet acquired the target English translation equivalent. In an early study, Nicoladis and Secco (2000) reported that 90% of the switches produced by a 12-18 month-old boy could be explained by gaps in his vocabulary (see also Tulloch & Hoff, 2023 for 2-3 year olds). In the classroom, teachers may code-switch to help students understand concepts and learn new words (e.g., Cahyani et al., 2018; Siboro & Agung, 2022).

Lexical gaps may also exist among adults, particularly unbalanced adult bilinguals. During an online study designed to assess the executive functioning abilities of French-English bilinguals (Gosselin & Sabourin, 2023b, 2024), over two hundred participants (*n*=225) also completed a questionnaire about their switching habits. From this sample, 172 individuals (76%) reported that they use a French word when speaking English if they do not know the English equivalent. This is neither surprising nor worrisome, as bilinguals have often been found to have complementary (rather than completely overlapping) vocabularies across their languages (the Complementary Principle: Grosjean, 2008). Switching may thus be used as a strategy to convey an otherwise unavailable concept (e.g., resolving a tip-of-tongue state).

Relatedly, some lexical items do not have direct translations in other languages (Tokowicz & Degani, 2010). This could be described as a lexical gap in the language (or 'translation ambiguity'), rather than an idiosyncratic gap within the speaker. For instance, "*I like him"* and "*I love him*" are both translated as "*Je l'aime*" in French, even though *like* and *love* have graded emotional meanings. Bilinguals may thus choose to switch languages in order to select the most appropriate word or expression to describe a concept, an emotion, or a situation (e.g., "*Je le like*" / "*Je le* love"). Going back to the sample from Gosselin and Sabourin (2023b, 2024), 133 individuals (59%) reported using a French word when speaking English if their intended meaning had a poor translation correlate in English. Again, this demonstrates how bilinguals can maximize their semantic accuracy and expressive power by choosing to pass from one language to another.

2.1.2 Switching as a strategy for efficient communication and saliency

Rather than filling lexical gaps, bilinguals may code-switch to optimize conversational productivity and/or task efficiency. In one fascinating analysis (Beatty-Martínez et al., 2020a), Spanish-English bilinguals described a visual scene containing distinguishable duplicates (e.g., a shelf full of objects, including a red car and a blue car). Approximately 32% of the adjectival phrases produced by the participants were code-switched (i.e., "*el* red *car"* / "*el* car *rojo"*), and code-switching was more frequently employed to describe duplicate than singleton objects in the visual scene. Crucially, 85% of the mixed adjectival phrases contained an English prenominal modifier (i.e., "*el* red car"). The authors posited that speakers used code-switching as a disambiguation strategy. That is, a listener could more quickly distinguish between a blue car and a red car in the visual scene if they heard "*el* red car" (discrimination at word 2) than if they heard "*el* car *rojo*" (discrimination at word 3).

In the same vein, it is also possible that bilinguals code-switch in order to signal that a lower frequency word or new word is incoming. For instance, listeners can exploit subtle acoustic code-switching indices (e.g., decreased speech rate) in order to fine-tune their expectations about upcoming speech (Fricke et al., 2016). In a visual world paradigm, participants looked at low-frequency targets much more when the instructional carrier phrase was Spanish-English rather than unilingual Spanish (Tomić & Valdés Kroff, 2022).

Relatedly, when asked to guess the ending of discourse passages, bilinguals were more likely to use a code-switch if the completion was difficult to predict (Myslín & Levy, 2015). Finally, bilinguals have reported higher attention levels for (and better memory of) content containing switches (Salig et al., preprint). Thus, code-switching can assist both in informational cueing and efficient task completion.

2.1.3 Switching opportunistically or for ease of access

Beyond cueing a listener, a bilingual may code-switch to ease their own computational system. This has been called "opportunistic" switching (e.g., Green & Wei, 2014). Compelling research shows that bilinguals may simply use the most accessible lexical item (in terms of lexical retrieval), especially when the speaker can ascertain a shared linguistic knowledge with the co-interlocutor(s) (see *Section 3.2.3*). To measure lexical accessibility, Sarkis and Montag (2021) asked Spanish-English bilinguals to label nouns in the language of their choice. The nouns ranged in their "lexical accessibility" in each language. For example, 'door/*puerta*' was labelled in English only approximately 40% of the time, while 'mushroom/*hongo*', was virtually always labelled in English. In a subsequent production task (where instructions were in Spanish, but code-switching was explicitly allowed), a different group of bilinguals were found to code-switch into English more frequently as the lexical accessibility of the English labels increased (see also de Bruin & Martin, 2022).

Instead of indirectly computing lexical accessibility, Xu and colleagues (2021) modelled the semantic networks of Spanish-English and Mandarin-English bilinguals. Using this network approach, they were able to compute clustering coefficients for lexical items and their translation equivalents. Items with high clustering coefficients are words that are more difficult to access, as they are attached to many other nodes in the network (i.e., the network is denser in that region). Importantly, the authors' corpus analyses revealed that bilinguals tended to code-switch when a translation equivalent had a lower clustering coefficient (i.e., was easier to access) than the target in the original language.

On one hand, this "opportunistic" code-switching could be a strategy employed by bilinguals to avoid more effortful lexical access (i.e., retrieving less accessible words or words with more semantic neighbours). On the other hand, switching in these scenarios could simply be a result of the increased cross-linguistic competition.[1] What remains clear is that code-switchers can use both of their languages as a tool to circumvent potential processing difficulties.

2.1.4 Switching to regulate emotions

Interestingly, bilinguals may also pass from one language to another in order to call upon the more emotional language (typically, the L1: e.g., Dewaele, 2008; Ferré et al., 2022) or to distance themselves from negative affect. Research has shown that bilinguals may switch to their L1 when conveying high-emotion messages (see (2)); this state of arousal has been linked to creativity and innovation (Kharkhurin & Wei, 2015). For instance, code-

[1] This second interpretation perhaps more so falls into line with the 'triggering hypothesis', a theory based on the finding that code-switching may be 'triggered' by cognates (Broersma, 2009; Broersma et al., 2020; Broersma & Bot, 2006). The idea here is that it may be easiest to pass from one language to another when cross-language activation is so high.

switching is more common during competitive video-gaming (particularly at the end of matches) compared to casual video-gaming (AlBathi, 2022). Relatedly, swearing generally takes place in L1 rather than in the L2 (Dewaele, 2010). These types of switches perhaps result from lapses in language control, as emotions like anxiety can consume significant cognitive resources (Eysenck et al., 2007)—in some cases (e.g., fatigue), these resources may already be depleted. Unintentional switching indeed appears likelier when an individual is in a high-stress or emotional situation (e.g., Ladegaard, 2018), or if a speaker is already fatigued (Grosjean, 1982).

(2) **English (L1)** / Portuguese (L2) student from Prelovskaia (2013):

a. *Não, não resolvi.* ***Oh, Jesus****, era um dia horrivel... Quando cheguei la o metro não estava a funcionar por causa de greve, e eu tinha marcação as 10 de manha!* ***Oh, I was so pissed! Every time you need it, it doesn't work!*** *Então, tinha que pegar o autocarro mas ao final, não consegui chegar a tempo, porque tambem havia muito transito nas ruas, ..e pronto, perdi a minha marcação.* ***I hate*** *greves!*

'No, I didn't solve it. **Oh, Jesus,** it was a horrible day... When I got there the metro wasn't working because of a strike, and I had an appointment at 10 in the morning! **Oh, I was so pissed! Every time you need it, it doesn't work!** So, I had to catch the bus but in the end, I couldn't get there in time, because there was also a lot of traffic on the streets,...and that's it, I missed my appointment. **I hate** strikes!'

By contrast, switching away from an L1 (or a language in which encoding has occurred) can result in feelings of detachment from a troubling situation or memory (Tehrani & Vaughan, 2009). This means that code-switchers possess the tools (i.e., multiple languages) to shift away from difficult events in order to create "emotional distance" (Ladegaard, 2018: 709). As taboo words (e.g., *diarrhea*) are associated with heightened processing effort, bilinguals may use a more neutral language to produce them (also likened to "saving face":

Brown & Levinson, 1987). For instance, Tomić and Valdés Kroff (2023) observed that bilinguals more easily integrated taboo words when they were preceded by a code-switch in the sentence frame (e.g., "***Los niños*** *start talking about* ***sex*** *very early these days*.") than if the sentence frame was unilingual English ("***Kids*** *start talking about* ***sex*** *very early these days*.") (see also Bond & Lai, 1986; Shi et al., 2023). Overall, bilinguals can switch towards their more emotion-ladden or more neutral language in order to regulate their emotional state and expressional needs.

2.1.5 Switching to identify with a group or according to sociocultural norms

Finally, the reason for switching is often sociocultural rather than linguistic. Code-switching is largely regarded as 'in-group' behaviour: bilinguals switch up to four times more frequently with someone from the same in-group compared to an out-group stranger, and usually code-switch in informal settings (Poplack, 1983). For this reason, code-switching may simply be part of some bilinguals' identity; group solidarity indeed appears to be a driving factor in many bilinguals' switching habits (Hsiao, 2022; Wentker & Schneider, 2022; Yim & Clément, 2021). In Cameroon, for example, speakers may insert Cameroon Pidgin to consolidate Cameroonian identity (in-group), and use French to denigrate colonization and its adherents (out-group) (3a) (Anchimbe, 2015).

In the classroom, teachers may code-switch to build rapport with students (e.g., Cahyani et al., 2018; Siboro & Agung, 2022). Among biculturals, code-switching can be used to circumvent sociocultural norms that pervade one culture/language, but not the other. For instance, giving explicit encouragement and complimenting is more typical in Western cultures than in Eastern cultures (e.g., Leech, 2007). As such, Cahyani and colleagues (2018) found that teachers often switched to English to give their students praise (3b). One teacher even stated that she was "not comfortable" giving praise in Bahasa, because it "sounds not natural" (Cahyani et al., 2018: 9).

(3) Socioculturally-driven code-switching:

a. **English / *Cameroon Pidgin* / <u>French</u>** (Anchimbe, 2015):

   i. Once in a while, a few fools from our divide are made ministers and because they think they don't deserve it, they spend all their working time saying '<u>je voulais d'abord remercier le chef de l'etat pour m'avoir donner cet confiance</u>' whenever any quack of a journalist stands before them ... these good-for-nothing-brothers of the coast will stick with their so called 'Sawa' brothers because to them they are '<u>en haute</u>' ... *Na their own flop cup.*

   Once in a while, a few fools from our divide are made ministers and because they think they don't deserve it, they spend all their working time saying '<u>I would first of all like to thank the head of state for trusting me</u>' whenever any quack of a journalist stands before them ... these good-for-nothing-brothers of the coast will stick with their so called 'Sawa' brothers because to them they are <u>privileged</u> ... *Good for them*.

b. **Bahasa Indonesia / *English*** (Cahyani et al., 2018):

   i. *Okay, well done*! [...] Saya harapkan kalian bisa membuat slide seperti ini. *It's very nice slide*.

   Okay, well done! I hope you can make a slide like this. *It's a very nice slide*.

Beyond these strategies, certain demographic groups may code-switch more frequently. Women in general (Dewaele & Li, 2014), or younger women (Gosselin & Sabourin, 2023a) alternate between their languages significantly more often (based on self-reported switching habits).[2] This effect may go hand in hand with the robust sociolinguistic finding that women (particularly young women) are the drivers of linguistic change (Labov, 1990), including in stable bilingual communities (Shin & Otheguy, 2013).

Altogether, code-switching can take place for a variety of reasons; bilinguals may partake in this behaviour to fill gaps in their vocabulary, to increase their conversational efficiency and ease lexical retrieval mechanisms, to regulate their emotions, or to reinforce their identity. However, not all linguists agree with what constitutes a code-switch. Let us review some the ways in which linguists have distinguished code-switching from BORROWING.

2.2 Is code-switching different from borrowing?

Linguists do not agree on whether 'borrowing' falls under the same umbrella as code-switching, or whether it is an independent phenomenon requiring distinct cognitive-linguistic processes. Some (e.g., Poplack et al., 1988) distinguish 'established borrowings' (single donor words recurrently inserted into a recipient language by a given speech community) and 'nonce-borrowings' (idiosyncratic single donor words inserted into a recipient language by a given speaker); others (e.g., Johns & Dussias, 2022) ascertain that nonce-borrowings are simply instances of single-word code-switches (i.e., they do not differ from code-switching in general).

Furthermore, experts dispute the ways in which 'borrowings' can be identified in the first place. researchers originally claimed that code-switches were faithful to the

[2] Individual personality also seem to play a role. For instance, extraverts appear to code-switch more frequently than introverts (Dewaele & Li, 2014).

phonological grammar of their original language (e.g., 'smart' produced as English-like /smɑrt/). On the other hand, borrowed words were believed to be phonologically integrated into the recipient language (e.g., 'smart' produced as French-like /smaʁt/). Since these original claims, the picture has complexified: experimental studies show mixed results with regards to the phonological integration of code-switches (Antoniou et al., 2011; Balukas & Koops, 2015; Bullock et al., 2006; Grosjean & Miller, 1994; López González, 2012; Muldner et al., 2019; Ojeda et al., 2018; Piccinini & Arvaniti, 2015) and borrowings (Besset, 2017; Gosselin & Manning, 2022; Poplack, 1980, 2017; Poplack et al., 2020). Nevertheless, evidence suggests that morphological integration is usually accompanied by phonological integration (e.g., Besset, 2017; Gosselin & Manning, 2022; Stefanich & Amaro, 2018). This is important given that morphological integration may not always be overt (e.g., in the case of null morphemes).

For the scope of this thesis, I operate under a minimalist model of the bilingual language faculty (MacSwan, 2000; MacSwan & Colina, 2014; see also Gosselin, 2022); this model theorizes that bilinguals possess two independent phonological systems (one for each language), since phonology is made up ordered rules and combining the grammars would result in "ranking paradoxes" (MacSwan & Colina, 2014: 193). This implies that bilinguals must parse lexical material into their appropriate phonological grammar when they are code-switching. However, borrowed words, which may contain morphological information for the recipient language, are parsed into the phonological grammar of the recipient language and are thus spelled-out to the phonological form (PF) according to the grammar of the recipient language. For instance, in "*Elle est smart*" ('She is smart') /smɑrt/

would be considered a code-switch because it passed from the English lexicon to the English PF (in an otherwise French utterance). By contrast, /smaʁt/ would considered a borrowing since it passed from the English lexicon to the French PF.

Altogether, I operate from the position that phonological integration is a hallmark of borrowing; this will be an important consideration for the data described in later chapters.

2.3 Is it costly to produce a switch?

In a seminal paper, David Green put forth a model of bilingual production: the Inhibitory Control Model (ICM; Green, 1998). According to the ICM, (interconnected) lemmas in a language network possess language-specific tags. Thus, a concept like {🐕} would activate both *'chien'* (L1) and *'dog'* (L2). The ICM posits that a 'Supervisory Attentional System' specifies a target language (according to a goal) to 'language task schemas'. The language task schemas then supress lemmas from the non-target language (e.g., in an English context, *chien* is suppressed), so that the most activated lemma can then be produced (e.g., *dog*).

This model, however, was not intended to elucidate contexts in which multiple languages are used (i.e., code-switching). To account for these situations, the Control Process Model (CPM) of code-switching was later presented (Green, 2018; Green & Wei, 2014). Crucially, the CPM integrates 'language gates'. When no code-switching is to take place (competitive control mode), the gate is closed and locked: the language task schemas only queue lemmas from a single language. When insertion or alternation is expected (cooperative coupled control mode), the gate is closed but unlocked: control passes from one language task schema to the other (i.e., the gate can swing back and forth). Finally, when congruent lexicalisation is expected, the gate simply remains open (cooperative open control mode): the language task schemas hold no top-down influence on the queueing of lemmas; the most activated item is selected regardless of language membership.

The CPM suggests that control processes are not always needed when it comes to producing code-switches (e.g., in an open control mode). Let us review the empirical data.

2.3.1 Forced and volitional language switching

Before naturalistic code-switching attracted the attention of psycholinguists, the effects of producing language switches had long been established. During a classic LANGUAGE-SWITCHING paradigm, participants are instructed to verbally name pictures in one of their languages. Crucially, the target language is pre-determined by an external cue. For instance, in a mixed block, participants may be instructed to name an image in French if it is framed in red, and name a picture in English if it is framed in blue. This paradigm therefore gives rise to trials wherein the participant stays in a given language (red-red; blue-blue), and trials in which the participant must switch languages (red-blue; blue-red). A very robust finding emerged from this literature: bilinguals consistently take more time to respond to a trial when they need to go from one language to another (e.g., Costa & Santesteban, 2004; Meuter & Allport, 1999; Thomas & Allport, 2000).

While language-switching studies provide a solid footing for examinations of bilingual production, language-switching is distinct from code-switching for many reasons. First, language-switching involves isolated words, whereas code-switches are typically produced within a broader context. Secondly, language-switching tasks have been deemed "artificial" (e.g., Blanco-Elorrieta & Pylkkänen, 2017), since the participants are "forced" to pass from one language to another (i.e., based on a lab-made external cue). By contrast, code-switching can occur voluntarily (see *Section 2.1*). If switching is obligatory (e.g., passing from a monolingual English co-interlocutor to a monolingual French co-interlocutor), it is presumably cued by some kind of contextually-relevant language cue (e.g., the co-interlocutor's identity).

Recently, some researchers have adapted the classic language-switching paradigm to include a volitional condition or block, where participants can switch languages freely. It appears that bilinguals are faster at naming pictures under these conditions, compared to language-cued conditions (e.g., de Bruin et al., 2018; de Bruin & McGarrigle, 2024; Zhu et al., 2022). In fact, bilinguals show a mixing benefit: they exhibit faster response times when they can switch languages freely rather than when they are instructed to stay in a single language (de Bruin et al., 2018; Gollan et al., 2014, experiment 2; Grunden et al., 2020; Jevtović et al., 2020; cf. Zhu et al., 2022), particularly if the unilingual context is in a non-dominant language (Gollan & Ferreira, 2009). However, even when switching voluntarily, language-switch trials still elicit longer response times than language-stay trials in mixed blocks (e.g., de Bruin & McGarrigle, 2024; Gollan & Ferreira, 2009; Grunden et al., 2020; cf. Liu et al., 2020)[3], though this switch cost may be smaller in magnitude in the voluntary condition than in the cued

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[3] There are exceptions when additional parameters are manipulated. Blanco-Elorrieta and Pylkkänen (2017) allowed participants to switch voluntarily when they saw a photo of a (previously denoted) bilingual interlocutor. Zhu and colleagues (2022) allowed bilinguals to switch freely when blended Asian-Caucasian faces were presented. Under these conditions, no switch cost was observed.

condition (Jevtović et al., 2020; Timmer et al., preprint; Zhang et al., 2015). This suggests that language control mechanisms are diminished when bilinguals know that they can produce picture names in the language of their choice, but that even fully volitional language switching (which is perhaps more directly comparable to code-switching) requires control mechanisms at some level of bilingual production.

The picture is further complexified by differences in lexical access of the language-specific labels. When bilinguals have the choice to switch towards the preferred label (e.g., *mushroom* in English), their response times decreased (de Bruin & Martin, 2022). Furthermore, when bilinguals are asked to name an image in the language that first came to mind, then to stick to that language for all instances of the same image (e.g., if *mushroom* is used for the first "🍄", then all subsequent "🍄" should be named in English), language-switch costs are nullified (Kleinman & Gollan, 2016).

Overall, language control mechanisms almost certainly play a role in producing (isolated) switches, but may be reduced or circumvented if the ease of lexical retrieval outweighs the expenditure involved in language switching (e.g., Gollan & Ferreira, 2009). Let us now move on to paradigms that more closely approximate the production of contextual code-switches.

2.3.2 Artificial sentential code-switching

Researchers have occasionally embedded language-switching-*esque* paradigms within sentential contexts. For instance, Gullifer and colleagues (2013) asked Spanish-English bilinguals to silently read sentences one word at a time, until they reached a target word in red font. Every two sentences, the stimuli alternated from fully Spanish to fully English, making it resemble (disjointed) inter-sentential code-switching. The analyses revealed that participants were just as quick to produce target words aloud in language-switch sentences compared to language-stay sentences. However, target words appeared relatively late in the sentence, making it possible that switch costs had already decayed and therefore did not affect production of target words (see Blanco-Elorrieta & Pylkkänen, 2016 for gradual decline in behavioural switch costs).

It appears that code-switching *junctures* indeed engender production costs (de Bruin & Shiron, 2024; Li et al., 2022; Salig et al., 2024). However, contextual (top-down) information also plays a crucial role: participants are faster at reading aloud a code-switched completion (intra-sentential switches) when it is more predictable (i.e, within high-constraining sentences: Kheder & Kaan, 2016, 2019; see Li & Gollan, 2021 for switch costs in low-constraining sentences; according to distributional patterns: Salig et al., 2024). These results suggest that switching production costs are somewhat alleviated by ease of lexical access (i.e., top-down info helps pre-activate an expected ending), but they still generally persist, even in sentential contexts.

While the studies reviewed above are sentential, they can still be seen as "forced" switching: participants were producing the lab-made stimuli rather than code-switching according to their own preference or state. A recent study elicited volitional sentential switching from participants: Spanish-English bilinguals were asked to describe the movement of a cursor over a set of images in a network (e.g., "*The dot goes right over the straight line to the egg.*"). Under these conditions, switching at the image label was still generally costly (main effect of switching; see also Declerck et al., 2017; Declerck, Grainger et al., 2021), but the cost appeared to be restricted to naming in the L2. Though this design allowed for free labelling of images, the sentence structure was rather rigid (it had to include a direction, a line type, and image name). To examine the production of fully naturalistic switching, more ecologically valid studies, such as corpora analyses, are required.

2.3.3 Corpus analyses and other naturalistic methods

Unsurprisingly, "artificial" paradigms greatly outnumber naturalistic ones. This discrepancy undoubtably reflects the significant time and resource involved in collecting, transcribing, and analyzing naturalistic production data. As no standard yet exists, each of these studies has examined production switch costs using slightly different indices (speech rate, intersyllabic duration, disfluencies).

Recently, Faroqi-Shah and Wereley (2022) obtained naturalistic speech by recording a semi-structured conversation between participants and an experimenter. It should be noted that the experimenter followed a script that always included code-switching, and participants "were asked to code-switch whenever it felt natural" (i.e., they knew that code-switching was the feature of interest) (p.315). The authors found that the intersyllabic durations before spontaneous code-switches were longer than those preceding matched instances of spontaneous unilingual speech. An analysis of naturalistic speech from the Bangor Miami Corpus (Deuchar et al., 2014) yielded similar results: speech rate was slower in code-switched utterances compared to unilingual utterances, and switches contained significantly more disfluencies (Fricke et al., 2016). These effects suggests that code-switching is costly to produce, even during naturalistic conversations where context clues are available and switching is completely volitional.

However, an analysis of speech rate in the New Mexico Spanish-English Bilingual corpus (NMSEB; Torres Cacoullos & Travis, 2018) led to opposite findings. Johns and Steuck (2021) extracted prosodic sentences that contained only English intonational units, only Spanish intonational units, or both English and Spanish intonational units (i.e., classical 'alternations', like "*se me hace que come que, que lo tenía que hacer, porque nadie lo hacía y, and I didn't want to be criticized that I couldn't do it*"). First, code-switches were more likely to occur later in the prosodic item. Crucially, bilinguals exhibited *faster* normalized speech rate during code-switched utterances than during unilingual utterances, even when only the unilingual portions (e.g., "*se me hace que come que, que lo tenía que hacer*") of the code-switch were examined.

To date, the existing corpus studies have generated directionally opposite results: code-switching has been linked both to slower speech rates (a production cost) and faster speech rates (a production benefit)[4]. It is possible that switching *junctures* yield production costs, but that the planning of a switched utterance is more rapid than the planning of a unilingual utterance. Indeed, in their artificial sentential switching paradigm, Li and colleagues (2022) observed slower response times at a switch point, but faster speech onset times for sentences containing a switch. Further research is needed to disentangle the inconsistent results.

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[4] Gardner-Chloros and colleagues (2013) found similar speech rate for unilingual and English-Greek code-switched speech, but this pilot study examined short passages (three one minute excerpts) from only four speakers, and the data was not analyzed statistically.

2.3.4 Neuroimaging methods

To my knowledge, implicit techniques have only ever been paired with language-switching paradigms. When language-switching is cued, increased brain activity is usually observed for language-switch trials compared to language-stay trials. Brain activation is modulated in regions like the inferior parietal lobule (De Baene et al., 2015; Timofeeva et al., 2023), the (pre)-supplementary motor area (Abutalebi et al., 2013; De Baene et al., 2015; de Bruin et al., 2014 for switching into the L2/L3; Timofeeva et al., 2023), the inferior frontal cortex (De Baene et al., 2015; de Bruin et al., 2014 for switching into the L2/L3; Sierpowska et al., 2018), the prefrontal cortex (Blanco-Elorrieta & Pylkkänen, 2017) and the cingulate cortex (Abutalebi et al., 2013; Blanco-Elorrieta & Pylkkänen, 2017; De Baene et al., 2015).

By contrast, when participants are given the option to switch freely, brain activation can be similar (Blanco-Elorrieta & Pylkkänen, 2017; Liu et al., 2020; Reverberi et al., 2018; Zhu et al., 2022) or even reduced (Geng et al., 2024; Zhu et al., 2022) relative to single-language naming. It is possible that forced and volitional switching both engage cortical regions, but that the exact regions do not overlap (Zhang et al., 2015; cf. Geng et al., 2024). For instance, Reverberi and colleagues (2018) found that the prefrontal cortex was used to encode the language (i.e., planning) throughout free language switching; during cued language-switching, the premotor cortex, caudate nucleus and occipital cortex were instead activated. In line with this finding, Liu and colleagues (2020) showed that transcranial stimulation of the prefrontal cortex *induces* voluntary switch costs; these same costs are not observed when participants name images freely under sham stimulation.

The differences in brain activation between forced and volitional switching suggests that more ecologically valid paradigms (i.e., free switching) recruit less overall cognitive resources. Neuroimaging studies examining the production of naturalistic code-switches are much needed, though this poses enormous methodological challenges. Fortunately, the implicit *processing* of code-switches has been well-established.

2.3 Is it costly to process a switch?

Compared to the modality of production, far more experiments—both behavioural and implicit—have examined the processing of code-switching proper (as opposed to language-switching). While I am not aware of any code-switching-specific comprehension models, more general models of bilingual processing can be applied to the phenomena. One widely supported model is the Bilingual Interactive Activation Plus (BIA+) model (Dijkstra & Heuven, 2002), which spells out bilingual word recognition. The BIA+ assumes that an orthographic (or auditory) input will activate a network of lemmas according to sublexical features, which will in turn activate lexical and semantic features (with parallel interactions possible). Inspired by Green's (1998) ICM, Dijkstra and van Heuven (2002) also posit that language nodes relay the language membership of activated lemmas, and that the whole process is supervised by task schemas (e.g., an English lemma should be recognized because of the English environment and English-like cues). Importantly, activation in the BIA+ is non-selective. This means that an input like /ʃu/ may activate 'shoe' (spreading to 'shoot', 'foot', '*soulier*') or '*chou*' (spreading to '*chouette*', '*légume*', 'cabbage').

During code-switching, word recognition also occurs according to phonetic and contextual cues (e.g., Li, 1996). The BIA+ model implies that activated lemmas from the non-target language are inhibited once selection of the target lemma occurs. It is possible that processing language in code-switching contexts involve very high cross-language competition (e.g., increased uncertainty: Gullifer & Titone, 2021), and as such, robust inhibition mechanisms (i.e., a 'cost'). The bulk of research indeed indicates that processing code-switches is costly: this evidence will be reviewed in the following sections.

2.3.1 Behavioural and eye-tracking studies

Both behavioural and eye-tracking paradigms have been adopted to examine the mechanisms which underlie the processing of code-switching. One common behavioural paradigm is self-paced reading: participants are presented sentences (or utterances) word-by-word, in time with their self-controlled button presses. The idea is that participants will take longer to execute the motor action (i.e., slower reaction times or RTs) when they encounter a word or event that is difficult to process. During self-paced reading, code-switches typically elicit longer RTs than single-language counterparts (e.g., Burkholder, 2018; Litcofsky & Van Hell, 2017; Salig, 2021; Wang et al., 2023; see also Wang, 2015 for a maze task), even when the paradigm takes place in the auditory modality (Heredia et al., 2022). This effect appears to be modulated by the switching direction and switching type: asymmetrical switch costs are sometimes solely observed for switches into the dominant language (e.g., Bultena et al., 2015; Faroqi-Shah & Wereley, 2022; Litcofsky & Van Hell, 2017; see also Wang et al., 2023). Alternations may also also require longer reading times than dense code-switches (Jiang et al., 2023).

A more implicit behavioural technique is eye-tracking, wherein a system tracks and records the fixations of a participant who is looking at a computer screen. Eye-tracking paradigms assume that i) individuals look at images/words they are processing; and ii) longer fixations indicate more effortful processing (Conklin & Pellicer-Sánchez, 2016). Such assumptions allow for the comparison of code-switched and unilingual stimuli. For instance, Hui and colleagues (2022) showed that participants fixate (natural) code-switches longer than unilingual words while reading, but that they show similar regressions and saccades for these conditions. To complicate matters, the mode induced by the experimental design may modulate switch costs (see *Section 3.2.2*). In a 'monolingual mode' (e.g., "*El chico dijo que quiere ver* spiders c*uando anda en el bosque*."), images depicted single-word switches into the dominant language ("spider") are fixated more slowly than unilingual counterparts (see also Byers-Heinlein et al., 2017's adult group in an infant-based experimental design). However, in a 'bilingual mode' (e.g., "She closed her eyes *porque no quería ver* spiders *y otros bichos*."), single-word switches ("spider") do not elicit switch costs (Olson, 2017; see Adamou & Shen, 2019 for button-press RTs during an eye-tracking study).

With many eye-tracking devices, it is also possible to measure the dilation of an individual's pupil. This new technique, known as pupillometry, lends physiological data to the participants internal state during language processing: cognitive effort is typically accompanied by pupil dilation (McCloy et al., 2017; Zekveld et al., 2018). In a trail-blazing experiment (Beatty-Martínez et al., 2021), Spanish-English bilinguals from Puerto Rico listened to code-switched and unilingual sentences while the size of their pupil was recorded. On average, switching was linked to pupil dilation (see also Byers-Heinlein et al., 2017's adult group; Johns & Dussias, 2022). However, the authors discovered that this physiological switch cost was mediated by the participants' degree of language cooperativeness. Bilinguals who reported typically using their languages in separate contexts (low cooperativeness) displayed pupil dilation in response to code-switches, but bilinguals who reported using their languages cooperatively (high cooperativeness) did not.

Though behavioural and eye-tracking studies typically show some form of processing cost for code-switches, it is important to note that such carefully-measured effects almost certainly bare no functional impact for bilinguals. Bilinguals remember information just as well (Antón & Duñabeitia, 2021; cf. Hofweber & Marinis, 2023; Yow et al., 2018 for comprehension questions) or better (Salig et al., preprint) when it was presented in a mixed-language compared to a single-language context. Furthermore, code-switching does not impede the learning of new concepts (Antón et al., 2015), and may even cue listeners to expect new or low-frequency information (Tomić & Valdés Kroff, 2022), due to an increased attentional level (Salig et al., preprint).

2.3.2 Event-related brain potential (ERP) studies

Electrophysiological studies also point towards the fact that code-switching generates costs at an implicit level, as indexed by distinct Event-Related Potential (ERP) components. ERPs are obtained in the following way: participants' continuous EEGs are recorded while they are attending to specific language events. The continuous signal is subsequently segmented and time-locked to the event-of-interest (e.g., the code-switch). EEG segments are averaged within experimental conditions, giving rise to interpretable neural peaks. These components are defined in relation to their polarity, amplitude, timing, and distribution.

A first component of interest is the N400, a centro-parietal negativity occurring approximately 400 ms after a critical stimulus. The N400 is classically related to semantic unexpectedness or abnormality (Kutas & Federmeier, 2000; Kutas & Hillyard, 1980, 1984). For instance, an increased negativity (an N400 effect) is usually found when a semantically anomalous sentence is compared to a canonical sentence, or when a low-cloze (i.e., unexpected) sentential ending is compared to a high-cloze (i.e., expected) ending.

Several ERP studies indeed indicate that code-switching generates an N400 effect, at least among certain populations. For instance, code-switched words are often indexed by an increased negativity (Moreno et al., 2002; Ng et al., 2014; Proverbio et al., 2004; Ruigendijk et al., 2016; Van Der Meij et al., 2011; Blackburn & Wicha, 2022 for a left anterior negativity), suggesting that the participants had difficulty in understanding the mixed sentence, or experienced the code-switch as an unexpected speech event. Importantly, however, it appears that these effects reflect the psychological reality of non-switchers only. When it is habitual code-switchers who are examined, the N400 is no longer observed (Gosselin & Sabourin, 2021; Kaan et al., 2020; Litcofsky & Van Hell, 2017). This discovery is unsurprising: code-switching is *not* an unexpected event for habitual code-switchers.

A second component of interest is the Late Positive Component (LPC), often used interchangeably with the P600 in the field of psycholinguistics. The P600 is classically attributed to morphosyntactic processing; sentences with grammatical errors or sentence-level ambiguities typically elicit an increased posterior positivity (approximately 600 ms after a critical word) compared to canonical sentences (Hagoort & Brown, 1999; Kaan & Swaab, 2003; Osterhout & Holcomb, 1992). While the LPC overlaps in polarity, timing and distribution with the P600, their equivalence is not crystal clear. In fact, original literature links the LPC to processes related to memory (e.g., Münte et al., 2000). LPCs have also been observed in executive functioning studies in which syntactic processing cannot be used as an explanation for the effect (e.g., Stroop: Eppinger et al., 2007; task switching: Kieffaber & Hetrick, 2005; Tarantino et al., 2016), perhaps making it more analogous to the P300 (see Donchin & Coles, 1988) than the P600.

ERP studies also consistently show that code-switching yields an increased positivity. Note that this is true of both habitual code-switchers and non-habitual (or otherwise unspecified) code-switchers (Gosselin & Sabourin, 2021; Kaan et al., 2020; Moreno et al., 2002; Ng et al., 2014; Proverbio et al., 2004; Ruigendijk et al., 2016; Valdés Kroff et al., 2020; Van Der Meij et al., 2011; see also Litcofsky & Van Hell, 2017 for an asymmetric LPC; cf. Beatty-Martínez & Dussias, 2017; Jiang et al., 2024). Assuming that these observed neural peaks are distinct from the P600, such effects may be interpreted as generally-defined control processes, since code-switching imposes inhibitory control demands in certain contexts (e.g., activation-inhibition mechanisms; see CHAPTER 3). The LPC is indeed observed in language switching studies, where comprehension (or integration) is minimal as the switching occurs without semantic or syntactic context (e.g., Jackson et al., 2001; Liu et al., 2014, 2016; Timmer et al., 2019). Furthermore, the LPC involved in processing code-switches is related to the participants' inhibitory abilities (Jiang et al., 2024; Jiao et al., 2020).

Given these findings, a distinction must be made between comprehension costs of code-switching and other related processing costs (see **Table 2.1**). It appears that the N400 is indicative of *intrinsically linguistic* comprehension costs, while the LPC indicates that code-switching incites a more *general* cognitive processing effort. This rationalization explains why participants' switching habits determine the presence (or absence) of N400 effects, but do not eliminate LPC effects. While habitual code-switchers have no difficulty in understanding the content of bilinguals sentences (absence of the N400), they may inherently need to engage mechanisms that allow them to pass from one language to the other (presence of the LPC). Nevertheless, the size of the LPC may be modulated by participants' inhibition abilities (Jiang et al., 2024) or their switching habits (Blackburn & Wicha, 2022; Valdés Kroff et al., 2020).

Table 2. 1. ERP components pertinent to the study of code-switching, and their hypothesized interpretations.

	N400	**LPC**
Classical interpretation	Semantic integration difficulties due to unexpectedness or abnormality.	No real established classical interpretation. It is often assimilated to classical P600 interpretations (e.g., syntactic reanalysis).
Code-switching-specific interpretation	Code-switching is more difficult to understand than unilingual language; code-switching is unexpected.	Code-switching necessitates processes which call upon the EF system (e.g., inhibitory control).
Type of cost?	Linguistic comprehension cost	**Cognitive processing cost**

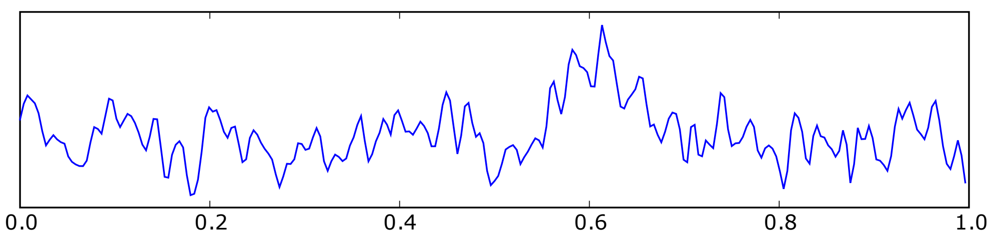
Indeed, a few studies have teased apart difficult lexical expectation effects (indexed by the N400) and other cognitive effects (indexed by the LPC) during the processing of switches. In one particularly ecologically valid study (Yacovone et al., 2021), Spanish-English bilinguals listened to naturalistic spoken narratives. These narratives were manipulated such that utterances could end with an strong-fitting word (code-switched or unilingual), or a weak-fitting word (code-switched or unilingual) (e.g., "*And the wig itself is so hot and heavy on my **head / cabeza / cranium / cráneo**.*"). The authors observed similar N400 effects for both code-switched conditions and the weak-fit English condition compared to the strong-fit English condition (i.e., *cabeza / cranium / cráneo* vs. *head*). In addition, strong-fit switches (*cabeza* compared to *head*), and weak-fit switches (*cráneo* compared to *cranium*) both elicited LPC effects (see Blackburn & Wicha, 2022 for no LPC when utilizing semantic *violations*). These results suggest that code-switching indeed induces costs outside of expected lexical integration effects during auditory comprehension (for comparable results see FitzPatrick & Indefrey, 2014; Liao & Chan, 2016; Valdés Kroff et al., 2020).

2.3.3 Electroencephalography (EEG) studies

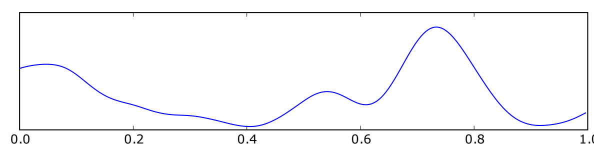
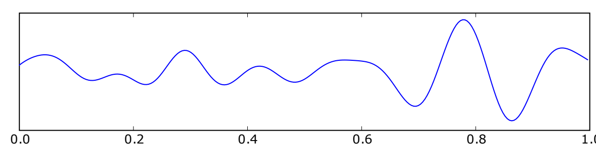
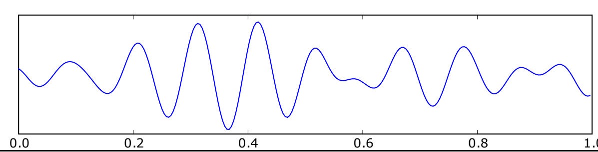
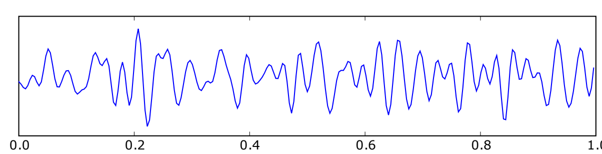
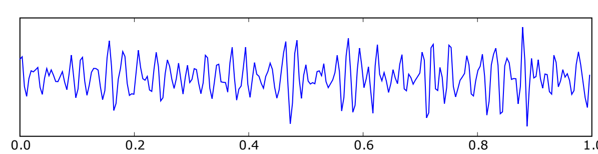
Instead of restricting EEG analyses to the time domain (as is the case for ERPs), it is also possible to examine EEGs according to the frequency domain. Put simply (see Donoghue et al., 2022; Rossi et al., 2023 for more complete introductions), the raw EEG signal is made up of several different wave 'shapes'. These waves differ in terms of their frequency (number of oscillations per second). Mathematical transformations (e.g., Fourier transform, wavelet transform) can decompose the complex EEG signal into its various constituents (see **Table 2.2**). Five types of waves (frequency bands) are standardly recognized: delta (<4 oscillations per second), theta (4-8 oscillations per second), alpha (8-12 oscillations per second), beta (12-30 oscillations per second), and gamma (>30 oscillations per second).

Table 2. 2. Raw EEG data decomposed into the standard frequency bands. The images of waveforms were taken from Wikimedia Commons, licensed under CC BY-SA 3.0 (originally by Hugo Gamboa): delta, theta, alpha, beta, gamma.

RAW EEG DATA



FREQUENCY-DECOMPOSED DATA

Wave	Frequency band	Waveform (one second)
Delta	<4 Hz	
Theta	4-8 Hz	
Alpha	8-12 Hz	
Beta	13-30 Hz	
Gamma	>30 Hz	

The EEG signal can thus be analyzed in order to examine the power density of each frequency band at rest, during a given task, or according to established experimental conditions (at a precise time: time-frequency domain). Spectral power represents "the amount of rhythmic activity within each frequency band, either across time (time-frequency representation, TFR) or averaged for the time-window of interest" (Rossi et al., 2023: 3). The idea is that increased power within a given frequency band is caused by neuronal impulse synchronization, which gives insight into specific cognitive processes. For instance, alpha waves have been linked to inhibition (Jensen & Mazaheri, 2010) while beta waves have been linked to set maintenance (Engel & Fries, 2010).

Spectral analyses of EEGs have only very recently been adopted in bilingualism studies. A number of language background characteristics (proficiency, usage, age of acquisition) appear to modulate EEGs, even while bilinguals are at rest (Bice et al., 2020; Calvo & Bialystok, 2021; Pereira Soares et al., 2021).

At least four studies have examined neural oscillations that occur when bilinguals read (Litcofsky & Van Hell, 2017; Tomić & Kaan, 2022) or listen to (Fernandez et al., 2019; Pérez & Duñabeitia, 2019) code-switches. Compared to unilingual conditions, processing code-switching results in decreased beta band power (Pérez & Duñabeitia, 2019; cf. Fernandez et al., 2019). However, this effect appears to be modulated by switching direction: when switching into the weaker language, beta is indeed decreased (Fernandez et al., 2019; Litcofsky & Van Hell, 2017; Tomić & Kaan, 2022), suggesting that switching into the weaker language is unexpected and therefore leads to difficult sentence-level integration/unification (Fernandez et al., 2019; Litcofsky & Van Hell, 2017; Tomić & Kaan, 2022). By contrast, switching into the dominant language results in increased power in theta (Litcofsky & Van Hell, 2017) or alpha (Fernandez et al., 2019) bands. Such increases likely reflect the additional cognitive resources (Litcofsky & Van Hell, 2017) that must be used to inhibit (and then release) the dominant language (Fernandez et al., 2019).

Altogether, the (limited) available evidence from the frequency domain shows that processing code-switches differs from processing unilingual language. Notably, the comprehension of switches appears to be permeated by an underlying cognitive effort.

2.4 Reconciling the evidence: Listeners at the mercy of speakers

Given the array of tasks, experimental manipulations, statistical analyses, and population samples examined in the literature, summarizing the findings becomes thorny. Nevertheless, I will highlight a few emergent patterns.

From the production viewpoint:

a) Forced switching of isolated words almost unanimously elicits production costs and increased neural activation.
b) Forced switching within sentential contexts also generally elicits production costs, but this cost can be mitigated by useful top-down information
c) When switching is volitional (or when participants use the most accessible label) but still artificial, switch costs are reduced and mixing benefits may be observed. Neural activation is also reduced compared to forced switching.
d) Spontaneous code-switches are marked at the switching juncture (i.e., longer pre-switch pause, increased disfluencies), but may be faster to plan in the big picture (overall faster speech rate).

From the processing viewpoint:

a) Reading times generally increase (i.e., a processing cost) when a participant meets a sentential code-switch.

b) Participants often fixate code-switches longer (and show increased pupil dilation for switches), but this cost may be absent in a bilingual language mode (or if bilinguals report a high degree of cooperation between their languages).
c) Reading or listening to code-switching virtually always elicits neural indices linked to increased processing effort (i.e., Late Positive Component, frequency band modulation), even when top-down cues are available
d) Bilinguals report higher attentional levels when they listen to switches, and code-switching does not negatively impact information retention or concept learning

Overall, it appears that distinct processes may be at play during the production of code-switches and the processing of code-switches. Production costs are mitigated by subject-internal factors: Did the participant switch freely? Did they use the label that is more frequent/more accessible to them? On the other hand, processing costs are imposed by the communication setting (and even habitual code-switchers continue to show physiological 'costs'): Is switching expected in the context? In the sentence? Instinctively, this difference is coherent, as eloquently stated by Guzzardo Tamargo and colleagues (2016: 139):

> *Code-switching presents a unique cognitive puzzle on the link between production and comprehension. In particular, **the production of code-switched speech is putatively under the control of bilingual speakers**, as evidenced by their ability to speak in one language when necessary (e.g., when speaking to a monolingual conversational partner). Yet **bilingual comprehenders do not a priori know when a code-switch will occur in speech**. In this sense, switches can be unexpected and, thus, potentially more difficult to process than within-language sentences.*

Despite the chasm between bilingual 'speakers' and 'listeners', it is important to note that production and comprehension mechanisms do not make up autonomous systems. Plenty of research indicates that obstructing articulation impedes comprehension (e.g., Martin et al., 2018; see Skipper et al., 2017 for a review). Relatedly, processing is easier for forms that are frequently produced (the Production-Distribution-Comprehension [PDC] model; MacDonald, 2013; MacDonald & Thornton, 2009). For instance, Spanish-English bilinguals take longer to read "*los turistas* ***han*** enjoyed" than "*los turistas* **have** enjoyed" (Guzzardo Tamargo et al., 2016; see also Salig et al., 2024). This heightened processing cost reflects an asymmetry in production in this speech community: corpus analyses show that Spanish-English bilinguals are much more likely to produce a switch at a Spanish auxiliary than at an English auxiliary (Guzzardo Tamargo et al., 2016). Inversely, bilinguals produce switches that were previously the least challenging to process (Beatty-Martínez & Dussias, 2017). The idea is that speakers are biased to produce consistent structures to alleviate speech planning; these patterns eventually form distributions that are learned and exploited during processing (MacDonald, 2013). If certain code-switches are consistently produced, bilingual 'prefabrications' or 'prefabs' (i.e., chunks) can be formed to ease processing, just like in unilingual speech (Hui et al., 2022).

Even so, humans are unlikely to participate in cognitively effortful behaviours if a more economical alternative is available; consider the principle of least effort, or Zipf's law (Zipf, 2016). Why then do bilinguals continue to code-switch, even if this potentially induces costs for listeners? Again, only the modality of *production* is 'under the direction' of the speaker: they decide when to switch, and can do so if it is deemed (cognitively, socially, emotionally) beneficial. It is thus the *production* of code-switches that adheres to the principle of least effort. For instance, a speaker may produce fewer code-switches in situations of perceived high cognitive load (Liu et al., 2024). On the other hand, the listener is more or less 'at the mercy' of the speaker. They *must* integrate the code-switches they meet in order to maintain communication—even if this is more costly than comprehending unilingual speech. Of course, the processing of a switch can also be done in the most economical way (i.e., by exploiting acoustic, top-down and distributional cues). Interestingly, the number of intrusion errors produced while reading switches aloud are largely unrelated to reading times for code-switches (i.e., both frequent and frequent 'intruders' exhibited similar switch costs during reading), supporting the dissociation of the modalities (Ahn et al., 2020).

In previous work, I've advanced that "some mechanism [...] is indeed elicited when bilinguals process switched sentences, but that any switching-related costs become negligible in production, since they are outweighed by the greater ease of opportunistic word retrieval for habitually code-switching individuals" (Gosselin & Sabourin, 2021: 11). This interpretation is an adaptation of the "switch now, pay later" principle (Gollan & Ferreira, 2009), originally advanced to explain language-switching costs. The idea is that bilinguals do not recognize the eventual *processing* cost for code-switching (i.e., "I will need to process my co-interlocutor switches") , and therefore opt to produce code-switches on the basis of a more immediate alleviation in lexical access (Gollan & Ferreira, 2009).

It must be noted that these conjectures have only been supported rather indirectly. That is, I am not aware of any study that teased apart the production and comprehension of code-switching within a given communication event. Recurrent limitations in the literature will be considered in the following section.

2.5 Some limitations with the existing code-switching literature

A slew of recent reviews have discussed meaningful limitations in the code-switching literature (Beatty-Martínez et al., 2018; Blanco-Elorrieta & Pylkkänen, 2018; González-Vilbazo et al., 2013; van Hell et al., 2018). Most notably, researchers question the ecological validity of the experimental paradigms used, and therefore the generalisability of the results they yield. The ramifications of such designs are perhaps exacerbated by the firm community norms that often characterize code-switching: bilinguals tend to code-switch with members of their in-group, and code-switching can be disparaged in the public sphere. I add to the existing critiques by highlighting the modality issue: it is the norm to conflate production and comprehension studies in the code-switching literature.

2.5.1 The ecological validity issue

Ecological validity alludes to the ways in which an in-lab experiment approximates the real-world conditions it is meant to generalize (Schmuckler, 2001). For instance, a self-paced reading study can be thought to have low ecologically validity since humans are unlikely to encounter situations in which they are required to read sentences word-by-word via button press. The results yielded by such an experimental paradigm, though important, do not necessarily allow us to draw conclusions about reading in general (in the real-world); rather, they tell us about reading in a restricted set of conditions (i.e., low generalizability). It is important to note, however, that the term "ecological validity" is quite vague, and no real parameters exist to quantify the extent to which an experiment is ecologically valid (Holleman et al., 2020). Researchers must juggle ecology and scientific rigor to obtain worthwhile conclusions: an overly controlled paradigm might result in ungeneralizable findings, but a completely naturalistic experiment may introduce confounds or lack of precision.

With this in mind, some unnaturalistic (and persistent) experimental features in the code-switching literature are criticized. First, many of the seminal findings (and the models they inspired) about bilingual production come from artificial language switching studies, wherein participants are required (or given the option) to name images in one of their languages. These experimental conditions bear little resemblance to real-life code-switching[5], which is context-imbued, sometimes rich in morphosyntax, and an inherently social behaviour. Indeed, when the ecological validity of the experiment is increased (e.g., a stimuli is presented alongside an image of a co-interlocutor with obvious language membership), both behavioural and brain-based differences are observed (Blanco-Elorrieta & Pylkkänen, 2017; see also Kaan et al., 2020).

Second, it is important to note that the lion's share of code-switching studies utilize *written* code-switches. For instance, in the electrophysiological literature, only three studies presented their stimuli auditorily (to my knowledge): Fernandez and colleagues (2019), Pérez & Duñabeitia (2019), and Yacovone and colleagues (2021). When it comes to code-switching, written stimuli probably lack ecological validity (Beatty-Martínez et al., 2018; González-Vilbazo et al., 2013; van Hell et al., 2018); it is fair to assume that bilinguals are far more likely to hear code-switches than to read them in their day-to-day life. Furthermore, the written modality strips listeners of existing acoustic cues (Balukas & Koops, 2015; Faroqi-Shah & Wereley, 2022; Fricke et al., 2016; Johns & Steuck, 2021; Muldner et al., 2019) that may signal an incoming switch. Some have even argued that the switching-generated LPC is veritably an artifact of the written modality (Gosselin & Sabourin, 2021; though see Koronkiewicz & Ebert, 2018 for an acceptability judgement task).

[5] Slight design manipulations also result in divergent results. For instance, increasing the preparation time in a language-switching task reduces switch costs (Shen, 2023).

To compound matters, many studies present carefully controlled, lab-made instances of code-switching to their participants (i.e., rigid sentence structure, consistent switching junctures, etc.). This is problematic because code-switching adheres to specific community norms (e.g., Balam et al., 2020; Cisneros et al., 2023), and lab-made switches may feel (or be) unnatural. Furthermore, real-life code-switching is often interlaced with stretches of unilingual speech, and presenting complete blocks of code-switched sentences/utterances results in more effortful processing (Johns et al., 2018). Corpus-based studies are few-and-far-between, but these likely represent a step in the right direction: if participants hear/see code-switched stimuli collected from a similar speech community (e.g., Faroqi-Shah & Wereley, 2022), this unquestionably improves the ecological validity of the experiment.

2.5.2 The stigmatization issue

It must also be noted that sociolinguistic factors likely play a role in the study of code-switching. Different bilingual communities maintain diverse attitudes about the bilingual phenomenon. In the francophone Canadian context, code-switching is highly stigmatized (see Poplack, 1988; Rodrigo-Tamarit & Loureiro-Rodríguez, 2024), particularly in the public sphere. For instance, a common sentiment in the general public is that '*franglais*' is used to compensate for low language competency, that it reflects lazy or careless language usage, and/or that it must be combatted for the "survival" (4) of the French language. Such attitudes are doubtlessly the result of complex social-cultural, political and economic issues that have remained omnipresent in bilingual Canada for hundreds of years (see Gosselin & Sabourin, 2023b for a discussion).

The following excerpts (4) illustrate real examples (emphasis added and orthographical errors corrected) demonstrating the pervasive stigmatization of code-switching in the francophone Canadian context. I encountered (and recorded) each of these examples inadvertently, while browsing social media during my own free time.

(4) **Code-switching stigma in the francophone Canadian context**:

a. As seen on an advertisement for a brand of deodorant:

   i. **INFLUENCER:** *Je vous ai déjà parlé de* ***mon struggle*** *à trouver un déodorant sans aluminium qui fonctionne. J'ai testé celui de [brand redacted]. [...] Et puis* ***je suis complètement fan****.*
   'I've already told you about my struggle to find an aluminum-free deodorant that works. I tested the one from [brand redacted]. [...] And I'm completely a fan.'

   ii. **COMMENTER**: *Ton « struggle »... Bravo, une représentante de marque francophone qui parle en anglais... une autre qui s'est éduquée sur les médias sociaux et qui ne peut pas articuler une phrase complète en français !*
   'Your "struggle"... Bravo, a French-speaking brand representative who speaks in English... Another who learned on social media and who cannot articulate a complete sentence in French!'

b. As seen in a Facebook group for Franco-Ontarians:

   i. **ORIGINAL POST**: *Ce qui me fait vraiment ch[ier]...?* ***Être servi en anglais à Ottawa quand on s'adresse en français avec des mots de base: Bonjour—hello. Merci—you are welcome, have a nice day.*** *Franchement! Un minuscule effort? Ils n'enseignent AUCUN français dans les écoles anglaises???*
   'What really pisses me off...? Being served in English in Ottawa when addressed in French with basic words: Bonjour—hello. Thank you—you are welcome, have a nice day. Frankly! A tiny effort? They don't teach ANY French in English schools???'

   ii. **COMMENTER**: *Accepter ça dans le contexte de la survie du français en Ontario; c'est accepter l'assimilation. L'assimilation au quotidien ressemble à ça*.
   'Accepting this in the context of the survival of French in Ontario is accepting assimilation. Daily assimilation looks like this.'

Given that social attitudes may bias processing (e.g., McGowan, 2015), it is very much possible that participants' intolerance towards code-switching impact their production or processing patterns. Even habitual code-switchers may change their speech habits towards more socially acceptable variants (i.e., the social desirability bias) when they are in unfamiliar and perceivably formal settings (i.e., a laboratory), or with a stranger (i.e., an experimenter). Indeed, bilinguals switch up to four times more frequently with someone from the same in-group compared to an out-group stranger, and usually code-switch in informal settings (Poplack, 1983).

The stigmatization issue can lead to several consequences. First, participants may underreport their switching habits, putting into question any analysis aimed to examine the impact of experience on the production and processing of code-switches. Second, participants may simply produce less switches (or code-switch with difficulty) when under observation—even in volitional experimental paradigms—as social convention maintains that switching in the lab is unusual, and switching with a stranger, unnatural or awkward. Finally, the stigma associated with code-switching may impact the participant's underlying processing. Indeed, non-standard language variants elicit P600 effects even among speakers who use them in their dialect (Zaharchuk et al., 2021). This challenges seminal findings from the code-switching literature: code-switches deemed non-standard (by way of community norms) could inherently manifest underlying effects — like differential ERPs— when compared with normative variants (i.e., unilingual speech), particularly in a context reinforcing more formalistic language usage.

2.5.3 The modality conflation issue

In the preceding literature review, I discussed the findings related to producing switches and processing (comprehending) switches separately. An overview of the findings makes it evident that the results do not entirely overlap between these modalities. However, it is commonplace in the literature to conflate production and processing experiments, and to apply production-based models to processing-based results. This is particularly problematic, as behavioural results predominate the production literature, while implicit measures are customary in the pool of processing studies. Researchers regularly cite the ease with which bilinguals produce code-switching in order to rebut the reliable switch cost found in processing studies. Examples of this issue, which I dub the PRODUCTION-PROCESSING PARADOX, are quoted in (5).

(5) **Examples of the modality conflation issue**:

a. **Beatty-Martínez & Dussias, 2017, p. 174**: "*Overall, these findings pose an interesting paradox: if bilingual speakers exhibit larger processing costs when switching languages, why do they customarily codeswitch?*"

b. **Blanco-Elorrieta & Pylkkänen, 2018, p. 1118**: "*[...] the finding that switching languages is effortful does not typically match the intuitive experience of bilingual individuals. After all, language switching in bilingual communities is a widespread and well documented phenomenon. If switching was effortful, why would bilinguals do it so much?*"

c. **Gosselin & Sabourin, 2021, pp. 1–2**: " [...] *if code-switching incurs cognitive costs, seemingly both at the initiation and the reception of the communicative act, why would code-switching be prevalent in many bilingual communities? The observed processing cost is especially remarkable, as code-switching has often been characterized by researchers as fluent and smooth (Poplack, 1980), and by speakers as the "most comfortable way" to speak (Dorleijn, 2017, p.12).*"

d. **Hofweber & Marinis, 2023, p. 70**: "*Despite the frequent occurrence of language mixing in bilingual conversations, the processing effort associated with code-switching is poorly understood. [...] This raises the question of whether sentences involving code-switching are harder to process than single-language sentence*."

Though production and processing are evidently interlinked, the cognitive processes for each modality are likely not identical: speakers are in 'control' of their productions (at least, in the real-world setting), but listeners must process code-switches as they are heard—even if certain bilingual "prefabs" may exist (Hui et al., 2022). For this reason, it becomes important to distinguish the *comprehension* of code-switches from the *production* of code-switches. As the 'switch-now, pay-later' principle implies, we cannot assume that a cost at the level of code-switching comprehension automatically entails a cost during code-switching production (or vice versa). Furthermore, the observable ease with which bilinguals mix their languages does not discredit more fine-grained covert processes (e.g., physiological observations).

2.5.4 Where to go from here?

Overall, some common caveats exist in the code-switching literature: researchers routinely compare findings from production and corpora studies to processing results, and often apply established models to the erroneous modality. Furthermore, experiments are often highly controlled and unnaturalistic, expounding pre-existing limitations surrounding the study of code-switching (i.e., community-based stigmatization). Possible remedies for each of these issues is presented in **Table 2.3**.

Table 2. 3. Potential solutions for current issues in the code-switching literature.

Issue	Potential solutions
Ecological validity	• Production: Collect spontaneous speech data • Processing: Present instances of real-life switches produced by a similar speech community • Prioritize auditory stimuli
Stigmatization	• Test participants with members of their in-group • Reduce the formality of the setting (e.g., private room, out of sight of the experimenter) • Prioritize objective measurements of code-switching habits
Modality conflation	• Tease apart the cognitive effects of producing vs. comprehending switches within a single experimental design (e.g., testing speaker-listener pairs)

In short, it would be beneficial to conduct an experiment designed to disentangle the switching modalities (production vs. comprehension of code-switching). The results would be further legitimized if participants are tested among peers (i.e., with members of the same in-group) in a naturalistic setting and/or with naturalistic stimuli. These goals constitute the aims of the present dissertation.

CHAPTER 3: *Comment* code-switching *peut moduler* bilingual executive functioning

3.1 Executive functioning and bilingualism

3.1.1 Inhibitory control in a nutshell

Humans cannot solely rely on automatic instincts or impulsive habits. Rather, in modern society, individuals must be able to adapt their behaviours, concentrate on goal-relevant information, remember important data, and ignore attractive lures. These paramount mental processes, known as EXECUTIVE FUNCTIONS (EF), are primarily regulated by the prefrontal cortex (e.g., Banich, 2009; Duncan & Owen, 2000; Otero & Barker, 2014) a region of the brain which is organisationally unique to primates (Pribram, 1973; Schoenemann et al., 2005; Teffer & Semendeferi, 2012). Indeed, fine-grained executive functioning is often benchmarked as the ‘crux of human cognition’. The core EFs are reviewed in **Table 3.1**.

Inhibitory control is the most studied EF when it comes to bilingualism-related research[1]. These processes refers to an individual’s ability to concentrate on important information and ignore potential attention-drawing but irrelevant cues (Diamond, 2013). For instance, a person with high inhibitory control abilities may be very good at rejecting intrusive thoughts during test-taking, avoiding impulsive actions, delaying gratification,

[1] Inhibitory control is widely believed to be the EF that is the likeliest to be modulated by bilingualism (see *Section 3.1.2*). This perhaps causes a cyclical effect in the literature, wherein the other EFs, particularly working memory, are much less studied. That is, if bilingualism is not hypothesized to modulate working memory, this interaction is only seldom tested.

and/or ignoring loud or salient distractions. Lower inhibitory control has been linked to poorer mental health (Taylor Tavares et al., 2007), reduced job success (Bailey, 2007) and increased criminal involvement (Denson et al., 2011).

Table 3. 1. Core executive functions (EF) (Diamond, 2013: 136-137).

Core EF	Definition
Inhibitory control	"Controlling one's attention, behavior, thoughts, and/or emotions to override a strong internal predisposition or external lure".
Working memory	"Holding information in mind and mentally working with it (e.g., relating one thing to another, using information to solve a problem)".
Cognitive flexibility	"Changing perspectives or approaches to a problem, flexibly adjusting to new demands, rules, or priorities (as in switching between tasks)".

Both linguistic tasks (e.g., Stroop) and non-linguistic tasks (e.g., Flanker, Simon, Anti-saccade) are widely used to quantify inhibition and conflict monitoring. Though these paradigms are compared across studies, it is important to note that even tasks bearing the same name vary considerably in terms of their design and procedure (Salo et al., 2001). Nevertheless, these paradigms standardly compare trials involving high conflict (i.e., a target is presented with antagonistic information) or to high conformity trials (i.e., a target is presented alongside harmonious information). It is also possible to compare high conflict and/or high conformity trials to neutral trials, wherein a target is presented with neither conflicting nor concordant information (see **Table 3.2**).

High conformity trials (the congruent condition) typically elicit more rapid reaction times (RTs) than neutral trials. The FACILITATION EFFECT is thus quantified by subtracting average RTs to neutral trials from average RTs to congruent trials. Note that the facilitation effect operationalizes an individual's ability to monitor goal-relevant info; larger facilitation effects reflect high executive functioning. In contrast, high conflict trials (incongruent condition) elicit slower RTs than neutral and congruent trials. The INTERFERENCE or CONFLICT EFFECT is thus quantified by subtracting average RTs to incongruent trials from average RTs to congruent trials (e.g., Hartanto & Yang, 2019; Hofweber et al., 2016; Jylkkä et al., 2017, 2018, 2020; Sanchez-Azanza et al., 2020). Note that some studies instead compute an INHIBITION EFFECT, wherein high conflict trials (incongruent trials) are subtracted directly from neutral trials (e.g., Gosselin & Sabourin, 2023b; Sanchez-Azanza et al., 2020; Yow & Li, 2015) in order to avoid overlap with the facilitation effect. Interference/inhibition effects measure an individual's ability to ignore external lures; a lesser effect indicates better inhibitory executive functioning. Finally, it is also possible for individuals to experience GLOBAL ADVANTAGES, wherein they respond faster to all trials concurrently, nullifying any visible facilitation, inhibition, or interference effects.

Table 3. 2. Examples of standard conditions used to test inhibitory control. During a Flanker task, participants must indicate the direction of the center arrow. During a Stroop task, participants must indicate the color of the font of the presented word.

Condition	FLANKER Stimuli	FLANKER Answer	STROOP Stimuli	STROOP Answer	
Congruent	→ → → → →	right	RED	red	+ RT
Neutral	— — → — —	right	BOOK	red	↕
Incongruent	→ → ← → →	left	RED	green	- RT

In the last few decades, researchers have established that inhibitory control (and human executive functioning in general) is impacted by a diverse range of external factors, including age (Allain et al., 2005), education (Dorbath et al., 2013), fitness level (Guiney & Machado, 2013) and emotional affect (Yang et al., 2013). Crucially, numerous studies have also demonstrated that executive functioning is remarkably trainable (Bialystok, 2006; Bialystok & DePape, 2009; Draganski et al., 2004), with bilingualism sometimes outweighing all other modulating factors (Hartanto & Yang, 2019).

3.1.2 Bilingualism-based EF effects

Since the turn of the millennial, many studies have reported that individuals who speak multiple languages may benefit from increased executive functioning abilities compared to monolinguals (see Bialystok et al., 2012 for a review), an effect that was eventually coined the BILINGUAL ADVANTAGE HYPOTHESIS (BAH). Today, this nomenclature is criticized (Luk, 2023), as it inequitably implies prestige and inferiority according to (sometimes unavoidable) language experiences. In this dissertation, I instead refer to BILINGUALISM-BASED EFFECTS (BBE) or bilingual differences.

The interest in BBE stems from robust findings showing that the languages of bilinguals and multilinguals are perpetually co-activated. Research indicates that cognates are identified as words more quickly than non-cognates, even when bilinguals are in single-language mode (Costa et al., 2000), and even if the cognates appear in non-isolated contexts (Bultena et al., 2014; Duyck et al., 2007; Libben & Titone, 2009). For instance, when a French-English bilingual is in a unilingual French environment, activation spreads from their French lexicon, but also to some degree, from their English lexicon. This language "non-selectivity" implies that bilinguals must actively manage their languages in order to stay on task.

Importantly, the act of juggling multiple co-activated languages requires EFs. Bilinguals become specialists in activating their goal-relevant language, and inhibiting their non-pertinent language, sometimes according to external triggers. This suggests that, when it comes to inhibitory control, bilinguals are "practicing during almost every waking hour" (Kroll et al., 2012: 250). Such a cognitively effortful task may entrain the neural substrates underlying generalized EFs, resulting in bilingualism-based functional and structural differences in the brain (e.g., increased grey matter volume/thickness: (Abutalebi et al., 2012, 2015; Burgaleta et al., 2016; Mechelli et al., 2004; Midrigan-Ciochina et al., 2024; Olulade et al., 2016); increased connectivity and white matter integrity: Anderson, 2023; Anderson et al., 2024; DeLuca & Voits, 2022; Luk et al., 2011). Consequently, the original BAH posits that such bilingualism "benefits" bleed into domain-general cognition; rather than simply being language experts, bi-/multilinguals are specialists in executive functions, particularly those requiring monitoring and inhibition.

Indeed, convincing results reveal that speaking multiple languages sometimes bolsters positive cognitive effects across the lifespan. Bilingual toddlers exhibit better inhibitory control than monolingual toddlers (Poulin-Dubois et al., 2011). Children who start language immersion programs sooner perform better on executive function tasks (Barac & Bialystok, 2012). Adult bilinguals also exhibit increased cognitive control skills, such as conflict monitoring (Costa et al., 2009). Older bilinguals recuperate better after a stroke than older monolinguals (Alladi et al., 2016), and bear a delayed onset of dementia (Gold, 2016). However, countless experiments produce no bilingualism-related effects (see Hilchey & Klein, 2011 for a review), and some researchers outright refute their existence (Paap, 2022). This perspective is not at all unwarranted. Some meta-analyses suggest that BBE disproportionately saturate the literature due to a publication bias favouring positive results (de Bruin, Treccani et al., 2015; Paap et al., 2020), though this publication bias has recently been shown to be "overinflated" (Leivada et al., 2023; see also Sanchez-Azanza et al., 2017). Seminal papers supporting BBE are not consistently replicable (e.g., Paap & Greenberg, 2013). When meta-analyses are conducted, BBE are usually negligeable or absent (Lehtonen et al., 2018; Nichols et al., 2020; cf. Grundy, 2020).[2]

All hope is not lost: researchers continue to investigate BBE, but with a progressively finer-tooth comb. First, the growing prevalence of neuroimaging techniques shows quite consistently that bilingualism reshapes the brain (DeLuca et al., 2019a, 2019b, 2020; Hervais-Adelman et al., 2018; Korenar et al., 2023b; Marin-Marin et al., 2022; Pliatsikas, 2020; Yee et al., 2023), even if this does not affect observable function or overt behaviour (whether positively or negatively). Second, it is now the norm to abstract away from the dichotomous view of BBE and group-based analyses. If a given bilingual is not different from a given monolingual in any given study, this does not mean that no bilingual in the world will ever show BBE. Rather, it implies that bilingualism does not *inherently* modulate EFs. This is

[2] Interestingly, a recent meta-analysis shows that 'bilingual advantages' and 'bilingual disadvantages' balance themselves out, and result in a "zero-sum game" (Dentella et al., 2024: 13). In other words, an 'advantage' in a given task is usually accompanied by a 'disadvantage' in a slightly different task within and across studies. This suggests that BBE should be viewed as dynamic trade-offs or experience-related adaptations (see also Leivada et al., 2023), rather than global "advantages" or "disadvantages".

not very surprising, as bilinguals (and monolinguals, for that matter) are not all the same. Given the diversity of language experiences, positive and null results are likely both genuine, and can co-exist in the literature. Non-replications may even be regarded as "a source of new insights and a motor of future scientific progress" (Bak, 2016: 702). Instead of examining bilingualism as a generalized construct, it becomes crucial to tease apart bilingualism-related factors in order to discover what modulates BBE.

A number of researchers have followed the call (e.g., Backer & Bortfeld, 2021; Beatty-Martínez & Titone, 2021; Bialystok, 2021) to examine bilingual executive functioning according to language experience-related dimensions, such as age of acquisition (e.g., Hartanto & Yang, 2019; Karimi & Hosseini Rad, 2021; Kousaie et al., 2021; Pelham & Abrams, 2014), proficiency (e.g., Antón et al., 2016), dominance (e.g., Goral et al., 2015; Wu & Struys, 2022), language distance (Wolfsthurn et al., 2023) and language entropy (e.g., Gullifer & Titone, 2020; Wagner et al., 2023). The present dissertation keeps with this tradition by honing-in on a particular parameter which defines bilingualism: code-switching. As such, the subsequent sections review experiments that have previously considered the impact of code-switching habits on bilingual executive functioning.

3.2 Code-switching and bilingual executive functioning

In a recent paper, Kałamała and colleagues (2023) determined that bilingualism is best represented by a network model, thereby supporting modern arguments which assert that bilingualism should be viewed as the interaction between several idiosyncratic dimensions, especially experience-related dimensions (DeLuca, Rothman, et al., 2020). Crucially, language mixing was found to be one of the "most central indices of bilingualism" (Kałamała et al., 2023: 157) in this network model. This suggests that code-switching (alongside language entropy and L2 proficiency) is a promising factor when it comes to accounting for conflicting BBE results.

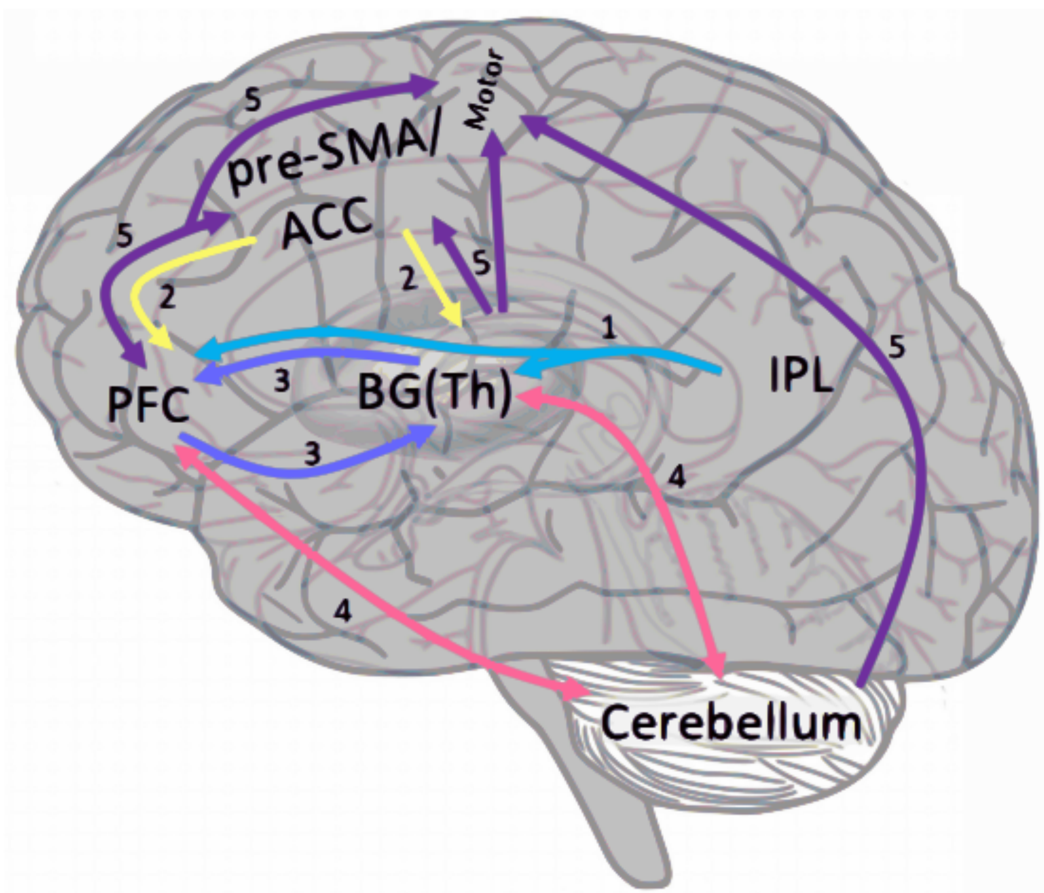
3.2.1 The neural substrates involved in language switching

Before one can claim that code-switching exerts causal effects on the bilingual executive functioning system, the following question must be answered: Does code-switching mobilize the same underlying neural substrates involved in domain-general EFs? If distinct—or even mostly distinct—networks are involved, it becomes much more difficult to conceive how a language-specific behaviour like code-switching can come to train a generalized inhibitory ability.

Evidence suggests that the neural networks involved in language switching and inhibitory control do indeed overlap (e.g., Branzi et al., 2016; De Baene et al., 2015; de Bruin et al., 2014; Hosoda et al., 2012; see Luk et al., 2012; Tao et al., 2021 for reviews), and that they are distinct from those involved in single-language naming (Sierpowska et al., 2018) or staying in a single language (Weissberger et al., 2015). Functional similarities also exist, as ERPs elicited by language switching cannot be disambiguated from ERPs elicited by domain-general switching (Declerck, Meade et al., 2021).

Blackburn (2019) describes a simplified version of Abutalebi and Green's (2016) language switching network (see **Figure 3.1**) involving both cortical and subcortical structures. In this network, the anterior cingulate cortex (ACC) and pre-supplementary motor area (pre-SMA) engage the prefrontal cortex (PFC) when conflict between languages has been detected (e.g., during a language switching task). The PFC calls upon subcortical structures like the caudate nucleus in order to select an appropriate language and allow for the switching to take place. Meanwhile, the inferior parietal lobule (IPL) is believed to play a role in context monitoring (biasing towards the language in use, and away from the non-target language). As this network is based on verbal language switching, the network ends by sending motor schemes from the selected language to regions involved in articulation.

Figure 3. 1. *Blackburn's language control model based on Abutalebi & Green (2016). Source: Blackburn, A. M., 2017, 'Language Control Model 2017', https://openclipart.org/detail/284976/language-control-model-2017, under CCO 1.0.*



Note that the ACC, pre-SMA, PFC, and caudate nucleus have each been related to domain-general executive functions (see Abutalebi & Green, 2016 for a review). In one particularly relevant study, the same participants completed both a cued language switching task, and a series of general task-switching paradigms (identifying motion, color, or gender of a face according to a cue) while in an fMRI machine. Analyses revealed an array of regions activated (to a similar degree) in *both* language-specific and domain-general tasks, including the posterior cingulate cortex, and regions of the PFC (De Baene et al., 2015; see also Branzi et al., 2016).[3]

It must be noted, however, that these models mainly draw from language switching studies. Recall that a language switching task generally involves cued picture naming, wherein a participant is 'forced' to alternate the language used to name a stimulus. One might believe that the established language control networks are not implicated in more naturalistic code-switching. Nevertheless, neuroimaging data from volitional language switching paradigms (see *Section 2.3.1*) mostly indicate that the key regions identified in **Figure 3.1** are activated during voluntary (context-free) language switching (Geng et al., 2024; Reverberi et al., 2018; Zhang et al., 2015; cf. Blanco-Elorrieta & Pylkkänen, 2017; Zhu et al., 2022), or when isolated language switches are heard and followed by an explicit task (Blanco-Elorrieta & Pylkkänen, 2016, 2017). Even passive listening or reading of contextually-embedded switches engages the language control networks (e.g., PFC, pre-

[3] Relatedly, if these regions are lesioned, bilingual patients can display pathological language switching (e.g., Fabbro et al., 2000). Among healthy aging bilinguals, increased cross-language intrusions is sometimes highly related to decreased Flanker performance (Gollan et al., 2011; though see Calabria et al., 2015; Weissberger et al., 2012 for disassociation between domain-general and language specific abilities). When transcranial stimulation is applied to the lesion (e.g., in the dorso-lateral PFC), pathological switching is briefly attenuated (Nardone et al., 2011).

SMA, caudate, ACC) (Abutalebi et al., 2007; cf. Blanco-Elorrieta & Pylkkänen, 2017), including among habitually code-switching participants (Rossi et al., 2021).

Perhaps most compellingly, structural adaptations in the control network are associated to bilinguals' code-switching frequency: more habitual code-switchers display increased caudate and thalamic volume (Korenar et al., 2022; see also Gullifer et al., 2018; Li et al., 2021; Sulpizio et al., 2020 for other neural adaptations related to language entropy or switching habits respectively). Altogether, this data supports the idea that practicing language control (e.g., via code-switching) may positively impact domain-general control: since both processes utilize overlapping neural substrates, training one could improve the other. [4]

Operating from the starting point that bilinguals do indeed recruit domain-general EFs when they activate, select, maintain and inhibit their languages, the interest in code-switching is quite intuitive. Presumably, bilinguals who frequently alternate between their languages (i.e., habitual code-switchers) are executing activation-inhibition processes more often than 'regular' bilinguals or monolinguals—sometimes multiple times within a conversation, or even within a given sentence. The question thus stands: Do habitual code-switchers exhibit increased EF abilities, given that they are believed to put their executive functioning system through extensive practice?

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[4] It is also important to note that bilingualism-based neural adaptations appear to occur in a U-shape, rather than linearly (the Dynamic Restructuring Model: Pliatsikas, 2020). That is, bilinguals may first display structural brain differences, but can 'return to baseline' under conditions of longstanding practice, exposure and usage (Claussenius-Kalman et al., 2021; DeLuca, Segaert et al., 2020; Gallo et al., 2021; Korenar et al., 2023b, 2023a; Marin-Marin et al., 2022; Yee et al., 2023). Indeed, metabolites involved in synaptic pruning have been linked to significant bilingual engagement (Pliatsikas et al., 2021). This complicates brain analyses, since the absence of structural adaptations may signal the 'peak efficiency' (renormalization) of an experienced bilingual.

3.2.2 Context matters: The Adaptive Control Hypothesis

Up to this point, we have established that the networks involved in language switching (and potentially code-switching) overlap with those involved in domain-general executive functioning. However, we have also demonstrated that not all switching is the same, particularly at the level of production. Recall the Control Process Model (CPM; Green, 2018; Green & Wei, 2014), which posits different control modes (or 'language gates') for various types of switches. What if a given bilingual mostly finds themselves in situations requiring controlled switching? Consider the following scenarios:

(1) **Potential scenarios of French-English bilingualism in the capital region:**

a. When Gabrielle is at home in Orléans, she speaks French. On weekdays from 8 to 4, she speaks only English at her workplace in Gloucester.
b. Theresa works at a museum visited by francophone and anglophone families from all over Ottawa-Gatineau. Theresa addresses visitors in the language they first use with her. At home, she mainly speaks English.
c. Melanie lives in Vanier with her bilingual parents. She works at a French immersion school, where her colleagues (and students) are also bilingual.

Theresa and Melanie likely produce code-switches more frequently than Gabrielle. Furthermore, Theresa's switches presumably require more control processes (i.e., a coupled control mode) than Melanie's (i.e., an open control mode), as Melanie can always assume a common linguistic knowledge with her co-interlocutors. Given that bilingualism-based differences stem from frequently exercising the substrates underlying EFs, the idea would follow that Theresa is likelier to show increased EFs compared to Melanie (or Gabrielle). Indeed, such a theory was put forward as the ADAPTIVE CONTROL HYPOTHESIS (Green & Abutalebi, 2013). Green and Abutalebi posited that bilinguals operate in different interactional contexts, and that they come to adapt to the demands of their principal context.[5] In a single-language context, speakers are expected to converse in a single language within a given environment. In a dual-language context, bilinguals may converse in more than one language within a given environment, but usually maintain a single language for different conversations. Inter-sentential code-switches may occur, though they are likely contextual. Finally, in a dense code-switching context, bilinguals are free to use multiple languages with the same co-interlocutor and within the same conversation. These three bilingual contexts roughly translate to scenarios (1a), (1b) and (1c), respectively.

Crucially, according to the ACH, each context is believed to impose differential cognitive control demands on the bilingual speaker. Producing switches in the dual-language context engages the most control processes (see rows 1 and 2 of **Table 3.3**), as bilinguals in this environment must learn to monitor their environment in order to activate, supress and maintain their languages according to external cues (i.e., coupled control mode). By contrast, the dense code-switching context recruits the *least* amount of control processes, even though the individuals who exist in such an environment likely alternate between their languages quite frequently. In a dense code-switching context, speakers expect their fellow interlocutors to be bilingual as well; they seldom need to attend to their environment in order to select the appropriate language for mutual understanding. Instead, individuals who exist in a dense code-switching context may partake in opportunistic language usage (e.g., selecting more appropriate or more accessible word/expression).

[5] It is important to note here that bilinguals do not operate in a given interactional context *all of the time*. While there is fluidity between contexts, individuals may become adapted to the most recurrent context.

In brief, producing code-switches is not necessarily beneficial for domain-general EFs: if the bilingual primarily operates in a dense code-switching context (i.e., switches opportunistically rather than deliberately), the substrates underlying inhibitory control are not put into practice. In fact, Abutalebi and Green (2016) hypothesize that dual-language bilinguals will experience neural adaptations throughout their control network (*Section 3.2.1*), but that dense code-switching bilinguals will only show adaptations in the fronto-cerebellar loop (i.e., a circuit implicated in syntactic combination).

Table 3. 3. Different predictions relating to interactional contexts. Notice than the first two rows concern *production*. The last two rows concern *comprehension*.

Model / Hypothesis	Single-language	Dual-language	Dense code-switching
Adaptive Control Hypothesis (Green & Abutalebi, 2013)	Production trains goal maintenance, interference control	Production trains goal maintenance, interference control, salient cue detection, selective response inhibition, task (dis)engagement	Production trains opportunistic planning
Control Process Model of code-switching (Green & Wei, 2014)	Production occurs in a competitive control (language 'gate' is closed and locked); no switching is expected	Production occurs in a cooperative coupled control (language 'gate' is closed but unlocked; insertion and/or alternation is expected	Production occurs in a cooperative open control (language 'gate' is open); any type of switching is expected, especially congruent lexicalization)
Adaptation caused by **linguistic uncertainty** (Gullifer & Titone, 2021)	Environment has low uncertainty	Environment has high uncertainty: adaptation to proactive control mechanisms	Environment has high uncertainty, but both languages are acceptable and can be used
Adaptive Predictability hypothesis (Valdés Kroff & Dussias, 2023)		Less cognitive control required for processing inter-sentential switches	More cognitive control required for processing intra-sentential switches

Some empirical data supports the ACH. When interactional contexts are induced by experimental design, bilinguals subjected to a dual-language condition outperform bilinguals subjected to a dense code-switching condition on a subsequent inhibitory control task (e.g., Jiang et al., 2023; see also Yow et al., 2017; Zhang, 2023 for dual-language outperforming single-language contexts). Bilinguals in a dual-language context (or bilinguals who produce alternations) exhibit faster RTs than diglossics (single-language context presumed) (Alrwaita et al., 2024) and more indices of attentional control than habitual code-switchers (Beatty-Martínez et al., 2021; see also Beatty-Martínez et al., 2020b; cf. de Bruin, Bak, et al., 2015). Furthermore, recent research utilizing a novel verbal planning task show that dense code-switchers exhibit opportunistic planning (Ng & Yang, 2022). However, the dense code-switching context (often operationalized by a higher language entropy) is sometimes linked to better inhibitory control (Hartanto & Yang, 2020; Hofweber et al., 2016, 2020b; Li et al., 2021; Ooi et al., 2018; Yang et al., 2023 see also Jylkkä et al., 2021; for a dual-language detriment; cf. van den Berg et al., 2022). In many cases, the interactional context of the participants holds no significant impact (Kałamała et al., 2020; Lai & O'Brien, 2020; Paap et al., 2021; Wagner et al., 2023).

Once again, it is important to remember that the ACH is a model of bilingual *production*. From the level of *comprehension*, it is possible that dense code-switching contexts require the most control processes, as listeners experience the highest degree of uncertainty in such an environment (Gullifer & Titone, 2021; Valdés Kroff & Dussias, 2023; see rows 3 and 4 of **Table 3.3**). At any given moment (and especially at common code-switching junctures), the listener does not yet know whether they will need to continue retrieving concepts in one language, or whether they will suddenly need to access their other language. They must actively use available cues (e.g., voice onset time differences; Balukas & Koops, 2015) to predict the incoming speech as best as they can. Unfortunately, the literature has not teased apart the experiences of frequently producing dense code-switches (no hypothesized impact on inhibitory control) and frequently being exposed to dense code-switches (potentially positive impact on inhibitory control).

3.2.3 Conflict adaptation paradigms

Though the literature has mostly employed self-reports and standard executive functioning tasks, a growing number of studies utilize code-switching-specific CONFLICT ADAPTATION paradigms. The conflict adaptation effect (or Gratton effect) occurs when a given control-intensive event is preceded by another intensive event. For instance, during a Stroop task, participants will respond more quickly to the incongruent trial "**GREEN**" if it is preceded by another incongruent trial (**RED** → **GREEN**), rather than if it is preceded by a congruent trial (**BLUE** → **GREEN**). The idea is the following: once control processes are triggered for a given stimulus, a subsequent 'challenging' stimulus will be facilitated, as the top-down control processes required have already been initiated (Gratton et al., 1992; Ullsperger et al., 2005). This established effect can be exploited in code-switching research: i) if code-switching indeed requires control processes, and ii) if these processes are similar to the ones recruited for domain-general inhibition, we might expect that processing of switches will trigger conflict adaptation (i.e., better performance) in subsequent domain-general trials.

The first to test this hypothesis were Wu and Thierry (2013), who interleaved isolated words in a Flanker task. In a single-language block, participants completed Flanker trials interspersed with only English words, or only Welsh words. In the mixed-language block, participants completed Flanker trials interspersed with both English and Welsh words. The authors discovered that participants were more accurate on incongruent Flanker trials during the mixed-language block than during single-language blocks (but no RT differences were observed). Since then, other studies have shown that mixed-language blocks (containing isolated words) decrease Flanker RTs (Jiao, Liu, et al., 2019; Jiao et al., 2022), but do not modulate non-conflict tasks (i.e., a Flanker task with only neutral trials: Jiao, Liu, et al., 2019). Conflict adaptation may be observed on Flanker trials immediately preceded by *sentential* code-switches (Adler et al., 2020; cf. Bosma & Pablos, 2020; Hofweber et al., 2020a). It may also be observed if a pure EF task is prefaced by producing/reading/listening to code-switches (particularly, inter-sentential switches: Han et al., 2024; Jiang et al., 2023; Yow et al., 2017; Zhang, 2023). In the inverse direction, code-switching reading times do not appear to be modulated by the congruency of a preceding Flanker trial (Salig et al., 2021).

Despite these inconsistent behavioural results, the electrophysiological literature is quite coherent: in the mixed-language blocks (Jiao et al., 2020; Wu & Thierry, 2013), or following alternation-type switches (Bosma & Pablos, 2020), the P300 effect is reduced in amplitude. The existence of such conflict adaptation suggests that code-switching "recruits domain-general cognitive-control procedures" (Adler et al., 2020: 748).

The difference between studies utilizing conflict adaptation and those relying on self-reports (*Section 3.3*) highlights a distinction between bilingual 'traits' and bilingual 'states' (Salig et al., 2021). TRAITS are (baseline) by-participant attributes, and thus conjure the participants' self-reported code-switching habits (e.g., "Ariane is a habitual code-switcher, as she reports code-switching frequently in her daily life"). STATES are (manipulated) by-situation attributes, and therefore invoke the conflict adaptation paradigm (e.g., "Ariane performed better in a setting of heightened cognitive control"). Studying states help us understand the dynamics of code-switching and cognitive control (Salig et al., 2021), especially given that executive functioning possesses a large genetic component (Friedman et al., 2008; see also D. Liu et al., 2023; Vaughn & Hernandez, 2018). Furthermore, it is likely easier to control moment-by-moment states (e.g., via experimental design or manipulation) than it is to account for the traits characterizing complicated bilingual populations. Nevertheless, 'trait' studies dominate the literature; these will be reviewed in the subsequent section.

3.3 Self-reported experience with code-switching and EFs

3.3.1 Behavioural evidence

A notable upsurge in recent behavioural scientific publications has examined whether code-switching modulates inhibitory control skills (see Rayo et al., 2024 for a review). The overwhelming majority of these studies (see **Table 3.4**) conform to the following template: participants are asked to self-report their code-switching habits (though see Han et al., 2024; Keijzer & Schmid, 2016; Lai & O'Brien, 2020; Yim & Bialystok, 2012 for objective measures), then researchers examine the ways in which their self-reports are related to the participants' performance on executive functioning tasks.

Unsurprisingly, the literature yields inconsistent results. Some studies do indeed observe that habitual code-switching positively impact language-related (Gosselin & Sabourin, 2023b; Gullifer et al., 2023; Han et al., 2024; Yow & Li, 2015) and/or domain-general inhibitory control (Gosselin & Sabourin, 2023b; Han et al., 2022, 2024; Hartanto & Yang, 2020; Hofweber et al., 2016, 2019, 2020b; Jylkkä et al., 2020; Kheder & Kaan, 2021; Lai & O'Brien, 2020; López-Penadés et al., 2020; Ooi et al., 2018; Pot et al., 2018; Sanchez-Azanza et al., 2020; Thanissery et al., 2020; Verreyt et al., 2016). However, many experiments yield no effect for code-switching frequency (domain-general: Barbu et al., 2018, 2020; Chan et al., 2020; Gullifer et al., 2023; Jiao, Zhang, et al., 2019; Jylkkä et al., 2017, 2021; Kałamała et al., 2020; Keijzer & Schmid, 2016; Soveri et al., 2011; Woumans et al., 2019; Yim & Bialystok, 2012; Yow & Li, 2015; language-specific: Kałamała et al., 2020; Keijzer & Schmid, 2016; Lai & O'Brien, 2020; Yang et al., 2023; Yow et al., 2017). Negative effects, albeit rarer, have also been reported (i.e., bilinguals who code-switch *less* exhibit increased inhibitory control: Jylkkä et al., 2021; Sanchez-Azanza et al., 2020), though this may be related to unintentional switching (Gosselin & Sabourin, 2023b).

The variability in the results is not inherently worrisome: the studies utilized various tasks, tested different participant samples, and measured diverse code-switching habits (e.g., intra vs. inter-sentential; intentional vs. unintentional; alternation vs. dense; into L1 vs. into L2) in distinct ways (e.g., self-reports, frequency judgements, objective proportions).

Table 3. 4. Summary of adult studies examining the role of code-switching (CS) habits in inhibitory control (reactive/proactive control measures, attentional measures, working memory measures, and mixing/switching measures are not shown here). If a monolingual group was also tested, this *n* is not included. When physiological data was also collected, these results are not indicated in the present table.

Study	Sample	CS measure	Task	DV	Effect
Barbu et al., 2018 *	French + L2 bilinguals in Belgium; 21 high switchers, 21 low switchers	Switches per day, based on self-reports High frequency switchers > 20 per day; Low frequency switchers < 6 per day	Alertness subtest	RTs	ns
			Go / No-go		ns
Barbu et al., 2020 *	French-German bilinguals in Belgium; 30 high switchers, 21 low switchers		Alertness subtest	RTs	ns
			Go / No-go		ns
Chan et al., 2020 +	76 aging bi/multilinguals in Singapore	BSwQ	Stroop	global RT, interference effect	ns
			Flanker		ns
Gosselin & Sabourin, 2023b	225 French-English bilinguals in Ottawa	BSwQ	Flanker	facilitation effect	More CS into English = better performance; More unintentional CS = worse performance (Stroop only)
				inhibition effect	
			Stroop	facilitation effect	
				inhibition effect	
Gullifer et al., 2023	777 French-English / English-French bilinguals in Montréal	Mixed-language engagement based on self-reports	Simon arrows	conflict adaptation effect	ns
			Number Stroop		• More mixed-language usage = better adaptation
Han et al., 2022	31 Chinese-English bilinguals living in various anglophone countries	LSBQ and BSwQ	Go / No-go	false alarms (No-go trials)	• More unintended switching/intra-CS = less false alarms (frequentist); • Habitual code-switching (intra-CS or inter-CS) = less false alarms (Bayesian)
Han et al., 2024	41 Chinese-English bilinguals living in various anglophone countries	BInConQ, BSwQ and objective CS during narration/conversation task	verbal Stroop	incongruent RTs	• More self-reported inter-CS = faster RTs
			spatial Stroop		• More self-reported inter-CS = faster RTs; • More objective intra-CS = faster RTs

Study	Sample	CS measure	Task	DV	Effect
Hartanto & Yang, 2020	175 bi/multilinguals in Singapore (English + Chinese and/or Tamil and or Malay)	BInConQ, BSwQ	Arrow Flanker Letter Flanker Colour Flanker	Latent inhibitory control variable (ranked/binned interference effect)	• More dense CS = better inhibitory control (ns when individual tasks are considered)
Hofweber et al., 2016, 2019 *	22 German-English bilinguals (11 dense code-switchers in South Africa, 11 single/dual-language switchers in the UK)	FJT, bilingual email production (2019 paper)	Flanker	interference effect (low conflict block)	ns
				interference effect (med conflict block)	ns
				interference effect (high conflict block)	• Dense code-switchers = smaller effect
Hofweber et al., 2020b	43 German-English bilinguals in the UK	FJT of alternation, insertion and dense CS; self-reports	Flanker low conflict (92/8)	interference effect (reactive)	• More alternation = smaller effect
			Flanker high conflict (50/50)	interference effect (proactive)	• More dense CS = smaller effect
			Go / No-go Flanker	RTs, interference effect	ns
Jiao, Zhang, et al., 2019	34 Chinese-English bilinguals in China	BSwQ (all items collapsed)	Spatial Stroop	RTs	ns
Jylkkä et al., 2017 +	Swedish-Finnish bilinguals (*n*=66 from polytechnic in Finland, *n*=111 from general Finnish population)	BSwQ, Recent vs. childhood switching, degree of switching coefficients	Flanker	interference effect	ns
			Simon	interference effect	ns
Jylkkä et al., 2020	30 Swedish-Finnish bilinguals in Finland	BSwQ; single-question Likert; EMA	Flanker	interference effect	• More contextual CS = smaller effect
			Simon	interference effect	
Jylkkä et al., 2021	33 Finnish-English bi/multilinguals in Finland	Modified EMA for intended, unintended, within-speaker and between speaker CS	Simon	interference effect	ns
			Flanker	interference effect	• More between-speaker CS = larger effect
Kałamała et al., 2020	195 Polish-English bi/multilinguals in Poland	BInConQ and dual-language intensity score (includes a reverse-coded switching measure)	Anti-saccade	error rate	ns (both the latent factor and for individual tasks)
			Stroop	interference effect	
			Go / No-go	error rate on No-go	
			Stop-signal	Stop-signal RT	

Study	Sample	CS measure	Task	DV	Effect
Keijzer & Schmid, 2016 +	29 aging late Dutch-English bilinguals living in Australia	Switches per min from a semi-structured interview (objective)	Simon	interference effect	ns
			Stroop	interference effect in Dutch, English	
Kheder & Kaan, 2021	134 Arabic-French bilinguals in Algeria	ACSES	Simon	RTs, congruency effect	• For high-proficiency bilinguals, more CS = smaller effect across trials
Lai & O’Brien, 2020	74 English-Mandarin bilinguals in Singapore	Self-reports (5-point Likert scales) and objective CS during narration/conversation tasks	Stroop	incongruent RTs (mixed block)	ns (both subjective and objective measures)
				interference effect	
				incongruent RTs (pure block)	
			Global-local task	incongruent RTs (mixed block)	• More objective inter-CS = faster RTs (*ns* for subjective)
				interference effect	ns
				incongruent RTs (pure block)	ns
López-Penadés et al., 2020	112 Catalan-Spanish bilinguals in Balearic Islands	BSwQ	Flanker	global RTs, interference effect	• More CS into the L2 = faster global RTs
Ooi et al., 2018 *	63 late bilinguals in Edinburgh, 48 early bilinguals in Edinburgh, 70 bilinguals in Singapore (English + various Ls)	two questions from the BSwQ; Singapore bilinguals switch significantly more	ANT	global RTs, interference effect	• Singapore bilinguals are overall faster and have reduced interference effect • Marginal positive correlation between self-reported switching tendency and interference effect
Pot et al., 2018 +	311 aging bi/multilinguals in the Netherlands	BSwQ	Flanker	interference effect	• Contextual switching into the L2 = smaller effect
López-Penadés et al., 2020	184 Catalan-Spanish bilinguals in the Balearic Islands	Latent variable of language switching frequency computed via self-reports on the BSwQ	Flanker	latent variable of inhibition (proportional inter-ference, prop-ortional inhibition, inverse efficiency)	Higher CS frequency = better executive control latent variable ... but negative association with inhibition

Study	Sample	CS measure	Task	DV	Effect
Soveri et al., 2011 +	38 Finnish-Swedish bilinguals in Finland	BSwQ	Simon	interference effect	*ns*
			Flanker	interference effect	*ns*
Thanissery et al., 2020 (study 2)	101 Hindi-English bilinguals in India	BSwQ	Go / No-go (different proportions)	RTs (Go), false alarms (No-go)	• More contextual switching = faster RTs in high-conflict block (50 go / 50 no-go)
Verreyt et al., 2016 *	Dutch-French bilinguals in Belgium (also speak EN); 28 unbalanced, 17 balanced non-switching, 20 balanced switching	Self-reports on a scale from 0-7. Switchers > 4 Non-switchers < 2	Flanker	RTs	• Balanced switchers = smaller congruency effect (supported with correlations)
			Simon arrow	RTs	
Woumans et al., 2019	18 Dutch + L2 bilinguals in Ghent, Belgium	Self-reports on a scale from 1 to 5	Simon	interference effect	*ns*
Yang et al., 2023 +	69 aging bilinguals in Singapore (English + various Chinese dialects)	BInConQ, BSwQ	Stroop	interference effect	ns (for just inhibitory control)
Yim & Bialystok, 2012	78 Cantonese-English bilinguals in Toronto	Objective CS score from conversation task	Faces task	interference effect (green/red eyes)	*ns*
				interference effect (straight/not gaze)	*ns*
Yow et al., 2017	83 bi/multilinguals in Singapore (Chinese + at least English)	9 questions about language switching (5-point Likert scales)	Stroop	interference effect	*ns*
Yow & Li, 2015	72 bi/multilinguals in Singapore (at least English and Mandarin)	BSwQ	Stroop	inhibition effect	• More balanced usage (correlated with CS) = smaller inhibition
			Flanker	interference effect	*ns*

* Categorical groups compared. + Sample mean age > 35 years.

NOTE: BSwQ: Bilingual Switching Questionnaire (Rodriguez-Fornells et al., 2012). **BInConQ**: Bilingual Interactional Contexts Questionnaire Hartanto & Yang, 2016). **FJT**: Frequency judgement task. Participants are asked how often they encounter different types of switches. **Bilingual emails**: Participants compose an email on a given topic or provide a past email. **EMA**: Ecological Momentary Assessment. Participants use an app to report their code-switching frequency every two hours. **ACSES**: Assessment of Code-Switching Experience Survey (Blackburn, 2013). **LSBQ**: Language Social Background Questionnaire (Anderson et al., 2018).

Importantly, participants' code-switching frequency has scarcely been disentangled from their bilingual interactional context of origin; some authors do indeed address language context when discussing their null results, noting that their language background questionnaire did not allow them to disambiguate interactional contexts (Chan et al., 2020; Jylkkä et al., 2017; Soveri et al., 2011). As such, it is possible that research yielding null results tested participants who originate from dense code-switching contexts; such bilinguals are not expected to possess executive functioning advantages (e.g., bilinguals in Singapore: Chan et al., 2020; Lai & O'Brien, 2020; Yow et al., 2017; Yow & Li, 2015), at least where production is concerned. It is also possible that null results are observed among populations that report overall infrequent switching or who speak typologically-close language pairs (e.g., bilinguals in Finland: Jylkkä et al., 2017, 2021; Soveri et al., 2011).

3.3.2 Electrophysiological evidence

I am aware of one electrophysiological study that examined participants' EEGs in relation to their self-reported code-switching habits (Carter et al., 2023). Carter and colleagues operationalized bottom-up control (P300 and N2 ERP components), and top-down control (theta and alpha power) during Flanker and Simon interference. They additionally computed a series of latent bilingualism experiential factors based on self-reports and proficiency tests: duration of bilingual language use, diversity of language use, language switching, and relative proficiency. Among their large sample (*n*=135 bilinguals), the authors observed that frequent language switching and more diverse language use was related to diminished theta power (i.e., efficient / reduced top-down control), which was in turn linked to reduced interference effects at the behavioural level. The reduction in top-down control among more diverse language users falls into line with the ACH: in an environment where languages can be used highly cooperatively, language selection can be biased by internal activation states, thereby bypassing top-down inhibitory control mechanisms prioritizing language maintenance. More on this in *Section 3.5*.

3.4 Some limitations with the existing EF literature

Similar to the psycholinguistic code-switching literature, several recurrent issues afflict the bilingual executive functioning literature (de Bruin et al., 2021; Paap & Sawi, 2014; Poarch & Krott, 2019). Most notably, researchers criticize the reliability and convergence of the tasks used to draw general conclusions about bilingual-based effects. As previously mentioned, published articles favour the use of self-reports when it comes to operationalizing code-switching in bilingual samples. Finally, I once again highlight the modality issue: production and comprehension have not been examined independently when it comes to the impact of code-switching on executive functioning.

3.4.1 Task specificity, reliability, and convergent validity

Though 'standard' tests are used to measure inhibitory control (e.g., Flanker, Stroop, ANT, Simon...), even tasks bearing the same name can vary greatly from one study to another. In fact, the 'standard' part of these task mostly calls back to the conditions being examined (congruent, incongruent, and sometimes neutral conditions; see *Section 3.1.1*).

There are no established conventions when it comes to experiment design (e.g., number of trials, stimulus or inter-stimulus presentation time, preparation time, breaks, font/background colour and size), data cleaning (e.g., absolute/relative thresholds, within-/between-subject cleaning, outlier removal, data transformations), or analyses (e.g., expected power[6], type of statistical analysis, random effects structure, multiple comparison correction). Such details may seem trivial, but similar experimental manipulations have been shown to affect research outcomes substantively (Mosca & Clahsen, 2016; Privitera et al., 2023; Shen, 2023; Zhou & Krott, 2016).

Lack of reliability *within* EF tasks has also been criticized (Paap & Sawi, 2016). Reliability can be assessed by testing an individual on separate occasions (e.g., test-retest), or by splitting the data obtained from one participant into two halves (e.g., odd vs. even test), and then comparing both subsets. If a task is reliable, an individual should display similar performance from test to retest, or between split-halves. Reliability for mean RTs (e.g., incongruent RT) is generally satisfactory in executive functioning tasks, but computed effects (e.g., interference effect) retain moderate reliability (e.g., Paap & Sawi, 2016; see also Gosselin & Sabourin, 2023b; Jylkkä et al., 2017, 2020; López-Penadés et al., 2020). This is problematic given that effects are used to operationalize specific cognitive processes (i.e., they are often the dependent variable of interest). However, the low reliability may also

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[6] The literature concerning the relationship between code-switching and inhibitory control seems to be afflicted by important statistical power issues. For instance, of the thirty (behavioural) studies summarized in **Table 3.4**, 67% (*n*=20) tested samples under 100 participants, and nearly half (n=13) tested samples or groups under 50 participants. Over 80% of studies (*n*=25) did not report the power expected for their sample size. This is especially concerning given the fact that code-switching effects, when present, are small in size (e.g., Gosselin & Sabourin, 2023b), and that analyses often contain a large number of predictors/fixed factors.

be caused by small between-participant variance generated by the tasks (i.e., virtually all participants are faster on congruent compared to incongruent trials; Hedge et al., 2018). A paradox begins to take shape when we consider the goals of the literature and the nature of the executive functioning tasks. EF tasks were built to produce predictable, consistent results across populations. However, the study of BBE is essentially a study of individual differences. Statistical analyses like correlations and regressions attempt to distinguish individuals (based on given variables/predictors) and therefore rely on the presence of variability in the data. This means that established EF tasks may inherently be "unsuitable" (Hedge et al., 2018: 1167) for individual difference questions.

Going further, comparable tasks are not always inter-correlated within a single study (lack of convergent validity: Paap & Sawi, 2014; see also Jylkkä et al., 2018; Kałamała et al., 2020; Paap et al., 2017). For instance, Gosselin and Sabourin (2023b) failed to observe a correlation between participants' inhibitory control skills (i.e., facilitation and inhibition effects) during a Flanker task and Stroop task. If tasks meant to operationalize similar underlying control process are not related to each other (and are not reliable within a given task), the question stands: what is being measured? It could be argued that different tasks tap into distinct subcomponents of a given control process (e.g., language-specific inhibitory control from a Stroop task is unlike domain-general inhibitory control from a Flanker task). This would make non-convergence a matter of scientific interest rather than a discreditation of existing results.

Altogether, it can become difficult to determine whether divergent results in the literature mostly reflect task/design differences, or whether they reflect the factors of interest (e.g., a given EF). The ecological validity and generalizability of the existing findings is challenged: If observed results are highly task-specific, and these tasks do not much resemble real-world functioning, *what exactly are researchers making conclusions about*?

3.4.2 The subjectivity issue

Of the thirty studies summarized in **Table 3.4**, twenty-four utilized purely self-reported code-switching measures and two utilized frequency judgement measures (i.e., participants rate the acceptability of a given switch). This means that only four studies (Han et al., 2024; Keijzer & Schmid, 2016; Lai & O'Brien, 2020; Yim & Bialystok, 2012) utilized objective measures, wherein participants' code-switching habits were operationalized via the analysis of spontaneous speech (e.g., conversation tasks). Furthermore, various types of self-reporting tools are implemented, even though the content of code-switching questionnaires are deemed complimentary rather than overlapping (Dass et al., 2024). This challenges the way in which researchers directly compare findings in the literature.

While self-reports are convenient and accessible tools, the question stands as to whether they accurately reflect bilinguals' language habits. In order to have confidence in experimental conclusions, we first need to be confident in "(1) the validity of the constructs established [by the questionnaire], and (2) the accuracy of the participants' self-reports" (Gosselin & Sabourin, 2024: 16). In a meta-synthesis, Zell and Krizan (2014) found that humans difficultly judge themselves, especially when they must self-evaluate broad or complex behaviours. A few external factors are known to influence self-reports, such as the social desirability bias and the observer effect: participants are susceptible to sway their answers towards what is socially acceptable, or what they think the experimenter expects (e.g., Paulhus, 1984). Such biases may be especially detrimental to code-switching research: since switching is 'non-standard' (see *Section 2.5.2*), participants may underreport their code-switching habits in line with social desirability. On the other hand, it has been argued that this bias impacts participant samples as a whole, and therefore does not compromise code-switching habits measured on a continuum (Gosselin & Sabourin, 2024).

Few studies have compared subjective and objective measures of code-switching. In one such experiment (Cox et al., 2020), Spanish-English bilinguals were asked to talk about an autobiographical memory. Later in the session, they completed the Bilingual Switching Questionnaire (BSwQ; Rodriguez-Fornells et al., 2012), a commonly used self-reported measure used to operationalize code-switching habits. A broad relationship was observed: participants who code-switched more during the spontaneous production task also self-reported more frequent switching; specific code-switching subcomponents were assessed less accurately (Cox et al., 2020). It is worth noting that participants' self-reports may have been improved by their recent completion of the speech elicitation task (i.e., they could base their self-evaluation on their recent switching behaviour). Other studies yield no relationship between objective and subjective code-switching measures (Han et al., 2024; Lai & O’Brien, 2020; see also Woumans et al., 2019 for switching in a semantic fluency task), or even independent inhibitory control correlates for objective measures and self-reports (Han et al., 2024; Lai & O’Brien, 2020).

This calls back to the traits vs. states distinction (Salig et al., 2021; *Section 3.2.3*): perhaps bilinguals are better at self-evaluating a state (e.g., "I code-switched frequently when I was telling you about that memory"), rather than a trait (e.g., "I don't switch from one language to another much in my day-to-day life"). In any case, future research should prioritize objective code-switching measures in order to avoid potential limitations driven by the subjectivity of self-reports.

3.4.3 The modality conflation issue

Not unlike the more general psycholinguistic code-switching literature, researchers examining the link between cognitive control and switching have not disambiguated the correlates associated to *producing* switches and being exposed to (i.e., *processing*) switches (though see H. Liu et al., 2018; S. Liu et al., 2023 for joint production-comprehension artificial switching paradigms). As discussed, this is problematic since the cognitive processes for each modality are likely not identical: speakers are in 'control' of their productions (at least, in the real-world setting), but listeners must process code-switches as they are heard. This means that one modality (i.e., comprehension) may discriminately engage (and therefore potentially train) inhibitory control. The ACH (Green & Abutalebi, 2013) specifically posits that *producing* switches in certain contexts requires little-to-no-control processes; the distinction between interactional contexts may not apply to frequent code-switching exposure.

Questionnaires used to operationalize bilinguals' code-switching habits sometimes target distinct modalities but are consistently conflated in the literature. For instance, the

BSwQ likely reflects production, as it asks participants to rate declarations like "*I tend to switch languages during a conversation*" (Rodriguez-Fornells et al., 2012). By contrast, frequency judgement tasks (FJT) presumably target exposure (comprehension), as they instruct participants to indicate how often they "*encounter*" different types of switches (Hofweber et al., 2019).

Altogether, the effect of code-switching frequency on bilingual inhibitory control is promising, but its existence has been markedly compromised by confounds (e.g., interactional context, modality). These confounds must be addressed in order to unveil a richer and more complete understanding of putative relationships.

3.5 Putting it all together

It is noticeable that the literature examining the relationship between bilingual executive functioning and code-switching is in its youth. For instance, from the thirty articles summarized in **Table 3.4** (pp.66-69), seventeen were published in the 2020s and none is older than 2011. This makes it clear that the subfield is of high interest for relevant experts, and that conflicting findings are signs of progress rather than inherent issues. Below, I attempt to regroup emergent patterns from the burgeoning literature up to this point.

a) The neural substrates involved in language switching (and perhaps code-switching) overlap with those involved in domain-general executive functioning.
b) Code-switching in different bilingual interactional contexts likely imposes distinct control mechanisms; this has not been disambiguated from modality.
c) Reading or listening to code-switching usually improves cognitive control within a single experimental session.

d) When it comes to the relationship between frequent self-reported code-switching and behavioural inhibitory control, both positive and null results are commonplace; negative effects are rather sparse.
e) Studies measuring 'code-switching traits' (i.e., self-reports) do not distinguish modality (i.e., self-reported production vs. self-reported exposure). Studies measuring 'code-switching states' (i.e., conflict adaptation paradigms) have uniquely tested the modality of processing.

How to bring together the variability in the literature? One recently advanced proposal is that dense code-switching and dual-language switching (e.g., alternations) engage different aspects of cognitive control. Notably, it is possible that PROACTIVE CONTROL is mobilized by dense code-switchers and that REACTIVE CONTROL is mobilized by dual-language bilinguals (Beatty-Martínez et al., 2020b; Gullifer et al., 2018; Hofweber et al., 2020b, 2020a; Jiang et al., 2023). Proactive control reflects mechanisms which allow individuals to optimally gear and bias responses ahead of time, thereby suspending top-down mechanisms (Kleinman & Gollan, 2016). In a dense code-switching context—where common linguistic knowledge between co-interlocutors is assumed—, bilinguals' can allow their own internal states of activation to bias their productions. For example, in the case of high cross-linguistic lexical activation, proactive control may bias the speaker towards a code-switch; they thus circumvent the top-down inhibitory control mechanisms prioritizing language maintenance (Kleinman & Gollan, 2016; see also Carter et al., 2023; Ng & Yang, 2022). Reactive control reflects mechanism which allow individuals to change their behaviours 'on the fly', based on conflict detected on moment-by-moment basis (Seo & Prat, 2019). In a dual-language context, bilinguals need to switch languages based on environment-based cues (e.g., hearing "Hello" rather than "Bonjour" when one picks up the phone). For this reason, internal states like lexical accessibility may not bias their productions. A series of studies indeed support the distinct impact of interactional context on proactive and reactive control (Beatty-Martínez et al., 2020b; Gullifer et al., 2018; Hofweber et al., 2020b, 2020a; Jiang et al., 2023).

Notice, however, that the proactive-reactive distinction abstracts away from the production-processing paradox. That is, while dense code-switchers may rely on internal states while producing code-switches ('bottom-up switches': Kleinman & Gollan, 2016), they likely cannot do so while listening to code-switches. It is thus possible that proactive control is implicated in *production* (recall that the ACH is based on the modality of production), but that reactive control is implicated in comprehension. This was described by Garbin et al. (2011: 129); emphasis added):

> *...the involvement of the speaker in language switching in production and comprehension is very different.* ***In production,*** *the speaker is the one that decides whether or not (and when) to switch languages, and hence t**he switching performance is mostly <u>pro-actively driven</u>**. In contrast,* ***in comprehension*** *the listener is a passive receptor of language switching, and hence* ***the switching performance is <u>mostly re-actively driven</u>***.

Indeed, in a review targeting bilingual control, it has been noted that proactive control is a feature of bilingual production (to alleviate cross-linguistic interference), but not of bilingual comprehension (Declerck, 2020; see also Declerck et al., 2019; Eben & Declerck, 2019; c.f. Struys et al., 2019). Relatedly, distinct circuits are recruited for both modalities. For instance, Blanco-Elorrieta and Pylkkanën (2016) used design-equivalent artificial switching paradigms to compare the underpinnings of language switching in production and comprehension. For the Arabic-English bilinguals tested, producing switches recruited prefrontal regions (particularly the dorsolateral PFC), but comprehending switches recruited the ACC. The ACC is mainly linked to conflict monitoring (Abutalebi & Green, 2016), when "reactive adjustments" are need to manage conflict (Botvinick et al., 2004: 544). On the other hand, the dorsolateral PFC is linked to inhibition mechanisms needed for "efficient selection of the target stimulus" (Abutalebi & Green, 2016: 690).

Altogether, this entails that circuits fine-tuned for reactive control are mobilized during switching comprehension (i.e., listeners must detect cues in order to activate the target language spontaneously[7]) but that circuits implicated in proactive control may be mobilized during production (i.e., speakers can bypass top-down language maintenance if a more efficient bottom-up cross-linguistic item exists) (see Blanco-Elorrieta & Pylkkänen, 2016; cf. Seo & Prat, 2019).

3.5.1 Linking the subfields

Up to this point, I have presented an overview of two distinct lines of research regarding code-switching. The first pertinent subfield concerns the processing costs of code-switching. This line of research has established that (some types of) code-switches elicit (some types of) cognitive costs, but that there are modulations according to switching modality, and based on participant-specific linguistic factors/habits. The second relevant subfield pertains to the potential neurocognitive impact of bilingualism. This subfield has lately begun to expose that an individuals' code-switching habits may play a key role in

[7] In line with this idea, bilinguals who engage in congruent lexicalization (i.e., dense code-switches) show reduced cue detection and interference control, but improved opportunistic planning (Ng & Yang, 2022).

spearheading BBE; however, the literature often blurs interactional contexts, and does not associate code-switching measures to specific modalities.

Ultimately, the present dissertation aims to unify both subfields (the experimental linguistic literature and the neurocognitive EF literature) in order to uncover a better understanding of code-switching and its impact on cognitive functioning. I rationalize that the above lines of questioning are inherently related: If (some types of) code-switching do indeed engender cognitive costs, perhaps it is precisely *this* augmented effort which trains the neural substrates fundamental to bilingual executive functioning.

Importantly, however, we do not yet fully understand the state and trait differences between *producing* code-switches and *processing* (i.e., comprehending) code-switches. A long tradition of research has separated the mechanisms underlying language production from those underlying language processing. Why then, do many experts assume that code-switching cannot be difficult to process if it is so observably 'easy' to produce? Under the hypothesis that code-switching puts into practice inhibitory control mechanisms, we may ask whether it is the *production* and/or the *processing* of code-switches that is effortful (and in which ways). In other words, once we determine exactly what is costly when it comes to code-switching, this can lead us towards understanding the processes that are put into place to fine-tune bilinguals' executive functioning system.

3.5.2 Where to go from here?

Some common caveats exist in the literature examining the relationship between code-switching and bilingual executive functioning: researchers routinely rely on subjective (trait) measures of code-switching, and do not discern the modality primarily targeted by the self-report. Furthermore, the nature of the experiments used to test inhibitory control (and EFs in general) minimize critical between-subject variability. The constructs used for hypothesis testing (i.e., EF effects) exhibit contentious reliability and convergence. Possible remedies for each of these issues is presented in **Table 3.5**.

Table 3. 5. Potential solutions for current issues in the bilingual executive functioning literature.

Issue	Potential solutions
Task effects, reliability and convergence	• Always report measures of reliability and convergence • Ensure that there is sufficient variability in the data • Prioritize statistical analyses that use by-trial data and allow for random effects; report power of analyses • Be careful not to overgeneralize findings
Subjectivity of code-switching measures	• Prioritize objective measurements of code-switching habits, particularly those obtained in a naturalistic way (e.g., spontaneous speech, with peers, etc.)
Modality conflation	• Tease apart the cognitive effects of producing vs. comprehending switches within a single experimental design (e.g., testing speaker-listener pairs)

In short, it would be valuable to design a (statistically robust) experiment comparing the inhibitory control correlates linked with the production of switches *versus* the comprehension of switches. The conclusions would be further legitimized if participants were tested among peers (i.e., with members of the same in-group) and code-switching was operationalized objectively. To accomplish these goals, the current dissertation built a novel, ecologically valid code-switching corpus. Its construction and composition will be described in the following Chapter.

CHAPTER 4: *La construction de* FEBLOC

Is code-switching veritably difficult to produce? Is it difficult to process? What are the consequences of frequent production and/or comprehension of switching on the bilingual executive functioning system? In order to answer these questions, it is important to consider code-switching in the most natural circumstances. To circumvent common caveats in code-switching research (i.e., ecological validity, stigmatization, use of subjective measures), the fundamental goal of the present thesis was to create a novel and naturalistic code-switching corpus. The following sections describe the creation of the French-English Bilingual Loved Ones Corpus (FEBLOC), as well as its contents. This corpus was used as a tool to answer the main research questions of the dissertation (CHAPTERS 5-7). Note that the questionnaires and tasks reported in this chapter are available for previewing and testing here. The methods described were pre-registered here.

4.1 Speakers included in the corpus

Twenty-two pairs (*n*=44) of adult French-English bilinguals gave informed consent (REB file #S-04-22-8029) and completed the study. All were recruited via word-of-mouth, social media, in-class announcements at the University of Ottawa, and through the University of Ottawa Integrated System of Participation in Research (ISPR) pool. Participants recruited through ISPR were compensated with partial course credit; those recruited outside of ISPR were entered into a draw for a $50 CAD gift card. Prior to in-person testing, the experimenter contacted participants to ensure that members of each pair were well-known to each other in the real world (i.e., couples, family members, close friends, etc.).

Table 4. 1. Pairs/speakers included in the corpus.

Pair	Relationship	Years known	Partner	Alias	Sex	Age	L1(s)
0.1 (pilot)	cousins	> 50 yrs	A	*Sarah*	F	60	FR
			B	*Mary*	F	59	FR
0.2 (pilot)	co-workers / friends	15 yrs	A	*Daphné*	F	49	FR
			B	*Max*	M	60	FR
01	married / common law	36-40 yrs	A	*Manon*	F	61	FR
			B	*Calvin*	M	61	EN
02	niece and aunt	20 yrs	A	*Camille*	F	20	EN and FR
			B	*Renée*	F	58	FR
04	daughter and father	18 yrs	A	*Audette*	F	18	EN and FR
			B	*François*	M	52	FR
06	married / common law	12 yrs	A	*Mina*	F	35	FR
			B	*Jack*	M	33	FR
07	married / common law	10 yrs	A	*Sébastien*	M	34	FR
			B	*Kathleen*	F	32	EN
08	daughter and mother	19 yrs	A	*Charlotte*	F	19	EN and FR
			B	*Gabrielle*	F	42	FR
09	couple	6 yrs	A	*Freya*	F	18	EN and FR
			B	*Caleb*	M	18	EN

Pair	Relationship	Years known	Partner	Alias	Sex	Age	L1(s)
10	couple	6 yrs	A	*Danielle*	F	18	EN and FR
			B	*Jérémie*	M	18	FR
11	friends	14 yrs	A	*Lydia*	F	18	FR
			B	*Sandra*	F	18	EN and FR
12	couple	< 1 yr	A	*Kira*	F	18	EN and FR
			B	*Sabrina*	F	20	FR
14	married / common law	26-30 yrs	A	*Gemma*	F	41	FR
			B	*Moïse*	M	41	FR
15	friends	5 yrs	A	*Hazel*	F	22	EN and FR
			B	*Naomi*	F	22	EN and FR
16	siblings	> 50 yrs	A	*Léona*	F	61	FR
			B	*Brian*	M	59	FR
17	niece and aunt	26-30 yrs	A	*Valérie*	F	26	EN and FR
			B	*Sylvie*	F	54	FR
18	couple	2 yrs	A	*Aaron*	M	21	EN
			B	*Virginie*	F	22	FR
19	couple	< 1 yr	A	*Molly*	F	17	EN
			B	*Stéphane*	M	19	FR
20	siblings	19 yrs	A	*Noah*	M	24	EN and FR
			B	*Bertrand*	M	19	EN and FR

Each participant completed extensive demographic and language background questionnaires (Sabourin et al., 2016). Three pairs (*n*=6) were excluded from the corpus, as each member reported exposure to an additional language from birth (*n*=2 Creole, *n*=4 Arabic). As such, the final sample of speakers included 19 pairs (*n*=38) of French-English bilinguals (*M* age= 33.8 years, *SD*=17.0 years, 17-61 years; 25 female, 13 male). All participants were exposed to and/or immersed in both languages by the age of 8. They reported current advanced-to-native competence in both languages (i.e., at least 3 out of 5 on self-reported proficiency scales). All individuals possessed normal or corrected-to-normal hearing and vision. On average, pairs were recorded for 56 minutes (*SD*=10 minutes). The full list of speakers included in the corpus is presented in **Table 4.1**.

4.1.1 Pair questionnaire

In order to gauge the relationship between members of each pair, a novel questionnaire was administered to the participants prior to the experimental tasks. Pairs completed the questionnaire together. Nine pairs were couples (married, common law, or dating). Four pairs were first-degree relatives (parent/child, siblings) and three pairs were second-degree or third-degree relatives (cousins, aunt/niece). The remaining three pairs were friends. On average, members of each pair knew each other for 19 years (*SD*=17 years, *range*=1-59 years). When asked to judge the frequency with which they interacted in their day-to-day lives (1=every day or nearly every day to 6=less than once a month), most pairs indicated communicating "every day or nearly every day" (*M*=1.9, *SD*=1.7, *range*=1-6).

Table 4. 2. Results from the pair questionnaire (1=completely agree; 2=agree; 3=somewhat agree; 4=somewhat disagree; 5=disagree; 6=strongly disagree).

Question	*Mean (SD)*
The two of you have similar language backgrounds.	2.4 (1.1)
The two of you often speak in formal settings or about formal topics (e.g., work, studies, professional life...).	3.8 (1.6)
The two of you often speak in informal settings or about informal topics (e.g., affective or personal life, hobbies...).	1.2 (0.4)
The two of you "speak similarly".	2.1 (0.9)
The two of you are sometimes told that you "speak like each other".	3.6 (1.5)

The participants were also asked about the types of interactions they share (see **Table 4.2**). Pair members reported discussing informally much more frequently than formally ($t(18)=6.7$, $p<.0001$). Together with the length and type of relationship, this confirms that the goal of testing pairs from the same in-group was indeed achieved.

4.1.2. Demographic and language background

Each participant also completed an extensive demographic and language background questionnaire through the Gorilla Experiment Builder interface (www.gorilla.sc, Anwyl-Irvine et al., 2020). The questionnaire was adapted from a tool originally built for the French-English population in the capital region (Sabourin et al., 2016). An overview of the sample characteristics is presented in **Table 4.3**.

Table 4. 3. Overview of the participant sample.

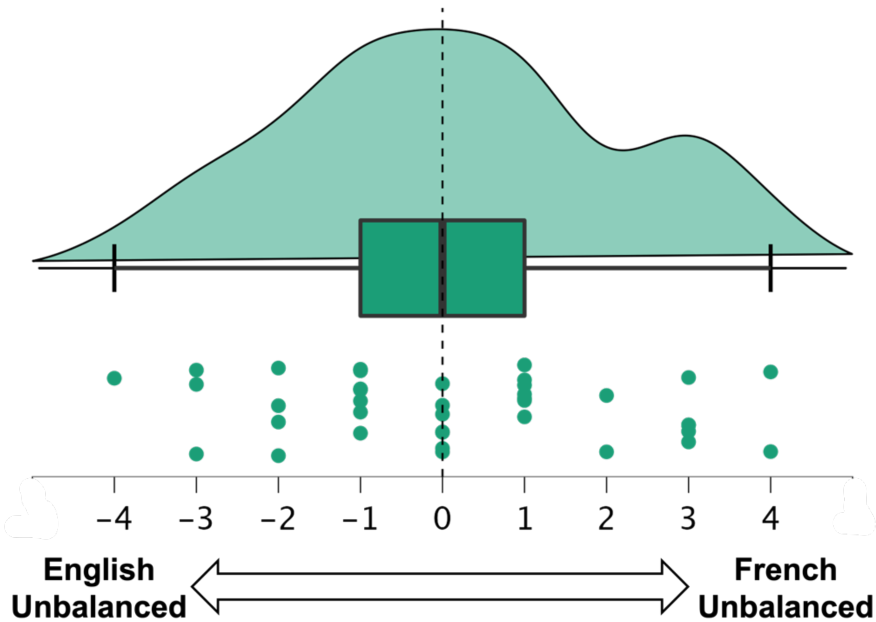
		1	2	3	4	5
Highest level of education obtained*		23.7% (9)	26.3% (10)	44.7% (17)	5.3% (2)	-
Video-game habits**		31.6% (12)	47.4% (18)	10.5% (4)	7.9% (3)	2.6% (1)
				Ontario	**Québec**	**Other**
Current province of residence				81.6% (31)	18.4% (7)	-
Proportion of time lived				.73 (.37)	.22 (.35)	.06 (.18)
				Only French	**Only English**	**Both**
Self-reported L1				55.3% (21)	13.2% (5)	31.6% (12)
Self-reported dominant language				47.4% (18)	52.6% (20)	-
				Mean	***SD***	***Range***
French	***Age of exposure (years)***			.55	1.54	0-7
	Proportion exposure during infancy			.69	.33	0-1
	Current usage (%)			.36	.21	.00-.85
	Current global proficiency (out of 5)†			4.66	.58	3-5
	Oral comprehension			4.95	.23	4-5
	Oral production			4.61	.50	4-5
	Writing			4.45	.92	1-5
	Reading			4.63	.75	2-5
	Pronunciation			4.63	.59	3-5
English	***Age of exposure (years)***			2.29	3.21	0-12
	Proportion exposure during infancy			.33	.35	0-1
	Current usage (%)			.64	.21	.15-1.00
	Current global proficiency (out of 5)†			4.66	.58	3-5
	Oral comprehension			4.76	.54	3-5
	Oral production			4.61	.59	3-5
	Writing			4.47	.83	1-5
	Reading			4.63	.71	2-5
	Pronunciation			4.45	.83	2-5
L3/L4 +	***Age of exposure (years)***			14.1	2.38	11.5-19
	Proportion exposure during infancy			<.01	.01	0-.05
	Current proficiency (out of 5)†			0.67	.75	0-2.5
	Current usage (%)			<.01	.02	0-.05

*** Education**: 1=high school; 2=1-2 years post-secondary; 3=3-4 years post-secondary; 4=master's; 5=doctorate.
**** Videogames:** 1=never; 2=once in a while; 3=at least once a week; 4=almost every day; 5=every day.
† Proficiency: 0=very low; 1=low; 2=intermediate; 3=advanced; 4=near-native; 5=native.
+ L3/L4: nine participants reported knowledge of an additional language, and four participants reported knowledge of two additional languages.

In general, participants were highly proficient simultaneous or early bilinguals. Though the majority of bilinguals reported that French was (one of) their native language, most participants currently reported being more dominant in English. This is unsurprising, since French is a minority language in Ontario (the current province of residence for most participants). Research has shown that minority language are more difficult to upkeep, and often hinge on usage at home (e.g., Gathercole & Thomas, 2009).

As language background characteristics are highly interrelated, I opted to compute a latent variable representing degree of balance (in line with Gosselin & Sabourin, 2023b, 2024) for future analyses. This variable considers i) self-reported L1(s); ii) age of exposure; iii) current proficiency; and iv) current usage. In the case of a characteristic skewing towards French (i.e., self-reported L1 of French, lower age of exposure in French, higher current proficiency in French, more current usage of French) a value of +1 was added to the balance variable. In the case of a characteristic skewing towards English (i.e., self-reported L1 of English, lower age of exposure in English, higher current proficiency in English, more current usage of English) a value of -1 was subtracted from the balance variable. Finally, in the case of equivalent characteristics (i.e., both French and English are reported as L1s, same age of exposure for English and French, current equivalent proficiency and current usage in both languages), no value was added or subtracted to the balance variable (zero value). As such, the Degree of Balance (DB) variable scales from -4 (most unbalanced towards English) to +4 (most unbalanced towards French). The mean computed DB was 0.16 (*SD*=2.06), and was not significantly different from zero ($t(37)=.47$, $p=.64$) (see **Figure 4.1**). This confirms that the goal of testing generally balanced bilinguals was indeed achieved.

Figure 4. 1. Degree of balance latent variable.



4.1.3 Self-reported code-switching behaviour

The participants completed two questionnaires meant to assess their general code-switching habits. The first was adapted from Byers-Heinlein (2013). The second was a translation of the BSwQ (Rodriguez-Fornells et al., 2012). The BSwQ separates code-switching habits into four code-switching components (with three questions corresponding to each component): switching according to direction (e.g., into English, into French), contextual switching (i.e., code-switching according to an external context) and unintentional switching (i.e., code-switching not governed by an external context). The presumption (see Gosselin & Sabourin, 2023b, 2024) is that contextual switching is a proxy for the dual-language interactional setting, while unintentional code-switching is indicative of a dense code-switching context.

Table 4. 4. Self-reported code-switching habits of the participant sample.

		Mean	*SD*	*Range*
Byers-Heinlein (2013) questionnaire *	***Switching into French***	3.95	2.12	1-7
	Switching into English	4.58	2.05	1-7
	Borrowing French items	3.90	2.15	1-7
	Borrowing English items	5.40	1.81	2-7
	Global switching	4.76	2.32	1-7
BSwQ †	***Switching into French***	2.80	.78	1-4.33
	Switching into English	3.19	.86	1-4.67
	Contextual switching	3.46	.93	1-5
	Unintentional switching	2.58	.95	1-4

*** Self-reports based on a 7-point scale**: 1=not true; 7=very true.
† Self-reports based on a 5-point scale: 1=never; 5=always.

The participants' self-reported code-switching habits are reported in **Table 4.4**. As expected (given the minority language context), the bilinguals were more likely to switch/borrow into English than into French (*t*s>2.49, *p*s<.02). Furthermore, contextual switches were far more habitual than unintentional switches ($t(37)=6.37$, $p<.0001$). This suggests that participants originated from speech communities bolstering dual-language interpretations (for a full discussion, see Gosselin & Sabourin, 2023b, 2024). Nevertheless, diverse code-switching habits are observed in the sample tested.

4.1.4 Language entropy

Finally, participants were asked to rate the proportion in which they used their languages in various social situations. These measures were implemented in order to calculate LANGUAGE ENTROPY. Language entropy is a relatively new measure meant to operationalize language cooperativeness; it represents the predictability that a given language will be used in a given context (Gullifer & Titone, 2020). Language entropy is calculated by using Shannon's entropy formula ($H = -\sum_{i=1}^{n} P_i log_2(P_i)$), where the proportion that a given language is used (P_i) is multiplied by the log of itself, and *n* products (*n* being the number of languages in a given context) are then summed. For example, if an individual reported using 60% French and 40% English at school, $School\ Entropy = (.60 * log_2(.60)) + (.40 * log_2(.40))$, which equals about .97.

But what does language entropy represent exactly? Gullifer and Titone (2020: 285) summarize the measure as follows (emphasis added):

> Language entropy values range from 0 to log n, where n is the number of languages that entropy is computed over (e.g., with two languages, max entropy is 1 [...]). A communicative context that is **completely compartmentalized**, where an individual reports using only one language, **will have an entropy of 0**, signifying **no language diversity and very high predictability of an upcoming language** within this context (i.e., a single-language interactional context). In contrast, a communicative context that is **completely integrated**, where two or more languages are used in perfect balance, **will have maximum entropy**, signifying **high language diversity and very low predictability** of an upcoming language within this context. Language entropy ranges continuously between 0 and the maximum1, allowing for the assessment of language use that falls in between compartmentalized and integrated dual language contexts.

In the current study, entropy was calculated by averaging the entropy in seven contexts: i) at school; ii) at home; iii) with friends; iv) in the media; v) during extracurriculars; vi) in the community; and vii) at work. For "Last2" entropy, participants were asked to indicate the proportion of use for their languages[1] *during the last two years*. For "Lifetime" entropy, participants were asked to report the proportion of languages used in each context over the course of their lifetime. These values are reported in **Table 4.5**.

[1] If usage in an additional language was reported for any given context (e.g., a number of participants reported slight engagement with media in an L3/L4), the proportion of English and French were adjusted to produce a sum of 100%. This was implemented to maintain consistent maximum entropy (when three languages make up the *n*, the maximum entropy can be about 1.5).

Table 4. 5. Language entropy measures for the participant sample.

		Mean	*SD*	*Range*
Last two years	***Last2 Average Entropy***	.60	.18	.17-.90
	At school	.46	.38	0-1
	At home	.72	.28	0-1
	With friends	.78	.22	0-1
	Media consumption	.42	.33	0-.97
	Extracurriculars	.46	.40	0-1
	In the community	.66	.29	0-1
	At work	.66	.33	0-1
Lifetime	***Lifetime Average Entropy***	.69	.13	.31-.89
	At school	.58	.29	0-1
	At home	.75	.28	0-1
	With friends	.84	.18	.29-1
	Media consumption	.60	.24	0-1
	Extracurriculars	.66	.27	0-1
	In the community	.69	.27	0-1
	At work	.71	.30	0-1

4.2 Speech elicitation activities

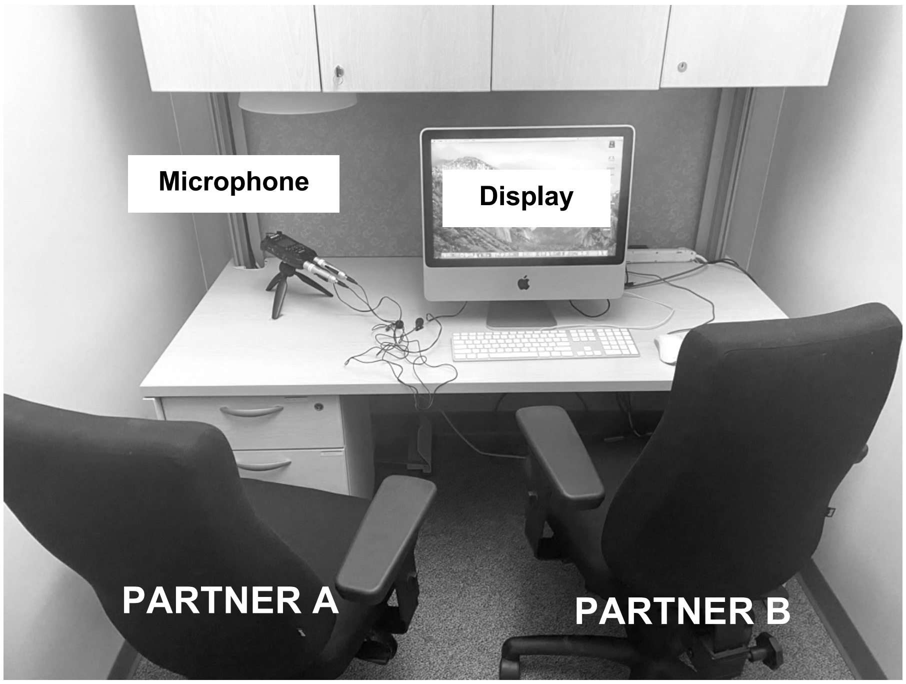
Before beginning the activities (and after completing the pair questionnaire), pair members were randomly given a nametag that identified them as Partner-A or Partner-B. Each pair was then assigned to one of four experimental lists. Participants were brought into a small private room equipped with a desk, two computer chairs, an iMac and a Zoom H4n Pro Handy Recorder (see **Figure 4.2**). Each participant was fitted with an individual Lavalier condenser QL5 microphone (Samson) which was plugged into the stereo channels of the Zoom Recorder. The lapel was clipped to the participants' clothing, approximately 15 centimeters below their mouth. The channels were kept consistent across pairs (i.e, Partner-A was always seated on the left, with the lapel plugged into the first channel of the Zoom Recorder). The participants were asked to read a few lines from a script so that the experimenter could adjust the audio level to a ‘12 o’clock’ recording volume (i.e., a recording volume of approximately 60 dB across participants, regardless of their speaking voice characteristics).

Once the technical equipment was configured, the experimenter handed a folder of physical materials to each participant. They were directed to keep the folders closed until specified in the experimental instructions. The experimental flow was presented on the iMac via Gorilla Experiment Builder interface (www.gorilla.sc, Anwyl-Irvine et al., 2020). All instructions were included in both French and English (see here). Note that no other verbal instructions were given; crucially, participants were never given directions about their language usage. The study was framed in such a way that led participants to believe that it was their puzzle-solving abilities which were of interest.

Once the experimenter started the auditory recording, they exited the private room and closed the door. All pairs of participants completed the speech elicitation tasks in the same order, from the most structured activity (Bilingual Taboo) to the semi-structured activity (Spot-the-difference) to the most spontaneous activity (Free discussion). The experimenter did not give instructions between activities. They only entered the room to answer questions when prompted by the participants (five pairs) or to ask the participants to begin a game timer when this was missed (three additional pairs).

The participants completed the pair questionnaire prior to the speech elicitation activities; the demographic and language background questionnaires (including the code-switching questionnaires) were completed at the end of the session.

Figure 4. 2. Configuration of the testing room for the speech elicitation activities



4.2.1 Bilingual Taboo activity

The first speech elicitation activity was a spin-off of the classic party game, Taboo (*Hasbro Inc.*). During this game, a clue-giver is meant to make his partner or team guess a secret target word within an allotted amount of time. The clue-giver must avoid using the 'taboo words' on the card. The taboo words are directly related to the secret word (e.g., the target *KEY* has the taboo words *door*, *open*, *car*, *house*, *lock*), such that the clue-giver must often censor their speech and explain the secret word in a round-about way. While this type of game has been adopted in past speech elicitation tasks (Meffert et al., 2011), to my knowledge, I am the first to implement a bilingual version of the game.

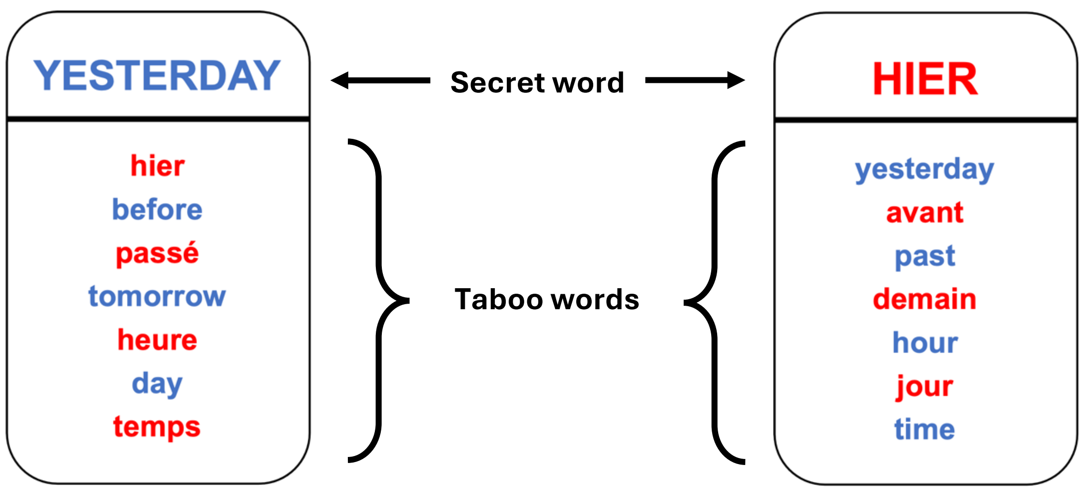
In my version of Bilingual Taboo, the deck of cards contains English and French secret words. The taboo words on each card also alternate between English and French. For instance, for the secret word *YESTERDAY*, the clue-giver must avoid the taboo words *hier*, *before*, *passé*, *tomorrow*, *heure*, *day* and *temps* (see **Figure 4.3**). Crucially, the taboo words are language specific: the clue-giver can use their translations (i.e., *avant*, *past, demain, hour, jour, time*). This means that participants can choose to switch between their languages strategically in order to give the most efficient clues while avoiding taboo words. The different languages were made evident with the use of coloured fonts on the cards (i.e., French words appeared in red font, while English words appeared in blue font).

In total, 160 Bilingual Taboo cards (**APPENDIX A**) were created (80 different secret words, each with French and English versions). Each card included one secret word and seven taboo words. The first taboo word was the direct translation of the secret word. while the next six taboo words (three English, three French) were semantic associates. The frequency of the secret words did not differ significantly between French and English ($F(1,75)=.003$, $p=.96$); the same is true for the taboo words ($F(1,459)=.284$, $p=.59$). The 160 cards were divided into four decks of 40 cards (half with French target words, half with English target words). Each pair of participants has access to one of these decks (pre-determined by counterbalancing lists) during the activity (20 cards for each participant).

During the experiment, the bilingual pairs were instructed to select a card from their (shuffled) deck, and in turn, try to make their partner guess the secret word they selected.

Partner-A started as the clue-giver; once Partner-B successfully guessed the target, the roles reversed (i.e., Partner-B became the clue-giver). Clue-givers were forbidden to use gestures or rhymes, and could pass a card if the pair stayed stuck for too long. The goal of the activity was to obtain as many points as possible during 10 minutes of play. Once this time was elapsed, participants were asked to enter their combined "score". Each card (i.e., secret word) correctly guessed equalled one point; each time a taboo word was used, one point was subtracted from their score.

Figure 4. 3. Example of Taboo cards for the secret word YESTERDAY / HIER.



4.2.2. Spot-the-difference (Diapix) activity

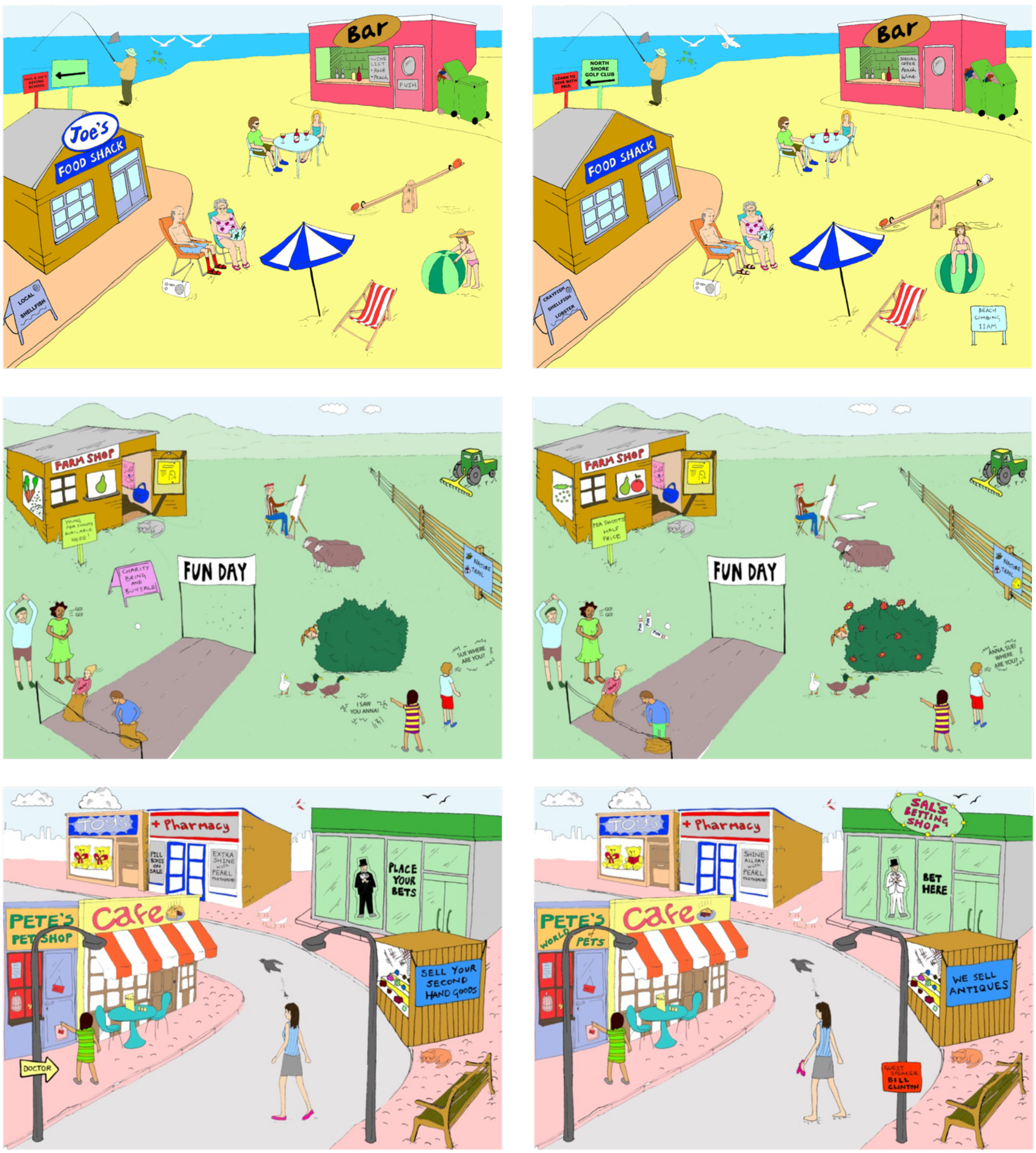
The Diapix paradigm (Baker & Hazan, 2011; Van Engen et al., 2010) is essentially a verbal ‘spot-the-difference’ game. During this game, participants were given images depicting colourful scenes. Crucially, Partner-A and Partner-B were given slightly different versions of each image. They were instructed to find the subtle differences between the versions of their images without looking at each other's materials. That is, rather than completing a visual search (as in the classic "spot-the-difference" game), the pairs were asked to identify the differences via collaborative communication.

The images used for this activity are publicly available (DiapixUK images, see Baker & Hazan, 2011). The Diapix materials consist of pairs of cartoon-like scenes depicting one of three settings: the beach, the farm, or the street. There are twelve differences between the two versions of each image (approximately three differences in each quadrant). The differences range from more obvious (e.g., a differing text on a sign) to more subtle (e.g., an action in various stages of movement).

For the current study, 12 sets of Diapix images (three from each setting; see **Figure 4.4**) were printed and laminated, and organized into four lists. Each list contained a beach scene, a farm scene, and a street scene (in counterbalanced order). Thus, according to their assigned experimental list, the pairs of participants completed the spot-the-difference activity for three sets of images. They had a period of five minutes to identify all twelve differences, and could mark differences with a dry-erase marker as they went along. After the timer elapsed, a solution was displayed on the computer monitor. Participants could check their answers and enter their "score" (i.e., how many differences they successfully identified). This procedure was repeated for the three sets of images, totalling 15 minutes of play.

Figure 4. 4. Example of Diapix images (one each from the beach, farm, and street).

Partner-A (version 1) | Partner-B (version 2)



4.2.3 Free discussion activity

The free discussion task was used to obtain the most spontaneous form of speech from the bilinguals. During this activity, the participants were simply asked to hold conversations about different discussion prompts.

Twelve (bilingual) prompts (i.e., open-ended declarations) were created (see **Table 4.6**). These centralized one of four broad themes: past narrative experiences, individualistic qualities, family affairs, and future life. These twelve prompts were organized into four lists. Thus, according to their assigned experimental list, the pairs of participants discussed three prompts (each differing in their broad theme).

After each discussion prompt was presented (alongside an attention-grabbing image), the pairs were given one minute to individually jot down their ideas on a sheet of paper (**APPENDIX B**). The instructions stated that the participants could use this time to brainstorm their thoughts, but did not need to explicitly refer back to their notes. This procedure was implemented to encourage a fluid and productive conversation once the discussion began[2]. Note that there were no time constraints for the discussion. The pairs could make their discussions as brief or as long as was desired; they simply continued the next prompt when they felt that they were finished with their conversation.

Once three discussion prompts were concluded, the instructions informed the participants that the speech elicitation activities were now over, and that they could alert

[2] The one-minute brainstorm period was added to experimental flow after the first pair was tested. The brevity and disfluencies in the discussions of the pilot pair were noticeable (about four minutes of conversation for all three prompts). The brainstorm period appeared to considerably improve the conversational flow of all subsequent pairs (*M*=21 minutes for the three prompts).

the experimenter. The experimenter entered the private room, stopped the recording, and removed the participants' lapel microphones. The subsequent part of the experiment, notably a Flanker task, is described in CHAPTER 6).

Table 4. 6. Discussion prompts used for the free discussion activity.

Theme	Item	Prompt in English	Prompt in French
past	1	*Travelling is fun, but it can also be very stressful.*	*C'est amusant de voyager, mais cela peut aussi être très stressant.*
	2	*Collaborating with colleagues or classmates is not always easy.*	*Ce n'est pas toujours facile de collaborer avec des collègues ou des camarades de classe.*
	3	*Conflict at work can be difficult to deal with.*	*Les conflits au travail peuvent être difficiles à gérer.*
quality	4	*Some people are mainly led by their hearts, while others are mostly led by their brains.*	*Certaines personnes sont principalement menées par leur cœur; d'autres sont surtout menées par leur tête.*
	5	*Competition can be healthy.*	*La compétition peut être saine.*
	6	*Some people are extraverted, others are introverted, and many are somewhere in the middle.*	*Certaines personnes sont extraverties, d'autres sont introverties et beaucoup se situent quelque part entre les deux.*
family	7	*Different generations have different values.*	*Les personnes de générations différentes ont des valeurs différentes.*
	8	*Domestic chores should be shared.*	*Les tâches ménagères devraient être partagées.*
	9	*Siblings are often very similar to one another.*	*Frère(s) et sœur(s) sont souvent très similaires les uns aux autres.*
future	10	*It can take many years to achieve a life goal.*	*Ça peut prendre de nombreuses années pour atteindre un objectif de vie.*
	11	*Half of lottery winners say they are happier after their big win.*	*La moitié des gagnants de la loterie se disent plus heureux après leur gros gain.*
	12	*In the next 25 years, the world will undergo significant changes.*	*Au cours des 25 prochaines années, le monde connaîtra des changements importants.*

4.2.4 Incomplete disclosure for the purpose of naturalistic production

It has long been established that participants may alter their speech in laboratory settings when they know they are being recorded, if they are interacting with an experimenter (a stranger), or if they infer the purpose of the study (see Eisenbeiss, 2010). As such, the current study involved a certain degree of incomplete disclosure or slight deception.

Recruitment scripts and advertisements implied that the goal of the study was to investigate bilinguals' puzzle-solving abilities. At the time of testing, language usage was not broached. The experimenter followed the participants' lead in regard to interactions in the laboratory: when pair members spoke French to each other, the experimenter also spoke French; when pair members code-switched, the experimenter code-switched with them. Though the participants knew they were being recorded, they were lead to believe that the researcher was interested in their *performance* on the speech elicitation activities (not the language used to achieve that performance). They were given absolutely no specification about language usage during the study and all instructions were provided in both languages.

This type of incomplete disclosure was implemented to encourage naturalistic speech production. If the bilinguals knew that their language usage was being studied, they may have underused stigmatized variants, like code-switching. If they knew that code-switching was the phenomenon of interest for the researcher, they could have overused such variants (including unnatural instances). However, when participants are focused on their performance, they are less likely to monitor their speech, and the recorded language thus more closely approximates the vernacular. In other words, this ensures that code-switchers code-switch, and non-code-switchers don't.

Once the experiment was complete (i.e., after language background questionnaires were administered, etc.), participants were debriefed on the veritable objectives of the study. The English version of the debriefing script is included below:

> *Before you both completed the tasks, I told you that I was interested in investigating the ways in which bilingual individuals solve problems. While this premise is true, I am specifically interested in the ways that bilinguals' language habits affect their cognition. There is a controversy in psycholinguistics and cognitive sciences that states that bilinguals have advantages when it comes to their executive functioning (i.e., the 'human' functions governed by the pre-frontal lobes, like maintaining attention, avoiding distractions and delaying gratification). The topic is controversial since researchers are not sure what it is about bilingualism that brings about cognitive advantages.*
>
> *You might have noticed that the language background questionnaires asked many questions about how often you use English vs. French, and how often you mix both of these languages when you speak. This is because I believe that code-switching is what might train bilinguals' executive functions. Think about it: when you switch between your languages, you have to inhibit one language and activate the other, and this certainly requires the executive functioning system. As such, you were being recorded during the paired tasks because I am going to compute how often you code-switched while you were discussing with your friend/family member/partner. I will see if my participants' code-switching frequency is in anyway related to their performance on the non-verbal task with the arrows (a task that is known to require the executive functioning system).*
>
> *One problem with the research on code-switching is that researchers almost never use utterances produced naturalistically or 'in the wild' as their stimuli/materials. So, the experiment you've just participated in is a precursor study for the next experiment in my dissertation. For my next experiment, I will be asking bilinguals to listen to some of your naturalistic utterances to see how their brains react. Are they more difficult to process than single-language utterances? Please know that any identifying information will be removed from these utterances and their transcriptions, and that they will only be associated to your anonymized participant number. Now that you have completed all the task and produced the speech, is this something you are okay with? Is there are sensitive bits of speech that you can think of that you'd like me to remove or not use for the next study?*

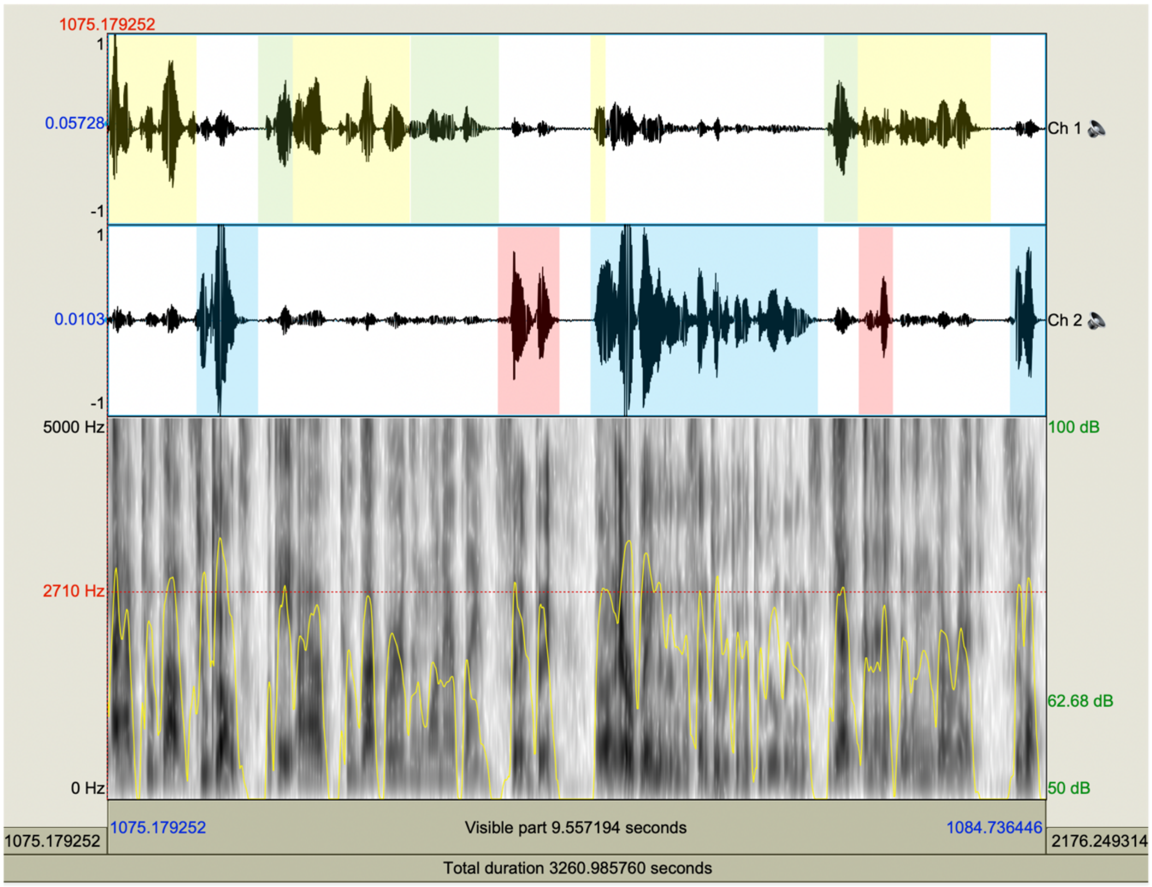
Note that, as part of the debriefing procedure, participants were given the opportunity to omit any parts of their recording they'd produced. One pair of participants asked for curse words to be removed from their transcript. All other participants consented for their recordings to be transcribed used in full (minus identifying information) in the succeeding studies (see CHAPTERS 6, 7).

4.3 Transcription

On average, the full recording for each pair was 56 minutes in length (*SD*=10 minutes, *range* = 44 to 87 minutes). Each of these recordings was imported into Praat, where both channels could be played back together, or independently (see **Figure 4.5**). The recordings were then manually transcribed in a text processor, using the CHAT protocol (MacWhinney, 2014). The CHAT (Codes for the Human Analysis of Transcripts) transcription format is the standard in corpus banks, such as TalkBank and CHILDES. It was created with three goals in mind: clarity, readability, and ease of data entry (MacWhinney, 2014). Importantly, characters and symbols are systematically and uniquely used to convey definable linguistic and paralinguistic events. The most commonly used CHAT notations used in FEBLOC are described and exemplified in **Table 4.7**.

Transcription took place as follows: utterances were transcribed in the text processor line-by-line by listening to the recording and observing the waveforms in Praat. When needed, individual microphone channels were isolated to better hear overlapping speech. Each utterance is transcribed on an independent line, even if the same speaker produced several consecutive utterances. Utterances are essentially delimited by intonational patterns (i.e. rising/falling intonation), and do not necessarily represent a speaker's entire turn. They could also be regarded as a 'conversational units', that is, "main clause[s] [...] [that] may be incomplete and may include disfluencies, retraces, etc. which would not be

Figure 4. 5. 10-second segment from the FEBLO-Corpus (pair04, 1075 seconds), as it is viewed in Praat during the transcription process. Individual utterances are highlighted. Utterances produced by Member-A (top waveform, *FIR) alternate between yellow and green. Utterances produced by Member-B (bottom waveform, *SEC) alternate between blue and red.




```
*FIR:     [- eng] I have two clouds .
*SEC:     [- eng] two clouds .
*FIR:     okay@s:eng&fra .
*FIR:     [- eng] I have (.) two black birds .
*FIR:     [- eng] and one airplane .
*SEC:     [- eng] same thing .
*FIR:     okay@s:eng&fra .
*SEC:     +< [- eng] &-uh airplane is in the center
          between the two buildings .
*FIR:     [- eng] yes .
*SEC:     okay@s:eng&fra .
*FIR:     +< [- eng] and then the wings are red .
*SEC:     [- fra] cé [: c'est] bon .
```

Table 4. 7. 'Cheat sheet' of most frequent CHAT notations used in FEBLOC. All examples taken from pair04.

NOTAT.	ACTION	EXAMPLE
Transcription uncertainty:		
[?]	Best guess: residual uncertainty about the transcription	***SEC:** [- fra] cé [: c'est] correct [?].
xxx	Unintelligible	***FIR:** +< xxx.
www	Not transcribable	***FIR:** [- fra] ça dit www [=! whispers].
Disfluencies:		
[*]	Error	***FIR:** +< [- fra] sandales bruns [*].
[/]	Repetition of a portion of speech	***SEC:** [- eng] yeah it's [/] it's scary.
[//]	Retracing: a speaker repeats a basic idea but with a specific correction	***SEC:** [- fra] un [//] une belle surprise.
[///]	Reformulation (without any specific correction)	***SEC:** +< [- fra] &-uh les [///] y'a [: il y a] deux portes à droite?
&-	Filled pauses (um, mm, uh, hm...)	***FIR:** +< [- fra] &-uh une sécurité .
(.)/(..)/(...)	Silent pause: short, moderate or long	***SEC:** [- eng] during my (..) sleep .
&+	Phonological fragment	***SEC:** [- eng] &-uh &+f strawberry .
Other in-text notations		
[: *text*]	Replacement: for contractions, assimilations	***SEC:** [- fra] s'pas [: c'est pas] mal la même couleur .
[:: *text*]	Lexical replacement (can be tagged as errors by using [*])	***SEC:** [- fra] consoler [:: consommer] [*] [//] consommer d'la [: de la] drogue .
()	Incomplete form / shortening	***SEC:** [- fra] pa(r)ce que .
:	Lengthened syllable	***FIR:** [- fra] et est-ce que tu voi:s +/.
Specialized utterance start / end :		
+,	Self-completion: a speaker is interrupted then continues the utterance	***FIR:** [- fra] moi j't'ai [: je t'ai] demandé précisément +. ***SEC:** +< [- fra] ah@s:eng&fra oui ? ***FIR:** +, [- fra] si t'avais un animal sur la roche.
+<	Lazy overlap: a speaker starts before the other completes their utterance.	
+.	To indicate that an uncompleted, utterance is continued on next line.	
+...	Trailing off: incomplete but not interrupted utterance	***SEC:** [- eng] don't [/] don't [/] don't wake the +...
+..?	Trailing off with question	***FIR:** [- fra] oui mais +..?
+!?	Question with exclamation	***FIR:** [- fra] vide +!?
+/.	Interruption marker (unwanted interruption)	***SEC:** [- eng] someone who +/. ***FIR:** +< [- eng] a wrench?
+//.	Self-interruption	***SEC:** [- eng] I guess it could be (..) a French or an English +//. ***SEC:** [- eng] ah@s:eng&fra it's in red .
Paralinguistic material:		
&=	Simple events (cries, laughs, coughs, sighs, groan, mumble, whisper, sneeze, yawn...)	***SEC:** [- fra] j'pense [: je pense] qu'on a: [/] on a bien fait . ***FIR:** +< [- eng] &=claps <next prompt> [=! singing:voice] .
<> [=! *text*]	Paralinguistic material	
+"	Direct quotation	***SEC:** +< [- fra] moi cé [: c'est] t'écris [: écris] +. ***SEC:** +" [- eng] bet here .

present in written language" (MacWhinney, 2024: 61). Productions from Member-A of each pair are identified as `*FIR` (first speaker); productions from member-B are identified as `*SEC` (second speaker). In cases where the experimenter (the present author) produced recorded speech, these are identified as `*INV` (investigator) and the pseudonym 'Beth' is invariably used.

Speech is transcribed according to pronunciation, not standard grammar. For instance, "chépas" is transcribed instead of "je ne sais pas" and "I dunno" is transcribed instead of "I don't/do not know". As per CHAT guidelines, the standard form is then indicated in brackets (e.g., `*FIR: [- fra] chépas [: je sais pas]`). Non-standard spellings are kept consistent throughout the corpus. A list of frequently recurring non-standard expressions in French are listed in **APPENDIX C**. Phonetic, morphological and transcription tiers have not been implemented in the corpus at this point.

The language of each utterance is indicated directly in the transcription, as per CHAT conventions. When an utterance is entirely in French, it is preceded by the `[- fra]` language marker. When an utterance is entirely in English, it is preceded by the `[- eng]` language marker. If an utterance contains both French and English words, words are individually language-tagged by using `@s:fra` or `@s:eng`. Words that cannot be attributed a language (both in unilingual and bilingual utterances); are given the 'undetermined' tag (`@s:eng&fra`) these include locutions such as "mm-hm", "mm", "oh", "ah", "eh", "awh", "ugh", "oops", "ouch", and "okay". Proper names and bilingual expressions (e.g., "shit", "fuck") are also given undetermined tags. If participants read the instructions verbatim, this was transcribed as `&=reads:instructions` (with the appropriate language marker).

A time-stamp is given at the beginning and end of each new activity by using a commenting tier (e.g., `%com: timer for image 1 (item: 11, street1A/B) of spot-the-difference begins at 1071 seconds (19:31 minutes)`). After each activity was transcribed (i.e., the taboo task, a single Diapix image, or a single discussion prompt), the relevant portion of the recording was played back in full (alongside the text processor transcription), and revisions were made as needed.

Note that *all* utterances were transcribed, including utterances which occurred while participants were going through task instructions, or while they were note-taking for the free discussion task. This was implemented as I noticed that even these interactions, though not specifically occurring during speech elicitation activities, provided additional spontaneous data points. For instance, the conversations in (1)-(3), though occurring outside of the "timed" activity windows, clearly show differences in code-switching proportions (habitual code-switching in 1-3a, and single-language usage in 1-3b).

(1) **BILINGUAL TABOO ACTIVITY**:

a) **Pair10 (Danielle and Jérémie), 174 seconds:**

```
*SEC:  [- eng] oh@s:eng&fra wait .
*SEC:  [- fra] on peut juste les mettre (.) dans des piles .
*SEC:  [- eng] so .
*FIR:  [- fra] on va pas les mélanger .
*FIR:  what@s:eng if@s:eng les@s:fra mots@s:fra cé@s:fra [: c'est] &-uh
       &-uh [=! mumbles] .
*SEC:  [- fra] non on fait (.) une [///] si [/] si je l'ai .
*SEC:  [- fra] tu mets dans une pile .
*SEC:  like@s:eng tu@s:fra l(e)@s:fra mets@s:fra face@s:eng up@s:eng .
*FIR:  +< okay@s:eng&fra .
*SEC:  si@s:fra  je@s:fra  l'ai@s:fra  pas@s:fra  tu@s:fra  l(e)@s:fra
       mets@s:fra face@s:eng down@s:eng .
*FIR:  okay@s:eng&fra .
*SEC:  [- eng] I'll do same [/] same for you .
*SEC:  (o)kay@s:eng&fra ?
*FIR:  okay@s:eng&fra .
```

b) **Pair19 (Noah and Bertrand), 70 seconds:**

```
*SEC:  [- eng] okay@s:eng&fra so I can't say them in English or French.
*SEC:  [- eng] the [/] the taboo words .
*FIR:  [- eng] well I guess the [/] the [/] the word that you're tryna
       [: trying to] get me to guess .
*FIR:  [- eng] is gonna [: going to] be either in French .
*FIR:  [- eng] or in English .
*SEC:  okay@s:eng&fra .
*FIR:  [- eng] yeah .
*FIR:  [- eng] and then you &+k have to avoid those language specific
       words .
*FIR:  [- eng] yeah .
*FIR:  [- eng] it's another example .
*FIR:  [- eng] yeah .
```

(2) **SPOT-THE-DIFFERENCE ACTIVITY**:

a) **Pair16 (Léona and Brian), 2548 seconds:**

```
*SEC:  [- eng] we got (th)em all !
*SEC:  [- fra] ouais [: oui] .
*SEC:  [- fra] on a les mêmes là .
*FIR:  [- eng] yeah !
*SEC:  on@s:fra a@s:fra la@s:fra sheep@s:eng .
*SEC:  on@s:fra a@s:fra le@s:fra chainsaw@s:eng .
*SEC:   [- fra] on a l'arb(re) .
*SEC:  on@s:fra a@s:fra le@s:fra beekeeper@s:eng .
*SEC:  [- fra] on a ça .
*SEC:  on@s:fra   a@s:fra   la@s:fra   si(gn)@s:eng   [//]   la@s:fra
       pancarte@s:fra .
*SEC:  [- fra] on a ça .
*SEC:  on@s:fra a@s:fra les@s:fra bowling@s:eng pins@s:eng .
*SEC:  [- fra] on a les pois .
*SEC:  [- fra] oui .
```

b) **Pair01 (Manon and Calvin), 1735 seconds:**

```
*FIR:  [- fra] qu'est-ce qui manque [=! mumbles] ?
*FIR:  [- fra] à part [=! mumbles] ?
*FIR:  [- fra] parce que j'en compte juste dix [=! mumbles] .
*SEC:  [- fra] bin [: bien] y'en [: il y en] a deux .
*SEC:  [- fra] un deux trois [=! mumbles] .
*SEC:  ahh@s:eng&fra .
*SEC:  [- fra] l' [/] l'homme le marié ?
*FIR:  ah@s:eng&fra .
*SEC:  +< [- fra] porte un: [///] yé [: il est] +.
*FIR:  +< [- fra] ah@s:eng&fra cé [: c'est] ça l'aut(re) .
*SEC:  +, [- fra] en vert .
*SEC:  [- fra] au lieu d'noir [: de noir] .
```

(3) FREE DISCUSSION ACTIVITY:

a) **Pair07 (Sébastien and Kathleen), 2130 seconds:**

```
*SEC:  one@s:eng minute@s:eng en@s:fra silence@s:fra !
*FIR:  ah@s:eng&fra [=! mumbles] .
*SEC:  &=yawns .
*SEC:  [- fra] ah@s:eng&fra tu veux tu la feuille pour écrire ?
*SEC:  [- eng] don't waste a paper if you don't have any good thoughts
       .
*SEC:  [- eng] I'm joking [=! laughing] !
*FIR:  +< [- eng] I don't have any good thoughts [=! mumbles] .
*FIR:  [- fra] sérieux là [=! mumbles] .
*SEC:  +< [- eng] well then don't waste it .
*FIR:  [- fra] &=reads:prompt +/.
*FIR:  [- fra] non des fois les collègues y [: ils] font chier .
*SEC:  +< shh@s:eng&fra !
*FIR:  +< &=laughs .
*FIR:  &-uh [=! mumbles] .
*FIR:  &-uh [=! mumbles] .
*FIR:  [- fra] &-uh j'ai rien n'a [: a] dire [=! mumbles].
*SEC:  [- eng] you still have twen(t)y seconds to think about it [=!
       mumbles] .
```

b) **Pair15 (Hazel and Naomi), 2080 seconds:**

```
*FIR:  okay@s:eng&fra [=! laughing] .
*FIR:   [- eng] this is gonna [: going to] be so random [=! laughing] .
*SEC:  +< [- eng] what are you writing [=! laughing] ?
*FIR:  [- eng] what's that ?
*SEC:  [- eng] what are you [=! laughing] +//.
*SEC:  &=laughs .
*FIR:  +< &=laughs .
*FIR:  [- eng] it's (be)cause this could go so many different ways [=!
       laughing] !
*FIR:  [- eng] let's say we go on a tangent [=! laughing] !
*FIR:  [- eng] ahh@s:eng&fra god !
*FIR:  [- eng] I'm so sorry in advance .
*FIR:  [- eng] you're gonna [: going to] hear (a)bout this .
*SEC:  [- eng] I have a lot to say too don't worry [=! mumbles] .
*FIR:  +< [- eng] I have a lot to say !
*FIR:  okay@s:eng&fra .
```

For all nineteen pairs, the first-pass transcription process lasted approximately two years. Given this extensive period of time, a second-pass transcription was implemented at the end of the process to ensure consistency in the corpus. Each pair recording was reviewed twice in full: recordings were once again listened to in tandem with the text transcription and revisions were made throughout the review process. Revisions were particularly substantial for the earliest transcriptions (pair0.1 to pair07).

It is estimated that one minute of 'multiparty' speech can take an hour or more to transcribe (Ehlich, 1993: 140). As FEBLOC is composed of over 1000 minutes of speech, this results in approximately 1000 hours of work for a first-pass transcription. The second-pass (i.e., the revision procedure) is estimated to have taken about ten additional hours per pair (190 hours total). As such, FEBLOC represents approximately 1200 hours of work over a two year span of time.

4.3.1 Transcribing borrowings

Recall (*Section 2*.2) that linguists do not agree on whether 'borrowing' falls under the same umbrella as code-switching, or whether it is an independent phenomenon requiring distinct cognitive-linguistic processes. Some (e.g., Poplack et al., 1988) distinguish 'established borrowings' (single donor words recurrently inserted into a recipient language by a given speech community) and 'nonce-borrowings' (idiosyncratic single donor words inserted into a recipient language by a given speaker); others (e.g., Johns & Dussias, 2022) ascertain that nonce-borrowings are simply instances of single-word code-switches (i.e., they do not differ from code-switching in general).

Furthermore, experts dispute the ways in which 'borrowings' can be identified in the first place. While morphological and phonological integration was originally taken to be a hallmark for borrowing (Poplack, 1980), phonological integration is now disputed (Poplack, 2017; Poplack et al., 2020). Nevertheless, evidence suggests that morphological integration is usually accompanied by phonological integration (e.g., Besset, 2017; Gosselin & Manning, 2022; Stefanich & Amaro, 2018). This is important given that morphological integration may not always be overt (e.g., in the case of null morphemes).

In order to avoid the contentious borrowing/code-switching debate, words containing morphological integration (e.g., French words) and/or words with obvious phonological integration (e.g., an English-origin word pronounced French-like) were considered borrowings and thus tagged with `@s:eng+fra` (English donor item integrated into French) or `@s:fra+eng` (French donor item integrated into English) in the transcription. This was done whether or not the 'borrowing' appeared idiosyncratically or repeatedly throughout the corpus. Single-word switches without morphological and/or phonological integration were simply tagged for language (`@s:eng` or `@s:fra`). Examples of these borrowings are provided in (4).

(4) **Examples of borrowings in FEBLOC**:

a. `*SEC: pis@s:fra [: puis] là@s:fra tu@s:fra vas@s:fra être@s:fra porté@s:fra à@s:fra giver_up@s:eng+fra.` [pair11, 2522 secs]
b. `*SEC: +< faut@s:fra juste@s:fra k'tu@s:fra [: que tu] sois@s:fra smart@s:eng+fra.` [pair04, 3186 secs]
c. `*FIR: [...] su(r)@s:fra l(e)@s:fra top@s:eng+fra?` [pair06, 2142 secs]
d. `*FIR: tu@s:fra vas@s:fra toute@s:fra scrapper@s:eng+fra son@s:fra étude@s:fra là@s:fra.` [pair07, 1652 secs]
e. `*FIR: avec@s:fra une@s:fra strip@s:eng+fra blanche@s:fra en@s:fra haut@s:fra?` [pair11, 1899 secs]

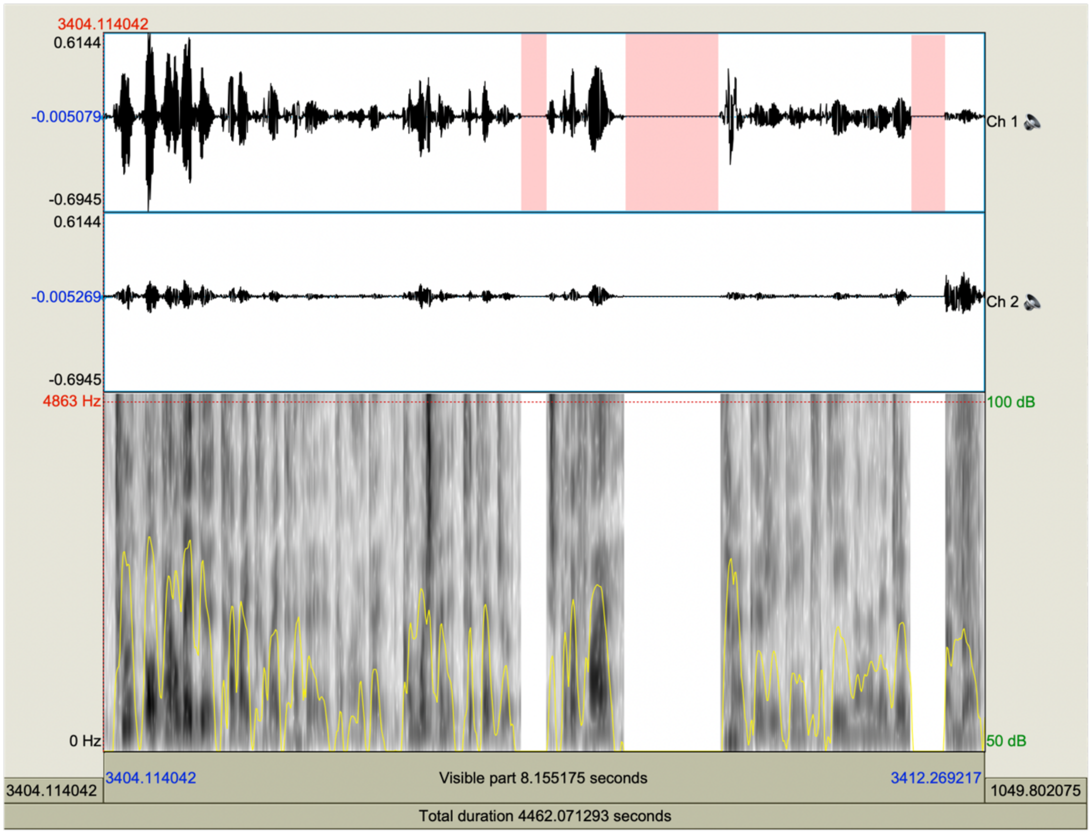
4.3.2 Anonymizing the transcriptions

Speakers were told that names and identifying information would be omitted from the transcriptions before speech elicitation activities were commenced. During the transcription process, all first and/or last names produced by the speakers (i.e., 'third parties') were attributed pseudonyms in the transcription text. An effort was made to match the pseudonym with the 'flavour' of the original name (e.g., a francophone name was attributed a francophone pseudonym). The spectrogram representing the produced names was muted (i.e., 'set to zero') directly in the recorded audio files.

Beyond names, some passages were removed from the transcription if they were deemed to contain identifying information. In such cases, the passage was transcribed as `www` in the text ('not transcribable', as per CHAT guidelines), and muted in the recording. Nevertheless, the language of production of these passages was still indicated by using a language marker (`[- fra]` or `[- eng]`) or, in the case of a bilingual utterance, a language tag (`@s:fra` or `@s:eng`). An example of a passage containing anonymous information (pair16, 3403 seconds) is illustrated in **Figure 4.6**.

The types of information listed in (5) were deemed to be identifying. More general information, such as international or large-city travel destinations (e.g., "Florida", "Cuba", "Paris"), hobbies (e.g., "learning Japanese"), sibling placement (e.g., "oldest", "the baby"), and political opinions (e.g., "leftists") were judged as non-identifying and thus retained in the recordings and transcription.

Figure 4. 6. Passage from the FEBLO-Corpus (pair16, 3403 seconds), containing anonymized excerpts. Muted segments are highlighted in red in the waveform.




```
*FIR:    [- fra] tout [///] on parlait de    travail travail
         travail <travail  travail> [=! mumbles] .
*FIR:    comme@s:fra moé@s:fra [: moi] j'connais@s:fra [: je
         connais] toute@s:fra la@s:fra job@s:eng+fra à@s:fra
         Amos@s:eng&fra .
*FIR:    ch'pourrais@s:fra [: je pourrais] faire@s:fra www@:eng.
*FIR:    tant@s:fra que@s:fra j'ai@s:fra été@s:fra
         impliquée@s:fra dans@s:fra la@s:fra job@s:eng+fra
         à@s:fra Amos@s:eng&fra .
```

In order to maintain dignity and respect for all speakers included in the corpus, a 'courtesy pass' was implemented as an additional step. During this pass, other types of potentially problematic passages were transcribed as `www` and muted in the recordings. These include passages containing discriminatory jokes or sexual innuendos, passages discussing potential criminal activity (e.g., drug use), and discussions of money (speaker salary, budget, expense costs).

(5) **Types of identifying information**:

a. A specific place of birth, residence (current or past) or local vacation for the speaker or a third party (or information allowing to deduce these places);
b. A passage identifying a speaker or third party's month or day of birth
c. A specific job/career title, place of work or other related information (speaker or third party);
d. A specific program, class title, school/university name, or other related information (taken/attended by the speaker or a third party);
e. Specific makes of cars (owned by a speaker or a third party);
f. A passage identifying specific physical traits of the speaker

4.4 Coding

Once transcription was complete, the utterances were imported into an Excel template (one file per pair). Rows containing comment tiers were removed. Each utterance was attributed an utterance number, and was associated to a given speech elicitation activity. Utterances from the onset of the recording until the presentation of spot-the-difference instructions were coded as "1-taboo". Utterances from the onset of the spot-the-difference instructions until the presentation of free discussion instructions were coded as "2-diapix". Finally, utterances from the onset of the free discussion instructions until the offset of the recording were coded as "3-discussion". Note that this includes interactions outside of timed activity windows (see *Section 4.3*).

The Excel template[3] contained an automatic column identifying utterance speaker (`*FIR`, `*SEC` or `*INV`), and a column identifying the language of the utterance. The language of the utterance was coded semi-automatically. In the case of unilingual utterances, a formula was used to call upon the language marker from the transcription (`[- fra]` or `[- eng]`). In the case of bilingual utterances (code-switches, borrowings), or undetermined utterances (e.g., "Okay"), coding was applied manually, as follows:

(6) **By-language utterance coding**:

a. **ENG**: the entire utterance has been marked as `[- eng]`
b. **FRE**: the entire utterance has been marked as `[- fra]`
c. **CS**: the utterance has no overall language marker but contains both individual words tagged as `@s:fra` and `@s:eng`
d. **N/A**: the utterance can't be attributed to a specific language. This is the case for words like "um", "okay" (i.e., tagged as `@s:eng&fra`), non-verbal events such as laughing, or utterances that contain unintelligible passages ('`xxx`').
e. **BOR**: the utterance contains a word tagged with `@s:eng+fra` (ENG word with FRE phonology/morphology) or `@s:fra+eng` (FRE word with ENG phonology/morphology)

Once this baseline coding was complete, condition coding was realized. The utterances (i.e., rows) were thus sorted according to two criteria: time, and speaker. This allows for time-linear coding and speaker-grouped coding.

[3] The Excel template can be found at https://osf.io/3davs. A description of the coding procedure can be found at https://osf.io/e8h23.

4.4.1 Time-linear coding

Time-linear coding preserves the order of the utterances as they were produced by the speakers (i.e., sorted by utterance number). The condition of each target utterance is based on the utterance immediately preceding in time (*n-1*). Within-speaker conditions reflect consecutive utterances produced by the same speaker (A-to-A or B-to-B). Between-speaker conditions reflect consecutive utterances produced by opposite speakers (A-to-B or B-to-A). Possible conditions include: i) unilingual within-speaker French utterances; ii) unilingual within-speaker English utterances; iii) unilingual between-speaker French utterances; iv) unilingual between-speaker English utterances; v) intra-utterance (within-speaker) switches; vi) inter-utterance within-speaker switches; vii) inter-utterances between-speaker switches; viii) utterances with borrowings.

The criteria for each condition are listed in (7) and examples are given in **Table 4.8**. A comprehensive coding flow chart is also illustrated in **Figure 4.7**. Note that Conditions could be automatically computed by using Excel formulas referring to the "speaker" column (`*FIR`, `*SEC` or `*INV`) and the "language" column (`ENG`, `FRE`, `CS`, `N/A`, or `BOR`) described in the previous section.

(7) **LINEAR CONDITION CODING CRITERIA**:

a. **Unilingual within-speaker French (uni-FR)**:

i. <u>Member-A</u>: a `FRE` utterance produced by `*FIR` immediately follows another `FRE` utterance produced by `*FIR`;

ii. <u>Member-B</u>: a `FRE` utterance produced by `*SEC` immediately follows another `FRE` utterance produced by `*SEC`.

b. **Unilingual within-speaker English (uni-EN)**:
    i. Member-A: an `ENG` utterance produced by `*FIR` immediately follows another `ENG` utterance produced by `*FIR`;
    ii. Member-B: an `ENG` utterance produced by `*SEC` immediately follows another `ENG` utterance produced by `*SEC`.

c. **Unilingual between-speaker French (uni-FR)**:
    i. Member-A: an `FRE` utterance produced by `*FIR` immediately follows an `FRE` utterance produced by `*SEC`;
    ii. Member-B: an `FRE` utterance produced by `*SEC` immediately follows another `FRE` utterance produced by `*FIR`.

d. **Unilingual between-speaker English (uni-EN)**:
    i. Member-A: an `ENG` utterance produced by `*FIR` immediately follows an `ENG` utterance produced by `*SEC`;
    ii. Member-B: an `ENG` utterance produced by `*SEC` immediately follows another `ENG` utterance produced by `*FIR`.

e. **Intra-utterance code-switches (intra-CS)**:
    i. Member-A: a `CS` utterance produced by `*FIR`;
    ii. Member-B: a `CS` utterance produced by `*SEC`.

f. Inter-utterance within-speaker switches (inter-CS):
    i. Member-A: a `FRE` utterance produced by `*FIR` immediately follows an `ENG` utterance also produced by `*FIR`; or an `ENG` utterance produced by `*FIR` immediately follows a `FRE` utterance also produced by `*FIR`;
    ii. Member-B: a `FRE` utterance produced by `*SEC` immediately follows an `ENG` utterance also produced by `*SEC`; or an `ENG` utterance produced by `*SEC` immediately follows a `FRE` utterance also produced by `*SEC`.

g. **Inter-utterance between-speaker switches (between-CS)**:
    i. Member-A: a `FRE` utterance produced by `*FIR` immediately follows an `ENG` utterance produced by `*SEC`; or an `ENG` utterance produced by `*FIR` immediately follows a `FRE` utterance produced by `*SEC`;
    ii. Member-B: a `FRE` utterance produced by `*SEC` immediately follows an `ENG` utterance produced by `*FIR`; or an `ENG` utterance produced by `*SEC` immediately follows a `FRE` utterance produced by `*FIR`.

h. **Borrowings**:
    i. Member-A: a `BOR` utterance produced by `*FIR`;
    ii. Member-B: a `BOR` utterance produced by `*SEC`.

Figure 4. 7. Flow chart illustrating by-utterance condition coding.

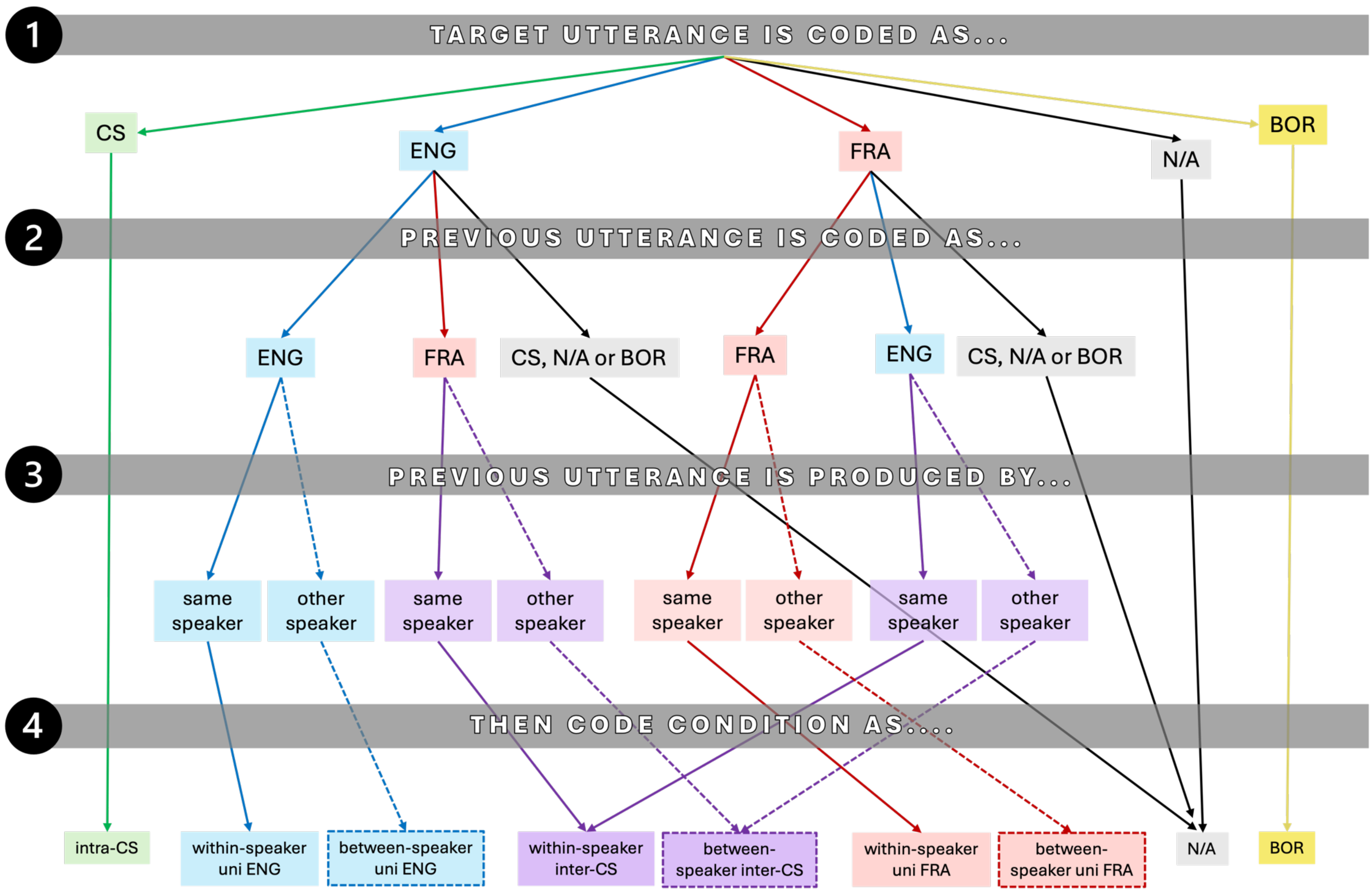


Table 4. 8. Examples of target utterances for each condition code. The condition code is based on the utterance immediately preceding the target utterance n, depicted here as utterance *n-1*.

Condition	Previous utterance (*n-1*)	Target utterance (*n*)
Uni within-speaker	***SEC**: [- fra] bin [: bien] y'en [: il y en] a deux .	***SEC**: [- fra] un deux trois [=! mumbles] . [pair01, 1735]
Uni between-speaker	***FIR**: [- fra] parce que j'en compte juste dix [=! mumbles] .	***SEC**: [- fra] bin [: bien] y'en [: il y en] a deux . [pair01, 1735]
Intra-CS	any	***SEC**: on@s:fra a@s:fra les@s:fra bowling@s:eng pins@s:eng . [pair16, 2548]
Inter-CS within-speaker	***SEC**: [- fra] ah@s:eng&fra tu veux tu la feuille pour écrire ?	***SEC**: [- eng] don't waste a paper if you don't have any good thoughts. [pair07, 2130]
Inter-CS between-speaker	***FIR**: [- fra] &-uh j'ai rien n'a [: a] dire [=! mumbles].	***SEC**: [- eng] you still have twen(t)y seconds to think about it [=! mumbles] . [pair07, 2130]
Borrowing	any	***SEC**: +< faut@s:fra juste@s:fra k'tu@s:fra sois@s:fra smart@s:eng+fra. [pair04, 3186]

Table 4. 9. Examples of excluded target utterances. Exclusion can be based on the target utterance itself (*n*) , or on the utterance immediately preceding the target utterance (*n-1*).

Exclusion	Previous utterance (*n-1*)	Target utterance (*n*)
N/A	any	***FIR**: +< &=laughs . [pair15, 2080 secs]
Borrowing	any	***FIR**: su(r)@s:fra l(e)@s:fra top@s:eng+fra? [pair06, 2142 secs]
FRE/ENG preceded by N/A	***FIR**: okay@s:eng&fra .	***SEC**: [- eng] I'll do same [/] same for you . [pair10, 174]
FRE/ENG preceded by CS/BOR	***SEC**: on@s:fra a@s:fra le@s:fra beekeeper@s:eng .	***SEC**: [- fra] on a ça . [pair16, 2548 secs]
Produced by *INV	any	*INV: +< [- fra] chaque paire d'images. [pair0.2, 1410]
Preceded by *INV	*INV: +< [- fra] chaque paire d'images .	*FIR: [- fra] parfait . [pair0.2, 1410]

Utterances which do not meet any of the criteria listed in (7) are considered excluded utterances (i.e., they are not attributed a condition). These include utterances tagged as `N/A` (or `FRE` / `ENG` utterances immediately following an `N/A` utterance), and utterances produced by `*INV` (or `*FIR` or `*SEC` utterances immediately following an `*INV` utterance). Examples of excluded utterances are included in **Table 4.9**.

4.4.2 Speaker-grouped coding

Speaker-grouped coding organizes the utterances according to the speaker that produced them (i.e., sorted by speaker *then* utterance number). The condition of each target utterance is based on the previous *same-speaker* utterance (*n-1*). As such, only within-speaker conditions are possible (A-to-A or B-to-B): i) unilingual within-speaker French utterances; ii) unilingual within-speaker English utterances; iii) intra-utterance (within-speaker) switches; iv) inter-utterance within-speaker switches; v) utterances with borrowings. This second type of coding is required to operationalize inter-utterance switching from the perspective of production. Consider the following excerpt, first shown time-linearly (8), then shown according to speaker-grouping for `*FIR` (9).

(8) **Pair0.1, Sarah and Mary (1196 secs)**, Time-linear order:

```
1.   *FIR:  +< [- fra] y'a [: il y a] des poules oui .
2.   *SEC:  [- eng] an:d they're pecking ?
3.   *FIR:  [- fra] oui .
4.   *SEC:  okay@s:eng&fra .
5.   *SEC:  [- eng] &-uh are they white and: red ?
6.   *FIR:  [- fra] non .
7.   *FIR:  [- fra] sont toutes blanches .
8.   *SEC:  [- fra] sont +//.
9.   *FIR:  +< [- eng] so there's a difference .
10.  *SEC:  [- fra] les pattes sont tu (.) blancs [*] ?
```

11. ***FIR:** [- fra] oui .
12. ***SEC:** [- fra] &-uh les pattes sont blanches ?
13. ***FIR:** [- fra] non sont <rouges> [=! laughs] .
14. ***SEC:** okay@s:eng&fra .
15. ***SEC:** [- eng] &-uh during the [//] (..) &-uh &-uh in the back of that.
16. ***SEC:** [- eng] there's a sheep that's brown .
17. ***FIR:** [- fra] oui .
18. ***SEC:** [- eng] on a piec'a [: piece of] wood with &-uh +...
19. ***SEC:** [- eng] another sheep that's half brown half (..) &+b &-uh white?
20. ***FIR:** [- fra] non .

(9) **Pair0.1, Sarah and Mary (1196 secs)**, Speaker-grouped order for Sarah (`*FIR`):

1. ***FIR:** +< [- fra] y'a [: il y a] des poules oui .
3. ***FIR:** [- fra] oui .
6. ***FIR:** [- fra] non .
7. ***FIR:** [- fra] sont toutes blanches .
9. ***FIR:** +< [- eng] so there's a difference .
11. ***FIR:** [- fra] oui .
13. ***FIR:** [- fra] non sont <rouges> [=! laughs] .
17. ***FIR:** [- fra] oui .
20. ***FIR:** [- fra] non .

Operating from the entirely time-linear view in (8), Sarah did not produce any inter-utterance code-switches. The only consecutive utterances produced by Sarah (utterance [6] to [7]) occur in the same language (French). By contrast, the speaker-grouping in (9) allows us to see that Sarah indeed produced two inter-utterance code-switches: from utterance [7] to utterance [9], and from utterance [9] to utterance [11]. In other words, I presume that an inter-utterance code-switch has occurred (i.e., been produced) even if there is interim content from the partner[4]. The idea is the following: when a speaker produces an utterance, they select a language schema; this selection may not shift until the

[4] On the other hand, a participant likely does not process or 'hear' an utterance as a switch if there is interim content between the partner's opposite-language utterances; this will be important for CHAPTER 6.

speaker themselves produces another utterance from a different language. In order to capture this notion, speaker-grouped coding is required.

Note that speaker-grouped coding essentially adheres to the same criteria as time-linear coding, except that conditions are based on the previous *same-speaker* utterance. These criteria are verbalized in (10). Just like in time-linear coding, utterances which do not meet any of the criteria listed in (10) are considered excluded utterances.

(10) **SPEAKER-GROUPED CONDITION CODING CRITERIA**:

a. **Unilingual within-speaker French (uni-FR)**:
   i. <u>Member-A</u>: a `FRE` utterance immediately follows another `FRE` utterance in the `*FIR` grouping;
   ii. <u>Member-B</u>: a `FRE` utterance immediately follows another `FRE` utterance in the `*SEC` grouping.

b. **Unilingual within-speaker English (uni-EN)**:
   i. <u>Member-A</u>: a `ENG` utterance immediately follows another `ENG` utterance in the `*FIR` grouping;
   ii. <u>Member-B</u>: a `ENG` utterance immediately follows another `ENG` utterance in the `*SEC` grouping.

c. **Intra-utterance code-switches (intra-CS)**:
   i. <u>Member-A</u>: a `CS` utterance produced by `*FIR` in the `*FIR` grouping;
   ii. <u>Member-B</u>: a `CS` utterance produced by `*SEC` in the `*SEC` grouping.

d. Inter-utterance within-speaker switches (inter-CS):
   i. <u>Member-A</u>: a `FRE` utterance immediately follows a `ENG` utterance or an `ENG` utterance immediately follows a `FRE` utterance in the `*FIR` grouping;
   ii. <u>Member-B</u>: a `FRE` utterance immediately follows a `ENG` utterance or an `ENG` utterance immediately follows a `FRE` utterance in the `*SEC` grouping.

e. **Borrowings**:
   i. <u>Member-A</u>: a `BOR` utterance produced by `*FIR` in the `*FIR` grouping;
   ii. <u>Member-B</u>: a `BOR` utterance produced by `*SEC` in the `*SEC` grouping.

4.4.3 Proportion indices

Recall that the recordings differed in length for different pairs. Some pairs took longer to talk through activity instructions, or to calculate their final scores (after Taboo and Spot-the-difference). Since the free discussion activity was not timed, some pairs discussed their prompts much longer than others (e.g., 45 minutes for pair02 compared to 11 minutes for pair11). As such, the raw count of each condition could not be used as a switching index, since this would inherently lead to higher values among pairs with longer recordings (or for members in a pair who produced a disproportionate number of utterances). Instead, the *proportion* of utterances corresponding to each condition was computed. The equation used to calculate each index (as well as a plain-English description) is included (and described) **in Table 4.10**.

A few details merit discussion. First, observe that inter-CS is based on values from speaker-grouped coding (SG), while the remaining conditions are based on time-linear coding (TL). Once again, this is implemented since an inter-CS can be said to have been produced even if there is interim content from the partner (*Section 4.4.2*). Second, notice that in all cases, the denominator of the equation consists of *included* utterances. 'Included utterances' are utterances that could be coded according to the coding criteria in (7) (pp.118-119). Excluded utterances do not contribute to the n count of the denominator in any of the equations.

Take Virginie, member-B of pair18, as an example. Though 1528 utterances were transcribed for Virginie, only 957 utterances were coded; the remaining 571 utterances were excluded for the reasons listed in **Table 4.10** (e.g., tagged as `N/A`, tagged as `BOR`, following an N/A, BOR or CS utterance). Since Virginie produced 280 utterances coded as uni-FR, we calculate $\% \text{ uni}{-}\text{FR}_{18\text{B}} = \frac{280}{957} =$ .29; she produced unilingual French 29% of the time.

Table 4. 10. Indices used to operationalize participants' language usage.

Index	Description	Equation
uni-FR	Divide the count of *time-linear* utterances coded as uni-FR for a given speaker by the total number of included utterances for that speaker.	$\% \text{ uni}{-}\text{FR}_i = \dfrac{n \text{ TL uni}{-}\text{FR}_i}{n \text{ TL included}_i}$
uni-EN	Divide the count of *time-linear* utterances coded as uni-EN for a given speaker by the total number of included utterances for that speaker.	$\% \text{ uni}{-}\text{EN}_i = \dfrac{n \text{ TL uni}{-}\text{EN}_i}{n \text{ TL included}_i}$
intra-CS	Divide the count of utterances coded as intra-CS for a given speaker by the total number of included utterances for that speaker.	$\% \text{ intra}{-}\text{CS}_i = \dfrac{n \text{ intra}{-}\text{CS}_i}{n \text{ included}_i}$
inter-CS	Divide the count of *speaker-grouped* utterances coded as inter-CS for a given speaker by the total number of included utterances for that speaker.	$\% \text{ inter}{-}\text{CS}_i = \dfrac{n \text{ SG inter}{-}\text{CS}_i}{n \text{ SG included}_i}$
between-CS	Divide the count of *time-linear* utterances coded as between-CS for a given speaker by the total number of included utterances coded for that speaker.	$\% \text{ btwn}{-}\text{CS}_i = \dfrac{n \text{ TL btwn}{-}\text{CS}_i}{n \text{ TL btwn}_i}$

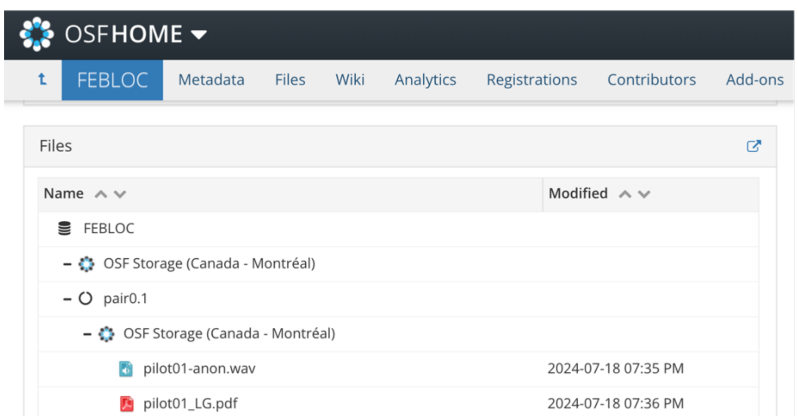
Note: i = FEBLOC speaker (e.g., pair01A); TL = time-linear; SG = speaker-grouped

I have now described the collection of the data for the FEBLO-Corpus, as well as the speakers that compose it. We have reviewed the ways in which the data was transcribed and coded, to ultimately yield objective code-switching measures for each FEBLOC speaker. Let us now get to the fruit of our labour: the content of the corpus.

4.5 Contents of FEBLOC

The FEBLO-Corpus contains 1066 mins (17.8 hours) of speech. As mentioned, the average length of each recording was 56 minutes (*SD*=10 mins, *range*=44-87 mins). While the Bilingual Taboo activity (*M*=15 mins; *SD*=2 mins, *range*=11-18 mins) and Spot-the-Difference activity (*M*=21 mins; *SD*=3 mins, *range*=16-29 mins) were similar in duration across pairs (i.e., only the time to pass through instructions fluctuated), the Free discussion was entirely participant-controlled and thus varied greatly between pairs (*M*=20 mins; *SD*=9 mins, *range*=4-45 mins). The anonymized transcriptions as well as their respective recordings can be found on [private link redacted] (see **Figure 4.8**). Note that these files do not necessarily represent the corpus in its end state and should thus be kept private.

Figure 4. 8. FEBLOC transcriptions and recordings stored on Open Science Framework.



The number of utterances coded (i.e., only included utterances) for each FEBLOC speaker is presented in **Table 4.11**. On average, each participant produced a total of 942 codable utterances (*SD*=271, *range*=500-1683 utterances). This means that the entire FEBLO-Corpus is made up of 35,800 codable utterances (roughly translating to 1275 pages of transcribed text).

Table 4. 11. Number of included utterances for each FEBLOC speaker.

Pair	Member	1-taboo	2-diapix	3-discussion	TOTAL
0.1	A	237	584	101	922
	B	190	505	53	748
0.2	A	171	423	119	713
	B	133	416	182	731
01	A	69	301	130	500
	B	66	367	181	614
02	A	331	528	824	1683
	B	200	475	998	1673
04	A	178	462	226	866
	B	277	604	299	1180
06	A	145	503	312	960
	B	259	578	288	1125
07	A	324	649	296	1269
	B	242	389	199	830
08	A	193	403	135	731
	B	158	376	119	653
09	A	184	433	405	1022
	B	152	433	467	1052
10	A	139	312	212	663
	B	221	454	396	1071
11	A	242	579	188	1009
	B	231	500	138	869
12	A	190	503	453	1146
	B	169	369	272	810
14	A	250	510	262	1022
	B	206	279	144	629
15	A	126	357	596	1079
	B	105	319	294	718
16	A	127	506	520	1153
	B	135	535	518	1188
17	A	99	368	128	595
	B	133	295	151	579
18	A	201	426	666	1293
	B	174	336	447	957
19	A	222	460	310	992
	B	165	459	245	869
20	A	244	509	260	1013
	B	161	483	229	873
Mean (SD)		186 (62)	447 (93)	310 (206)	942 (271)

4.5.1 Unilingual speech

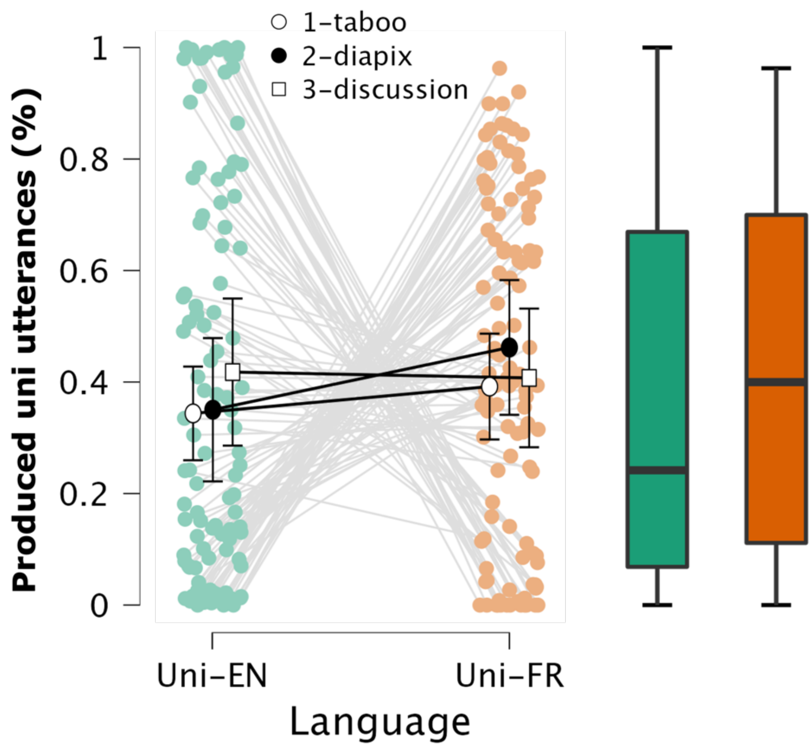
The proportion of unilingual speech produced by FEBLOC speakers (for each activity and overall) is summarized in **Table 4.12**. Approximately 80% of the (included) utterances in the corpus were coded as either unilingual French or unilingual English. A Repeated-Measures ANOVA with the variables of Activity (1-taboo, 2-diapix, 3-discussion) and Language (French, English) revealed that the proportion of unilingual French and unilingual English did not differ in the corpus overall (no main effect of Language: $F(1, 37)=.25$, $p=.62$) or within individual activities (Activity by Language interaction: $F(2, 74)=2.61$, $p=.08$). However, less unilingual speech was used in the Bilingual Taboo activity compared to the two other activities (main effect of Activity: $F(2, 74)=19.21$, $p<.001$)[5]. The distribution of unilingual proportions across FEBLOC is presented in **Figure 4.9**.

Table 4. 12. Summary of unilingual speech in the FEBLO-Corpus according to activity. Means indicated with standard deviations in parentheses.

	1-taboo	2-diapix	3-discussion	Complete recording
uni-FR (%)	39.1 (24.7)	46.1 (31.8)	40.7 (33.2)	36.6 (34.9)
uni-EN (%)	34.3 (25.9)	35.0 (38.4)	41.7 (39.2)	43.0 (29.5)
TOTAL UNI (%)	73.4 (10.9)	81.1 (14.0)	82.4 (14.8)	79.7 (12.8)

[5] This might reflect the fact that code-switching could be used strategically during the Bilingual Taboo activity. Bilinguals could alternate between their languages (i.e., produce less unilingual speech) in order to avoid language-specific Taboo words during clue-giving; guessers would thus be to able guess secret words in a more timely, efficient manner and the pair would collect a higher number of points (more on this in CHAPTER 5). This would entail that the speech produced during Spot-the-difference and Free Discussion activities more so represent the participants' naturalistic unilingual/code-switching proportions.

Figure 4. 9. Proportion of unilingual speech in the FEBLO-Corpus.



4.5.2 Code-switched speech

The proportion of code-switched speech produced by FEBLOC speakers (for each activity and overall) is summarized in **Table 4.13**. Approximately 5% of the (included) utterances in the corpus were coded as intra-utterance switches, 13% were coded as inter-utterance switches (i.e., approximately 18% within-speaker switches), and 9% were coded as between-speaker code-switches.

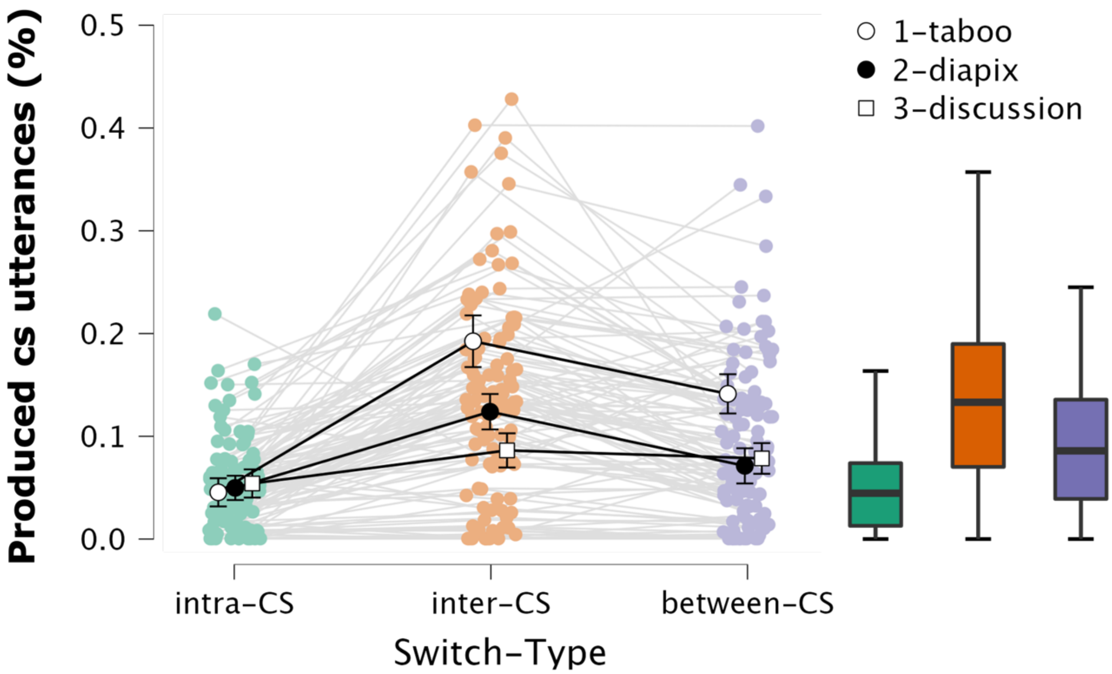
A Repeated-Measures ANOVA with the variables of Activity (1-taboo, 2-diapix, 3-discussion) and Switch Type (intra-CS, inter-CS, between-CS) first replicated the results from the previous section, demonstrating that more code-switched speech (across Switch Types) was present during the Bilingual Taboo activity compared to the two other activities (main effect of Activity: $F(2, 74)=28.83$, $p<.001$). Second, the ANOVA revealed that different types of switches were used to various degrees in the corpus (main effect of Switch Type: $F(2, 74)=42.60$, $p<.001$; Activity by Switch Type interaction: $F(4, 148)=27.57$, $p<.001$). Post-hoc comparisons showed significantly less intra-CS than inter-CS and between-CS (*t*s>5.9, *p*s<.001), and significantly more inter-CS compared to between-CS ($t=5.06$, $p<.001$) in FEBLOC overall. This same pattern was present for the Bilingual Taboo activity (*t*s>4.4, *p*s<.001), but not for the Spot-the-Difference and Free Discussion activities.[6] For Spot-the-Difference, inter-CS were significantly more frequent compared to intra-CS and between-CS (*t*s>4.6, *p*s<.001), but intra-CS and between-CS were produced to similar degrees ($t=1.88$, $p=.56$). For the Free Discussion, there were no significant differences according to Switch Type (*t*s<2.9, *p*s>.07). The distribution of code-switched proportions across FEBLOC is presented in **Figure 4.10**.

Table 4. 13. Summary of unilingual speech in the FEBLO-Corpus according to activity. Means indicated with standard deviations in parentheses.

	1-taboo	2-diapix	3-discussion	Complete recording
intra-CS (%)	4.7 (3.2)	5.2 (4.5)	5.6 (5.6)	5.2 (4.2)
inter-CS (%)	19.4 (9.3)	12.5 (9.1)	8.8. (8.2)	12.8 (7.1)
into FR (%)	9.2 (4.5)	5.9 (4.3)	4.4 (4.2)	6.1 (3.4)
into EN (%)	10.2 (5.0)	6.7 (4.8)	4.4 (4.1)	6.7 (3.7)
TOTAL within-speaker (%)	24.1 (10.5)	17.7 (12.9)	14.4 (12.6)	18.0 (10.6)
between-CS (%)				
into FR (%)	7.2 (5.5)	4.6 (6.5)	4.4 (6.6)	5.1 (6.0)
into EN (%)	7.1 (4.9)	2.7 (3.9)	3.6 (5.1)	3.9 (4.0)
TOTAL between-speaker (%)	14.3 (6.5)	7.3 (7.6)	8.0 (8.0)	9.1 (6.9)

[6] Again, this likely reflects the inherent differences between the activities. During Bilingual Taboo, single-word (and short) clues were common-place, giving less opportunity for intra-utterance switches to arise.

Figure 4. 10. Proportion of code-switched speech in the FEBLO-Corpus.



4.5.3 Borrowings

In total, fifty-five English-origin nouns, eleven English-origin adjectives, and forty-six English origin verbs were integrated into French and thus considered to be English borrowings. Six French-origin nouns and one French-origin verb were integrated into English and thus considered to be French borrowings. A full list of borrowed words as well as their raw frequency of attestation is included in **APPENDIX D.** A word cloud illustrating the borrowings produced by the most speakers is included in **Figure 4.11**. For instance, `top@s:eng+fra` and `fun@s:eng+fra` were produced by thirteen unique FEBLOC speakers, while `business@s:eng+fra` was produced by three FEBLOC speakers.

Of note is the remarkable difference in attestation between English and French borrowings. In fact, in the entire corpus, only a single instance of a French verb + English conjugation was observed (11). This speaks to distributional patterns in code-switching behaviours: while English verbs are regularly 'frenchified' with French morphology (e.g., *driver, skipper, agreer, timer, planner, follower, setter up*...), it is generally unacceptable to apply English morphology to French verbs. Similar to the Spanish-English pattern, this likely reflects syntactic differences between English and French/Spanish, such as verb raising/lowering (González-Vilbazo & López, 2011, 2012).

(11) **Idiosyncratic usage of V_{FR} + ing** (pair019, Molly and Stéphane, 1600 seconds):

```
*SEC:  [- eng] there's like two (.) green (.) garbages ?
*FIR:  [- eng] yeah .
*FIR:  [- eng] one is like full .
*FIR:  debording@s:fra+eng .
```

Figure 4. 11. Word cloud illustrating borrowings attested in FEBLOC. Larger words are produced by more unique speakers in the FEBLO-Corpus.

4.6 An interim summary of FEBLOC

The present chapter described the construction and the contents of the French-English Bilingual Loved Ones Corpus, a new ecologically valid code-switching database. Nineteen pairs of bilinguals from the same in-group (i.e., couples, siblings, friends, etc.) completed a series of speech elicitation activities in a private room while their interactions were auditorily recorded. The speech elicitation activities ranged from structured (Bilingual taboo activity), to semi-structured (Spot-the-difference activity), to unstructured (Free discussion activity). Their recordings were subsequently transcribed using the CHAT method. Individual utterances were coded as being i) unilingual English; ii) unilingual French; iii) intra-utterance switches; iv) inter-utterance switches; or v) between-speaker switches. Utterances which could not be coded were excluded. Objective code-switching measures were thus computed for each individual FEBLOC speaker.

The corpus is made up of approximately 18 hours of speech, including 35,800 condition-coded utterances. Overall, 80% of the corpus is made up of unilingual utterances, while 18% is code-switched (intra-utterance, inter-utterance). The subsequent chapter considers a series of exploratory questions which utilize the FEBLO-Corpus. Future chapters utilize this novel corpus in order to answer the primary research questions of the dissertation.

CHAPTER 5: Exploratory analyses *pertinentes pour* FEBLOC

Given the size of the corpus and the amount of background characteristics collected, you may have been pondering various 'out-of-curiosity' questions while reading this dissertation. For instance, did participants who code-switched more do better on the speech elicitation activities? Did members within a same pair code-switch to a similar degree? Did the relationship between pair members (e.g., couple vs. siblings) impact their language usage? Did the age and sex of the speakers—or other aspects of their language background—modulate their code-switching habits? Were participants accurate in self-rating their code-switching habits? These questions are deemed exploratory, as they do not make up the primary aims of the dissertation and no hypotheses were made *a priori*. Nevertheless, a series of short exploratory analyses are described in the following sections.

5.1 Code-switching as a strategy for efficient communication

In CHAPTER 2, I discussed various motivations for producing code-switches. For instance, bilinguals may switch languages when they are looking to fill a lexical gap, if they find a translation more semantically suitable, when a cross-linguistic item is more readily accessible, or if they wish to signal the arrival of new information. Some of these reasons point towards the idea that producing code-switches can be beneficial for productive communication, perhaps even increasing task efficiency. On the other hand, numerous psycholinguistic studies indicate that code-switching is effortful. Presumably, higher cognitive load demands may impede productive communication and task efficiency.

In FEBLOC, two (semi-)structured speech elicitation tasks were utilized: Bilingual Taboo, and Spot-the-difference. Importantly, these activities were pitched to participants as games or puzzles, wherein they were encouraged to "collect as many points as possible". A review of the activities shows different degrees of 'success' across pairs. For example, pair18 (Aaron and Virginie) identified 34/36 differences during the Spot-the-difference activity, while pair02 (Camille and Renée) found only 21/36. Speaking in general terms, pairs who showed increased performances during the structured speech elicitation tasks can be said to have possessed better task efficiency. It is thus possible to ask whether code-switching proportions were related to task efficacy by operationalizing performance during FEBLOC speech elicitation activities.

If code-switching is indeed used as a productive communication strategy, we would expect that FEBLOC speakers switch languages in order to "collect more points". A few idiosyncratic examples of this are presented in (1). In (1a), the speaker (Gabrielle) switches to a translation equivalent (*'trunk'* instead of *'capot'*) when she realizes that the listener (Charlotte) does not understand her utterance. In (1b), the speaker (Noah) systematically uses the French noun *'flèche'*, even though he produced almost uniquely English utterances during the Spot-the-difference activity. It is likely that Noah produced the cross-linguistic item more quickly due to lexical frequency and/or activation (*'flèche'* frequency per million=12.76; *'arrow'* frequency per million=11.23; Brysbaert & New, 2009; New et al., 2004), thereby maximizing playing time. In (1c), the speaker (Hazel) appears to produce a cross-linguistic item that is more semantically accurate or clear-cut, (*'bonhomme'* instead of *'stick figure'*, '*drawing*', '*little man*', etc.), resulting in increased listener precision. Finally, in (1d), when Mary is describing an image with two signs next to each other (a red and a green; see first row in **Figure 4.4**, p.99), she produces *'une red sign'* instead of *'une enseigne rouge'* (1d). This code-switch is productive as it allowed the listener (Sarah) to disambiguate the message more rapidly (i.e., the pre-nominal adjective in English disambiguates the duplicates more rapidly; see also Beatty-Martínez et al., 2020a).

(1) **Idiosyncratic examples in FEBLOC demonstrating code-switching as a tool:**

a) **Pair08 (Charlotte and Gabrielle), 1492 seconds:**

```
*SEC:  [- fra] pis [: puis] la voiture elle é: [: est] &-uh blanche .
*SEC:  [- fra] pis [: puis] elle a l(e) &+s [//] comme le &-mm [/] le
       [/] (.) le capot yé [: il est] brun ?
*SEC:  le@s:fra trunk@s:eng yé@s:fra [: il est] brun@s:fra ?
*FIR:  [- fra] ouain [: oui] .
```

b) **Pair20 (Noah and Bertrand), 1257 seconds:**

```
*FIR:  [- eng] &-uh is there a sign that says +.
*FIR:  +" [- eng] doctor +.
*FIR:  +, [- eng] on it ?
*FIR:  with@s:eng a@s:eng flèche@s:fra ?
*SEC:  [- eng] no .
*FIR:  [- eng] mine has a sign that says +.
*FIR:  +" [- eng] doctor .
*FIR:  there's@s:eng a@s:eng flèche@s:fra pointing@s:eng
       towards@s:eng the@s:eng middle@s:eng of@s:eng this@s:eng [//]
       (..) the@s:eng image@s:eng .
*SEC:  okay@s:eng&fra .
```

c) **Pair15 (Hazel and Naomi), 1765 seconds:**

```
*FIR:  [- eng] what is she reading ?
*SEC:  [- eng] &-uh a &+n [/] a newspaper that's blue ?
*FIR:  &-uh with@s:eng a@s:eng li(tt)le@s:eng bonhomme@s:fra on@s:eng
       it@s:eng ?
*SEC:  [- eng] yeah .
```

d) **Pair0.1 (Sarah and Mary), 2176 seconds:**

```
*SEC:  une@s:fra red@s:eng sign@s:eng .
*SEC:  [- fra] à la gauche .
*SEC:  [- fra] de t'ça [: ça] .
```

On the other hand, if code-switching impedes task efficiency, we may expect frequent code-switchers in FEBLOC to underperform during the speech elicitation tasks. This may be due to lower speech rates (i.e., increased disfluencies) or increased processing time on the listeners' behalf, both presumably caused by a heightened cognitive load.

In order to test these possibilities, separate coding and analyses were carried out for the Bilingual Taboo activity and the Spot-the-difference activity.

5.1.1 Bilingual Taboo

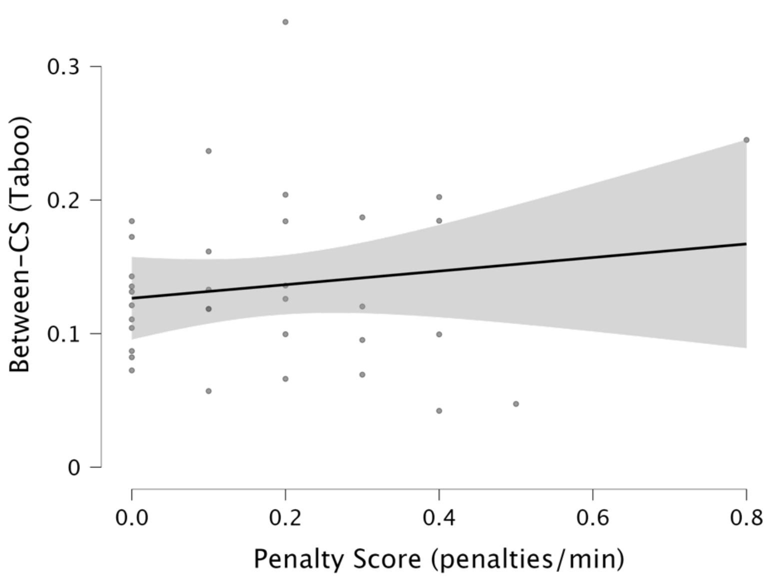
An independent volunteer reviewed the anonymized FEBLOC recordings (alongside their transcriptions) in order to code the participants' performance on the Bilingual Taboo task. Each time that the secret word of a card was accurately guessed (i.e., a speaker produced utterances leading to a correct guess by their partner), +1 point was given to the clue-giver for the variable of Guess Count. Each time a taboo word was accidentally produced (i.e., a speaker produced an utterance containing an 'illicit' word while giving their clue), +1 point was given to the clue-giver for the variable of Penalty Count. The volunteer coder also took note of the total playing time of the pair (i.e., did participants complete all ten minutes of the game, or did they finish the activity before time elapsed?).

As such, for Bilingual Taboo, there are two performance measures (**Table 5.1**): number of correctly-induced guesses, and number of penalties produced. In order to normalize these measures across participants, Guess Count and Penalty Count were divided by the total play time of the pair. This gave rise to two variables: Guess Score (i.e., number of correct guesses per minute), and Penalty Score (i.e., number of penalties per minute).

Separate mixed models (containing by-pair random intercepts) were computed on the proportion of intra-CS, inter-CS and between-CS produced during the Bilingual Taboo activity (i.e., the first portion of FEBLOC). In each model, the fixed factors included Guess Score and Penalty Score, which were allowed to interact.[1]

Guess score and Penalty score did not predict intra-CS (*F*s<.25, *p*s>.61) or inter-CS (*F*s<.28, *p*s>.60). However, one trend was observed for between-CS: Between-speaker switching was marginally predicted by Penalty score (*Est*.=.13, *SE*=.08, *t*=1.62, *p*=.12), but not by Guess score or their interaction (*F*s<.66, *p*s>.42). Estimated marginal means demonstrated that more frequent between-speaker switching led to increased penalties per minute. This effect is presented visually in **Figure 5.1**.

***Figure 5. 1*.** Descriptive plots illustrating the trending relationship involved between-CS and penalties produced during the Bilingual Taboo activity. 95% Confidence intervals are shaded.



[1] Two pairs (four participants) were excluded from these analyses as they did not follow the activity instructions. Instead of avoiding taboo words, they believed they were required to read aloud the taboo words on the playing cards in order to make their partner guess the secret word.

5.1.2 Spot-the-difference

The same independent volunteer coded the participants' performance on the Spot-the-difference activity. Recall that pairs played this activity for three sets of images; they had a maximum of five minutes to find 12 possible differences between each set. The coder reviewed the recording and transcript and made note of the number of correct difference found by each pair. Each time that a correct difference was identified, +1 point was given to both pair members for the variable of Identification Count. The volunteer coder also took note of the playing time of the pair (i.e., did participants find all twelve differences before the five minutes elapsed?).

As such, there was one performance measure for the Spot-the-difference task (**Table 5.1**): the number of correctly identified differences (across all three images). In order to normalize this measures across participants and pairs, Identification Count was divided by the total play time (across all three images). This gave rise to the variable of Identification Score (i.e., number of correctly identified differences per minute). Separate mixed models (containing by-pair random intercepts) were computed on the proportion of intra-CS, inter-CS and between-CS produced during the Spot-the-difference activity (second portion of FEBLOC). In each model, Identification Score was included as a fixed factor.

Table 5. 1. *Performance on the structured speech elicitation tasks. Means with SD in parentheses.*

Task	Measure	Raw count	Score (number per min)
Bilingual Taboo (*n*=34)	**Correct guesses**	8.94 (4.10)	.89 (.41)
	Produced penalties	1.79 (1.86)	.18 (.19)
Spot-the-Difference (*n*=38)	**Identified differences**	31.47 (3.16)	2.18 (.27)

None of the mixed models yielded significant results. That is, identification score did not predict intra-CS (F=.73, p=.41), inter-CS (F=1.33, p=.27), or between-CS (F=.40, p=.54).

5.1.3 Summary

Overall, there is little evidence that suggests that code-switching either enhanced or impeded task efficiency in FEBLOC. One trend indicated that between-speaker switching may be related to increased penalties during the Bilingual Taboo task. This points towards the idea that shifting the language away from the one used in conversation may stem from—or result in—a temporary lapse in cognitive control (i.e., accidentally producing a presumably 'inhibited' taboo word).

5.2 Switching within pairs

5.2.1 Did pair members match each other's language usage?

A well-known human social behaviour is 'mirroring' (for language, imitation, alignment, or convergence: Szczepek Reed, 2020). Research has shown that humans match the style of co-interlocutors (e.g., Ireland & Pennebaker, 2010), and that 'familiarity breeds similarity' (see Pickering & Garrod, 2004 'interactive alignment account'). Since FEBLOC pairs were members of the same in-group, the question can be asked: did members within a pair produce similar proportions of code-switches?

The proportion of code-switches produced by each pair-member is presented in **Figure 5.2**. Visually, it appears that members from the same pair generally match in terms of their switching habits. For instance, member-A and member-B of pair09 both code-switched rarely, while member-A and member-B of pair10 both code-switched quite frequently. In order to test this statistically, the speaker's proportion of produced intra-CS, inter-CS, and between-CS (in the corpus overall) were each submitted to a linear regression (entry threshold: p<.05; removal threshold: p>.10). When "Pair" was entered as a categorical factor, the inter-CS and between-CS regressions were significantly improved from the null model (inter-CS: F=2.34, p=.04, *adj.* R^2=.40, R^2 *change*=.69; between-CS: F=7.10, p<.001, *adj.* R^2=.75, R^2 *change*=.87); by contrast, the intra-CS regression only trended towards significance (F=1.57, p=.17, *adj.* R^2=.22, R^2 *change*=.60)[2].

The difference (in absolute values) in code-switching proportions between member-A and member-B of each pair is plotted in **Figure 5.3**. Once again, a visual inspection of this figure shows that pairs generally matched each other's language usage (+/- <15% when all code-switching types are summed), with the exception of pair02 and pair18. The difference scores for intra-CS, inter-CS, and between-CS were each submitted to a stepwise linear regression (entry threshold: p<.05; removal threshold: p>.10), with participants' responses to the pair questionnaire (*Section 4.1.1*) entered as predictors. None of the predictors were retained for the intra-CS or between-CS difference scores. For inter-CS, the self-rated frequency of interactions significantly improved the model: pair members who interacted more frequently in their day-to-day lives exhibited decreased inter-CS difference scores (see **Figure 5.4**). In other words, pairs who interacted the most 'in-the-wild' displayed more similar language usage (at least in terms of inter-utterance switching).

---

[2] This effect may be trending rather than significant since intra-CS is attested the least and maintains the smallest variance of the code-switching types. The substantial R^2 change lends credence to its existence.

In brief, exploratory analyses conducted on the FEBLO-Corpus revealed that members of the same pair code-switched to similar extents during the speech elicitation activities. Language usage was especially convergent for pairs who reported the most frequent real-word interactions.

Figure 5. 2. The proportion of code-switches produced by each FEBLOC speaker. Bars are grouped according to pair number, with Member-A on the left and Member-B on the right of each cluster.

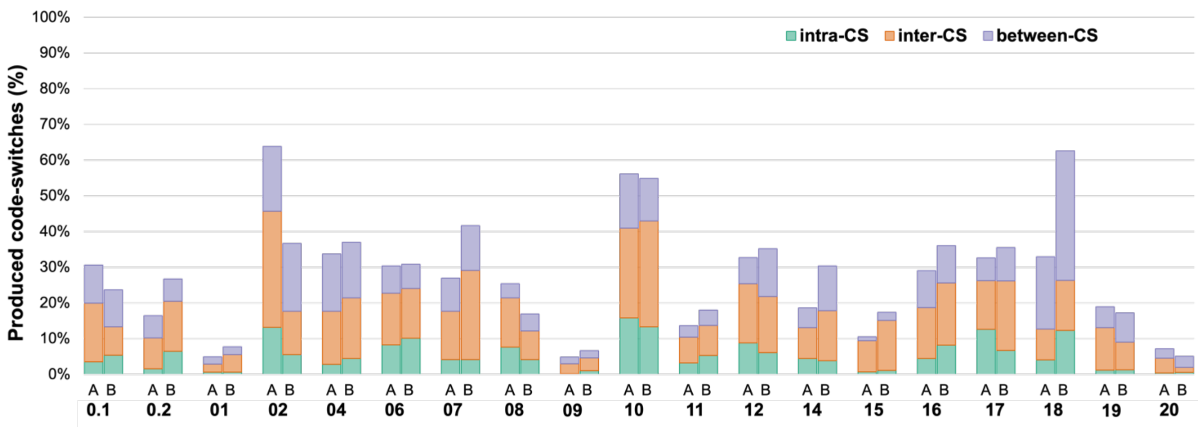


Figure 5. 3. Difference scores (in absolute values) for switches produced by members of a same pair.

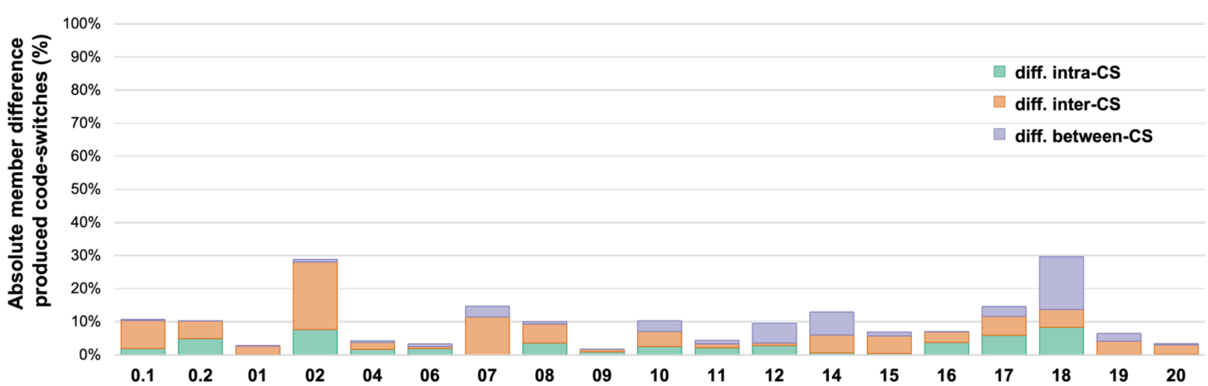
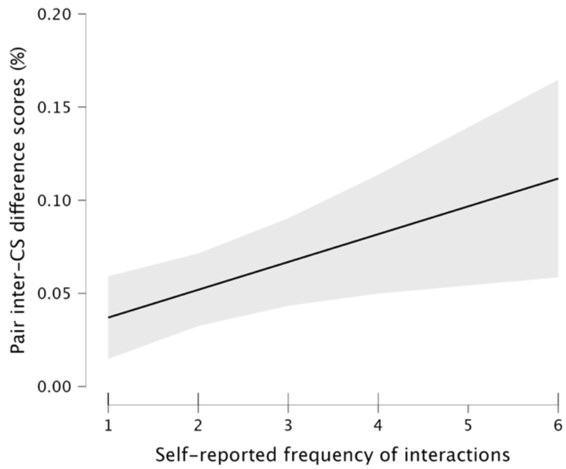


Figure 5. 4. Marginal effects plot illustrating the relationship between by-pair difference scores for inter-CS and the pairs' self-reported frequency of real-world interactions (1=every day or nearly every day; 6=less than once a month). 95% Confidence intervals are shaded.



5.2.2 Does pair relationship impact code-switching?

Considering that code-switching is stigmatized in the communities under study (Poplack, 1988), it may be the case that certain types of relationships foster habitual code-switching more than others (e.g., consider 'familects' or 'couple dialects'). To test this, linear mixed models including the fixed factor of Relationship Type (couple, 1st-degree relative, other relative, friends) and random effect of Pair was performed on the proportion of switches produced by each participant. The relationship type did not modulate the proportion of intra-CS, inter-CS or between-CS produced by the bilinguals (*F*s<1.1, *p*s>.39).

The 'proportion of years known' was computed by dividing the length of the pair's relationship by each participant's age. For instance, a 54-year-old participant who knew her testing partner for 26 years would possess a proportion of 0.48.[3] This metric was then added

[3] This index was used instead of raw "years known", as older pairs have necessarily known each other longer than younger pairs.

to a correlation matrix with the proportion of switches produced by each participant. The 'years known' metric did not modulate the proportion of intra-CS, inter-CS or between-CS produced by the bilinguals ($rs<.21$, $ps>.21$). Finally, the proportion of produced switches was not correlated to the degree of formality of their interactions (i.e., formal vs. informal: $rs<.19$, $ps>.26$), as self-reported on the pair questionnaire (*Section 4.1.1*).

To summarize, the proportion of code-switches (intra-CS, inter-CS, between-CS) produced by participants during the speech elicitation activities did not appear to vary according to the characteristics of the pair (type of relationship, length of relationship, or nature of the interactions).

5.3 Participant-specific factors

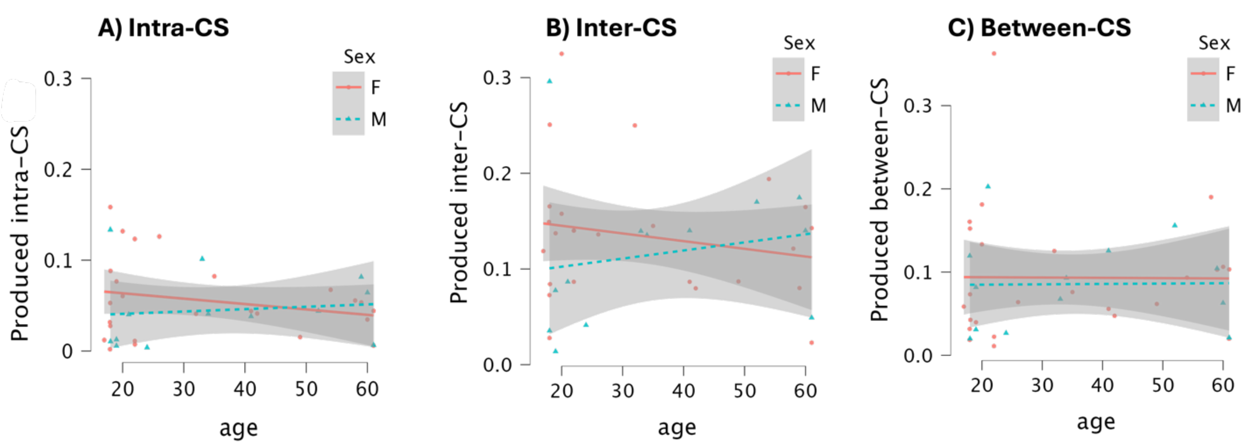
5.3.1 Code-switching according to sex and age

My own previous work, based on self-reports, indicated that women (particularly young women) code-switch more habitually than men (Gosselin & Sabourin, 2023a). To test whether these sex and age effects persist when objective code-switching is examined, separate mixed models were conducted on the proportion of intra-CS, inter-CS, and between-CS. The models contained the fixed factors of Sex (F, M) and Age (and the interaction between these factors), as well as by-pair random intercepts to account for similar language usage within pairs.[4]

[4] Note that same-sex pairs (two women, two men) produced similar proportion of code-switches compared to opposite-sex pairs (a woman and a man) ($ts<1$, $ps>.34$).

Sex was marginal for both intra-CS (F=2.78, p=.11) and inter-CS (F=3.21, p=.09), but not for between-CS (F=1.84, p=.19). Similarly, the interaction between Sex and Age was marginal for intra-CS (F=2.66, p=.12) and inter-CS (F=3.06, p=.09), but not between-CS (F=1.06, p=.32). Estimated marginal means showed more intra-CS and inter-CS for women (intra-CS: *Est*.=.055, *SE*=.009; inter-CS: *Est*.=.135, *SE*=.017) compared to men (intra-CS: *Est*.=.047, *SE*=.012; inter-CS: *Est*.=.119, *SE*=.020). Furthermore, Age modulated intra-CS and inter-CS differently according to Sex: for women, age was related to a decline in switching (intra-CS: *Est. slope*= -.0009, *SE*=.0005; inter-CS: *Est. slope*= -.001, *SE*=.0008); for men, age was related to an increase in switching (intra-CS: *Est. slope*=.0004, *SE*=.0007; inter-CS: *Est. slope*=.0009, *SE*=.001). These effects are illustrated in **Figure 5.5**. The main effect of Age was not a significant predictor of any of the code-switching types (F<.6, p>.44). Furthermore, a separate analyses indicated that the participants' highest completed educational level did not impact their code-switching habits (Fs<.5, ps>.49).

Figure 5. 5. Descriptive plots illustrating the relationship between produced switches and the participants sex and age (marginal in A and B, ns in C). 95% Confidence intervals are shaded.



Overall, the objective code-switching measures obtained via the FEBLO-Corpus appear to replicate previously reported sex and age differences: young women produced more intra-utterance and inter-utterance switches.

5.3.2 Code-switching according to language background

Code-switching has been related to several other language background characteristics, such as increased dominance and proficiency (e.g., Poplack, 1980; Yow & Li, 2015). To test whether such effects are present in FEBLOC, separate mixed models were conducted on the proportion of intra-CS, inter-CS, and between-CS. The models contained the fixed factors of Age of Exposure (AoE) to French and English, self-rated proficiency in French and English, exposure to French during infancy (%), and current usage of French (%)[5], as well as by-pair random intercepts.

None of the factors were significant for intra-CS (Fs<1.9, ps>.18) or inter-CS (Fs<.8, ps>.37). For between-CS, two factors trended towards significance. First, the speakers' current proficiency in English trended towards being negatively associated to between-CS proportions (F=2.22, p=.15): those who reported lower proficiency in English produced more between-speaker switches. Second, speakers' exposure to French during infancy trended towards being positively related to between-CS proportions (F=2.35, p=.14): those who were exposed to more French during infancy produced more between-speaker switches.

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[5] Degree of balance (DB), exposure to English during infancy (%) and current usage of English (%) were excluded from the model as they were highly collinear with the other fixed effects. A separate mixed model containing only the fixed factor of DB was not significant for intra-CS, inter-CS, or between-CS (ts<1.5, p>.15).

Altogether, only between-CS was (marginally) modulated by the participants' language background characteristics. The exploratory analyses appear to indicate that between-speaker switching (e.g., Brian speaks in English but Léona replies in French) can be used by bilinguals who are less balanced (less proficient, skewed childhood exposure) when there is no risk of compromising communication (i.e., if all speakers are bilinguals, as in FEBLOC).

5.4 Comparing objective FEBLOC proportions to self-reports

5.4.1 Are objective and subjective code-switching measures related?

As I have previously discussed (*Section 3.4.2*), one of the major limitations in the cognitive-linguistic code-switching literature is the reliance on self-reports. While subjective measures are convenient, basing conclusions on self-reports assumes i) that the chosen tool reliably taps into the specific behaviours it is meant to target; and ii) that individuals are accurate in self-evaluating those behaviours. Very few studies have tested this empirically in the code-switching literature (though see Cox et al., 2020). Since the FEBLOC database includes both subjective (from the BSwQ) and objective (computed proportions) code-switching measures from the same sample, it is possible to examine speakers' accuracy in self-reporting their code-switching habits.

The BSwQ is arguably the most used tool when it comes to measuring subjective code-switching habits; it separates the behaviour into four components: switching according to direction (e.g., into English, into French), contextual code-switching (i.e., externally-motivated switching), and unintentional code-switching (i.e., internally-motivated switching). As such, separate mixed models were conducted on the following (objective) dependent variables, computed via the FEBLO-Corpus: i) proportion of intra-CS; ii) proportion of inter-CS into English; iii) proportion of inter-CS into French; iv) proportion of between-CS into English; and v) proportion of between-CS into French. In every model, the fixed factors included the self-reported BSwQ components ('FR-to-EN', 'EN-to-FR', 'Contextual', 'Unintended'), as well as by-pair random intercepts. If subjective and objective code-switching measures are related, we would expect at least the following:

(2) **Expected effects:**

a. The proportion of inter-CS and/or between-CS into English should be related to the 'FR-to-EN' BSwQ component

b. The proportion of inter-CS and/or between-CS into French should be related to the "FR-to-EN" BSwQ component

The results of the mixed models are presented in **Table 5.2a-e**. The proportion of intra-utterance switching in FEBLOC was predicted by the bilinguals' self-reported FR-to-EN switching frequency. Crucially, this effect was directionally opposite to prediction: *more* objective switching was related to *less* subjective switching. This same pattern was marginal for inter-utterance switching into English. On the other hand, self-reported contextual switching was positively related to objective intra-utterance proportions in FEBLOC. Likewise, the proportion of between-speaker switching into French in FEBLOC was positively predicted by the bilinguals' self-reported frequency of switching into French. These effects are illustrated visually in **Figure 5.6**.

Table 5. 2. Fixed effect estimates for mixed models comparing objective and subjective code-switching measures. Dependent variables are objective code-switching measures computed from FEBLOC; they are listed in each table. For every model, the four self-reported BSwQ components are included as fixed factors and by-pair intercepts make up the random effect structure.

a. Proportion produced intra-CS

Term	Estimate	SE	t	p
Intercept	0.042	0.030	1.400	0.171
BSwQ: FR-to-EN	-0.030	0.013	-2.396	0.023
BSwQ: EN-to-FR	0.010	0.011	0.931	0.360
BSwQ: Contextual	0.017	0.010	1.764	0.087
BSwQ: Unintented	0.008	0.010	0.848	0.403

b. Proportion produced inter-CS into English

Term	Estimate	SE	t	p
Intercept	0.065	0.027	2.400	0.022
BSwQ: FR-to-EN	-0.021	0.012	-1.771	0.086
BSwQ: EN-to-FR	0.007	0.010	0.686	0.499
BSwQ: Contextual	0.009	0.009	1.006	0.322
BSwQ: Unintented	0.007	0.009	0.814	0.422

c. Proportion produced inter-CS into French

Term	Estimate	SE	t	p
Intercept	0.060	0.025	2.356	0.025
BSwQ: FR-to-EN	-0.017	0.011	-1.603	0.119
BSwQ: EN-to-FR	0.005	0.009	0.519	0.608
BSwQ: Contextual	0.007	0.008	0.833	0.411
BSwQ: Unintented	0.008	0.008	0.970	0.339

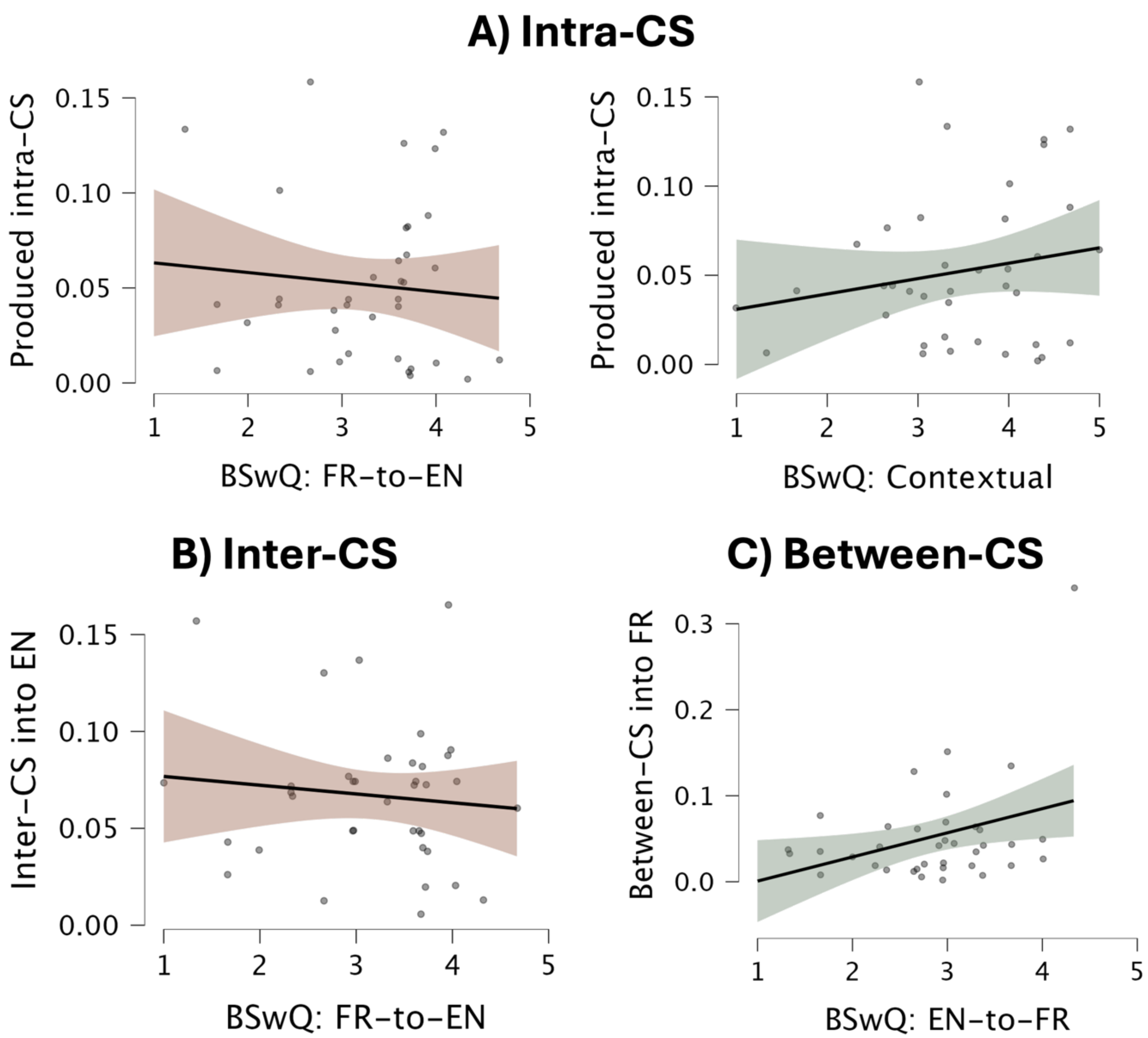
d. Proportion produced between-CS into English

Term	Estimate	SE	t	p
Intercept	0.019	0.030	0.622	0.538
BSwQ: FR-to-EN	-0.005	0.013	-0.412	0.683
BSwQ: EN-to-FR	-0.006	0.011	-0.567	0.574
BSwQ: Contextual	0.008	0.010	0.843	0.405
BSwQ: Unintented	0.010	0.010	1.076	0.290

e. Proportion produced between-CS into French

Term	Estimate	SE	t	p
Intercept	-0.008	0.042	-0.182	0.857
BSwQ: FR-to-EN	-0.015	0.019	-0.806	0.426
BSwQ: EN-to-FR	0.037	0.016	2.338	0.026
BSwQ: Contextual	-0.012	0.014	-0.851	0.401
BSwQ: Unintented	0.017	0.014	1.278	0.210

Figure 5. 6. Descriptive plots illustrating the relationships between objective code-switching proportions and subjective self-reported code-switching habits. 95% Confidence intervals are shaded.



Note that the dependent variables in these mixed models were the proportions of switches in FEBLOC *as a whole*. One may argue that the amount of switches produced during the Bilingual taboo activity (and perhaps, during the Spot-the-difference activity) do not represent the participants' naturalistic switching habits, and that this might account for the discrepancy between subjective and objective measures. However, **APPENDIX E** showcases the same analyses conducted on the Free discussion activity only (i.e., the unstructured elicitation activity); the results remain largely unchanged.

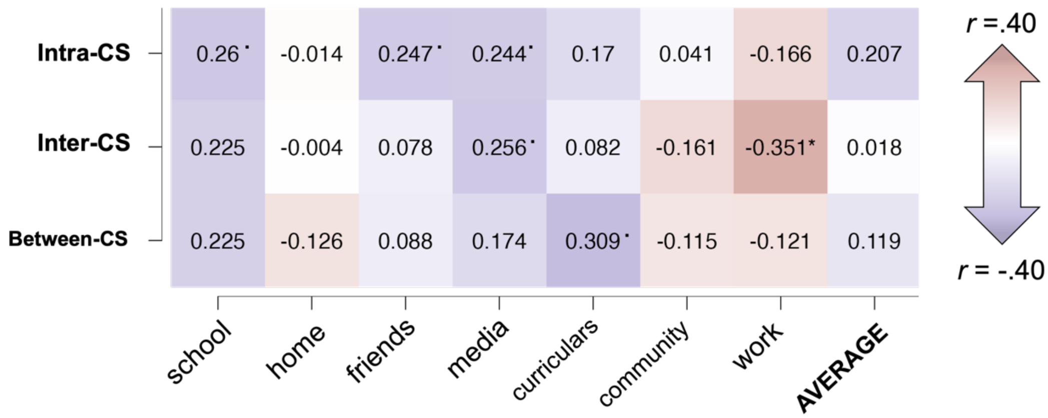
5.4.2 Does language entropy predict code-switching?

Language entropy (Gullifer & Titone, 2020) is touted as an excellent measure to tease apart fine-grained bilingual experiences. One commonly-held assumption is that contexts with higher language entropy (i.e., increased language diversity) are contexts in which code-switching is more frequent—or at least, more expected. Given that language entropy coefficients were computed for FEBLOC speakers (*Section 4.1.4*), it is possible to test whether these measures are related to bilinguals' objective code-switching proportions.

A correlation matrix was computed between each of the lifetime entropy statistics (at school, at home, with friends, media consumption, extracurriculars, in the community and at work) and the objective intra-CS, inter-CS and between-CS proportions. A heatmap of this correlation matrix is presented in **Figure 5.7**.

Only one correlation was returned as significant: more linguistic diversity at work was related to reduced inter-utterance switching (r= -.35, p=.03). Nevertheless, several marginal correlations were also observed. It is notable that entropy coefficients for given contexts are coherent across all code-switching types. For instance, increased entropy at school and in media consumption was consistently positively related to code-switching proportions. By contrast, increased entropy at work and in the community is consistently negatively related to code-switching proportions.

Figure 5. 7. Heatmap of the correlation matrix between objective code-switching proportions and language entropy coefficients. ˚ p<.15; * p<.05.



The number of marginal effects, as well as the context-specific coherence in these effects, leads credence to the language entropy measure. This is especially true if one considers the relatively small sample size of this exploratory analysis. Overall, it appears that diversity is some environments, but not all, bolsters code-switching. Furthermore, more positive relationships were observed for intra-CS than for inter-CS or between-CS (though this is a purely qualitative statement).

5.5 Interim discussion

The present chapter reviewed a series of short exploratory analyses conducted on the FEBLO-Corpus. In a nutshell, I observed no coherent effect of code-switching frequency on task efficiency (during the structured speech elicitation activities). Members of the same pair largely exhibited similar code-switching habits, but that this was not modulated according to relationship type (e.g., couples vs. siblings). The analyses pointed towards the fact that women in the FEBLO-Corpus (particularly young women) code-switched more than their male counterparts, and that between-speaker switching is a marker of less balanced bilingualism. Finally, the relationship between objective and subjective code-switching measures was generally not supported. These results will be discussed briefly below.

5.5.1 Task efficiency and code-switching: Cost-effective or zero-sums game?

Some motivations for code-switching point towards the idea that producing switches can be beneficial for productive communication, perhaps even increasing task efficiency. By contrast, numerous psycholinguistic studies indicate that code-switching is cognitively demanding, thereby potentially impeding productive communication and task efficiency. In order to test these conflicting ideas, the performance of FEBLOC speakers during Bilingual Taboo and Spot-the-difference activities was examined in relation to their objective code-switching proportions while playing these activities.

The exploratory analyses revealed little support for increased or decreased task efficiency as a consequence of frequently producing switches. Correct guesses (Bilingual Taboo) and correctly identified differences (Spot-the-difference) were not related to any of the code-switching types (intra-CS, inter-CS, between-CS). One trend indicated that between-speaker switching may be related to increased penalties during the Bilingual Taboo task (i.e., accidentally producing a language-specific Taboo word). This points towards the idea that shifting the language away from the one used in conversation may stem from—or result in—a temporary lapse in cognitive control; presumably, Taboo words are also 'inhibited, and a penalty arises when this inhibition is not maintained. This finding perhaps fall into line with those of Festman and colleagues (2010), who found that bilinguals with more cross-linguistic intrusion errors during picture naming were those who exhibited decreased inhibitory control.

How to explain the largely null results? One possibility is that code-switching is 'cost-effective'. That is, speakers may use code-switching as a tool during moments of decreased task efficiency (e.g., tip-of-the-tongue state). For instance, in (3a), Camille appears to not be able to retrieve *'poteau'*; after a series of disfluencies, she instead recruits the translation equivalent *'pole'*. François does the equivalent (3b), but in the opposite direction: he retrieves the French word *lavabo* after producing a series of disfluencies in English. If code-switching is used as a 'palliative strategy', frequent code-switching may represent a return to baseline efficiency, rather than an increased efficiency per say. In other words, code-switching may prevent underperforming, rather than leading to increased performance. To probe this possibility further, it would be important to test monolinguals on the same structured speech elicitation tasks. If bilinguals can circumvent disfluencies and maximize playing time with the help of code-switching—as I have speculated—, we would expect that monolinguals (who cannot recruit such a tool) would exhibit diminished activity scores compared to bilinguals.

(3) **Code-switching as a palliative strategy:**

a) **Pair02 (Camille and Renée), 2212 seconds:**

***FIR:**	y'a@s:fra [: il y a] un@s:fra [//] (..) like@s:eng a@s:eng (...) pole@s:eng .
***FIR:**	avec@s:fra (.) un@s:fra [//] comme@s:fra un@s:fra flag@s:eng type@s:eng ?
***SEC:**	[- fra] ouais [: oui] .

b) **Pair04 (Audette and François), 2870 seconds**

```
*SEC:	[- fra] tsé [: tu sais] .
*SEC:	you@s:eng [//] she@s:eng can:@s:eng [/] she@s:eng
	[/] she@s:eng can@s:eng clean@s:eng up@s:eng
	the:@s:eng [//] le@s:fra [/] le@s:fra lavabo@s:fra .
*SEC:	&=laughs .
```

A second possibility is that code-switching amounts to a zero-sums-game, by way of the production-processing paradox. While code-switching can seem beneficial *to produce* for the speaker (e.g., ease of lexical access, increased semantic precision; see Gollan & Ferreira), the *comprehension* of a switch is potentially cognitively demanding for the listener (*Section 3.5*). Consider Noah, who produced '*flèche*' instead of '*arrow*' in (1b) (p.138). While this switch may have infinitesimally sped up the transmission of the message (for Noah), it probably also infinitesimally slowed down the reception of the message (for his partner, Bertrand). The speaker-listener (or production-processing) push-and-pull may essentially cancel out task efficiency effects, leading to null results.

Note that these two possibilities (code-switching is cost-effective, or code-switching amounts to a zero-sums-game) are not mutually exclusive. Switching strategically can be beneficial from a production standpoint, but still lead to comprehension costs for the listener. A more complete (qualitative) analysis of code-switching in FEBLOC would be required to answer the question of task efficiency.

5.5.2 Familiarity breeds code-switching similarity

Exploratory analyses revealed that members of the same FEBLOC pair largely exhibited similar code-switching habits. Indeed, when the explanatory variable of 'Pair' was added to the regression models, the variance explained for code-switching proportions was greatly improved. It is difficult to disentangle whether this reflects within-pair mirroring during the speech elicitation tasks (i.e., a state effect), or whether pair members speak alike because they are well-known to each other and presumably originate from similar sociolinguistic communities (i.e., a trait effect). I venture to hypothesize that the second option is likelier, as code-switching difference scores were inversely related to the bilinguals' frequency of real-world interactions: pairs who reported communicating 'every day or nearly every day' showed the most similar code-switching proportions. Furthermore, the difference in code-switching behaviours within two outlier pairs (pair02 and pair18) is hard to account for under the mirroring hypothesis (though see *Section 5.5.4* for a possible explanation about pair18).

While members of the same pair used language similarly, their code-switching proportions were not modulated by their relationship type. The fact that relationship type (couple, 1st-degree relative, other relative, friends) did not impact code-switching outcomes suggests that somewhat more lax recruitment techniques are acceptable when it comes to collecting corpus data. Researchers should feel comfortable in recruiting bilingual pairs regardless of their relationship in the real world, as long as they are members of the same in-group in some capacity.

5.5.3 Women as the drivers of linguistic change, including in code-switching

Previous research, including my own, has shown that women code-switch more than men (Dewaele & Li, 2014; Gosselin & Sabourin, 2023a). These studies were based on self-reports, which can be gender-biased (Sigmon et al., 2005). As such, the objective code-switching proportions in FEBLOC were examined in relation to the sex and age of the speakers who produced them. Exploratory analyses pointed towards the fact that women in the FEBLO-Corpus (particularly young women) indeed code-switched more than their male counterparts.

Why might women code-switch more habitually? One well-established finding in sociolinguistics is that women are the drivers of linguistic change. Working-class women are more innovative in their language usage, presumably in an effort to obtain "upward social mobility" (Labov, 1990: 214). This gender-based effect is not unique to unilingual environments, as it has been observed in situations of language contact. One example is the pronoun rate among Spanish-English bilinguals in New York City (Shin & Otheguy, 2013). While Spanish is traditionally a pro-drop language, immigrant women are the leaders of a change towards increased (English-like) pronoun rates in Spanish.

A wealth of research shows that code-switching is governed by systematic morphosyntactic rules (e.g., MacSwan, 2000; Poplack, 1980). Just like unilingual speech, not all utterances are acceptable. For instance, *Section 4.5.3* showed that FEBLOC speakers regularly attach French conjugation to English verbs (e.g., 'shuffler', shuffle$_{EN}$ + ER$_{FR}$), but not vice versa. In line with the robust gender-based sociolinguistic effects, I speculate that women are the drivers of 'code-switching grammar', and lead the change towards more innovative code-switching variants. As an idiosyncratic example, the only attestation of a French verb + English morphology ('débording', déborde$_{FR}$ + ING$_{EN}$) in the corpus was produced by Molly (pair19), the youngest FEBLOC speaker, and a woman.

A completely unrelated possibility is that women are better at managing cognitive control demands, and thus can code-switch more frequently. Large-scale research has indeed demonstrated that women exhibit better baseline EF, but steeper declines with age (Levine et al., 2021). Furthermore, women may be more positively impacted by bilingualism compared to men (i.e., increased EF performances: Subramaniapillai et al., 2019); diverse language usage in some contexts even reduces menopause-related cognitive decline (Duval et al., 2024). If women possess excellent baseline EF, they are perhaps better at managing activation-inhibition mechanisms in order to produce cost-effective code-switches. With this in mind, it is possible that sex differences in FEBLOC code-switching proportions have an underlying biological cause, rather than a sociolinguistic cause.

5.5.4 The causes/consequences of between-speaker switching

Two interesting findings were unique to between-speaker switching during the exploratory analyses. First, more frequent between-speaker switching was marginally related to decreased performance (i.e., producing more penalties) during the Bilingual Taboo activity. Second, producing higher proportions of between-speaker switching was marginally associated to decreased proficiency in English, and greater exposure to French during infancy (from birth to two years).

These findings suggest that between-speaker switches are more likely to be produced by less balanced bilinguals (skewed proficiency, skewed childhood exposure). Between-speaker switches also appear to represent lapses in cognitive control, as they are positively associated with slip-ups' during Bilingual Taboo (i.e., accidentally producing an 'inhibited' taboo word). In my view, both of these findings are related: unbalanced bilinguals must work hard to inhibit a highly activated L1. When such inhibition mechanisms falter (or are given up), unbalanced bilinguals revert to their L1, regardless of the language used by the conversational partner. Nevertheless, we know that bilinguals can maintain the language of conversation with monolinguals, even if they are unbalanced. This means that between-speaker switching may have been used strategically: unbalanced FEBLOC speakers could release effortful inhibition and revert to their L1 (i.e., produce a between-speaker switch), as they knew that there was no risk of compromising communication with their bilingual partner. One good example of this is from pair18 (Aaron and Virginie). Aaron's first and most dominant language was English, while Virginie's first and most dominant language was French. These speakers produced much more between-speaker switches (20% for Aaron, 36% for Virginie) than the average of the sample (*M*=9%).

Altogether, these exploratory findings indicate that distinct cognitive-linguistic processes may be at play for between-speaker switching compared to within-speaker switching (intra-CS or inter-CS). Between-speaker switching is extremely understudied: very little research has examined multiparty interactions, and I am not aware of any questionnaire which specifically probes between-speaker switching (e.g., "Rate how often you reply in French when you've been spoken to in English"). Interestingly, between-speaker switching (into French) was also the only accurately self-evaluated behaviour on the self-reports (see the subsequent section). In any case, this behaviour merits further examination; it is evidently an important part of bilingual interactions.

5.5.5 Self-reported code-switching measures are not very reliable

Of the thirty experiments summarized in the literature review of CHAPTER 3 (**Table 3.4**), only roughly 13% operationalized code-switching objectively via the analysis of spontaneous speech (four studies: Han et al., 2024; Keijzer & Schmid, 2016; Lai & O'Brien, 2020; Yim & Bialystok, 2012). Given that self-reports are the dominant tool in the literature, the question stands as to whether bilinguals' can accurately self-evaluate their code-switching habits. FEBLOC allowed for this to be tested empirically, since self-reports (BSwQ) were collected alongside the operationalization of objective code-switching proportions.

The exploratory analyses demonstrated that FEBLOC bilinguals were generally inaccurate (and sometimes, outright contradictory) in self-reporting their code-switching habits. For instance, FEBLOC speakers who produced the highest proportions of intra-CS self-reported significantly *less* switching into English, even though intra-utterance switches most typically include English insertions into French. They also reported marginally *more* contextual switching, even though contextual switches are usually associated to alternations (i.e., inter-CS), not intra-utterance switching (Green & Abutalebi, 2013). Most damningly, FEBLOC speakers with higher proportions of French-to-English inter-utterance switching self-reported *less* frequent switches into English ('FR-to-EN' component on the BSwQ). This result is especially concerning given that inter-CS (into English) and the FR-to-EN component seemingly represent completely overlapping concepts.

One slightly reassuring result is between-speaker switching: bilinguals who reported more switching into French (without distinguishing between- and within-subject switching) did indeed frequently alternate towards French after an English utterance produced by their pair member. Perhaps speakers are more cognizant of producing between-speaker switches, as they reflect moments of emotionally salient linguistic insecurity (i.e., reverting to an L1; see *Section 2.1.4*).

Overall, the exploratory analysis suggests that researchers should be somewhat weary of conclusions based solely on self-reports. It is likely not the case that self-reported measures simply represent noise; after all, much of the cognitive code-switching literature has yielded significant results that are mostly coherent. Some studies have even observed even independent inhibitory control correlates for self-reports compared to objective measures (Han et al., 2024; Lai & O'Brien, 2020). Surely, self-reports tap into *something,* but it is not clear *exactly what* they index in terms of code-switching habits.

What *is* clear is that, similar to other empirical verifications (Han et al., 2024; Lai & O'Brien, 2020; cf. Cox et al., 2020; see also Woumans et al., 2019 for switching in a semantic fluency task), FEBLOC yielded little-to-no relationship between objective and subjective code-switching measures. Future research should prioritize the analysis of spontaneous data in order to operationalize code-switching. In addition, it will be important to continue investigating the seemingly distinct relationships involving subjective and objective code-switching and executive functioning, particularly among larger sample sizes. Collecting (and comparing) both types of data may lead to a better understanding of exactly what the self-reports underlyingly represent.

5.6 Chapter conclusion

The present chapter detailed a series of exploratory analyses. In so far as the limited sample size is considered, preliminary findings were interpreted as follows: i) FEBLOC speakers produced cost-effective switches, which neither increased nor decreased their task efficiency; ii) speakers of the same pair code-switched similarly; iii) FEBLOC women code-switched more, supporting their role in language innovation; iv) between-speaker switching was a marker of less balanced bilingualism and/or lapses in inhibition; and v) FEBLOC speakers were inaccurate in self-evaluating their code-switching habits.

The subsequent chapter utilizes FEBLOC in order to answer one of the primary questions of the dissertation: Is producing and processing code-switches different? What is the impact of code-switching modality on inhibitory control?

CHAPTER 6: Disentangling the relationship between inhibitory control *et la modalité du* code-switch

6.1 Introduction

Code-switching production and processing studies are often seen as symbiotic. For instance, the code-switching processing cost has been questioned by researchers who remark on the apparent fluent production of code-switches (e.g., Gosselin & Sabourin, 2021). In parallel, bilingual production models simulating costly switching mechanisms (e.g., Green & Abutalebi, 2013) are often applied to processing studies. This is what I have called the modality conflation issue in CHAPTERS 2 and 3.

Importantly, a broad review of the literature suggests that the costs (or lack thereof) involved in producing and processing code-switches are not necessarily equivalent. Production is inherently self-controlled and its costs can be mitigated by internal bottom-up conditions, such as lexical accessibility. By contrast, processing (i.e., what is being heard) is entirely determined by the conversational partner; an individual must process code-switches 'on the fly' when they occur. It has thus been proposed that bilingual production is a proactive process, while bilingual comprehension is a reactive process (e.g., Declerck, 2020; Garbin et al., 2011).

Given that previous studies have found positive associations between code-switching and inhibitory control (Gosselin & Sabourin, 2023b; Han et al., 2022, 2024; Hartanto & Yang, 2020; Hofweber et al., 2020a; Jylkkä et al., 2020; Kheder & Kaan, 2021; López-Penadés et al., 2020; Ooi et al., 2018; Thanissery et al., 2020; Verreyt et al., 2016; Yow & Li, 2015), we may ask whether it is the processing and/or the production of code-switches that ultimately trains bilinguals' EFs. In other words, once we determine which part of code-switching is costly, this could lead to a better understanding of controversial bilingualism-based EF effects. To my knowledge, production and processing have not been disentangled in a single experimental session, even though all (oral/signed) natural conversations involve both speakers and listeners. The present chapter teases apart the effects of production and processing on inhibitory control by utilizing FEBLOC. The primary goal was to unify the experimental linguistic literature and the neurocognitive EF literature in order to help resolve the modality conflation issue.

6.1.1 Present study

Importantly, FEBLOC speech elicitation activities were accomplished in pairs. This means that all recorded interactions include both modalities: participants *produced* their own utterances and *processed* the utterances transmitted by their testing partner. Importantly, the FEBLOC speakers also completed a traditional Flanker task after the speech elicitation activities. The present study thus utilizes the corpus described in CHAPTER 4 in order to calculate the proportions of produced and heard code-switches for each participant; these modality-specific proportions are then related to the bilinguals' inhibitory control performance on the subsequent Flanker task. The present study is guided by the following research questions:

(1) **Primary Q**: How does code-switching modality and type impact inhibitory control?

  a. **Q1:** Is it the frequent production or the frequent processing of code-switching that leads to increased inhibitory control?

  b. **Q2:** Are there inhibitory control differences according to switch type?

Based on the inherent differences between producing and processing, it was hypothesized that producing switches would be generally linked to decreased inhibitory control performance (e.g., longer RTs, larger inhibition effects) and that processing switches would be linked to increased inhibitory control performance (e.g., shorter RTs, smaller inhibition effects). Given that the ACH (Green & Abutalebi, 2013) posits that alternation-type code-switches demand the most cognitive resources, I conjectured that producing intra-utterance and between-speaker switches would be particularly detrimental for inhibitory performance (compared to producing inter-utterance switches). I did not anticipate that switch type would modulate the beneficial impact of processing switches.

6.2 Methods

6.2.1 Participants

The final sample consist of the 38 bilinguals (*M* age= 33.8 years, *SD*=17.0 years, 17-61 years; 25 female, 13 male) described in CHAPTER 4 (i.e., the 19 FEBLOC pairs). In brief, the participants were native and/or near-native speakers of both English and French, with no substantial knowledge of an additional language. All individuals possessed normal or corrected-to-normal hearing and vision and no history of language disorders.[1] They were recruited via word-of-mouth, social media, in-class announcements at the University of Ottawa, and through the University of Ottawa Integrated System of Participation in Research (ISPR) pool. An extensive description of their demographic and language background can be found in *Section 4.1*.

6.2.2 Procedure

Upon arriving to the lab, both participants completed the pair questionnaire then proceeded to the speech elicitation activities. Recall that these activities (fully described in *Section 4.2*) were completed as a team, in a private room away from the experimenter. After the speech activities were concluded (approximately one hour into the experimental session), the participants returned to the main testing space and were each seated at a laptop (facing away from each other; see **Figure 6.1**). The participants completed the Flanker task individually, then ended the session with the demographic, language background, and code-switching questionnaires.

6.2.3 Flanker task

The Flanker task was used to operationalize the participants' non-linguistic cognitive control. During the Flanker task, arrows are presented on a computer screen. Participants are instructed to indicate the direction of the central arrow (while ignoring the peripheral

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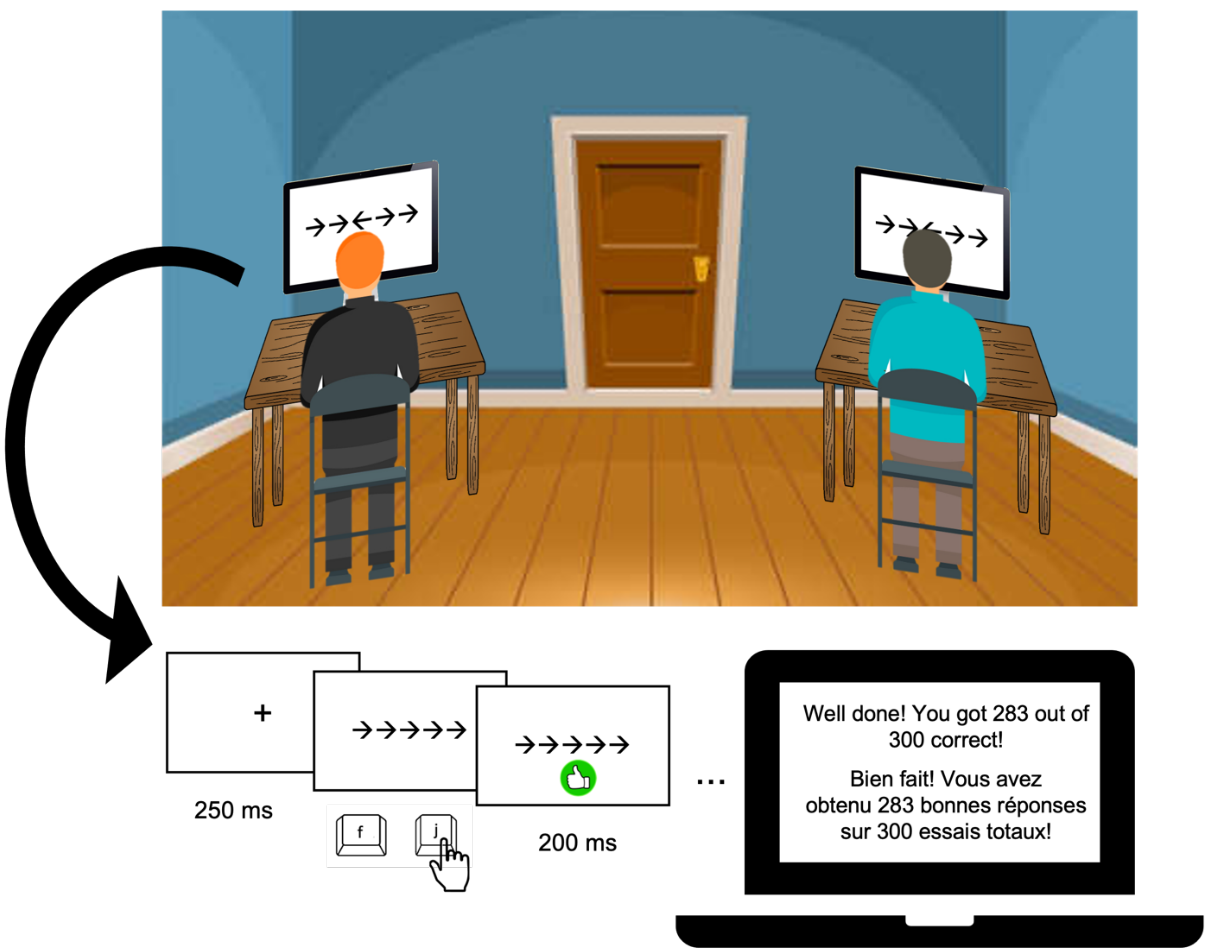
[1] One participant reported an ADHD diagnosis that was not presently being treated. Analyses completed without this individual yielded the same results as those reported in *Section 6.3*. As such, the participant was retained in the final sample.

symbols) by pressing a button on their keyboard. Arrows are presented in congruent, incongruent or neutral conditions. In the congruent condition, five arrows appear on the screen, all facing the same direction (e.g. → → → → →). In the incongruent condition, five arrows appear on the screen, with the central arrow pointing in the opposite direction of the flanking arrows (e.g. → → ← → →). In the neutral condition: one arrow appears on the screen, with two dashes on either side as flankers (e.g. — — → — —). The idea is that participants must inhibit the flanking arrows during incongruent trials; these targets thus engender longer RTs. By contrast, participants can benefit from matching flanking arrows during congruent trials; these targets thus generate more rapid RTs.

The current Flanker task was presented on a 15-inch laptop (1536 x 864 resolution) via the Gorilla Experiment Builder interface (Anwyl-Irvine et al., 2020). It follows the design of Gosselin and Sabourin (2023b), available for previewing and testing here. There were 10 practice trials and 300 fully randomized experimental trials (100 congruent, 100 incongruent, 100 neutral; equally split between left-facing and right-facing targets). Participants were given the option to take a break every 50 trials. A single trial is depicted in **Figure 6.1**: a fixation cross was first presented for 250 ms. Next, the target and its flankers appeared in black font over a white screen. All participants were instructed to press 'f' (the left-most keyboard option) with their left hand when the target-arrow faced left, and to press 'j' (the right-most keyboard option) with their right hand when the target faced right. The task flow did not proceed until a keyboard response was selected. Participants received feedback for 200 ms after each individual trial. A green thumbs-up appears in the case of correct responses, and a red thumbs-down appears in the case of an incorrect response. To keep the experiment interactive, participants saw their 'score' (proportion of correct responses) at the end of the practice trials and at the end of the task.

The participants' RTs and accuracy were recorded. The former was the dependant variable of interest (*Section 6.2.5*), while the latter was solely used for the purpose of data cleaning (*Section 6.2.4*) and verification of satisfactory participant attention. Every participant completed all 300 experimental trials. This took 5-9 minutes (*M*=7 minutes, *SD*=0.8 minutes).

Figure 6. 1. Top: Layout of the room during the Flanker task. Bottom: trial-by-trial design of the Flanker task.



6.2.4 Modality-specific code-switching measures

In order to investigate the relationship between inhibitory control and code-switching according to modality, the participants' proportion of produced and heard switches was computed by utilizing FEBLOC. Recall that the FEBLO-Corpus contains fully coded transcriptions, wherein utterances are attributed a condition (unilingual, intra-CS, inter-CS, between-CS), often based on the preceding utterance. Two types of coding are applied in FEBLOC. In time-linear coding, each target utterance is coded based on utterance *n-1* immediately preceding it in time. In speaker-grouped coding, each target utterance is coded based on utterance *n-1* produced by the same speaker. This distinction is crucial when it comes to teasing apart produced and heard switches. To illustrate, here is a passage of conversation from pair0.1 (Sarah and Mary).

(2) **Pair0.1, Sarah and Mary (1196 secs)**:

```
1.   *FIR:  +< [- fra] y'a [: il y a] des poules oui .
2.   *SEC:  [- eng] an:d they're pecking ?
3.   *FIR:  [- fra] oui .
4.   *SEC:  okay@s:eng&fra .
5.   *SEC:  [- eng] &-uh are they white and: red ?
6.   *FIR:  [- fra] non .
7.   *FIR:  [- fra] sont toutes blanches .
8.   *SEC:  [- fra] sont +//.
9.   *FIR:  +< [- eng] so there's a difference .
```

In time-linear coding, target utterance [9] would be coded based on the antecedent utterance [8]; it would thus be attributed the condition of a between-speaker code-switch. In speaker-grouped coding, target utterance [9] would be coded based on the last utterance also produced by *FIR (Sarah), utterance [7]; it would thus be attributed the condition of an inter-utterance (within-speaker) code-switch. Speaker-sorted coding is important for the modality of production: when a speaker produces an utterance, they select a language schema; this selection may not shift until the speaker themselves produces another utterance in a different language. That is, a switch is *produced* by a speaker even if there is interim (same-language) content from the partner. Conversely, *hearing* occurs in a purely time-linear fashion, as speakers also 'hear' and process their own productions. This means that utterance [9] in example (2) would be considered a *produced* inter-utterance switch for Sarah (her last production was in the opposite language), but a *heard* between-speaker switch for Sarah (the last utterance she heard was in the opposite language).

In CHAPTER 4 (*Section 4.4.3*), equations used to calculate code-switching proportions were described (repeated in **Table 6.1** for convenience). In reality, these measures represent the proportion of *produced* switches. Additional formulas are needed to also calculate the proportion of switches *heard* by participants (see **Table 6.1**). Note that *heard* proportions are based on FEBLOC partner utterances (represented by *j* indices in the table below). For instance, Sarah's proportion of heard intra-CS corresponds to Mary's produced intra-CS divided by Mary's total utterance count.

Overall, this means that six objective code-switching indices are computed for each participant: i) %Produced intra-CS; ii) %Produced inter-CS; iii) %Produced between-CS; iv) %Heard intra-CS; v) %Heard inter-CS; vi) %Heard between-CS. In other words, %Produced and %Heard indices each contain three levels according to code-switching type.

Table 6. 1. Indices used to operationalize proportion produced and heard code-switches for participants.

	Index	Description	Equation
PRODUCING	**intra-CS**	Divide the count of utterances coded as intra-CS **for a given speaker** by the total number of included utterances for that speaker.	$\%\text{prod intra}-\text{CS}_i = \dfrac{n \text{ intra}-\text{CS}_i}{n \text{ included}_i}$
	inter-CS	Divide the count of *speaker-grouped* utterances coded as inter-CS **for a given speaker** by the total number of included utterances for that speaker.	$\%\text{prod inter}-\text{CS}_i = \dfrac{n \text{ SG inter}-\text{CS}_i}{n \text{ SG included}_i}$
	between-CS	Divide the count of *time-linear* utterances coded as between-CS **for a given speaker** by the total number of included utterances coded for that speaker.	$\%\text{prod btwn}-\text{CS}_i = \dfrac{n \text{ TL btwn}-\text{CS}_i}{n \text{ TL btwn}_i}$
HEARING	**intra-CS**	Divide the count of utterances coded as intra-CS **for the other pair member** by the total number of included utterances for that other pair member.	$\%\text{heard intra}-\text{CS}_i = \dfrac{n \text{ intra}-\text{CS}_j}{n \text{ included}_j}$
	inter-CS	Divide the count of *time*-linear utterances coded as inter-CS **for the other pair member** by the total number of included utterances for that other pair member.	$\%\text{heard inter}-\text{CS}_i = \dfrac{n \text{ TL inter}-\text{CS}_j}{n \text{ TL included}_j}$
	between-CS	Divide the count of *time-linear* utterances coded as between-CS **for the other pair member** by the total number of included utterances for that other pair member.	$\%\text{heard btwn}-\text{CS}_i = \dfrac{n \text{ TL btwn}-\text{CS}_j}{n \text{ TL btwn}_j}$

Note: i = FEBLOC speaker (e.g., pair01A); j = FEBLOC partner (e.g., pair01B). TL = time-linear; SG = speaker-grouped.

6.2.5 Cleaning the Flanker data

In order to preserve as much variability in the Flanker RTs as possible (see Hedge et al., 2018; and discussion in *Section 3.4.1*), a conservative cleaning procedure was applied to the data. First, incorrect trials were excluded (377 data points, or 3.3% of the data). As expected, participants were highly accurate during the Flanker task (*M*=96.7%, *SD*=3.7%, *range*=81-100%); given this high homogeneity in the sample (and quasi ceiling effects), no analyses were conducted on the accuracy data.

Next, trial-by-trial data points were excluded on the basis of absolute minimum (< 150 ms) and maximum (> 1500 ms) thresholds (see Gosselin & Sabourin, 2023b; Gullifer et al., 2013; Hartanto & Yang, 2016, 2020; Kałamała et al., 2020; López-Penadés et al., 2020 for comparable methods). Absolute thresholds resulted in the exclusion of 35 additional data points (<1% of data). Relative within-participant and between-participant thresholds were not applied. After cleaning, all participants preserved at least 75% of data points (*M*=96.4%, *SD*=4.3%, *range*=76-100%), and were retained for the analyses.

6.2.6 Analyses[2]

Linear mixed model analyses were conducted on the Flanker RTs by using the `lme4` and `lmerTest` packages in R (version 4.21). Since RTs are known to violate the assumption of normal distribution (they are inherently positively-skewed; Jensen, 2006), they were log transformed before being entered into the models (e.g., Alrwaita et al., 2022, 2024; Jylkkä et al., 2017; Kałamała et al., 2020; Kheder & Kaan, 2021; Yang et al., 2023).

The mixed models contained two categorical fixed factors: CONGRUENCY (incongruent, congruent, neutral), and CS-TYPE (intra-CS, inter-CS, between-CS). Recall that inhibitory control is usually operationalized by comparing trial conditions; the fixed factor of CONGRUENCY was thus contrast coded. The first contrast (CON1) compares incongruent and

[2] The full data set and the scripts used to conduct the described analyses (including the cleaning procedure) are included on OSF.

neutral trials (incongruent= 1, congruent=0, neutral=-1). The second contrast (CON2) compares congruent and neutral trials (incongruent=0, congruent=1, neutral=-1). As such, a significant result for CON1 (or an interaction involving the contrast) can be viewed as a modulation of the inhibition effect, while a significant result for CON2 (or an interaction involving the contrast) can be viewed as modulation of the facilitation effect. This type of contrast coding makes the analyses much more powerful (and ecological), as trial-by-trial data (with increased variance) are inputted into the model, rather than by-subject aggregate effects.

The second categorical fixed factor (CS-TYPE) was Helmert coded. This type of coding compares a given level of a variable to the level(s) which precede(s) it. The first defined contrast (TYPE1) compares intra-utterance and inter-utterance code-switches (intra-CS=-1, inter-CS=1, between-CS=0). The second defined contrast (TYPE2) compares the mean of intra- and inter-utterance switches to between-speaker switches (intra-CS=-1, inter-CS=-1, between-CS=2). Helmert coding was implemented as it allows for both the comparison of different types of within-speaker switching (TYPE1), and the comparison of within-speaker switching overall with between-speaker switching (TYPE2). The exploratory analyses in CHAPTER 5 indeed bolster the idea that between-speaker switching involves distinct mechanisms from within-speaker switching.

Next, two continuous fixed factors were included in the model: %PRODUCED (proportion of switches produced), and %HEARD (proportion of switches heard). These continuous factors were allowed to interact with both CONGRUENCY (e.g., %Produced could modulate the inhibition effect only) and/or TYPE (e.g., %Produced could modulate RTs, but only for between-CS).

Several covariates are known to impact RTs on inhibitory control tasks, such as age (Bialystok et al., 2004), education level (Dorbath et al., 2013), video-game habits (Bialystok, 2006) and language-dominance (Gathercole et al., 2014). An initial model was built wherein these covariates were allowed to interact with CONGRUENCY (with by-subject and by-item random intercepts). A second model was built with only Age[3] as a covariate (interacting with CONGRUENCY), and a final model was built with no covariates. A comparison using the `anova` function revealed that the more complex model (conserving all the covariates) was by far a better fit (Chi^2=308.99, p<.0001).

As such, the final model included i) the predictors of %PRODUCED and %HEARD, which could interact with CS-TYPE and Flanker CONGRUENCY; ii) the covariates of age, education, video-game habits, and degree of balance, which could each interact with Congruency; iii) by-subject and by-item (i.e., left-pointing or right-pointing target arrow) random intercepts.[4] The final model is written out in (3), following the `lmer` syntax in R.

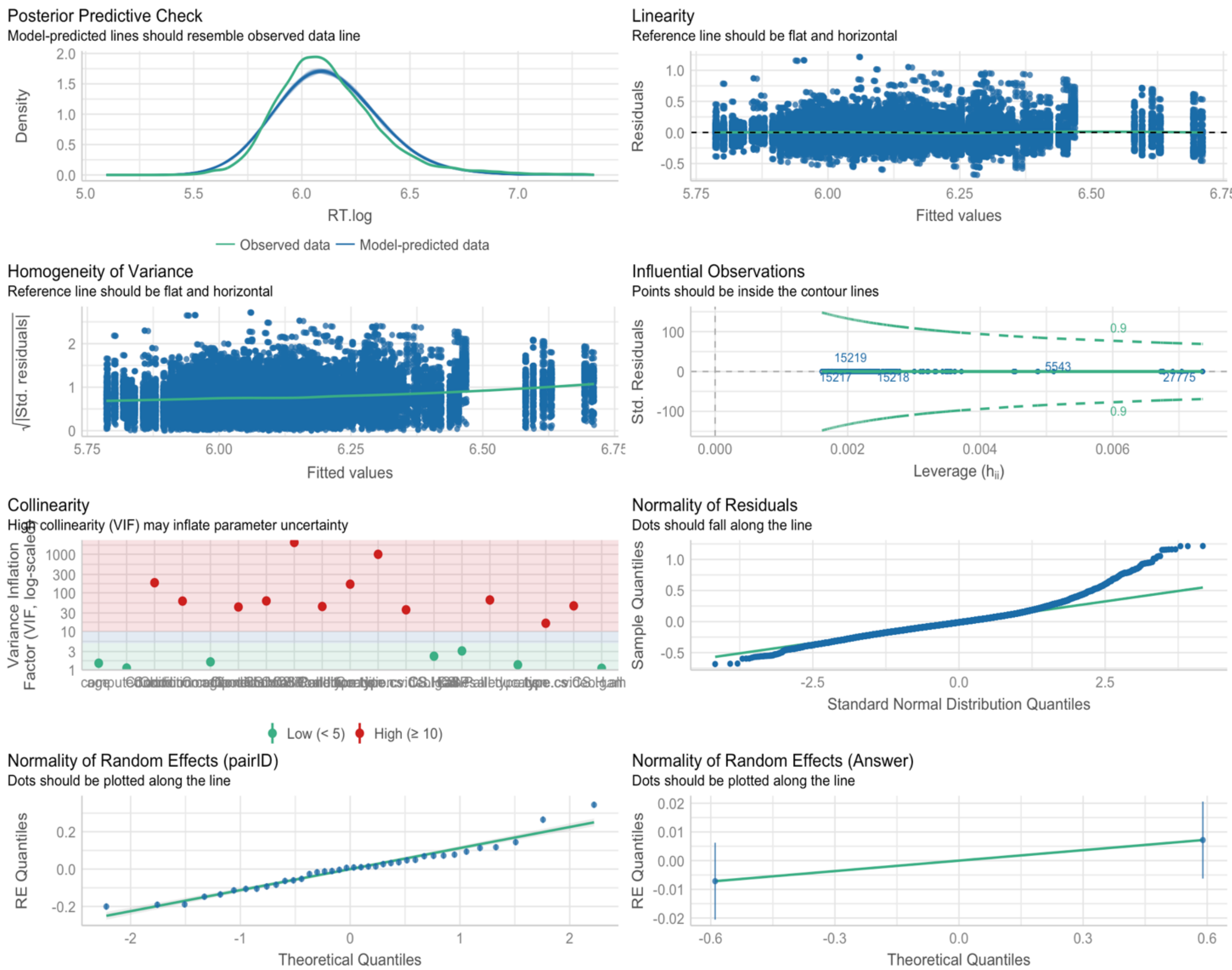
(3)
```
lmer(RT.log ~ (Congruency * %Produced * Type) + (Congruency *
%Heard * Type) + (Congruency * (age + education + video.games +
balance) + (1|subject) + (1|item), data=df)
```

The output of the `check_model` function suggests that prerequisite assumptions were met and that linear mixed models were appropriate for the data (see **Figure 6.2**). Note that the high variance inflation factor (VIF) is artificially inflated by the interactions in the

[3] This model was attempted since only Age yielded a significant main effect on Flanker RTs.
[4] The model failed to convergence when by-Congruency random slopes were added.

model; a by-subject correlation matrix including %Produced, %Heard, age, education, video game habits, and degree of balance confirms that collinearity was not problematic (*r*s ≤.45; Plonsky & Ghanbar, 2018).

Figure 6. 2. Assumptions of the final model (`check_model` function).



In the case of significant effects involving categorical factors, planned comparisons were conducted with the `emmeans` package (with a Tukey correction applied for multiple comparisons); in the case of significant effects or interactions involving continuous factors, slopes were examined via the `emtrends` function of the same package. Finally, fitted models figures were built using `emmips::emmeans` and `ggplot2`.

Post-hoc power analyses

A priori power analyses are reported in the pre-registration of this project (https://osf.io/7je9n). However, these power analyses were conducted for Flanker aggregate effects (using the multiple linear regression option with fixed effect R^2 increase in G*Power) and therefore ignore random effects. This method likely underestimates the power of the analysis, as it assumes a single aggregate observation for each subject, rather than (up to) 300 observations (or 100 observations per level of Congruency) for each subject.

To remedy this, post-hoc 'observed' power analyses were conducted in R by using `powerSim::simr` (nsim=100). This package computes the statistical power of a (trial-by-trial) linear mixed model by using simulations. To start, covariates were dropped to simplify the model (i.e., `lmer(RT.log ~ (Congruency * %Produced * Type) + (Congruency * %Heard * Type) + (1|subject) + (1|item), data=df`). This primary model was compared to additional models wherein target fixed effects were removed. For instance, when the primary model is compared to a model containing only `RT.log ~ %Produced` (with the same random effect structure as the primary model), this allows us to verify the power estimate for `Congruency * %Heard * Type` (i.e., the most complex interaction for %Heard). Likewise, when the primary model is compared to a model containing only `RT.log ~ %Heard` this allows us to verify the power estimate for `Congruency * %Produced * Type` (i.e., the most complex interaction for %Produced). In both cases, the returned observed power was well over the accepted 80% threshold (*95%CI* =96-100%).

6.3 Results

The results of the main model are reported in **Table 6.2** (covariates) and **Table 6.3** (primary predictors). The random variance was larger for subjects (σ^2=.0148, *SD*=.1219) compared to items (σ^2=.0001, *SD*=.0102). When only fixed effects/covariates are considered, the model explained 28% of the data (*marginal* R^2=.280); when both fixed effects/covariates and random effects are considered, the model explained 54% of the data (*conditional* R^2=.536. In order to facilitate model interpretability, the results are divided into several subsections below.

Table 6. 2. Results of the fitted linear mixed-effects model. Only the fixed effects involving covariates (and their interactions) are shown here. Note that "Congruency1" contrasts incongruent and neutral trials; "Congruency2" contrasts congruent and neutral trials. Significant effects and interactions are highlighted in green. Significance levels are indicated as follows: p<.10 •, p<.05 *, p<.01 **, p<.001 ***.

Fixed effects	*Estimate*	*SE*	| *t* |	Interpretation
Age	.0064	.0014	4.39***	global effect for age
Education	-.0134	.0136	0.98	*ns*
Video-games	-.0193	.0211	0.91	*ns*
Balance	.0127	.0103	1.23	*ns*
Age * Congruency1	<.0001	<.0001	0.70	*ns*
Age * Congruency2	.0002	<.0001	2.65**	facilitation effect * age
Education * Congruency1	-.0089	.0009	9.75***	inhibition effect * education
Education * Congruency2	.0039	.0009	4.39***	facilitation effect * education
V-games * Congruency1	.0041	.0014	2.90**	inhibition effect * video-games
V-games * Congruency2	-.0059	.0014	4.20***	facilitation effect * video-games
Balance * Congruency1	.0080	.0007	11.08***	inhibition effect * dominance
Balance * Congruency2	-.0013	.0007	1.80 •	facilitation effect * dominance

```
lmer(RT.log ~ (Congruency * %Produced * Type) + (Congruency * %Heard * Type)
+ (Congruency * (age + education + video.games + dominance)) + (1|subject) +
(1|item), data=df)
```

Table 6. 3. Results of the fitted linear mixed-effects model. The main predictors (and their interactions) are shown here. Note that 'Congruency1' contrasts incongruent and neutral trials, while 'Congruency2' contrasts congruent and neutral trials. 'Type1' contrasts intra-CS and inter-CS, while 'Type2' contrasts within-CS (inter + intra) and between-CS. Significant effects and interactions are highlighted in green. Significance levels are indicated as follows: p<.10 •, p<.05 *, p<.01 **, p<.001 ***.

Fixed effects	*Estimate*	*SE*	*| t |*	Interpretation
Congruency1	.1141	.0048	23.96***	inhibition effect
Congruency2	-.0050	.0047	10.62***	facilitation effect
%Produced	<.0001	.0347	<0.01	*ns*
%Produced * Type1	<.0001	.0314	<0.01	*ns*
%Produced * Type 2	-.0003	.0180	0.02	*ns*
%Produced * Congruency1	-.1486	.0321	4.64***	inhibition effect * producing
%Produced * Congruency2	.0789	.0317	2.49*	facilitation effect * producing
%Prod * Con1 * Type1	.0943	.0395	2.38*	inhibition effect for produced intra vs. inter
%Prod * Con2 * Type1	-.0621	.0391	1.59	
%Prod * Con1 * Type2	-.0135	.0220	0.62	
%Prod * Con2 * Type2	-.0231	.0218	1.06	
%Heard	-.0033	.0400	.08	
%Heard * Type 1	.0019	.0363	0.03	
%Heard * Type 2	.0013	.0204	0.07	
%Heard * Congruency1	-.0790	.0383	2.07*	inhibition effect * hearing
%Heard * Congruency2	.0250	.0378	0.66	
%Heard * Con1 * Type1	-.0528	.0473	1.12	
%Heard * Con2 * Type1	.0220	.0467	0.47	
%Heard * Con1 * Type2	.0540	.0247	2.19*	inhibition effect for heard within vs. between
%Heard * Con2 * Type2	.0032	.0244	0.13	

```
lmer(RT.log ~ (Congruency * %Produced * Type) + (Congruency * %Heard * Type)
+ (Congruency * (age + education + video.games + dominance)) + (1|subject) +
(1|item), data=df)
```

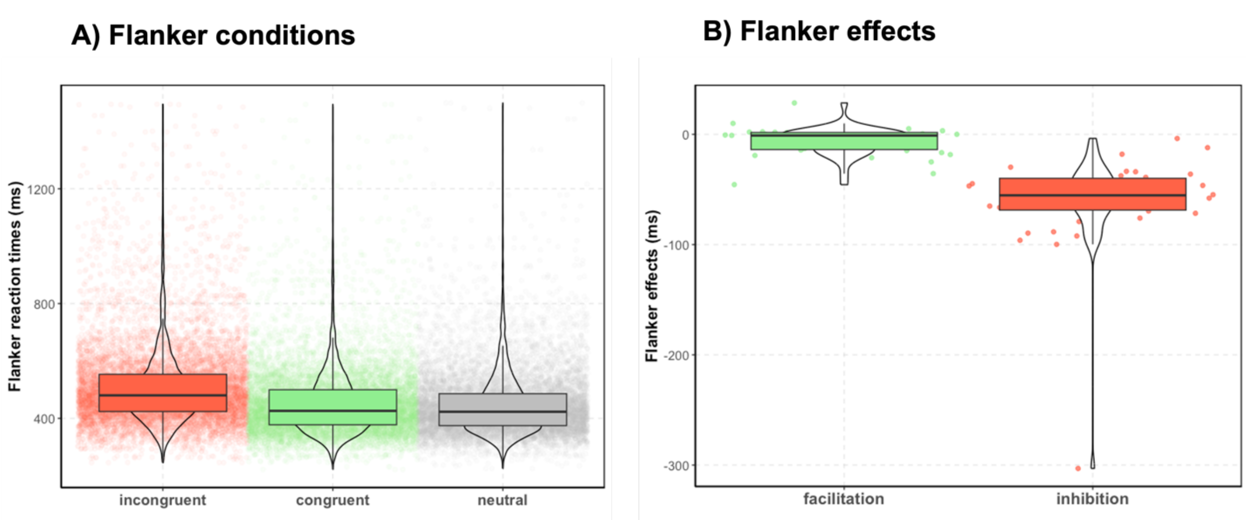
6.3.1 Flanker effects

Recall that both inhibition effects (incongruent vs. neutral trials) and facilitation effects (congruent vs. neutral trials) are expected during the Flanker task. Descriptive RTs according to Flanker condition as well as by-subject Flanker effects (global RTs, inhibition, facilitation) are indicated in **Table 6.4** and presented visually in **Figure 6.3**.

Table 6. 4. Flanker task descriptives. Facilitation=$M_{neutral} - M_{congruent}$; inhibition= $M_{neutral} - M_{incongruent}$.

Conditions/Effects		Mean	SD	Range
Conditions	**Incongruent**	507.7	98.6	368.1 – 814.3
	Congruent	452.5	85.3	334.6 – 791.3
	Neutral	446.6	78.8	336.6 – 755.6
Effects	**Global**	468.1	85.4	350.8 – 786.6
	Inhibition	-61.1	46.2	-303.0 – -3.7
	Facilitation	-5.9	13.0	-45.6 – 28.5

Figure 6. 3. Boxplots (with jitter and violin overlay) of Flanker task descriptives.



The relevant portion of the model that tests these Flanker effects are the two Congruency contrasts (Congruency1, Congruency2). The first contrast confirms that a significant difference was observed between incongruent and neutral trials (*Est*=.1141, *SE*=.0048, *t*=23.98, *p*<.0001), and between congruent and neutral trials (*Est*= -.0050, *SE*=.0047, *t*=10.62, *p*<.0001). Planned comparisons indicated that, as expected, incongruent RTs were significantly longer than neutral RTs (estimated marginal means: incongruent=6.19, *95%CI*=6.15–6.24; neutral=6.08, *95%CI*=6.04–6.12). However, contrary to prediction, congruent trials were also significantly longer than neutral trials (estimated marginal means: congruent=6.09, *95%CI*=6.05–6.13; neutral=6.08, *95%CI*=6.04–6.12), though this difference was descriptively small in size (and congruent/neutral conditions possessed largely overlapping confidence intervals). Indeed, **Table 6.3** shows that participants displayed a sizable inhibition effect (*M*= -61.1 ms), but no positive facilitation effect on average (*M*= -5.9 ms).

Overall, the model confirms the presence of expected inhibition effects, but not expected facilitation effects. The lack of a facilitation effect across the sample is reminiscent of the Flanker task conducted in Gosselin and Sabourin (2023b), where 217 French-English bilinguals displayed an average facilitation effect of -1.76 ms, but with relatively large inter-subject variability (*SD*=14.63 ms). Paired with the lack of split-half reliability for this effect (see *Section 6.3.4*), this does not lend much confidence to the existence of meaningful facilitation effects in the traditional Flanker task.

6.3.2 Covariates

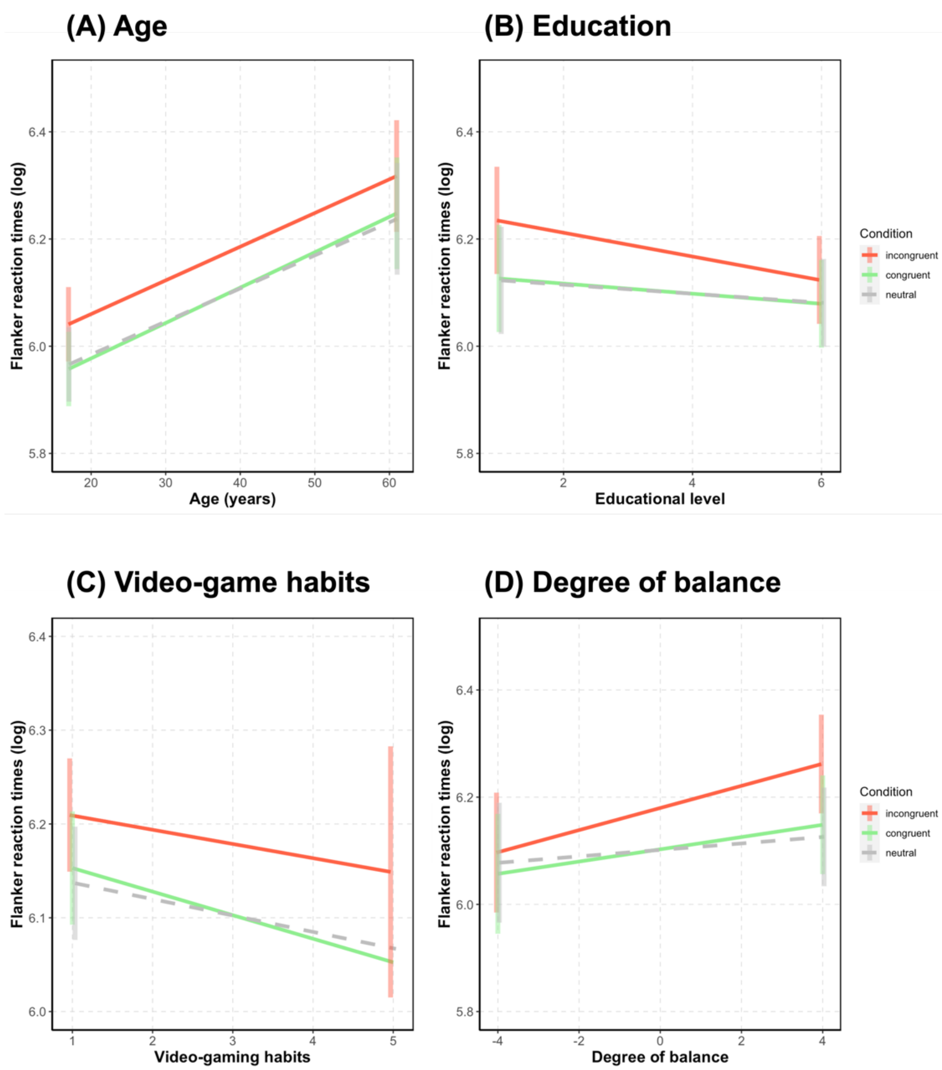
Age

Unsurprisingly, age was a highly significant predictor of RTs: younger participants displayed quicker RTs across conditions (*Est*= .0064, *SE*=.0014, *t*=4.39, *p*=.0001). Age also independently modulated the facilitation effect (Age* Congruency2: *Est*= .0002, *SE*<.0001, *t*=2.65, *p*=.008). Planned comparisons indicated that congruent RTs showed a significantly steeper slope (*Est*=.0004, *SE*=.0002, *z*=2.67, *p*=.021) with age compared to neutral RTs (estimated marginal trends: congruent=.0066, *95%CI*=.0038–.0095; neutral=.0062, *95%CI*=.0033–.0090). In other words, increasing age was associated to a diminished (less positive) facilitation effect. Incongruent and neutral RTs increased similarly with age (*Est*=.0001, *SE*=.0002, *z*=.71, *p*=.76). These results are illustrated in Panel A of **Figure 6.4**.

Education

The participants' highest completed education level was not a significant predictor of RTs overall (*Est*=.0134, *SE*= .-136, *t*=.98, *p*=.332). However, education independently modulated the inhibition effect (Education* Congruency1: *Est*= -.0089, *SE*=.0009, *t*=9.75, *p*<.0001) and the facilitation effect (Education* Congruency2: *Est*=.0039, *SE*=.0009, *t*=4.39, *p*<.0001). Planned comparisons indicated that incongruent RTs (estimated marginal trends: incongruent= -.0222, *95%CI*= -.0489 –.0044) showed a significantly steeper negative slope as education level increased compared to congruent RTs (congruent= -.0094, *95%CI*= -.0361–.0172) and neutral RTs (neutral= -.0084, *95%CI*= -.0350–.0183). Indeed, the contrast between incongruent and neutral slopes was significant (*Est*= -.0138, *SE*=.0016, *z*=8.83, *p*<.0001), indicating that increasing educational level was associated to a reduced (less negative) inhibition effect. The planned contrast was not significant for the facilitation effect (congruent vs. neutral: *Est*= -.0010, *SE*=.0015, *z*=.68, *p*=.775), despite the interaction in the original model. These results are illustrated in Panel B of **Figure 6.4.**

Figure 6. 4. Predicted linear values for Flanker reaction times (log-transformed) according to covariates. 95% confidence intervals are indicated. *Educational level*: 1=high school, 2=one-year post-secondary, 3=two-years post-secondary, 4=three-years post-secondary, 5=four-years post-secondary, 6=grad school. *Video-game habits*: 1=never; 5=every day. *Balance*: -4 = most unbalanced towards English; 0 = perfectly balanced; 4 = most unbalanced towards French.



Video-game habits

Though the participants' self-rated frequency of playing video games was not a significant predictor of RTs overall (*Est*= .0193, *SE*=.0211, *t*=.91, *p*=.368), it independently modulated the inhibition effect (Video-games* Congruency1: *Est*=.0041, *SE*=.0014, *t*=2.90,

p=.004) and the facilitation effect (Video-games* Congruency2: Est= -.0059, SE=.0014, t=4.20, p<.0001). Planned comparisons indicated that congruent RTs (estimated marginal trends: congruent= -.0251, *95%CI*=-.066–.0163) showed a significantly steeper negative slope as video-game habits increased compared to incongruent RTs (incongruent= -.0152, *95%CI*= - .0566–.0263) and neutral RTs (neutral= -.0175, *95%CI*= -.0589–.0239). Indeed, the contrast between congruent and neutral slopes was significant (Est= -.0076, SE=.0024, z=3.16, p=.004), indicating that frequently playing video-games was associated to an increased (more positive) facilitation effect. The planned contrast was not significant for the inhibition effect (incongruent vs. neutral: Est=.0023, SE=.0024, z=.95, p=.607), despite the interaction in the original model. These results are illustrated in Panel C of **Figure 6.4**.

Degree of balance

Recall that the degree of balance was computed by scoring each participant's: i) self-reported L1(s); ii) age of French/English exposure; iii) current proficiency in French/English; and iv) current usage of French/English. The variable scales from -4 (most unbalanced towards English) to +4 (most unbalanced towards French), with zero being attributed to balanced bilinguals.

The participants' degree of balance was not a significant predictor of RTs overall (Est= .0127, SE=.0103, t=1.23, p=.226). However, balance independently modulated the inhibition effect (Balance* Congruency1: Est=.0080, SE=.0007, t=11.08, p<.0001) and (marginally) the facilitation effect (Balance* Congruency2: Est= -.0013, SE=.0007, t=1.80, p=.072). Planned comparisons indicated that incongruent RTs (estimated marginal trends:

incongruent=.0207, *95%CI*=.0004–.0409) showed a significantly steeper positive slope as dominance was French-skewed (*Est*=.0146, *SE*=.0012, *t*=11.81, *p*<.0001) compared to neutral RTs (neutral=.0060, *95%CI*= -.0142–.0263). Similarly, when compared to neutral trials, congruent RTs (congruent=.0114, *95%CI*= -.0088–.0317) showed a significantly steeper positive slope as dominance was French-skewed (*Est*.=.0054, *SE*=.0012, *t*=4.42, *p*<.0001). These findings indicate that larger (more negative) inhibition effects and reduced (less positive) facilitation effects are associated to less balanced bilingualism, notably skewed dominance towards French. These results are illustrated in Panel D of **Figure 6.4**.

Summary

The series of covariates did indeed modulate participants' Flanker RTs. The main findings are summarized in **Table 6.5**. Note that for global effects, a better performance reflects overall faster (shorter) RTs and a worse performance reflects overall slower (longer) RTs. For inhibition, a better performance indicates a less negative effect, while a worse performance indicates a more negative effect. Finally, for facilitation, a better performance reflects a more positive effect; a worse performance reflects a less positive effect.

Table 6. 5. Summary of results observed for covariates.

Covariate	Global effects	Inhibition effect	Facilitation effect
Age	older = worse performance	*ns*	older = worse performance
Education	*ns*	more education = better performance	*ns*
Video-game habits	*ns*	*ns*	more gaming = better performance
Degree of balance	*ns*	less balance = worse performance	less balance = worse performance

6.3.3 Code-switching predictors

Producing code-switches

Though the participants' proportion of produced switches was not a significant predictor of RTs overall (*Est*= <.0001, *SE*=.0347, *t*<.01, *p*=1), it independently modulated the inhibition effect (%Produced* Congruency1: *Est*= -.1486, *SE*=.0789, *t*=4.64, *p*<.0001) and the facilitation effect (%Produced* Congruency2: *Est*=.0789, *SE*=.0317, *t*=2.49, *p*=.013). Planned comparisons indicated that incongruent RTs showed a steep negative slope as %Produced increased, while congruent RTs and neutral RTs exhibited a *positive* slope as %Produced increased (see **Table 6.6**). The contrast between incongruent and neutral slopes was significant (*Est*= -.2184, *SE*=.0553, *z*=3.952, *p*=.0002), but the contrast between congruent and neutral slopes was not (*Est*=.0091, *SE*=.0546, *z*=.166, *p*=.98). The %Produced slope for each level of congruency (incongruent, congruent, neutral) was compared to zero (i.e. a completely flat slope) in order to verify whether individual Flanker conditions were significantly modulated by %Produced. The slope for incongruent was significant, the slope for congruent was marginal, and the slope for neutral did not reach significance (see **Table 6.6**). Altogether, this means that an increased proportion of produced code-switches (collapsed across all code-switching types) was associated to a reduced (less negative) inhibition effect; producing more switches bore no impact on the facilitation effect, but was marginally related to increased RTs on congruent trials.

The fixed effect of code-switch Type (intra vs. inter; within vs. between) did not interact with just %Produced (*Est*<|.0003|, *t*s<.02, *p*s>.98), indicating that these predictors did not work together to modulate RTs as a whole. However, a three-way interaction between

Congruency1 (incongruent vs. neutral), Type1 (intra vs. inter) and %Produced was observed (*Est*=.0943, *SE*=.0395, *t*=2.38, *p*=.017); no other three-way interaction was significant (*Est*< |.0630|, *t*s<.1.60, *p*s>.11). Planned contrasts using `emtrends` yielded *negative* slopes for incongruent RTs in all three code-switching types, as well as *positive* slopes for congruent and neutral RTs in all three code-switching types (see **Table 6.6**). The difference between incongruent and neutral slopes was significant for intra-CS and between-CS (*Est*>|.29|, *z*s>2.4, *p*s<.04), but not for inter-CS (*Est*= -.0419, *SE*=.0641, *t*=.65, *p*=.79); by contrast, congruent slopes were not significantly different from the neutral slopes for any switching type (*Est*<|.111|, *z*s<1.23, *p*s>.44). These results are illustrated in **Figure 6.5**.

Table 6. 6. Summary emtrends slopes for %Produced according to the two categorical predictors. The final two columns indicate whether each slope is significantly different from null; significant negative differences are highlighted in green, while significant (or marginal) positive differences are highlighted in red.

CS-type	Congruency	Slope	95% CI		Different from zero?	
			upper	*lower*	*|z|*	*p*
Collapsed	**Incongruent**	-.149	-.242	-.055	3.124	.002
	Congruent	.079	-.013	.171	1.683	.093
	Neutral	.070	-.022	.162	1.490	.136
Intra	**Incongruent**	-.229	-.417	.041	2.386	.017
	Congruent	.164	-.021	.349	1.743	.081
	Neutral	.066	-.119	.250	.697	.486
Inter	**Incongruent**	-.040	-.141	.060	.793	.428
	Congruent	.040	-.058	.138	.801	.423
	Neutral	.001	-.097	.099	.026	.979
Between	**Incongruent**	-.176	-.316	-.037	2.473	.013
	Congruent	.032	-.106	.170	.458	.647
	Neutral	.143	.005	.280	2.034	.042

Finally, each %Produced slope generated by `emtrends` for the three-way interaction was compared to zero; this allows us to verify whether individual levels of Flanker congruency (incongruent, congruent, neutral) are modulated by %Produced*Type (**Table**

6.6). First, the slope for intra-CS and between-CS was significantly more negative than zero for incongruent RTs. This means that participants who produced more intra-utterance and between-speaker switches during FEBLOC displayed quicker RTs on incongruent Flanker trials. Second, the slope for intra-CS was marginally larger than zero for congruent RTs, and the slope for between-CS was significantly larger than zero for neutral RTs. This tells us that participants who produced more intra-utterance and between-speaker switches during FEBLOC displayed slower RTs on non-conflict trials (congruent and neutral).

Hearing code-switches

The participants' proportion of heard switches was not a significant predictor of RTs overall (*Est*= -.0033, *SE*=.0400, *t*=.08, *p*=.935). Nonetheless, %Heard modulated the inhibition effect (%Heard* Congruency1: *Est*= -.790, *SE*=.0383, *t*=2.07, *p*=.039) but not the facilitation effect (%Heard* Congruency2: *Est*=.0250, *SE*=.0378, *t*=.66, *p*=.509). Planned comparisons indicated a slightly negative slope for incongruent RTs (estimated marginal trends: incongruent= -.0822, *95%CI*=-.1916–.0272) and slightly positive slope for neutral RTs (neutral=.0507, *95%CI*= -.0566–.1581) as %Heard increased. The difference between these slopes was marginal (*Est*= -.133, *SE*=.0659, *z*=2.019, *p*=.108). On the other hand, there were no differences in slopes between congruent and neutral RTs (*Est*= -.029, *SE*=.0651, *z*=.0446, *p*=.900). The %Heard slope for each level of congruency (incongruent, congruent, neutral) was compared to zero in order to verify whether individual Flanker conditions were significantly modulated by %Produced. None of the slopes were significantly different from null (see **Table 6.7**). As such, an increased proportion of heard code-switches (collapsed across all code-switching types) was associated to a marginally reduced (less negative) inhibition effect, but no modulation of the facilitation effect.

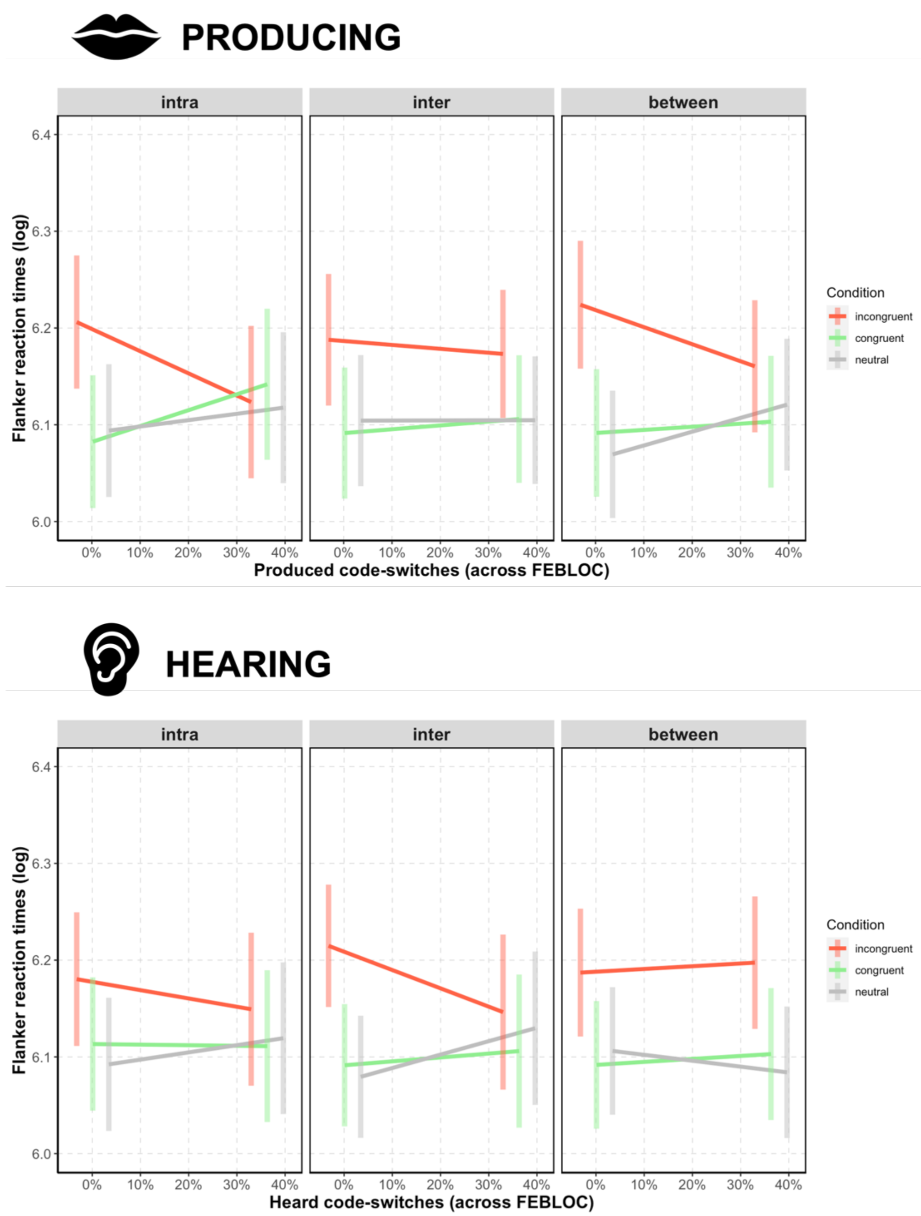
The fixed effect of code-switch Type (intra vs. inter; within vs. between) did not interact with just %Heard (*Est*<.002, *t*s<.08, *p*s>.94), indicating that these predictors did not work together to modulate RTs as a whole. However, a three-way interaction between Congruency1 (incongruent vs. neutral), Type2 (within vs. between) and %Heard was observed (*Est*= .0540, *SE*=.0247, *t*=2.19, *p*=.029); no other three-way interaction was significant (*Est*<|.053|, *t*s<1.13, *p*s>.26). Planned comparisons yielded only one notable contrast: incongruent RTs exhibited a negative slope as inter-CS increased, while neutral RTs exhibited a positive slope as inter-CS increased (see **Table 6.7**); this difference was significant (*Est*= -.3279, *SE*=.1151, *t*=2.85, *p*=.012). No other contrasts reached significance for any code-switching type (*Est*<|.230|, *z*s<2, *p*s>.113).

Table 6. 7. Summary emtrends slopes for %Heard according to the two categorical predictors. The final two columns indicate whether each slope is significantly different from null; significant negative differences are highlighted in green, while significant (or marginal) positive differences are highlighted in red.

CS-type	Congruency	Slope	95% CI		Different from zero?	
			upper	*lower*	*|z|*	*p*
Collapsed	**Incongruent**	-.082	-.192	.027	1.473	.141
	Congruent	.022	-.086	.129	.397	.692
	Neutral	.051	-.057	.158	.926	.354
Intra	**Incongruent**	-.086	-.277	.105	.881	.378
	Congruent	-.006	-.194	.182	.062	.950
	Neutral	.075	-.113	.262	.779	.436
Inter	**Incongruent**	-.189	-.367	-.012	2.087	.037
	Congruent	.040	-.132	.213	.459	.647
	Neutral	.139	-.034	.312	1.573	.116
Between	**Incongruent**	.029	-.113	.169	.395	.693
	Congruent	.031	-.108	.169	.437	.662
	Neutral	-.061	-.197	.075	.877	.381

The last two columns of **Table 6.7** show whether each %Heard slope is different from zero (i.e. a completely flat slope). The slope for inter-CS was significantly more negative than zero for incongruent RTs. This means that participants who heard more inter-utterance during FEBLOC displayed quicker RTs on incongruent Flanker trials. No other slope was significantly different from zero.

Figure 6. 5. Predicted linear values for Flanker reaction times (log-transformed) according to code-switching predictors. 95% confidence intervals are indicated.



Summary

The main findings for the primary code-switching predictors are summarized in **Table 6.8**. In short, producing more switching during FEBLOC (particularly intra-utterance and between-speaker switches) was linked to increased inhibitory performance during the Flanker task (i.e., shorter RTs for incongruent trials and reduced inhibition effects). However, producing more switching during FEBLOC was also associated to diminished performance (i.e., increased RTs) on non-conflict trials. On the other hand, hearing more switching during FEBLOC (particularly inter-utterance switches) was uniquely linked to increased inhibitory performance (shorter RTs for incongruent trials and reduced inhibition effects).

Table 6. 8. Summary of results observed for primary predictors. Plus symbols (++ for significant results, + for marginal results) indicate that more produced switches results in better Flanker performance (i.e., reduced RTs and/or effect sizes). Minus symbols (-- for significant results, - for marginal results) indicate that more produced switches results in worse Flanker performance (i.e., increased RTs and/or effect sizes).

	Producing				**Hearing**			
Condition / Effects	overall	*by CS Type*			*overall*	by CS Type		
		intra	inter	*between*		intra	inter	between
Incongruent	++	++	*ns*	++	*ns*	*ns*	++	*ns*
Congruent/neutral	-	-	*ns*	--	*ns*	*ns*	*ns*	*ns*
Global effects	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*
Inhibition	++	++	*ns*	++	+	*ns*	++	*ns*
Facilitation	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*

6.3.4 Split-half reliability

Construct reliability can be assessed by splitting the data obtained from one participant into two halves (e.g., odd vs. even test), and then comparing both subsets. If a task is reliable, an individual should display similar performance between split-halves. In order to test the consistency in the split-halves, intraclass correlation coefficients (see Shrout & Fleiss, 1979) were computed via the `ICC` function in the `psych` R package. The coefficients are type ICC(2,k), as participants were randomly selected from the population, and reliability is estimated based on split-half averages (i.e., mean congruent RTs on even trials vs. mean congruent RTs on odd trials). For individual levels of Flanker congruency (congruent, incongruent, neutral), odd/even reliability was excellent in all cases (*ICCs*>.95). For the computed inhibition effect (neutral – incongruent), split-half reliability was also excellent (*ICC*=.91, *CIs*=.83–.95). Finally, for the computed facilitation effect (neutral – congruent), split-half reliability was very poor (*ICC*=0, *CIs*=|0|–.48) (see Koo & Li, 2016 for ICC thresholds). The significant Congruency contrasts in the present study (see **Table 6.8**) always concern the inhibition effect; its excellent split-half reliability lends confidence to these results, as it suggests that the contrast was tracking a meaningful construct.

6.3.5 Exploratory analysis: Self-reported code-switching predictors

Recall that self-reported code-switching habits were also collected from the participant sample, via the BSwQ (Rodriguez-Fornells et al., 2012). This questionnaire separates code-switching habits into four components (with three questions corresponding to each component): switching according to direction (e.g., into English, into French), contextual switching (i.e., code-switching according to an external context) and unintentional switching (i.e., code-switching not governed by an external context). Note that this questionnaire does not disentangle the participants' production habits from their exposure (i.e., processing habits).

An exploratory analysis was conducted in order to examine the participants' Flanker performance in relation to their self-reported code-switching habits. The objective code-switching predictors from the primary model were exchanged for the BSwQ subjective predictors: `lmer(RT.log ~ (Congruency * ((BSwQ_FR.EN + BSwQ_EN.FR + BSwQ_Context + BSwQ_Unintented))) + (Congruency * (age + education + video.games + balance) + (1|subject) + (1|item), data=df)`. The results of the exploratory analysis are presented in **Tables 6.9** and **6.10**.

BSwQ Component 1: FR-to-EN switching

Self-reported FR-to-EN switching did not appear to modulate the RTs overall (no main effect), but interactions between the component and the Congruency contrasts were observed (**Table 6.9**). Post-hoc comparisons indicated that the slope for incongruent trials was significantly more negative than the slope for neutral trials (Est=-.0121, SE=.0048, z=2.506, p=.033), but that none of the slopes were different from zero (**Table 6.10**).

BSwQ Component 2: EN-to-FR switching

Self-reported EN-to-FR switching did not impact the Flanker RTs overall (no main effect), but it interacted with both of the Congruency contrasts (**Table 6.9**). Post-hoc comparisons indicated the slopes for incongruent and congruent trials were not different from the slopes for neutral trials (Est<|.008|, zs<1.75, ps>.19) and that none of the slopes were different from zero (**Table 6.10**).

Table 6. 9. Results of the fitted exploratory linear mixed-effects model. Only the fixed effects involving the BSwQ components (and their interactions) are shown here. Note that "Congruency1" contrasts incongruent and neutral trials; "Congruency2" contrasts congruent and neutral trials. Significant effects and interactions are highlighted in green. Significance levels are indicated as follows: p<.10 •, p<.05 *, p<.01 **, p<.001 ***.

Fixed effects	*Estimate*	*SE*	| *t* |	Interpretation
BSwQ FR-to-EN	-.0381	.0427	.890	*ns*
BSwQ EN-to-FR	.0319	.0369	.866	*ns*
BSwQ Contextual	.0620	.0319	1.942 •	global effect * Contextual
BSwQ Unintended	-.0308	.0315	.980	*ns*
FR-to-EN * Congruency1	-.0101	.0028	3.596***	inhibition effect * FR-to-EN
FR-to-EN * Congruency2	.0080	.0028	2.905**	facilitation effect * FR-to-EN
EN-to-FR * Congruency1	.0072	.0024	2.972**	inhibition effect * EN-to-FR
EN-to-FR * Congruency2	-.0071	.0024	2.990**	facilitation effect * EN-to-FR
Contextual * Congruency1	.0128	.0021	6.111***	inhibition effect * Contextual
Contextual * Congruency2	-.0031	.0021	1.523	*ns*
Unintended * Congruency1	-.0050	.0021	2.426*	inhibition effect * Unintended
Unintended * Congruency2	-.0005	.0020	.267	*ns*

```
lmer(RT.log ~ (Congruency * (BSwQ_FR.EN + BSwQ_EN.FR + BSwQ_Context +
BSwQ_Unintented)) + (Congruency * (age + education + video.games +
dominance)) + (1|subject) + (1|item), data=df)
```

Table 6. 10. Summary emtrends slopes for BSwQ components according to the two categorical predictors. The final two columns indicate whether each slope is significantly different from null; significant negative differences are highlighted in green, while significant (or marginal) positive differences are highlighted in red.

CS-type	Congruency	Slope	95% CI		Different from zero?	
			upper	*lower*	| *z* |	*p*
FR-to-EN	**Incongruent**	-.048	-.132	.036	1.123	.261
	Congruent	-.030	-.114	.055	.701	.483
	Neutral	-.036	-.120	.048	.841	.400
EN-to-FR	**Incongruent**	.039	-.033	.112	1.058	.290
	Congruent	.025	-.048	.097	.671	.502
	Neutral	.032	-.041	.104	.863	.388
Contextual	**Incongruent**	.075	.012	.137	2.338	.019
	Congruent	.059	-.004	.121	1.839	.066
	Neutral	.052	-.010	.115	1.635	.102
Unintentional	**Incongruent**	-.036	-.098	.026	1.137	.256
	Congruent	-.031	-.093	.030	.995	.320
	Neutral	-.025	-.087	.037	.801	.423

BSwQ Component 3: Contextual switching switching

More self-reported contextual switching marginally increased Flanker RTs globally. Furthermore, the BSwQ component interacted with the first Congruency contrast (**Table 6.9**). Post-hoc comparisons indicated that the slope for incongruent trials was significantly more positive than the slope for neutral trials (*Est*=.0225, *SE*=.0036, *z*=6.220, *p*<.0001). The incongruent slope was significantly different from null, while the congruent and neutral slopes were marginally different from null (**Table 6.10**).

BSwQ Component 4: Unintentional switching

Self-reported unintentional switching did not appear to modulate the RTs overall (no main effect), but an interaction with the first Congruency contrast was observed (**Table 6.9**). Post-hoc comparisons indicated that the slope for incongruent trials was significantly more negative than the slope for neutral trials (*Est*=-.0106, *SE*=.0036, *z*=2.967, *p*=.009), but that none of the slopes were different from zero (**Table 6.10**).

Summary

Only one robust relationship between self-reported code-switching habits and subsequent inhibitory control was observed: bilinguals who reported more frequent contextual code-switching exhibited slower Flanker RTs, particularly on conflict (incongruent) trials. This unexpected result once again puts into question the validity of self-reported code-switching measures (*sections 3.4.2* and *5.4.1*). Since the BSwQ components abstract away from the main goal of this Chapter (i.e., disentangling production from processing), this will not be discussed further.

6.4 Discussion

The present study teased apart the effects of production and processing on inhibitory control. In particular, the current study took advantage of the multiparty nature of the interactions in the FEBLO-Corpus in order to compute the proportion of *produced* switches and proportion of *heard* switches for each bilingual. These modality-specific indices were then modelled in relation to each participants' performance on a subsequent Flanker task. First, a series of covariates modulated the bilinguals' Flanker performance: increased inhibitory control was related to younger age, higher educational levels, more experience with video-games, and a higher degree of balanced bilingualism. Second, code-switching proportions exerted distinct effects according to modality. On one hand, producing more code-switches during FEBLOC (particularly, intra-utterance and between-speaker switches) was associated to better inhibition effects and quicker RTs on conflict trials (i.e., incongruent condition), but slower RTs on low-conflict trials (i.e., neutral and congruent conditions). On the other hand, hearing more code-switches during FEBLOC (particularly, inter-utterance switches) was only related to better inhibition effects and quicker RTs on conflict trials (i.e., incongruent condition). These primary findings will be discussed in the following sections.

6.4.1 The covariates: No surprises here

As expected, several demographic and linguistic covariates modulated the participants performance on the Flanker task. First, older bilinguals showed overall slower RTs and reduced facilitation effects. This result falls into line with a large body of research indicating that executive functioning abilities begin to decline with age (e.g., Bialystok et al., 2004). Second, higher educational levels were related to better inhibitory control; education as a confound has indeed often been cited to 'explain away' bilingualism-based differences (e.g., Paap et al., 2015). Third, compatible with Bialystok (2006), bilinguals who reported playing video-games frequently exhibited increased monitoring abilities; this is especially unsurprising given that the administered Flanker task was computerized. Lastly, bilinguals who were more balanced displayed better Flanker performance, supporting the idea that balanced usage positively impacts EFs (e.g., Yow & Li, 2015).

Though none of these effects are surprising, it should be remarked that the improved fit of the model resulting from the addition of the covariates demonstrates the complexity of the data under study. Studying a single facet of the bilingual experience (e.g., code-switching) does not do justice to the multiplicity of bilingual individuals.

6.4.2 Producing switches: yay for suppression, nay for disengagement

The results indicated that FEBLOC speakers who produced more code-switches (collapsed across code-switching types) exhibited decreased RTs for conflict (incongruent) trials and increased RTs for non-conflict (congruent) trials; this translated to a decreased inhibition effect as the proportion of produced switches increased. Recall that the inhibition effect is believed to measure the ease with which individuals are able to ignore external lures (e.g., Diamond, 2013). In our case, lures are the antagonistic flanking arrows in incongruent trials; the better participants suppress the flankers, the smaller their inhibition effect. Since individuals with the highest proportions of produced code-switches exhibited reduced inhibition effects, this implies that producing switches involves/requires interference suppression. This is expected under the dominant model of bilingual production, the Inhibitory Control Model (Green, 1998). It also bolsters previous findings which indicate that more frequent self-reported code-switching leads to reduced Flanker interference (Gosselin & Sabourin, 2023b; Hartanto & Yang, 2020; Hofweber et al., 2016, 2019, 2020b; Jylkkä et al., 2020; Pot et al., 2018, 2018; Verreyt et al., 2016; cf. Chan et al., 2020; Jylkkä et al., 2017, 2021; Soveri et al., 2011; Yow & Li, 2015).

However, the picture is complexified once we consider that the reduced inhibition effects were not only caused by quicker incongruent RTs, but also by *slower* congruent RTs as produced switches increased. Non-conflict RTs are often related to goal maintenance abilities (e.g., Chan et al., 2020); quicker responses to non-conflict trials may reflect the ease with which individuals *disengage* inhibitory control mechanisms (Linck, 2015). Since individuals with the highest proportions of produced code-switches exhibited slower non-conflict RTs, this implies that producing switches hinders subsequent interference disengagement.

Bilingual-based differences have previously been observed on non-conflict trials. For instance, active bilinguals exhibit smaller switching costs than monolinguals during a task switching paradigm, but this effect is prompted by *slower* RTs on low-conflict (i.e., non-switch) trials (de Bruin, Bak et al., 2015). Other studies reported reduced Simon interference for bilinguals compared to monolinguals, but a closer inspection reveals that these effects are led by descriptively *slower* congruent RTs for bilinguals (e.g., Bialystok et al., 2008; Schroeder & Marian, 2012; see Paap et al., 2015 for a discussion). Perhaps most compellingly, fMRI evidence has shown that differences in neural activation for switch vs. repeat trials during a task-switching paradigm are due to adaptation during repeat (i.e., low conflict) trials (De Baene et al., 2012; Weissberger et al., 2015). All of this considered, it has been suggested that bilingualism-based EF differences arise because bilinguals use "a different strategy [...] than monolinguals" (de Bruin, Bak et al., 2015: 23); perhaps they are able to fine-tune the disengagement of their inhibitory control mechanisms.

If inference disengagement is a crucial facet of bilingual adaptation, this does not bode well for producing code-switches; as mentioned, individuals with the highest proportions of produced code-switches exhibited poorer disengagement abilities (i.e., slower congruent RTs). Nevertheless, it is important to consider that the production index was not linked to decreased Flanker performance across the board. If producing more switches is associated to both *increased* interference suppression and *reduced* interference disengagement, this once again leads to a zero-sum game for code-switching. This falls into line with a recent meta-analysis demonstrating that bilingualism is best characterized an experience resulting in dynamic trade-offs: some or other 'advantage' is usually accompanied by a 'disadvantage' of a slightly different nature (Dentella et al., 2024).

It should also be noted that producing different types of code-switches in FEBLOC impacted the participants' inhibitory control in distinct ways. Indeed, it was discovered that the primary pattern of results (i.e., decreased conflict RTs, increased non-conflict RTs) held true as more intra-utterances and between-speaker switches were produced, but not as more inter-utterance switches were produced. This is comparable to much of the previous research indicating that more dense types of switches (e.g., intra-utterance, between-speaker, congruent lexicalization, unintended switches) are related to decreased domain-general interference (Han et al., 2022; Hartanto & Yang, 2020; Hofweber et al., 2016; Ooi et al., 2018; Yow & Li, 2015; cf. Jylkkä et al., 2021). However, it is contra studies reporting reduced interference for *dual-language* switches (e.g., alternations, contextual switching: Han et al., 2024; Hofweber et al., 2020b; Jylkkä et al., 2020; Pot et al., 2018). It is important to remember that these studies utilized self-reports, and did not disentangle producing vs. processing switches. Of the literature utilizing objective code-switching measures based on elicitation tasks, both intra-CS (Han et al., 2024) and inter-CS (Lai & O'Brien, 2020) have been related to quicker conflict RTs.

Why might producing more intra-CS and between-CS in the present study translate to faster conflict RTs and—in particular—slower non-conflict RTs? One possibility is that producing these dense types of switches engage proactive control (Beatty-Martínez et al., 2020b; Gullifer et al., 2018; Hofweber et al., 2020b, 2020a; Jiang et al., 2023), which then impedes task disengagement. Since common linguistic knowledge is assumed in a dense code-switching context, bilinguals' can allow their own internal states of activation to bias their productions beyond top-down mechanisms prioritizing language maintenance (Kleinman & Gollan, 2016; see also Carter et al., 2023; Ng & Yang, 2022). In turn, the respite in top-down mechanisms may result in decreased interference disengagement performance (i.e., slower non-conflict RTs). By contrast, inter-CS are dual-language switches engaging reactive control (Beatty-Martínez et al., 2020b; Hofweber et al., 2020b, 2020a; Jiang et al., 2023); as top-down mechanisms are not suppressed for these alternations, task disengagement is not hindered.

Note that this view does not quite explain why producing inter-CS was not associated to increased interference suppression; instead, null results were observed in the current study. Perhaps producing inter-CS necessitates moderate reactive control, but these mechanisms are not intense enough to trigger differences in subsequent EF performance. Alternatively, perhaps the proactive control 'detriment' cancels out any observable reactive control 'benefits'. This question should be considered further in the future.

6.4.3 Hearing switches: yay for interference suppression

The main analyses revealed that FEBLOC bilinguals who heard more inter-utterance code-switches exhibited decreased RTs for conflict (incongruent) trials; this translated to a decreased inhibition effect as the proportion of heard switches increased. Since the inhibition effect is believed to measure the ease with which individuals are able to ignore external lures (e.g., Diamond, 2013), this findings suggests that hearing (some types of) switches involves/requires interference suppression.

Crucially, unlike the modality of production, heard switches were *not* associated to longer non-conflict RTs. In line with my previous discussion, this might reflect proactive control adaptations in bilingual processing: individuals cannot gear and bias their processing ahead of time, as they are passive receptors in the transmission of the message. Instead, listening/hearing is reactively-driven, and necessitates top-down mechanisms. This view explains why interference disengagement was not impaired by higher proportions of code-switches heard during FEBLOC. It further bolsters that 'hearing' switches (or being exposed to switches) is a crucial modulator for bilingualism-based EF differences (perhaps even more so than producing switches): its positive impact on interference suppression is unencumbered by negative impact on interference disengagement.

One might ask why hearing more dense code-switching did not lead to increased interference control. One possibility is that intra-utterance switches follow certain distributional regularities (bilingual 'prefabs': Guzzardo Tamargo et al., 2016; Hui et al., 2022) that make them slightly more predictable compared to switching at utterance junctures. Indeed, speech patterns form distributions that are learned and exploited during processing (MacDonald, 2013). Furthermore, evidence has shown that listeners use acoustic cues (e.g., speech rate) in order to deduce whether a switch is coming (Fricke et al., 2016). These intra-utterance distributional cues probably relax the need for high reactive control during the processing (i.e., hearing) of dense switches. This would explain why FEBLOC bilinguals did not exhibit increased inhibition as they heard more dense code-switching: the moderate reactive control mechanisms involved in such switches are likely not intense enough to positively modulate subsequent EF performance.

6.4.4 Putting it together: Proactive and reactive control

The current study revealed that producing and hearing switches differentially impact inhibitory control. Frequently producing dense code-switches is beneficial for interference control, but detrimental to interference suppression. By contrast, frequently processing dual-language switches is beneficial for interference control. Given that bilingual-EF differences are thought to result from neural adaptation during non-conflict trials (De Baene et al., 2012; Weissberger et al., 2015), my findings point towards the idea that *processing* switches is a key experiential factor in shaping cognitive differences. Unlike the modality of production, being regularly exposed to language alternations does not hinder interference disengagement abilities; perhaps the processing of switches even *prevented* the impediment on non-conflict RTs.

In the past, proactive control has been related to the dense code-switching context, while reactive control has been associated to the dual-language context (Beatty-Martínez et al., 2020b; Gullifer et al., 2018; Hofweber et al., 2020b, 2020a; Jiang et al., 2023). In parallel, proactive control has been characterized as feature of bilingual *production* (Declerck, 2020), while comprehension has been called "mostly re-actively driven" (Garbin et al., 2011: 129). Notice that the first thesis abstracts away from the production-processing paradox, and that the second thesis does not consider interactional contexts. The results from the present study allow us to to integrate both facets. **Table 6.11** illustrates the postulated relationship between modality, interactional context, and proactive/reactive control. Here, I use the shorthand '+' to signal a robust observable relationship, and '(+)' to signal an expected but covert relationship in the present data. I speculate the following:

a) Producing dense code-switches involves both proactive control (state-internal language bias) and reactive control (at the switching juncture).
b) Producing dual-language switches likely involves some sort of reactive control (i.e., at the switching juncture), but this was not observed in the present data.
c) Processing dense code-switches probably necessitates some level of reactive control (e.g., at the switching juncture), but this was covert in the present data. This may be due to the fact that intra-CS can follow learnable distributions, making them more predictable than inter-CS.
d) Dual-language switches require robust reactive control mechanisms (at the switching juncture).

Table 6. 11. The postulated relationship between modality, interactional context, and proactive/reactive control according to the present findings.

Modality	Context	Proactive control	Reactive control	Consequence
Producing	Dense CS	+	+	Reduced disengagement; increased interference control
	Dual-language		(+)	No effects
Hearing	Dense CS		(+)	No effects
	Dual-language		+	Increased interference control

These findings are somewhat compatible with existing theories. The widely accepted ACH (Green & Abutalebi, 2013) postulates that bilingual production in a dense code-switching context trains opportunistic planning (see also the Control Process Model of code-switching: Green & Wei, 2014); this is congruous with the adaptation in proactive control observed in the present study. However, the ACH also suggests that production in a dual-language context trains a series of control mechanisms, many of which are compatible with reactive control. Though reactive control is expected during the production of inter-CS, it was not observed in the present data (perhaps as it was too moderate to train subsequent EFs, or because of cancelled-out EF effects).

From the perspective of processing, Gullifer and Titone (2021) posited that proactive control adaptations will be observed in the dual-language context due to its high degree of linguistic uncertainty. This theory is congruous with the present data, as frequently hearing dual-language switches (unlike producing switches) did not impede interference disengagement. Finally, my results do not support the Adaptive Predictability Hypothesis (APH: Valdés Kroff & Dussias, 2023), which proposed that it is more difficult to process intra-

CS compared to inter-CS. Indeed, the present data did not yield any overt relationship between processing dense code-switches and subsequent inhibitory control.

6.4.5 Traits or states?

One question that can be asked is whether the current findings reflect differences according to bilingual traits, or bilingual states. Traits are by-participant attributes (e.g., "Ariane performed better because she is a habitual code-switcher"). States are (manipulated) by-situation attributes (e.g., "Ariane performed better in a setting of heightened cognitive control caused by code-switching") (Salig et al., 2021). Assimilating the present findings to a 'traits' approach assumes that the proportions of switches in the FEBLO-Corpus truly reflect the speakers' day-to-day habits (e.g., Stéphane is a habitual code-switcher, as manifested in FEBLOC, and this is why he showed better interference suppression). On the other hand, assimilating the conclusions to a 'states' approach surmises that the code-switching elicited by the speech elicitation activities *primed* the Flanker performance of FEBLOC speakers (e.g., Stéphane code-switched a lot during FEBLOC, and this is why he showed better interference suppression).

I speculate that the current data lies somewhere in the middle of traits and states. While it is likely that participants were primed by their language usage during the speech elicitation activities, the reality remains that speakers code-switched *voluntarily* during FEBLOC. The corpus activities were designed to elicit code-switching behaviour according to the comfortability of the participants (i.e., according to their vernacular). The variation in the code-switching proportions makes it clear that bilinguals with the habit of language separation did not, in fact, code-switch. In other words, bilinguals who were code-switchers (a trait) produced more switches in FEBLOC, and were subsequently primed (a state) for the Flanker task. To study the trait in the absence of the state, FEBLOC speakers would have needed to return for a second session to complete the Flanker task.[5] This is an interesting avenue for future research.

6.5 Conclusion

The current chapter described the first empirical study (to my knowledge) that teased apart the effects of producing code-switches and processing code-switches on bilingual cognition. Objective switching proportions were computed for each speaker in the FEBLO-Corpus (how many switches they produced, and how many switches they heard from their partner). These modality-specific indices were then examined in relation to a subsequent Flanker task. Frequently producing dense code-switches was beneficial for interference control, but detrimental to interference suppression. By contrast, frequently processing dual-language switches was only beneficial for interference control. These findings suggest that proactive control is a central feature of producing dense code-switches, and point towards the idea that *processing* switches is a key experiential factor in shaping cognitive differences (i.e., in preventing decreased task disengagement).

[5] It could be argued that the code-switching proportions during the Free discussion task best reflect trait characteristics, as the speech was completely unstructured. As a supplementary analysis, the primary mixed effects model was applied to the %Produced_discussion and %Heard_discussion (producing and hearing code-switches during the Free discussion task). These results are presented in **APPENDIX F**.

It is important to remember that the current study only utilized explicit behavioural measures (i.e., RTs). There is still much left to learn from a neurophysiological lens, as implicit measures are needed to uncover the underpinnings of proactive/reactive control and code-switching. The next Chapter describes a pilot electrophysiological experiment utilizing the FEBLO-Corpus.

CHAPTER 7: The electrophysiological processing *de vraies conversations bilingues*

7.1 Introduction

Up to this point, the present dissertation has shown that naturalistic code-switching engages behavioural inhibitory control mechanisms. In particular, producing code-switches (particularly dense switches) is related to better interference control but reduced task disengagement; processing (hearing) code-switches is only related to increased interference control. However, an important part of the puzzle is missing: how do individuals process the code-switches themselves in real-time? Is their processing related to their inhibitory control abilities? The present pilot study utilizes electrophysiology in order to gauge the mechanisms underlying the concurrent processing of code-switches (passive listening task) and their relationship with cognitive control mechanisms (Flanker task).

7.1.1 The electrophysiology of code-switching

At least a dozen studies have examined the implicit processing of code-switches by utilizing Event-Related Potentials (ERPs). ERPs are obtained by segmenting continuous EEG waves and time-locking them to specific experimental events (e.g., the onset of a critical word, the onset of a trial, etc.). The most consistent result in the literature is that code-switches elicit a Late Positive Component (LPC) compared to unilingual controls (Moreno et al., 2002; Ng et al., 2014; Proverbio et al., 2004; Ruigendijk et al., 2016; Van Der Meij et al., 2011; Yacovone et al., 2021), even among bilinguals who report habitual code-switching

(Blackburn & Wicha, 2022; Gosselin & Sabourin, 2021; Kaan et al., 2020; Litcofsky & Van Hell, 2017; Valdés Kroff et al., 2020). In these contexts, the LPC is usually assimilated to P3-like effects, and is thus associated to control processes (e.g., an individual must inhibit the non-target language when processing a code-switch). Previous research has indeed shown that the size of the LPC is related to the participants' inhibitory control abilities (Jiang et al., 2024; Jiao et al., 2020).

One important constraint limits these findings: utilizing ERPs necessarily implies that the stimuli is time-locked within the continuous EEG signal. Methodological rigor imposes strict constraints on the stimuli being presented, since conditions need to be well-matched. Take, for instance, the comparison between sentences containing code-switches and unilingual control sentences; an example from an actual study is given in (1). The researcher(s) must ensure that the manipulation (i.e., the onset of the code-switch) occurs at a similar position in the sentence, with words of similar grammatical classes, within sentences of similar length. Typically, the stimuli is presented word-by-word to facilitate time-locking of a critical region (below, '*tienda*' vs. '*shop*').

(1) **Example of stimuli from Litcofsky and van Hell (2017)**:
   a. The girl saw some nice shirts in the *tienda frente a su escuela*.
   b. The girl saw some nice shirts in the shop across the street from her school.

Such restrictions are important, as they validate that the manipulation of interest (i.e., code-switch vs. unilingual) is actually responsible for any observed statistical differences in the time-locked (and averaged) epochs. However, they also require the use of lab-made materials, since it is virtually impossible to fit naturally-produced utterances into stringent stimuli restrictions. The ecological validity of the conclusions can thus be questioned: to my knowledge, the ERP literature has only utilized highly-controlled 'artificial' code-switches. These switches are almost always visually-presented (even though code-switching is more typical of the oral/auditory modality) and are usually 'disembodied'. In other words, participants read a series of sentences (some of which contain code-switches), with arbitrary content, that do not connect to each other.

All of this being said, it is clear that more naturalistic stimuli should be considered. The problem here lies with balancing ecological validity and methodological rigor. Real-life code-switches, if they are truly natural, cannot be carefully controlled. This means that the time-locking required by ERPs (and time-frequency representations) is not feasible. For instance, consider the FEBLOC utterance produced by Jérémie in (2). In theory, one could examine the ERPs occurring precisely at the switch '*tu*' and at the switch '*face up*' (even though these are quite different types of switches). But what would these waves then be compared to? There is no carefully-matched unilingual control for these utterances.

(2) **Pair10 (Danielle and Jérémie), 178 seconds:**

```
*SEC:  like@s:eng tu@s:fra l(e)@s:fra mets@s:fra face@s:eng up@s:eng .
*FIR:  +< okay@s:eng&fra .
*SEC:  si@s:fra  je@s:fra  l'ai@s:fra  pas@s:fra  tu@s:fra  l(e)@s:fra
       mets@s:fra face@s:eng down@s:eng .
```

One potential solution is to examine the continuous EEG waves elicited by the utterances in (2), rather than time-locking according to a specific region in the stimuli. In order to get informative data, we can turn to the frequency domain. The raw EEG signal is made up of several different wave 'shapes'. These waves differ in terms of their frequency (number of oscillations per second). Mathematical transformations (e.g., Fourier transform, wavelet transform) can decompose the complex EEG signal into its various spectral constituents. Five types of waves (frequency bands) are standardly recognized: delta (<4 oscillations per second), theta (4-8 oscillations per second), alpha (8-12 oscillations per second), beta (12-30 oscillations per second), and gamma (>30 oscillations per second). The power density of the frequency bands can thus be compared between conditions, under the assumption that increased power is caused by neuronal impulse synchronization, and gives insight into specific cognitive and/or linguistic processes.

Spectral analyses of EEGs have only very recently been adopted in the field of bilingualism (Bice et al., 2020; Calvo & Bialystok, 2021; Pereira Soares et al., 2021). Many of these seminal studies recorded the brainwaves of bilinguals while no task was being completed (resting-state EEGs or rEEGs). The rEEG is split into equal sized segments (i.e., no time-locking), decomposed into its spectral constituents, then averaged together. Interestingly, a number of language background characteristics appear to modulate EEGs, even while bilinguals are sitting quietly. For instance, the earlier an individual reports acquiring an L2, the more beta and gamma power they exhibit at rest (Pereira Soares et al., 2021). When it comes to the processing of code-switching within an experimental task, decreased beta oscillations are observed for switches into the weaker language compared to unilingual conditions (Fernandez et al., 2019; Litcofsky & Van Hell, 2017; Tomić & Kaan, 2022; see also Pérez & Duñabeitia, 2019). By contrast, switching into the dominant language results in increased power in theta (Litcofsky & Van Hell, 2017) or alpha (Fernandez et al., 2019) bands, likely reflecting additional cognitive control demands.

It is important to note that the previous EEG studies examining code-switching still utilized lab-made stimuli, and were thus able to time-lock the frequency domain to critical regions of interest (i.e., time-frequency representations). By contrast, completely naturalistic stimuli would require an analysis resembling the one adopted for rEEGs[1]: the continuous brainwaves elicited by reading/listening to real-life switches (vs. real-life unilingual passages) would be split into equal sized segments, transformed to the frequency domain, then averaged within conditions. This is indeed the kind of exploratory analyses that the present pilot study employs.

7.1.2 The electrophysiology of the Flanker task

CHAPTER 6 reported on the (behavioural) Flanker performance of participants according to their objective code-switching proportions. By contrast, the present chapter aims to investigate the neural mechanisms underlying the concurrent processing of code-switches (passive listening task) and their relationship with cognitive control mechanisms. As such, an online executive functioning task is needed: I once again utilize the Flanker test, one of the more classical and simple tasks tapping into inhibitory control.

The neural responses underlying the Flanker task are relatively well-established. The relevant ERP components are summarized in **Table 7.1**; the peak, distribution, and interpretation of these components is largely based on a recent meta-analysis (Antoniou, 2023). First, an increased negativity is often observed for incongruent trials within earlier

[1] This could also be compared to perception studies examining the EEGs of participants who are watching/listening to videos or movie clips (e.g. Y.-J. Liu et al., 2018).

time-windows (N1, N2 effects) (e.g., Hsieh & Fang, 2012; Kopp et al., 1996; Nigbur et al., 2011; Tillman & Wiens, 2011; Wild-Wall et al., 2008). Second, an increased positivity can be observed for incongruent trials within later time-windows (P3, LPC effects) (Clayson & Larson, 2011; Kopp et al., 1996; Wild-Wall et al., 2008). These components reflect several aspects of cognitive control, including response inhibition, conflict monitoring, and attentional control.

Table 7. 1. ERP components pertinent to the Flanker task, and their hypothesized interpretations (based on Antoniou, 2023).

ERP	Peak	Distribution	Interpretation
N1	100-200 ms	occipital	Increased negativity for incongruent trials, linked to early attentional processing and discrimination (visual).
N2	200-350 ms	fronto-central	Increased negativity for incongruent trials, linked to response inhibition, conflict monitoring.
P3	250-500 ms	centro-parietal	Increased positivity for incongruent trials, linked to response inhibition and attentional control.
LPC	500-800 ms	centro-parietal	Increased positivity for incongruent trials, linked to inhibition processes. May simply be an extension of the P3.

As for EEGs, the Flanker task usually modulates theta and alpha bands, with incongruent trials eliciting increased theta oscillations and reduced alpha oscillations (e.g., Haciahmet et al., 2021; McDermott et al., 2017; Nigbur et al., 2011; Polich, 2007). Theta activity/synchronisation and alpha desynchronization are both linked to attention and conflict management (e.g., Nigbur et al., 2011; Polich, 2007). Indeed, ERPs during EF tasks, such as the P3 component, covary with theta and alpha band modulations (Jasiukaitis & Hakerem, 1988).

7.1.3 Present study

In the current pilot study, French-English bilinguals (from the same language community as the participants tested in CHAPTER 6) listened to naturalistic bilingual conversations and performed a Flanker task while their EEGs were recorded. Importantly, the bilingual conversations were excerpts from the FEBLO-Corpus. To my knowledge, this is the first neuroimaging study that has utilized real-life instances of code-switches as the experimental materials. The oscillations (frequency-specific power) elicited by the passive listening task (and during resting-state) were compared to the ERPs and time-frequency representations of the Flanker task. The following research questions guided the study:

(1) **Primary Q**: What are the spectral signatures underlying the processing of real-life instances of code-switching?
   a. **Q1:** Do by-subject demographic and linguistic traits modulate the EEGs of bilinguals at rest?
   b. **Q2:** Do bilingual conversations elicit increased oscillations in theta-to-gamma frequency bands compared to unilingual conversations?
   c. **Q3**: What are the ERP and time-frequency representations of the Flanker task?
   d. **Q4**: How are Flanker ERPs/EEGs (i.e. cognitive control indices) related to the spectral signatures underlying passive listening?

Based on the results from CHAPTER 6, it was hypothesized that listening to naturalistic code-switches would be marked by some index of increased cognitive control (e.g., increased power in theta or alpha bands; Litcofsky & Van Hell, 2017; Fernandez et al., 2019). In line with recent rEEG studies (e.g., Pereira Soares et al., 2021), I also anticipated that oscillations during passive listening and at rest would be modulated by participant characteristics, such as degree of balanced bilingualism. As for the Flanker task, I expected N2 and/or P3 effects (in the time domain) and theta and/or alpha modulations (in the time-frequency domain) for incongruent trials, as is typical in the relevant literature. Finally, I hypothesized that Flanker indices would be related to passive listening EEGs, with participants possessing good inhibitory control (e.g., reduced ERP effects for incongruent trials) displaying the least effortful processing of naturalistic code-switches.

7.2 Methods

7.2.1 Participants

Thirteen French-English bilinguals gave informed consent (REB file #S-04-22-8029) and completed the study. All were recruited via word-of-mouth, social media, in-class announcements at the University of Ottawa, and through the University of Ottawa Integrated System of Participation in Research (ISPR) pool. Participants recruited through ISPR were compensated with partial course credit; those recruited outside of ISPR were entered into a draw for a $50 CAD gift card. Three participants were excluded (one due to a complex language background, a second due to equipment failure, and a third due to unsatisfactory impedances), leading to a final sample size of ten participants (*M* age= 32.0 years, *SD*=15.2 years, 18-56 years; 6 women, 3 men, 1 non-binary). All individuals possessed normal or corrected-to-normal hearing and vision, and no history of language disorders or ADD/ADHD.

The sample completed extensive demographic and language background questionnaires (Byers-Heinlein, 2013; Gullifer & Titone, 2020; Rodriguez-Fornells et al., 2012; Sabourin et al., 2016). Most participants reported that French was their L1, but three indicated that they were native speakers of both French and English. Exposure to English

Table 7. 2. Overview of the participant sample.

<table>
<tr><th colspan="2"></th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th></tr>
<tr><td colspan="2">Highest level of education obtained*</td><td>20% (2)</td><td>20% (2)</td><td>60% (6)</td><td>0% (0)</td><td>0% (0)</td></tr>
<tr><td colspan="2">Video-game habits**</td><td>40% (4)</td><td>20% (2)</td><td>40% (4)</td><td>0% (0)</td><td>0% (0)</td></tr>
<tr><th colspan="4"></th><th>Ontario</th><th>Québec</th><th>Other</th></tr>
<tr><td colspan="4">Current province of residence</td><td>80.0% (8)</td><td>10.0% (1)</td><td>10.0% (1)</td></tr>
<tr><td colspan="4">Proportion of time lived</td><td>.73 (.41)</td><td>.17 (.35)</td><td>.10 (.28)</td></tr>
<tr><th colspan="4"></th><th>Only French</th><th>Only English</th><th>Both</th></tr>
<tr><td colspan="4">Self-reported L1</td><td>70% (7)</td><td>0% (0)</td><td>30.0% (3)</td></tr>
<tr><td colspan="4">Self-reported dominant language</td><td>60% (6)</td><td>40% (4)</td><td>-</td></tr>
<tr><th colspan="4"></th><th>Mean</th><th>SD</th><th>Range</th></tr>
<tr><td rowspan="9">French</td><td colspan="3">Age of exposure (years)</td><td>0</td><td>-</td><td>-</td></tr>
<tr><td colspan="3">Proportion exposure during infancy</td><td>.83</td><td>.22</td><td>.30-1.00</td></tr>
<tr><td colspan="3">Current usage (%)</td><td>.45</td><td>.30</td><td>.05-.95</td></tr>
<tr><td colspan="3">Current global proficiency (out of 5)†</td><td>5.00</td><td>-</td><td>-</td></tr>
<tr><td colspan="3">Oral comprehension</td><td>5.00</td><td>-</td><td>-</td></tr>
<tr><td colspan="3">Oral production</td><td>5.00</td><td>-</td><td>-</td></tr>
<tr><td colspan="3">Writing</td><td>4.60</td><td>.52</td><td>4-5</td></tr>
<tr><td colspan="3">Reading</td><td>4.90</td><td>.32</td><td>4-5</td></tr>
<tr><td colspan="3">Pronunciation</td><td>5.00</td><td>-</td><td>-</td></tr>
<tr><td rowspan="9">English</td><td colspan="3">Age of exposure (years)</td><td>2.10</td><td>2.77</td><td>0-9</td></tr>
<tr><td colspan="3">Proportion exposure during infancy</td><td>.17</td><td>.21</td><td>0-.65</td></tr>
<tr><td colspan="3">Current usage (%)</td><td>.56</td><td>.32</td><td>.05-.95</td></tr>
<tr><td colspan="3">Current global proficiency (out of 5)†</td><td>4.80</td><td>.42</td><td>4-5</td></tr>
<tr><td colspan="3">Oral comprehension</td><td>4.80</td><td>.63</td><td>3-5</td></tr>
<tr><td colspan="3">Oral production</td><td>4.60</td><td>.70</td><td>3-5</td></tr>
<tr><td colspan="3">Writing</td><td>4.70</td><td>.48</td><td>4-5</td></tr>
<tr><td colspan="3">Reading</td><td>4.90</td><td>.32</td><td>4-5</td></tr>
<tr><td colspan="3">Pronunciation</td><td>4.60</td><td>.70</td><td>3-5</td></tr>
<tr><td rowspan="4">L3</td><td colspan="3">Age of exposure (years)</td><td>8.33</td><td>10.41</td><td>0-20+</td></tr>
<tr><td colspan="3">Proportion exposure during infancy</td><td><.02</td><td>.03</td><td>0-.05</td></tr>
<tr><td colspan="3">Current proficiency (out of 5)†</td><td>1.00</td><td>-</td><td>-</td></tr>
<tr><td colspan="3">Current usage (%)</td><td>.05</td><td>-</td><td>-</td></tr>
</table>

*** Education**: 1=high school; 2=1-2 years post-secondary; 3=3-4 years post; 4=master's; 5=doctorate.

**** Videogames:** 1=never; 2=once in a while; 3=at least once a week; 4=almost every day; 5=every day.

† Proficiency: 0=very low; 1=low; 2=intermediate; 3=advanced; 4=near-native; 5=native.

L3: three participants reported knowledge of an additional language.

occurred on average at 2 years old (range: 0-9 years). All bilinguals reported current near-native to native competence in both languages (i.e., at least 4 out of 5 on self-reported proficiency scales), and no substantial knowledge of an additional language. The participants' demographic and language background is presented in **Table 7.2**; their degree of balance, self-reported code-switching habits, and language entropy statistics are reported in **Table 7.3**.[2]

Table 7. 3. Bilingualism-related characteristics of the participant sample.

		Mean	***SD***	***Range***
Bilingualism load	***Degree of balance ****	1.20	1.69	-1 - 4
	Proportion bilingual interactions	.13	.09	.05 - .30
BSwQ †	***Switching into French***	2.43	.47	1.67-3.30
	Switching into English	2.70	.76	1.30-4.00
	Contextual switching	2.47	.53	1.67-3.00
	Unintentional switching	2.24	.85	1.33-3.67
Lifetime language entropy **	***At school***	.48	.41	0-.93
	At home	.50	.32	0-.97
	With friends	.70	.32	0-.98
	Media consumption	.59	.27	.29-1.00
	Extracurriculars	.49	.35	0-.97
	In the community	.55	.34	0-.98
	At work	.53	.43	0-1.00
	Lifetime entropy average	.55	.23	.16-.84

*** Degree of balance:** -4 = most unbalanced towards English; 0 = perfectly balanced; 4 = most unbalanced towards French.

† Self-reports based on a 5-point scale: 1=never; 2=very infrequent; 3=occasionally; 4=frequent; 5=always.

** **Entropy** is calculated based on Shannon's formula ($H = -\sum_{i=1}^{n} P_i log_2(P_i)$), where the proportion that a given language is used (P_i) is multiplied by the log of itself, and *n* products (*n* being the number of languages in a given context) are then summed. An entropy value of 0 indicates a complete compartmentalization of languages; an entropy value of 1 indicates complete language cooperativeness (diversity).

[2] Note that the sample tested are relatively infrequent code-switchers (according to their self-reports). For instance, FEBLOC speakers (CHAPTERS 4/5) indicated switching into English regularly (M=3.19/5), while the EEG participants reported infrequent switching into English (M=2.70/5); switching into English is the most expected direction in the community under study.

7.2.2 Listening task

The participants listened to forty audio excerpts from the FEBLO-Corpus (and answered forty comprehension questions) while their EEGs were recorded.

Materials

Forty-two audio excerpts were selected from the Free discussion portion of the FEBLO-Corpus (across nine different discussion prompts). Twenty passages were selected for their high rates of code-switching; twenty comparable unilingual excerpts (ten entirely in English, ten entirely in French) were also chosen. Importantly, all pairs who contributed (at least one) code-switching excerpt also contributed (at least one) unilingual excerpt, ensuring that speaker identity was not confounded with condition (code-switch, unilingual). This means that pairs who did not yield a dense code-switching excerpt during the Free discussion activity (pair0.1, pair01, and pair20) did not contribute to the materials.

Since the materials were elicited completely naturally, they occasionally required some editing. If an excerpt contained muted identifying information, this silence was removed (or, if possible, the utterance(s) containing the identifying information was/were removed). When speakers "broke the fourth wall" (i.e., if they directly referred to the prompt or the instructions of the discussion activity), these utterances were eliminated. Extended pauses between utterances and between turn-taking were cut. In code-switched passages, any borrowings were edited out. Passages were still included as unilingual if they contained short expressions in the opposite language (e.g., in a fully unilingual French excerpt, someone replies "yeah"); these short other-language expressions were nevertheless edited out of the final audio. Finally, utterances of low audio quality were occasionally removed from the discussion flow (e.g., a soft-spoken utterance, a loud laugh, etc.). Note that in all cases, care was taken to ensure that the alterations did not impact the integrity of the audio recording. If the edits were perceptible or 'strange' (either acoustically or semantically), the passage was substituted in the final pool of stimuli.

Once the forty excerpts were finalized, a number of features were verified to ensure counterbalancing across conditions. The conditions were well-matched in terms of length, number of utterances, partner turn-taking, interruptions, overlapping segments, hesitations, repetitions, retakes, rephrases, phonological segments and segment lengthening (see **Table 7.4**). However, there were originally marginally more silent pauses in code-switched excerpts compared to unilingual excerpts (t=1.73, p=.09). Nine short pauses were edited into various unilingual passages, resulting in comparable numbers across conditions (see **Table 7.4**). On average, code-switched excerpts contained 6.3 switches, or one switch every 3.8 seconds. The excerpts were converted to mono (a single-channel playing in both ears), and intensity was scaled to 65 dB.

Forty comprehension questions were composed for the stimuli. These consisted of true/false declarations about the content of each corresponding audio excerpt. The declarations were always unilingual, and asked in the dominant language of the preceding passage. For instance, if a code-switched excerpt was composed of seven utterances in French and fourteen utterance in English, the comprehension question was posed in English. Half of the questions required 'True' answers, and half required 'False' answers (counterbalanced across conditions.

Table 7. 4. Characteristics of the FEBLOC excerpts according to condition.

Characteristic	Code-switched	Unilingual	Condition comparison *t*	*p*
Excerpt length (secs)	24.0 (4.4)	23.1 (3.8)	.71	.48
Number of utterances	20.1 (5.9)	18.8 (4.1)	.81	.43
Turn-taking between speakers	7.4 (4.3)	7.1 (4.3)	.26	.80
Number of interruptions	.45 (.61)	.45 (.83)	.00	1.00
Number of overlapping utterances	2.75 (2.25)	2.85 (2.25)	.14	.89
Number of disfluencies	7.95 (4.05)	7.00 (3.33)	.81	.42
Silent pauses	2.35 (1.53)	2.10 (.79)	.65	.52
Hesitations (filled pauses)	1.15 (1.50)	1.15 (1.23)	.00	1.00
Repetitions	1.20 (1.58)	1.15 (1.60)	.10	.92
Retakes	1.15 (1.04)	.70 (.98)	1.41	.17
Rephrases	.15 (.37)	.05 (.22)	1.04	.30
Phonological segments	.50 (.83)	.65 (1.04)	.51	.62
Lengthening	1.45 (1.23)	1.20 (1.20)	.65	.52
Number of switches	6.30 (2.94)			
Intra-CS	2.75 (1.41)			
Inter-CS	1.30 (1.22)			
Between-CS	1.25 (1.07)			

Norming

Seven informants who spoke both French and English but were not tested in the main part of the study (*M* age= 27.8 years, *SD*=12.9 years, 18-51 years; 5 women, 1 man, 1 non-binary) listened to the auditory excerpts and answered the comprehension questions (via the online Gorilla Experiment Builder interface: Anwyl-Irvine et al., 2020). They were tasked with rating the intelligibility of each recording (out of 100). The informants were highly accurate in responding to comprehension questions (*M*=94%, *SD*=4%, *range*=88-100%), with no differences across conditions (*t*=.26, *p*=.80). The excerpts were also rated as very intelligible (*M*=92 out of 100, *SD*=5.0, *range*=77.7-98.4), with similar ratings across conditions (*t*=.56, *p*=.58). No excerpts were flagged as odd or difficult to follow. Informants commented that the recordings were "natural", "not challenging", and "fun" to listen to.

Design

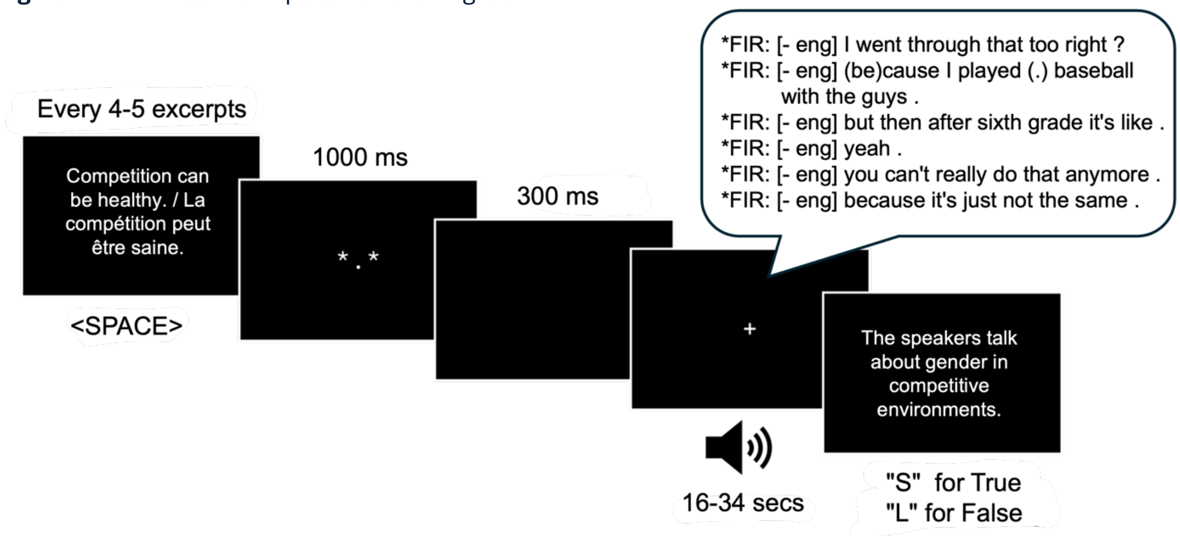
Each participant heard the same forty excerpts. The nine discussion prompts were arranged into three separate orders, which were then randomly assigned to participants. There were 4-5 excerpts per discussion prompt (counterbalanced for condition and True/False answer to the comprehension questions).

Before starting the task, the experimenter explained to the participants that they would be "eavesdropping" on actual conversations between real-life bilinguals. They were told that the speakers in the recordings were couples, friends, siblings, etc. who had previously come to the lab. The participants were instructed to listen carefully to the excerpts, since they would be tasked with answering a T/F question about the conversation they'd just heard. They first heard two practice audio excerpts (with accompanying questions). After practice, the experimenter explained to the participants that they could begin the task once the door to the ERP chamber was shut.

During the task itself (see **Figure 7.1**), participants first read the discussion prompt (presented in both languages) relevant for the following 4-5 excerpts. They were instructed to press the spacebar to start listening to the recordings. Before each excerpt, the symbols *.* were presented for 1000 ms (indicating that participants should blink), followed by a 300 ms blank screen. While the audio passages played, participants were instructed to keep their eyes open and to look at the fixation cross in the center of the screen. Comprehension questions were presented up to ten seconds after every excerpt. Participants pressed "S" (left index) to answer 'True', and "L" (right index) to answer 'False'. At the end of the task, they were shown their accuracy on the comprehension questions. The task took approximately 20 minutes to complete.

The full set of FEBLOC excerpts used as stimuli, as well as by-item characteristics, are included in **APPENDIX G** (a-b).

Figure 7. 1. Procedure of passive listening task.



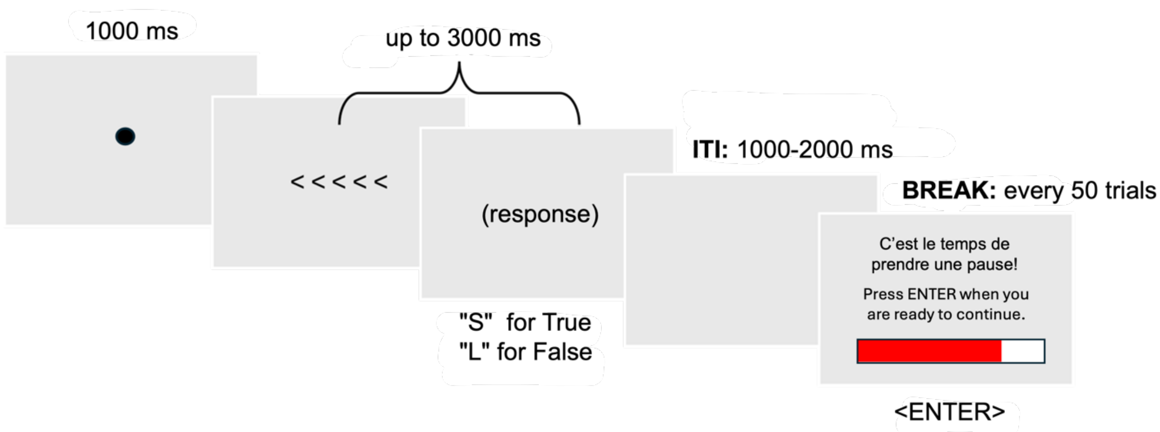
7.2.3 Flanker task

The Flanker task was used to operationalize the participants' non-linguistic cognitive control. During the Flanker task, arrows are presented on a computer screen. Participants are instructed to indicate the direction of the central arrow (while ignoring the peripheral symbols) by pressing a button on their keyboard. In the present task, target arrows were either congruent with the flankers (< < **<** < <; > > **>** > >) or incongruent with the flankers (< < **>** < <; > > **<** > >). The idea is that participants must inhibit the flanking arrows during incongruent trials, and these trials thus generate longer reaction times (and/or distinct brain responses). The difference between congruent and incongruent trials (the interference effect) operationalizes an individual's inhibitory abilities.

Note that neutral trials were not included in the experiment design (see also Tillman & Wiens, 2011). The reason for this is threefold. First, there is no standard 'neutral' in the Flanker ERP/EEG literature (e.g., flanking the central target with squares/rectangles: Hsieh & Fang, 2012; Kopp et al., 1996; Wild-Wall et al., 2008; removing the flankers and only presenting the central target: Kousaie & Phillips, 2012; Wild-Wall et al., 2008). The current experimental script was adapted from an existing template available at Neurobehavioral Systems, wherein trials are only compatible or incompatible. Second, CHAPTER 6 (as well as my previous work: Gosselin & Sabourin, 2023a), has shown poor reliability for the facilitation effect (neutral — congruent trials). Since this effect is not being operationalized here, neutral trials are not required. Third, eliminating the neutral condition from the study design means that a higher amount of congruent and incongruent trials could be presented to the participants. Preserving a high number of quality data points (after cleaning) is crucial for reliable ERP/EEG grand averages, particularly given the small sample size tested here.

The current Flanker task was made up of 10 practice trials and 300 fully randomized experimental trials (150 congruent, 150 incongruent; equally split between left-facing and right-facing targets). A single trial is depicted in **Figure 7.2**: a fixation point was first presented for 1000 ms. Next, the target and its flankers appeared in black font over a gray screen. All participants were instructed to press "S" (left index) when the target-arrow faced left, and to press "L" (right index) when the target-arrow faced right. The next trial commenced if no response was selected within 3000 ms. To avoid rhythmic responses, inter-trial intervals (a blank screen) were randomly assigned a duration of 1000 ms, 1250 ms, 1500 ms, 1750 ms or 2000 ms. Participants were given the option to take a break every 50 trials (at which point a progress bar was displayed). The participants' RTs and accuracy were recorded. Every participant completed all 300 experimental trials. The task lasted approximately 10 minutes.

Figure 7. 2. Procedure of Flanker task.



7.2.4 Procedure

Participants completed the consent form in their language of choice (French or English). After exfoliating and cleaning the face, midline, and mastoids, six external electrodes were applied to the participants' face and mastoids. Vertical eye movements were tracked via electrodes above and below the left eye; horizontal eye movements were tracked via electrodes on both temples. Participants were fitted with a 64-channel 10/20 Quik-Cap by Compumedics Neuroscan (impedances ≤ 10 kΩ). The data was recorded at a sampling rate of 1000 Hz with Scan 4.5 (Compumedics Neuroscan), using a SynAmps amplifier. The online reference electrode was located between Cz and CPz. Participants were also fitted with disposable earbuds. During the capping procedure, an additional experimenter filled out a portion of the demographic and language background questionnaire by interviewing the participant.

All tasks were programmed and run in Presentation 17.2 (Neurobehavioural Systems). Before the experimental tasks (passive listening and Flanker) began, five minutes of continuous eyes-open resting-state EEG (rEEGs) were collected. The participants were instructed to sit comfortably in the low-lit quiet ERP chamber, and to look at the fixation cross on the screen. They were encouraged to stay still and relaxed, but to keep awake.

Following rEEG collection, participants completed the passive listening task, then the Flanker task. The experimenter explained the importance of avoiding sudden muscle movements and excessive blinking/eye saccades before each task.

After the experimental portion of the study was completed, the EEG cap and external electrodes were removed and participants were given the option to wash their hair. They then completed the questionnaires (in the language of their choice) through the Gorilla Experiment Builder interface. Finally, participants were debriefed and given the opportunity to ask questions. All stated that they had no difficulty in understanding the audio clips, but many expressed that the comprehension questions were tricky.

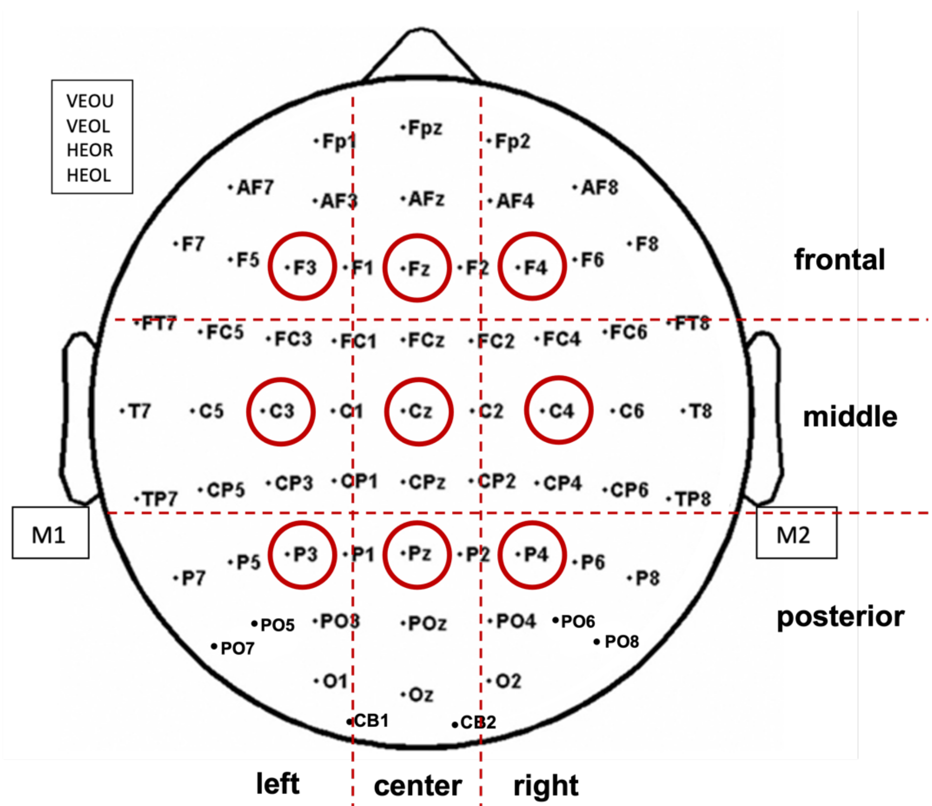
7.2.5 EEG processing

The EEG data was processed in Brain Vision Analyzer 2.2 (Brain Products GmbH). The data was re-referenced offline to the average of both mastoid electrodes, and down-sampled to 512 Hz. A low cut-off filter of 0.03 Hz, a high cut-off filter of 50 Hz, and a notch filter of 60 Hz were applied. Blinks were corrected via a semi-automatic Independent Component Analysis (ICA); this method decomposes the EEG signal into various frequencies in order to isolate those which best account for ocular noise (Hoffmann &

Falkenstein, 2008). The component accounting for the most horizontal noise, as well as the component accounting for the most vertical noise, were manually selected and subtracted. Comparison to uncorrected data confirmed that blinks were satisfactorily corrected.

To simplify subsequent analyses, only nine electrodes were examined: F3, Fz, F4, C3, Cz, C4, P3, Pz, P4. These can be divided into three levels of Longitude (frontal: F3, Fz, F4; middle: C3, Cz, C4; posterior: P3, Pz, P4) and three levels of Latitude (left: F3, C3, P3; center: Fz, Cz, Pz; right: F4, C4, P4). The distribution of electrodes on the cap and selection of the final set of electrodes is illustrated in **Figure 7.3**.

Figure 7. 3. Configuration of EEG cap. Electrodes selected for the analyses are circled in red. Levels of Longitude are shown vertically and levels of Latitude are shown horizontally.



Resting-state EEGs

Following previous research (Bice et al., 2020; Pereira Soares et al., 2021), the continuous rEEG was split into two second segments with a 50% overlap between segments. Semi-automatic artifact inspection (maximum amplitude: 100 µv, minimum amplitude: -100 µv) was then applied to the segments. Any segment violating artifact inspection was excluded across all channels (2.2% of all segments). On average, rEEGs contained 293 segments per subject (*SD*=9.9, *range*=269-299).

Fast Fourier transform (FFT) was applied to the segments using maximum resolution (.5 Hz) and a 10% Hanning window. The output of the FFT is the power density (μv^2/Hz) across the full spectrum. Finally, the FFT output for each segment was averaged within participants, and then grand-averaged for the sample as a whole. Based on previous research (Fernandez et al., 2019; Litcofsky & Van Hell, 2017; Tomić & Kaan, 2022), the power density of the following frequency bands were extracted: theta (4-7 Hz), alpha (8-12 Hz), lower-beta (15-18 Hz), upper-beta (20-30 Hz), lower-gamma (30-40 Hz), upper-gamma (40-50 Hz).

Passive listening EEGs

As the audio excerpts come from real, naturalistic conversations, there are no specific manipulated "critical areas" (i.e., there is no exact time-locking for switches within excerpts). As such, the data was analyzed similarly to the rEEGs. First, the continuous data was segmented into individual items (i.e., 15-30 second clips according to the auditory excerpts). Next, each item was split into two second segments (50% overlap) and artifact inspection was conducted. On average, 22 segments were included for each code-switched item (*SD*=4.5; grand-average total=198 segments) and 21 segments were included for each unilingual item (*SD*=3.9; grand-average total=197 segments).

Fast Fourier transform (FFT) was applied to the included segments using maximum resolution (.5 Hz) and a 10% Hanning window. The FFT output was averaged within items, and then grand-averaged across items from the same condition (code-switched excerpts, unilingual excerpts) for the sample as a whole. The exports thus include the power density (μv^2/Hz) of theta, alpha, lower-beta, upper-beta, lower-gamma, and upper-gamma bands for each participant and item, on each target electrode.

Flanker task

Unlike the passive listening task, the Flanker task is conducive to time-locking. As such, the continuous EEG data was segmented into epochs that were time-locked to the onset of the stimulus (i.e., when the target and flankers were presented). Epochs possessed a 200 ms corrected pre-stimulus baseline and extended until 1500 ms post-stimulus. Artifact inspection was applied, and segments without a response (i.e., surpassing the maximum threshold of 1500 ms; see *Section 7.3.3*) were discarded (4.9% of total epochs). By-participant averaging was completed for trials from the same level of Congruency (congruent, incongruent). On average, 146 segments were included per subject for congruent trials (*SD*=4.7, *range*=133-149) and 139 segments were included per subject for incongruent trials (*SD*=7.2, *range*=126-146). The ERPs on the target electrodes were then extracted within four time-windows. The first time-window (150-200 ms) accounts for potential differences on the N1 component. The second and third time-windows (200-350, 350-500 ms) examine N2 and P3a/b effects. The last time-window (500-700 ms) accounts for an LPC effect (i.e., an extension of the P3, or its own inhibition-related process) (see Antoniou, 2023 for a review).

The frequency domain for the Flanker task was also examined. Given that the Flanker task has been found to modulated theta and alpha oscillations (e.g., Haciahmet et al., 2021; McDermott et al., 2017; Nigbur et al., 2011; Polich, 2007), Morlet Complex wavelets were extracted for these two frequency bands (in 40 logarithmic frequency steps). The wavelets were normalized using Gabor normalization. The output thus includes a congruency-specific (i.e., congruent, incongruent) complex wavelet coefficient (μV) for every subject on each of the target electrodes. These coefficients were subsequently extracted within the same time-windows as the ERPs (150-200 ms, 200-350 ms, 350-500 ms, 500-700 ms).

7.2.6 Analyses

All analyses were conducted in *R* (version 4.21). Linear mixed model analyses utilized the `lme4` and `lmerTest` packages. Model comparison was done by using the `anova` function. In the case of significant effects involving categorical factors, planned comparisons were conducted with the `emmeans` package (with a Tukey correction applied for multiple comparisons); in the case of significant effects or interactions involving continuous factors, slopes were examined via the `emtrends` function of the same package. Finally, fitted models figures were built using `emmips::emmeans` and `ggplot2`. The scripts for the analyses and all complete datasets can be found on Open Science Framework at https://osf.io/7c2p4/?view_only=4d1b328cd0d745a786b1d8ce20d69f9a.

7.3 Results

7.3.1 Resting-state EEGs

The periodic power density (uV^2/Hz) of each of the relevant frequency bands (theta, alpha, lower beta, upper beta, lower gamma, upper gamma) were submitted to linear mixed effect models (scaled to better suit linear model assumptions). The power density distribution of the rEEGs is illustrated in Panel A of **Figure 7.4**.

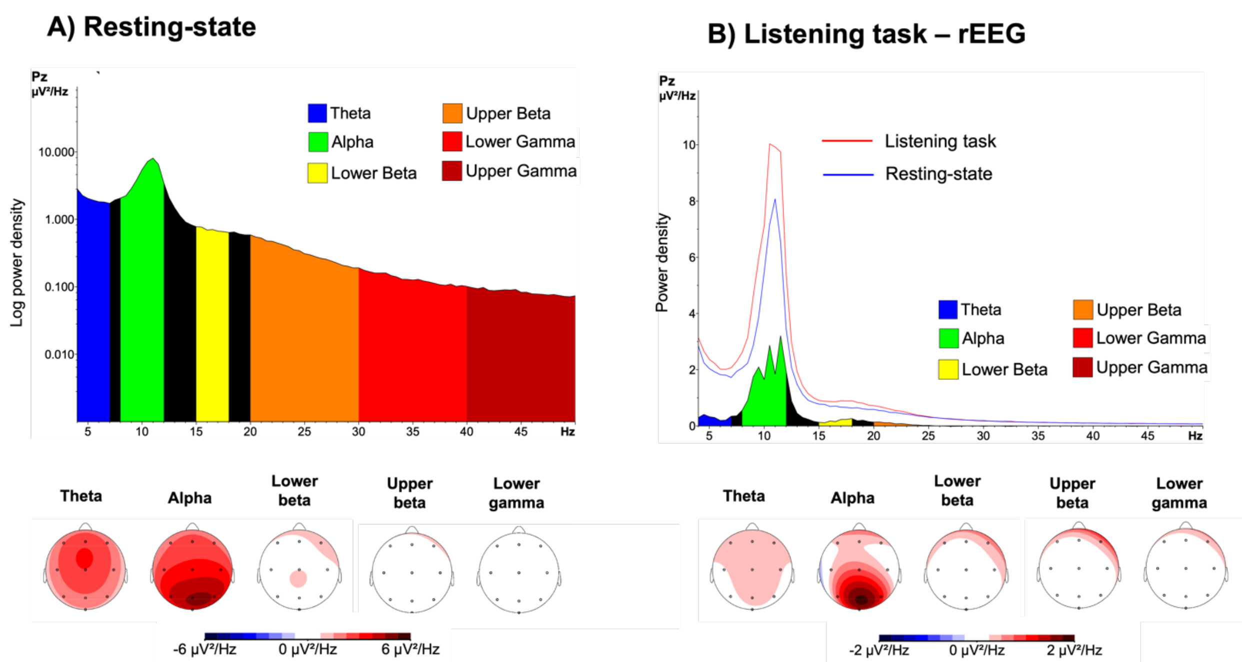
Confidence check: Are rEEGs different from passive listening EEGs?

The power density of each frequency band during rest was compared to the power density of the same frequency bands during passive listening (see *Section 7.3.2*), collapsed across all excerpts. To do so, mixed models included the fixed factors of State (contrast-coded: resting=-1, listening=1) as well as dummy-coded Latitude (center=0/0; left=1/0, right=0/1) and Longitude (frontal=0/0; middle=1/0, posterior=0/1); interactions between State and topographic factors were permitted. Maximal models were first fitted (by-subject random intercepts and slopes for State, Latitude, and Longitude); in the case of non-convergence or singularity, the random effect structure was pruned first by removing slopes for the topographic factors (beginning with the factor contributing the least variance), then (if needed), the random slopes for State. For simplicity, I report the results from the anova summary of each model below.

There were significantly more theta oscillations (main effect of State: F=13.089, p=.006), posterior alpha oscillations (State*Longitude interaction: F=5.034, p=.007), lower-beta oscillations (main effect of State: F=10.802, p=.009), frontal upper-beta oscillations

(State*Longitude interaction: F=5.464, p=.005), frontal lower-gamma oscillations (State*Longitude interaction: F=3.571, p=.031), and frontal upper-gamma oscillations (State*Longitude interaction: F=3.145, p=.046) during passive listening than during rest. These differences are shown in Panel B of **Figure 7.4**.

Figure 7. 4. A) Power density of the frequency spectrum during resting-state. B) Difference in power density between passive listening and resting-state.



Are rEEGs modulated by participant traits?

A handful of previous studies have shown that participant characteristics modulate EEGs, even at rest (Bice et al., 2020; Pereira Soares et al., 2021). To test this, mixed models were performed on the the power density of each frequency band during rest. Fixed factors included dummy-coded Latitude (center=0/0; left=1/0, right=0/1) and Longitude (frontal=0/0; middle=1/0, posterior=0/1), as well as participants traits of Age, Education, Video-game habits, Degree of Balance and Lifetime Entropy (with no interactions). Maximal models were first fitted (by-subject random intercepts and slopes for Latitude and Longitude); in the case of non-convergence or singularity, the random effect structure was pruned by removing slopes for the topographic factors contributing the least variance. The significant results are illustrated in **Figure 7.5**.

Theta (4-7 Hz). Theta oscillations during rest were not modulated by any of the participant traits (ts<1.2, ps$>.30$).

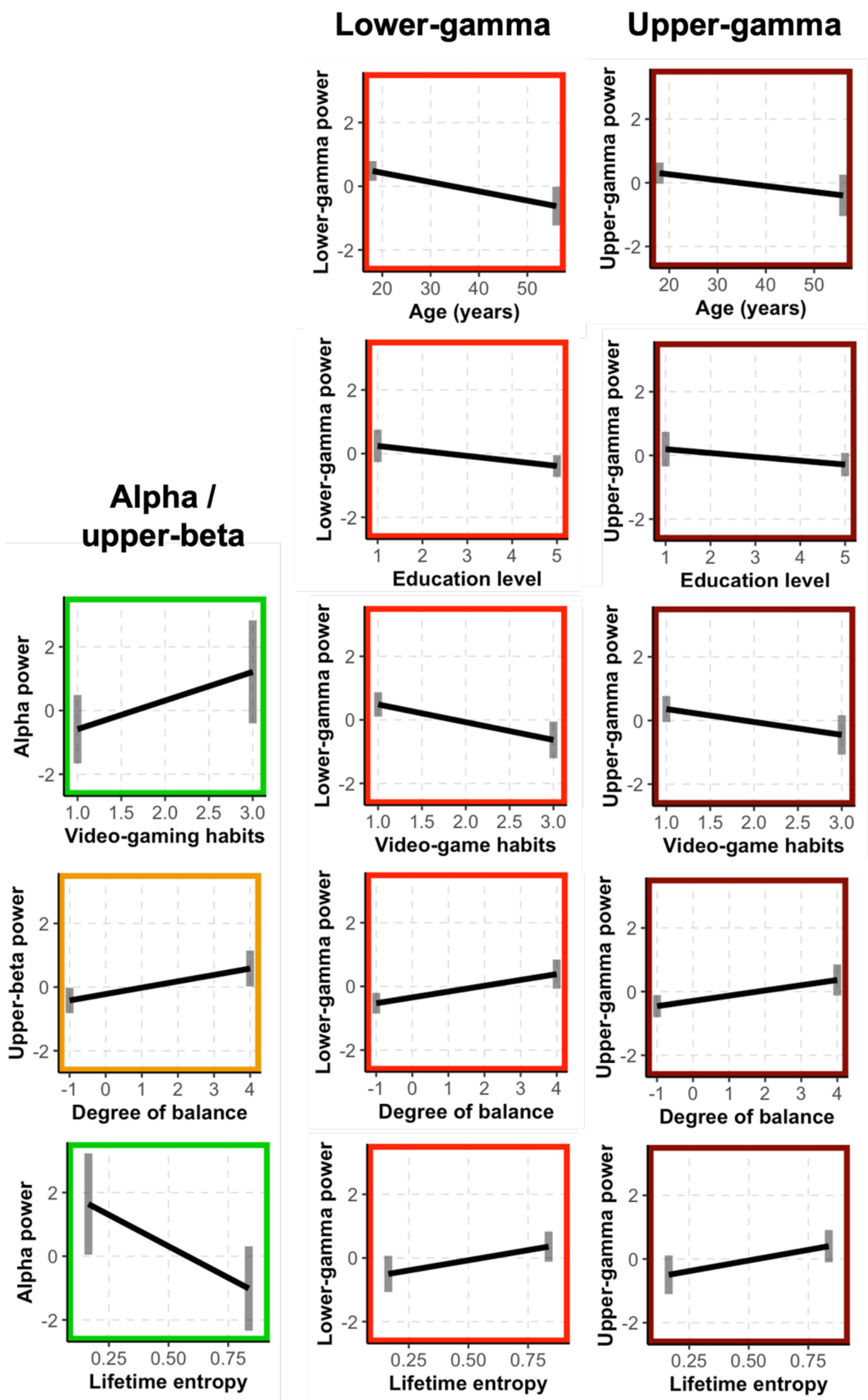
Alpha (8-12 Hz). Alpha oscillations during rest were marginally modulated by the participants video-game habits (*Est*=.901, *SE*=.426, t=2.112, p=.102) and significantly modulated by their language entropy coefficient (*Est*=-3.948, *SE*=1.381, t=2.857, p=.046). Individuals who reported frequently playing video-games exhibited increased alpha power at rest, while individuals with higher language diversity displayed reduced alpha power.

Lower-beta (15-18 Hz). Lower-beta oscillations during rest were not modulated by any of the participant traits (ts<1.14, ps$>.31$).

Upper-beta (20-30 Hz). Upper-beta oscillations during rest were significantly modulated by the participants' degree of balance (*Est*=.200, *SE*=.0549, t=3.651, p=.022). Individuals who were more unbalanced (skewed towards French) displayed increased upper-beta power at rest.

Lower-gamma (30-40 Hz) and Upper-gamma (40-50 Hz). Gamma oscillations (lower and upper) during rest were significantly reduced as a function of Age (ts>2.1, ps$<.03$), Education (ts>1.7 ps$<.08$), and Video-gaming habits (ts>2.4, ps$<.014$). By contrast, gamma oscillations were significantly augmented as a function of increased French-dominance (ts>3.4, ps$<.001$) and language diversity (ts>2.5, ps$<.011$).

Figure 7. 5. Predicted linear values for power density of frequency bands (scaled) during resting-state according to participant traits. Only the significant effects are shown (with 95% confidence intervals). *Educational level*: 1=high school, 2=1-2 years post-secondary, 3=3-4 years post-secondary, 4=master's, 5=doctorate. *Video-game habits*: 1=never; 5=every day. *Balance*: -4 = most unbalanced towards English; 0 = perfectly balanced; 4 = most unbalanced towards French. *Entropy*: 0= compartmentalized languages; 1=integrated languages.



7.3.2 Listening task

Comprehension questions

Overall, participants were quite accurate in responding to the True/False declarations following each audio excerpt (overall: *M*=83.5%, *SD*=9.6%, code-switched excerpts: *M*=82.0%, *SD*=13.2%; unilingual excerpts: *M*=85.0%, *SD*=10.0%). A binomial generalized mixed model was fitted to participants' comprehension question accuracy (correct=1, incorrect=0) during the listening task. Fixed factors included the Condition of the corresponding excerpt (code-switched, unilingual), as well as the control covariates of Age, Education, Video-games, and Degree of balance. The model failed to converge with by-subject random slopes for Condition. Therefore, only by-subject and by-item random intercepts were included in the final model. Condition was not a significant predictor of the participants' accuracy (*Est*=.399, *SE*=.454, *z*=.878, *p*=.38), indicating that participants were able to understand the content from code-switched excerpts just as well as the content from unilingual excerpts.

EEGs

Recall that continuous EEGs for each excerpt were split into two second segments; their FFT were then averaged over the length of the excerpt. As such, the output includes the periodic power density of items on the target electrodes. Each of the relevant frequency bands (theta, alpha, lower beta, upper beta, lower gamma, upper gamma) were submitted to linear mixed effect models (scaled to better suit linear model assumptions). In all cases, the fixed effects included contrast-coded Condition (Code-switched=1, Unilingual=-1), as well as dummy-coded Latitude (center=0/0; left=1/0, right=0/1) and Longitude (frontal=0/0; middle=1/0, posterior=0/1); interactions between Congruency and topographic factors were permitted. Furthermore, the covariates of Age, Degree of balance, and Lifetime Entropy were included and allowed to interact with Condition. Maximal models were first fitted (by-subject and by-item random intercepts, as well as by-subject random slopes for Condition, Latitude, and Longitude); in the case of non-convergence or singularity, the random effect structure was pruned first by removing slopes for the topographic factors (beginning with the factor contributing the least variance), then (if needed), the random slopes for Condition. The data is visualized in **Figure 7.6**.

Theta (4-7 Hz). The final model included by-subject random slopes for Condition. Condition did not significantly modulate theta power density (Est= -.0291, SE=.0413, t=.704, p=.49), and did not interact with the topographic factors (ts<.74, ps>.46) or the covariates (ts<1.2, ps>.28). The covariates did not produce main effects (ts<.76, ps>.47).

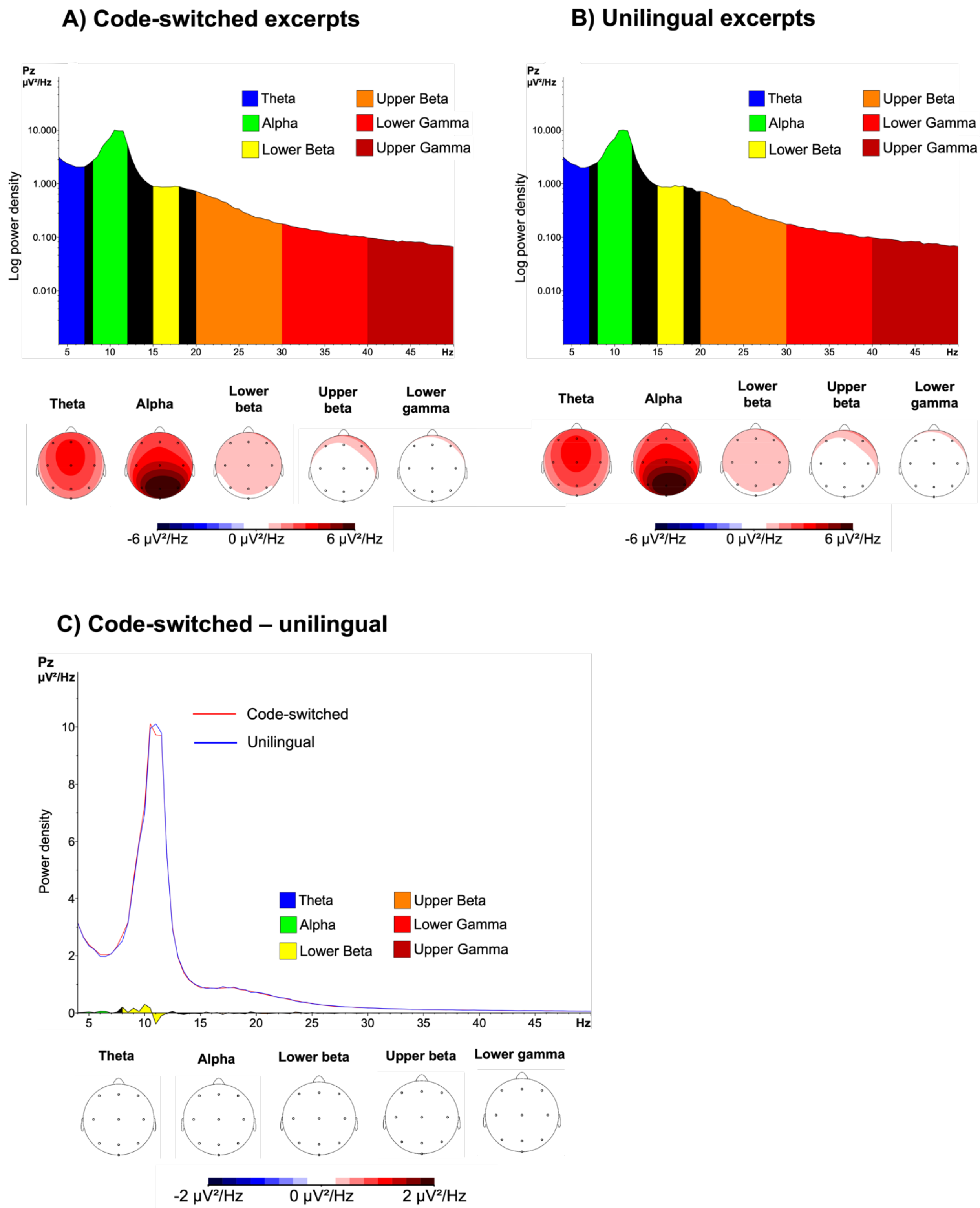
Alpha (8-12 Hz). The final model included by-subject random slopes for Condition. Condition did not significantly modulate alpha power density (Est=.0464, SE=.0528, t=.878, p=.39), and did not interact with the topographic factors (ts<.24, ps>.81) or the covariates (ts<1.56, ps>.35). However, alpha power was significantly related to entropy (Est= -2.222, SE=.8417, t=2.640, p=.039): bilinguals with more language diversity exhibited reduced alpha oscillations during the listening task, regardless of Condition.

Lower beta (15-18 Hz). The final model included by-subject and by-item random intercepts. Condition did not significantly modulate lower-beta power density (Est= -.0332, SE=.0549, t=.605, p=.55), and did not interact with the topographic factors (ts<.52, ps>.61), or Age / Degree of balance (ts<1.2, ps>.25). One potential trend was observed for the main effect of Entropy (Est= -1.728, SE=1.019, t=1.695, p=.141) and its interaction with Condition (Est= -.0782, SE=.0554, t=.1.410, p=.158). Participants with increased entropy coefficients (higher language diversity) displayed somewhat reduced lower-beta oscillations; this effect trended towards being steeper for unilingual excerpts (Est. slope=-1.81, SE=1.02, CIs= -3.81–.19) compared to code-switched excerpts (Est. slope=-1.65, SE=1.02, CIs= -3.65–.35).

Upper beta (20-30 Hz). The final model included only by-subject random intercepts. Condition did not significantly modulate upper-beta power density (Est=.0322, SE=.0606, t=.532, p=.59), and did not interact with the topographic factors (ts<.24, ps>.81) or the covariates (ts<1.0, ps>.34). However, upper-beta power was marginally related to age (Est= -.0243, SE=.0089, t=2.296, p=.061) and significantly related to degree of balance (Est=.1937, SE=.0804, t=2.411, p=.053). While older participants exhibited reduced upper-beta oscillations during the listening task, participants who were more French-dominant displayed increased oscillations.

Lower gamma (30-40 Hz). The final model included only by-subject random intercepts. Condition did not significantly modulate lower-gamma power density (Est=.0206, SE=.0608, t=.339, p=.73), and did not interact with the topographic factors (ts<.48, ps>.63) or the covariates (ts<1.3, ps>.22). However, lower-gamma power was significantly related to age (Est= -.0146, SE=.0047, t=3.112, p=.021) and degree of balance (Est=.2314, SE=.0423, t=5.472, p=.0016). While older participants exhibited reduced lower-gamma oscillations during the listening task, participants who were more French-dominant displayed increased oscillations.

Figure 7. 6. Power density of the frequency spectrum while listening to code-switched passages (A) or unilingual passages (B). C) Difference in power density between the conditions.



Upper gamma (40-50 Hz). The final model included only by-subject random intercepts. Condition did not significantly modulate upper-gamma power density (Est= -.0279, SE=.0641, t=.433, p=.66), and did not interact with the topographic factors (ts<.23, ps>.82) or the covariates (ts<1.1, ps>.28). However, upper-gamma power was significantly related to age (Est= -.0096, SE=.0036, t=2.651, p=.038), degree of balance (Est=.0211, SE=.0327, t=.6.448, p=.0007), and entropy (Est=.5627, SE=.2314, t=2.432, p=.051). While older participants exhibited reduced upper-gamma oscillations during the listening task, participants who were more French-dominant and those with higher language diversity displayed increased oscillations.

Summary

The EEG results from the listening task are summarized in **Table 7.5**. Overall, participants exhibited similar oscillations for code-switched and unilingual conversations. In fact, the oscillations appeared to be modulated much more by trait characteristics (age, balance, entropy) rather than by the experimental manipulations. Overall, a reduction in oscillations was observed with age, while increased language diversity and French dominance was associated to intensified oscillations in the higher frequency bands (upper-beta, lower-gamma, upper-gamma).

Table 7. 5. Summary of EEG results for the passive listening task.

<table>
<tr><th rowspan="2">Frequency band</th><th rowspan="2">Condition (CS vs. uni)</th><th rowspan="2">Condition * Covariate</th><th colspan="3">Covariate</th></tr>
<tr><th>Age</th><th>Balance</th><th>Entropy</th></tr>
<tr><td>Theta</td><td>ns</td><td>ns</td><td colspan="3">ns</td></tr>
<tr><td>Alpha</td><td>ns</td><td>ns</td><td>Older age= reduced oscillations</td><td colspan="2">ns</td></tr>
<tr><td>Lower-beta</td><td>ns</td><td>Negative entropy slope is somewhat less steep for CS excerpts</td><td colspan="2">ns</td><td>Increased language diversity = decreased oscillations</td></tr>
<tr><td>Upper- beta</td><td>ns</td><td>ns</td><td rowspan="3">Older age= reduced oscillations</td><td rowspan="3">French-skewed balance = increased oscillations</td><td rowspan="2">ns</td></tr>
<tr><td>Lower-gamma</td><td>ns</td><td>ns</td></tr>
<tr><td>Upper-gamma</td><td>ns</td><td>ns</td><td>Increased language diversity = increased oscillations</td></tr>
</table>

7.3.3 Flanker task

Behavioural data

Participants were exceptionally accurate during the Flanker task (overall: *M*=98.6%, *SD*=1.0%, congruent: *M*=99.9%, *SD*=0.3%; incongruent: *M*=97.4%, *SD*=1.9%). Given these ceiling effects, no further analyses were conducted on the accuracy data.

Incorrect trials (*n*=41, 1.4% of the data), and trials with RTs faster than 150 ms or slower than 1500 ms (*n*=24, 0.8% of the data) were rejected. The remaining Flanker RTs were log transformed and submitted to linear mixed models. The fixed effects included contrast-coded Congruency (congruent=1, incongruent=-1) as well as the control covariates of Age, Education, Video-games, and Degree of balance (which were each allowed to interact with

Congruency). The maximal model (with by-subject random intercepts and by-subject random slopes according to Congruency) converged. The model yielded a significant main effect of Congruency (*Est*= -.1307, *SE*=.0416, *t*=3.14, *p*=.03), indicating that incongruent trials elicited significantly longer RTs than congruent trials (congruent: *M*=479 ms, *SD*=135 ms; incongruent: *M*=548 ms, *SD*=156 ms). Indeed, descriptive statistics show the presence of a large interference effect across participants (*M*=-72 ms, *SD*=33 ms).

A marginal interaction between Congruency and Age was also observed (*Est*=.0019, *SD*=.0008, *t*=2.30, *p*=.07). Planned comparisons using `emtrends` revealed that both congruent and incongruent RTs were slower with age, but that this slope was marginally steeper for congruent trials (*Est*=.008, *SE*=.008) compared to incongruent trials (*Est*=.004, *SE*=.009) trials.

Split-half reliability

In order to test the consistency in the split-halves (odd vs. even), intraclass correlation coefficients (see Shrout & Fleiss, 1979) were computed via the `ICC` function in the `psych` R package. The coefficients are type ICC(2,k), as participants were randomly selected from the population, and reliability is estimated based on RT averages (e.g., mean congruent RTs on even trials vs. mean congruent RTs on odd trials). For individual levels of Flanker congruency, odd/even reliability was excellent (congruent: *ICC*=.95, *CIs*=.97–.1; incongruent: *ICC*=1, *CIs*=.99–.1). For the computed interference effect (congruent – incongruent), split-half reliability was also excellent (*ICC*=.87, *CIs*=.51–.97) (see Koo & Li, 2016 for ICC thresholds). This speaks to satisfactory variance in the data (across participants) and the validity of the constructs under study.

Event-related potentials

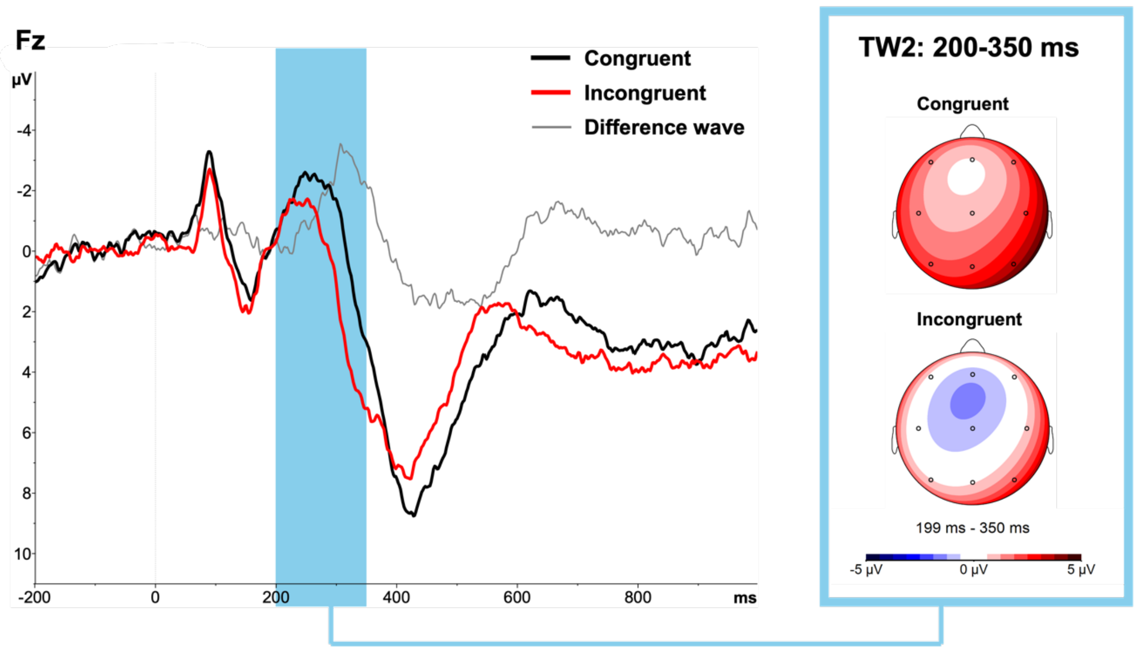
After cleaning and artifact rejection, the ERPs from each exported time-window (N1, N2, P3, LPC) were submitted to linear mixed effect models. In all cases, the fixed effects included contrast-coded Congruency (congruent=1, incongruent=-1), as well as dummy-coded Latitude (center=0/0; left=1/0, right=0/1) and Longitude (frontal=0/0; middle=1/0, posterior=0/1); interactions between Congruency and topographic factors were permitted. Given the wide range of ages of the participants, it was verified whether Age (or Age * Congruency) contributed significantly to the model; Age only improved the fit of the model for the P3 time-window (Chi^2=8.14, *p*=.004), and was thus discarded for all other time-windows. Maximal models were first fitted (by-subject random intercepts and by-subject random slopes for Congruency, Latitude, and Longitude); in the case of non-convergence or singularity, the random effect structure was pruned first by removing slopes for the topographic factors (beginning with the factor contributing the least variance), then (if needed), the random slopes for Congruency.

Time-window 1: 150-200 ms. The final model included only by-subject random intercepts. Congruency did not significantly modulate ERPs (*Est*=.0842, *SE*=.3733, *t*=.226, *p*=.822), and did not interact with the topographic factors (*t*s<.10, *p*s>.92).

Time-window 2: 200-350 ms. The final model included by-subject random slopes for Congruency and Longitude. Congruency modulated Flanker ERPs in this time-window

(*Est*=.8042, *SE*=.3559, *t*=2.259, *p*=.039). Emmeans indicated that incongruent trials elicited significantly more negative responses compared to congruent trials (congruent: *M*=1.865, *SE*=1.35; incongruent: M=.272, *SE*=1.13). Congruency did not interact with the topographic factors (*ts*<.61, *ps*>.54), reflecting a wide distribution across the scalp. This time-window and its topography is illustrated in **Figure 7.7**.

Figure 7. 7. ERPs for the Flanker task. The time-window with a significant difference between the levels of Congruency (N2 time-window, 200-350 ms) is highlighted in blue. The topography of this time-window is shown on the right.



<u>Time-window 3: 350-500 ms.</u> The final model included by-subject random slopes for Congruency and Longitude. Congruency did not significantly modulate ERPs (*Est*= -.3334, *SE*=.4362, *t*=.764 *p*=.454), and did not interact with the topographic factors (*ts*<1.3, *ps*>.20). However, a main effect of Age was observed (*Est*=.1302, *SE*=.0276, *t*=4.711, *p*=.002): older participants elicited more positive responses (*Estimated slope*=.13, *SE*=.0366, *CIs*=.0459 – .214), regardless of Congruency.

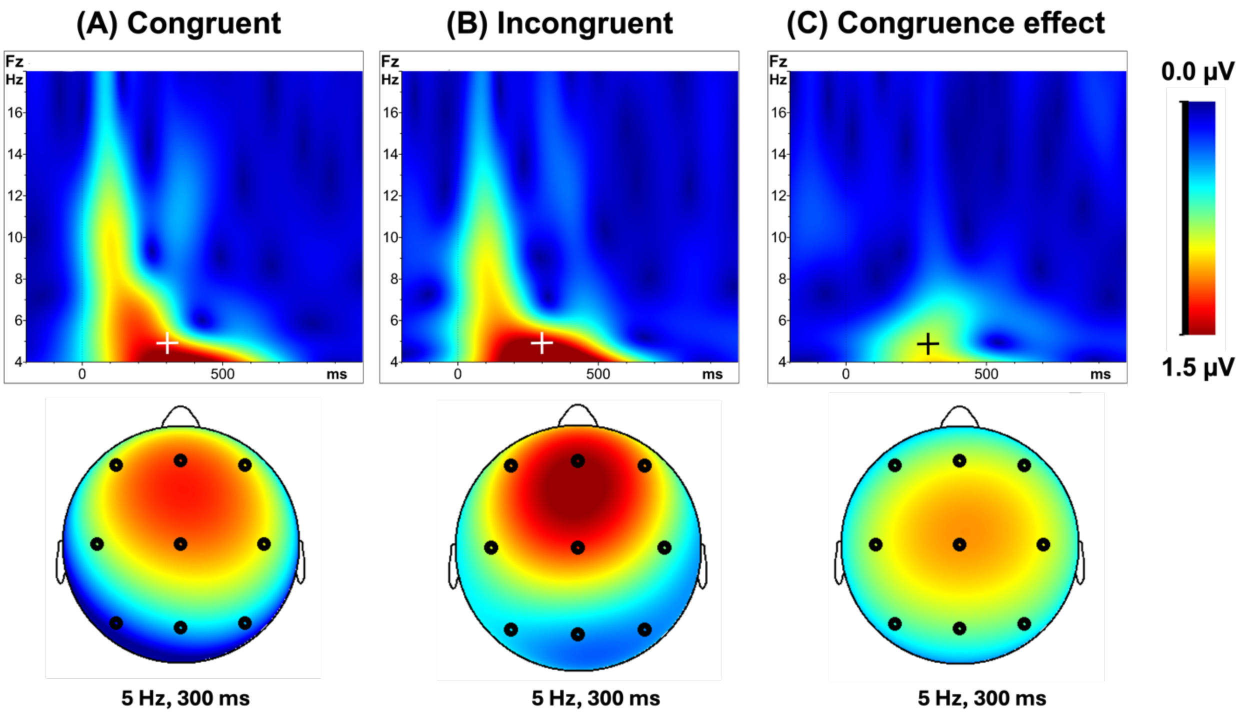
<u>Time-window 4: 500-700 ms.</u> The final model included by-subject random slopes for Congruency and Longitude. Congruency did not significantly modulate ERPs (*Est*= -.0267, *SE*=.2771, *t*=.096 *p*=.92), and did not interact with the topographic factors (*t*s<1.2, *p*s>.24).

EEGs

Recall that trials were averaged within levels of Congruency, and Morlet Complex wavelets extracted theta (4-7 Hz) and alpha (8-12 Hz) oscillation coefficients (µV) for every subject in the four time-windows. These coefficients were subsequently submitted to linear mixed effect models. In all cases, the fixed effects included contrast-coded Congruency (congruent=1, incongruent=-1), as well as dummy-coded Latitude (center=0/0; left=1/0, right=0/1) and Longitude (frontal=0/0; middle=1/0, posterior=0/1); interactions between Congruency and topographic factors were permitted. Given the wide range of ages of the participants, it was verified whether Age (or Age * Congruency) contributed significantly to the model. Maximal models were first fitted (by-subject random intercepts and by-subject random slopes for Congruency, Latitude, and Longitude); in the case of non-convergence or singularity, the random effect structure was pruned first by removing slopes for the topographic factors (beginning with the factor contributing the least variance), then (if needed), the random slopes for Congruency. The data is illustrated visually in **Figure 7.8**.

<u>Time-window 1: 150-200 ms.</u> The final models included included by-subject random slopes for Congruency and Longitude; Age did not improve the fit of the models (*p*s>.19) and was not retained as a fixed factor. Congruency did not significantly modulate theta (*Est*= - .0194, *SE*=.0671, *t*=.289, *p*=.774) or alpha (*Est*=.0548, *SE*=.0729, *t*=.752, *p*=.458) wavelets in the first time window; interactions with the topographic factors were not observed (*t*s<.1.3, *p*s>.20).

Figure 7. 8. Top: Time-frequency representations for congruent trials (A), incongruent trials (B), and the Congruency effect (incongruent – congruent trials) during the Flanker task. Time 0 reflects the onset of the trial. Both theta (4-7 Hz) and alpha (8-12 Hz) bands are illustrated. Bottom: The maps illustrate a snapshot of the topography of 5 Hz oscillations (theta) at 300 ms.



<u>Time-window 2: 200-350 ms.</u> The final models included included by-subject random slopes for Congruency and Longitude; Age (interacting with Congruency) improved the fit of the models (*p*s<.001) and was thus retained as a fixed factor. Congruency significantly modulated theta coefficients (*Est*= - .3087, *SE*=.0858, *t*=3.599, *p*=.0007) with no topographic interactions (*t*s<.1.5, *p*s>.15); this main effect appeared to be caused by a strong interaction between Age and Congruency (*Est*=.0069, *SE*=.0015, *t*=4.674, *p*<.0001). That is, while planned comparisons yielded no reliable effect of Congruency overall (*Est*= -.0441, *SE*=.0974, *t*=.453, *p*=.66), emtrends showed opposite slopes for age according to Congruency (congruent: *Estimated slope*=.0092, *SE*=.0119, *CIs*=.0183 – .0366; incongruent: *Estimated slope*=-.0046, *SE*=.0119, *CIs*= -.0321 – .0228): older participants displayed increased theta wavelets for congruent trials, but decreased theta wavelets for incongruent trials (*Est*=.0138, *SE*=.0036, *t*=3.816, *p*=.005). By contrast, Congruency did not significantly modulate alpha wavelets in this time-window (*Est*= -.0056, *SE*=.1132, *t*=.049, *p*=.96; by age: *Est*=.0005, *SE*=.0029, *t*=.180, *p*=.86; by topography: *t*s<.80, *p*s>.46).

Time-window 3: 350-500 ms. Age (interacting with Congruency) improved the fit of the models (*p*s≤.002) and was thus retained as a fixed factor. The final model for theta included by-subject random slopes for Congruency. Incongruent trials elicited increased theta wavelets compared to congruent trials (main effect of congruency: *Est*= -.3978, *SE*=.0996, *t*=3.994, *p*=.0014). Planned comparisons following a Congruency*Longitude interaction (*Est*=.1513, *SE*=.0592, *t*=2.555, *p*=.012) indicated that the difference between congruent and incongruent trials was largest in frontal electrodes (*Est*= -.3123, *SE*=.103, *t*=3.036, *p*=.011), marginal on middle electrodes (*Est*= -.1973, *SE*=.103, *t*=1.918, *p*=.081), and not significant on posterior electrodes (*Est*= -.0977, *SE*=.103, *t*=.950, *p*=.36). Finally, an interaction between Age and Congruency was observed (*Est*=.0068, *SE*=.0024, *t*=2.802, *p*=.023): emtrends showed opposite slopes for age according to Congruency (congruent: *Estimated slope*=.0025, *SE*=.0102, *CIs*= -.0210 – .0261; incongruent: *Estimated slope*= -.0111, *SE*=.0123, *CIs*= -.0396 – .0173): older participants displayed increased theta wavelets for congruent trials, but decreased theta wavelets for incongruent trials (*Est*=.0137, *SE*=.0060, *t*=2.288, *p*=.052). The final model for alpha included by-subject random slopes for

Congruency and Longitude. Congruency marginally modulated alpha coefficients (*Est*=.0885, *SE*=.0495, *t*=1.788, *p*=.083) with no topographic interactions (*t*s<.1.1, *p*s>.29); this main effect appeared to be caused by a strong interaction between Age and Congruency (*Est*= -.0035, *SE*=.0009, *t*=3.695, *p*=.002). That is, while planned comparisons yielded no reliable effect of Congruency overall (*Est*= -.0285, *SE*=.0576, *t*=.494, *p*=.63), emtrends showed opposite slopes for age according to Congruency (congruent: *Estimated slope*= - .0056, *SE*=.0075, *CIs*= -.0229 – .0117; incongruent: *Estimated slope*= .0013, *SE*=.0067, *CIs*= -.0142 – .0168): older participants displayed decreased alpha wavelets for congruent (but not incongruent) trials (*Est*= -.0069, *SE*=.0023, *t*=3.017, *p*=.017).

<u>Time-window 4: 500-700 ms</u>. The final models included by-subject random slopes for Congruency and Longitude. Age (interacting with Congruency) improved the fit of the model for theta wavelets (*p*=.006), but not for alpha wavelets (*p*=.12). Incongruent trials elicited increased theta wavelets compared to congruent trials (main effect of congruency: *Est*= -.1604, *SE*=.0042, *t*=3.787, *p*=.002); this effect was significant over frontal electrodes (*Est*= -.0933, *SE*=.0388, *t*=2.402, *p*=.031), but not over middle and posterior electrodes (*t*s<1.4, *p*>.18) (Congruency*Longitude interaction: *Est*=.0835, *SE*=.0289, *t*=2.887, *p*=.005). Finally, an interaction between Age and Congruency was observed (*Est*=.0034, *SE*=.0011, *t*=3.231, *p*=.012): emtrends showed opposite slopes for age according to Congruency (congruent: Estimated slope=.0029, SE=.0052, CIs= -.0091 – .0149; incongruent: *Estimated slope*= -.0039, *SE*=.0048, *CIs*= -.0150 – .0071): older participants displayed increased theta wavelets for congruent trials, but decreased theta wavelets for incongruent trials (*Est*=.0068, *SE*=.0026, *t*=2.638, *p*=.030). As for alpha wavelets, the model yielded a marginal main effect of Congruency (*Est*= -.0469, *SE*=.0249, *t*=1.880, *p*=.069), but this effect was not preserved in the planned comparisons (*Est*= -.0439, *SE*=.0355, *t*=1.237, *p*=.25). There were also no interactions with the topographic factors (*ts*<.1.3, *ps*>.20).

Summary

The ERP/EEG results from the Flanker task are summarized in **Table 7.6**. Overall, a significant N2 effect was observed for incongruent trials relative to congruent trials. In the frequency domain, incongruent trials elicited increased frontal theta oscillations in the P3 time-window. Age was negatively associated to these oscillations in the N2, P3, and LPC time-windows, likely reflecting a depreciation of inhibition-related mechanisms with age.

Table 7. 6. Summary of ERP and EEG results for the Flanker task.

	ERPs	EEGs	
		Theta	**Alpha**
150-200 ms	ns	ns	ns
200-350 ms	• increased negativity for incongruent	• decreased wavelets with age for incongruent	ns
350-500 ms	• older participants elicit overall more positive responses	• increased wavelets for incongruent (frontal) • decreased wavelets with age for incongruent	• decreased wavelets with age for congruent trials
500-700 ms	ns		ns

7.3.4 Relationship between listening EEGs and inhibitory control

Recall that neural oscillations did not differ between code-switched excerpts and unilingual excerpts during the passive listening task. However, it is possible that participants possess individual differences in the ways that they process the bilingual conversations. For instance, perhaps participants exhibiting increased indices of inhibitory control display fewer code-switching "costs" during passive listening than those with poorer inhibitory control. This would also support the commonly held belief that inhibitory mechanisms indeed play a role in bilingual processing.

In order to explore this, the power density for unilingual excerpts on Fz (collapsed across items) was subtracted from the power density for code-switched excerpts on Fz (collapsed across items). This gives us a difference score operationalizing the "code-switching cost" exhibited by each participant. A more positive value indicates that a given frequency band had more power for code-switched excerpts; a more negative value indicates that a given frequency band had more power for unilingual excerpts.

Next, the N1, N2, P3, and LPC Flanker congruency effect were calculated by subtracting the ERPs for the congruent condition (collapsed across trials) from the ERPs for the incongruent condition (collapsed across trials). Essentially, these indices reflect Flanker difference waves for each time-window: more *negative* N1/N2 difference waves represent larger Congruency effects, while more *positive* P3/LPC difference waves represents larger Congruency effects.

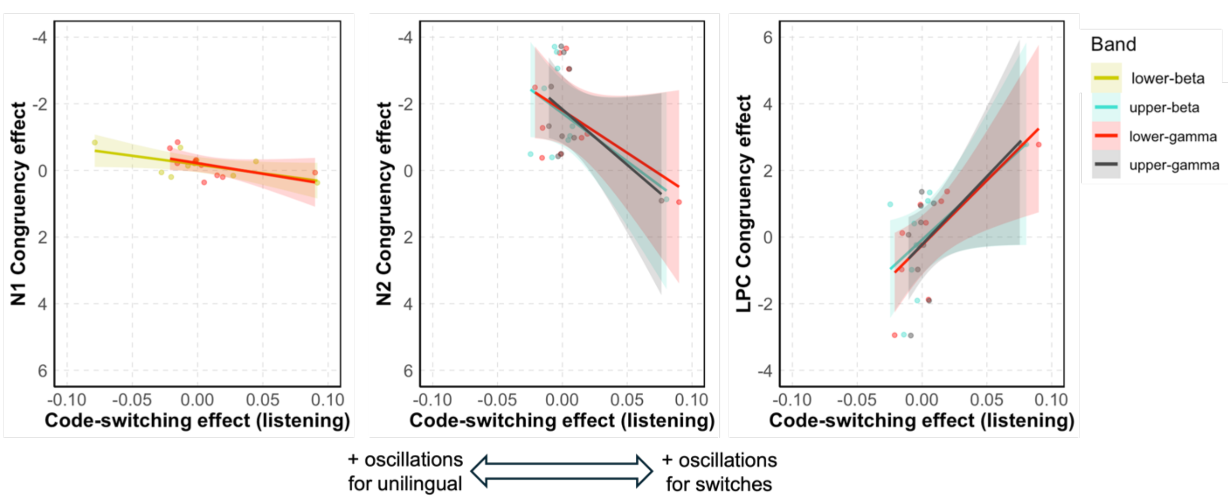
A (two-tailed) Pearson correlation matrix was computed between the Code-switching effects (by frequency band) and the Flanker Congruency effects (by time-window). The results of this analysis are presented in **Table 7.7**. Several correlations were marginal or significant, which is somewhat unexpected given the small sample size. For the N1 and N2, the correlations consistently showed increased Code-switching costs (i.e., more oscillations for code-switches vs. unilingual excerpts) for participants with *reduced* Flanker

Congruency effects (left and middle panels of **Figure 7.9**). For the LPC, the correlations consistently showed increased Code-switching costs (i.e., more oscillations for code-switches vs. unilingual excerpts) for participants with *larger* Flanker Congruency effects (right panel of **Figure 7.9**).

Table 7. 7. Pearson correlation matrix between the Flanker Congruency Effect (by time-window) and the Code-switching effect (oscillations for code-switched excerpts – oscillations for unilingual excerpts) during passive listening. Pearson's *r* is shown with *p*-value in parentheses. Significant results and trends are bolded.

Code-switching Effect (listening)	Flanker Congruency Effect			
	N1	N2	P3	LPC
Theta	-.400 (.252)	-.182 (.615)	-.239 (.506)	.263 (.464)
Alpha	.059 (.870)	-.284 (.426)	.047 (.898)	.056 (.877)
Lower-beta	**.628 (.052)**	-.450 (.192)	.332 (.349)	-.336 (.343)
Upper-beta	.267 (.457)	**.544 (.104)**	.019 (.957)	**.616 (.058)**
Lower-gamma	**.528 (.117)**	**.532 (.113)**	.077 (.834)	**.742 (.014)**
Upper-gamma	.407 (.244)	**.551 (.099)**	.033 (.927)	**.616 (.058)**

Figure 7. 9. Relationship between listening EEGs and Flanker Congruency effect (ERPs). Linear regressions represented with standard errors shaded.



7.4 Discussion

Ten French-English bilinguals listened to real-life bilingual conversations (excerpts from FEBLOC) and performed a Flanker task while their EEGs were recorded. The oscillations during resting-state, passive listening (hearing bilingual vs. unilingual conversations), and the Flanker task were decomposed into their spectral components and analyzed in terms of band-specific power density. To my knowledge, this is the first neuroimaging study that has utilized genuine instances of code-switches as stimuli, and to have processed the EEG signal globally rather than at specific time-locked switching points.

First—and as expected—, there was more power across all the frequency bands during passive listening compared to resting-state. Specific by-subject demographic and language background traits modulated both resting-state and passive listening EEGs. Crucially, there were no differences in any of the frequency bands according to excerpt conditions: code-switched excerpts and unilingual excerpts elicited similar oscillations. The Flanker task yielded expected N2 congruency effects and increased theta oscillations for incongruent trials. Finally, the size of the Flanker congruency effect in the N2 window was negatively related to the code-switching cost in high-frequency bands (upper-beta, lower-gamma, upper-gamma); in the LPC window, the Flanker congruency effect was *positively* associated to the code-switching cost in the same high-frequency bands.

7.4.1 Language background shapes bilingual cognition, even at rest

The present study indicated that resting-state EEGs were modulated by language-related participant traits. In particular, gamma oscillations were heightened among individuals with more language diversity (i.e., larger entropy coefficients), while alpha oscillations decreased with language entropy. Furthermore, bilinguals who were more dominant in French displayed increased upper-beta and gamma oscillations. These results are relatively consistent with the previous studies. Indeed, alpha power and coherence have been associated to L2 usage (Bice et al., 2020) or "non-societal language use" (Pereira Soares et al., 2021), while gamma waves were related to L2 age of acquisition (Pereira Soares et al., 2021). This makes sense, as French is the 'non-societal language' (i.e., the minority language) among the present sample. Furthermore, the directionally-opposite effect of language entropy on alpha and gamma can be explained by the fact that alpha *desynchronization* is a proxy for cognitive engagement (see Klimesch et al., 2007). Indeed, Pereira Soares et al. (2021) observed decreased alpha coherence among individuals who used the 'non-societal language' more frequently. Presumably, more usage of a minority language is conducive to higher language diversity (i.e., increased entropy coefficients), making this finding quite comparable to previous research.

Altogether, these findings bolster the idea that there is a long-lasting impact of bilingualism on cognition; these differences persist even when no task is being undertaken.

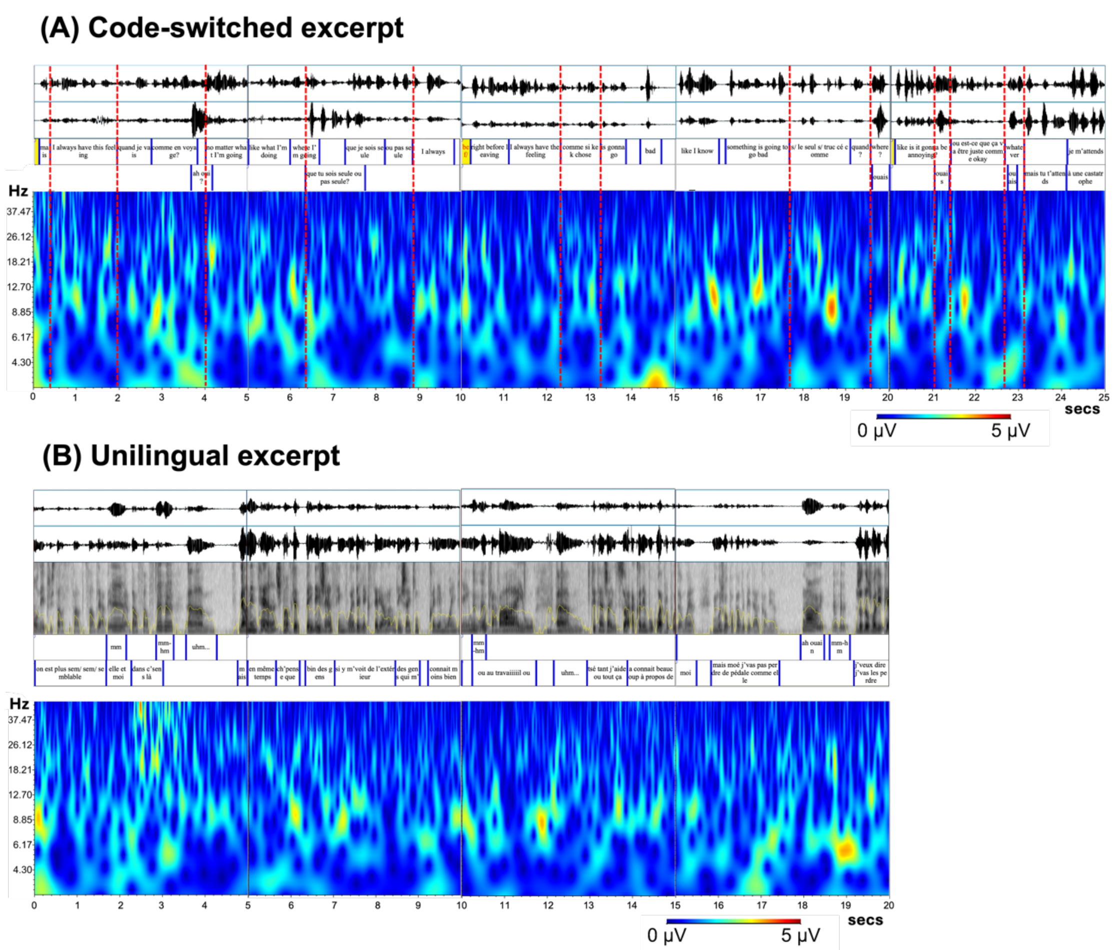
7.4.2 Naturalistic code-switches are (globally) processed just like unilingual passages

Crucially, participants exhibited equivalent neural responses to code-switched excerpts and unilingual excerpts from the FEBLO-Corpus. In other words, there were no differences in the power density of theta, alpha, beta or gamma bands according to the Condition of the audio clip being heard. This implies that processing naturalistic code-switches is *not* inherently cognitively costly: when bilinguals from a given community listen to others from the same speech community (with the established knowledge that they are indeed listening to bilinguals), no index of heightened inhibitory control is observed. Such a finding is quite surprising, given that the vast majority of previous studies report some form of effortful processing for switches. The null result in the present experiment suggests that the reliable code-switching cost in the literature is a feature of lab-made stimuli, not of real-life bilingual processing.

In CHAPTER 6, I observed that participants who heard more inter-utterance switches during FEBLOC exhibited better Flanker performance. However, hearing intra-utterance switches was unrelated to Flanker performance. Returning to **Table 7.4** (p.221), it is possible to see that the FEBLOC excerpts selected for the current study were predominantly made up of intra-utterance switches. If we assume that these excerpts fall under dense code-switching, then the results from the present experiment are compatible with the findings in the previous chapter. Hearing more dense switches does not modulate Flanker performance (CHAPTER 6), implying that cognitive control mechanisms do not underlie the processing of dense code-switches (CHAPTER 7).

However, it is crucial to remember that the analysis used for the passive listening task (splitting the excerpts into equal-sized segments, then averaging over items) only allows us to draw conclusions about the *global* processing of bilingual utterances. It is possible that code-switches generate time-sensitive effects (e.g., increased theta 600 ms post-switch), which become sufficiently attenuated when the neural responses are examined for complete excerpts. In order to examine this, one would need to time-lock markers to the variable code-switching junctures in each FEBLOC excerpt. Perhaps these markers would then be characterized by short bursts of increased power in a given frequency band within a given time-window (compared to unmarked portions of the conversation). Out of curiosity, I extracted the time-frequency representations of an excerpt with exceptionally dense code-switching (item 3) and mapped it alongside its auditory waveform (**Figure 7.10**). A purely visual inspection reveals no evident or consistent bursts at switching junctures. Nevertheless, this would need to be done much more systematically and rigorously before any further conclusions can be drawn.

Figure 7. 10. Time-frequency representation of FEBLOC excerpts used as stimuli in the present study (top: item 3; bottom: item 5; both from pair02). The utterances are mapped in the corresponding Praat waveform. Code-switches are marked with a dotted red line in Panel A.



While the lack of time-locking is a valid criticism for the methods used in the analyses, I would like to defend the importance of this novel examination of 'global' processing. As mentioned, the majority of behavioural and implicit studies investigating the processing of code-switches have found that switching junctures are marked by indices of heightened cognitive effort (e.g., increased reading times, pupil dilation, ERP effects, oscillation differences...). However, functionally-significant effects are rarely observed. Bilinguals remember information just as well (Antón & Duñabeitia, 2021; cf. Hofweber & Marinis, 2023) or better (Salig et al., preprint) when it is presented in a mixed-language compared to a single-language context. This includes the current passive listening task, in which participants were equally accurate in answering questions based on code-switched content and unilingual content. Furthermore, code-switching does not impede the learning of new concepts (Antón et al., 2015), and may even cue listeners to expect new or low-frequency information (Tomić & Valdés Kroff, 2022), due to an increased attentional level (Salig et al., preprint). In CHAPTER 5, I observed that code-switching proportions did not affect bilinguals' performance on the speech elicitation tasks; FEBLOC pairs who code-switched very habitually achieved similar scores to pairs who did not code-switch at all.

To reiterate, real-time costs associated to the processing of code-switching almost certainly bare no functional impact for the bilingual individual. If specific code-switching junctures are marked by effortful processing, such local costs are probably fleeting and quickly attenuated; this would make then somewhat negligeable outside of the lab, or when overall processing is examined. A second option is that the brief cognitive cost at the local switch point is accompanied by a 'benefit' somewhere else in processing, resulting in zero-sum effects (as in Dentella et al., 2024) for global processing. One interesting example of this is from an artificial sentential switching paradigm, wherein participants exhibited slower response times at a switch point (local costs), but faster speech onset times (i.e., more efficient articulatory planning) for sentences containing a switch (Li et al., 2022). In any case, I believe that the analysis in the current pilot experiment (i.e., examining how bilinguals process code-switches globally rather than locally) better reflects (the absence of) functionally significant outcomes. Honing-in on the brief switching juncture can lead us to overvalue the cognitive consequences of code-switching. Outside of the lab, these local costs are, it appears, inconsequential.

In the future, it would be beneficial to separate the FEBLOC excerpts according to their condition. In the current pilot experiment, the participants heard code-switched conversations interlaced with unilingual conversations. In theory, it is possible that the 15-35 second bilingual passages did not generate measurable global differences because a 'reset' could take place whenever a unilingual excerpt was heard (i.e., every 1-2 excerpts). By presenting code-switched excerpts consecutively within a bilingual block, this may lead to observable global processing costs (that is, compared to a unilingual block). Note, however, that this would decrease the ecological validity of the materials: code-switching rarely occurs uninterrupted by unilingual speech in real-life bilingual interactions (see Johns et al., 2018 for experimental consequences of blocking).

To summarize, power density analyses across the frequency spectrum yielded no differences between processing code-switched excerpts and unilingual excerpts. On one hand, this may be due to the ecological validity of the materials: the auditory stimuli were genuine conversations between real pairs of bilinguals. On the other hand (though not mutually exclusively), this null result may reflect the fact that code-switches are indexed by local costs (when switches are time-locked), but not global costs (when overall processing is examined). The absence of global costs better reflects the lack of significant functional outcomes associated to code-switching in bilingual individuals.

7.4.3 Theta AND gamma, or theta-gamma coupling?

Since the same participants performed both the passive listening task and the online Flanker task, it was possible to roughly compare the neural mechanisms involved in the processing of code-switches and those involved in domain-general cognitive control.

Speaking purely qualitatively, the two tasks did not appear to modulate the same frequency bands. For the Flanker task, engaging inhibitory control (i.e., responding to incongruent trials vs. congruent trials) resulted in increased frontal theta oscillations; this effect was less pronounced among older participants. Theta activity/synchronisation has indeed been linked to conflict management in inhibition tasks like Flanker (e.g., Nigbur et al., 2011; see also Chikhi et al., 2022), and has previously been shown to decrease with healthy aging (e.g., Cummins & Finnigan, 2007). By contrast, the most pronounced peak of periodic activity for passive listening was found in the alpha band. Crucially, it was the higher frequency bands (upper-beta to upper-gamma) that were impacted by language background covariates, like entropy and degree of balance. Along with the aforementioned rEEG studies supporting the association between language and gamma waves (Bice et al., 2020; Pereira Soares et al., 2021), previous research has shown that gamma oscillations in

2-3 year olds positively predict language outcomes at 4-5 years old (Gou et al., 2011). Gamma oscillations characterize states of high vigilance (see Engel et al., 2001; Engel & Singer, 2001) and are believed to be involved in the "temporal binding of early sensory information to relevant top-down processes" (Gou et al., 2011: 263). It is likely that such high-frequency neuronal synchronization is involved in language processing, where sensory processing (e.g., speech perception) is crucial.

At first glance, the results from the present study might lead us to believe that domain-general and language-specific cognitive control mechanisms are distinct, as they are manifested by descriptively dissimilar electrophysiological footprints (i.e., frontal theta for domain-general, gamma for language-specific). However, the picture is complexified by research indicating that gamma oscillations can be nested within theta oscillations (Lisman & Jensen, 2013), and that these two frequency bands are known to couple together. In fact, theta-gamma coupling is linked to increased task performance (Pahor & Jaušovec, 2014; Wang et al., 2014). If gamma plays a key role in sensory processing, and theta is involved in inhibition[3], perhaps the theta-gamma coupling is a key neural adaptation for bilingual processing. Very recent research indeed indicates that theta and gamma activity is more

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[3] Nyhus and Curran (2010: 1033) summarize the gamma-theta interaction as follows: " [G]amma oscillations can act in the cortex to bind modality specific perceptual representations and in the hippocampus to bind the rich perceptual and contextual information from diverse brain regions into episodic representations. Theta oscillations act to temporally order these individual episodic memory representations. Through feedback projections from the hippocampus to the cortex, these gamma and theta patterns could cause the reinstatement of the entire memory representation in the cortex. In addition, theta oscillations could provide top-down control from frontal cortex to the hippocampus for selective encoding and retrieval of episodic memories. Therefore, this unified model demonstrates how neural oscillations allow for transient interactions between brain regions to perform complex cognitive tasks."

synchronized when bilinguals listen to intelligible speech, and when they are more proficient in the language being processed (Lizarazu et al., 2023). Altogether, the present study shows that gamma is a key feature of language processing, and that theta is a key feature of domain-general cognitive control. While I did not consider cross-frequency coupling or other measures of coherence, such results strongly support the need to further investigate theta-gamma coupling in the field of code-switching and bilingualism.

7.4.4 Individual differences matter when it comes to processing code-switches

In order to roughly test the relationship between processing code-switches and by-subject inhibitory control abilities, the frequency-specific code-switching 'cost' (i.e., difference in power density for code-switched excerpts vs. unilingual excerpts) was correlated to the Flanker ERP effects (i.e., incongruent — congruent trials). For the N1 and N2 time-windows, participants with larger Flanker Congruency effects exhibited decreased code-switching costs (i.e., less oscillations for code-switches vs. unilingual excerpts) in beta and gamma bands. For the LPC time-window, participants with larger Flanker Congruency effects exhibited increased code-switching costs (i.e., more oscillations for code-switches vs. unilingual excerpts) in beta and gamma bands.

What does this mean? These preliminary findings suggest that participants with better early inhibition abilities (i.e., smaller N1 and N2 Flanker effects) are those who elicit cognitive control mechanisms while listening to code-switches. Perhaps these individuals can't 'turn off' (or disengage) early automatic inhibitory mechanisms; even dense code-switches are reflexively marked by heightened cognitive control. By contrast, participants who exhibit better 'late' inhibition abilities (smaller LPC Flanker effect) are more likely to display similar processing for code-switches and unilingual speech. Recall that average Flanker responses for incongruent trials were about 550 ms, making the LPC time-window (500-700 ms) conducive to a response suppression period. It is possible that this time-window best represents top-down inhibitory abilities that can be recruited when needed; while these mechanisms were certainly useful during the Flanker task (in particular, during the incongruent trials), they were seemingly not required in the context of hearing naturalistic conversations. The idea is that an individual with good EF could engage their top-down inhibitory abilities during Flanker, and disengage them during passive listening.

The positive relationship between the code-switching cost and the Flanker LPC effect is especially interesting, since this time-window is usually associated with language processing. Indeed, the LPC is the most consistently observed component in previous ERP studies examining the processing of code-switches (Blackburn & Wicha, 2022; Gosselin & Sabourin, 2021; Kaan et al., 2020; Litcofsky & Van Hell, 2017; Moreno et al., 2002; Ng et al., 2014; Proverbio et al., 2004; Ruigendijk et al., 2016; Valdés Kroff et al., 2020; Van Der Meij et al., 2011; Yacovone et al., 2021). Furthermore, it is noteworthy that the positive correlations were only significant within high-frequency waves (upper-beta, lower-gamma, upper-gamma), given that these bands are impacted by language-related participant traits during resting-state (*Section 7.4.1*).

In brief, I speculate that the directionally-opposite associations between individualistic inhibitory skills and the code-switching cost (negative for the N1/N2, positive for the LPC) reflect inherent differences between bottom-up and top-down processing.

Bottom-up conflict detection (e.g., based on perceptual processing) is not necessarily beneficial when it comes to bilingual language processing, as it is applied automatically (possibly unproductively) whenever a code-switch is encountered. On the other hand, top-down (trainable) response inhibition is beneficial for bilingual language processing, as it can be applied when needed (e.g., hearing dual-language switching) and disengaged when counterproductive (e.g., hearing dense code-switching). These findings are highly compatible with CHAPTER 6, where producing dense code-switches engaged proactive control, but processing alternations engaged reactive control. Under the assumption that reactive control reflects top-down mechanisms (e.g., Kleinman & Gollan, 2016), it makes sense that a positive relationship was observed between the top-down Flanker LPC and the processing of code-switches.

It is important to note that my conjectures here are based on rough exploratory analyses that ignore many subtleties (e.g., topography, item variation), and use a very small sample size (n=10). Though the remarkably high correlation coefficients (up to .74) lend confidence to the existence of effects, these findings merit future research before any clear conclusions can be drawn.

7.5 Conclusion

The present pilot experiment examined the online processing of naturalistic bilingual conversations (excerpts from FEBLOC). Resting-state EEGs and Flanker EEGs were also collected and analyzed. Overall, code-switched excerpts and unilingual excerpts elicited similar power density across the frequency spectrum, suggesting that genuine instances of code-switching do not engender global processing costs. Both rEEGs and listening EEGs varied according to participant traits; in particular, language background characteristics like entropy and degree of balance modulated high-frequency bands (e.g., gamma). By contrast, fluctuations in theta were observed for the Flanker task. Flanker congruency effects were correlated to listening EEGs, supporting a cognitive individual-differences approach to bilingual processing. To my knowledge, this is the first neuroimaging study that has utilized genuine instances of code-switches as stimuli, and to have processed the EEG signal globally rather than at specific time-locked switching points. There is much left to explore, including blocked stimuli, measures of coherence, local processing costs, and theta-gamma coupling.

CHAPTER 8: *La fin*

The goal of the present dissertation was to unify two prominent subfields in the study of code-switching. The first pertinent subfield concerns the production and processing of code-switching; the second pertains to the potential consequences of code-switching on bilingual cognition. In order to meet this goal, I created a novel multiparty corpus, rich with naturalistic code-switching. I conducted a behavioural study designed to tease apart the modalities of production and processing in code-switching; this type of investigation had not yet been accomplished in the literature. Finally, I collected and analyzed EEG data in an exploratory pilot study—to my knowledge, this is the first electrophysiological study that has utilized completely genuine instances of bilingual conversations as the experimental materials. The following sections briefly summarize the main findings of the thesis, before addressing the big picture, contributions, and future directions.

8.1 Summary of results

8.1.1 The FEBLO-Corpus

A few existing code-switching corpora, such as the NMSEB (Torres Cacoullos & Travis, 2018) and the Bangor-Miami Corpus (Deuchar et al., 2014), have been absolutely invaluable in advancing scientists' knowledge of code-switching. As such, one of the primary aims of this dissertation was to build a novel French-English code-switching corpus, which could be utilized in subsequent experiments. The corpus is named the 'French-English Bilingual Loved Ones Corpus' (FEBLOC), since it contains the speech from pairs of bilinguals who know each other in the real world (parent-child, siblings, married couples, etc.). The speakers completed a series of speech elicitation activities together, ranging from semi-structured 'puzzle-solving' games (e.g., bilingual Taboo, communicative spot-the-difference task) to unstructured discussions. Importantly, the participants were naive to the fact that their code-switching behaviours were of interest to the researcher. Overall, FEBLOC contains 18 hours of transcribed speech, resulting in nearly 36,000 language-coded utterances.

A series of exploratory analyses revealed several interesting points about code-switching in FEBLOC. During the semi-structured activities, participants used their languages efficiently; code-switching frequency did not impact task performance (e.g., scoring during spot-the-difference game). Members from the same pair (i.e., participants from the same testing session) tended to match each other's language usage, likely due to common language community membership. Though the nature of the pair relationship (e.g., relatives vs. friends) did not affect code-switching behaviours, women tended to code-switch more often than men. It is unclear whether this difference is sociolinguistically-driven (women are the drivers of language change: Labov, 1990), or cognitively-driven (women possess better baseline cognitive control: Levine et al., 2021), but it matches previous findings in the literature (Dewaele & Li, 2014; Gosselin & Sabourin, 2023a). Overall, FEBLOC speakers were inaccurate in self-reporting their code-switching habits via questionnaires, but language entropy was a decent predictor of objective language usage. Finally, between-speaker switching (e.g., Aaron says something in English and Virginie replies in French) was somewhat of an outlier in the data: only this type of switching was related to decreased proficiency and lapses in cognitive control; it was also the most accurately self-evaluated language behaviour.

The FEBLO-Corpus circumvents many of the pre-existing issues in the literature (e.g., stigmatization, social desirability, ecological validity, subjectivity), since (naive) in-group bilinguals were tested in a private room, and code-switching was operationalized objectively. Though presently incomplete (see *Section 8.3.1*), the novel FEBLO-Corpus was an indispensable tool in understanding the production and processing of naturalistic code-switches within the subsequent experiments; with any luck, the corpus can continue to instruct future research (see *Section 8.3.2*).

8.1.2 The production-processing paradox

In my own previous work, I have argued that code-switching cannot be costly to process, since bilinguals mix their languages seemingly effortlessly (Gosselin & Sabourin, 2021). This conjecture ignores the production-processing distinction: speaking and comprehending do not necessarily employ completely overlapping mechanisms. Producing is driven by an individual's internal state (in situations of assumed common linguistic knowledge), while comprehending implies processing a message controlled by an external individual (i.e., not driven by an internal state).

In order to disentangle the production-processing paradox, the speakers from FEBLOC completed an individual Flanker task after the speech elicitation activities. Since FEBLOC is composed of speech from pairs of bilinguals, it was possible to compute proportions of produced switches (i.e., what partner-A said themselves) and heard switches (i.e., what partner-A heard from partner-B) in the recordings. These indices were then examined in relation to the participants' subsequent Flanker performance, thereby testing the modality-specific consequences of code-switching on cognitive control.

The findings revealed a dissociation in the cognitive consequences of code-switching according to modality. FEBLOC speakers who *produced* more code-switches (particularly dense switches) exhibited decreased conflict RTs and increased non-conflict RTs in the Flanker task. By contrast, FEBLOC bilinguals who *heard* more code-switches (particularly inter-utterance switches) exhibited only reduced RTs for conflict trials. In other words, producing and hearing code-switches were both linked to ameliorated interference suppression (quicker responses to conflict trials), but interference disengagement was uniquely negatively associated to producing switches (slower responses to non-conflict trials). What does this mean?

Essentially, I hypothesized that producing dense code-switches engages proactive control, which then impedes task disengagement. In a dense code-switching context, bilinguals' can allow their own internal states of activation to bias their productions beyond top-down mechanisms prioritizing language maintenance (Kleinman & Gollan, 2016; see also Carter et al., 2023; Ng & Yang, 2022). This respite in top-down mechanisms may result in decreased interference disengagement performance (i.e., slower non-conflict RTs). By contrast, hearing inter-CS engages reactive control: individuals cannot bias their processing ahead of time, as they are passive receptors in the transmission of the message. Since proactive control is not implicated, hearing code-switches does not hinder task disengagement.

Let me now return to the first primary research question of the dissertation, as presented in the introductory chapter (CHAPTER 1):

(1) **RQ1:** Does the frequent *production* and/or *processing* of code-switching lead to increased cognitive functioning?

My findings point towards the idea that *processing* switches is a key experiential factor in shaping bilingual cognition: being frequently exposed to code-switches is associated to increased interference suppression (without decreased disengagement abilities). This falls into line with arguments claiming that bilingual-EF differences result from neural adaptation at non-conflict, rather than during conflict (De Baene et al., 2012; Weissberger et al., 2015).

8.1.3 The neural processing of real-life switches

Almost all electrophysiological studies examining the processing of code-switching have presented their materials visually, even though code-switching is usually regarded as an oral/verbal phenomenon. Several other methodological restrictions challenge the ecological validity of the findings in the literature. Since genuine bilingual conversations were recorded during FEBLOC, I was able to use excerpts of these discussions to test the neural processing associated to naturalistic (ecologically valid) code-switches. In a pilot EEG experiment, French-English bilinguals completed a resting-state recording, a passive listening task, and a Flanker task. Importantly, the passive listening EEGs were analyzed similarly to rEEGs: the data was split into equal-sized segments, then spectral components were extracted and averaged over items, giving a measure of 'global' processing.

First, participant traits modulated EEGs. During both resting state and passive listening, gamma oscillations were heightened among individuals with more language diversity (i.e., larger entropy coefficients) and those who were more dominant in French. Crucially, participants exhibited equivalent neural responses for densely code-switched excerpts and unilingual excerpts during the passive listening task. This 'null cost' may be due to the high ecological validity of the materials. However, it may also reflect the fact that code-switches are indexed by local costs (when switches are time-locked), but not global costs (when overall processing is examined). In any case, equivalent global processing for switches and unilingual conversations accurately attests to the lack of functionally significant code-switching costs for bilinguals in the real world.

During the Flanker task, participants exhibited increased frontal theta oscillations and a significant N2 effect for incongruent trials compared to congruent trials. The modulation of theta during the domain-general task and gamma during the listening task is interesting, given that these two frequency bands are known to couple together in order to utilize top-down control mechanisms (theta) while binding sensory information (gamma) (Nyhus & Curran, 2010). Remarkably large correlation coefficients were also observed between by-subject passive listening EEGs and Flanker EEGs. Participants with larger N1/N2 Congruency effects exhibited decreased code-switching listening costs, while participants with larger LPC Congruency effects exhibited *increased* code-switching listening costs. If we assume that N1/N2 effects reflect (automatic) bottom-up processing, and that LPC effects reflects (controlled) top-down processing (i.e., reactive control), these findings suggest that only the latter is beneficial for bilingual language processing. Bilinguals with increased top-down control can use these abilities when required and disengage them when counterproductive.

Let us return to the second research question of the dissertation, introduced in CHAPTER 1:

(2) **RQ2:** Is code-switching more difficult to produce and/or process than unilingual language, even in the most ecologically valid contexts?

My findings point towards the idea that genuine code-switches are globally processed like unilingual passages. However, there is still much to discover in terms of local processing costs, as well as cross-frequency (theta-gamma) coupling in bilingual processing.

8.1.4 The big picture

What are the takeaway messages here? The bottom line is that bilingual production and bilingual processing involve distinct mechanisms. It is not necessarily incompatible to observe an underlying processing cost among bilinguals who produce code-switches habitually and fluidly. In the past, proactive control has been related to the dense code-switching context, while reactive control has been associated to the dual-language context (Beatty-Martínez et al., 2020; Gullifer et al., 2018; Hofweber et al., 2020a; Jiang et al., 2023; Treffers-Daller et al., 2020). In parallel, proactive control has been characterized as a feature of bilingual *production* (Declerck, 2020), while comprehension has been called "mostly re-actively driven" (Garbin et al., 2011: 129). The results presented in the preceding chapters allow us to integrate both interactional context and modality: *producing dense code-*

switches engages (and therefore potentially trains) proactive control. By contrast, the processing of code-switches—and the production of more dual-language alternations—does *not* engage proactive control. Instead, the processing of (ecologically valid) code-switches is modulated by top-down inhibitory control abilities (i.e., reactive control). Nevertheless, bilingual conversations are treated similarly to unilingual conversations, at least from the perspective of global processing (overall neural responses). Given that existing studies have focused on time-sensitive code-switching junctures (local processing), the current literature may be over-evaluating the cognitive consequences of code-switching. Though bilingualism doubtlessly shapes cognition (even at rest), code-switching costs are probably functionally inconsequential outside of the lab.

8.2 Contributions and implications

8.2.1 Addressing the gaps in the literature

Throughout this thesis, I highlighted several methodological and conceptual caveats in the linguistic and cognitive code-switching literature. First, the vast majority of existing analyses rely on subjective measures of code-switching (the subjectivity issue), which can be impacted by external influences, like social desirability (the stigmatization issue). Second, participants are almost always tasked with producing and/or processing lab-made (i.e., artificial) code-switches in order to satisfy methodological rigour (the ecological validity issue). Finally, producing and processing are often seen as symbiotic in these fields (the modality conflation issue), and are regularly compared across methodological techniques (e.g., a picture naming task is used to support/refute the results of an electrophysiological reading study).

The data provided in the current dissertation responds to each of these gaps. Stigmatization was addressed by testing bilinguals from the same in-group in a private room (CHAPTER 4); crucially, they did not know that their specific language usage was of interest. The design of FEBLOC promoted true vernacular speech. Presumably, self-monitoring was reduced and the unfamiliar lab context could be perceived as less formal (i.e., playing games with a friend, out of sight of the experimenter). The high rates of switching in FEBLOC (18%) support the importance of engaging with these methodological difficulties; bilinguals switch up to four times more frequently with someone from the same in-group compared to an out-group stranger, and usually code-switch in informal settings (Poplack, 1983).

Collecting this type of speech data also addresses the subjectivity issue: code-switching behaviours could be operationalized completely objectively (CHAPTER 6), thereby avoiding the biases that are known to plague self-reports. In fact, exploratory analyses (CHAPTER 5) show little relationship between self-reports and objective switching measures, putting into question generalized conclusions from studies investigating subjective code-switching habits and executive functioning.

The existence of FEBLOC subsequently allowed me to address ecological validity concerns in the electrophysiological literature. Participants who completed the passive listening task (CHAPTER 8) listened to genuine code-switches produced by real-life bilinguals. I believe that my experiment is comparable to day-to-day bilingual processing, thereby greatly boosting the generalizability of the findings.

Finally, the modality conflation issue was addressed as the main goal of the dissertation. Production and processing were teased apart by testing pairs of bilinguals simultaneously. Since the data was collected within a single experimental design (CHAPTER 6), the modalities did not cross methodological paradigms.

Beyond these specific caveats, several more global critiques in psychology and linguistics were considered in the present dissertation. An effort was made to test participants from the community at large (74% of participants in CHAPTER 6; 80% of participants in CHAPTER 7), rather than focusing on undergraduate students from the University. This population provides the additional advantage of a wide age range for the samples (CHAPTER 6: *M*=34 years, *range*= 17-61 years; CHAPTER 7: *M*=32 years, *range*=18-56 years). Young adult populations are known to perform at ceiling in executive functioning tasks (Bialystok et al., 2014), reducing the variability in the data set and invalidating individual differences analyses (Hedge et al., 2018). In my data, Flanker split-half reliability proved to be excellent in both experiments for all but one measure (the facilitation effect in CHAPTER 6). This likely reflects satisfactory variance in the data due to participant characteristics like age. Finally, I made sure to utilize statistical methods that could account for the random variance in the data, thereby improving the statistical power of the analyses (Linck & Cunnings, 2015) and making the findings more ecological for human data.

Altogether, the primary aims of the dissertation were inspired by recurrent caveats in the abundant code-switching literature. I believe that the data and findings reported here support the importance of balancing methodological rigor and ecological validity, among other considerations of construct validity.

8.2.2 Down with linguistic purism!

From a more applied perspective, I sincerely hope that the findings in the present thesis can promote a sense of pride and cultural identity for Canadian francophones. Approximately 500,000 Ontarians reported speaking French as a mother tongue on the 2016 census; nearly all of these individuals are at least bilingual, since French is a minority language across the province (with a few exceptions). An additional 54,000 individuals noted that both English and French were mother tongues (Statistics Canada, 2017). The dialects of Canadian francophones (especially Franco-Ontarians) are often perceived as being a ‘lesser variety’ of French (d’Anglejan & Tucker, 1983), even though francophones have existed in the area for centuries (see Allaire, 2007), usually in situations of high language contact. A history of forced assimilation towards Anglo language and culture has left its footprint among francophone communities today (e.g., Darroch & Ornstein, 1980; Jean-Pierre, 2018; Martel, 2019), where 'good French' equals 'pure French' (i.e., French 'uninfected' by English). Canadian francophones thus often harbour harmful linguistic insecurity or "general malaise" (d’Anglejan & Tucker, 1983: 349) about their language usage.

Anecdotally, this was observed during my own testing. Many francophone participants hesitated in rating themselves as being highly proficient in French (particularly for reading and writing abilities), since they 'used slang', or 'made a lot of grammar mistakes'. When the aims of the studies were explained to the participants during debriefing, some speakers joked that they probably mix their languages too much; others proudly expressed avoiding *franglais*. Notice that both of these sentiments position code-switching as the inferior language behaviour: more code-switching is embarrassing and linked to French incompetence; less code-switching is celebrated and attributed to speaking 'good French'.

Optimistically, the dissemination of FEBLOC and the other experiments in this dissertation may help lessen the stigma surrounding code-switching in the bilingual Canadian context. At the very least, code-switching was discussed from a positive viewpoint in the present dissertation, where it was asserted that *'franglais'* is a highly natural and skillful use of a bilinguals' languages. Being able to use multiple languages to communicate efficiently should be viewed as a tool, rather than an affront to 'speaking well'. I firmly believe that embracing code-switching (instead of leaning into linguistic prescriptivism) could buttress the revitalization efforts that currently back Francophonie in Ontario.

8.3 What comes next? Future directions for FEBLOC

8.3.1 Finalizing the corpus

The ultimate goal is to make FEBLOC open access. While thousands of hours of work have already been dedicated to the corpus, it is not yet ready to publish. In the future, it will first be important to compute some sort of transcription confidence index. A second researcher will need to transcribe a portion of the recordings in order to test agreement between transcribers. Some portions of the CHAT method are somewhat open to interpretation. For instance, It was sometimes difficult to decide what constituted a single utterance, and which streams of speech should be split into multiple utterances. This, of course, impacts the way that utterances are coded (e.g., going from an inter-utterance switch to an inter-utterance switch). In general, I operated under a rule of "when in doubt, split" and prioritized consistency within and across recordings. However, this likely accounts for the low proportion of intra-utterance switches (5.2%) compared to inter-utterance switches (12.8%) in the corpus.

Next, the CHAT transcription method is designed to be analyzed within the (open-access) CLAN program (Computerized Language ANalysis: MacWhinney, 2014). CLAN allows for the computation of frequency information (and other lexical features), and gives researchers the capacity to conduct corpus-wide searches (words, expressions, actions, etc.). Typically, transcribed utterances are time-stamped within CLAN. This means that scrolling through any given recorded audio file will also scroll through the transcribed utterances. Evidently, this is extremely useful when it comes to analyses and data sharing. Unfortunately, due to time constraints, the transcriptions have not been validated in CLAN (to ensure formatting requirements are met), and time-stamping has not yet taken place. This will be an important step to complete before FEBLOC can be shared publicly.

Finally, CHAT and CLAN are compatible with multiple 'tiers' of transcription (MacWhinney, 2014). I give an example of this in (3). Each utterance can be spelled out phonologically in a `%pho` tier, and/or morphologically in a `%mor` tier. Non-English utterances can be translated in an `%eng` tier. A `%flo` (flow) tier improves the readability of the transcript, as all transcription conventions are removed from the corresponding utterance. None of these tiers are currently included in FEBLOC, as they were not crucial for the present dissertation. However, completing these tiers may be an important step precluding the publication of FEBLOC, so that the data can be used widely, across disciplines of linguistics.

(3) **Pair16, Brian, 2550 seconds**:

```
*SEC:  on@s:fra a@s:fra le@s:fra chainsaw@s:eng .
%phon: ɔ̃ ə lə ʃeɪnsɑ
%mor:  PRO|on&1P AUX|avoir&PRE DET|le&DEF&MASC N|chainsaw.
%eng:  we got the chainsaw .
%flo:  on a le chainsaw.
```

8.3.2 Answering diverse questions with the help of FEBLOC

The present dissertation merely scratches the surface of potential scientific contributions conferred by FEBLOC. I will continue to use this tool in my future work, and I am optimistic that it will be of use to linguists in various disciplines.

Recall that the CHAT method includes various transcription conventions meant to convey phenomenon beyond the content or language of a given utterance. Several expressions denote different types of disfluencies, such as filled pauses, silent pauses, repetitions, reformulations, and fragments (see CHAPTER 4, p.106). These 'paralinguistic' phenomena have been painstakingly transcribed in FEBLOC, but were seldom addressed in the present dissertation. As a next step, I would like to compare the disfluencies in code-switched utterances and unilingual utterances. Interestingly, an initial analysis of the experimental materials in CHAPTER 7 revealed that the twenty code-switched excerpts contained marginally more silent pauses (i.e., silences) than the twenty unilingual excerpts. Disfluencies in the speech output have previously been linked to cognitive load: increased repetitions, repairs, and pauses—as well as diminished speech rate—are proxies for high cognitive load (Berthold & Jameson, 1999). This begs the question: How are code-switched utterances and unilingual utterances characterized by disfluencies in the FEBLO-Corpus? Here, a qualitative analysis is probably required just as much as a quantitative analysis;

merely observing a greater number of disfluencies in code-switched utterances does not give us the full picture. It is possible that code-switches are used to *repair* compromised speech output, and thus technically co-exist with disfluencies without causing them. An idiosyncratic example of this was presented in CHAPTER 5 (p.156), where Camille (pair02) code-switched to '*pole*' because she appeared to have difficulty retrieving the French equivalent, '*poteau*'. It may be necessary to classify the motivations behind the switch, as well as its position in relation to the disfluency (i.e., does the disfluency follow or precede the switch?). Furthermore, it will be interesting to verify whether disfluencies in code-switched utterances are accompanied by changes in speech rate. For instance, if speech rates increase after a code-switch, this may indicate that switching is used as a palliative strategy. On the other hand, if code-switching is accompanied by reduced speech rates, this will point towards a production cost for switching. Future work of mine will include a thorough analysis of speech disfluencies in FEBLOC, with the aim of getting further insight into the mechanisms underlying bilingual production.

A second issue that has been somewhat glossed over in the present dissertation is the controversy surrounding borrowing and code-switching. Borrowings were simply excluded for the analyses and experimental materials, under the assumption that borrowed words constitute phonologically integrated lone other-language items (LOLIs). However, this classification was done entirely by ear, and phonological integration is not fully accepted as a proxy for borrowing membership (e.g., Poplack et al., 2020). Phonetic/phonological information is not always accessible, as is the case for studies examining written language (e.g., social media usage: Bali et al., 2014; Patro et al., 2017). Furthermore, integration can mistakenly be attributed to speakers with a non-native accent (Poplack & Dion, 2012). FEBLOC is composed of auditory recordings, and is primarily made up of speakers with native accents in both languages (excluding about five speakers). Borrowings also ranged in frequency of attestation (e.g., 'top' was produced 33 times by 13 different speakers but 'plug' was only produced twice by two different speakers; see **APPENDIX D**). This means that the corpus is a promising avenue to study phonological integration in LOLIs, and to verify whether there is a difference between 'nonce-borrowings' (idiosyncratic use) and established borrowings (community-spread use) (Poplack, 1988).

One final relevant concept which has not been covered in the present dissertation is the triggering hypothesis. The triggering hypothesis posits that a switch is likelier to take place within the proximity of a cognate (a word with overlapping form and meaning cross-linguistically, like *image/image* in English/French), since this is where cross-language activation is the highest (Broersma, 2009; Broersma et al., 2020; Broersma & Bot, 2006). However, recent research has put into question the phenomenon (Neveu et al., 2022). Given that French and English contain a high number of cognates, it would be possible to test the triggering hypothesis via the FEBLO-Corpus in the future.

The potential future work I've highlighted above are particularly relevant for my own interests. In (4), I provide examples of diverse research questions that could be answered through the analysis of FEBLOC. The comprehensive nature of the corpus (i.e., it includes acoustic information, morpho-syntactically rich structures, social interactions between speakers, diverse topics, etc.) makes it interdisciplinary. Altogether, I believe that FEBLOC could be appealing to linguists and cognitive scientists across subdisciplines.

(4) **Examples of research questions relevant for FEBLOC:**

a. **Phonetics**: What is the VOT of stops in code-switched utterances? Do acoustic measures, like VOT, vary in relation to the speakers' code-switching habits and/or language background? Are LOLIs (i.e., small 'islands') more vulnerable to acoustic assimilation compared to multi-word switches (i.e., larger 'islands')?

b. **Phonology**: Can phonological rules cross linguistic boundaries? Does phonological integration accompany morphological integration? Where in the suprasegmental structure is code-switching more likely to occur?

c. **Morphology**: How is French grammatical gender used for English nouns? Which lexical features (e.g., frequency, neighbours...) bias a speaker towards a code-switch? Why can't English morphology be applied to French words?

d. **Syntax**: Is structural priming observed between speakers? Are some syntactic structures inadmissible in French-English code-switches? Which previously theorized syntactic rules for code-switching are best supported by FEBLOC data?

e. **Semantics:** What type of semantic relationship triggers speakers to correctly guess a word during Bilingual Taboo? Can code-switching be used to correct semantic ambiguity in speech? Which types of speakers utilize this strategy?

f. **Pragmatics:** Does extralinguistic information change depending on the language being used? Is code-switching accompanied by fluctuations in affect? Do couples display more pragmatic alignment than non-couples?

g. **Discourse analyses:** Do speakers use the same strategies during the speech elicitation activities? How do different speakers handle the 'high pressure' timed activities? Why and when do interruptions occur between partners?

h. **Sociolinguistics:** What is the sociodemographic phenotype of the Canadian code-switcher? Which code-switched linguistic structures appear to be subject to ongoing linguistic change? Who are the leaders of this change?

i. **Computational linguistics:** Can the code-switching in FEBLOC be mapped in a finite-state machine? How can algorithms determine the language membership of a given item in bilingual speech? Can FEBLOC be used to train bilingual transcription programs?

8.4 Final reflections

Graduate school is a journey full of surprises. Early in my journey, I was fully afflicted with the production-processing paradox. Being a speaker of *franglais* from birth, I firmly believed that code-switching generally could not be costly. Surprise! My first independent experiment yielded an LPC for switches compared to unilingual utterances (Gosselin & Sabourin, 2021), which I attempted to explain away by citing ecological validity issues. After becoming interested in the interface between bilingualism and cognition, I then investigated the ways in which habitual code-switching could shape executive functioning, and indeed found positive effects (Gosselin & Sabourin, 2023b, 2024). Surprise! I soon came to the realization that my ideas were difficult to reconcile. How could code-switching be a high-level cognitive skill, while also being equivalent to unilingual language?

Conceptualizing the research questions for my eventual dissertation made something very clear to me—largely thanks to Gollan and Ferreira's (2009) 'switch now, pay later principle'. Even if I am (like many bilinguals) most comfortable mixing my languages in *production*, this does not inherently imply effortless *processing* when I hear (or read) switches. I began to spot similar assumptions sprinkled in the literature, and to notice that both modalities were almost never tested simultaneously. The primary goal of the thesis emerged: How to disentangle the production-processing paradox in bilingualism research?

The creation of FEBLOC and its contribution to subsequent experiments has allowed me to draw initial conclusions about code-switching and modality. Producing and processing switches are not entirely alike: the former is subject to (bottom-up) proactive control, and may thus impede certain facets of cognitive control; the latter is reactively-driven, and is modulated by individualistic top-down control abilities. Nevertheless, the global processing of code-switches is similar to the global processing of unilingual language, confirming that switching does not significantly alter functional outcomes. Ultimately, collecting the data and writing this dissertation has taught me to challenge any and all assumptions I've maintained along the way. The journey is far from over—there are still countless paths begging to be explored.

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Appendices

Appendix A: Stimuli for the Bilingual Taboo speech elicitation activity.

Item / Version		Secret word	Language	Translation	TabooFR-1	TabooFR-2	TabooFR-3	TabooEN-1	TabooEN-2	TabooEN-3
1	A	**KEY**	EN	clé	porte	auto	maison	open	locking	metal
1	B	**CLÉ**	FR	key	ouvre	vérrouiller / barrer	métal	door	car	house
2	A	**VOYAGE**	FR	holiday	valise	avion	partir	trip	travel	adventure
2	B	**HOLIDAY**	EN	voyage / voyager	vacance	aventure	congé	suitcase	airplane	go
3	A	**DRIVE**	EN	conduire	chauffer	route	auto	car	license	vehicle
3	B	**CONDUIRE**	FR	drive	auto	permis	véhicule	operate	highway	car
4	A	**HIER**	FR	yesterday	avant	demain	jour	past	hour	time
4	B	**YESTERDAY**	EN	hier	passé	heure	temps	before	tomorrow	day
5	A	**JEALOUS**	EN	jaloux	gourmand	envie / envieux	négatif	emotion	want	green
5	B	**JALOUX**	FR	jealous	sentiment	vouloir	vert	greed	envy /envious	negative
6	A	**CHANDAIL**	FR	sweater	porter	tricot	vêtement	cold	wool	cardigan
6	B	**SWEATER**	EN	chandail	froid	laine	veste	wear	knit	clothes / clothing
7	A	**PURPLE**	EN	mauve	bleu	cœur	raisin	colour	violet	lavender
7	B	**MAUVE**	FR	purple	couleur	violet	lavande	blue	heart	grape
8	A	**GRENOUILLE**	FR	frog	coasser	cuisse	lac	swamp	green	amphibian
8	B	**FROG**	EN	grenouille	marais	vert	amphibien	croak	leg	lake
9	A	**STEW**	EN	ragoût	manger	cuire	bœuf	soup	food	autumn
9	B	**RAGOÛT**	FR	stew	soupe	nourriture	automne	eat	cook	beef
10	A	**AVOCAT**	FR	lawyer	notaire	procès	loi	tribunal	court	judge
10	B	**LAWYER**	EN	avocat	tribunal	cour	juge	attorney	trial	law
11	A	**MOON**	EN	lune	nuit	soleil	espace	sky	full	planet
11	B	**LUNE**	FR	moon	ciel	pleine	planète	night	sun	space
12	A	**BIJOUX**	FR	jewelry	pierre	collier	famille	ring	diamond	gold
12	B	**JEWELRY**	EN	bijoux	bague	diamant	or	stone	necklace	family

Item / Version		Secret word	Language	Translation	TabooFR-1	TabooFR-2	TabooFR-3	TabooEN-1	TabooEN-2	TabooEN-3
13	A	**ALONE**	EN	seul	solo	soi	personne	single	unique	only
13	B	**SEUL**	FR	alone	célibataire	unique	seulement	solo	self	nobody
14	A	**APPEL**	FR	call	téléphone	sonner	liste	cellular / cell	dial	talk
14	B	**CALL**	EN	appel / appeler	cellulaire / cell	composer	parler	telephone	ring	list
15	A	**THROW**	EN	lancer	envoyer	balle	sport	hand	toss	play
15	B	**LANCER**	FR	throw	main	jeter	jouer	pitch	ball	sport
16	A	**RECETTE**	FR	recipe	faire	livre	ingrédients	cook	food	eat
16	B	**RECIPE**	EN	recette	cuire	nourriture	manger	make	book	ingredients
17	A	**NEEDLE**	EN	aiguille	coudre	foin	acuponcture	thread	blood	clothes / clothing
17	B	**AIGUILLE**	FR	needle	fil	sang	vêtement	sewing	haystack	acupuncture
18	A	**EMPLOI**	FR	job	poste	carrière	entrevue	work	boss	salary
18	B	**JOB**	EN	emploi	travail /travailler	patron	salaire	position	career	interview
19	A	**BUBBLE**	EN	bulle	savon	laver	bain	foam	shower	blow
19	B	**BULLE**	FR	bubble	mousse	douche	souffler	soap	wash	bath
20	A	**GORGE**	FR	throat	avaler	mal	amygdale	neck	choke	eat
20	B	**THROAT**	EN	gorge	cou	étouffer	manger	swallow	sore	tonsil
21	A	**COMMA**	EN	virgule	ponctuation	signe	phrase	pause	period	write
21	B	**VIRGULE**	FR	comma	pause	point	écrire	punctuation	mark	sentence
22	A	**ÉCHELLE**	FR	ladder	monter	escabeau	haut	rung	paint / painting	roof
22	B	**LADDER**	EN	échelle	barreaux	peinture / peinturer	toit	climb	step	high
23	A	**FEATHER**	EN	plume	aile	voler	léger	pillow	bird	write
23	B	**PLUME**	FR	feather	oreiller	oiseau	écrire	wing	fly	light
24	A	**COUCHE**	FR	diaper	puant	jetable	poudre	cloth	baby	change
24	B	**DIAPER**	EN	couche	tissu	bébé	changer	smelly	disposable	powder
25	A	**GRAPE**	EN	raisin	rouge	grappe	fruit	wine	green	vegetable
25	B	**RAISIN**	FR	grape	vin	vert	légume	red	bunch	fruit
26	A	**IRRITER**	FR	irritate	fâcher	peau	rougeur	nerves	annoy	bother
26	B	**IRRITATE**	EN	irriter	nerfs	agacer	embêter	anger	skin	redness

Item / Version		Secret word	Language	Translation	TabooFR-1	TabooFR-2	TabooFR-3	TabooEN-1	TabooEN-2	TabooEN-3
27	A	**DUST**	EN	poussière	saleté / sal	balai	meubles	vacuum	tidy	clean
27	B	**POUSSIÈRE**	FR	dust	aspirer	propre	nettoyer	dirt / dirty	broom	furniture
28	A	**OREILLER**	FR	pillow	lit	dormir	draps	head	feather	cushion
28	B	**PILLOW**	EN	oreiller	tête	plume	coussin	bed	sleep	sheets
29	A	**APPOINT-MENT**	EN	rendez-vous	date	heure	dentiste	meeting	doctor	calendar
29	B	**RENDEZ-VOUS**	FR	appointment	réunion	docteur	calendrier	date	time	dentist
30	A	**MOUFFETTE**	FR	skunk	animal	puant	senteur	stripe	spray	white
30	B	**SKUNK**	EN	mouffette	rayure	arroser	blanc	animal	stink	smell
31	A	**NURSE**	EN	infirmière	hôpital	autorisé	malade	white	doctor	woman
31	B	**INFIRMIÈRE**	FR	nurse	blanc	docteur	femme	hospital	registered	sick
32	A	**CHAUVE**	FR	bald	tête	toupet	homme	hair	wig	old
32	B	**BALD**	EN	chauve	cheveux	perruque	vieux	head	toupet	man
33	A	**FREEZE**	EN	geler	glace	hiver	réfrigérateur	cold	water	shiver
33	B	**GELER**	FR	freeze	froid	eau	frisson	ice	winter	fridge
34	A	**SENTEUR**	FR	scent	odeur	nez	renifler	perfume	aroma	candle
34	B	**SCENT**	EN	senteur	parfum	arôme	chandelle	smell	nose	sniff
35	A	**EGG**	EN	œuf	matin	blanc	déjeuner	yolk	bacon	chicken
35	B	**ŒUF**	FR	egg	jaune	bacon	poule	morning	white	breakfast
36	A	**SAC**	FR	bag	papier	main	épicerie	garbage	black	purse
36	B	**BAG**	EN	sac	poubelle	noir	sacoche	paper	hand	groceries
37	A	**BEACH**	EN	plage	océan	vagues	nager	sand	shells	sea
37	B	**PLAGE**	FR	beach	sable	coquillages	mer	ocean	waves	swim
38	A	**CHIRURGIEN**	FR	surgeon	docteur	hôpital	opération	blade	cut	white
38	B	**SURGEON**	EN	chirurgien	lame	incision	blanc	doctor	hospital	operation
39	A	**HAM**	EN	jambon	porc	fromage	salé	egg	meat	sandwich
39	B	**JAMBON**	FR	ham	œuf	viande	sandwich	pork	cheese	salty
40	A	**JUPE**	FR	skirt	vêtement	mini	porter	blouse	dress	woman
40	B	**SKIRT**	EN	jupe	blouse	robe	femme	clothes/clothing	mini	wear
41	C	**TICKLE**	EN	chatouiller	rire	ricaner	plume	touch	ribs	feet

Item / Version		Secret word	Language	Translation	TabooFR-1	TabooFR-2	TabooFR-3	TabooEN-1	TabooEN-2	TabooEN-3
41	D	**CHATOUILLER**	FR	tickle	toucher	côtes	pieds	laugh	giggle	feather
42	C	**FUMÉE**	FR	smoke	détecteur	pipe	briquet	fire	cigarette	burn
42	D	**SMOKE**	EN	fumée	feu	cigarette	brûler	detector	pipe	lighter
43	C	**CANDLE**	EN	chandelle	mèche	flamme	lumière	wax	burn	scent
43	D	**CHANDELLE**	FR	candle	cire	brûler	senteur	wick	flame	light
44	C	**LAME**	FR	blade	patin	pointue	couper	knife	razor	slice
44	D	**BLADE**	EN	lame	couteau	rasoir	trancher	skate	sharp	cut
45	C	**PINEAPPLE**	EN	ananas	fruit	jus	tropical	Hawaii	cake	yellow
45	D	**ANANAS**	FR	pineapple	Hawaii	gâteau	jaune	fruit	juice	tropical
46	C	**ARGENT**	FR	money	monnaie	acheter	poche	penny	spend	dollars
46	D	**MONEY**	EN	argent	cenne	dépenser	dollars	cash	buy	pocket
47	C	**BREAKFAST**	EN	déjeuner	matin	manger	dîner	meal	supper	early
47	D	**DÉJEUNER**	FR	breakfast	repas	souper	tôt	morning	eat	lunch
48	C	**CHUTE**	FR	waterfall	Niagara	rivière	baril	water	high	cliff
48	D	**WATERFALL**	EN	chute	eau	haut	falaise	Niagara	river	barrel
49	C	**SLAP**	EN	taper	frapper	poing	main	hit	face	smack
49	D	**TAPER**	FR	slap	coup	visage	claque	strike	fist	hand
50	C	**OMBRE**	FR	shade	soleil	arbre	refroidir	hot	window	sunglasses
50	D	**SHADE**	EN	ombre	chaud	fenêtre	lunettes	sun	tree	cool
51	C	**BOOK**	EN	livre	poche	roman	magazine	page	library	read
51	D	**LIVRE**	FR	book	page	bibliothèque	lire	paperback	novel	magazine
52	C	**NID**	FR	nest	oiseau	arbre	construire	egg	house	branch
52	D	**NEST**	EN	nid	œuf	maison	branche	bird	tree	build
53	C	**CAST**	EN	plâtre	jambe	casser	os	sign	arm	doctor
53	D	**PLÂTRE**	FR	cast	signer	bras	docteur	leg	break	bone
54	C	**AÉROPORT**	FR	airport	voyager/voyage	piste	voler	airplane	takeoff	break
54	D	**AIRPORT**	EN	aéroport	avion	décoller	congé	travel	runway	fly
55	C	**EMERGENCY**	EN	urgence	crise	secours	santé	911	call	hospital
55	D	**URGENCE**	FR	emergency	911	appeler	hôpital	crisis	help	health
56	C	**FER**	FR	iron	acier	golf	repasser	metal	horse	clothes / clothing

Item / Version		Secret word	Language	Translation	TabooFR-1	TabooFR-2	TabooFR-3	TabooEN-1	TabooEN-2	TabooEN-3
56	D	**IRON**	EN	fer	métal	cheval	vêtement	steel	golf	press
57	C	**TRASH**	EN	poubelle	contenant	cuisine	jeter	pick up	garbage	rubbish
57	D	**POUBELLE**	FR	trash	ramasser	déchets	ordures	can	kitchen	throw
58	C	**TERRE**	FR	earth	globe	planète	semer	world	round	ground
58	D	**EARTH**	EN	terre	monde	rond	sol	globe	planet	plant
59	C	**SHOVEL**	EN	pelle	outil	creuser	terre	hole	snow	pick up
59	D	**PELLE**	FR	shovel	trou	neige	ramasser	tool	dig	dirt
60	C	**SERVIETTE**	FR	towel	sécher	mouillé	bain	shower	soaked	wipe
60	D	**TOWEL**	EN	serviette	douche	trempe	essuyer	dry	wet	bath
61	C	**MARSHMALLOW**	EN	guimauve	blanc	griller	léger	fire	soft	camping
61	D	**GUIMAUVE**	FR	marshmallow	feu	mou	camping	white	roast	fluffy
62	C	**FÊTE**	FR	party	cadeau	invitation	anniversaire	celebration	friend	cake
62	D	**PARTY**	EN	fête	célébration	ami	gâteau	gift	invitation	birthday
63	C	**FINGER**	EN	doigt	bague	main	orteil	point	thumb	index
63	D	**DOIGT**	FR	finger	pointer	pouce	index	ring	hand	toe
64	C	**FANTÔME**	FR	ghost	esprit	Halloween	hanter	sheet	Casper	dead
64	D	**GHOST**	EN	fantôme	drap	Casper	mort	spirit	Halloween	haunt
65	C	**ISLAND**	EN	île	océan	entouré	eau	country	beach	small
65	D	**ÎLE**	FR	island	pays	plage	petit	ocean	surrounded	water
66	C	**ÉPÉE**	FR	sword	couteau	escrime	lame	weapon	steel	knight
66	D	**SWORD**	EN	épée	arme	acier	chevalier	knife	fencing	blade
67	C	**BEE**	EN	abeille	cire	piqûre	miel	nest	flower	wasp
67	D	**ABEILLE**	FR	bee	nid	fleur	guêpe	wax	sting	honey
68	C	**BEURRE**	FR	butter	margarine	laitier / lait	maïs soufflé	spread	yellow	kitchen
68	D	**BUTTER**	EN	beurre	tartiner	jaune	cuisine	margarine	dairy / milk	popcorn
69	C	**DONUT**	EN	beigne	tremper	trou	manger	round	sweet	dessert
69	D	**BEIGNE**	FR	donut	rond	sucré	dessert	dunk	hole	eat
70	C	**TAPIS**	FR	carpet	plancher	mur	poils	vacuum	decor	rug
70	D	**CARPET**	EN	tapis	aspirateur	décor	carpette	floor	wall	shag
71	C	**CHIMNEY**	EN	cheminée	toit	brique	Père Noël	smoke	fire	house

Item / Version		Secret word	Language	Translation	TabooFR-1	TabooFR-2	TabooFR-3	TabooEN-1	TabooEN-2	TabooEN-3
71	D	**CHEMINÉE**	FR	chimney	fumée	feu	maison	roof	brick	Santa Claus
72	C	**BLAGUE**	FR	joke	farce	comédien	drôle	laugh	friend	knock
72	D	**JOKE**	EN	blague	rire	ami	toc	practical	comedian	funny
73	C	**SCREW-DRIVER**	EN	tournevis	outil	main	marteau	nail	turn	carpenter
73	D	**TOURNEVIS**	FR	screwdriver	clou	virer	charpentier	tool	hand	hammer
74	C	**ÉTERNUER**	FR	sneeze	poussière	rhume	nez	allergy	pepper	achoo
74	D	**SNEEZE**	EN	éternuer	allergie	poivre	atchoum	dust	cold	nose
75	C	**SHY**	EN	géné	timide	parler	social	quiet	person	introverted
75	D	**GÊNÉ**	FR	shy	silencieux	personne	introverti	timid	speak	social
76	C	**ARC-EN-CIEL**	FR	rainbow	bleu / jaune /rouge	pluie	soleil	colour	sky	flag
76	D	**RAINBOW**	EN	arc-en-ciel	couleur	ciel	drapeau	blue / yellow / red	rain	sun
77	C	**YELLOW**	EN	jaune	couleur	banane	citron	submarine	bright	happy
77	D	**JAUNE**	FR	yellow	sous-marin	vif	content	colour	banana	lemon
78	C	**BALANCE**	FR	scale	poids	peser	kg / lbs	diet	equal	justice
78	D	**SCALE**	EN	balance	diète	égal	justice	size	weigh	kg / lbs
79	C	**MOUNTAIN**	EN	montagne	grimper	ski	Rocheuses	range	Everest	high
79	D	**MONTAGNE**	FR	mountain	chaîne	Éverest	haut	climb	ski	Rockies
80	C	**RONFLER**	FR	snore	dormir	nuit	bruit	sound	nose	throat
80	D	**SNORE**	EN	ronfler	son	nez	gorge	sleep	night	noise

Appendix B: Brainstorming sheet for the free discussion speech elicitation activity.

FREE DISCUSSION ACTIVITY / ACTIVITÉ DE DISCUSSION LIBRE

FIRST DISCUSSION PROMPT / PREMIER MESSAGE GUIDE
My notes / mes notes:

SECOND DISCUSSION PROMPT / DEUXIÈME MESSAGE GUIDE
My notes / mes notes:

THIRD DISCUSSION PROMPT / TROISIÈME MESSAGE GUIDE
My notes / mes notes:

Appendix C: Recurrent non-standard expressions in French in FEBLOC.

Non-standard	Spelled-out
a	elle
a	elle a
al	elle
al	elle a
bin	bien
boutte	bout
c'était	c'(é)tait
cé	c'est
cé	ces
ché	je sais
chépas	je (ne) sais pas
chui	je suis
debord	d'abord
deboutte	debout
devoù	où
é	est
erdescend	redescend
ergarde	regarde
ermonte	remonte
faque	fait que
icitte	ici
inque	rien que
k'ça	que ça
k'cé	que c'est
k'c'était	que c'était
k'c'(é)tait	que c'était
k'j'ai	que j'ai
k's't'...	que c'est ...
k's't'à cause	que c'est à cause
k'si	que si
k't'as	que tu as
k'y'a	qu'il a
k'y'a	qu'il y a
k'y'a	qui a
k'yé	il est
k'y'en	qu'il y en
kes	qu'est-ce que
kessé	qu'est-ce que
kessék	qu'est-ce que

Non-standard	Spelled-out
kesséki	qu'est-ce qui
moé	moi
nwoir / nwér	noir
oùske	où est-ce que
oubindonc	ou bien donc / ou
oubedonc	ou bien donc / ou
p(eu)t-êt(re)	peut-être
p(eu)t-être	peut-être
pa(r)ce	parce
pis	puis
que(l)que	quelque
que(lque)	quelque
s'ça	c'est ça
s'correct	c'est correct
s'cuse	je m'excuse
s'cuse	excuse
s'ke	ce que
s't'...	c'est ...
s't'à dire	c’est-à-dire
s't'assez	c'est assez
s't'écrit	c'est écrit
s't'en	c'est en
s't'un	c'est un
s't'une	c'est une
sé	ses
sé	sais / sait
t'sou	dessous
t'su	dessus
toé	toi
toute	tout
tsé	tu sais
twoi	trois
vwé	vois / voit
y	il
y'a	il a
y'a	il y a
y'en	il y en a
y'inque	rien que
yé	il est

Appendix D: List of borrowings (in alphabetical order) attested in FEBLOC.

- Dark grey cells are French borrowings. All others are English borrowings.

BORROWING	Raw count	Count speakers	BORROWING	Raw count	Count speakers	BORROWING	Raw count	Count speakers
agreer	1	1	follower	1	1	set	4	1
anana	1	1	fun	26	13	setter up	1	1
antique	1	1	funky	1	1	shack	12	5
appointment	1	1	get	2	2	shooter	1	1
backpacker	1	1	giver up	1	1	shop	4	2
bale (de foin)	5	4	grocerie	1	1	shopping	1	1
bar	6	3	hanger	1	1	short(s)	15	7
basket(ball)	16	5	hippy	1	1	show	1	1
bill	3	2	horloge	1	1	shuffler	2	2
bitcher	1	1	hotdog	1	1	skimmer	1	1
blowé	1	1	job	19	11	skipper	4	4
blue	1	1	joke	1	1	smart	2	2
boss	3	2	kick(er) /é	9	6	smoothie	8	4
boy	15	7	kid	26	4	sniff(er)	6	5
break	1	1	kit	1	1	speedo	1	1
business	4	3	knock	3	1	splash	4	3
busy	2	1	leader	2	2	spotter/é	4	2
buzz	1	1	leverager	1	1	stand	3	1
catch	1	1	locké	1	1	stop	3	3
chainsaw	4	2	logistics	1	1	strip	4	2
check(er)	14	6	marshmallow	2	2	stripé	2	1
chimnée	1	1	match	1	1	struggl(e)	1	1
chips	1	1	micro	1	1	stuff	10	5
clash	1	1	mix	1	1	switcher	1	1
clip	5	3	pack	1	1	tee-shirt	1	1
condom	1	1	pin	12	4	ticket	3	3
cool	13	6	pitch(er) /é	3	3	timé	1	1
cowboy	1	1	planner	1	1	toast	1	1
dealer avec	1	1	plug	2	2	top	33	13
debording	1	1	plum	2	1	tough	7	4
driver	3	2	poke bowl	1	1	track	1	1
feel	1	1	reacher	1	1	tractor	2	1
fill[ed]	1	1	relater	1	1	trip	1	1
flash	2	1	renter	1	1	user	1	1
flinger	1	1	riff	4	2	veston	1	1
flip-flop	1	1	rush	1	1	volleyball	2	1
flipper	1	1	sandwich	4	3	watch	1	1
flipper [spatule]	1	1	scrapper	2	2	web	1	1
focuser	2	1	scratch	1	1			

Appendix E: Relationship between self-reported switching habits and switching proportions during the Free Discussion task.

- Dependent variables are listed in each table (objective measure).
- Fixed factors: the four BSwQ code-switching components (subjective measure).
- Random effects: by-pair random intercepts.

a. ***Proportion produced intra-CS (free discussion only)***

Term	Estimate	SE	t	p
Intercept	0.038	0.039	0.966	0.341
BSwQ: FR-to-EN	-0.036	0.016	-2.166	0.038
BSwQ: EN-to-FR	0.006	0.014	0.465	0.646
BSwQ: Contextual	0.030	0.013	2.406	0.022
BSwQ: Unintented	0.004	0.013	0.290	0.774

b. ***Proportion produced inter-CS into English (free discussion only)***

Term	Estimate	SE	t	p
Intercept	0.026	0.030	0.878	0.386
BSwQ: FR-to-EN	-0.020	0.013	-1.609	0.118
BSwQ: EN-to-FR	0.008	0.010	0.806	0.427
BSwQ: Contextual	0.017	0.010	1.794	0.082
BSwQ: Unintented	-.0002	0.009	-0.023	0.982

c. ***Proportion produced inter-CS into French (free discussion only)***

Term	Estimate	SE	t	p
Intercept	0.033	0.031	1.070	0.292
BSwQ: FR-to-EN	-0.020	0.013	-1.505	0.142
BSwQ: EN-to-FR	0.007	0.011	0.633	0.532
BSwQ: Contextual	0.015	0.010	1.519	0.138
BSwQ: Unintented	.0009	0.010	0.092	0.927

d. ***Proportion produced between-CS into English (free discussion only)***

Term	Estimate	SE	t	p
Intercept	0.010	0.039	0.251	0.803
BSwQ: FR-to-EN	-0.011	0.017	-0.645	0.523
BSwQ: EN-to-FR	-0.002	0.014	-0.122	0.904
BSwQ: Contextual	0.011	0.013	0.849	0.402
BSwQ: Unintented	0.011	0.012	0.895	0.378

e. ***Proportion produced between-CS into French (free discussion only)***

Term	Estimate	SE	t	p
Intercept	-0.009	0.046	-0.200	0.843
BSwQ: FR-to-EN	-0.020	0.020	-0.987	0.331
BSwQ: EN-to-FR	0.041	0.017	2.397	0.022
BSwQ: Contextual	-0.014	0.015	-0.939	0.354
BSwQ: Unintented	0.020	0.015	1.338	0.190

Appendix F: Supplementary mixed model analysis conducted on switching proportions for the Free Discussion activity.

Table F-i: Results of the supplementary fitted linear mixed-effects model for the **Free Discussion activity**. Only the main predictors (and their interactions) are shown here. Note that 'Condition1' contrasts incongruent and neutral trials, while 'Condition2' contrasts congruent and neutral trials. 'Type1' contrasts intra-CS and inter-CS, while 'Type2' contrasts within-CS (inter + intra) and between-CS. Significant effects and interactions are highlighted in green. Significance levels are indicated as follows: p<.10 •, p<.05 *, p<.01 **, p<.001 ***.

Fixed effects	*Estimate*	*SE*	| *t* |	Interpretation
Condition1	.1091	.0045	24.125***	inhibition effect
Condition2	-0478	.0045	10.685***	facilitation effect
%Produced	<.001	.0273	.003	*ns*
%Produced * Type1	-.0009	.0223	.039	*ns*
%Produced * Type 2	-.0004	.0161	.025	*ns*
%Produced * Condition1	-.1472	.0255	5.770***	inhibition effect * producing
%Produced * Condition2	.0814	.0252	3.233**	facilitation effect * producing
%Prod * Con1 * Type1	.0299	.0281	1.062	*ns*
%Prod * Con2 * Type1	-.0411	.0278	1.586	*ns*
%Prod * Con1 * Type2	.0037	.0191	.194	*ns*
%Prod * Con2 * Type2	-.0309	.0189	1.638 •	facilitation effect * produced within vs. between
%Heard	-.0012	.0322	-.036	*ns*
%Heard * Type 1	.0003	.0307	.008	*ns*
%Heard * Type 2	.0009	.0188	.047	*ns*
%Heard * Condition1	-.0051	.0321	.156	*ns*
%Heard * Condition2	-.0127	.0317	.400	*ns*
%Heard * Con1 * Type1	-.0367	.0387	.949	*ns*
%Heard * Con2 * Type1	.0278	.0382	.727	*ns*
%Heard * Con1 * Type2	.0175	.0216	.807	*ns*
%Heard * Con2 * Type2	.0183	.0214	.855	*ns*

```
lmer(RT.log ~ (Condition * %Produced.discussion * Type) + (Condition *
%Heard.discussion * Type) + (Condition * (age + education + video.games +
dominance)) + (1|subject) + (1|item), data=df)
```

Table F-ii. Summary emtrends slopes for %Produced_discussion according to the two categorical predictors. The final two columns indicate whether each slope is significantly different from null; significant negative differences are highlighted in green, while significant (or marginal) positive differences are highlighted in red.

CS-type	Condition	Slope	95% CI *upper*	95% CI *lower*	Different from zero? |*z*|	Different from zero? *p*
Collapsed	**Incongruent**	-.1472	-.2210	-.0735	3.916	.001
	Congruent	.0814	.0087	.1540	2.195	.0282
	Neutral	.0657	-.0070	.1383	1.772	.0764
Intra	**Incongruent**	-.1795	-.3076	-.0515	2.749	.0060
	Congruent	.1576	.0314	.2839	2.447	.0144
	Neutral	.0255	-.1008	.1517	.396	.6925
Inter	**Incongruent**	-.1216	-.2054	-.0378	2.843	.0045
	Congruent	.0677	-.0142	.1496	1.619	.1054
	Neutral	.0523	-.0297	.1342	1.250	.2115
Between	**Incongruent**	-.1406	-.2730	-.0083	2.083	.0373
	Congruent	.0188	-.1112	.1488	.283	.7770
	Neutral	.1192	-.0104	.2488	1.803	.0714

Figure F-i. Predicted linear values for Flanker reaction times (log-transformed) according to types of produced code-switches during the Free Discussion activity. 95% confidence intervals are indicated.

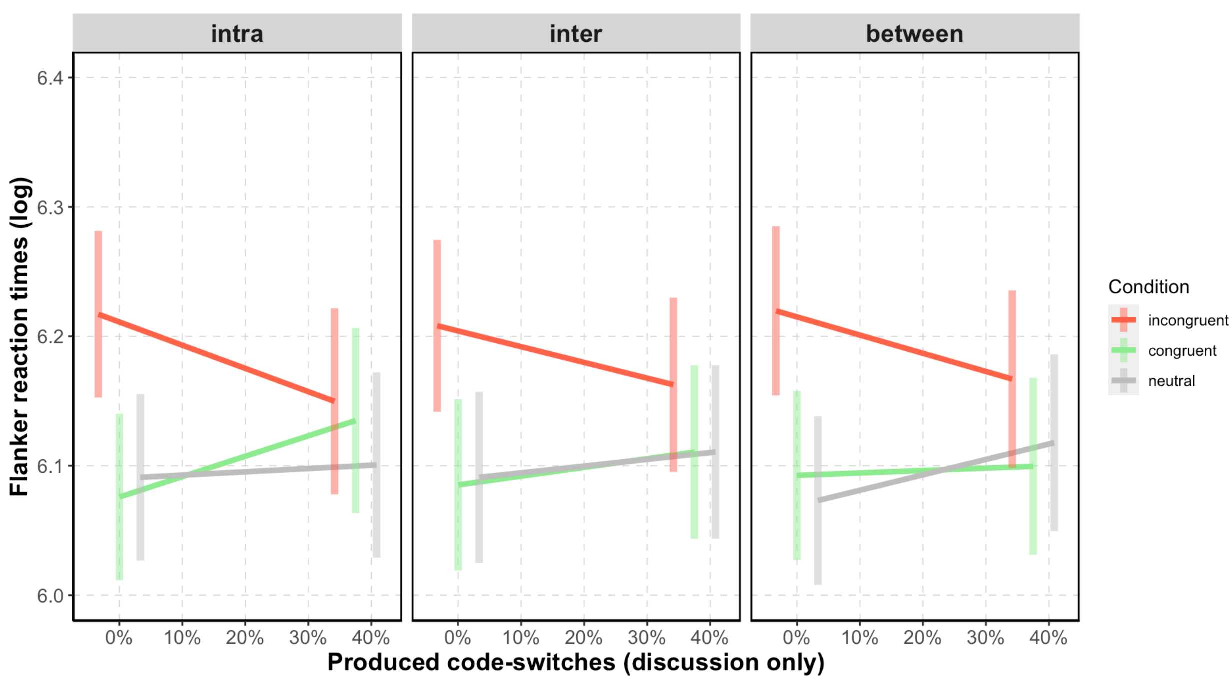
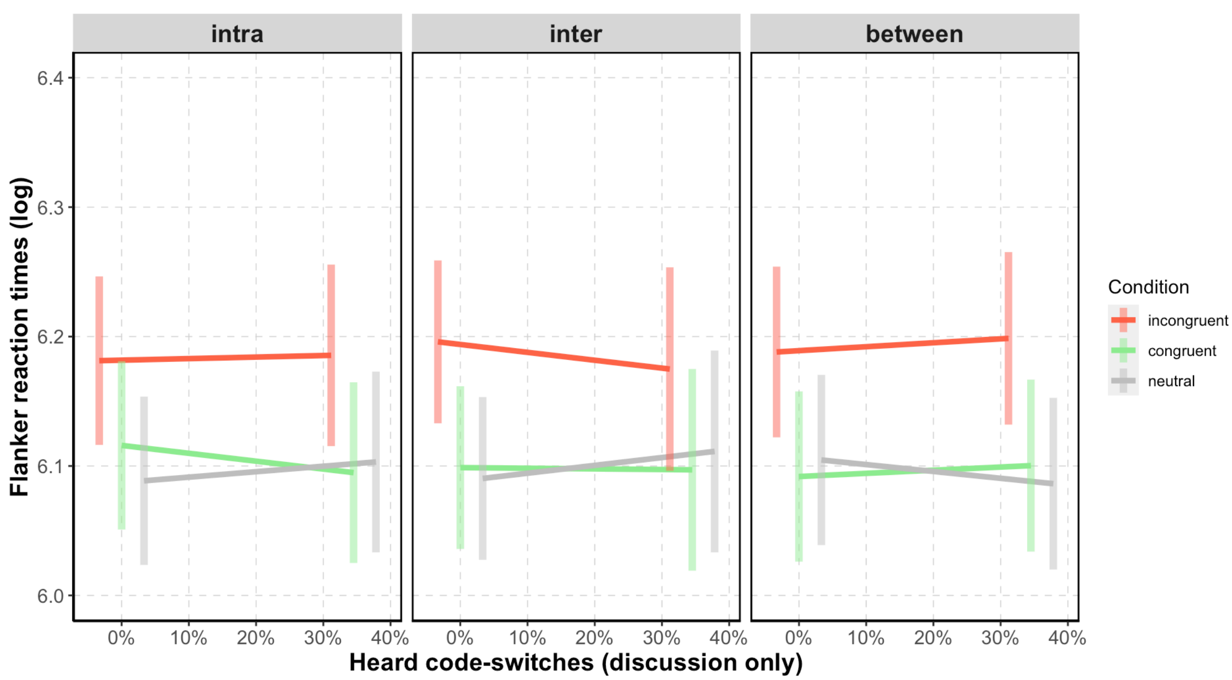


Table F.iii. Summary emtrends slopes for %Heard_discussion according to the two categorical predictors. The final two columns indicate whether each slope is significantly different from null; significant negative differences are highlighted in green, while significant (or marginal) positive differences are highlighted in red.

CS-type	Condition	Slope	95% CI		Different from zero?	
			upper	*lower*	*|z|*	*p*
Collapsed	**Incongruent**	-.0062	-.0960	.0837	.135	.893
	Congruent	-.0139	-.1021	.0744	.308	.758
	Neutral	.0166	-.0716	.1048	.368	.713
Intra	**Incongruent**	.0120	-.117	.1408	.182	.856
	Congruent	-.0610	-.188	.0661	.941	.347
	Neutral	.0422	-.085	.1694	.650	.516
Inter	**Incongruent**	-.0610	-.229	.1075	.709	.478
	Congruent	-.0050	-.170	.1598	.059	.953
	Neutral	.0606	-.104	.2255	.720	.472
Between	**Incongruent**	.0305	-.102	.1634	.450	.653
	Congruent	.0245	-.106	.1544	.369	.712
	Neutral	-.0531	-.182	.0756	.809	.419

Figure F-ii. Predicted linear values for Flanker reaction times (log-transformed) according to types of produced code-switches during the Free Discussion activity. 95% confidence intervals are indicated.



Appendix G.a: Audio excerpts from FEBLOC used in the passive listening task (Chapter 7). Red text marks edits.

Excerpt	Pair	Utterance	Question
1	pair06	*FIR: [- fra] &+i partout où s'qu'on [: est-ce qu'on] a été s'(é)tait très &-uh (...) anglais . *FIR: [- fra] faque [: fait que] j'ai jamais vraiment comme +//. *SEC: [- fra] ouais [: oui] mais dans les Caraïbes . *FIR: [- fra] cé [: c'est] &+an [/] cé [: c'est] hispanique mais . *FIR: [- fra] y: [: ils] vont toute parler au moins français ou anglais . *FIR: [- fra] faque [: fait que] s'pour [: c'est pour] ça j'ai jamais eu une [/] **(.) une langage [*]** [//] une barrière là [//] une +//. *FIR: [- fra] wayons [: voyons] . *SEC: +< [- fra] ouais [: oui] . *FIR: +< [- fra] une barrière de langage . *SEC: [- fra] moi j'trouve [: je trouve] cé [: c'est] comme tu dis . *SEC: s'qui@s:fra [: ce qui] peut@s:fra être@s:fra stressant@s:fra cé@s:fra **[: c'est] la@s:fra logistics@s:eng+fra .** ***SEC: [- fra]** organiser toute ça . *SEC: [- fra] surtout quand tu organises pour . *SEC: [- fra] quelqu'un comme tes parents . *FIR: +< [- fra] bin [: bien] oui mais s'pa(r)ce que +//. *FIR: [- fra] cé [: c'est] ça . *FIR: [- fra] non [//] oui mais s'pa(r)ce que . *FIR: [- fra] toé [: toi] tu te stresses (.) tell:ement avant l'voyage [: le voyage] . *SEC: +< [- fra] oui . *FIR: [- fra] pa(r)ce que tu organises toute de a@l à z@l . *SEC: [- fra] j'aime ça d'avoir un idée oui . *FIR: [- fra] que là cé [: c'est] +//. *FIR: [- fra] cé [: c'est] [/-] cé [: c'est] pas avoir une idée **Jack@s:eng&fra .** *FIR: [- fra] tu sé [: sais] toute à [//] de a@l à z@l &=laughs .	Le couple a souvent visité des endroits qui n'étaient pas majoritairement francophone ou anglophone. Answer = F
2	pair18	*FIR: [- eng] my biggest thing that brings me stress . *FIR: [- eng] is (.) planning . ***FIR: [- eng] right ?** ***FIR: [- eng] (be)cause I'm (.) like +//.** ***SEC: mm@s:eng&fra .** ***FIR: [- eng] planning is [/] +.** ***SEC: +< [- fra] oui .** ***FIR: +, [- eng] is really stressful .** *FIR: [- eng] because you wanna [: want to] make sure you get everything: . *FIR: [- eng] you wanna [: want to] make sure everything is &+a accounted fo:r . *FIR: [- eng] you wanna [: want to] make sure you don't get (.) something you don't see: . *FIR: [- eng] but then also . *FIR: [- eng] I hate when &+pi other people plan ! *SEC: &=laughs . *FIR: [- eng] because I fee:l like other people don't do due &+djil [/] due diligence like I do . ***FIR: [- eng] like Sierra@s:eng&fra who (..) told us two months befo:re .** ***FIR: [- eng] that we needed to book something .** ***FIR: [- eng] and then a month later was like .** ***FIR: [- eng] oh@s:eng&fra guys .**	The man generally doesn't trust others to organize his vacation. Answer = T

Excerpt	Pair	Utterance	Question
		***FIR: [- eng] I haven't booked it yet .** ***FIR: [- eng] so all that time you had [///] the [///] all you people that you already asked for your time off ?** ***FIR: [- eng] go ask again !** *SEC: mm-hm@s:eng&fra . *FIR: +< [- eng] like that's frustrating . *FIR: [- eng] and things like that are stressful to me . ***FIR: [- eng] so I don't like letting other people plan .** ***FIR: [- eng] I'm not mad at Sierra@s:eng&fra don't worry [=! mumbles] .** ***FIR: [- eng] but like I don't like letting other people plan sometimes .** ***SEC: +< mm-hm@s:eng&fra .** ***SEC: [- fra] ouais [: oui] [=! mumbles] .** *FIR: [- eng] so: letting things outta [: out of] your control . *FIR: [- eng] can be stressful . *FIR: [- eng] but also . *FIR: [- eng] having to feel like you have to control everything is also stressful . *SEC: mm-hm@s:eng&fra [=! mumbles] .	
3	pair02	*FIR: mais@s:fra I@s:eng always@s:eng have@s:eng this@s:eng feeling@s:eng . *FIR: [- fra] quand je vai:s (.) comme en voyage ? *SEC: +< [- fra] ah@s:eng&fre oui ? *FIR: [- eng] no matter what I'm &+go [//] like what I'm doing . *FIR: [- eng] where I'm going . *SEC: [- fra] que tu sois seule ou pas seule ? *FIR: [- fra] que je sois seule ou pas seule . *FIR: [- eng] I always . *FIR: bef(ore) [//] right before leaving . *FIR: [- eng] I always have the feeling . *FIR: comme@s:fra si@s:fra que(l)que@s:fra chose@s:fra is@s:eng gonna@s:eng [: going to] go@s:eng (..) bad@s:eng . *FIR: [- eng] like I kno:w . *FIR: [- eng] something is going to go bad . *FIR: [- fra] &+s le seul &+s truc cé [: c'est] comme . *FIR: [- fra] quand ? *FIR: [- eng] where ? *SEC: +< [- fra] ouais [: oui] . *FIR: [- eng] like is it gonna [: going to] be annoying ? *SEC: +< [- fra] ouais [: oui] . *FIR: [- fra] ou est-ce que ça va être juste comme . *FIR: okay@s:eng&fra . *FIR: [- eng] whatever . *SEC: +< [- fra] ouais [: oui] . *SEC: [- fra] mais tu t'atten:ds +. *FIR: +< [- fra] je m'attends . *SEC: +< [- fra] à une catastrophe . *FIR: que@s:fra [//] (.) like@s:eng +/. *SEC: +< [- fra] ou quelque chose va mal . *FIR: +< [- eng] like +//.	La jeune femme se sent détendue avant de partir en voyage. Answer = F

Excerpt	Pair	Utterance	Question
		*FIR: [- eng] worst of the worst . *SEC: okay@s:eng&fre .	
4	pair10	*SEC: [- fra] okay@s:eng&fra moé [: moi] j'ai dit . *SEC: [- fra] début et fin . *SEC: cé@s:fra [: c'est] là@s:fra [//] like@s:eng that's@s:eng where@s:eng the@s:eng stress@s:eng is@s:eng . *FIR: m'kay@s:eng&fra [: okay] . *FIR: [- fra] mais quand t'arrives [: tu arrives] . *FIR: [- eng] you hafta [: have to] check in . *SEC: [- eng] yeah . *FIR: [- fra] pis [: puis] là &+f +/. *SEC: +< [- eng] like that's a big [//] (.) that's like (.) a bit of stress . *FIR: okay@s:eng&fra . *SEC: +< [- eng] and then . *SEC: also@s:eng j'ai@s:fra écris@s:fra . *SEC: it's@s:eng ironic@s:eng comment@s:fra . *SEC: like@s:eng le@s:fra voyage@s:fra cé@s:fra [: c'est] fait@s:fra pour@s:fra destress@s:eng> [?] . *FIR: [- eng] yeah . *SEC: [- fra] mai:s . *SEC: [- fra] j'ai aussi dit . *SEC: cé@s:fra [: c'est] stressful@s:eng . *SEC: [- fra] la première fois . *SEC: [- fra] mais on s'habitue .	L'homme semble être moins stressé par les voyages que la femme. Answer = T
5	pair02	***SEC: +< [- fra] ta sœur et moi** on é [: est] plus &+sen &+sen semblable . *FIR: mm@s:eng&fra . *SEC: +< [- fra] elle et moi . *SEC: [- fra] dans s'sens [: ce sens] là . *FIR: +< mm-hm@s:eng&fra . *SEC: &-uhm +... *SEC: [- fra] mais en même temps . *SEC: [- fra] ch'pense [: je pense] ya [: il y a] **(.)** bin [: bien] des gens s'y [: si ils] m'voient [: me voient] de l'extérieur . *SEC: [- fra] des gens qui m(e) **(.)** connaient [: me connaissent] moins bien . *FIR: +< mm-hm@s:eng&fra . *SEC: [- fra] ou au travai:l ou . *SEC: &-uhm . *SEC: [- fra] tsé [: tu sais] quand j'aide **Lauren@s:eng&fra** ou t(out) ça . *SEC: [- fra] a [: elle] connait beaucoup à propos de moi . *SEC: [- fra] mais moé [: moi] j'vas [: je vas] pas perdre les pédales comme elle . *FIR: [- fra] ah@s:eng&fra ouais [: oui] . *FIR: mm-hm@s:eng&fra . *SEC: [- fra] j'veux [: je veux] dire j'vas [: je vas] les perdre . *SEC: [- fra] j'vas [: je vas] les perdre t'seule [: toute seule] dans ma chambre .	Si l'individu perd le calme, elle préfère le faire toute seule. Answer = T

Excerpt	Pair	Utterance	Question
6	pair18	*FIR: +< [- eng] and sometimes it makes me worry (be)cause I don't know . *FIR: [- eng] which I am and (.) what (.) comes more important to me . *FIR: [- eng] and that makes me worry a little bit about myself . *FIR: [- eng] that maybe I don't know myself as much as I thought I did . ***SEC: [- fra] mais cé [: c'est] correct d'être les deux [=! mumbles] .** ***FIR: [- fra] ouain [: oui] je sé [: sais] mais .** *FIR: [- eng] the fact that I don't kno:w which one does like +//. *FIR: [- eng] the [//] one of them is gonna [: going to] take priority . *FIR: [- eng] you know what I mean ? *SEC: mm-hm@s:eng&fra [=! mumbles] . *FIR: +< [- eng] like if you ha:ve to make a decision . *FIR: [- eng] which one are you gonna [: going to] pick . *FIR: [- eng] the one that's logical ? *FIR: [- eng] or the one that's (.) emotional . *FIR: [- eng] you want something . *FIR: [- eng] but you know you shouldn't buy it . *FIR: [- eng] are you gonna [: going to] buy it ?	The speaker states that he tends to be driven by his brain. Answer = F
7	pair06	*FIR: [- fra] &-uh toé [: toi] j'ai l'impression k'tu [: que tu] veu:x (..) écouter à ton cœur . *FIR: mais@s:fra k'ça@s:fra [: que ça] clash@s:eng . **REMOVE PAUSE** %com: here "clash" is pronounced English-like. *FIR: [- eng] against +. *SEC: ma@s:fra brain@s:eng ! *FIR: +, ta@s:fra brain@s:eng . *SEC: [- eng] all the time ! *FIR: +< [- fra] cé [: c'est] [/] &=stutters cé [: c'est] ça qui t'donne [: te donne] la difficulté j'pense [: je pense] . *SEC: +< [- eng] all: the time . *FIR: [- fra] mais: . **REMOVE PAUSE** *SEC: [- eng] all the time. *SEC: [- fra] parce que . *SEC: [- fra] j'veux [: je veux] que(l)que cho:se . *SEC: but@s:eng ma@s:fra brain@s:eng dit@s:fra . *SEC: [- fra] si j'prends [: je prends] s'ke [: ce que] j'veux [: je veux] . *SEC: j'vas@s:fra [: je vas] &+p souffrir@s:fra later@s:eng . *SEC: [- eng] I'm gonna [: going to] pay for it later .	L'homme dit qu'il a parfois de la difficulté à suivre son cœur. Answer = T
8	pair14	*FIR: [- fra] moi ma perception cé [: c'est] que: . **REMOVE LONG PAUSE** *FIR: I@s:eng kinda@s:eng [: kind of] don't@s:eng care@s:eng <là@s:fra> [=! mumbles] . *FIR: [- fra] à propos de [//] (.) des autres personnes . **REMOVE LOUD CRACK** *FIR: [- fra] mais j'pense [: je pense] que . *FIR: [- fra] on: veut chercher à +... **REMOVE LONG PAUSE** *FIR: [- fra] comme l'idéal cé [: c'est] d'trouver [: de trouver] un équilibre là . *FIR: [- fra] tsé [: tu sais] d'chercher [: de chercher] comme +... **REMOVE LONG PAUSE** *FIR: y@s:fra [: il] [/] y@s:fra [: il] me@s:fra semble@s:fra que@s:fra cé@s:fra [: c'est] un@s:fra (..) well@s:eng known@s:eng fact@s:eng là@s:fra . *FIR: [- fra] que tu veux (.) un équilibre entre les deux .	La femme suggère qu'il est préférable d'être moins sensible. Answer = F

Excerpt	Pair	Utterance	Question
		*FIR: [- fra] kes [: qu'est-ce que] t'en [: tu en] penses [=! mumbles] ? **REMOVE LONG PAUSE** *FIR: [- fra] comme . *FIR: [- eng] neither is (.) better than the other ?	
9	pair09	*FIR: [- eng] she's grown up to be a different person . *SEC: [- eng] well . *FIR: [- eng] I [//] which she's allowed to . *SEC: +< mais@s:fra cé@s:fra [: c'est] ça@s:fra la@s:fra vie@s:fra right@s:eng ? *FIR: [- eng] &-uh yeah . *FIR: [- eng] but +/. *SEC: +< [- fra] comme elle va [/] elle va (.) transformer dan:s sa propre personne . *FIR: [- eng] &=sighs I know . *FIR: [- eng] but (.) we've never been so different . *FIR: [- eng] in our entire lives . **REMOVE PAUSE** *SEC: &+s (.) ça@s:fra va@s:fra s'retourner@s:fra [: se retourner] though@s:eng . *SEC: [- eng] like what goes around comes around . *FIR: mm-hm@s:eng&fra . *SEC: [- eng] right the pendulum . *SEC: it's@s:eng always@s:eng gonna@s:eng [: going to] [//] (.) ça@s:fra va@s:fra retourner@s:fra là@s:fra . *SEC: [- eng] it's gonna [: going to] swing back . *FIR: [- eng] yeah .	The young man is trying to comfort the young woman. Answer = T
10	pair14	*FIR: [- fra] cé [: c'est] ça . *FIR: [- fra] si on r(e)vient vraiment des valeurs fon:damentales . *FIR: [- fra] ch'pas [: je suis pas] certaine qu'elles changent nécessairement (.) énormement d'une génération à l'aut(re) . *FIR: [- fra] tsé [: tu sais] ? *FIR: [- fra] ch'pense [: je pense] k'ya [: qu'il y a] une pyramide des valeurs . *FIR: [- fra] pis [: puis] (.) d'après moi si j'avais à deviner . *FIR: [- fra] dans une mê:me famille . *FIR: [- fra] à travers les générations . *FIR: [- fra] y'a [: il y a] beaucoup d'valeurs [: de valeurs] qui sont (.) transmises . **PAUSE** *FIR: [- fra] pis: [: puis] [=! mumbles] +... *FIR: [- fra] tsé [: tu sais] [=! mumbles] . ***FIR: [- fra] &+ch même (.) pas <à travers les familles> [=! mumbles] .** ***FIR: [- fra] <à travers> [=! mumbles] les sociétés .** ***FIR: [- fra] tsé [: tu sais] .** *FIR: [- fra] ch'pense [: je pense] que les valeurs s:ociales +... ***FIR: [- fra] &-mm se [///] (..) tsé [: tu sais] ça prend plus qu'une génération .** ***FIR: [- fra] <tsé [: tu sais] ça> [=! mumbles] +... REMOVE LONG PAUSE** *FIR: [- fra] ça perdure là [=! mumbles] . *SEC: mm-hm@s:eng&fra . *FIR: [- fra] cé [: c'est] mon impression [=! mumbles] .	Selon la femme, les valeurs sociales changent beaucoup d'une génération à l'autre. Answer = F

Excerpt	Pair	Utterance	Question
11	pair17	*SEC: [- fra] cé [: c'est] pas juste (.) dan:s la façon qu'on approche les choses . *SEC: [- fra] mais cé [: c'est] aussi des fois les façons qu'on pa:rle . *SEC: [- fra] &-uh les expressions qu'on utili:se . *SEC: [- fra] les gestes . *SEC: [- fra] compo:rte(ment) . *SEC: [- fra] des fois on ma:rche d'la [: de la] même façon comme . *SEC: [- fra] cé [: c'est] &+s +//. *SEC: [- fra] tsé [: tu sais] ? **REMOVE PAUSE** *FIR: [- fra] mais pas comme les aut(res) . ***SEC: [- fra] toi ?** ***FIR: [- fra] mais .** *SEC: [- fra] moins comme les aut(res) . *FIR: [- fra] mais comme maman puis: (...) son frère . *FIR: [- fra] eux autres y [: ils] se ressemblent . ***FIR: [- fra] mais y [: ils] marchent pas semblable mais .** ***SEC: [- fra] non mais .** *SEC: [- fra] le &+ca [/] le +. *FIR: +< [- fra] cé [: c'est] +/. *SEC: +, [- fra] personnage [//] la personnalité é [: est] +. *FIR: +< [- fra] ouain [: oui] . *SEC: +, [- fra] un peu plus: semblable .	La locutrice croit que les valeurs peuvent être exprimées de multiples façons. Answer = T
12	pair10	*SEC: [- eng] it's that it [/] it reflects the realities . *SEC: [- eng] of [/] of each one . *SEC: [- eng] and then . *SEC: [- eng] I think also the importance of each (.) &-uhm [/] (..) of each value . *SEC: [- eng] changes . *SEC: [- eng] right like ? *SEC: [- eng] &-uh the import(ance) [/] the importance is fairly the same . *SEC: it's just how much [//] &-uh the [/] the value is fairly the same . *SEC: [- eng] it's the importance that changes . *SEC: [- eng] when you get older . *SEC: [- eng] family values . *SEC: [- eng] are gonna [: going to] be . *SEC: [- eng] stronger than when you were . *SEC: [- eng] young rebellious kid [=! mumbles] .	The speaker states that the importance we place on values stays consistent. Answer = F
13	pair02	*FIR: [- eng] would it be wei:rd . *FIR: [- eng] to say . *FIR: [- fra] que: +... *FIR: [- fra] les générations . *FIR: [- fra] là maintenant là? *SEC: [- fra] ouais [: oui] . *FIR: [- eng] have like . *FIR: [- eng] much (.) freer values ? *FIR: [- fra] dans le sens où ya [: il y a] +//.	La jeune femme suggère que les nouvelles générations ont des idées

Excerpt	Pair	Utterance	Question
		*FIR: [- eng] I +/. *SEC: +< [- fra] j'aimerais croi:re . *FIR: [- eng] I wouldn't think . *FIR: [- fra] que [//] ou j'arrive pas &+tch voir un truc où: . *SEC: +< mm@s:eng&fra . *FIR: [- fra] ya [: il y a] une [/] une valeur . *FIR: kyé@s:fra [: qui est] comme@s:fra widely@s:eng spread@s:eng . *FIR: [- fra] dans toute ma génération . *FIR: où@s:fra we@s:eng all@s:eng agree@s:eng . *FIR: [- eng] that like this is a thing . *FIR: [- eng] that should happen . *SEC: +< [- fra] dans ta génération ? *FIR: [- fra] ouais [: oui] .	beaucoup plus restreintes. Answer = F
14	pair18	*FIR: [- fra] cé [: c'est] comme . *FIR: [- fra] ta mère et ton père . **REMOVE LONG PAUSE** *FIR: or@s:eng &+m moins@s:fra ton@s:fra père@s:fra . *FIR: ton@s:fra père@s:fra y:@s:fra [: il] [/] he@s:eng doesn't@s:eng seem@s:eng like@s:eng he@s:eng totally@s:eng cares@s:eng . *FIR: [- eng] but I think it's because he's learnt that . *FIR: [- eng] after valuing money for so long when he was younger . *FIR: [- eng] he missed time with you guys . *FIR: [- eng] when he was younger . *FIR: [- eng] and he regrets that . *FIR: [- eng] so I think he's +. *SEC: +< [- fra] mais si +/. *FIR: +, [- eng] f:ine if you take a job that's not paying (.) two hundred thousand a year . *SEC: [- fra] moé [: moi] j'pense [: je pense] que y [: il] dit ça . *SEC: [- fra] mais en même temps . *FIR: [- fra] y [: il] +/. *SEC: +< [- fra] y'a [: il a] quand même des heures (..) folles . *SEC: pis@s:fra [: puis] cé@s:fra [: c'est] [/] cé@s:fra [: c'est] [/] (.) cé@s:fra [: c'est] self-imposed@s:eng . *FIR: [- fra] ouain [: oui] je sé [: sais] . *SEC: +< [- fra] cé [: c'est] lui qui décide ses heures . *FIR: +< je@s:fra sé@s:fra [: sais] but@s:eng I'm@s:eng saying@s:eng . *FIR: [- eng] his expectations for you have [//] aren't (..) the same expectations he has for himself .	The young man believes that his father-in-law is starting to value money less than he used to. Answer = T
15	pair07	*FIR: +< [- fra] ça donne tellement rien . *FIR: [- fra] mais ah@s:eng&fra les +/. *SEC: [- fra] pis [: puis] aussi si tu't [: tu te] tiens tout l'temps [: le temps] avec du monde négatif . *SEC: [- fra] comme ç'ça [: c'est ça] k'j'ai [: que j'ai] +. *FIR: +< [- fra] yo@s:eng&fra mais +/. *SEC: +, [- fra] dit à mon éducatrice . *SEC: [- fra] chu [: je suis] comme . *SEC: [- fra] j'peux [: je peux] pa:s (.) tout l'temps [: le temps] v(e)nir au salon du personnel pa(r)ce que cé [: c'est] trop: négatif . *FIR: &+pj +/. *SEC: [- fra] pis [: puis] j'veux [: je veux] pas tout l'temps [: le temps] travailler pendant la pause .	La femme n'aime pas se tenir avec ses collègues pendant sa pause de travail. Answer = T

Excerpt	Pair	Utterance	Question
		*SEC: [- fra] j'ai l'droit [: le droit] d'aller marcher . *SEC: [- fra] j'ai l'droit [: le droit] +. *FIR: +< [- fra] cé [: c'est] vrai . *SEC: +, [- fra] de: respirer . *SEC: [- fra] j'ai l'droit [: le droit] de: &=lip:trill .	
16	pair15	*SEC: [- eng] our like final project was like a sixty percent paper . *FIR: [- eng] stop ! *SEC: +< [- eng] and I was assigned with this one girl . *SEC: [- eng] that like . *SEC: [- eng] just [///] (.) she didn't know what was going on . *SEC: [- eng] like ever . *SEC: [- eng] she wrote (.) the most +... *SEC: [- eng] I didn't understand +. *FIR: +< &=laughs . *SEC: +, [- eng] what she was saying ! *SEC: [- eng] and I was just like . *SEC: [- eng] hey like . *SEC: [- eng] can we chat about this ? *SEC: [- eng] and she's like what's there to chat about ? *SEC: [- eng] and I'm like . *FIR: +< &=laughs . *SEC: [- eng] it was a nightmare . *SEC: [- eng] I hated every second of it . *FIR: +< [- eng] s:top ! *FIR: [- eng] oh@s:eng&fra my god [=! laughing] !	One of the women talks about her negative experience doing group work for class. Answer = T
17	pair11	*SEC: [- fra] j'ai écrit comme beaucou:p plus . *SEC: [- fra] &-uh expériences de vie différentes . *SEC: des@s:fra barriers@s:eng . *SEC: [- fra] fait que . *SEC: [- fra] des fois t'essaie d'faire [: de faire] un travaux [*] . *SEC: [- fra] mais t'as [: tu as] pas [//] (..) des travaux mais t'as pas les mêmes idées . *FIR: [- fra] ouais [: oui] . *FIR: [- fra] non j'comprends [: je comprends] . *SEC: +< [- fra] tsé [: tu sais] tu vas avoir des différentes pensées . *SEC: [- fra] ou même le monde qui sont têtus: là . *SEC: [- fra] ton caractère: . *FIR: +< [- fra] oui . *SEC: [- eng] personality traits . *SEC: [- fra] ça va [///] cé [: c'est] vraiment différent pour tout l'monde [: le monde] .	L'individu croit qu'il est généralement facile de travailler en groupe. Answer = F

Excerpt	Pair	Utterance	Question
18	pair19	*FIR: [- eng] las:t semester I had this project with this guy . *FIR: [- fra] y'avait [: il avait] (.) lu le mauvais document . *FIR: [- fra] pis [: puis] y'arrêtait [: il arrêtait] pas de s'astiner [: s'obstiner] avec moi . *FIR: [- fra] y'était [: il était] comme . *FIR: [- fra] non t'as [: tu as] pas raison . *FIR: [- fra] ch'tais [: j'étais] comme . *FIR: [- fra] gros . *FIR: [- fra] est-ce que t'as [: tu as] lu le document ? *SEC: &=laughs . *FIR: [- fra] pis [: puis] là yé [: il est] comme . *FIR: oh@s:eng&fra . *FIR: [- eng] I read the wrong one . *FIR: &=laughs . *SEC: +< &=laughs . *FIR: [- eng] or like when I would (.) put ideas down ? *SEC: [- eng] yeah . *FIR: [- eng] and like . *FIR: quelqu'un@s:fra who@s:eng didn't@s:eng work@s:eng the@s:eng entire@s:eng project@s:eng . *FIR: [- eng] would just come in and (.) erase . *SEC: [- eng] yeah . *FIR: +< [- eng] what I did . *FIR: [- eng] all over my work . *SEC: [- eng] oh@s:eng&fra my god [=! whispers] ! *SEC: [- eng] yeah [=! mumbles] +... *FIR: [- eng] I [//] or I &-uh like . *FIR: [- fra] en français ? *FIR: [- fra] cette année ? *SEC: mm-hm@s:eng&fra . *FIR: +< [- fra] y'a [: il a] toute &-uh effacé mon paragraphe . *SEC: [- eng] yeah +...	The woman had to work with a classmate who didn't properly follow instructions. Answer = T
19	pair16	*SEC: [- eng] or you know you have to recognize +. *FIR: +< [- fra] ouais [: oui] . *FIR: [- fra] ouais [: oui] ouais [: oui] . *SEC: +< +, [- eng] all: the differences . *FIR: [- fra] ouais [: oui] . *SEC: [- eng] and you haf [: have] to take into perspective all the diff(erences) +//. *SEC: [- eng] that's why it can be difficult to deal with . *SEC: [- fra] pa(r)ce que . *SEC: [- fra] &+s ça [/] ça +//. *SEC: [- fra] juste parce que cé [: c'est] pas ta manière . *SEC: ça@s:fra veut@s:fra pas@s:fra dire@s:fra k'cé@s:fra [: que c'est] wrong@s:eng . *FIR: mm-hm@s:eng&fra . *SEC: [- fra] pis [: puis] faut t'acceptes [: tu acceptes] que . *SEC: [- fra] cé [: c'est] correct d'avoir des différences d'opinion . *SEC: [- fra] chu [: je suis] d'accord avec toi .	L'homme dit que ses collègues devraient changer leurs habitudes de travail. Answer = F

Excerpt	Pair	Utterance	Question
		*SEC: [- eng] you gotta [: have got to] deal with it . *SEC: [- eng] becau:se otherwise it's a toxic environment . *FIR: +< mm-hm@s:eng&fra . *SEC: [- eng] it's horrible . *SEC: pis@s:fra [: puis] j'l'ai@s:fra [: je l'ai] vit@s:fra ça@s:fra right@s:eng ? *SEC: &-uhm . *SEC: mais@s:fra toé@s:fra [: toi] too@s:eng . ***SEC: [- fra] ché [: je sais] au deuxième [?] [=! mumbles] .** ***FIR: +< [- fra] wa-oui [: oui] wa-oui [: oui] .** ***SEC: +< [- fra] ouain [: oui] [=! mumbles] .** ***FIR: [- fra] ouais [: oui] .** *SEC: [- fra] on l'a toute [: tous] vit ça . *FIR: +< [- fra] ouais [: oui] .	
20	pair07	*FIR: [- fra] faque admettons [: à mettons] k'moi [: que moi] j'fais [: je fais] des vélos . *SEC: +< mm@s:eng&fra . *FIR: [- fra] pis [: puis] &-uhm . *FIR: [- fra] mon vélo y'a [: il a] deux roues . *FIR: pi:s@s:fra [: puis] (..) **y@s:fra [: il] fonctionne@s:fra right@s:eng ?** ***FIR: [- fra]** comme tu pédales . *FIR: [- fra] pis: [: puis] y'avance [: il avance] . *FIR: [- fra] bin [: bien] . *FIR: [- fra] j'ai pas d'besoin [: de besoin] d'faire [: de faire] un meilleur vélo . *FIR: [- fra] parce que . *FIR: [- fra] &-uh j'ai pas d'compétition . *FIR: [- fra] mais admettons [: à mettons] que Bob@s:eng&fra de l'autre bord d'la [: de la] rue . *FIR: [- fra] lui aussi fait des vélos . *FIR: [- fra] pis [: puis] y'é [: il est] comme . *FIR: [- fra] ha-ha@s:eng&fra moi j'vas [: je vas] les faire plus légers . *FIR: [- fra] bin [: bien] là cé [: ses] vélos sont moins lourds . *FIR: [- fra] pis [: puis] là y [: il] monte les collines plus vite . *FIR: [- fra] donc . *FIR: [- fra] cé [: ses] vélos sont meilleurs . *FIR: [- fra] faque [: fait que] là toi tu vas faire un meilleur vélo . *FIR: et@s:fra ainsi@s:fra d'suite@s:fra [: de suite] **right@s:eng ? REMOVED**	L'homme explique comment la compétition peut nuire à l'innovation. Answer = F
21	pair19	*FIR: [- eng] gives you a lil [: little] fire <under your ass> [=! mumbles] . *FIR: [- eng] <you know> [=! mumbles] ? *SEC: +< [- eng] yeah . *FIR: [- eng] that like lil [: little] adrenaline . *FIR: [- eng] &-uhm helps [//] (.) for me: . *FIR: [- eng] it helps me motivate me . *FIR: [- eng] because +/. *SEC: +< [- eng] yeah . *SEC: [- eng] that's what I put too . *SEC: [- eng] motivation .	The young woman does better work when she doesn't have to compete. Answer = F

Excerpt	Pair	Utterance	Question
		*FIR: [- eng] like if I'm not (.) &-uhm (..) motivated to study . *FIR: [- eng] or like I'm not like having a lil [: little] competition with someone . *FIR: [- eng] then it's like . *FIR: [- eng] I'm bored . *SEC: mm@s:eng&fra . *SEC: [- eng] yeah . *FIR: &-uhm +... *FIR: [- eng] it like feeds my competitive side **&=laughs . REMOVED LOUD LAUGH** *SEC: +< [- eng] yeah . *FIR: [- eng] and it brings out the best like . *FIR: [- eng] performance in me normally .	
22	pair09	*SEC: [- eng] the only time we woulda [: would have] probably ever played together is if she'd'a [: she would have] stayed in house league . *SEC: [- eng] and she'd'a [: she would have] never done that . *FIR: [- eng] no . *SEC: +< [- eng] (be)cause by the time she got to like Atom@s:eng&fra . *SEC: [- eng] they were having her change in <different rooms> [=! laughing] . *FIR: [- eng] yeah: . *SEC: +< [- eng] and so it's like eh@s:eng&fra . ***SEC: [- eng] yeah. REMOVE** *SEC: [- eng] (be)cause there's oh@s:eng&fra yeah . *SEC: [- eng] she's a +. *FIR: +< &=laughs . *SEC: +, [- eng] (..) girl surrounded in a room by a bunch of guys: . *FIR: +< [- eng] yeah . *FIR: [- eng] you realize that . *FIR: [- eng] it's like <oh@s:eng&fra yeah> [=! laughing] ! *SEC: [- eng] oh:@s:eng&fra yeah . *FIR: [- eng] I went through that too right ? *FIR: [- eng] (be)cause I played baseball with the guys . *FIR: [- eng] but then after sixth grade it's like . *FIR: [- eng] yeah . *FIR: [- eng] you can't really do that anymore . *FIR: [- eng] because it's just not the same .	The speakers talk about gender in competitive environments. Answer = T
23	pair11	*SEC: &-uh moi@s:fra j'ai@s:fra parlé@s:fra le@s:fra (...) genre@s:fra pros@s:eng and@s:eng cons@s:eng . *SEC: [- fra] faque [: fait que] . *FIR: +< [- fra] moi aussi . *SEC: [- fra] &-uh ça donne la motivation . *SEC: [- fra] cé [: c'est] comme: [//] s't'un [: c'est un] [//] cé [: c'est] comme un: &-uhm . **REMOVE LONG PAUSE** *SEC: [- fra] s't'un [: c'est un] bon stress dans un sens . *SEC: [- fra] pa(r)ce que ça t'pousse [: te pousse] à faire mieux . *SEC: [- fra] comme si tu veux gagner . *SEC: pis@s:fra [: puis] &+m tsé@s:fra [: tu sais] mettons@s:fra t(u)@s:fra achieve@s:eng première@s:fra place . *SEC: [- fra] bin [: bien] . *SEC: cé@s:fra [: c'est] [/] (..) s't'une@s:fra [: c'est une] récompense@s:fra de@s:fra ton@s:fra hard@s:eng work@s:eng .	L'individu discute les négatifs liés à la compétition. Answer = F

Excerpt	Pair	Utterance	Question
24	pair15	*SEC: [- eng] she was like . *SEC: [- fra] bin [: bien] tsé [: tu sais] comme . *SEC: [- fra] vos collè:gues . *SEC: [- fra] comme tsé [: tu sais] comme . *SEC: [- fra] cé [: c'est] des ami:s . *SEC: [- fra] mais faut s'rappeler: [: se rappeler] . *SEC: [- fra] que cé [: c'est] l'monde [: le monde] qui compétitionne contre vous: . *SEC: so@s:eng comme@s:fra . *SEC: [- eng] you love each other . *SEC: [- eng] and you want the be:st . *SEC: [- fra] mais en même temps: . *SEC: [- fra] genre comme . *SEC: [- fra] tu sé [: sais] que si eux autres y'ont [: ils ont] une place . *SEC: [- fra] toé [: toi] tu vas pas avoir [/] avoir une place . *SEC: [- eng] I remember like the whole +/. *FIR: +< [- eng] they just get like bigger yeah . *SEC: +< [- eng] the whole class . *SEC: [- eng] like we were in second year at that time . *SEC: [- eng] no one really thinking about that . *SEC: [- eng] we were all just like . *SEC: [- eng] oh@s:eng&fra we're all friends . *FIR: +< [- eng] I don't know [=! laughing] . *SEC: [- eng] and then we were all just like looking around at each other like . *SEC: oh@s:eng&fra !	The student talks about the day that she was told her classmates are her competition. Answer = T
25	pair11	*FIR: [- fra] y'a [: il y a] certains buts aussi qui prennent (.) plus de temps . *FIR: [- fra] comme tsé [: tu sais] y'en [: il y en] a certain que même si j'voulais [: je voulais] k'ça [: que ça] soit tout d'suite [: de suite] . *FIR: [- fra] ça peut pas s'faire [: se faire] . *SEC: +< mm-hm@s:eng&fra . *FIR: [- fra] tsé [: tu sais] comme par exemple . *FIR: [- fra] moi j'pensais [: je pensais] genre . *FIR: [- fra] j'aimerais ça (.) tsé [: tu sais] [?] aller en méd(e)cine . *FIR: [- fra] mais en tu [: tout] cas . *FIR: [- fra] on s'croise [: se croise] les doigts . *FIR: &-uhm . *SEC: [- fra] &=chuckles finir mon bacc(alauréat) [=! mumbles] &=laughs . *FIR: +< [- fra] exactement . *FIR: [- fra] bin [: bien] cé [: c'est] ça . *FIR: [- fra] bin [: bien] comme à place de dire . *FIR: [- fra] bon bin [: bien] j'espère que j'vais [: je vais] graduer de l'école de méd(e)cine . *FIR: [- fra] aye@s:eng&fra on va prendre ça une étape à fois .	Le but de la locutrice c'est de compléter sa maîtrise en génie. Answer = F

Excerpt	Pair	Utterance	Question
26	pair19	*SEC: [- eng] but then if you have a life goal [?] ? *FIR: [- eng] yeah [=! mumbles] . *SEC: [- eng] then: you're gonna [: going to] be really motivated to do it . *FIR: [- eng] yeah . *FIR: [- eng] and you like . *SEC: [- eng] motivation . *FIR: +< [- eng] no matter what you know you're like working towards the bigger picture . *FIR: [- eng] rather than just like . *SEC: [- eng] yeah . *FIR: +< [- eng] focusing on your failures . *FIR: &+m +/. *SEC: +< [- eng] but you have to focus on the small steps . *FIR: [- eng] yeah . *SEC: +< [- eng] that you're making progress . *FIR: [- eng] but then like . *FIR: [- eng] even if you fail a small step . *FIR: [- eng] you're not gonna [: going to] be demotivated . *FIR: [- eng] (be)cause you're like okay@s:eng&fra . *FIR: [- eng] this is like (.) in the (.) short run . *SEC: [- eng] yeah . *FIR: +< [- eng] in the long run . *FIR: [- eng] this is gonna [: going to] help me be better . *SEC: [- eng] exactly . *SEC: [- eng] so it's (.) progress . *SEC: [- eng] and it will +. *FIR: +< [- eng] yeah . *SEC: +, [- eng] take many years . *FIR: [- eng] yeah [=! mumbles] . *SEC: +, [- eng] very many years . *FIR: [- eng] yeah [=! mumbles] .	The speakers agree that it is important to focus on the small steps of achieving a life goal. Answer = T
27	pair07	*FIR: [- fra] j't'à [: je suis tout à] fait d'accord avec cette affirmation . *FIR: [- fra] ça peut prendre (..) &-uh +/. *SEC: bin@s:fra [: bien] moi@s:fra j'm'é@s:fra [: je me suis] fait@s:fra des@s:fra life@s:eng goal@s:eng . *SEC: [- fra] j'voulais [: je voulais] avoir une maison par tel âge . *SEC: [- fra] j'voulais [: je voulais] avoir un chien . *SEC: [- fra] &-uh par (..) tsé [: tu sais] [///] (.) avant vingt cinq ans . *SEC: [- fra] j'pense [: je pense] c'(é)tait ça l'âge limite . *SEC: [- fra] pis: [: puis] . *SEC: [- fra] ç'a [: ça a] pris du temps . *SEC: [- fra] y'a [: il a] &+ra [/] y'a [: il a] fallu que j'aille étudier: . *SEC: [- fra] et cé [: c'est] [//] ça prend du travail: &-uh . *SEC: [- eng] hard work &-uh +... *SEC: [- fra] des étu:des . ***SEC: &-uhm [=! mumbles] . REMOVED** ***SEC: [- fra] cé [: c'est] ça . REMOVED (LONG PAUSE)**	Un des buts de la femme c'était d'avoir un chat. Answer = F

Excerpt	Pair	Utterance	Question
		*FIR: [- fra] ouain [: oui] . *SEC: [- fra] comme si mettons nous aut(res) . *SEC: cé@s:fra [: c'est] quoi@s:fra not(re)@s:fra life@s:eng goal@s:eng ? *SEC: [- fra] on a dit chalet ? *FIR: mm-hm@s:eng&fra . *SEC: [- fra] bin [: bien] ça va prendre du tem:ps à: toute &-uh gagner d'l'argent [: de l'argent] pour &-uh . *SEC: &+s pour@s:fra faire@s:fra un@s:fra down@s:eng payment@s:eng sur@s:fra un@s:fra chalet@s:fra . *SEC: [- fra] pis [: puis] trouver l'bon [: le bon] chalet . *SEC: [- fra] pis: [: puis] . *FIR: +< [- fra] ouain [: oui] . *SEC: [- fra] cé [: c'est] ça [=! mumbles] .	
28	pair17	*FIR: [- fra] idéalement j'vas [: je vas] avoir une maison aussi &=laughs . *SEC: [- fra] tu vas avoir une maison . *SEC: [- fra] pis [: puis] peut-être des enfants ! *FIR: [- fra] peut-être ! ***SEC: [- fra] pis [: puis] un chum !** ***FIR: [- fra] j'vas [: je vas] avoir <cinquante et un ans [=! laughing] .** ***FIR: so@s:eng** j'espère@s:fra que@s:fra oui@s:fra [=! laughing] . *SEC: +< [- fra] pis [: puis] moi j'vas [: je vas] pouvoir avoir des [/] des [/] des +//. *SEC: [- fra] comment on appelle ça ? *SEC: un@s:fra [/] un@s:fra grand@s:eng [/] grand@s:eng (..) nieces@s:eng ? *SEC: [- eng] and nephews ? **REMOVE PAUSE** *SEC: [- eng] great ? *FIR: +< [- eng] maybe +... ***SEC: [- eng] nephews [=! mumbles] ?** ***SEC: [- eng] great ?** ***SEC: [- eng] grand ?** *SEC: [- fra] je sais pas [=! mumbles] . *FIR: +< [- eng] yeah . *FIR: [- fra] j'pense [: je pense] que oui . **REMOVE PAUSE** *SEC: great@s:eng ou@s:fra grand@s:eng ? *FIR: +< [- eng] (be)cause you would be a great aunt . *SEC: [- eng] I'd be a great aunt .	Les femmes ont hâte que la plus jeune d'entre elles ait des enfants. Answer = T
29	pair08	*SEC: [- fra] tu travailles encore une fois avec beaucoup des jeunes . **REMOVE PAUSE** *FIR: [- fra] oui mais moi j'leur [: je leur] dis pas quoi faire . **REMOVE PAUSE** *SEC: [- fra] ouais [: oui] mais tsé [: tu sais] quand même des (.) confli:ts +... *FIR: [- fra] cé [: c'est] pour ça que j'ai écris . *SEC: [- fra] bin [: bien] y [: il] reste à gérer [=! mumbles] [?] . *FIR: +< [- fra] que cé [: c'est] difficile quand té [: tu es] amis avec les superviseurs <là> [=! mumbles] . **...** *SEC: [- fra] oui [=! mumbles] . ***SEC: [- fra] don:c des fois cé [: c'est] ça [=! mumbles] .** *SEC: [- fra] &=clears:throat cé [: c'est] l'équilibre . ***SEC: [- fra] pour +...**	Les deux femmes affirment qu'il n'est pas une bonne idée d'être ami avec son superviseur. Answer = T

Excerpt	Pair	Utterance	Question
		***SEC: [- fra] la personne à gérer ça .** *SEC: [- fra] parce que: . *SEC: [- fra] cé [: c'est] clair que pas tout l'monde [: le monde] où +//. *SEC: [- fra] dans notre environnement d'travail [: de travail] . *SEC: [- fra] peut être &-uh (.) **positif .** ***SEC: [- fra] et une [//] être** notre meilleure amie .	
30	pair04	*SEC: [- eng] and conflicts can be about . *SEC: [- eng] &-uh (.) personal matters . *SEC: [- eng] like it can [/] it can be on a personal level that you hate someone . *SEC: [- eng] you [/] you [/] you think that they're . *SEC: [- eng] you know [=! mumbles] . *FIR: [- eng] yeah +... *SEC: +< [- eng] not a nice person . *SEC: [- eng] and so you're [/] you're &+con +//. *SEC: [- eng] you're tempted to be in conflict more with that person . *SEC: [- eng] &-uh or you have &-uh very different views of life . *SEC: [- eng] and you disagree +. *FIR: +< mm-hm@s:eng&fra ! *SEC: +, [- eng] with everything that they do . *FIR: +< [- eng] I'm [//] yeah I see whatchu [: what you] mean [=! mumbles] . ***SEC: [- eng] and then you get a s:eparation .** ***SEC: [- eng] &=laughs no .** *SEC: [- eng] &-uh and it can be about the work substance . *SEC: [- eng] can be about the topic . *SEC: [- eng] you have different views on [/] on how to do a project . *FIR: +< mm-hm@s:eng&fra . *SEC: [- eng] and it's very very difficult .	The young woman disagrees with the man's views about work conflicts. Answer = F
31	pilot01	*SEC: [- fra] &-uhm &=clears:throat dans une situation d(e) mê:me . *SEC: souvent@s:fra cé:@s:fra [: c'est] que@s:fra t'as@s:fra [: tu as] un@s:fra gérant@s:fra **ou@s:fra un@s:fra boss@s:eng+fra .** *SEC: [- fra] kyé [: qui est] vraiment +... *SEC: [- eng] too much of a manager . *FIR: [- fra] ouais [: oui] . *FIR: un@s:fra micro@s:eng management@s:eng ? *SEC: [- fra] ouais [: oui] [=! mumbles] . ***FIR: [- fra] ouais [: oui] ça chu [: je suis] d'accord a(v)ec toi .** ***SEC: [- eng] good [=! mumbles] .** ***FIR: [- fra] &-uh les charges de travail .** ***SEC: [- eng] yep [: yes] [=! mumbles] .** ***FIR: +< [- fra] tsé [: tu sais] cé [: c'est] différent .** ***SEC: [- eng] yep [: yes] [=! mumbles] .** ***FIR: [- fra] que moi pis [: puis] toi .** ***SEC: [- fra] ouais [: oui] [=! mumbles] .** ***FIR: [- fra] &-uh quand qu'on rencontre les étudiants .** ***FIR: [- fra] moi cé [: c'est] pour des centernes [: certaines] (.) choses .**	Les locuteurs sont d'accord que la plupart des conflits au travail sont causés par un gérant. Answer = T

Excerpt	Pair	Utterance	Question
		***FIR: [- fra] toi cé [: c'est] (.) souvent pour (.) créer comme qu'est-ce qu'on fait présentement .** ***SEC: +< [- eng] yep [: yes] [=! mumbles] .** ***FIR: [- fra] pis [: puis] en même temps dans [?] rencontre avec les professeurs .** ***FIR: [- fra] cé [: c'est] souvent parler des laboratoires .** ***FIR: [- fra] tandis que moi (.) &-uh cé [: c'est] la charge de cours .** *SEC: [- fra] <cé [: c'est] ça> [=! mumbles] . *SEC: [- fra] bin [: bien] en s'k'ya [: ce qu'il y a] de conflit . *SEC: [- fra] souvent cé [: c'est] basé sur notre performance . *FIR: [- fra] ouais [: oui] . *SEC: +< et:@s:fra (.) souvent@s:fra (.) ça@s:fra cause@s:fra (.) du@s:fra stress@s:eng . *FIR: [- fra] tellement . *SEC: [- eng] right ? *FIR: [- fra] oui . *SEC: [- fra] et moi j'dis [: je dis] &+s cé [: c'est] souvent . *SEC: comme@s:fra t'as@s:fra [: tu as] dit@s:fra du@s:fra micro@s:eng management@s:eng . *SEC: [- fra] mais ç'a [: ça a] rapport à qui (..) kyé +... ***SEC: notre@s:fra boss@s:eng+fra ..** ***FIR: [- fra] oui .** *SEC: +< notre@s:fra (.) manager@s:eng [=! mumbles] . *FIR: +< [- fra] qui kyé [: qui est] en charge . *FIR: [- fra] ouais [: oui] cé [: c'est] ça .	
32	pair12	*FIR: [- eng] quotas is like how much shit we have to put out every day . **REMOVE PAUSE** *SEC: [- fra] cé [: c'est] quoi ça ? *FIR: +< [- eng] and that causes a lot of +//. **REMOVE PAUSE** *FIR: [- eng] quotas ? *SEC: [- eng] yea:h . *FIR: [- fra] cé [: c'est] genre &-uhm . *FIR: [- fra] par exemple +/. *SEC: [- eng] that's (be)cause you don't [?] [///] you work in retail . *SEC: [- eng] I don't . *FIR: [- eng] I know . *FIR: so@s:eng par@s:fra exemple@s:fra . ***FIR: bin@s:fra [: bien] it's@s:eng also@s:eng I@s:eng &+h [//] di(d)n't@s:eng have@s:eng to@s:eng do@s:eng this@s:eng at@s:eng www .** *FIR: [- fra] mai:s &-uhm +... *FIR: &-uh . *FIR: output@s:eng of@s:eng clothes@s:eng par@s:fra exemple@s:fra . *FIR: [- fra] y'a [: il y a] littéralement comme . *FIR: avant@s:fra que@s:fra le@s:fra monde@s:fra peuvent@s:fra (.) aller@s:fra sur@s:fra leur@s:fra break@s:eng . *FIR: [- fra] y [: il] faut qu'y [: qu'ils] finissent (.) trente trois pourcent . *FIR: pour@s:fra leur@s:fra **première@s:fra [//] (.)** premier@s:fra break@s:eng . *FIR: trente@s:fra trois@s:fra pourcent@s:fra des@s:fra quotas@s:eng de@s:fra la@s:fra journée@s:fra. *FIR: avant@s:fra d'aller@s:fra (.) dans@s:fra [//] d'aller@s:fra chercher@s:fra un@s:fra break@s:eng . *SEC: +< [- eng] that's stupid .	One speaker is explaining to the other why salary discussions cause conflict. Answer = F

Excerpt	Pair	Utterance	Question
33	pilot01	*SEC: [- fra] mais cé [: c'est] pas vraiment . *SEC: [- fra] &-uh l'homme fait ça . *SEC: [- fra] pis [: puis] la femme fait ça . *FIR: [- fra] non . *FIR: [- fra] cé [: c'est] vrai . *SEC: [- fra] et . *SEC: [- fra] moi j'ai aussi ajouté . *SEC: [- fra] que j'pense [: je pense] que . *SEC: [- fra] qu'est-ce kyé [: qui est] t'important [: important] . *SEC: [- fra] cé [: c'est] que les enfants (.) aident avec les: (.) tâches dans maison . *SEC: [- fra] et souvent on va les [/] on va les payer une (pe)tite compensation là . *SEC: [- fra] pour que y [: ils] nous aident dans maison . *FIR: [- fra] ouain [: oui] [=! mumbles] . *FIR: [- fra] jusqu'à temps ky'aillent [: qu'ils aillent] &-uh douze ans treize ans [=! mumbles] . *FIR: [- fra] après ça là [=! mumbles] +... *SEC: [- fra] <laisse faire> [=! mumbles] . *FIR: [- fra] ouain [: oui] .	L'homme affirme que les enfants devraient aider avec les tâches ménagères. Answer = T
34	pair16	*FIR: [- eng] I think that it's [//] in [/] in not sharing domestic chores . *FIR: [- eng] you are actually (..) &+as assigning a gender . *FIR: [- eng] to the (.) domestic chores . *FIR: [- eng] and to [//] as soon as you assign a gender to domestic chores . *FIR: [- eng] it becomes . *FIR: [- eng] this is the woman's job . *SEC: +< [- eng] yep [: yes] . *FIR: [- eng] and this is the man's job . *FIR: [- eng] you talked about shoveling . *FIR: [- eng] I love shoveling . *SEC: okay@s:eng&fra . *FIR: [- eng] I don't like doing dishes . **... ADDED 3234** ***SEC: ah@s:eng&fra .** ***FIR: +< [- eng] I don't like it .** **... ADDED 3313** ***SEC: [- eng] we have those same struggles !** ***FIR: +< [- eng] I have +/.**	The woman prefers when chores are assigned a gender. Answer = F
35	pair08	*FIR: [- fra] ça m'a fait beaucou:p (.) penser . *FIR: [- fra] au fait que cé [: c'est] moi qui lave la salle de bain en haut . **REMOVE PAUSE** *FIR: [- fra] et que Casius@s:eng&fra . **REMOVE PAUSE** *FIR: [- fra] respecte pas (.) l'espace . *FIR: [- fra] partagé entre les deux . *FIR: à@s:fra cause@s:fra y@s:fra [: il] fait@s:fra un@s:fra m:ess@s:eng . *FIR: [- fra] dans la salle de bain que j'ai: lavé . ***FIR: [- fra] pa(r)ce que oui &+m des fois moi j'la [: je la] salis .** ***FIR: [- fra] mais cé [: c'est] moi qui la lave .**	La jeune femme aime partager sa brosse à cheveux. Answer = F

Excerpt	Pair	Utterance	Question
		*FIR: [- eng] you know [=! mumbles] ? *FIR: [- fra] ça m'fait [: me fait] juste penser à ça . *FIR: &+t tsé@s:fra [: tu sais] que@s:fra par@s:fra exemple@s:fra ça@s:fra m(e)@s:fra piss@s:eng off@s:eng quand@s:fra . *FIR: [- fra] &-uh y'utilise [: il utilise] ma brosse à ch(e)veux . *SEC: [- fra] oui . REMOVE *SEC: [- fra] mais la question cé [: c'est] est-ce qui [: qu'ils] devraient être partagés . *FIR: [- fra] mm-mm@s:eng&fra cé [: c'est] ça k'ça [: que ça] m'a fait pensé à . *SEC: mm-hm@s:eng&fra . *FIR: (o)kay@s:eng&fra . *SEC: [- fra] &-uh oui cent pourcent . *SEC: un:@s:fra ça@s:fra devrait@s:fra être@s:fra partagé@s:fra dan:s@s:fra like@s:eng [?] [//] partagé@s:fra (.) non@s:fra seulement@s:fra . *SEC: [- fra] tous les membres de la famille . *SEC: [- fra] les parents et les enfants . *SEC: [- fra] &-uh +. *FIR: +< [- eng] good point . *SEC: [- fra] parce que: cé [: c'est] une très bonne leçon de la vie .	
36	pair12	*FIR: [- eng] the &-uhm [///] (.) establishing (..) shared labour: . *FIR: [- eng] versus equitable labour . REMOVE PAUSE *SEC: [- eng] can you say that in French ? *FIR: [- fra] &-uhm genre pa(r)ce que +//. *FIR: m'kay@s:eng&fra [: okay] . *FIR: [- fra] genre . *FIR: &=sighs . *FIR: [- fra] tsé [: tu sais] . *FIR: des@s:fra fois@s:fra cé@s:fra [: c'est] [/] cé@s:fra [: c'est] [//] it's@s:eng beneficial:@s:eng . *FIR: [- fra] pour un coup(le) d' [/] d'être comme . *FIR: [- fra] okay@s:eng&fra moi j'vais [: je vais] faire (.) la vaisselle . *FIR: pis@s:fra [: puis] toi@s:fra like@s:eng sweep@s:eng . *SEC: mm-hm@s:eng&fra [=! mumbles] . *FIR: [- eng] you know ? *FIR: [- eng] sometimes it's [/] it's [/] it's good . *FIR: [- eng] and I agree like . *FIR: [- eng] &=stutters house [//] you know household chores should be [/] (.) should be: (.) like (.) split .	The speaker explains that it can be good to divide household chores. Answer = T
37	pilot01	*FIR: [- fra] mai:s cé [: c'est] vrai qu'est-ce que t'as [: tu as] dit . *FIR: [- fra] ça fait de la jalousie . *SEC: [- fra] cé [: c'est] ça [=! mumbles] . *FIR: [- fra] l'argent &-uh [//] (.) quand que t'as [: tu as] d(e) l'argent [////] quand ça arrive à l'argent . *FIR: [- fra] t'as [: tu as] pas d'amis . *FIR: [- fra] t'as [: tu as] pas d'famille [: de famille] . *SEC: +< [- fra] cé [: c'est] ça [=! mumbles] . *SEC: [- fra] mais comm:e la [///] ça nous d(e)mande . *SEC: [- fra] cé [: c'est] d'être content [///] la moitié sont contents . *SEC: [- fra] tsé [: tu sais] tu vas faire des choses que t'as [: tu as] jamais pu faire +. *FIR: +< [- fra] oui . *SEC: +, [- fra] dans ta vie .	Les locuteurs discutent uniquement les négatifs liés à la loterie. Answer = F

Excerpt	Pair	Utterance	Question
		*FIR: [- fra] exact . *SEC: &-uh . *SEC: [- fra] tsé [: tu sais] soit pour toi même . *SEC: [- fra] ou des voya:ges ou . *SEC: +, [- fra] tsé [: tu sais] des autos . *SEC: [- fra] des maisons . *SEC: [- fra] des +... *SEC: [- fra] toute sorte des [/] des affaires . *FIR: +< [- fra] pis [: puis] gâter le &+s [/] le [//] leurs proches . *SEC: +< [- fra] gâter &+l +/. *FIR: +< [- fra] &+k comme qu'on dit . *SEC: +< [- fra] donner l'argent à des sociétés . *SEC: [- fra] des choses du genre . *FIR: [- fra] ouais [: oui] .	
38	pair12	*SEC: [- eng] I dunno [: don't know] I feel like I'd save a part of it . *SEC: [- eng] of course I'd like spend some . *SEC: [- eng] yeah why no:t . *FIR: +< [- eng] yeah me too . *SEC: [- eng] hello ? *FIR: +< [- eng] (be)cause I'd have like a li(tt)le windfall . *FIR: [- eng] I [/] (.) I would probably have my moment and be like . *SEC: +< [- eng] I feel like +/. *FIR: +< [- eng] <oh@s:eng&fra my god> [=! yells] ! *FIR: [- eng] like I'm not gonna [: going to] go and buy like a lamborghini . *SEC: [- eng] no: . *FIR: [- eng] but like I would buy the +. *SEC: +< [- eng] like help +/. *FIR: +, [- eng] things that I've been wanting to ge:t . *FIR: [- eng] and like (.) help the people I've been wanting to he:lp . *FIR: [- eng] and like maybe go +. *SEC: +< [- eng] yeah [=! mumbles] . *FIR: +, [- eng] on a li(tt)le vacation . *FIR: [- eng] to celebrate my new found richness somewhere . *SEC: +< [- eng] yeah .	If they won the lottery, the women state that they'd save some money and spend some too. Answer = T
39	pair04	*SEC: [- eng] money and happiness . *SEC: [- eng] sometimes it equates but . *SEC: really@s:eng not@s:eng all@s:eng the@s:eng time@s:eng j'pense@s:fra [: je pense] . ***FIR: m'kay@s:eng&fra [: okay] .** ***FIR: cool@s:eng bin@s:fra [: bien] cé@s:fra [: c'est] bien@s:fra [//] bin@s:fra [: bien] ça@s:fra dit@s:fra fifty@s:eng fifty@s:eng .** ***FIR: [- eng] I guess it depends on +/.** ***SEC: +< [- fra] ouain [: oui] bin [: bien] .** ***SEC: [- fra] cé [: c'est] &=reads:prompt .** ***FIR: +< mm-hm@s:eng&fra .** ***FIR: [- fra] moi: [/] (.) moi j'ai écris en anglais aussi mais .** ***SEC: +< mm@s:eng&fra .** ***FIR: [- fra] moi j'voulais [: je voulais] parler du fait que .**	La jeune femme estime que l'agréable surprise de gagner de l'argent finit par s'atténuer.

Excerpt	Pair	Utterance	Question
		*FIR: [- fra] ce gros gain . *FIR: cé@s:fra [: c'est] quand@s:fra même@s:fra short@s:eng term@s:eng . *FIR: [- eng] right ? **REMOVE PAUSE** *SEC: +< mm@s:eng&fra . *FIR: [- eng] you win once . **REMOVE PAUSE** *SEC: [- fra] ouais [: oui] . *SEC: mm-hm@s:eng&fra . *FIR: [- eng] you win once and then you +. *SEC: +< [- fra] ouais [: oui] . *FIR: +, [- eng] &+s you +//. *FIR: [- eng] yes okay@s:eng&fra you have the money for a while . *SEC: mm@s:eng&fra . *FIR: [- eng] but chu [: you] win once . *FIR: [- fra] t'as [: tu as] cet +. *SEC: +< mm@s:eng&fra . *FIR: +, [- fra] effet de surprise . *FIR: [- fra] une fois dans ta vie . *SEC: [- fra] cé [: c'est] ça . *SEC: [- fra] ouais [: oui] . *FIR: +< faque@s:fra [: fait que] cé@s:fra [: c'est] du:@s:fra short@s:eng term@s:eng . *SEC: +< [- fra] cé [: c'est] pas répétitif . *SEC: [- fra] cé [: c'est] ça . *FIR: +< [- fra] cé [: c'est] pas répétitif . *SEC: +< [- fra] ouais [: oui] . *SEC: [- fra] ouais [: oui] . *FIR: +< [- fra] ça revient pas . *FIR: [- fra] cé [: c'est] pas pour longtemps .	Answer = T
40	pair16	*SEC: [- eng] I would like to be able to impact more people's lives . *SEC: [- fra] tsé [: tu sais] ? *SEC: [- fra] j':em [: je me] [/] j': [/] j(e) dis [/] (.) j(e) dis pense là . *SEC: [- fra] tsé [: tu sais] si j'gagne [: je gagne] trente millions moé [: moi] . *SEC: [- eng] &-uh part of me says I'm gonna [: going to] give a million bucks to . *SEC: [- eng] each one of your kids . ***SEC: [- eng] and each one of &-uh +//.** ***SEC: tsé@s:fra [: tu sais] d'une@s:fra manière@s:fra cé@s:fra [: c'est] pas@s:fra fair@s:eng .** ***SEC: [- fra] &-uh pa(r)ce que Mabelle@s:eng&fra on a juste une nièce su(r) son bord .** ***SEC: [- fra] su(r) not(re) bord on a plusieurs .** *FIR: [- fra] ouain [: oui] [=! mumbles] . **REMOVE PAUSE** *SEC: [- fra] pis [: puis] en même temps que: [/] que j'pense [: je pense] . *SEC: [- fra] j'aimerais ça les aider . *SEC: [- fra] ça m'fait [: me fait] peur aussi . *SEC: [- eng] (be)cause I would hate . *SEC: [- eng] to give a million bucks to one of your kids and find out . *SEC: [- eng] that the couple has difficulty (.) with that . *SEC: [- eng] and ends up causing them (.) issues [//] grief as a couple .	L'homme déclare qu'il garderait pour lui-même l'entièreté du gros gain. Answer = F

Appendix G.b: Details of audio excerpts used in the passive listening task (Chapter 7).

excerpt	prompt	con.	con.bin	pair	time stamp	length	FIR age	SEC age	FIR sex	SEC sex	total utt	speaker _switch	cs_total	uni total	dysfl total	flow total	intell avg	acc_avg
1	1	UNI FR	UNI	pair06	2435-2474	31.4	35	33	1	0	23	10	0	22	12	8	86.14	0.86
2	1	UNI EN	UNI	pair18	2219-2275	25.9	21	22	0	1	17	5	0	11	11	1	97.57	1.00
3	1	CS	CS	pair02	2980-3009	29.1	20	58	1	1	31	15	13	12	12	10	94.86	0.86
4	1	CS	CS	pair10	2288-2307	19.7	18	18	1	0	20	8	9	4	6	3	94.00	0.86
5	4	UNI FR	UNI	pair02	3756-3780	21.6	20	58	1	1	19	8	0	7	7	4	89.57	1.00
6	4	UNI EN	UNI	pair18	2438-2465	23.9	21	22	0	1	15	2	0	12	6	3	98.29	1.00
7	4	CS	CS	pair06	2953-2976	21.2	35	33	1	0	16	7	10	1	8	2	87.43	0.86
8	4	CS	CS	pair14	2752-2780	21.5	41	41	1	0	12	0	3	6	8	2	92.71	1.00
9	4	CS	CS	pair09	2752-2774	20.9	18	18	1	0	17	10	5	6	10	3	91.00	1.00
10	7	UNI FR	UNI	pair14	3093-3135	27.9	41	41	1	0	15	2	0	12	7	2	97.14	0.86
11	7	UNI FR	UNI	pair17	2631-2665	27.7	26	54	1	1	17	8	0	16	14	4	94.00	0.86
12	7	UNI EN	UNI	pair10	3009-3031	22.6	18	18	1	1	14	0	0	13	11	0	77.71	0.86
13	7	CS	CS	pair02	4976-5001	25.2	20	58	1	1	22	8	10	7	8	6	91.29	1.00
14	7	CS	CS	pair18	3332-3362	29.0	21	22	0	1	21	8	7	10	11	6	98.00	1.00
15	2	UNI FR	UNI	pair07	2281-2296	15.6	34	32	0	1	15	7	0	12	7	6	84.71	0.86
16	2	UNI EN	UNI	pair15	2138-2161	22.6	22	22	1	1	20	7	0	15	4	5	96.00	1.00
17	2	CS	CS	pair11	2159-2176	16.9	18	18	1	1	14	4	3	9	7	2	89.29	1.00
18	2	CS	CS	pair19	2179-2206	27.1	17	19	1	0	30	13	4	15	7	5	92.43	1.00
19	2	CS	CS	pair16	2829-2857	26.7	61	59	1	0	24	9	9	8	5	6	91.86	0.86
20	5	UNI FR	UNI	pair07	2493-2518	24.6	34	32	0	1	20	2	0	17	5	1	86.14	1.00
21	5	UNI EN	UNI	pair19	2301-2322	20.9	17	19	1	0	21	8	0	16	8	5	94.71	1.00
22	5	UNI EN	UNI	pair09	2702-2731	24.3	18	18	1	0	21	9	0	18	4	4	97.57	1.00
23	5	CS	CS	pair11	2294-2312	17.4	18	18	1	1	11	2	3	6	11	1	94.00	0.86
24	5	CS	CS	pair15	2565-2597	22.9	22	22	1	1	24	4	4	17	7	4	96.29	1.00

excerpt	prompt	con.	con.bin	pair	time stamp	length	FIR age	SEC age	FIR sex	SEC sex	total utt	speaker _switch	cs_total	uni total	dysfl total	flow total	intell avg	acc_avg
25	10	UNI FR	UNI	pair11	2569-2586	18.1	18	18	1	1	16	4	0	11	3	2	94.14	1.00
26	10	UNI EN	UNI	pair19	2630-2656	25.5	17	19	1	0	30	19	0	27	5	7	92.00	1.00
27	10	CS	CS	pair07	2750-2786	33.5	34	32	0	1	24	7	5	13	21	3	95.57	0.86
28	10	CS	CS	pair17	3052-3079	19.5	26	54	1	1	17	9	5	9	5	6	91.86	0.86
29	3	UNI FR	UNI	pair08	2296-2309, 2332-2351	19.9	19	42	1	1	12	6	0	11	6	3	86.00	0.86
30	3	UNI EN	UNI	pair04	2443-2474	27.2	18	52	1	0	19	8	0	16	12	6	94.00	1.00
31	3	CS	CS	pilot01	2691-2757	27.5	49	60	1	0	21	9	8	8	11	5	83.14	0.86
32	3	CS	CS	pair12	2365-2397	22.6	18	20	1	1	21	7	10	5	10	5	96.29	1.00
33	8	UNI FR	UNI	pilot01	2900-2920	20.3	49	60	1	0	17	5	0	16	6	1	91.00	1.00
34	8	UNI EN	UNI	pair16	3200-3218	21.3	61	59	1	0	15	7	0	10	6	2	88.29	1.00
35	8	CS	CS	pair08	2462-2513	25.4	19	42	1	1	15	3	5	6	14	1	81.86	1.00
36	8	CS	CS	pair12	2671-2696	21.3	18	20	1	1	15	4	3	6	15	1	94.14	1.00
37	11	UNI FR	UNI	pilot01	3107-3130	20.8	49	60	1	0	25	12	0	22	12	8	88.86	0.71
38	11	UNI EN	UNI	pair12	3065-3084	19.2	18	20	1	1	20	12	0	19	4	9	98.14	1.00
39	11	CS	CS	pair04	3069-3106	23.0	18	52	1	0	29	17	7	10	2	9	95.14	1.00
40	11	CS	CS	pair16	4061-4098	29.5	61	59	1	0	14	2	4	9	12	0	98.43	0.86