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Contrôle des langues et code-switching dans une population switchant fréquemment: Une approche multiméthode des bilingues français-libanais

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Language Control and Code-Switching in Frequent Switchers: A Multimethod Approach of French–Lebanese Bilinguals

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To my beautiful, chaotic, resilient Lebanon

بشمالك، بجنوبك، بسهلك بحبك

Acknowledgments

How does one become a researcher?, I asked myself.
It was the thrill of finding a new question behind every answer,
the curiosity to delve deeper into knowledge,
the relentless desire to always want to try something new,
the will to understand more and ask more.

It was also deciding to travel to the city where my father before me pursued his dream to become a researcher, Toulouse, with nothing but eyes full of hope and a head full of dreams. It was spending timeless hours as a kid watching him prepare his university courses, run experiments and write articles. It was looking up to him all these years, and finally, when I realize my dream of following his path, realizing he's not there anymore to see me.
It was also having the resilience to lose both my parents so early, and the strength to keep going, carried by their love.
To them, I dedicate this thesis.

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شكرًا تيتا لدعمك، مثل ما علّمتينا نكون أقوياء رغم كلّ المصاعب، نحتاط بالأصدقاء والأحبّاء، اليوم عم بسمعك عم تغنّيلي: ما لقيت فرحان في الدُنيا زي الفرحان في نجاحه.

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List of Acronyms

DMC Dual Mechanisms of Control. 32, 33, 42, 207, 249, 261

DS Digit Span. 104, 134, 137, 143, 145, 146, 157, 159, 197, 302

EEG Electroencephalography. 22, 60, 63

ERP Event-Related Potentials. 22, 52

FCS Frequent Code-Switchers. 8, 16, 17, 29, 42, 46, 52, 56, 63–66, 69, 82, 85, 86, 88, 90, 100, 147, 148, 150–152, 155, 161, 162, 168, 191, 192, 194–200, 203, 205, 206, 209, 211, 246, 251–255, 259, 263

fMRI Functional Magnetic Resonance Imaging. 22, 33, 52, 53, 57, 60, 155

FR French. 92–94, 96, 153

HS Hesitation Score. 168, 169, 180, 181, 184, 191, 193–196, 198, 199, 201, 203, 204, 206, 208, 211, 260–263

ICM Inhibitory Control Model. 25, 26, 33, 48, 63, 247, 249, 250

ITI Inter-Trial Interval. 44, 94, 202

L1 First Language. 11, 21, 25, 42, 43, 45, 46, 56–59, 71, 74–77, 82, 84, 92, 105, 108, 109, 146, 149–151, 159, 160, 194, 196, 204, 208, 211, 256

L2 Second Language. 10, 17, 18, 21, 25, 42, 43, 45–47, 52, 56–60, 71, 74–77, 82, 84, 85, 91, 105, 106, 108–110, 113–115, 144, 146, 147, 149–152, 160, 162, 171, 188, 189, 191, 194–198, 201, 202, 204–206, 208, 211, 212, 260, 261

L3 Third Language. 71, 74–77, 82, 84, 148, 149, 160, 161, 202, 209, 211, 263

LA Lebanese Arabic. 9–11, 13, 92–94, 96, 153

LCI Language Control Index. 169, 170, 184–187, 191, 193, 195–198, 200, 201, 204, 206, 208, 211, 258, 261, 262

LDI Language Dominance Index. 71, 75, 76, 82, 83, 253

LE Language Entropy. 8, 29, 46, 47, 64–66, 72, 78, 81, 82, 84–86, 88, 90, 105, 106, 110, 111, 113, 115, 144, 147, 150–152, 171, 188, 189, 191, 197–199, 205, 206, 209, 211, 212, 261

LEAP-Q Language Experience and Proficiency Questionnaire. 16, 17, 66, 69–73, 76, 81, 88, 246, 253

LHQ Language History Questionnaire. 16, 246

LMH Language Mode Hypothesis. 23, 24, 33, 37, 38, 204, 207, 208, 247, 249, 262

LOR Length of Residence. 46, 69, 70, 73, 90, 106, 110, 111, 113, 115, 144, 147, 150–152, 162, 163, 171, 188, 189, 191, 198, 205, 206, 212, 253, 255, 257, 259, 261

LSBQ Language and Social Background Questionnaire. 16, 46, 246

LSP Language Switching Paradigm. 28, 40, 42, 53, 58, 59, 63–66, 92, 93, 97, 99, 118, 147, 151, 152, 161, 169, 191, 199, 204, 207, 249, 251, 252, 254, 262

M Mean. 67, 70, 75–77, 107, 120, 121, 123–125, 132, 177, 182

MC Mixing Cost. 106, 170, 196

Md Median. 67, 70, 107, 120, 121, 124, 125, 132, 182

MEM Mixed-Effects Model. 106, 111, 113, 133, 150, 151, 160, 171, 188, 189, 191, 197, 205

MSA Modern Standard Arabic. 9–11

pre-SMA Pre-Supplementary Motor Area. 22, 52, 56

RCI Response-Cue Interval. 44, 45, 202

RSI Response-Stimulus Interval. 44, 45

RT Response/Reaction Time. 41, 42, 57, 64, 90, 94, 96, 97, 100–115, 128–135, 139, 140, 142–152, 155–158, 162, 200, 201, 203, 205, 206, 255–257, 260

SAS Supervisory Attentional System. 25

SC Switch Cost. 106, 170, 195

SD Standard Deviation. 67, 70, 75–77, 107, 109, 120, 121, 123–125, 132, 168, 169, 177

SLC Single-Language Context. 29

SOA Stimulus Onset Asynchrony. 44, 94, 202

SR Speech Rate. 168, 169, 182–184, 191, 193–196, 198, 199, 201, 203, 204, 206, 208, 211, 260–263

TSP Task Switching Paradigm. 39, 53–55, 58, 59

UCM Unified Competition Model. 33

WCST Wisconsin Card Sorting Test. 52, 53, 58, 59, 90, 103–105, 131, 136, 137, 141, 142, 145–147, 156–159, 162, 197, 256, 257

For ease of reference, you may find it useful to print this list separately when consulting the paper version of the thesis. In the digital version, each acronym is hyperlinked, allowing you to click on it to see its meaning. Similarly, clicking on an appendix letter in the text will take you directly to the corresponding section.

Introduction

Hi, kifak, ça va?
Trou7 3al mall na3mol shopping?
Shou l plans 3a Noël?
Tali3 3a bele salade-bar, ra7 2otlob delivery.[1]

My mother tongue is Arabic. I studied my entire life in French and spoke French at home, and here I am writing my PhD thesis in English. This simple example reflects how Lebanese people often navigate effortlessly between three languages, Arabic, French, and English, switching between them fluidly in daily conversations. Over time, I started reflecting on the role of languages and switching in my speech therapy practice. Receiving patients with language difficulties and working on their rehabilitation plans has been both enriching and challenging. When they switch to another language, is it a compensatory strategy? Should I encourage them to do so, or should I instead guide them to maintain one language during therapy?

Many of these questions have guided the long journey I began in 2020, when I decided to pursue a master's degree in linguistics while working as a speech therapist. The first question I asked myself, when I contacted Pr. Köpke, seemed simple at the time: why do we, as Lebanese, switch languages so often? Why is code-switching such a natural part of the way we speak?
At this stage, we designed a small experiment to collect data around the speech of ten young Lebanese adults in a "French monolingual context." We asked them to describe, in French, their experience of the Beirut port explosion on August 4th, 2020, an event that deeply affected every Lebanese person in some way. We then examined the reasons for code-switching, which occurred mainly in Lebanese Arabic and less frequently in English. Globally, switching happened when participants hesitated, needed to fill a gap, wanted to quote, or to comment on their own speech. The emotional nature of the event also prompted more switching into Arabic.

From this point, instead of getting answers, I found myself facing even more questions: Is it really possible for Lebanese people to stick to just one language when speaking? Does the "perfect Arabic monolingual Lebanese person" exist? How does switching actually take place? What does it cost to switch from one language to another, and why is it so effortless for Lebanese people? How do we control the languages we speak?

To satisfy my curiosity and attempt to answer these questions (and many others along the way), I naturally found myself drawn into the world of research, where I began developing an extensive experimental protocol, described in this PhD thesis.

[1] 1. Hello, how are you, are you okay?
2. Want to go to the mall for shopping?
3. What are your plans for Christmas?
4. I'm craving salad bar, I'll order delivery.

This work pursued three main goals through a multimethod approach, consisting of three consecutive and complementary studies: first, to chart a detailed sociolinguistic profile of Lebanese frequent code switchers, capturing individual factors such as language dominance, age of acquisition, and code-switching habits; second, to investigate how these individuals switch languages under both constrained and voluntary conditions, comparing performance in experimental and more ecological contexts through switch and mixing costs; and third, to explore the link between language control and executive control, testing whether the mechanisms supporting switching are domain-general or language-specific.

Because bilingual experience is highly heterogeneous, a thorough description of the target population was essential to begin with. In line with previous research, continuous measures such as language dominance, age of acquisition, as well as language entropy and code-switching habits, provide the most accurate description of bilingual experience (De Bruin, 2019; Gullifer & Titone, 2020; Olson, 2022). In Lebanon, however, research in this area remains scarce: while some authors have documented historical reasons for bilingualism (Kanaan, 2011; Shaaban, 2017), no comprehensive characterization of the population's detailed sociolinguistic profile(s) has been conducted. To address this gap, we developed a large-scale questionnaire targeting these key sociolinguistic characteristics among Lebanese individuals residing in France. Given the political and economic situation in Lebanon, it was more feasible to recruit participants living in France.

As extensive research on bilingual language control has proposed over the last decade, language switching paradigms have become one of the most widely used tools to experimentally assess the costs of switching between languages (Declerck & Philipp, 2015; Festman & Schwieter, 2015). Building on this approach, the second phase of the study focused on collecting laboratory data from Lebanese participants to examine language switch and mixing costs, with a particular interest in whether free language switching would be easier for this population of frequent code-switchers compared to more constrained, externally cued switching (De Bruin et al., 2018; Jevtović et al., 2020; Kennis et al., 2025). These experimental tasks were complemented by measures of executive control, allowing to investigate the domain-general versus language-specific nature of language control, a topic that remains debated in the literature, particularly in relation to the bilingual advantage hypothesis, which posits that bilinguals may develop enhanced executive functions through regular language switching (Donnelly, 2016; Mattschey, 2023).

We observed that laboratory experiments do not fully capture the reality of language switching in daily life, as they are highly structured and typically rely on single-word production rather than extended discourse. To address this limitation, we conducted a more ecological experiment inspired by the Adaptive Control Hypothesis (Green & Abutalebi, 2013), in which participants engaged in tasks simulating different communicative situations that required varied types of language use and control. Based on this framework, we introduced a novel Language Control Index to quantify language switch and mixing costs during naturalistic discourse.

The thesis is divided into two main parts: the first addresses the literature review, and the second presents the experimental studies. In the first part, Chapter 1 outlines general aspects of bilingualism, including definitions, typologies, and the Lebanese context, covering historical, educational, and social practices. Chapter 2 describes language control in relation to code-switching, including core theoretical models, experimental evaluation, and sources of individual variability. Chapter 3 reviews research on the domain-generality versus language-specificity of language control. In the second part, Chapter 4 presents the research objectives. As outlined above, the experimental work is organized into three consecutive studies, each with a dedicated chapter detailing methods, data analyses, results, and discussion: Chapter 5 covers the sociolinguistic study; Chapter 6 addresses the experimental language switching study; and Chapter 7 presents the exploratory discourse study. Finally, Chapter 8 provides a cross-study general discussion to synthesize the findings and their implications.

Part I

A Review of Language Control Mechanisms: Insights from Code-Switching in Bilinguals

Chapter 1

Understanding Bilingualism: Theoretical Foundations and Lebanese Realities

1.1 Bilingualism: Definitions and Classifications

Understanding bilingualism requires considering its historical definitions and the diverse classifications that have characterized it.

1.1.1 Definitions of Bilingualism

Bilingualism[1] has been conceptualized in varied ways across disciplines, times, and authors, reflecting its complexity. Bloomfield (1933) presented a strict definition, requiring native-like proficiency in two languages. Haugen (1953) and Mackey (1962) introduced a functional criterion: a person is considered bilingual when they can produce complete, meaningful utterances in both languages. Weinreich (1968) adopted a more usage-based definition, determining bilinguals as individuals who regularly alternate between two or more languages (Romaine, 1995).

Moving beyond proficiency and use, Grosjean (1982, 2008) further argued that bilinguals are not simply two monolinguals in one; instead, they use languages for complementary purposes (different languages in different settings), creating a cohesive and flexible linguistic system. He also emphasized that bilingual language use depends on context and interlocutor. This aligns with Cook (1992)'s concept of *multi-competence*, which views a bilingual's languages as an integrated system.

In sum, the definitions of bilingualism highlight four key dimensions: proficiency, use, integration, and context. Nonetheless, definitions are also largely linked to the various typological distinctions within bilingualism.

[1]While some authors have adopted the term "Plurilingualism" (Bhatia & Ritchie, 2012) to refer to both "Bilingualism" and "Multilingualism", in this thesis, the term "Bilingualism" covers both "Bi and Multilingualism", referring to all types of use of two languages or more.

1.1.2 Classifications and Typology of Bilingualism

Bilingualism includes different typologies, reflecting the various ways individuals acquire and use multiple languages.

1.1.2.1 Time-Based Definitions

The following definitions are related to the Age of Acquisition (AoA) of languages.

Early vs. Late Bilingualism

- **Early bilingualism**: describes individuals who acquire two languages or more in early childhood, usually before the age of six. This is typically the case in families of immigrants and mixed-cultural families.
- **Late bilingualism**: describes individuals who learn a second language after early childhood and up to adulthood. This is often the case for university students who travel abroad to pursue higher education or exchange programs.

Simultaneous vs. Sequential Bilingualism

- **Simultaneous bilingualism**: both languages are acquired at the same time. This may be the case for mixed-cultural families where one-parent one-language policy is adopted, when one distinct language is used by each parent (De Houwer, 1996).
- **Sequential bilingualism**: the second language is acquired after the first one is already established. This is the case in immigrant families where the heritage language is spoken at home and differs from the schooling language used in the host country, the latter is typically acquired only upon the child's entry into the educational system.

1.1.2.2 Dominance-Based Definitions

The following definitions are related to the dominance of languages, based on relative proficiency (defined as linguistic competence and processing speed Kohnert et al., 2020), and to language use (Treffers-Daller, 2016).

Balanced vs. Dominant Bilingualism

- **Balanced bilingualism**: refers to individuals who have equal proficiency in both languages across multiple modalities (speaking, understanding, writing, reading).
- **Dominant bilingualism**: refers to individuals who possess one language that is dominant over the other(s), often due to differences in use or exposure.

Nonetheless, measuring language dominance is a complex and challenging process, as it requires assessing both proficiency and use, which are themselves difficult to quantify. Treffers-Daller (2016) suggests a gradient definition of dominance, moving beyond the traditional categorical distinction between balanced and dominant bilingualism. Her typology defines dominance relatively to a criterion selected by the researcher, such as skill (e.g., reading, writing) or modality (e.g., comprehension, production). Language dominance is thus task- and domain-specific, which makes the calculation of an overall dominance score less meaningful. Similarly, Birdsong (2014) introduced the concepts of *dimensions* and *domains* of dominance: dimensions are linked to *linguistic competence*, *production*, and *processing* (including fluency of speech, lexical diversity, morphosyntactic knowledge, length of utterances, etc.). Domains refer to the contexts of language use, such as conversations at the workplace, in the community or social media exposure. Thereafter, a bilingual's languages are compared based on each of these two parameters to determine dominance.

1.1.2.3 Linguistic System-Based Definitions

The following definitions are related to the linguistic system through which languages are acquired (Ervins & Osgood, 1954) (see Figure 1.1).

Compound vs. Coordinate Language System

- **Compound language system**: Both languages are integrated into a single conceptual system. Words from the two languages correspond to the same concepts, leading to shared mental representations. Translation involves decoding a sign in one language and producing the equivalent in the other (see left diagram in Figure 1.1).
- **Coordinate language system**: Each language has a separate conceptual system. Words from each language are linked to distinct mental representations, allowing independent processing in each language. Translation occurs through alternative circuits at different stages of fluency development (see right diagram in Figure 1.1).

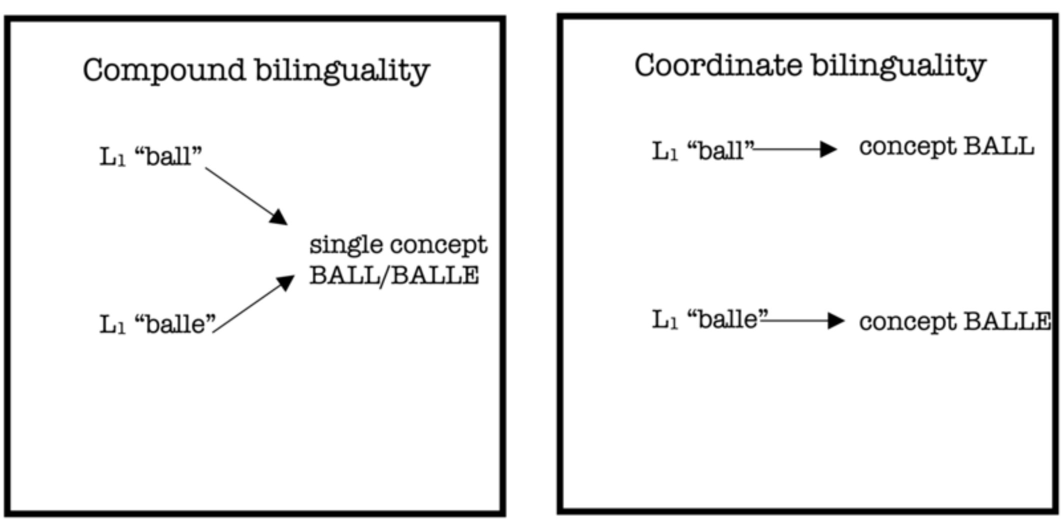

Figure 1.1: Compound vs. Coordinate Bilingual Language Systems, adapted by Hamers and Blanc (2000) from Ervins and Osgood (1954)

1.1.2.4 Language Entropy-Based Definitions

The following classification is related to the measure of Language Entropy (LE).

LE, introduced by Gullifer and Titone (2020), characterizes the social diversity of language use across contexts. It is derived from the scientific concept of *entropy*, which refers to a state of disorder or uncertainty, and was originally developed in thermodynamics. The concept of entropy has since been applied in fields such as physics, biology, and telecommunication, and more recently, to language. Gullifer and Titone (2020) adapted the entropy formula to quantify bilingual language use. LE values range from 0 to $\log_2 n$, where n is the number of languages considered.

$$H = -\sum_{i=1}^{n} P_i \log_2(P_i)$$

- H is language entropy
- n is the total possible languages within the context
- P_i is the proportion that language i is used within a context

Importantly, LE enables bilingualism to be characterized either categorically (*compartmentalized* vs. *integrated*) or continuously along a spectrum: low H values indicate compartmentalized use restricted to specific contexts, while high H values indicate integrated, flexible use of multiple languages. This approach provides a more nuanced, context-sensitive complement to traditional linguistic system–based classifications.

Compartmentalized vs. Integrated Bilingualism

- **Compartmentalized bilingualism:** Low LE values indicate that each language is restricted to specific social contexts. For example, a bilingual speaker may use one language at home and another at work. This pattern reflects minimal overlap between languages in daily life.
- **Integrated bilingualism:** High LE values reflect flexible and mixed use of multiple languages across contexts. For instance, the bilingual speaker may switch between languages within social interactions. This pattern often includes frequent code-switching, and bilinguals with integrated bilingualism are referred to as Frequent Code-Switchers (FCS).

LE can also be treated as a continuous measure, allowing bilingualism to be described along a spectrum from compartmentalized to integrated language use. This provides a context-sensitive complement to traditional classifications.

1.1.2.5 Toward A Continuous Classification

Recent approaches to bilingualism are shifting from rigid categorical classifications toward a continuous spectrum. De Bruin (2019) emphasizes considering individual variation such as AoA, proficiency, use, and switching habits. She also highlights the value of LE, noting that treating bilingual language experiences as a continuous variable can more accurately capture the subtle differences between bilinguals and better reflect the bilingualism continuum. The author further reviews existing tools (LEAPQ, LSBQ, BSWQ) designed to capture these dimensions of bilingual experience and calls on researchers to adopt more rigorous and comprehensive assessments of bilingual participants. Although questionnaires also document language exposure and skills, implementing them varies across tools, highlighting the need for transparency and standardized measures (Kašćelan et al., 2022). Various methods such as interviews, questionnaires, audio/video recordings, transcription, corpora, ethnography, social network analysis, conversation and interactional analysis, critical discourse analysis, narrative analysis, and media analysis, etc., support the different ways of defining, characterizing and differentiating bilinguals (Wei & Moyer, 2009). Technological advances now allow for more continuous classification using machine learning. For instance, Coco et al. (2025) trained algorithms called ”support vector classifiers” on Italian speakers' language productions to distinguish monolinguals, heritage speakers, and attriters, illustrating the move toward spectrum-based conceptualizations of bilingualism.

While typologies provide a useful framework for distinguishing types of bilingualism, real-world contexts often exhibit greater complexity. The Lebanese context illustrates how many languages can coexist and interact across multiple domains of daily life. The following section examines how Lebanon's distinct sociolinguistic environment influences bilingualism practices.

1.2 Bilingualism in Lebanon

“Multilingualism is seen, heard, felt, spoken and even touched wherever you go in Lebanon.”
(Bassam, 2022, p. 174).

Lebanon's historical, geographical, and political situation has fostered a rich multilingual environment, where Lebanese Arabic (LA) (the local vernacular), French, and English coexist and mix in daily conversations. Additional minority languages such as Armenian, Turkish, and Kurdish further contribute to the country's linguistic diversity (Grosjean, 1982; Kanaan, 2011).

Arabic is Lebanon's official language, encompassing both Modern Standard Arabic (MSA) and LA[2]. Although French lost its official status after the French Mandate, it maintains a strong institutional presence in education and public life (Kanaan, 2011). Approximately half of the Lebanese population are Arabic–French bilinguals (Grosjean, 1982). English, introduced more recently through globalization, has gained prominence as a *Lingua Franca*, particularly in science, business, higher education and social media (Smairat, 2020).

1.2.1 The Status of Languages in History and Education

Lebanon's strategic position at the crossroads of East and West, combined with its historical and sociopolitical open environment, has contributed to the country's multicultural and multilingual character (Shaaban & Ghaith, 1999).

Following twenty-three years under the French Mandate (1920–1943), French was established as a co-official language alongside Arabic in the Lebanese Constitution. Although this status was later

[2]Throughout this thesis, the term ”Arabic” refers to vernacular LA, unless specified otherwise. MSA is restricted to written contexts and certain formal situations.

removed, French retained its strong sociolinguistic position, particularly as the primary language of instruction in many private schools, a legacy of the mandate period (Kanaan, 2011). Religious missions, particularly in Christian-majority areas, established numerous francophone schools across the country. In contrast, Muslim-majority regions, such as the South and the Bekaa Valley, which faced marginalization and occupation at various points, received a more traditional Arabic-based education (Abou, 1962). English was introduced to Lebanon in the 19^{th} century through American Protestant missionaries who established several educational institutions, including the Syrian Protestant College in 1866, which later became the American University of Beirut. Although English, unlike French, has never held official status in the Lebanese Constitution, it became a key language of instruction in anglophone schools (Kanaan, 2011; Shaaban, 2017).

Later, with the rise of globalization and the growing influence of American culture, English gained worldwide prominence. This global shift extended to Lebanon, where English gradually challenged French in both educational and societal domains. The number of English-medium schools increased, and English became a widespread Second Language (L2) and a strong competitor within the Lebanese linguistic landscape. Notably, English began to be introduced around the third grade, even in many francophone institutions (Bacha & Bahous, 2011; Shaaban, 2017). Learners are often categorized based on the dominant language of instruction in their schooling: those educated primarily in French are considered French-educated, while those whose curriculum is delivered mainly in English are labeled English-educated (Bacha & Bahous, 2011).

In higher education, American institutions such as the American University of Beirut (AUB) and the Lebanese American University (LAU), along with English-speaking universities like Beirut Arab University (BAU) and the Lebanese International University (LIU), have gained significant influence (Thonhauser, 2001). These institutions have surpassed French-speaking universities, such as Saint Joseph University (USJ) and the Lebanese University (LU), in both regional and global rankings. For example, in 2025, AUB is ranked 6^{th} in the Arab region and 237^{th} worldwide, and LAU ranks 31^{st} regionally and 535^{th} globally. In comparison, USJ ranks 48^{th} in the Arab region and 618^{th} worldwide (QS Top Universities, 2025). It is important to note that the LU is the only public university in the country; the rest of the higher education sector is privatized and financially restrictive to many students.

1.2.2 Arabic: A Situation of Diglossia

The diglossic nature of Arabic in Lebanon exhibits distinctive traits compared to other Arabic-speaking countries. LA, the colloquial variety, is not only dominant in informal speech but is also widely present in public life and media, particularly on television and social media, where a fluid continuum between LA and MSA is frequently observed (Myers-Scotton, 2006). Attempts to represent LA in writing are typically restricted to informal domains such as advertising, online messaging, and restricted literature. One notable example is the work of Said Akl, who advocated for writing LA using Latin letters (Bizri, 2013). Such efforts generally rely on non-standardized, latinized transliteration systems, and are commonly used nowadays in texting (Bassam, 2022).

Despite its central role in everyday communication, LA is not recognized as a formal or standardized language. It is commonly perceived as lacking regulated grammar and being too internally variable to systematize. Consequently, MSA remains the institutional and educational variety of Arabic, taught in schools and used in official settings. Nevertheless, MSA does not dominate all formal registers: French and English frequently supplement, or even replace it in sectors such as education, administration, and public discourse. Fishman's (1980) description of multilingual societies that include a Western language of wider communication, a standardized national variation, and one or more local vernaculars (Shaaban & Ghaith, 1999) is consistent with this layered linguistic arrangement.

1.2.3 Patterns of Language Acquisition

Available evidence indicates that LA is typically the First Language (L1) acquired in early childhood, while French and/or English are introduced alongside Arabic in formal education settings, often from kindergarten, and in many households, even from birth. In Lebanon, children grow up in structurally bilingual or trilingual environments. The country's trilingual education policy, introduced with the 1997 curriculum reform, instructs that students begin learning their first foreign language (English or French) in Grade 1, with a second foreign language added by Grade 7, although some private schools begin this second language as early as Grade 4 or 5 (Esseili, 2014). According to the national curriculum, Arabic receives approximately 8 hours of instruction per week, while French and/or English can receive up to 23 hours (Hreich et al., 2022).

In many public schools, MSA remains the primary language of instruction, with French or English limited to language courses. However, this pattern is gradually shifting, partly due to changes in national language policy. Since the release of Decree No. 5589 in 1994, which authorized both public and private schools to choose the language of instruction, foreign languages have gained more space in educational settings. As a result, public schools have started increasingly adopting practices more common in private institutions since the late 90s (Shaaban & Ghaith, 1999). These schools often implement a split-language model, using French or English for scientific subjects such as biology, physics, and chemistry, while humanities like philosophy, history, and geography are taught in MSA (Thonhauser, 2001).

French has traditionally dominated private and religious schools, whereas English has gained significant ground in recent years due to globalization and educational reforms, and is now more commonly associated with higher education curricula. Additionally, other languages such as Armenian, Kurdish, or Berber may also be acquired in the home environment within specific communities.

1.2.4 Official and Public Language Practice

Bilingual language use in Lebanon extends beyond education and is widespread across many institutional domains, further the central role of multiple languages in daily interactions. In public life, Arabic, French, and English are frequently visible and audible in various settings. As Grosjean (1982, p. 8) noted: "There are newspapers and radio and TV programs in all three languages, and many road signs, legal documents, telephone directories, and so on are in Arabic and French." Public signs, including road signs and public announcements, are commonly presented in Arabic and French, while legal documents and government services remain predominantly in MSA. Advertisements often appear in Arabic and English/French on billboards and TV commercials. Although Lebanese TV series and programs are primarily in Lebanese Arabic, presenters and actors frequently incorporate English and French words into their dialogue (Smairat, 2020, Baidoun, 2018). This widespread use of multiple languages promotes an environment where multilingualism is a normalized aspect of everyday life and social interactions.

1.2.5 Language Ideologies and Societal Attitudes

Language ideologies in Lebanon are deeply related to historical, cultural, and socioeconomic factors.

Arabic represents national identity and is favored in cultural and religious contexts. However, due to its diglossic nature and reduced formal use, it is often perceived as less instrumental in domains such as science, business, and international mobility (Shaaban & Ghaith, 2002).

Traditionally, French has been associated with cultural refinement, artistic expression, and high social status (Abou, 1962). It continues to hold a strong position in the educational system, partly due to the involvement of French experts in curriculum design and teacher training, as well as Lebanon's membership in the *Organisation Internationale de la Francophonie.* French is also seen as the language of literature prestige, thanks to internationally recognized Lebanese authors such as Charif Majdalani, Georges Chéhadé and Amin Maalouf who write in French (Shaaban & Ghaith, 2002).

English is increasingly viewed as a global language of opportunity, especially among younger generations (Shaaban, 2017). It dominates domains like science and technology, business, medicine, and higher education. In a study on Lebanese students' language perceptions (Bahous et al., 2014; Shaaban & Ghaith, 2002), English was rated as the most useful language for career advancement and international communication. This perception is reinforced by the country's massive diaspora, estimated at over 15 million globally compared to about 4 million residents, many of whom rely on English in their host countries (Pukas, 2018). The unstable political and economic situation of the country has further amplified this trend, encouraging Lebanese youth to pursue studies or careers abroad, where English is often essential.

The coexistence of multiple languages in Lebanon naturally leads to frequent and dynamic interactions between them. These interactions are most clearly reflected in language contact phenomena, particularly code-switching, which has become a routine and socially embedded aspect of communication in Lebanese society.

1.3 Language Contact and Code-Switching Practices in Lebanon

1.3.1 A Definition of Code-Switching

Code-switching refers to the alternate use of two or more languages, varieties, or dialects within the same communicative event, sentence, or conversational turn, without violating the grammatical rules of any of the languages involved (Gardner-Chloros, 2009; Myers-Scotton, 1993; Poplack, 1980). It comprises combining linguistic segments from different grammatical systems (Gumperz, 1982), and may occur between utterances (intersentential), within a single utterance, or even within a single constituent (intrasentential) (Bokamba, 1989; Poplack, 1980).

The term *code-mixing* is sometimes used interchangeably with *code-switching* (Bokamba, 1989; Muysken, 1997; Romaine, 1986). However, several scholars draw a clear distinction between the two (Gumperz, 1982; Ritchie & Bhatia, 2012), defining *code-mixing* more specifically as a form of intrasentential switching that combines various linguistic units (morphemes, words, clauses) from two distinct grammatical systems within a single utterance (Wei, 2000).

1.3.2 Code-Switching in the Lebanese Community

In Lebanon, code-switching is a widespread and routine feature of daily interactions, reflecting the country's multilingual identity (Thonhauser, 2001). The alternation between Arabic, French, and English occurs naturally across multiple social contexts and is the norm rather than the exception. This fluid practice is embedded in daily communication, shaping discourse in both formal and informal settings. A simple greeting such as *"Hi, kifak, ça va?"*, blending English, Arabic, and French, is the classic example of how effortlessly Lebanese speakers navigate between languages in the same sentence (Abou, 1962; Bassam, 2022; Nashef, 2013).

1.3.2.1 Code-Switching in the Academic Setting

In scholarly and higher education contexts, attitudes toward multilingual classroom practices have evolved. While earlier research highlighted concerns among university instructors about their limited ability to teach effectively in both Arabic and English (Thonhauser, 2001), more recent studies suggest a shift in practice. Instructors now frequently switch between languages to clarify or emphasize key concepts (Bahous et al., 2014). This shift is also reflected in student perceptions: approximately 80% reported that they learn more effectively when teachers use both LA and English during instruction. Notably, both teachers and students described code-switching as offering a sense of familiarity, and 69% of students indicated they were often unaware they were switching, considering it a mostly unconscious and habitual practice (Bahous et al., 2014).

1.3.2.2 Code-Switching in Contemporary Communication

Although research on code-switching in Lebanon remains relatively limited, the few existing studies have primarily focused on written and media-based communication, particularly television discourse and SMS exchanges, reflecting broader patterns of language use in Lebanese society.

Esseili (2014) showed that code-switching is widely used in the Lebanese community: in TV programs, Facebook comments, shops, restaurants, cafés, television commercials, music clips, radio stations, and modern art. Many researchers have examined Lebanese TV shows and films, as these forms of media reflect how people use different languages in everyday life. French is reported to frequently transmit prestige and politeness, often appearing in greetings (*bonjour, merci*) and formal titles (*monsieur*). English, on the other hand, tends to dominate in technical, commercial, and digital domains, with common examples including terms related to cosmetics (*tattoo, extension*), medicine (*side effects*), affection (*baby*), IT and social media (*voice note, selfie*), and business (*files, sponsor*). Educational terminology reflects similar trends: school subjects are often expressed in French (*physique, chimie*) (Smairat, 2020) or English (*math, sports*) (Baidoun, 2018), depending largely on the speaker's own educational background.

The motivations behind these switching practices are diverse. Structural factors, such as Lebanon's multilingual educational system and widespread proficiency in French and English (El Samaty, 2002), create an environment where code-switching is almost inevitable. Additional exposure to English through media and social media (Baidoun, 2018; Bassam, 2022; Smairat, 2020), international travel and professional opportunities abroad (Diab, 2009; Shaaban & Ghaith, 2002), and interactions with foreign domestic helpers in households (Bacha & Bahous, 2011) may also contribute to its emergence as a third language among younger Lebanese adults. Beyond these structural roots, pragmatic and interactional motivations are highly salient: speakers may switch to compensate for lexical gaps in Arabic, to align with an interlocutor, or to display a particular social identity (Baidoun, 2018). Code-switching is also employed to express emotions, to participate more effectively in social interactions, to convince or impress, and to show one's socio-economic status (Smairat, 2020). Furthermore, some switching practices extend beyond code-switching and evolve into borrowings/loanwords. In the Lebanese community, the boundary between code-switching and loanwords is often blurred as a result of frequent switching (refer to Section 2.3.2 for a more detailed explanation).

In addition to media-based analyses, other research has focused on written digital communication, particularly SMS messages. Bassam (2017) explored gender differences in code-switching among Lebanese undergraduates and found that women code-switch significantly more than men. The study also highlighted the widespread use of Romanized Arabic in text messages, called "Arabizi", raising concerns about the decreasing use of the Arabic script and the long-term implications for Arabic language vitality in Lebanon. An analysis based on the same dataset emphasized the expressive and cultural dimensions of code-switching: students reported using multiple languages to express emotions, create humor, and represent their diverse cultural and linguistic identities (Bassam, 2022).

1.3.2.3 Attitudes toward Code-Switching in Lebanon

Globally, code-switching has traditionally been viewed negatively, often perceived as a sign of linguistic deficiency or incomplete language mastery (Gumperz, 1977). However, this perspective has been increasingly challenged. More recent research highlights the positive social, cultural, and educational roles of code-switching, recognizing it as a legitimate communicative strategy in bilingual contexts (Kim, 2006). Code-switching is closely linked to bicultural identity, with attitudes varying according to individuals' cultural belonging (Yim & Clément, 2021). A large-scale study by Dewaele and Wei (2014) involving 2,070 participants from more than 200 different nationalities, found that attitudes toward code-switching are influenced by personality traits such as empathy, multilingual experience, and individual factors including age, education, and exposure to diverse environments. Surprisingly, younger individuals in their teens and twenties tend to hold less positive attitudes toward code-switching compared to older age groups, and those with moderate language proficiency levels express less favorable views than individuals at either end of the proficiency spectrum (Dewaele & Wei, 2014).

In the Lebanese society more specifically, there is a common concern that frequent code-switching between Arabic and other languages may lead to a decline in the exclusive use of Arabic as a mother tongue. This concern is notably expressed in educational settings, where university teachers have expressed frustration that students frequently mix Arabic and English in class, fearing it may negatively impact their academic performance in English-medium courses (Bahous et al., 2014). Similarly, the increasing use of Arabizi has raised concerns about the decline of Arabic script among youth (Bassam, 2017; Bassam, 2022). However, these concerns are not yet supported by empirical evidence. On the contrary, studies show that classroom code-switching often facilitates clearer communication and understanding between teachers and students (Bahous et al., 2014; Bassam, 2022).

In general, attitudes toward code-switching among young Lebanese university students tend to be positive. Research further shows that students attach distinct symbolic values to each language: Arabic is often perceived as a marker of national and cultural identity, French is associated with high culture and formal education, while English is linked to business, science, and mass communication (Shaaban & Ghaith, 2002). Preferences also vary depending on language learning history: students who acquired French as their first foreign language tend to favor it over English, whereas those who learned English first show the opposite preference (Diab, 2009). As discussed above, code-switching serves various expressive and communicative functions, such as articulating emotions, asserting cultural identity, and promoting a sense of belonging (Bassam, 2022; Shaaban & Ghaith, 2002). Even when it is not the preferred language, English is generally viewed positively, shaped by its widespread presence on social media, with many Lebanese speakers, including public figures, frequently using it despite sometimes limited proficiency (Esseili, 2017). While these studies provide valuable insights, they represent only part of the picture, and attitudes toward code-switching remain a dynamic issue within the Lebanese society. Further perspectives are therefore needed to capture the diversity of opinions about code-switching, particularly among younger generations.

Overall, Lebanese code-switching reflects an integrated language repertoire rather than compartmentalized bilingualism (detailed description in 1.1.2.4). As described by Gullifer and Titone (2020), integrated bilingualism involves flexible use of all available languages across contexts, often including code-switching within and/or across utterances, whereas compartmentalized bilingualism restricts specific languages to specific communicative contexts and minimizes language switching. For example, a longitudinal case study documented a young Lebanese girl whose bilingual competence was shaped by positive familial attitudes toward Arabic, formal language education, rich social networks, and a personal drive to maintain both linguistic codes despite the challenge of Arabic diglossia (Logan, 2019). In her bilingual English-Arabic settings, code-switching was used to fully engage her entire linguistic repertoire, showing that Lebanese bilingualism relies on a complete, interconnected language system.

Building upon Lebanese code-switching practices, it is essential to consider how bilingual and multilingual experiences are assessed. Although code-switching is a common practice in the Lebanese society, individuals still differ in their relative language use, dominance, and switching habits. Therefore, accurate evaluation of language history, proficiency and usage patterns plays a central role in capturing individual variability in bilingualism and code-switching behavior.

1.4 Bilingualism and Code-Switching Assessment

Assessing bilingualism and language switching habits requires a multidimensional approach that combines objective and subjective tools alongside corpus-based analysis.

1.4.1 Subjective Assessment

Subjective assessment typically involves self-reported measures that reflect key aspects of language history (AoA, contexts of acquisition, frequency of use), choice, dominance, and attitudes. Together, these dimensions contribute to the construction of detailed sociolinguistic profiles that not only describe but can also help explain bilingual behavior (Nortier, 2008).

1.4.1.1 Commonly Used Questionnaires

Among the most widely used instruments is the *Language Experience and Proficiency Questionnaire (LEAP-Q)* (Kaushanskaya et al., 2020; Marian et al., 2007), which collects comprehensive data for up to five languages. For each language, it gathers information on AoA, duration of immersion in various contexts, self-rated proficiency in speaking, reading, and comprehension, extent of exposure across settings, as well as self- and other-rated foreign accent. Notably, the LEAP-Q does not yield a standardized composite score; instead, study-specific indices, such as ratings, may be derived to assess language proficiency or dominance, depending on research objectives. Similarly, the *Language History Questionnaire (LHQ)* (P. Li et al., 2006, 2020) provides proficiency, immersion, and dominance indices for each language in a participant's repertoire. The *Language and Social Background Questionnaire (LSBQ)* (Anderson et al., 2018) assesses language use and proficiency, emphasizing the social contexts in which languages are employed. It generates a composite factor score that places respondents on a bilingualism continuum, while also allowing for categorical classification into monolingual or bilingual groups based on established cut-off values.

The *Bilingual Language Profile (BLP)* (Birdsong et al., 2012) focuses on constructing a dominance index ranging from -218 to +218, by considering the history, use, proficiency, and attitudes related to two languages and weighing each module's score using specific adjustment factors (Birdsong, 2016).

Additionally, a more specific questionnaire was developed to assess language switching habits in bilinguals: the *Bilingual Code-Switching Profile (BCSP)* (Olson, 2022). Modeled on a similar design as the BLP, the BCSP provides a Code-Switching Profile (CSP) score ranging from 0 to 100, based on language history, use, proficiency, and attitudes toward code-switching.

1.4.1.2 Sociolinguistic Profiles of Frequent Code-Switchers

The questionnaires described above (LEAP-Q, LHQ, LSBQ, BLP, BCSP) have been used to characterize the sociolinguistic profiles of FCS, bilinguals who frequently switch between languages in their daily lives, across diverse populations. These profiles typically include measures of language history (AoA, immersion), usage patterns across contexts, self-rated proficiency, dominance indices, and attitudes toward code-switching.

For example, Chehimi and Hejase (2024) and Chehimi et al. (2024) reported data from 153 Lebanese university students using a four-section questionnaire assessing language background, students' attitudes toward English, family reading habits, and demographic information for students and parents. Results showed that parents predominantly spoke Arabic to their children in early childhood (94.7%), followed by English (19.7%) and French (11.2%), confirming the dominant role of Arabic in early family language exposure. English was generally used more than French during early childhood. Self-rated proficiency scores reflected this pattern: Arabic was highest ($M = 4.48/5$), English intermediate ($M = 3.29/5$), and French lowest ($M = 1.67/5$), highlighting variability in second- and third-language acquisition. On the contrary, Kassir et al. (2024) found that among 100 older Lebanese Arabic–French adults (mean age ≈68), assessed using the LEAP-Q, most exhibited balanced bilingualism ($N = 58$), followed by prominent Arabic dominance ($N = 35$) and French dominance ($N = 7$), reflecting the historical predominance of French in schooling during their youth.

Comparable patterns have been observed in similar bilingual contexts, such as Spanish-Catalan FCS (Rodriguez-Fornells et al., 2012). Soto-Corominas (2025) examined 146 Catalan–Spanish bilingual children and reported early exposure to both Catalan (Mean AoA = 7.04 months) and Spanish (Mean AoA = 4.05 months), with English introduced later (Mean AoA = 29.58 months), showing that early bilingualism is common across FCS.

The BCSP is a useful tool for assessing code-switching habits in bilinguals, particularly in FCS. Olson (2022) validated the BCSP on a diverse sample of 454 participants (aged 18–75, M = 29.2 years, SD = 10.9, range: 8.3–96.9), predominantly Hispanic, reporting an overall CSP of M = 58.7 (SD = 19.2, range: 8.3–96.9). As a relatively recent instrument, the BCSP has not yet been widely applied. Kheder et al. (2025) used it with Spanish–English bilinguals (N = 128 in Experiments 2 and 3; N = 36 in Experiment 4), reporting CSP values of 58.4, 66.1, and 64.7, respectively (the detailed sub-component scores were not provided).

Taken together, these findings illustrate that FCS typically exhibit high proficiency in multiple languages, early and extensive exposure to their languages, flexible language use across contexts, and moderate engagement in language switching. In the Lebanese context, these patterns reflect historical and educational influences on language use and further confirm the integration of English and French with Arabic in everyday communication.

While subjective questionnaires provide valuable information about participants' language background, their self-assessment components for language proficiency can be biased by personal judgment. Importantly, no single questionnaire captures the entire scope of bilingual experience: for example, the LEAP-Q provides detailed acquisition and exposure for each language, the BLP offers a weighted dominance index, and the BCSP adds a specific focus on code-switching practices. Taken together, such instruments can be used in a complementary way to provide a multidimensional account of bilingual experience. To address the limitation of personal judgment on one's own proficiency, objective assessments complete questionnaires by offering precise and measurable data on language skills through tests and performance-based tasks.

1.4.2 Objective Assessment

Standardized tests granting a CEFR level offer a holistic assessment of language proficiency across multiple languages (Olson, 2024). Most commonly, tests such as TOEFL and IELTS (for English) and DELF (for French) are used to assign a CEFR level (A1–C2), often motivated by administrative needs such as travel or immigration. In research contexts, however, scholars often use the *Lexical Test for Advanced Learners of English* (LexTale; Lemhöfer and Broersma, 2012). It is a fast (lasting around 3.5 min), objective vocabulary test based on a lexical decision task: participants evaluate a series of 60 letter strings (40 real words, 20 nonwords) and judge whether each is a valid word in the target language. However, the LexTALE has some important limitations. Its reliability for measuring overall L2 proficiency, especially in intermediate learners, is uncertain, as studies have found only low to moderate correlations with standardized proficiency tests (Puig-Mayenco et al., 2023). The test also depends on selected word lists and the decisions of its creator, which can be somewhat subjective, for example when creating pseudo-words. Because of this, the LexTALE exists in only a few languages and includes a limited number of words, making it hard to use repeatedly without memorization effects (Rijn et al., 2023). It was first developed in German, Dutch, and English, and later adapted to French (Brysbaert, 2013), Spanish (Izura et al., 2014), Chinese (Chan & Chang, 2018), Arabic (Alzahrani, 2024), and some other languages. For Arabic, LexArabic uses Modern Standard Arabic, the literary form of the language, which is quite different from regional dialects like Lebanese Arabic (Raish, 2021). Overall, the LexTALE still covers only a limited number of languages.

Another objective language proficiency test is DIALANG (Weber, 2007), granting a CEFR level in fourteen European languages, based on five skills: reading, writing, listening, grammar and vocabulary.

Tremblay (2011) further argues for, and provides evidence of, the validity, reliability, and practicality of a cloze (fill-in-the-blank) test designed to differentiate L2 learners of French across proficiency levels.

Furthermore, the OSCAR test (Centre d'Étude de Langues, 2025) is a computer-adaptive online instrument lasting approximately 15 minutes. It evaluates vocabulary, grammar, written expression, and comprehension, yielding both a categorical CEFR level and a continuous global proficiency score ranging from 0 to 100. Unlike traditional proficiency assessments that provide discrete labels for different levels (e.g., CEFR) and have been criticized for arbitrarily dividing a continuous variable (Olson, 2024), OSCAR's continuous scoring better reflects the underlying spectrum of language ability. The test also adapts in real time to the participant's level by selecting items of appropriate difficulty, offering an advantage compared to more classic proficiency assessments. Given its adaptive design, multidimensional scoring, and availability in several major languages (English, French as a foreign language, German, Spanish, and Italian), OSCAR currently may be considered as one of the most comprehensive and reliable tools for assessing language proficiency in research contexts.

1.4.3 Corpus-based Assessment

Corpus analysis constitutes an essential component of language assessment. While subjective and objective methods primarily assess specific dimensions such as dominance and proficiency, corpus-based approaches allow for a more complete evaluation of language use. These include the analysis of phonological features, degree of accentedness, lexical richness, and code-switching patterns, among other linguistic and discourse-level characteristics. As Xi (2017) highlights, corpus linguistics can serve several purposes: describing language use in specific domains, evaluating learner performance, explaining linguistic patterns, and making predictions through the analysis of real-world reference corpora. In practice, corpus-based data may be drawn from spontaneous and semi-spontaneous conversations, including self-recordings. Researchers can also manipulate conversations by showing pictures, introducing specific topics, or even engaging in shared activities such as watching videos together (Nortier, 2008).

Corpus-based analyses of conversational code-switching in bilingual speakers can reveal when inter and intra-sentential switches (alternation and insertion) are likely to occur, reflecting the simultaneous activation of both languages (Green, 2018). For instance, the CHILDES TalkBank database enables in-depth analysis of child–caregiver interactions across multiple languages, offering valuable insights into early bilingual development (MacWhinney, 2014).

Arabic corpora have also been developed and analyzed in recent years. One notable example is the ArPod corpus, an Arabic speech dataset compiled from dialectal podcasts in Saudi, Egyptian, Syrian, and Lebanese varieties (Lounnas et al., 2019). This corpus has been used for acoustic analysis, employing various supervised classifiers to identify dialects. Other significant Arabic corpora include the QASR corpus, which comprises approximately 2,000 hours of transcribed speech from Al Jazeera broadcasts, featuring linguistically motivated segmentation and speaker information (Mubarak et al., 2021). Moreover, the ZAEBUC-Spoken corpus offers 12 hours of multilingual, multidialectal Arabic-English speech data, capturing spontaneous conversations with code-switching between Modern Standard Arabic, Gulf Arabic, Egyptian Arabic, and English (Hamed et al., 2024). Another example is the ArzEn corpus, an Egyptian Arabic-English code-switching speech dataset collected from informal interviews with bilingual speakers, providing valuable data for training and evaluating automatic speech recognition systems in bilingual contexts (Hamed et al., 2022). These corpora offer diverse resources for analyzing various aspects of Arabic language use, from speech recognition and synthesis to dialect identification and code-switching analysis.

On the Lebanese scale, several corpora have been collected that capture spontaneous multilingual interactions, often involving code-switching between Lebanese Arabic and English or French (Baidoun, 2018; Bassam, 2017; El Samaty, 2002; Smairat, 2020; Zantout, 2019). These corpora mainly reflect language use without any analysis of language features, but they still provide resources that allow researchers to investigate bilingual speech patterns and code-switching phenomena.

For Lebanese Arabic, it is essential to collect corpus data alongside subjective and objective assessments within the same population, as this combined approach allows for a more ecologically valid examination of code-switching patterns in natural bilingual communication.

Summary of Chapter 1

Recent approaches depict bilingualism as a continuum, avoiding rigid categories in order to better capture the fluid nature of bilingual language use. In Lebanon more specifically, the interplay between educational, social and historical factors has encouraged widespread bilingualism, with Lebanese Arabic, French, and/or English being often acquired from early childhood and used together in daily life. Lebanese people frequently switch between these languages in most life settings, including at home, in the community, in academic and even professional contexts. Attitudes toward code-switching remain heterogeneous, highlighting the need for more empirical evidence to better understand bilinguals' perceptions. Capturing the full complexity of bilingualism in the Lebanese context requires integrating subjective self-reports, objective proficiency measures, and corpus-based analyses within the same population, in order to provide a more comprehensive and ecologically valid evaluation of bilingual language use.

Chapter 2

Code-Switching as a Window into Language Control

2.1 Language Control: Definition and Scope

2.1.1 Definition of Language Control

In bilinguals, language control refers to the ability to manage competing linguistic systems during speech production and comprehension. It involves selecting the appropriate language in a given context while suppressing interference from the non-target language. These control processes depend on several mechanisms that interact together: language inhibition, activation, selection, and interference suppression (Branzi et al., 2016; Green, 1986, 1998). Because bilinguals often switch between languages, language control helps them handle these shifts smoothly and keep communication fluid (Declerck & Philipp, 2015; Mishra, 2018). Hereafter, the main focus is on language control in the context of word and speech production.

Early research emphasized inhibition as the main component of language control, underlining its necessity for resolving lexical competition between words from different languages (De Bot, 1992; Green, 1998). Lexical competition occurs between lemma, during the lexical selection stage according to Indefrey and Levelt (2004)'s "Processing network and componential task analysis" model. At this stage, right after conceptual preparation, multiple lemmas sharing semantic features can be activated simultaneously. In monolinguals, competition can happen between "sheep" and "goat" for example. This competition is increased in bilinguals: a French-English bilingual in the same context would experience competition between four lemmas instead of two (sheep, mouton, goat, chèvre). Abutalebi (2008) argues that lemma competition from L1 and L2 is solved by inhibiting any active, non-target language. In practice, such inhibition makes accidental slips into the wrong language very rare, reflecting an efficient control mechanism in healthy bilingual speakers (De Bot, 1992; De Groot, 2011)[1].

Beyond inhibition, language control is dynamic and adaptive, emerging from a flexible management

[1]Other models of lexical access, including the BIA, BIA+ (Dijkstra & Van Heuven, 2002a; Dijkstra et al., 1998), and Multilink (Dijkstra et al., 2019) models, are also described in the literature. They are not discussed here because they focus on written language and orthographic processing, which is beyond the scope of the present discussion.

of two active languages. It enables bilinguals to consistently select the appropriate language and prevent accidental slips into the other language during speech (Declerck et al., 2015). Mishra (2018) further emphasizes that bilingual language control is the outcome of constant practice in selecting and switching languages in everyday use.

2.1.2 Neural Evidence for Language Control

Neurocognitive studies highlight that language control operates in real time, engaging brain networks responsible for selecting the target language and minimizing interference from the competing language (Abutalebi et al., 2008; Branzi et al., 2016).

Neuroimaging research provides evidence that language control is supported by a set of frontal and medial brain regions consistently recruited when bilinguals manage their languages. Functional Magnetic Resonance Imaging (fMRI) studies show that the Anterior Cingulate Cortex (ACC) plays a central role in monitoring conflict between competing language representations, detecting when interference is likely to occur and signaling the need for increased control (Branzi et al., 2016; Rossi et al., 2021; Yuan et al., 2021). Activation in this region increases when control demands are higher, such as during language switching or when managing a less proficient language (Calabria et al., 2018). The Dorsolateral Prefrontal Cortex (DLPFC) has been repeatedly linked to proactive control, helping to maintain the target language active and suppress the non-target one (Jiao et al., 2022; Seo & Prat, 2019). In particular, left prefrontal regions are associated with language selection, whereas right prefrontal and inferior frontal regions are more strongly related to domain-general inhibitory control (Calabria et al., 2018). In parallel, the Pre-Supplementary Motor Area (pre-SMA) contributes to task switching and the coordination of control demands across languages (M. Chen et al., 2021; Rossi et al., 2021; Zhu & Sowman, 2020). Moreover, parietal regions, particularly the inferior parietal lobules, support attentional control in bilingual language selection by biasing processing away from the non-target language and toward the target language. Subcortical structures contribute to motor, cognitive, and emotional aspects of language control, by tracking the target language and regulating lexical interference, with the left caudate relating to language proficiency and the left putamen supporting articulatory processes. In addition, the cerebellum interacts with key nodes of the language control network and is engaged in both overt and inner speech, showing increased activation during second-language naming and semantic processing to resolve conflicting speech inputs (Calabria et al., 2018).

Electroencephalography (EEG) studies also provide important insights into the mechanisms underlying bilingual language control, showing how the brain manages competing languages during production and comprehension. Event-Related Potentials (ERP) research indicates that inhibitory processes, reflected by N2 components, are engaged when suppressing the non-target language, particularly during language switching in production tasks (Dash & Kar, 2020; Massa et al., 2020; Zheng et al., 2020). Experience with dual-language use and prior switching habits influence how efficiently these control mechanisms operate (Gosselin & Sabourin, 2021; S. Liu et al., 2023; Zhang et al., 2021). In production, control supports fluent language by managing competing structures and suppressing irrelevant alternatives, whereas in comprehension, bottom-up processes help regulate the influence of competing representations (Gosselin & Sabourin, 2021; S. Liu et al., 2023). EEG findings show that bilingual language control is a flexible system that adjusts language activation and inhibition to support communication across contexts.

Taken together, neurocognitive data provide evidence for bilingual language control, further supported by multiple theoretical models.

2.2 Theoretical Models of Language Control

Over the past thirty years, the global increase of bilingualism has made language control a main topic of research, giving rise to multiple theoretical frameworks explaining cognitive and neural mechanisms underlying bilingual language control. The present review focuses specifically on models of language control in bilingual language production.

2.2.1 Language Mode Hypothesis (Grosjean, 1997b)

Grosjean's (Grosjean, 1997b, 1998, 2008, 2024) Language Mode Hypothesis (LMH) states that bilinguals navigate a continuum of language activation, ranging from monolingual to bilingual modes, influenced by factors such as interlocutor(s), setting, and communicative intent. Rather than providing a model of language control, the LMH originally aimed to show that both languages are continuously activated to varying degrees depending on the linguistic context, such as the situation and the interlocutor.

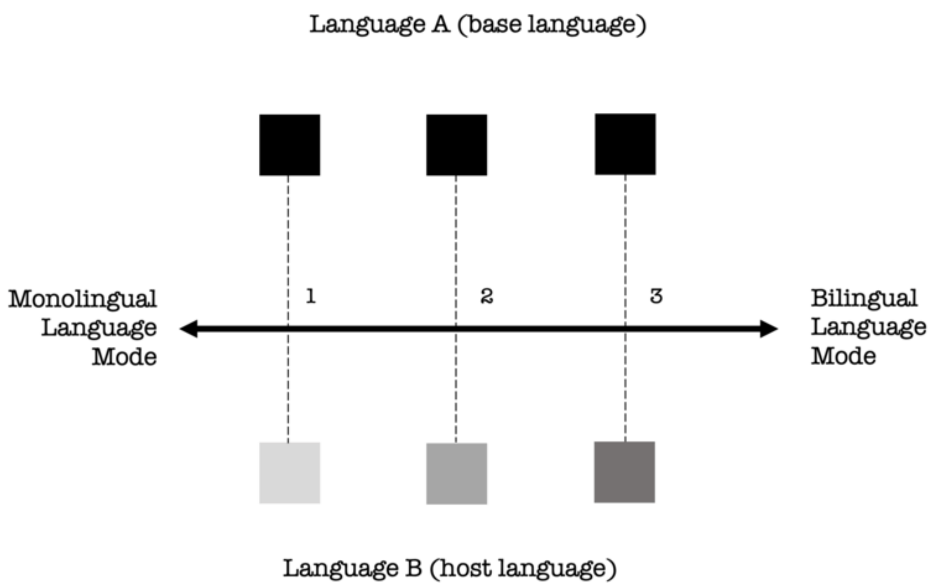

Figure 2.1: Language Mode Continuum, redrawn from Grosjean (2024)

On the language mode continuum (Figure 2.1), activation levels of both languages vary: the base language is consistently highly active (black square), while the guest language fluctuates in activation (shades of gray) based on context, yet is never fully inactive. Vertical dashed lines represent hypothetical speaker positions. For instance, Position 1 (monolingual mode) shows full activation of the base language and minimal activation of the guest language; Position 2 (intermediate) shows partial activation of both; and Position 3 (bilingual mode) shows both languages active, with dominance maintained by the base language.

In a study on the influence of language mode on lexical processing, Dunn and Fox Tree (2014) compared Spanish–English bilinguals in monolingual English mode and bilingual mode on a non-word recognition task. Results showed that bilinguals in monolingual mode performed similarly to English monolinguals, whereas bilinguals in bilingual mode responded more slowly, indicating that co-activation of both languages affected processing. The findings of this behavioral study support the LMH, demonstrating that bilinguals' language processing dynamically shifts along the monolingual–bilingual continuum.

To test the LMH in a more ecological setting, Dewaele (2001) interviewed 25 trilingual university students (Dutch, English, French) in both formal and informal situations. In the informal situation, participants were asked to chat in a relaxed atmosphere about their studies, hobbies, and other everyday topics in French. In the formal situation, they underwent an oral exam, during which their French proficiency was assessed while discussing politics or economics. The linguistic variables analyzed included mixed utterances (code-switching), speech rates, hesitation phenomena (pauses, fillers, repetitions), length of utterance, omission of "ne" in negation, choice of speech style, lexical richness, and lexical inventions. The author found a significant effect of formality: participants engaged in more code-switching in the informal situation compared to the formal one. Speech in the formal situation was also slower and less fluent, reflecting a position closer to the monolingual end of the language mode continuum. Conversely, informal situations allowed more switching, positioning participants toward the bilingual end of the continuum.

The contrast in response speed between Dunn and Fox Tree (2014) (slower in bilingual mode) and Dewaele (2001) (slower in monolingual mode) may stem from task differences. While Dunn used a controlled non-word recognition task, Dewaele's discourse task manipulated formality: in the formal oral exam, participants were aware that their language use would be evaluated, which likely led them to exert stricter control over their languages and inhibit non-target languages, reducing code-switching but also decreasing speech fluency (and accuracy). On the contrary, in the informal setting, participants could switch more freely, reflecting a position closer to the bilingual end of the language mode continuum.

Most other studies confirming the LMH relied on interpretations by Grosjean or applications of the LMH framework to previously published research. For instance, Poplack (1981) reported a case study of an English–Spanish bilingual whose discourse was recorded across multiple situations: formal, informal, and vernacular. Grosjean (2008) later interpreted the code-switching patterns from Poplack's study as supporting the LMH, observing approximately four times more code-switches per minute in the informal and vernacular sessions than in the formal sessions. Moreover, Treffers-Daller (1998) examined how a bilingual's position on the language mode continuum affects language choice and code-switching. A Turkish–German bilingual was observed in three contexts: in a monolingual-like context, most speech was in German with minimal mixing; in an intermediate context, flagged switches, accompanied by pauses, served pragmatic functions; and in a bilingual context, frequent intra and intersentential switching occurred fluently. This study highlights that language mode can predict both the frequency and type of code-switching. Similarly, Grosjean (1997a) conducted a laboratory study manipulating language mode in French–English bilinguals retelling French stories that contained English code-switches. Participants were told they were in a "telephone chain" task and retold the stories to three interlocutors designed to induce monolingual, intermediate, and bilingual modes. The measures extracted were the number of guest-language syllables (from the host language), the number of base-language syllables (from the base language), and the number of hesitations produced. Results showed that code-switching (guest language syllables) increased and base language syllables and hesitations decreased as participants moved from monolingual to bilingual mode, demonstrating that language mode directly influences bilingual speech production (Grosjean, 2008).

Empirical evidence for the LMH indicates that language activation is closely tied to the frequency of code-switching in discourse situations. Informal settings tend to elicit more switching, pushing participants toward a bilingual mode, whereas formal settings favor a monolingual mode, inhibiting all non-target languages. Although this empirical evidence is still limited and largely based on single-case studies, the observed patterns of dynamic activation and inhibition of languages aligns with Green's

(1998) Inhibitory Control Model, which postulates that bilinguals manage language selection through inhibitory mechanisms.

2.2.2 Inhibitory Control Model (Green, 1998)

Green's Inhibitory Control Model (ICM) offers a cognitive framework for understanding bilingual language control by outlining the interaction between three core components: the conceptualizer, the Supervisory Attentional System (SAS) (Shallice & Burgess, 1996), and language task schemas (Figure 2.2). The conceptualizer generates a communicative Goal (G) based on contextual demands, which is then relayed to the SAS. The SAS functions as a central executive that selects and activates the appropriate language task schema, such as "speak in L1" or "translate to L2." These schemas compete for control over the lexico-semantic system, where the selected schema enhances the activation of target-language lemmas and inhibits non-target ones through Inhibition (I). The final stage is Output (O), where the correctly selected representation is articulated. This inhibitory mechanism is particularly relevant in language switching tasks, where reactive inhibition is used to suppress interference from the non-selected language. Remarkably, switching back to the dominant L1 is often more difficult, reflecting the residual inhibition of previously suppressed representations.

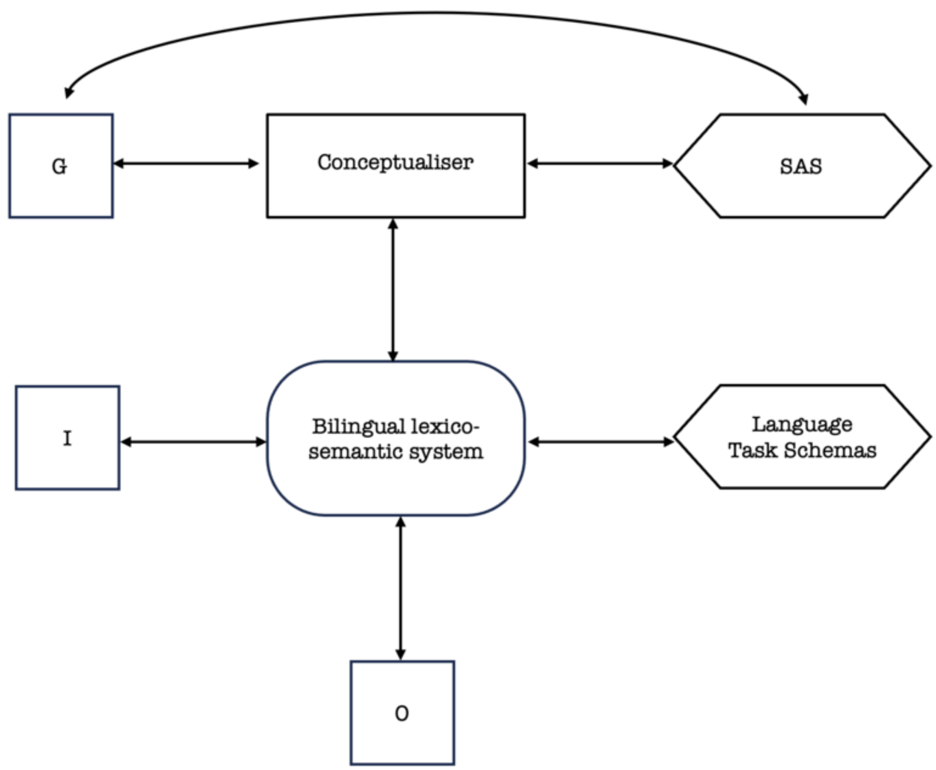

Figure 2.2: The Inhibitory Control Model, redrawn from Green (1998)

2.2.3 Adaptive Control Hypothesis (Green & Abutalebi, 2013)

In an updated version, the ICM was transformed into the Adaptive Control Hypothesis (ACH). The ACH was based on the more general ”adaptive control system”, initially reported in engineering autopilot systems for aircraft, and later in machine learning, referring to any system that can maintain performance despite major changes, while smaller variations are managed through dynamic mechanisms, including feedback and feed-forward control (Black et al., 2014). Building on this idea of adaptive systems, Green and Abutalebi (2013) introduced ”context” as a key component of control, by specifying how cognitive control processes proactively adapt to different interactional contexts.

The ACH suggests a hierarchical framework (Figure 2.3) comprising four interdependent components: (1) the **interactional context** shaping communicative demands; (2) the **speech pipeline**, encompassing the conceptual, linguistic, and sensorimotor representations involved in language use; (3) **control processes** regulating these representations in working memory to maintain communicative goals; and (4) **meta-control processes** dynamically adjusting control parameters.

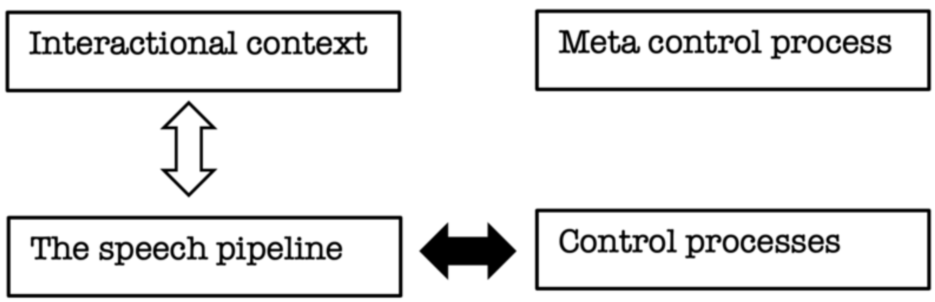

Figure 2.3: Architecture of The Adaptive Control Hypothesis, redrawn from Green and Abutalebi (2013)

Green and Abutalebi (2013) then define three interactional contexts (see Figure 2.3), describing daily conversational use settings:

- **Single-language context**: Bilinguals use one language exclusively in one setting and the other language in a separate, distinct environment. For example, they may speak their native language at home with family and their second language at work with colleagues. In such contexts, code-switching is infrequent.
- **Dual-language context**: Both languages are used within the same environment but with different interlocutors. For example, a bilingual English-French speaker would be using English with a coworker and French with their sibling during the same event. Code-switching occurs in one conversation, at the syntactic boundary, referring to alternation (Muysken, 1997) or inter-sentential switching (Poplack, 1980).
- **Dense code-switching context**: Both languages are used together within the same utterance, corresponding to *insertion* (Muysken, 1997), or intra-sentential switching (Poplack, 1980), such as in the sentence: ”Liom reḥet ‘a el-*marché*” (Today I went to the market). Additionally, adaptations of words from one language into the other are part of congruent lexicalizations (Muysken, 1997). For instance, in Lebanese Arabic-French code-switched speech, the compound word ”Bonjour-ein” is frequently used, with the word ”Bonjour” from French and the suffix ”-ein” from Arabic referring to dual/plural.

In addition, the broad inhibitory component, central in the ICM, was further clarified in the ACH as involving eight control processes that support the regulation of language capacities in these contexts:

- **Goal Maintenance** involves sustaining the current language goal in the presence of competing alternatives.
- **Interference Control** encompasses two sub-components:
  - **Conflict Monitoring** detects competition between potential language responses, signaling the need for increased control.
  - **Interference Suppression** inhibits irrelevant or competing representations, whether at the lexical, syntactic, or task schema level, to reduce conflict and facilitate the intended response.
- **Salient Cue Detection** enables speakers to identify contextually relevant cues that may require a change in language use. For example, the arrival of a new addressee may cue a language switch.
- **Selective Response Inhibition** refers to the ability to suppress an ongoing or dominant language response when a more relevant alternative is needed. This process can trigger disengagement from the current language and initiate switching.
- **Task Disengagement** involves deactivating the previously dominant language system. Effective disengagement minimizes interference and facilitates smoother transitions between language systems.
- **Task Engagement**: After disengaging from a previous task, the speaker must actively engage with the new language task.
- **Opportunistic Planning** involves the flexible use of available resources to achieve communication goals. In bilinguals, this may include adapting lexical items from one language into the syntactic structure of another. Less proficient speakers may also rely on gesture or mixed-language constructions when linguistic resources are insufficient.

	Interactional contexts		
Control processes	**Single language**	**Dual language**	**Dense code-switching**
Goal maintenance	+	**+**	=
Interference control: conflict monitoring & interference suppression	+	**+**	=
Salient cue detection	=	+	=
Selective response inhibition	=	+	=
Task disengagement	=	+	=
Task engagement	=	+	=
Opportunistic planning	=	=	**+**

+ : the context increases the demand on the target control process, and more so if bolded
= : the context has a neutral effect

Figure 2.4: Control Process Demands by Interactional Context (Green & Abutalebi, 2013)

Figure 2.4 shows how control processes are implemented in the different interactional contexts from the ACH. In the single-language context, demands on goal maintenance, conflict monitoring, and interference suppression are moderate due to activation of only one language, resulting in a stable control state with minimal switching. In contrast, the dual-language context imposes the highest demands on these control processes because both languages are simultaneously active and competing. Strong control is required not only to manage this competition and avoid interference, but also to convey the appropriate message in the correct language to each interlocutor. This context also requires frequent salient cue detection and switching mechanisms to balance stability and flexibility. In the dense code-switching context, demands shift toward opportunistic planning, reflecting an interactive relationship between languages that facilitates flexible integration of linguistic elements.

Experimental paradigms based on the ACH follow the interactional contexts set by Green and Abutalebi (2013): multiple Language Switching Paradigm (LSP)s (see Subsection 2.4.1 for a detailed description), usually picture-naming, have been developed within this framework, drawing a correspondence between interactional contexts and types of paradigms:

- Single-language context is assimilated to single-language/monolingual conditions, where participants are asked to name pictures in one language only.
- Dual-language context is assimilated to dual-language/cued, alternating or sequence-based bilingual conditions, where participants are asked to name pictures in two languages following a cue (flag or color) or a predetermined sequence.
- Dense code-switching context is assimilated to voluntary/free bilingual conditions, where participants are allowed to name each picture in the language they want, switching freely between languages throughout the task.

Commonly, in such paradigms, single-language/monolingual conditions are used as a baseline to which the bilingual experimental conditions are compared in terms of accuracy and response time. Bilingual cued conditions, corresponding to dual-language context, allow the extraction of *switch costs* and *mixing costs*, that is, the additional time required to switch between languages or to maintain two languages active during picture naming, (see Subsection 2.4.3 for a detailed explanation).These costs show that using two languages takes more time than using only one, indicating higher cognitive demands. The simultaneous activation of both languages and the need to inhibit one depending on task instructions illustrate adaptive control in bilinguals. Multiple studies have consistently found these costs in many language pairs, among which English-French, English-Italian, English-German, English-Portuguese, English-Spanish, Spanish-Catalan, German-Dutch, Spanish-English, Turkish-German, Chinese-English (Christoffels et al., 2007; Costa & Santesteban, 2004; Declerck et al., 2015; Gollan & Ferreira, 2009; H. Liu et al., 2021; Meuter & Allport, 1999). These findings confirm that switch and mixing costs are a well-established phenomenon in bilingual language production.

Recently, more research has turned to dense code-switching contexts. While earlier accounts of bilingualism often described language use as compartmentalized (one language at home and another at work), a growing body of research is exploring communities where switching languages is a social practice, such as Catalan–Spanish or Lebanese Arabic–French/English. To capture this context experimentally, studies have begun to use voluntary/free switching picture-naming tasks, where participants can choose which language to use on each trial. This approach builds on earlier research on voluntary task switching (Arrington & Logan, 2005), which showed that switch costs are smaller when participants choose themselves when to switch tasks than when they are instructed by an external cue. As an example of an early picture-naming voluntary switching paradigm, Gollan and Ferreira (2009) found that free switching facilitated responses in unbalanced and older bilinguals, unlike cued switching. In a more recent attempt to test the ACH using a picture-naming language-switching paradigm, Blanco-Elorrieta and Pylkkänen (2017) recruited 19 Arabic–English bilinguals in the United Arab Emirates, a country known for frequent daily switching between these languages. Participants named pictures in Arabic or English under three conditions. In the bilingual-interlocutor context, they could freely choose the language to use; in the monolingual-interlocutor context, they had to match the language of the pictured monolingual partner (based on ethnicity); and in a separate color-cued laboratory task, a red or green square indicated which language to use. The study found that when the interlocutor was bilingual, participants switched languages without behavioral costs or measurable engagement of executive control regions. This study is consistent with the ACH framework and suggests that voluntary switching in natural conversational contexts can be cost-free, confirming bilinguals' intuition that switching is easy with a bilingual partner (Kleinman & Gollan, 2016). This perspective finds additional support in a recent study by Kennis et al. (2025) that also found smaller behavioral switch costs in voluntary compared to cued language switching in highly proficient Dutch–English bilinguals. Another line of research suggests that for FCS, bilinguals who frequently switch languages in daily life (referring to the dense code-switching context from the ACH), switch costs can occur in both cued and voluntary conditions, but mixing costs appear only in cued tasks, whereas voluntary tasks may even show a mixing benefit, indicating that using two languages voluntarily can be less effortful than maintaining a single language (De Bruin et al., 2018; Jevtović et al., 2020).

Moreover, interactional contexts have been operationalized differently in other studies, putting the accent on daily language use and ecological paradigm design for corpus collection. For instance, Kałamała et al. (2020) developed specific sociolinguistic questionnaires, *The Patterns of Language Use Questionnaire* and *The Code-switching and Interactional Contexts Questionnaire*, and used a latent-variable approach to capture single and dual-language use in daily life. They extracted two distinct *measures of Dual-Language Context (DLC) intensity*, each based on a different questionnaire. *DLC intensity 1*, derived from the first questionnaire, included two measures: *LE* (see 1.1.2.4 for details) (Gullifer & Titone, 2020), which captures the diversity and distribution of language use across contexts, and *Language mixing*, reflecting how frequently participants combined elements from two languages within a single utterance. *DLC intensity 2*, derived from the code-switching questionnaire, also comprised two measures originally developed by Hartanto and Yang (2016): the *Index of Single-Language Context (SLC)*, quantifying the relative use of one language compared with the overall use of other languages, and the *Index of intra-sentential code-switching*, measuring the frequency of mixing languages within single sentences. Using an adapted version of the *Bilingual Interactional Context Questionnaire* (Hartanto & Yang, 2020), Ng and Yang (2022) calculated indices of different types of code-switching, aligned with the interactional contexts from the ACH: *alternation index* (corresponding to dual-language context), *insertion index* and *congruent lexicalization index* (both associated with the dense code-switching context). These indices were computed across four environments (home, work, school and other), by considering the percentage of time spent in each environment. Overall, these examples illustrate that the operationalization of interactional contexts varies across studies, likely contributing to differences in empirical findings, as each method may capture distinct aspects of bilingual language use.

More ecological research has also been developed, not directly within the ACH framework, but following hypotheses closely related to it. For example, the *Interactive Alignment Model* of Pickering and Garrod (2004), assumes dialogue partners come to align their syntactic, semantic and phonological representations. Applied to bilingualism, this means also aligning language knowledge between interlocutors. Based on this model, Fricke and Kootstra (2016) introduced the notion of *primed code-switching* and demonstrated that code-switching may be induced by priming mechanisms: when a participant hears a switch in their interlocutor's speech, they are more likely to code-switch themselves. Their study considered conversational factors such as the presence or absence of a code-switch in the interlocutor's utterance, the default language of the conversation, and the language of preceding turns (see Section 2.4.4 for the full list of predictors). In a more recent study, Kootstra et al. (2020) further observed that Dutch-English bilinguals were more likely to switch languages immediately after their interlocutor had switched, as well as after the use of cognates[2], indicating that lexical triggering is in fact driven by interactive alignment. These findings are consistent with the ACH's prediction that bilinguals' language control adapts to different interactional contexts.

The Language Mode Hypothesis (Grosjean, 1998, 2008) also supports the hypothesis of adaptive control in bilinguals (refer to subsection 2.2.1). In fact, language mode is influenced by the *person spoken to or listened to* (language proficiency, switching habits, personal proximity, etc.), the *situation* (location, presence/absence of monolinguals, formality), the *form and content of the message* (language, subject, code-switching), and the *function of the language act* (to request, communicate, including or excluding someone) (Grosjean, 2008). All these factors correspond to the interactional contexts described by

[2]Cognates are words in two different languages sharing the same etymology and phonological form.

Green and Abutalebi (2013), and determine the general language environment. For example, being in the presence of monolinguals would typically place a speaker in a single-language context, even if all other interlocutors are bilingual. However, the same situation could be reversed: if the goal is to exclude the monolingual person from the conversation, a single-language context in the language that the monolingual does not understand would be established. Conversely, two highly proficient bilinguals used to switching would frequently mix languages, creating a dense code-switching context. Finally, in the presence of two monolinguals speaking different languages, a bilingual speaker would be in a dual-language context, addressing each interlocutor separately in their respective language.

Taken together, these examples illustrate how interactional context shapes bilingual language use and how multiple theoretical perspectives and empirical evidence converge to explain bilingual language control. Nonetheless, previous studies testing the ACH have mostly collected single-word data, and no study to date has experimentally tested the ACH by placing bilingual speakers in each of the three contexts described by Green and Abutalebi (2013) and collecting discourse corpora. Filling this gap would make it possible to observe how language control works in practice across different situations. More ecological research would therefore be highly valuable for assessing the ACH and advancing theoretical accounts of adaptive control in bilingualism.

2.2.4 A Control Process Model of Code-Switching (Green & Wei, 2014)

Building on ACH's insight that control demands vary with interactional context (Green & Abutalebi, 2013), the Control Process Model of Code-Switching (CPM) introduced by Green and Wei (2014) aims to explain how bilingual speech planning handles language selection. Language task schemas regulate which language system is allowed selective access into the speech planning process.

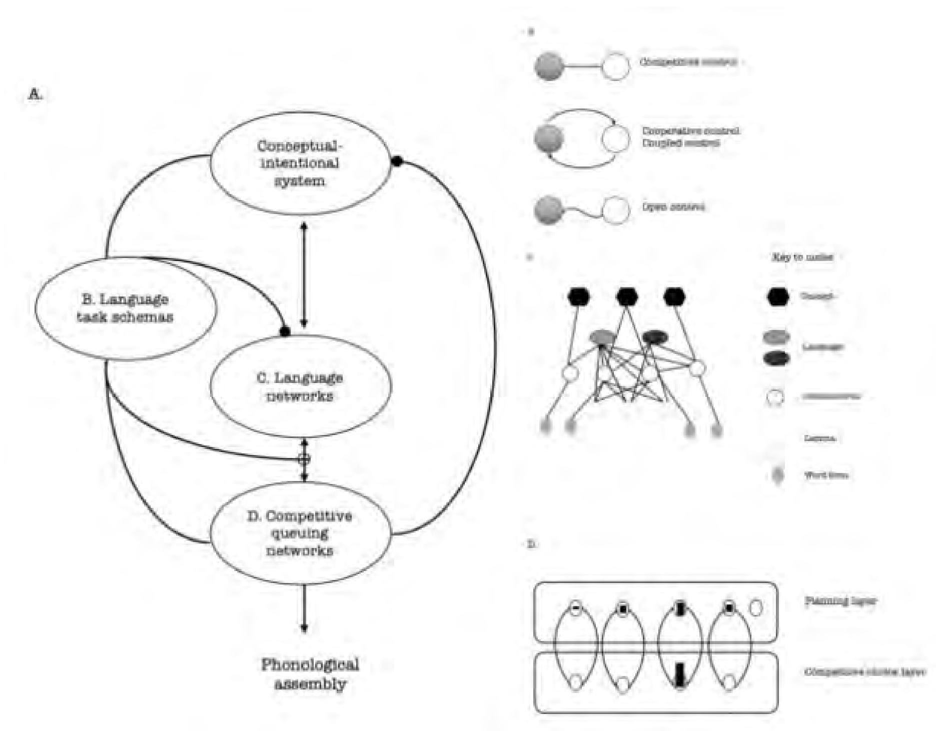

Figure 2.5: A Control Process Model of Code-Switching, redrawn from Green and Wei (2014)

According to the CPM (Figure 2.5, part A.), activation is initiated in the conceptual–intentional system, which primes parallel responses across both language networks. Control is managed by language task schemas (defined in Section 2.2.2), which filter this activation and selectively allow language-specific representations into the Competitive Queuing (CQ) network, where speech planning is serially organized. The model includes two inhibition mechanisms: feedback suppression from the CQ network, which eliminates ideas that have already been verbalized, and reactive inhibition from the schemas to the language networks, which prevents unintended lexical candidates from entering the planning process. The schemas function as a monitoring layer by detecting and rejecting any elements not aligned with the speaker's communicative intention.

Code-switching is regulated by three types of control (Figure 2.5, part B.):

- **Competitive control**: Only one language schema is active: the selected schema allows the corresponding lexical items to access the CQ network, while the other schemas are suppressed. This mode corresponds to the single-language context of the ACH, helping to prevent cross-language interference and maintain fluent monolingual speech, and dual-language context, using only intersentential switching (alternation) without intrasentential switching (insertion).
- **Cooperative control**: Both language schemas can be active, in two regulated configurations:
  - **Coupled control**: The dominant (matrix) language schema temporarily gives controlled access to the subordinate (embedded) schema, enabling intended utterances, such as specific insertions or alternations, to enter the CQ planning layer. Once these planned elements are included, full control returns to the dominant schema. This supports selective, intentional code-switching rather than opportunistic or accidental mixing.

- **Open control**: In dense code-switching contexts, both schemas remain active simultaneously; lexical items with highest activation, regardless of language, enter the speech plan, enabling fluid intrasentential switching.

The CPM represents bilingual lexical organization as two parallel networks (Figure 2.5, part C.), one per language, where lemma nodes are clearly tagged. Importantly, combinatorial nodes (common syntactic structures that link lemmas) enable grammatical overlap across languages. This structure supports controlled integration in code-switching by enabling shared syntax while keeping lexical items separate.

Figure 2.5, part D., illustrates how activated lexical candidates from the language networks are managed in the CQ network for speech planning. Within this network, candidate items compete through activation signals (arrows). Inhibitory connections (filled circles) ensure that only the most strongly activated item is selected at each step. The relative activation levels of candidates (bar heights) indicate which item is chosen next in the serial output. This disposition models how bilingual speakers order words in sequence despite simultaneous activation across languages, embedding both activation and inhibition in the selection process.

2.2.5 Dual-Mechanisms of Control Framework (Braver, 2012)

The Inhibitory Control Model and the Language Mode Hypothesis operate via proactive control, focusing on inhibition and context-driven regulation processes, whereas the Control Process Model of Code-Switching and the Adaptive Control Hypothesis integrate both proactive control, where the task schema is set in advance to guide planning, and reactive control, which dynamically suppresses unintended candidates. These dual modes align with the Dual Mechanisms of Control (DMC) framework (Braver, 2012), which emphasizes their distinct temporal dynamics in the brain. The DMC was developed to understand cognitive control mechanisms in monolinguals, or at least, processes operating independently from language knowledge. Proactive control is the anticipation and prevention of any interference before it occurs, whereas reactive control relies on the detection and resolution of interference after it takes place.

As illustrated in Figure 2.6 for the Dual-Mechanisms of Control Framework in a Stroop task, the upper panel represents reactive control, where task goals are not maintained across trials but are only activated after conflict detection, resulting in slower responses on incongruent trials. In contrast, the lower panel represents proactive control, in which task goals are continuously sustained during inter-trial intervals, leading to reduced conflict when incongruent stimuli are encountered. This distinction emphasizes that proactive control relies on sustained, anticipatory goal maintenance, while reactive control involves on-demand, stimulus-triggered goal reactivation.

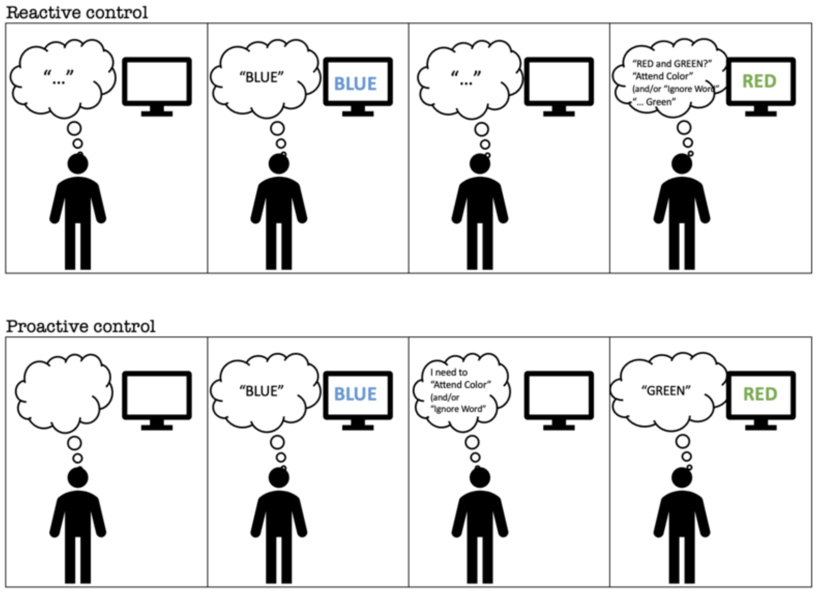

Figure 2.6: Dual Mechanisms of Control framework in a Stroop Task, redrawn and adapted from Braver (2012)

Chiew and Braver (2017) extend Braver's DMC framework by visually distinguishing how proactive and reactive control operate over time in context-dependent tasks. In their version, proactive control is characterized by sustained, preparatory activity, either across an entire block or following contextual cues, allowing to maintain task goals before a response is required. In contrast, reactive control is described as transient neural activation, recruited just before responding to resolve interference after it occurs. In their AX Continuous Performance Task (AX-CPT) experiment, the authors used a mixed block and event-related fMRI design to independently model sustained (block-level) and transient (trial-level) neural activity. This approach enabled them to validate the temporal dissociation between proactive and reactive control processes in the brain. By distinguishing sustained from transient control processes, this work provides a valuable framework for investigating language control in bilinguals.

While the previously discussed models (ICM, ACH, LMH, CPM, DMC) offer valuable insights into bilingual language control, they primarily address language processing in controlled experimental settings. Other influential models, including the Unified Competition Model (UCM) (MacWhinney et al., 2005) and the Bilingual Interactive Alignment (BIA) and BIA+ models (Dijkstra & Van Heuven, 2002b; Dijkstra et al., 1998), provide complementary insights into bilingual language processing. The UCM addresses general mechanisms of language learning and use, while the BIA models focus specifically on lexical access during reading. However, real-world bilinguals often navigate in complex linguistic environments where multiple languages are used within conversations. This dynamic interplay of languages, reflected precisely by code-switching, introduces unique challenges and demands on cognitive control mechanisms. Understanding how different types of code-switching engage reactive and proactive control processes is essential to developing a more ecological perspective on bilingual language control.

2.3 Code-Switching and Control Demands

Code-switching in bilinguals occurs in multiple types and is referred to by different terms in the literature, and it involves varying control demands.

2.3.1 Code-Switching Typologies

Throughout the years, multiple typologies of code-switching have emerged, mainly based on syntactic boundaries.

Poplack (1980) defined code-switching as either *intersentential* or *intrasentential*: intersentential switching occurs at sentence or clause boundaries, for instance : ”Hello dear, *comment vas-tu*?” or ”J’étais en Italie la semaine passée. *Ho mangiato pasta e pizza*.” On the contrary, intrasentential switching takes place within a sentence or a clause, integrating the grammatical structures of both languages, as in: ”Elle était très *kind* avec moi”.

Another classification by Muysken (1997) distinguishes *alternation*, *insertion* and *congruent lexicalization*. Alternation involves switching languages at syntactic boundaries; a speaker might begin a sentence in one language and finish it in the other, such as in the sentence ”Je vais au travail, *then I have to help my parents prepare dinner*.” Here a French clause is followed by an English clause, with each segment following its own grammar. Insertional code-switching, by contrast, inserts single words or phrases from one language into the syntactic frame of the other. For example: ”I need to go to the *marché* tomorrow.” In this case, one language provides the grammatical matrix (here English) and the other provides a lexical slot (here French). Congruent lexicalization occurs when two languages share grammatical structures that can be filled with lexical items from either language. In this case, the switch is about the joint use of a shared syntactic frame, such as in ”On a discuté du projet, *and finally* elle a décidé de *start* demain”.

2.3.2 Code-Switching, Code-Mixing and Loanwords

The terms *code-switching* and *code-mixing* are often used interchangeably, but some authors distinguish them from each other. According to Bokamba (1989), code-switching involves mixing words, phrases, or sentences from distinct grammatical systems within a single utterance, whereas code-mixing encompasses the incorporation of diverse linguistic units (affixes, words). Gumperz (1982) further narrows code-mixing to the insertion of morphemes from one language into the lexical frame of another, with the latter serving as the base language. From a sociolinguistic perspective, code-switching frequently carries pragmatic or identity-related functions, including quoting, emphasis, or signaling group membership, while code-mixing may simply reflect routine bilingual usage without distinct social intent.

Code-switching/mixing should be distinguished from loanwords/borrowings. While code-switching refers to the introduction of an unassimilated word of one language within the frame of another, a borrowing refers to ”the regular use of material from one language in another so that there is no longer either switching or overlapping” (Bentahila & Davies, 1983, p. 302). In other words, code-switching is characteristic of bilingual speakers, while a borrowing is used by monolinguals. For instance, the words *cool, parking, t-shirt, weekend* are borrowings from English that are fully integrated into French and commonly used by monolingual speakers.

Borrowings can occur at different levels of linguistic structure, ranging from content words to deep morphosyntactic and phonological changes. Thomason and Kaufman (1988)'s borrowing scale describes this continuum in five stages, illustrated in Figure 2.7 with examples illustrating Lebanese Arabic contact with English and French. The scale begins with (1) the borrowing of content words in casual contact situations (e.g., ['am ba'mol *shopping*] (=I am shopping)), followed by (2) the adoption of function words and minor phonological or syntactic features (e.g., [kenet 'am bedros *so* zhe'et] (=I was studying so I got bored)), then progressing to (3) prepositions and affixes (e.g., [bonjour-*ein*] (=Two times good morning)), and to (4) minor structural changes in morphology, word order (e.g., Use of Arabic */r/* in French words: [r]ouge instead of [R]ouge), and finally (5) to major changes in word structure rules, phonological systems under conditions of strong cultural pressure (e.g., [*dallatet* el-risele] (=I deleted the message)).

Treffers-Daller (2010) distinguishes between three types of borrowing:

- Loanword: morphemic importation without substitution. For example, when Lebanese bilinguals borrow the lexeme *computer* from English, they keep the English consonant [p] and do not replace it with an Arabic phoneme ([p] doesn't exist in Arabic).
- Loanblend: importation with substitution. For example, the Lebanese Arabic lexeme (*basku:t*) was borrowed from French *biscuit* but has been fully integrated phonologically into Arabic.
- Loanshift: substitution without importation. For example, the Lebanese Arabic lexeme *fa:ra* (= mouse) was extended to mean "computer mouse" by analogy with English mouse, importing the meaning but keeping the native form.

In a more recent study, Treffers-Daller (2025) proposes the *Simple View of Borrowing and Code-Switching*, which uses *listedness* in the mental lexicon (whether a unit is stored as a whole) as the key criterion for distinguishing borrowings from code-switches. Borrowed items are stored as fixed, formulaic units, whereas code-switched items are generated online during speech. Listedness is operationalized using *Mutual Information (MI)*, which quantifies how strongly words or *multiword units (MWU)* are associated in a corpus, with higher MI reflecting greater formulaicity and a higher likelihood that a MWU is stored in the lexicon. Analysis of an 87,000-word Turkish–German corpus showed that MWUs typically exceeded the MI threshold and were more often classified as borrowings, while single words were less consistently categorized. These findings highlight that formulaicity, rather than frequency alone, is a reliable marker for distinguishing borrowing from code-switching.

Taken together, these frameworks help distinguish borrowing from code-switching in both utterance-level and corpus-based analyses, highlighting that borrowing may range from single lexical items to deep structural changes in morphology, syntax, or phonology (e.g., change in word order, new rules), whereas code-switching remains a discourse-level practice reflecting the dynamic interplay of two (or more) active linguistic systems.

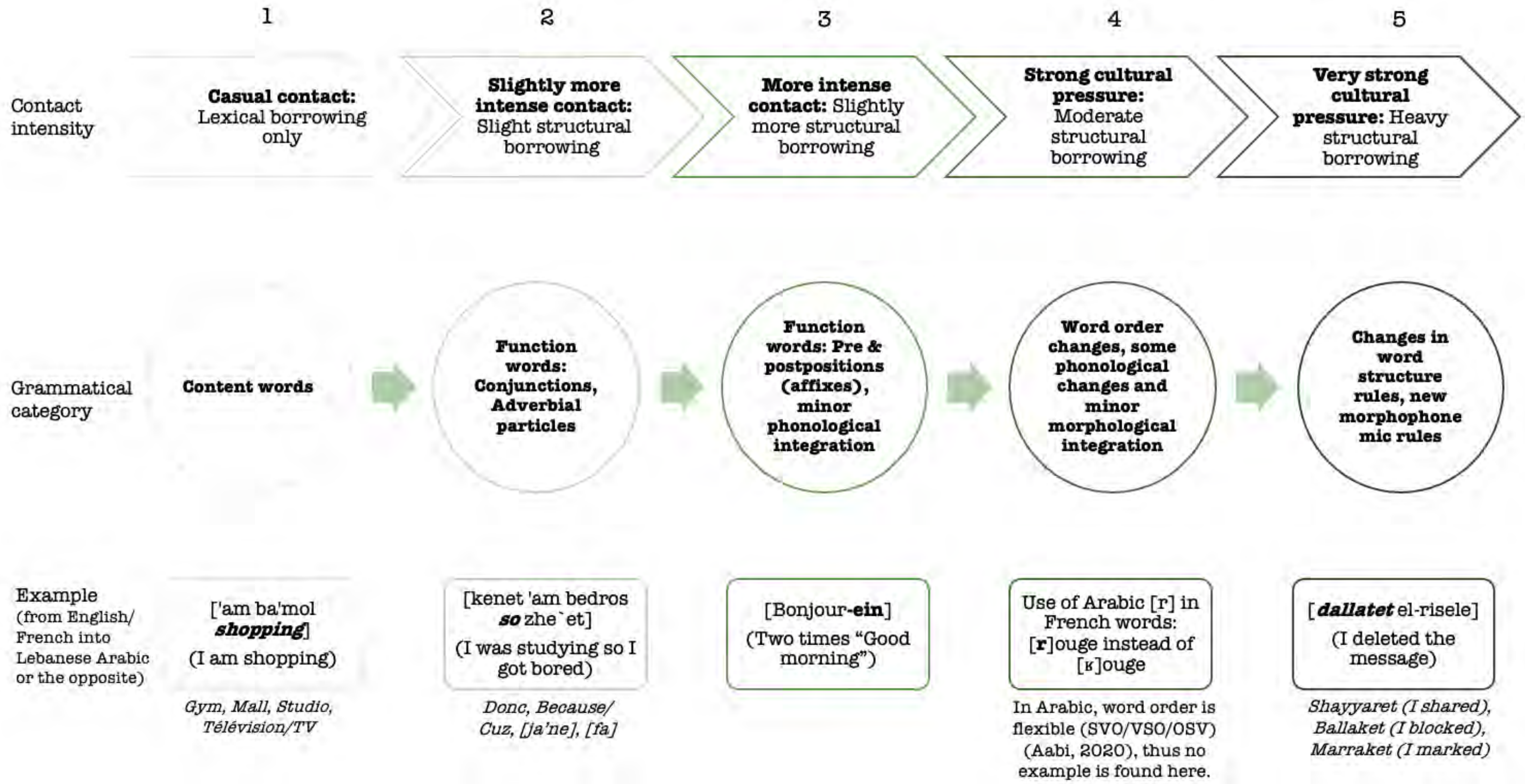

Figure 2.7: Stages of Borrowing based on Thomason and Kaufman (1988)'s Scale

2.3.3 Language Control Demands associated with Code-Switching

Code-switching involves the control of two language systems, where the bilingual speaker alternates between both languages. This process engages multiple control mechanisms, as outlined in the theoretical models of language control (see Section 2.2): language mode (Grosjean, 1998, 2008), interactional context (Green & Abutalebi, 2013), and control processes (Green & Wei, 2014) all play a role and are intertwined. Specifically, bilingual language use and code-switching require mechanisms for language activation, inhibition, selection and monitoring of contextual cues. In alternation/intersentential switching, general monitoring helps to structure discourse, whereas in insertion/intrasentential switching, speakers must simultaneously inhibit one language while activating another, ensuring grammatical and semantic coherence across languages (Green & Abutalebi, 2013; Green & Wei, 2014).

Integrating the insights from different control models appears essential to better illustrate language control demands within code-switching. Taken together, the LMH (Grosjean, 1998, 2008), ACH (Green & Abutalebi, 2013), and CPM (Green & Wei, 2014) highlight complementary perspectives that can be aligned as follows (see Figure 2.8):

- **Situation 1** (yellow squares in Figure 2.8): Monolingual language mode (LMH) can be assimilated to single-language context (ACH), where the bilingual individual is in a situation where they should speak only one language and inhibit the other(s), thus requiring competitive control (CPM) between languages. No code-switching occurs in this situation.
- **Situation 2** (green squares in Figure 2.8): Bilingual language mode (LMH) can be associated with dense code-switching context (ACH), in which the bilingual speaker interacts with another bilingual partner and switches freely between languages. Insertion/intrasentential code-switching and congruent lexicalization are commonly observed in this situation, respectively engaging both cooperative/coupled and open control mode (CPM).
- **Situation 3** (red squares in Figure 2.8): Because language mode is a continuum, many intermediate modes also exist. For example, the bilingual speaker may interact alternatively with two monolinguals who speak each a language; this can correspond to a dual-language context (ACH) and involve competitive control of the two languages (CPM). Alternation/intersentential code-switching is present in this situation.

Figure 2.8 represents a possible convergence between language control models from distinct theoretical perspectives, showing how language processing, executive control, and interactional contexts intersect to shape bilingual language regulation.

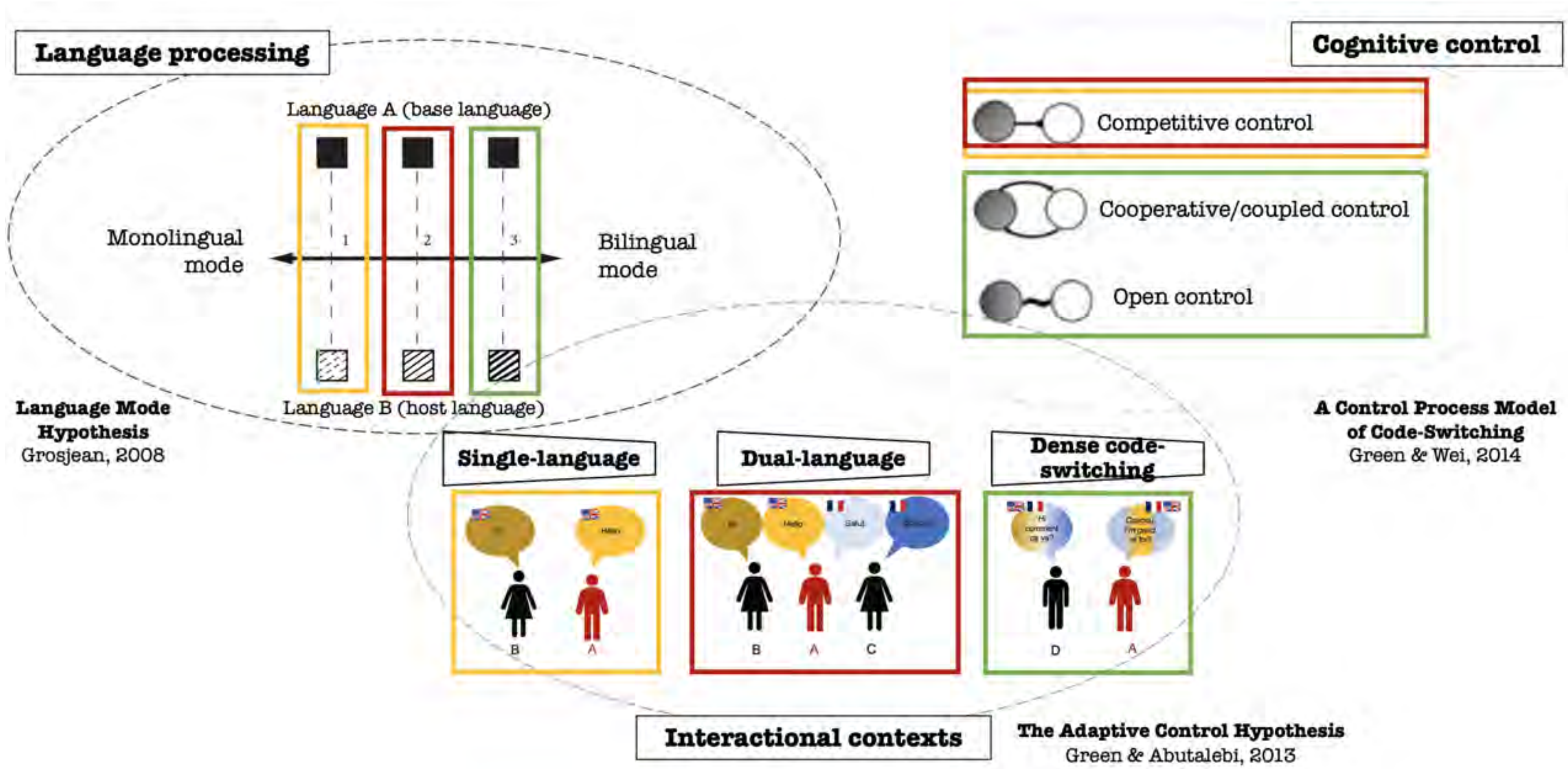

Figure 2.8: Mapping of Language Control Models:
LMH (Grosjean, 1998, 2008), ACH (Green & Abutalebi, 2013), CPM (Green & Wei, 2014).

These demands are particularly present in cued language switching tasks, which require quickly overriding the active language in response to external cues, as well as in voluntary switching, which relies more on self-initiated monitoring and decision-making (Declerck & Philipp, 2015).

2.4 Language Switching Paradigms and Associated Costs

2.4.1 Language Switching Paradigms (LSP)

Language switching paradigms, building on earlier Task Switching Paradigm (TSP) (Rogers & Monsell, 1995), assess bilingual language processing, based on color, picture or number naming tasks. They typically include two types of blocks: *single-language blocks* (also called monolingual blocks), requiring participants to name all items in the same language, and *mixed-language blocks* (also called bilingual blocks), requiring participants to name items in two (or more) languages following a predetermined (switching on every trial, ABAB) or random (AABABBAAA) sequence. Both types of blocks are analyzed and compared, in terms of speed (response time in milliseconds) and accuracy (correct/incorrect). Single-language blocks, in each of the assessed languages, are classically used as a baseline to which mixed-language blocks are compared. This is based on the assumption that naming in the same language throughout the block is easier, as the target language can remain activated while the non-target language(s) are inhibited. Mixed-language blocks require participants to shift between languages frequently, typically guided by an external cue such as a color or a flag. This continuous switching requires greater flexibility in activating the target language and inhibiting the competing one(s), engaging control processes more intensively (Festman & Schwieter, 2015). Two types of trials are distinguished: *stay* (or repetition) trials occur when two consecutive items are to be named in the same language, which is the case throughout single-language blocks, and *switch* trials occur when two consecutive items should be named in different languages (see Figure 2.9).

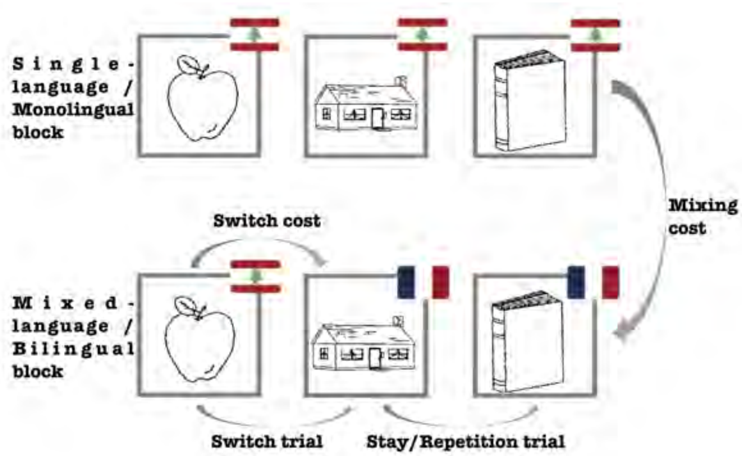

Figure 2.9: Language Switching Paradigm Example

Several LSPs exist, differing in their implementation of specific concepts and languages (Declerck & Philipp, 2015):

- **Alternating** language switching: Participants usually alternate languages every second trial (for example, L1–L1–L2–L2–L1–L1, etc.), following only the instruction, without any visual cue.
- **Sequence-based** language switching: Participants are required to memorize fixed sequences of both concepts and languages without visual cues, producing items in order, such as weekdays or numbers.
- **Cued** language switching: Most commonly used in the literature, this paradigm includes visual cues along each item, such as a color cue or a flag, indicating the language the item should be produced in (see Figure 2.9 for an example).
- **Voluntary** language switching: Participants are given a set of items without any cue, and they are free to switch languages whenever they want (Gollan & Ferreira, 2009).

2.4.2 Semantic Fluency as a Language Switching Paradigm

While picture-naming tasks have traditionally been used to study bilingual language switching, recent research has increasingly turned to semantic fluency tasks to investigate bilingual language control. Semantic fluency complements picture-naming by examining word retrieval in the absence of an external stimulus, providing additional insight into verbal control mechanisms. In these tasks, participants are asked to generate as many words as possible within a given category, either in a single-language (monolingual) condition or under forced[3] or voluntary mixed-language (bilingual) conditions.

Several studies have directly compared verbal fluency performance under voluntary and forced bilingual conditions. Taler et al. (2013) investigated English–French bilinguals performing animals category fluency under English, French, voluntary-switch, and forced-switch conditions. They found that semantic similarity (i.e., how closely related words are in meaning within a category, such as ”lion” and ”tiger” versus ”lion” and ”dolphin”) influenced output more than frequency, but under forced switching, the influence of frequency increased while semantic similarity decreased. This indicates that forced switching alters the structure of lexical output, likely due to increased executive demands. Other studies provide complementary evidence on verbal fluency in bilinguals. In a more recent study, Jevtović et al. (2020) examined 40 balanced Spanish–Basque bilinguals and found that participants produced significantly more words in the voluntary dual-language condition (M = 16.1, SD = 6.12) than in the forced/cued dual-language condition (M = 11.5, SD = 4.03) or in the weaker single-language condition (Basque only: M = 12.6, SD = 5.27). However, voluntary dual-language performance did not surpass the stronger single-language condition (Spanish only: M = 18.4, SD = 7.59), suggesting that freely using two languages improves output compared to forced switching or the weaker language, but does not exceed the dominant language. Categories included animals, clothes, fruits and vegetables, and furniture.

General normative data for verbal fluency tasks provide a benchmark for comparing bilingual and monolingual performance. Troyer (2000) collected data from 411 healthy adults aged 18–91, administering both phonemic fluency tasks and semantic fluency tasks (Animals and Supermarket categories) in English. Mean scores for semantic fluency were 19.5 ± 5.3 for Animals and 22.9 ± 5.8 for Supermarket items. Lazaridou-Chatzigoga and Alexiadou (2025) compared Greek–English late bilinguals to Greek monolinguals using semantic fluency tasks (animals, fruits/vegetables, objects).

[3]Forced corresponds to constrained, cued or alternate switching conditions.

While monolinguals produced more words overall, both groups showed similar clustering patterns.

Recent studies also suggest that verbal fluency norms may vary across languages and cultural contexts, and increasing efforts are being made to collect normative data from more diverse populations (Ardila, 2020; Villalobos et al., 2023). For Arabic, Khalil (2010) assessed 215 Saudi healthy adults, aged between 18 and 59 years, using a semantic fluency task tackling the category of animals. Younger adults (17–29 years, $n = 98$) produced on average 16.58 words (SD = 3.30), while participants aged 30–39 ($n = 70$) produced a mean of 17.82 (SD = 2.54). For Egyptian Arabic, Abdel Aziz et al. (2017) assessed 139 healthy adults aged 20–93 on animal semantic fluency. Overall, participants produced an average of 14.63 words (SD = 5.28), and in the younger group (20–40 years, $n = 55$), the mean was comparable to Khalil (2010)'s findings, at 17.84 (SD = 5.82).

Studies on Lebanese populations more specifically provide additional context for interpreting fluency performance in Lebanese Arabic. In younger adults (ages 19–39), Jebahi et al. (2022) reported category fluency means ranging from 7.24 ± 1.76 for Accessories to 17.96 ± 5.17 for Animals and Body Parts, with other categories falling in between (e.g., Fruits: 15.16 ± 2.46; Vegetables: 14.88 ± 3.63; Clothes: 11.68 ± 3.24). Age and education positively influenced performance, whereas gender showed no significant effect, and category-specific analyses suggested differential contributions of semantic (education) and non-semantic (age) components. Among older Lebanese adults (aged 55 years and above), El-Hayeck et al. (2023) reported that education remained the strongest positive predictor of category fluency, while age had a negative effect, particularly in category tasks. Gender differences were observed in vegetables and fruits, with women scoring slightly higher than men (Vegetables: Male 11.6 ± 3.8, Female 12.7 ± 3.7; Fruits: Male 10.3 ± 3.2, Female 11.1 ± 3.2), and Animals showing similar performance across genders (Male 13.2 ± 4.4, Female 12.8 ± 4.1). These data provide normative benchmarks for Lebanese adults, which are useful for comparative analyses when evaluating performance under voluntary versus forced bilingual fluency conditions.
These studies provide normative benchmarks for English, as well as Lebanese Arabic in Lebanese adults (Table 2.1), which can be used for comparative analyses when evaluating performance under voluntary and forced bilingual fluency conditions.

Study	**Language**	**Sample (n)**	**Age**	**Animals**	**Vegetables**	**Fruits**	**Clothes**
Troyer (2000)	English	411	18–91	19.5 ± 5.3	–	–	–
Khalil (2010)	Saudi Arabic	98	17–29	16.58 ± 3.30	–	–	–
Khalil (2010)	Saudi Arabic	70	30–39	17.82 ± 2.54	–	–	–
Abdel Aziz et al. (2017)	Egyptian Arabic	55	20–40	17.84 ± 5.82	–	–	–
Abdel Aziz et al. (2017)	Egyptian Arabic	139	20–93	14.63 ± 5.28	–	–	–
Jebahi et al. (2022)	Lebanese Arabic	25	19–39	17.96 ± 4.68	14.88 ± 3.63	15.16 ± 2.46	11.68 ± 3.24
El-Hayeck et al. (2023) Male	Lebanese Arabic	277	55–64	13.2 ± 4.4	11.6 ± 3.8	10.3 ± 3.2	–
El-Hayeck et al. (2023) Female	Lebanese Arabic		55–64	12.8 ± 4.1	12.7 ± 3.7	11.1 ± 3.2	–

Table 2.1: Semantic Fluency Means across Studies and Categories

2.4.3 Language Switch and Mixing Costs

Language switching in bilinguals often requires measurable performance costs, reflecting the cognitive effort needed to alternate between languages.

A *switch cost* refers to the cost of switching between languages, manifested as longer Response/Reaction Time (RT) on switch trials compared to stay trials, in mixed-language blocks. It reflects temporary adjustments between tasks from trial to trial, representing the challenge of selecting the appropriate language on each trial. The cue may be presented in advance (before the item rather than along with it), in which case the switch cost is reduced, but never absent (Declerck et al., 2013; Festman & Mosca, 2016; Mosca & Clahsen, 2016).

A *mixing cost* refers to the cost of managing two languages even when not switching, manifested as longer RT on stay trials from mixed-language blocks compared to Single-language blocks. It reflects a sustained control process across all trials in mixed blocks, as participants have to maintain two languages active and monitor the language cue (Festman & Schwieter, 2015).

In cued language switching, *switch costs* are large, as the external cue imposed by the task leads to additional cognitive demands. These external cues require the activation of both the target language and its corresponding control mechanisms, while simultaneously inhibiting the non-target language. This process is more demanding compared to using a single language (Green, 1998). As a result, when bilinguals switch between languages in a cued task, the need to inhibit the non-target language results in a notable increase in RT (slower responses) compared to stay trials (Costa & Santesteban, 2004; Meuter & Allport, 1999).

The switch cost is often significantly reduced in bilingual naming situations where no cue is involved. In voluntary picture-naming, bilinguals are free to switch between languages at will, and for FCS, this flexibility often results in significantly lower switch costs (De Bruin et al., 2018; Jevtović et al., 2020). This suggests that the cognitive demands of language switching are reduced when bilinguals can freely alternate between languages without the constraints imposed by cues, which better reflect natural, everyday bilingual language use. These results, often based on behavioral data, were also confirmed by Magnetoencephalography (MEG) (Blanco-Elorrieta & Pylkkänen, 2017) analyses.

Regarding *mixing costs*, some studies have found that voluntary switching can lead to lower cognitive costs compared to cued switching, with reduced mixing costs in voluntary conditions. For instance, in a study on 32 Spanish–Basque bilinguals, Jevtović et al. (2020) used two picture-naming tasks, one purely voluntary and one with intermixed cued and voluntary trials, and found lower mixing costs in the fully voluntary condition. Interestingly, some studies even report a mixing benefit rather than a cost, where bilinguals respond faster when they can switch languages freely than when restricted to a single language. In an extensive study on switching costs and benefits, Gollan and Ferreira (2009) assessed 73 Spanish–English bilinguals using a voluntary LSP. They found, among other results, that unbalanced bilinguals exhibited a mixing benefit in the nondominant language, whereas balanced bilinguals showed a mixing cost even when switching voluntarily. Similarly, De Bruin et al. (2018), in two studies involving 55 and 45 Spanish–Basque bilinguals respectively, found a clear mixing benefit in the voluntary condition compared to the cued one. This mixing benefit was found in both balanced and unbalanced bilinguals, contrary to Gollan and Ferreira (2009), and suggests that freely using both languages is less demanding than being restricted to just one for FCS, due to lower suppression of the non-target language.

Additionally, several tendencies have been observed that might reflect the involvement of proactive and reactive inhibitory control in switch and mixing costs in the literature (Declerck & Koch, 2023). *Proactive control*, as described in the DMC (Braver, 2012; Chiew & Braver, 2017) (see Section 2.2.5), involves anticipatory inhibition of the non-target language, preparing the bilingual speaker to avoid interference before it occurs and characterized by sustained, preparatory neural activity that maintains task goals prior to response execution. *Reactive control*, in contrast, refers to post hoc suppression of the non-target language, activated to resolve interference during language production and characterized by transient neural activity.

Proactive control is manifested by two empirical effects (Declerck & Philipp, 2015): *reversed language dominance* and *blocked language order effect*.

- The *reversed language dominance effect* occurs when bilinguals perform worse in their dominant language (L1) than in their less dominant language (L2) in mixed-language blocks. The extent of

L2 exposure relative to L1 appears to influence the emergence of this effect, as well as increased L2 activation (Christoffels et al., 2007). This effect may be explained by the proactive inhibition of L1 throughout mixed-language blocks, which brings L1 and L2 activation closer together and can improve overall performance.

- The *blocked language order effect* occurs when Single-language block performance is worse if it follows a single-language block in a different language. It may be explained by proactive inhibition, where performing in one language (L2) temporarily suppresses the other (L1), leading to lower performance when switching to that previously inhibited language.

On the other hand, the main indicators of reactive inhibitory control are *asymmetrical switch costs* and *n-2 language repetition costs*.

- *Asymmetrical switch costs* are prominently found in unbalanced bilinguals as a marker of bilingual inhibitory control. They appear as larger switch costs for L1 than for L2, reflecting the greater difficulty of switching to the more dominant language compared to the less dominant one (Meuter & Allport, 1999). For balanced bilinguals, some studies have instead found symmetrical switch costs in both languages (Costa & Santesteban, 2004; Festman & Schwieter, 2015).
- *n−2 language repetition costs* are typically observed in trilingual mixed-language blocks. They refer to slower or less accurate performance when returning to a language that was used two trials earlier (ABA sequence) compared to switching to a language not used in the previous two trials (CBA sequence) (Guo et al., 2013; Philipp et al., 2007).

These effects, while robust in controlled laboratory settings, raise the question of how language control operates in more naturalistic, everyday contexts, motivating the examination of more ecological tasks.

2.4.4 Language Switching in Ecological Contexts

Several studies have emphasized the importance of examining language switching in ecologically valid contexts, although the definition of *ecological* varies across studies. Blanco-Elorrieta and Pylkkänen (2017), for instance, conceptualized ecological bilingual production as single-picture naming, using the faces of ethnically English versus Arabic women as cues. In contrast, Sanchez et al. (2022) defined ecological as the production of short sentences rather than single words to describe action pictures. In their study with 26 highly proficient English–Spanish bilinguals, they observed switch costs for sentences produced in the second language, but no significant costs for sentences in the first language.

Moving toward more naturalistic settings, Myers-Scotton (2006) highlighted the value of naturally occurring code-switching in unstructured interviews for linking descriptive sociolinguistic data with psycholinguistic theory. Building on this approach, Yim and Bialystok (2012) examined semi-structured conversations where participants narrated events prompted in different languages (e.g., future career plans in English, Chinese New Year in Chinese). They derived a *code-switching score* as the number of switches divided by total speaking time in each condition. Similarly, Faroqi-Shah and Wereley (2021) used a conversational paradigm with English–French bilinguals, where pairs were asked to discuss three topics freely and switch languages as naturally as possible. Their results showed that producing a switch incurred a time cost regardless of direction or type, although switches were more frequent from L2 (French) to L1 (English).

Other work has used large-scale corpora. Following an analytical approach, Fricke and Kootstra (2016) investigated primed code-switching in the English–Spanish *Bangor Miami Corpus* (Deuchar et al., 2014), which comprises 56 conversations, each lasting 30 minutes, between 84 bilinguals. They found that code-switching was promoted by several factors:

- Presence vs. absence of code-switching in the interlocutor's speech,
- Default language of the conversation,
- Language of the preceding utterance,
- Language of the preceding ten utterances,
- Speaker change,
- Lexical overlap in the other language with the preceding utterance,
- Lexical overlap in the other language with the preceding ten utterances.

Further research on dialogue dynamics and interactive alignment (Kootstra et al., 2020) demonstrates that prior language use, lexical triggers, and interlocutor behavior strongly shape spontaneous switching. Methodological advances such as *Ecological Momentary Assessment* (EMA) and community-based analyses provide additional insight, tracking real-time switches in everyday contexts. For instance, EMA can track code-switching through a mobile application that prompts participants multiple times per day, assessing intended and unintended switches as well as the proportion occurring in contextually typical situations, revealing aspects of inhibitory control, set shifting, and working memory that laboratory paradigms may overlook. (Cacoullos & Travis, 2015; Jylkkä et al., 2020).

Collectively, these findings underscore the necessity of ecological approaches for fully capturing bilingual language control in naturalistic interaction.

2.5 Sources of Variability in Language Control

Language control in bilinguals is influenced by a variety of factors, including variables specific to experimental tasks as well as individual participant characteristics.

2.5.1 Experimental Design Variability

Experimental design features vary across studies and can contribute to variability in observed language control costs. Five key parameters are commonly reported (Festman & Mosca, 2016; Mosca, 2017):

- **Stimulus-Onset Asynchrony (SOA)**: Stimulus Onset Asynchrony (SOA) is the time between the onset of one stimulus and the onset of the next.
- **Response-Cue Interval (RCI)**: Response-Cue Interval (RCI) is the interval between the participant's response and the display of the next cue.
- **Response-Stimulus Interval (RSI)**: Response-Stimulus Interval (RSI) is the interval between the participant's response and the presentation of the next stimulus.
- **Cue-Stimulus Interval (CSI)**: Cue-Stimulus Interval (CSI) is the time between the display of the language cue (indicating which language to use) and the presentation of the upcoming stimulus, corresponding to preparation time.
- **Inter-Trial Interval (ITI)**: Inter-Trial Interval (ITI) is the interval between the display of one stimulus and the start of the subsequent trial.

Variations in timing parameters can influence the ease of language selection and switching because they affect the time available for preparing the upcoming response, recovering from the previous response, and resolving interference from competing languages. Shorter intervals increase competition and reduce preparation time, inflating observed switch and mixing costs, whereas longer intervals allow more time for proactive control and adjustment, potentially reducing these costs. For instance, Hirsch et al. (2016) observed slower responses following a short RSI compared with a long RSI. Extending these findings, several studies directly manipulated preparation time: Mosca et al. (2022) found that when Dutch-English bilinguals were given no preparation time (CSI = 0 ms), switching costs were substantial, but they disappeared when preparation time was provided (CSI = 250–800 ms). Similarly, Mosca and Clahsen (2016) and Shen (2023) reported that both switch and mixing costs decreased as the CSI and the RCI increased, indicating that sufficient preparation allows the cognitive system to anticipate and fully prepare for the upcoming language, thereby facilitating smoother language transitions. Festman and Mosca (2016) further showed that this preparation effect interacts with language proficiency, being largest for L1 and smaller for less proficient languages. These results collectively highlight that preparation time is a critical factor modulating both transient (proactive) and sustained (reactive) control processes in bilingual language production.

2.5.2 Individual Variability

In addition to experimental design, individual characteristics also influence language control performance, often in interaction with lexical access abilities.

L2 Proficiency

Higher L2 proficiency and more balanced language experience are generally associated with smaller, often symmetric, switch costs, whereas late L2 acquisition or strong L1 dominance tends to produce larger or asymmetrical costs (Declerck & Koch, 2023; Festman & Schwieter, 2015). For instance, Bonfieni et al. (2019) found that bilinguals' active L2 proficiency, measured by speeded naming tasks, predicted faster switch trials in both languages, in line with classic findings (Costa and Santesteban, 2004; Meuter and Allport, 1999, indicating that balanced proficiency yields minimal asymmetry). In contrast, low-proficiency bilinguals often show pronounced asymmetrical costs.

Age of Acquisition (AoA)

AoA also shapes control, in part via its effect on dominance. Early L2 acquisition often leads to more balanced dominance, whereas in many studies with late learners the L1 remains the dominant language. Notably, Bonfieni et al. (2019) observed that later AoA of a L2 predicted faster L2 naming in a mixed-language task. This suggests that late acquisition may lead to a more dominant L1, which can facilitate L2 access when both languages are co-activated. In other words, the later the L2 was acquired, the more it may rely on the established L1 system, potentially enhancing efficiency in bilingual language control.

Language Dominance and Preference

The general dominance or preference for one language has a critical influence on control. In practice, dominance can be measured in different modalities (Birdsong et al., 2012; Marian et al., 2007). For example, R. Wu and Struys (2022) found that even self-identified L1-dominant Uyghur–Chinese bilinguals recognized words faster in L2 (Chinese) than in L1, reflecting their self-reported preference for reading in L2.

Language Use and Code-Switching Habits

Language use is shaped by several factors, including the frequency and context of exposure, the languages spoken by daily interlocutors, the eventual Length of Residence (LOR) in a foreign country (Birdsong et al., 2012; Gullifer & Titone, 2020; Marian et al., 2007), and code-switching habits (Kheder & Kaan, 2021; Olson, 2022; Rayo et al., 2024). All these factors influence how bilinguals manage their languages across different communicative contexts (Green & Abutalebi, 2013; Grosjean, 2008), which can be quantified using various measures.

Language Entropy (LE)

One particularly interesting measure is LE (Gullifer & Titone, 2018, 2020), which captures part of the complexity of language use in bilinguals by quantifying how languages are distributed across different contexts (refer to Section 1.1.2.4 for a detailed description). LE is a continuous measure ranging from 0 to $\log_2 n$, where n is the number of languages considered. Low values (closer to 0) indicate compartmentalized use, where only one language is used in a given context and language choice is highly predictable. Higher values reflect more integrated use, where several languages may be used within the same context and language choice becomes less predictable. Thus, LE provides both a categorical perspective (compartmentalized vs. integrated use) and a continuous representation of bilingualism.

In their study, Gullifer and Titone (2020) tested bilinguals in Montreal, a city characterized by frequent language switching in daily life, and mapped LE on two languages across five domains: home (with family), social (with friends), work, reading, and speaking. Their results showed the highest LE in the Social context ($M = 0.94 \pm 0.28$), followed by moderate levels in Work ($M = 0.76 \pm 0.37$) and Speaking ($M = 0.70 \pm 0.41$), and lower entropy in Home ($M = 0.61 \pm 0.46$) and Reading ($M = 0.60 \pm 0.41$).

Given the recency of LE, few studies have computed it, yet a growing body of research is encouraging its use as a continuous measure of bilingualism in sociolinguistic studies (De Bruin, 2019; Gullifer et al., 2021; Kremin & Byers-Heinlein, 2021). In one of the rare recent studies actually using LE, Wagner et al. (2023) tested 523 bilinguals speaking over 45 different languages (e.g., Albanian, Chinese, Arabic, Dutch, French, Russian) alongside English, in Toronto. These participants were not FCS, exhibiting more compartmentalized language use than the participants in Gullifer and Titone (2020)'s study. LE was computed based on participants' responses to the LSBQ across 25 potential micro-contexts[4]. Across most communicative contexts, LE values were substantially lower, ranging from $M = 0.09$ to $M = 0.62$, reflecting a more compartmentalized pattern of language use compared with the highly integrated bilinguals in Gullifer and Titone (2020). Another study on non-FCS by Baulande and Köpke (in preparation) assessed LE in 58 native French speakers of English, with L2 proficiency levels ranging from A1 to C2, measured on a 0–100 scale using the *Oscar* tool (Centre d'Étude de Langues, 2025). Participants were divided into three L2 proficiency groups based on their continuous scores (Group A:

[4]Parents, Siblings, Grandparents, Relatives, Partner, Roommates, Neighbors, Friends, Home, School, Work, Social Activities, Religious Activities, Extracurricular Activities, Shopping/Restaurants, Healthcare, Email, Texting, Social Media, Writing lists, TV, Movies, Internet, and Praying.

0–40, Group B: 40–70, Group C: 70–100). Their results showed that LE varied as a function of L2 proficiency: Group A had a mean LE of 0.495 (± 0.141), Group B 0.561 (± 0.130), and Group C 0.627 (± 0.121), indicating that more balanced bilinguals exhibited higher entropy and lower variability.

Other Social and Biographical Variables

Aside from factors related to language acquisition and use, some additional inter-individual variables may also have an impact on bilingual language switching.

Age, gender and educational level were found by Dewaele and Wei (2014) to have an impact on language switching habits, with female participants and those at both the lowest and highest levels of education showing the greatest appreciation of code-switching, while participants in their teens and twenties expressing less appreciation than older adults. Additionally, code-switching seems more acceptable in bilingual and bicultural communities than in monolinguals (Yim & Clément, 2021). The motivation for switching languages also influences its practice: for some, code-switching is evicted as it is thought to show poorer knowledge of each language alone, while for others, it is a sign of higher socio-economic status (Smairat, 2020).

Summary of Chapter 2

The literature reviewed in this chapter shows that code-switching offers a valuable lens into bilingual language control. Theoretical models, from the Language Mode Hypothesis to the Adaptive Control Hypothesis, converge on the idea that bilinguals have to active, inhibit, and select between languages dynamically. Behavioral and neural evidence further shows that switching imposes measurable control demands, though more ecological observations suggest that bilinguals, especially frequent code-switchers, often manage these demands fluidly in daily communication. Distinctions between code-switching, mixing, and borrowing further clarify that some forms of language switching reflect structural integration, while others serve primarily communicative or discourse functions. Individual differences, including L2 proficiency, language dominance, and switching habits among others, shape how control is used and whether switching results in costs. Overall, these findings highlight the complexity of bilingual language control and point to the need for empirical research bridging experimental paradigms and ecological contexts, particularly in frequent code-switchers, such as in the Lebanese population, while taking individual differences into consideration.

Chapter 3

The Domain Generality vs. Specificity of Language Control

While code-switching allows to measure language control behaviorally, an ongoing theoretical debate concerns the nature of these control mechanisms: are they specific to language, or do they rely on domain-general executive functions?

3.1 Theoretical Debate

There is an ongoing debate in the literature concerning the relationship between language switching and executive functions[1]. The central question is whether the control processes that support bilingual language use rely on domain-general executive functions, such as inhibition, set shifting, and working memory, or whether they reflect mechanisms that are specific to language. Researchers advocating a domain-general perspective argue that bilinguals recruit the same control processes engaged in non-linguistic tasks, whereas others claim that language control relies on specialized, language-specific mechanisms.

This debate lies at the core of models such as Green's ICM (1998) and the Adaptive Control Hypothesis (2013), which posit that multiple inhibitory and control processes are involved in managing bilingual language use. Empirical studies have thus examined the presence or absence of shared control mechanisms between language and executive control by employing a range of executive tasks both with and without linguistic components.

This line of research is also motivated by the broader question of the "bilingual advantage," which asks whether bilingualism favors the increase of executive abilities compared to monolingualism due to their more frequent engagement of control processes.

The debate is further complicated by differences in how the components of ICM (Green, 1998) and ACH (Green & Abutalebi, 2013) are interpreted and operationalized. Initially, the ICM conceptualized the inhibitory component in relation to language. As stated above (in Section 2.2.3), in its updated

[1]"Domain-general control" is referred to in multiple ways in the literature. Terms such as "executive functions", "executive control", "cognitive control", and "domain-general control" are often used interchangeably to describe the same underlying concept.

version, the ACH, the authors suggest a "refined" version of Miyake et al. (2000)'s inhibition as three separate components (inhibition, set shifting, updating), by introducing eight control processes, such as goal maintenance, salient cue detection, and opportunistic planning (see Figure 2.4 for full list). However, these processes are applied to interactional contexts (single-language, dual-language, and dense code-switching) in the ACH, justifying their direct relationship with a linguistic component. In the literature based on the ACH as a theoretical framework, the way control is operationalized is not always clear: a large part of those studies refer to the ACH by only evaluating the control processes, using executive tasks such as the Simon task, Go/No go or Flanker (Kałamała et al., 2020; Semenova et al., 2025), while a more restricted number of studies identifies these processes as specific to language control, by exclusively assessing them within Green and Abutalebi (2013)'s interactional contexts (Blanco-Elorrieta & Pylkkänen, 2017). This fine line between executive and language control, referred to as 'the dynamics of control' by Green and Abutalebi (2013, p. 518) (with no explicit mention of "executive" nor "language" control), may be the origin of the conceptual confusion leading to this open debate within this extensively studied framework.

3.1.1 Domain-General Executive Control

Miyake et al. (2000)'s definition of domain-general control comprises three components: inhibition, set shifting and working memory.

Inhibition of prepotent responses refers to "one's ability to deliberately inhibit dominant, automatic, or prepotent responses when necessary" (Miyake et al., 2000, p.57). It can be assessed through multiple tasks, such as the Stroop task (Stroop, 1935) for verbal inhibition, involving language responses, as well as the Flanker task (Eriksen & Eriksen, 1974) and the Simon task (Simon & Rudell, 1967) for nonverbal material.

Set shifting refers to "shifting back and forth between multiple tasks, operations, or mental sets" (Miyake et al., 2000, p.55), and is classically tested through the *number-letter task* (Rogers & Monsell, 1995), updated to the *Trail Making Test* (Reitan, 1971), as well as the *Wisconsin Card Sorting Test* (Grant & Berg, 1993).

Finally, *working memory*, also called *updating*, "actively manipulate[s] relevant information in working memory, rather than passively store information" (Miyake et al., 2000, p.57). It is assessed through the *letter memory task* (Miyake & Friedman, 2012; N. Morris & Jones, 1990) in which participants are presented a series of letters they should memorize, or similarly a *number memory task* such as that in the *Weschler Adult Intelligence Scale* (Wechsler, 1955) where participants are asked to recall a series of numbers in identical, inverse and ascending order.

Together, inhibition, set shifting and updating contribute to complex executive tasks, as described by Miyake et al. (2000)'s structural equation modeling, in Figure 3.1, that illustrates the three executive functions, along with tasks used to assess each one of them.

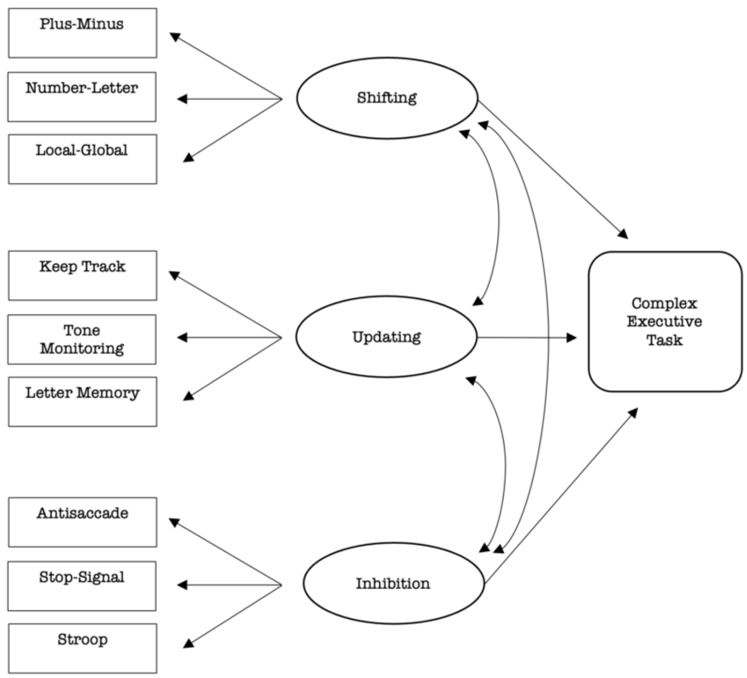

Figure 3.1: Structural Equation Modeling, redrawn and adapted from Miyake et al. (2000)

3.1.2 The Bilingual Advantage

Building on the domain-generality hypothesis for language control, the existence of a bilingual advantage has been extensively debated in the literature (Bialystok et al., 2012; De Bruin et al., 2021). According to this perspective, the constant need to manage two languages provides bilinguals with enhanced executive functions compared to monolinguals.

Despite the fact that most studies follow the definition of executive functions by Miyake et al. (2000), considerable variability exists in how the bilingual advantage has been captured across executive tasks. Some studies define it relative to baseline performance (interference effects), whereas others interpret any performance difference between bilinguals and monolinguals as potential evidence for an advantage. However, concerns have been raised about the robustness of these findings. For instance, De Bruin et al. (2015) reported signs of both confirmatory and publication bias: while 68% of studies supporting a bilingual advantage were published, only 36% of studies challenging it appeared in print, and 50% of those reporting mixed results were published. When correcting for publication bias, Lehtonen et al. (2018) concluded that the bilingual advantage largely disappears. Similarly, Donnelly (2016) found no effect of bilingualism on task switching, with benefits restricted only to interference control. In a comprehensive review, Paap et al. (2015) further emphasized the role of confounding variables and argued that the overall distribution of findings is consistent with a null effect. They also criticized the poor convergent validity of executive function tasks, noting that even if bilinguals outperform monolinguals on some measures, they may perform equally or worse on others (Mattschey, 2023).

3.1.3 Language-Specific Control in Non-Linguistic Executive Tasks

While domain-general accounts suggest overlap between executive functions and language control, other researchers argue for mechanisms specific to language. According to this perspective, bilingual language control is tailored to the demands of managing multiple languages and may not fully rely on the processes used in non-linguistic tasks. As seen in Section 2.2.3, Green and Abutalebi (2013) identify eight processes covering language control in different interactional contexts. For example, *goal maintenance* is necessary in single-language and dual-language contexts, as the speaker needs to keep in mind the language to use with each interlocutor, while *opportunistic planning* is more characteristic of the dense code-switching context where the individual mixes languages rather frequently. From this perspective, these processes should be regarded as language-specific, highlighting the unique mechanisms involved in managing multiple languages.

Empirically, Hartanto and Yang (2020) assessed *goal maintenance* using several tasks, including a color-shape switching task, where participants responded as quickly and accurately as possible to either the color or shape of bivalent targets according to given cues; a magnitude-parity switching task, in which participants classified a bivalent digit by parity or magnitude based on the cue; and an animacy-locomotion switching task, in which participants classified stimuli by animacy or locomotion. To measure interference control and salient cue detection, Ng and Yang (2022) employed the Attention Network Test for Interaction and Vigilance (ANTI-V), an adapted Flanker task using flanked cars. *Opportunistic planning* was also evaluated by Ng and Yang (2022) through an adapted Hayling sentence completion task, in which participants completed sentences with the most contextually appropriate words as quickly and accurately as possible, using any language to achieve the task goal.

Interestingly, the same Flanker-like tasks are used to measure multiple control processes, such as processing speed, nonverbal inhibition, selective attention, conflict monitoring, reflecting task impurity as reported by Hartanto and Yang (2020), where a single task can engage several mechanisms and blur distinctions between specific processes, making it difficult to isolate the contribution of each individual control process.

Ultimately, evidence supporting language-specific control includes studies showing dissociation between performance on linguistic and non-linguistic executive tasks (Lehtonen et al., 2023), neural regions uniquely activated during language switching (Jiao et al., 2022), and the study of aphasic patients whose executive functions remain preserved while having language difficulties (Ezzedine, 2023).

3.2 Experimental Evidence

3.2.1 Overlap Between Language Control and Executive Functions

Recent behavioral research has shown evidence for an overlap between language control and domain-general executive functions, as reported in Table 3.1. For instance, W. Xie and Ng (2024) investigated how bilinguals' switching frequency influenced executive function performance. Their research combined questionnaires on cultural and language behavior with experimental tasks. In Study 1 (n = 233), priming paradigms examined how young adult bilinguals shift between cultures in different social contexts, using Western, Neutral, and Ethnic (Chinese, Malaysian, Indian) cues. In Study 2 (n=48), participants completed classic executive function tasks: Simon, Flanker, Wisconsin Card Sorting Test (WCST), and Attention Network Tasks, to test whether frequent cultural-linguistic switchers show advantages in interference control, set shifting, and attention. They found that FCS outperformed infrequent switchers on tasks measuring inhibition, attention, and set shifting, suggesting that bilingual switching experience can enhance general cognitive control. Similarly, Z. Xie and Zhong (2024) compared cognitive control in bilinguals and bidialectals using the Flanker task and the WCST. They reported that high L2 proficiency was associated with better cognitive control, whereas dialect proficiency had no effect, indicating that bilingualism (but not bidialectalism) engages domain-general control processes. On the other hand, Declerck, Ivanova, et al. (2020) reported an opposite pattern in a register-switching study, demonstrating that control processes engaged during single- and dual-language production partially overlap, suggesting that some mechanisms may be shared across contexts, also in bidialectalism.

Some neurophysiological evidence further supports the overlap between language control and general executive functions. Declerck, Meade, et al. (2021b) used ERP to examine bilingual language-switching and task-switching, revealing similar neural responses for both types of switching. fMRI studies also demonstrated that language switching may engage neural networks commonly associated with executive control. M. Chen et al. (2021) showed that short-term language-switching training in unbalanced Chinese-English bilinguals modulated the efficiency of the domain-general cognitive control network, including regions such as the ACC and the pre-SMA. Mouthon et al. (2020) reported that L2 proficiency influenced brain activity during both linguistic and non-linguistic tasks, with low-proficiency bilinguals relying more on domain-general control regions, indicating that language selection and general executive tasks recruit similar neural resources. Similar findings were reported by Köpke et al. (2021), who showed that highly proficient bilinguals use the same neural network for language production and control regardless of age of acquisition, although structural differences were observed in regions associated with language control.

Meta-analyses also reinforce this perspective. Tao et al. (2021) reviewed 210 studies and concluded that bilingual language control largely relies on neural mechanisms shared with general cognitive functions, with bilingual experience contributing to neuroplasticity. In a quantitative review of bilingual aphasia studies, Nair et al. (2021) found that although both domain-general and language-specific control processes were involved, domain-general mechanisms sustained by regions such as the ACC, basal ganglia, and frontal lobe were more consistently engaged in language control.

Joint behavioral and neuropsychological evidence also supports this overlap. Gray (2020) examined bilingual adults with aphasia compared to age-matched bilingual controls and found that correlations between verbal and nonverbal control tasks were especially apparent under conditions of high cognitive load, further suggesting that domain-general executive resources are recruited when language demands increase. Table 3.1 summarizes key studies examining the overlap between language control and executive functions, highlighting evidence for domain-general mechanisms.

Study	Bilingualism	Sample (n)	Task	Method	Statistical Analysis	Key Findings
W. Xie and Ng (2024), Exp. 1	Singaporean (Languages not reported)	233 participants	Self-report, & cultural frame priming task	Questionnaire & Behavioral	ANOVA	Cultural switching frequency affects cognitive processing.
W. Xie and Ng (2024), Exp. 2	Singaporean (Languages not reported)	48 participants	Executive tasks: Simon, Flanker, WCST & Attention Network	Behavioral	ANOVA	A link exists between cultural-linguistic switching frequency and executive function performance.
Z. Xie and Zhong (2024)	Chinese-English	70 participants	Flanker and WCST	Behavioral	ANOVA	High L2 proficiency was associated with better executive control.
Declerck, Meade, et al. (2021b)	English-Spanish	26 participants	Cued LSP & TSP	Behavioral and ERP	Bayesian	No significant differences in switch-related ERP patterns (cue- or picture-locked) between LSP and TSP.
M. Chen et al. (2021)	Chinese-English	46 participants	LSP & TSP training task	Behavioral & fMRI	Linear regression analysis	Training reduced connectivity between the dACC/pre-SMA and the right thalamus, indicating more efficient domain-general cognitive control.
Nair et al. (2021)	English, Catalan, Dutch, French, etc., Bilingual with Aphasia (BwA)	20 studies	Executive: Flanker, Stroop, digit span, WCST & TSP	Behavioral & fMRI	Meta-analysis	Evidence for mainly domain-general control in BwA.
Tao et al. (2021)	English, Italian, Basque, Japanese, etc.	210 studies	LSP, TSP, Executive tasks: Flanker, Stroop, Go/No Go, digit span	Behavioral, EEG & fMRI	Meta-analysis	Bilingualism affected domain-general cognitive neural mechanisms, brain function, and structure, contributing to neuroplasticity and cognitive reserve across the lifespan.
Gray (2020)	Spanish-English	12 BwA & 20 controls	Language, semantic and nonverbal control tasks	Behavioral	ANOVA	BwA exhibited weaker semantic control, and correlations between language and nonverbal control suggest domain-general control effects under increased cognitive load.
T. Wu et al. (2020)	Not reported	289 studies	Executive: Flanker, Stroop, digit span, WCST, Simon tasks, etc.	Behavioral and fMRI	Meta-analysis	Uncertainty (ambiguity in decision-making or response selection) increased activation across the cognitive control network, confirming its domain-general role in supporting goal-directed behavior.
Mouthon et al. (2020)	French–German, French–English, German–French, German–English	35 participants	Letter-digit combinations and Picture-naming	Behavioral & fMRI	ANOVA	L2 proficiency modulated engagement of domain-general control brain regions, with greater resource demands in low-proficiency bilinguals.
Declerck et al. (2017)	German-English (2 exp), French-English (1 exp)	24 participants per experiment	Digit Categorization & LSP	Behavioral	ANOVA	Positive correlation between language- and task-switching; switch costs differed for linguistic but not non-linguistic tasks, suggesting overlapping mechanisms.
Calabria et al. (2012)	Catalan–Spanish	14 (exp 1), 15 (exp 2)	LSP (linguistic) and Card Sorting (non-linguistic)	Behavioral	ANOVA	Highly proficient bilinguals showed symmetrical switch costs in linguistic tasks but not in non-linguistic tasks, suggesting bilingual language control is only partly independent from domain-general executive control.

Table 3.1: Summary of Studies on the Overlap Between Language Control and Executive Functions

3.2.2 Dissociation Between Language Control and Executive Functions

In contrast to studies reporting an overlap, other research suggests that bilingual language control does not fully rely on domain-general control. Instead, dissociations have been documented across behavioral, electrophysiological, and large-scale experimental approaches. Table 3.2 summarizes key studies examining the dissociation between language control and executive control, supporting a language-specific perspective.

From a behavioral perspective, Paap et al. (2019) found no evidence that bilingual language control generalizes to nonverbal interference tasks. In a study comparing bilinguals and monolinguals across four interference paradigms, the authors found no evidence of a general bilingual advantage, and correlations between tasks were weak. This suggests that the inhibitory processes engaged by bilinguals may be highly task-specific, perhaps limited to lexical-level competition rather than broad domain-general inhibition. Similarly, Kałamała et al. (2020) tested the predictions of the ACH in a large-scale correlational study using latent variable modeling and Bayesian estimation. The intensity of dual-language context experience was unrelated to response inhibition efficiency, further supporting a dissociation between bilingual language control and domain-general inhibitory control. Likewise, Kheder et al. (2025) tested whether code-switching enhances non-linguistic conflict monitoring. Using a Flanker task following sentences with and without code-switches, they found no improvement in executive control; in fact, conflict effects were sometimes larger after code-switched sentences, suggesting that code-switching may temporarily tax rather than boost attentional resources. Also using a Flanker task, Hofweber et al. (2016) found that German–English bilinguals who engaged more frequently in dense code-switching exhibited enhanced inhibitory control and conflict-monitoring, suggesting that specific bilingual experiences, such as dense code-switching, may shape executive functioning in a language-specific manner. A complementary line of research used large-scale modeling. In a study with 957 participants, Bejjani et al. (2022) examined whether adaptation to conflict and to task-switching reflects shared or separate control mechanisms. Results showed distinct but correlated control-learning systems, indicating that people regulate distractors and task-switching through partially independent mechanisms.

Electrophysiological findings further underscore the complexity of the link between language control and executive control. Zunini et al. (2019) compared young and older bilinguals and monolinguals on TSPs. While bilinguals showed smaller switch and mixing costs behaviorally, ERP results revealed divergent neural dynamics: bilinguals exhibited larger N2 amplitudes than monolinguals, and older bilinguals showed smaller P3b amplitudes, indicating that the neural strategies recruited during task control differ between groups. According to the authors, these patterns suggest that bilinguals may not rely on the same neural pathways as monolinguals, supporting the possibility of bilingual-specific adaptations in control.

Study	Bilingualism	Sample (n)	Task	Method	Statistical Analysis	Key Findings
Kheder et al. (2025) Exp. 1	Spanish-English	112 participants	Oral Sentence-Flanker task (with dense or insertional switches)	Behavioral	MEM	No effect of code-switching on Flanker performance.
Kheder et al. (2025) Exp. 2	Spanish-English	128 participants	Oral Sentence–Flanker task (blocked switch type)	Questionnaire (BLP, BCSP) and Behavioral	MEM	Conflict effect was bigger after code-switched than monolingual sentences, mainly for incongruent Flankers; switch type had no effect, and overall RTs were faster after dense switches.
Kheder et al. (2025) Exp. 3	Spanish-English	128 participants	Written Sentence–Flanker (blocked switch type)	Questionnaire (BLP, BCSP) & Behavioral	MEM	Conflict effect was larger after code-switched sentences, with faster congruent and slower incongruent Flankers, and no effect of switch type.
Kheder et al. (2025) Exp. 4	Spanish-English	36 participants	Computerized Oral Sentence–Flanker (blocked switch type)	Questionnaire (BLP, BCSP) & Behavioral	MEM	Conflict effect was larger after code-switched sentences, with insertional switches producing the largest effect, mainly due to faster responses to congruent Flankers.
Bejjani et al. (2022)	Not reported	957 participants	Color-word list-wide proportion congruent (LWPC) & list-wide proportion switch (LWPS) paradigms	Behavioral and post-test questionnaire	SEM & ANOVA	Adaptation to changing task demands is supported by separate but interconnected mechanisms for conflict-control and task-switching, unaffected by individual differences in cognitive ability, motivation, or task awareness.
Kałamała et al. (2020)	Polish-English	195 participants	Questionnaires: Patterns of Language Use Questionnaire & Code-switching and Interactional Contexts Questionnaire, Intelligence test: Raven's Advanced Progressive Matrices test, Executive tasks: antisaccade, Stroop, Go/No Go, Stop-signal	Questionnaire & behavioral	Correlations, latent variable approach, & Bayesian estimation	No link between dual-language context and response inhibition.
Zunini et al. (2019)	French-English	89 participants	Cued letter-number TSP	Behavioral & ERP	ANOVA	Bilinguals had smaller switch and mixing costs than monolinguals; ERP results indicate that bilinguals and monolinguals engage different brain processes, with older bilinguals relying on distinct processing strategies compared to older monolinguals.
Paap et al. (2019)	English-Spanish, English-Mandarin, English-Cantonese English-Tagalog	104 bilinguals and 62 monolinguals	Executive tasks: Simon, Spatial and Vertical Stroop & Flanker	Behavioral	ANCOVA	No bilingual advantage on nonverbal interference tasks; language inhibition appears specific to lexical processing.

Table 3.2: Summary of Studies on the Dissociation Between Language Control and Executive Functions

3.2.3 Mixed Findings and Moderators

The evidence linking bilingual language control and domain-general control remains inconsistent, with results depending heavily on methodology, population, and analytic approach, as shown in Table 3.3.

Additionally, some behavioral research has yielded both support for and against an overlap. For instance, Mas-Herrero et al. (2021) found that bilinguals were faster and exhibited smaller switch costs than monolinguals in non-linguistic switching tasks, but no benefits emerged in language-switching tasks. Other studies emphasize the role of inhibitory control: S. Li et al. (2021) demonstrated that a smaller Simon effet interpreted as interference suppression was related to greater differences in switch costs at the local level, while faster response inhibition was linked to greater global slowing. On the other side, Zhu and Sowman (2020) reported mixed evidence for domain-general contributions of inhibition to bilingual speech production, whereas training paradigms suggest some transfer: Timmer et al. (2019) found that language-switching practice reduced non-linguistic switch costs, supporting partial overlap between the two domains. Similarly, Kheder and Kaan (2021) showed that FCS with high L2 proficiency displayed improved conflict adaptation and smaller Simon effects, indicating that both language use and proficiency jointly influence executive control. Jiao et al. (2019) reported that higher L2 proficiency predicted better executive control during a nonverbal Stroop task, independently of socioeconomic status, while language switching frequency alone had no effect. These behavioral findings highlight that bilingual advantages tend to be task and process-specific rather than general.

Brain imaging evidence reflects a similarly complex picture. For example, Wolna et al. (2024) reported that producing speech in an L2 primarily engages the domain-general Multiple Demand Network, with only localized increases in language-specific regions such as the left inferior frontal gyrus. In contrast, Yuan et al. (2021) showed that language control and cognitive control can dynamically influence one another across tasks, with changes in connectivity observed in the ACC/pre-SMA and thalamus depending on conflict demands. This suggests that bilingual language control relies on both domain-general circuits and a specialized neural network, with their overlap varying by task context and demands.

ERP findings also provide evidence for partial overlap between language control and executive functions. Kang et al. (2020) found that stronger general inhibition predicted greater neural responses (N2 variability) during bilingual word production. Similarly, Dash and Kar (2020) showed that L1 and L2 proficiency influenced inhibitory control differently in language and non-language tasks, as reflected in ERP responses. Age has also emerged as a potential moderator: Massa et al. (2020) reported that older bilinguals flexibly recruited neural resources during language tasks but did not display a bilingual advantage in non-linguistic executive control, suggesting that age and task type may influence transfer effects.

Broader meta-analyses of the literature converge on the idea that the bilingual advantage, if it exists, is neither universal nor uniform. Degirmenci et al. (2022) reviewed 24 studies in older adults and found consistent bilingual benefits in inhibitory control but no general advantage across executive domains. In a large-scale activation likelihood estimation meta-analysis, Jiao et al. (2022) reported overlapping activation between language and task switching in regions such as the left DLPFC and ACC/pre-SMA, but also important dissociations: language switching preferentially activated language-related occipital and fusiform regions, while task switching engaged more domain-general prefrontal areas. Similarly, Lehtonen et al. (2023) highlighted the debate between views that see bilingual effects as relying on general control versus those that stress language-specific processes. Other reviews have emphasized context as a critical moderator: Semenova et al. (2025) concluded that interactional contexts may shape executive functioning, though evidence remains inconclusive due to heterogeneity in study designs. Finally, Vïnerte and Sabourin (2019) and Calabria et al. (2019) both argued that the field requires more integrative frameworks that account for both shared and distinct neural substrates of bilingual language control and executive control.

Methodological differences across studies likely contribute to mixed findings regarding the overlap between language control and domain-general control. Variations in task design, measurement (RT, accuracy, ERP/fMRI markers), and sample characteristics (age, proficiency, bilingual profile) can influence observed effects, while low reliability and task impurity further complicate interpretations. Accounting for these factors is therefore essential when evaluating whether language control relies on shared or specialized mechanisms.

The mixed findings in the literature may be partially explained by the diversity of bilingual experiences and methodological differences across studies. Individual experience plays a central role: frequent code-switching and higher L2 proficiency improve conflict adaptation and accuracy (Jiao et al., 2019; Kheder & Kaan, 2021), and recent language exposure also shapes performance (Struys et al., 2019).

The effect of proficiency on language control appears to follow a continuum. Language switching engages executive control primarily in lower-proficiency bilinguals, suggesting that higher proficiency promotes automation (González et al., 2024). In early and highly proficient bilinguals, any advantages tend to be modest, context-dependent, and shaped by individual variability and modeling approaches (Bonfieni et al., 2019). In line with this, Hofweber et al. (2020) found that higher L2 proficiency modulated executive functions, with more balanced Dutch–English bilinguals outperforming strongly L1-dominant speakers on executive tasks.

Task-related factors also contribute to variability, with participants performing similarly on language-based tasks and non-linguistic tasks (Segal et al., 2021). Some mixed findings may reflect task impurity, where executive tasks are influenced by non-executive processes. For example, Stroop performance depends on reading and color discrimination, while Flanker performance also involves arrow-direction identification (Hartanto & Yang, 2020).

Also, contextual and sociolinguistic factors, including interlocutor characteristics (Rafeekh & Mishra, 2021), real-world language use (Thanissery et al., 2020), and interactional contexts (Hartanto & Yang, 2020; Lai & O'Brien, 2020), further shape performance, consistent with predictions of the ACH. Neural mechanisms show substantial overlap between L1 and L2 networks, with L2 additionally recruiting executive control regions and language switching engaging both executive and language control systems (Sulpizio et al., 2020).

Finally, age-related differences contribute to variability, as older adults generally respond more slowly in inhibitory tasks, though accuracy effects are inconsistent and influenced by task design (Guay & Boller, 2024).

Together, these findings suggest that bilingual advantages in executive functions are highly context-dependent, reflecting individual, linguistic, and methodological variability.

In sum, the ongoing debate on the bilingual advantage should be understood in relation to the way it was historically viewed. Because bilingualism was first portrayed as harmful, later research sought to counter this view by emphasizing potential benefits. In this sense, the search for an advantage stems from the need to overturn earlier negative perspectives (Mattschey, 2023).

Study	Bilingualism	Sample (n)	Task	Method	Statistical Analysis	Key Findings
Semenova et al. (2025)	Multiple (Spanish-English, Chinese-English, German-English, etc.)	49 studies	Executive tasks: Flanker, Simon, Stroop, color-shape switching, Go/No Go, digit span	Behavioral	Meta-analysis	Mixed evidence on interactional contexts and executive functions, highlighting the need for standardized designs and clear predictions.
Wolna et al. (2024)	Polish-English	42 participants	Single-language picture-naming (L1 and L2), language localizer, spatial working memory	Behavioral & fMRI	MEM	L2 production mainly engaged domain-general mechanisms, with local effects in language-specific areas.
Lehtonen et al. (2023)	Multiple (Japanese-English, Spanish-English, Finnish-English, etc.)	Not reported	Cued and Voluntary LSP & executive tasks	Behavioral	Meta-analysis	Mixed findings, with many results aligning more with a task-specific pattern than with broad domain-general enhancement.
Degirmenci et al. (2022)	Multiple (English, Basque, French, Spanish, Tamil, Welsh, etc.)	24 studies	Executive tasks: Anti-saccade, Flanker, Go/No Go, Simon, Stroop, TSP, WCST, digit span, etc.	Behavioral	Meta-analysis	Mixed support for a bilingual advantage, with consistent benefits primarily in inhibition tasks.
Jiao et al. (2022)	Not reported	300 LSP studies & 1402 TSP studies	LSP (pictures, words and digits) & TSP (number-letter pairs, shapes and color, digit span, etc.) switching	fMRI	Meta-analysis	Language switching and task switching engaged partially overlapping neural circuits, with shared activation in domain-general regions and distinct activation in language-specific areas.
Mooijman et al. (2022)	Multiple (Basque, Italian, French, English, etc.)	27 studies on BwA	Executive tasks: Stroop, Flanker, digit span, WCST, etc.	Behavioral	Meta-analysis	Executive control impairments in BwA are common, with mixed evidence on domain-general vs. language-specific control.
Luque and Morgan-Short (2021)	English-Spanish	28 participants	L2 proficiency, elicited imitation & executive tasks: Flanker & AX-CPT	Behavioral	Correlations and regression analysis	Domain-general reactive control predicted L2 proficiency, highlighting its role in developing bilingualism.
Yuan et al. (2021)	Chinese-English	83 participants	Cued LSP and TSP	Behavioral & fMRI	ANOVA	Conflict-induced activation showed partial overlap between bilingual language control and domain-general cognitive control, with shared neural adaptations in conflict detection and inhibition.
Mas-Herrero et al. (2021)	Catalan-Spanish	96 participants	Questionnaires (LHQ, BSWQ), LSP & TSP	Behavioral	MEM	Bilinguals showed advantages in task switching with high executive demands, but not in LSP requiring language control.

Study	Bilingualism	Sample (n)	Task	Method	Statistical Analysis	Key Findings
S. Li et al. (2021)	Chinese-English	54 participants	Cued LSP, Simon task & Go/No go	Behavioral	MEM	In bilinguals, interference suppression supported local language control, while response inhibition influences global language control.
Zhu and Sowman (2020)	Mandarin-English	16 participants	Univalent & bivalent cued LSP	Behavioral and fMRI	MEM	Disrupting the pre-SMA impaired general speech execution, but its role in whole-language vs. item-specific inhibition remains inconclusive.
Kang et al. (2020)	Chinese-English	55 participants	Cued LSP, TSP & executive tasks: Flanker & n-back	Behavioral & ERP	MEM	Domain-general inhibition predicted the strength of suppression on non-target lexical items, but bilingual language control only partially overlapped with executive functions.
Dash and Kar (2020)	Hindi-English	20 participants	LHQ, language proficiency & negative priming task	Behavioral & ERP	Bivariate correlation & multiple regression analysis	Bilingual language control showed inhibition effects that vary by stimulus type and were differentially predicted by L1 and L2 proficiency, indicating partial independence from domain-general cognitive control.
Massa et al. (2020)	French-Italian and French monolinguals	64 participants	Executive tasks: Stroop, Stop signal, anti-saccade, BCST, TMT, verbal fluency	Behavioral & ERP	ANOVA	A bilingual advantage was observed in linguistic tasks, but not in non-linguistic executive tasks, with older bilinguals showing flexible adaptation in language switching.
Vïnerte and Sabourin (2019)	English, Chinese-English, English-French	Not reported	Executive tasks: Flanker, Simon, n-back, Stroop and color-shape	Behavioral and fMRI	Meta-analysis	Bilingual language control may influence general cognition, but behavioral evidence for an advantage was mixed.
Timmer et al. (2019)	Catalan-Spanish	68 participants	TSP & LSP	Behavioral	ANOVA	Short-term language switching training reduced switch costs in both linguistic and non-linguistic tasks, suggesting partial overlap of control mechanisms across domains.
Calabria et al. (2019)	Not reported	BwA	LSP & executive tasks	Behavioral	Meta-analysis	Mixed evidence, though adaptive control models suggest context-dependent overlap.
Van den Noort et al. (2019)	Not reported	46 studies	TSP, Simon, Stroop, Flanker, Attention network test, n-back, verbal fluency, WCST, digit span, etc.	Behavioral, EEG, MEG, & fMRI	Meta-analysis	Mixed evidence, with methodological differences and participant variability likely driving inconsistent findings.

Table 3.3: Summary of Studies Reporting Mixed Findings on the Relationship Between Language Control and Executive Functions

Summary of Chapter 3

This chapter examined whether bilingual language control relies on general executive functions or language-specific mechanisms. The literature reviewed included a range of approaches, from meta-analyses to experimental behavioral studies and neural evidence using EEG and fMRI. The findings to date, although extensive, remain mixed: some studies indicate substantial overlap between language control and domain-general executive functions, suggesting that bilinguals recruit similar cognitive processes for both linguistic and non-linguistic tasks. Other studies, however, reveal dissociations, pointing to specialized mechanisms dedicated to managing competition between languages. These mixed results appear to be influenced by a variety of factors, including L2 proficiency, code-switching habits, interactional context, and the specific design of experimental tasks. Overall, bilingual control seems dynamic, shaped by both general executive and language-specific processes.

Part II

Examining Bilingual Language Control: Insights from Sociolinguistic, Experimental, and Ecological Studies

Chapter 4

Research Objectives

Having reviewed the theoretical and empirical literature on bilingual language control, this chapter aims to outline the research objectives of the present study. It starts by summarizing the key findings of existing studies, followed by identifying the current gaps in the literature and the motivations to pursue the current study. The chapter then presents the specific objectives of the study and provides an overview of the methodological approach adopted to fulfill these objectives.

4.1 Summary of Key Findings in the Literature

Recent research rejects the classic categorical classifications of bilingualism, and instead views it as a continuum that requires a detailed evaluation of individual factors, such as AoA, language dominance, preference, proficiency, use, etc. (De Bruin, 2019; Kašćelan et al., 2022). Studies use subjective (Birdsong et al., 2012; Marian et al., 2007; Olson, 2022), objective (Lemhöfer & Broersma, 2012; Tremblay, 2011; Weber, 2007), and corpus-based (Baidoun, 2018; Hamed et al., 2024; Lounnas et al., 2019; MacWhinney, 2014) assessments to capture these characteristics and obtain a comprehensive description of bilingualism.

In Lebanon, more specifically, bilingualism is widespread among the population, with individuals frequently switching between Lebanese Arabic, French, and English in daily conversations. As a result, the Lebanese population can be characterized as "frequent code-switchers" (FCS), a phenomenon shaped by the country's educational and political history, and reinforced through media and the educational system.

Behavioral studies consistently report switch and mixing costs across LSPs (Declerck et al., 2013; Festman & Schwieter, 2015; Mosca & Clahsen, 2016), and in some cases, benefits during voluntary switching (De Bruin et al., 2018; Jevtović et al., 2020), reflecting the cognitive demands of language control. Theoretical models of language control (ACH, CPM, ICM) help explain these effects by specifying how bilinguals activate, inhibit, and select languages, and monitor contextual cues; however, the number of studies that examine switching behavior in real-world, naturalistic settings is still limited (Fricke & Kootstra, 2016; Yim & Bialystok, 2012).

Whether language control depends on domain-general or language-specific mechanisms remains debated, with mixed findings reported across behavioral (Kheder et al., 2025; Lehtonen et al., 2023; Z. Xie & Zhong, 2024), EEG (Declerck, Meade, et al., 2021b; Zunini et al., 2019), and fMRI (M. Chen et al., 2021; Jiao et al., 2022; Mouthon et al., 2020) studies.

Lastly, individual differences, such as proficiency, dominance, language preferences, usage patterns, switching habits, and language entropy, not only influence language control, but also shape the question of whether control processes rely on domain-general or language-specific processes, emphasizing the need for more thorough assessments (De Bruin, 2019; Gullifer & Titone, 2020).

Together, these studies provide a foundation for understanding language control in bilinguals.

4.2 Research Gaps and Motivations

Nonetheless, several important issues remain unresolved. Assessing bilingualism involves more than looking at isolated factors. Key elements of language acquisition, such as AoA, proficiency, dominance, preference, switching habits, and entropy taken together all play a role (De Bruin, 2019). LE (Gullifer & Titone, 2018, 2020) is particularly useful because it captures how integrated or compartmentalized languages are in everyday use, the latter being especially relevant for FCS.

Research on voluntary language switching in FCS remains limited, although preliminary evidence suggests that FCS may exhibit reduced switch costs and mixing costs, and even mixing benefits when they switch languages without constraints (De Bruin et al., 2018; Jevtović et al., 2020; Kennis et al., 2025). Further investigation is required to confirm these patterns and clarify the underlying mechanisms supporting them.

There is also a need for studies that simultaneously assess language switching and executive functions using comparable experimental designs and performance measures (such as RT and accuracy). Most existing research either compares different populations, uses meta-analyses combining studies with varying age groups, bilingual experiences, or task demands (Lehtonen et al., 2023; Tao et al., 2021), or assesses language and executive control separately or incompletely (Paap et al., 2019; Zhu & Sowman, 2020). The criteria for measuring language use also vary: some studies report only sociolinguistic data (self-assessments of language use) (Kheder & Kaan, 2021; Vassiliu et al., 2024), while others include behavioral measures of language control using LSPs (Timmer et al., 2019; Zheng et al., 2020). Similarly, research on executive control differs in scope, with some studies focusing solely on inhibition via the Simon or Flanker tasks (González et al., 2024; Guay & Boller, 2024; Rafeekh & Mishra, 2021), whereas others provide a more comprehensive assessment of inhibition, set shifting, and working memory following Miyake et al. (2000)'s framework, often using multiple tasks to evaluate each component (Kałamała et al., 2022; Semenova et al., 2025; Yang et al., 2018). This wide variation makes it difficult to determine whether observed effects reflect shared or distinct mechanisms, underscoring the importance of studies that assess both language control and executive control within the same population under comparable conditions.

Finally, language switching has been mainly assessed in laboratory experimental settings, and fewer researchers have investigated it in more ecological discourse settings specifically designed to measure behavioral costs and mechanisms. This is distinct from the broader sociolinguistic literature on code-switching in fully naturalistic settings, which documents patterns of bilingual speech without quantifying control processes. Ideally, the same participants should be tested across both contexts, experimental and ecological, to allow direct comparisons and a comprehensive picture of language switching abilities. In line with the Adaptive Control Hypothesis (Green & Abutalebi, 2013), such research should examine how individuals modulate control processes when interacting with interlocutors differing in language knowledge : monolingual, bilingual, or FCS.

4.3 Objectives of the Current Study

In an attempt to address the gaps highlighted above, the present study was structured as three consecutive phases[1], aiming to examine language switching in FCS in depth. The experiment progressed from subjective measures to objective laboratory assessments, including LSPs and executive functions, and finally to more ecological narratives based on the ACH (Green & Abutalebi, 2013) (see Figure 4.1). This multimethod approach seeks to respond to the limited understanding of how individual differences (AoA, proficiency, dominance, switching habits, LE, etc.) shape language control in FCS, by combining laboratory and more ecological measures for the same participants.

Three main objectives guided the research:

1. To explore the influence of individual factors on language switching behavior by providing a detailed description of a population of FCS that has not been previously studied and is particularly relevant given its sociocultural context and everyday switching between Arabic, French, and/or English (Phase 1).
2. To compare constrained[2] and voluntary[3] language switching, both in controlled laboratory settings and in more ecological contexts (Phases 2 and 3), in order to test two general hypotheses:
    - Switching between languages incurs a *switch cost*, reflected in reduced performance when changing languages compared to staying in the same language. This cost is expected to be higher in constrained conditions than in voluntary conditions, where participants have more flexibility to select the most accessible language and can therefore reduce the cognitive demands of switching.
    - Mixing multiple languages in the same context incurs a *mixing cost*, reflected in reduced performance when staying in the same language in a mixed-language (bilingual) condition compared to performance in a single-language (monolingual) condition. This effect is typically observed in constrained conditions. However, in voluntary conditions, FCS are expected to exhibit reduced mixing costs, and may even experience a mixing benefit, as predicted by De Bruin et al. (2018), where performance improves or becomes more efficient due to the flexibility in language choice, allowing them to select the most accessible language at the moment of naming.
3. To examine the link between language control and executive control, testing whether the underlying mechanisms are domain-general or language-specific, through correlations between performance in LSP and executive function measures (Phase 2).

4.4 Overview of the Research Design

The empirical research was organized into three independent consecutive studies, described as Phases 1, 2 and 3, as illustrated in Figure 4.1. Each study addresses a different dimension of bilingual

[1]The phases correspond to the consecutive steps of the study, as some participants completed all three. The terms ”phase” and ”study” are used interchangeably (e.g., Study 1 = Phase 1).

[2]”Constrained” refers to situations where the bilingual speaker is asked to switch languages based on an external instruction. It is also called ”Cued” when a cue guides the switching or ”Alternate” when they are instructed to alternate languages regularly.

[3]”Voluntary” switching, also called ”Free” switching, refers to situations where the bilingual speaker is free to switch languages at their own will. The terms ”Voluntary” and ”Free” are used interchangeably.

language use in Lebanese speakers, combining experimental and ecological approaches to offer a multi-layered understanding of language control and code-switching.

Each study is presented independently, including its own method section, analyses, results, and discussion. This structure allows for a clearer focus on the specific aims and findings of each study.

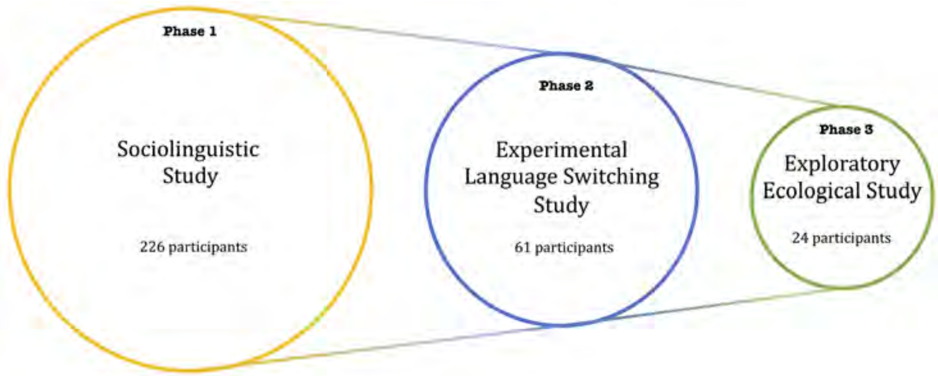

Figure 4.1: Study Overview

The three consecutive studies were as follows:

1. **Sociolinguistic Study (Chapter 5):**
The first study aimed to provide a comprehensive overview of Lebanese bilingualism in France, drawing a baseline for a population that has been rarely studied but is of particular interest for understanding frequent code-switching. Data were collected with a unified adapted version of three questionnaires: the LEAP-Q (Marian et al., 2007), the BLP (Birdsong et al., 2012), and the BCSP (Olson, 2022), adapted and administered to a large sample of Lebanese adults residing in France. This approach allowed for a holistic description of the participants' linguistic background and language habits, enabling a detailed assessment of bilingualism and the calculation of specific measures, such as the CSP and LE.

2. **Experimental Language Switching Study (Chapter 6):**
After establishing a baseline for linguistic acquisition and habits, the second study was conducted in a laboratory setting with a subgroup of participants from the first study. It included both cued and voluntary LSPs to examine switch and mixing costs in a population of FCS that had not been previously studied. In addition to the classic bilingual picture-naming task, a parallel bilingual semantic fluency task was developed to evaluate lexical access in FCS. Executive functions, more specifically inhibition, shifting, and working memory, following Miyake et al. (2000) framework, were also assessed using comparable computerized tasks, enabling the investigation of correlations between executive function performance and language switching. This approach enabled a quantitative test of the domain-generality versus specificity hypothesis.

3. **Exploratory Ecological Study (Chapter 7):**
The third study was motivated by the gap in the literature regarding the ecological aspects of language switching. It aimed to complete the subjective, objective, and experimental data from the first two studies by examining how participants use multiple languages in more naturalistic contexts. A subgroup of participants from the second phase took part in this pilot study, by describing short videos and narrating personal life events in response to open-ended questions asked by interlocutors with different language backgrounds: monolingual, bilingual, and FCS. Detailed transcription and annotation of the resulting corpora allowed for the analysis of spontaneous code-switching, providing rich, ecologically valid data that offer new insights into how language control operates in real-world communication.

To complete the study overview, a more detailed illustration of the tasks used in the three studies is presented in Figure 4.2.

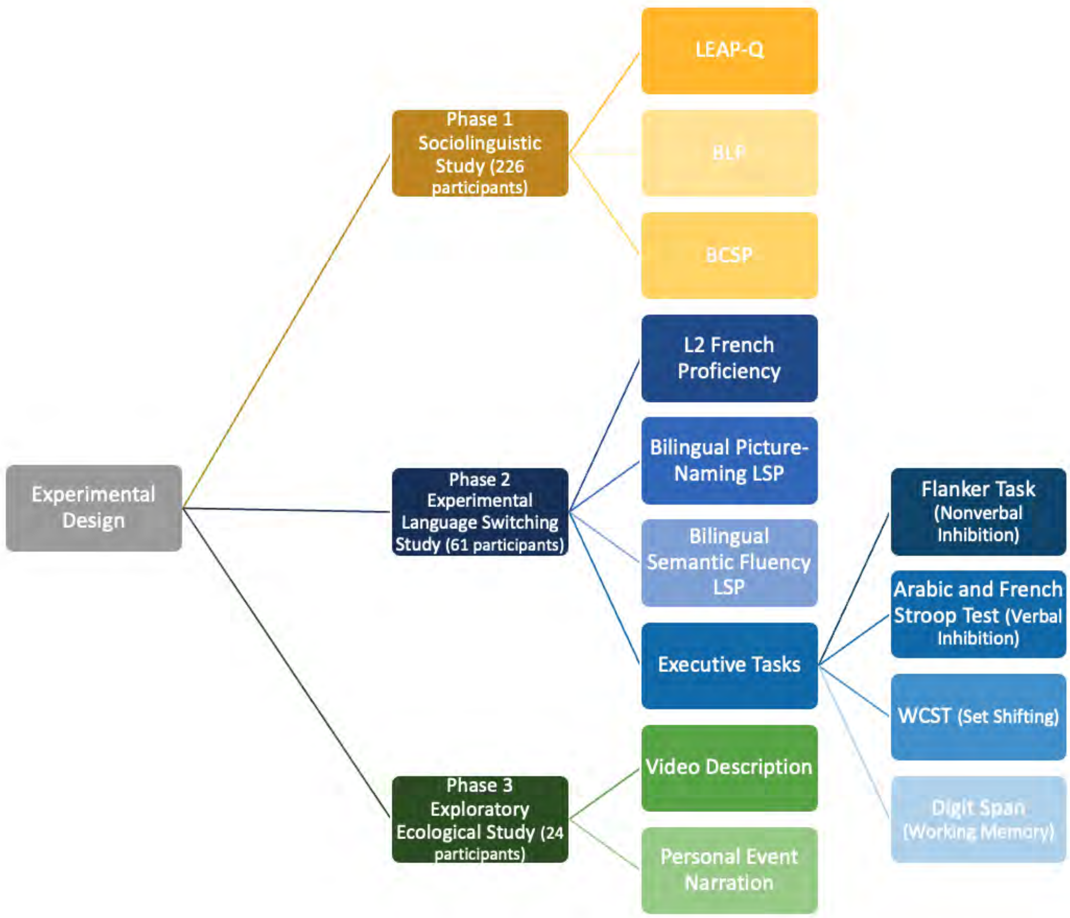

Figure 4.2: Overview of Tasks across the Three Studies

The experimental protocol was approved by Toulouse University's Research Ethics Committee (project 2023-662) and General Data Protection Regulation (N° R-202310090959).

For each study, descriptive statistics were reported first, followed by inferential analyses. Given the dispersion of the data in the three studies, both the Mean (M) (± Standard Deviation (SD)) and the Median (Md) were reported for most variables. While the mean provides an overall average, the median offers a more robust representation of the typical participant, as it is less influenced by extreme values or outliers. This dual reporting ensures a more comprehensive understanding of the central tendency in the dataset. In addition, across all three studies, and in line with recent recommendations (Benjamin et al., 2018; De Ruiter, 2019), a more conservative significance threshold of $p < 0.005$ was adopted instead of the conventional $p < 0.05$, to minimize false positives and strengthen the robustness of the findings.

Chapter 5

Sociolinguistic Study

In an attempt to describe sociolinguistic characteristics of the Lebanese population residing in France, Phase 1 of the study collected responses from a large-scale investigation using an adaptation of three questionnaires: the LEAP-Q (Marian et al., 2007), the BLP (Birdsong et al., 2012), and the BCSP (Olson, 2022).

5.1 Participants

5.1.1 Recruitment Criteria

The purpose of this research was to study language control in a population that frequently switches languages in their daily life, referred to as FCS. Lebanese people, particularly known to have this specific use of languages by mixing Arabic, French and/or English, represent an interesting population to be studied in this matter. Hence, French speaking Lebanese adults residing in France were selected for the sociolinguistic study. This choice was guided both by practical considerations and by theoretical interest: living in a French-speaking environment likely promotes more balanced bilingualism, with increased use of French compared to the population residing in Lebanon, making it possible to examine language use and code-switching in a context of intensified exposure to the second language.
Inclusion criteria were:

1. *Age:* adults 18 years old and above, with no limit of age.
2. *Languages:* native Lebanese Arabic with French as their second language.
3. *Current residence and linguistic context:* residing in France, with no limitation for the LOR. Controlling for current residence helps account for the influence of linguistic context on current language dominance and use.
4. *Education:* No restrictions were placed on participants' educational background.

Exclusion criteria for the participant pool included the presence of at least one of the following conditions: uncorrected visual impairment (participants with corrected vision, such as those wearing glasses or contact lenses, were eligible), hearing impairment, oral or written language disability, or any neurological disorder.

5.1.2 Recruitment Procedure

Participant recruitment was carried out from October 2023 to February 2024 via the only organization for the Lebanese diaspora in Toulouse, *Association les amis du Liban - Toulouse*. A message was also spread on social media groups of Lebanese people living in France, allowing a larger transmission all over the country.

5.1.3 Final Sample Description

A total of 226 participants (134 females) took part in the first phase of the study between October 2023 and February 2024, completing an online language questionnaire. Out of the 226 respondents, 220 filled in the questionnaire in its French version and 6 in the Arabic version.
All participants were Lebanese adults residing in France and were early bilinguals of Lebanese Arabic and French. Their ages ranged from 18 to 68 years ($M = 30.1$ years, $SD = 10.1$, $Md = 27.0$), with the majority holding higher education degrees (69.03% with a Master's or Ph.D.). Their LOR in France ranged from 4 months to 51 years, with an average LOR of 7.98 years ($\pm$ 9.4), and a median of 4.0 years.

5.2 Procedure

Participants completed the online questionnaire remotely from their homes. The task, which took approximately 30 minutes, was administered through the LimeSurvey platform hosted by Toulouse Jean Jaurès University. It consisted of an adapted combination of the LEAP-Q, the BLP, and the BCSP. Prior to participation, individuals were required to read the information sheet and provide informed consent online. There was no direct interaction with the experimenter during this phase (see Appendix A for the full questionnaire).

5.3 Materials

5.3.1 Sociolinguistic Questionnaire

The first study consisted of a questionnaire designed to describe participants' linguistic background and language use (available in Appendix A). The questionnaire was available in both French and Arabic versions to accommodate participants' language preferences. It combined three standardized instruments:

- **Language Experience and Proficiency Questionnaire (LEAP-Q)**
  The *LEAP-Q* (Marian et al., 2007) collects individual data on participants' sociolinguistic background, including AoA, context of acquisition, and language use. While the original

LEAP-Q is available in short (2 languages) and long (up to 5 languages) versions, an intermediate version was designed for this study, tailored to the multilingual Lebanese population, allowing participants to report on 3 languages. This adaptation was also intended to reduce the duration of administration.

- **Bilingual Language Profile**
  The *BLP* (Birdsong et al., 2012) gathers data on language dominance based on four modules: language history, current use, self-rated proficiency, and attitudes. Given the trilingual background of most Lebanese participants (Arabic, French, and English), the computerized version of the BLP used in this study included three languages instead of the original two.

- **Bilingual Code-Switching Profile**
  The *Bilingual Code-Switching Profile* (BCSP, Olson, 2022) assesses participants' experiences with and attitudes toward code-switching, including frequency, ease, and contextual use. In collaboration with the author, the BCSP was adapted and standardized for the Lebanese bilingual population by tailoring examples to reflect the local context [1]. Additionally, a supplementary question was incorporated in the "Attitudes toward code-switching" section, asking participants to share their subjective perception of code-switching (*Is code-switching an advantageous, disadvantageous, or neutral phenomenon, and why?*).

The full questionnaire consisted of 83 questions, requiring approximately 30 minutes for administration.

5.3.2 Measures of Interest

The three questionnaires provided a multitude of measures, from which the following were retained as measures of interest:

- **Language age of acquisition (AoA)**
  AoA captures the languages spoken by each participant and their respective ages of acquisition.
- **Language dominance index (LDI)**
  To contextualize the Language Dominance Index (LDI) classification, raw language dominance scores were first analyzed, offering a preliminary view of participants' relative dominance across the three languages. The LDI for each participant was then calculated using a relative weighting approach based on their responses in the BLP. A global score was first computed for each language (L1, L2, and Third Language (L3)) by considering participants' history, use, proficiency, and attitudes toward each language. To calculate the dominance score for each pair of languages (L1 vs.L2, L1 vs.L3, and L2 vs.L3), the average scores for the two languages were subtracted. For example, the dominance score for L1 versus L2 was determined by subtracting the combined score of L2 and L3 from the L1 score. Positive dominance scores indicated that the first language in the pair was more dominant, while negative scores suggested that the second language had greater dominance. Scores near zero reflected balanced bilingualism, where neither language was clearly dominant over the other. Based on these dominance scores, participants were classified into a dominant language category (L1, L2, or L3), depending on which language

[1] The adapted versions of the BCSP developed for this study are available on the project's webpage: https://danieljolson.weebly.com/bilingual-code-switching-profile-bcsp.html. These versions were created in collaboration with the original author and adapted for the following language pairs: French–English, English–French, Lebanese Arabic–French, and French–Lebanese Arabic, using culturally appropriate examples of code-switching.

had the highest relative dominance. This classification provides a clear understanding of each participant's linguistic profile and the distribution of language dominance across the sample.

- **Language Preference**
  Language preference was extracted from LEAP-Q questions regarding written and oral language use: "What language do you prefer reading a text in?" and "What language do you prefer engaging in a conversation in?" (see Appendix A for exact wording). Participants were asked to assign a percentage to each language, ensuring that the total added up to 100%. This measure reflects participants' relative preference for each language in different communicative contexts.

- **Self-Reported Language Proficiency**
  Language proficiency was self-evaluated by participants using the BLP, which included questions assessing self-reported proficiency in both oral and written comprehension and expression for each language. Participants rated their proficiency on a Likert scale ranging from 0 (not at all) to 6 (very well).

- **Language Entropy (LE)**
  LE was calculated based on answers to selected questions from the LEAP-Q and the BLP. It was computed for multiple contexts for each participant following the method outlined by Gullifer and Titone (2020).
  LE quantifies the social diversity of language use; its value ranges from 0 to log n (base=2), where n refers to the maximum number of languages it is computed over. For this study, with answers collected for three languages, LE ranges from 0 to 1.585.
  LE values vary depending on language use: when a participant compartmentalizes languages (using one language per communicative context), language diversity is low (closer to 0), and predictability of the upcoming language is high. In contrast, when multiple languages are used in the same context (integrated use), language diversity is higher (closer to 1.585), and predictability is lower. For this study, LE was computed across the following contexts: family, friends, work, reading, writing, self-talk, and counting. While the first five contexts align with those analyzed by Gullifer and Titone (2020), the addition of self-talk and counting was made based on their relevance to understanding language use.

- **Code-Switching Profile (CSP)**
  The CSP is a composite measure derived from participants' responses to the BCSP, covering four key categories: Code-Switching History, Code-Switching Use, Code-Switching Proficiency, and Code-Switching Attitudes. These categories reflect different aspects of a participant's engagement with and experience in Code-Switching, with each contributing to the final CSP score. The CSP score ranges from 0 to 100, where lower scores indicate less engagement and experience with code-switching, while higher scores reflect more frequent use and positive attitudes toward switching languages.

5.4 Data Analysis and Results

This section presents the results from the questionnaire data collected in Phase 1 of the study. Descriptive statistics are reported for key variables related to participants' language backgrounds, including AoA, language dominance, language preference, self-rated proficiency, code-switching habits (quantified by the CSP), and LE. While no hypotheses are directly tested at this stage, these variables offer a detailed overview of individual variability within the sample and provide the first in-depth description of a Lebanese bilingual population. They also serve as a critical foundation for understanding and interpreting performance in Phases 2 and 3, where behavioral data is analyzed to test hypotheses related to language control.

All analyses were conducted in R (R Core Team, 2021), with output files and the corresponding R scripts provided in Appendix N, within the folder *Phase 1* (Excel output file: *phase_1_questionnaire_data.xlsx*; R script: *PhD Analysis Phase 1.R*).

5.4.1 Data Preparation

Data preparation is explained in detail according to each questionnaire used in the study. Given the large volume of data from the various questionnaires, not all responses were used in the analysis. The following steps outline how the data from selected sections were cleaned and transformed to ensure consistency and uniformity across all participant responses.

The LEAP-Q used a scale ranging from 0 to 10, while the BLP and BCSP employed Likert-type scales ranging from 0 to 6. To account for these differences in scale, responses were standardized separately within each questionnaire. NA and missing data were removed prior to analysis.

All data cleaning and transformations were conducted using R (version 4.4.1) (R Core Team, 2021).

5.4.1.1 Language Experience and Proficiency Questionnaire (LEAP-Q)

Several variables from the LEAP-Q were cleaned and transformed to ensure consistency across participant responses. Educational level was simplified by regrouping original responses into two categories: "Undergraduate" (including "Bac/Lycée," "Un peu d'université," and "Licence/B.A., B.S.") and "Graduate/Postgraduate" (including "Master" and "Doctorat").

For LOR in France, values between 1900 and 2024 were interpreted as the year of immigration and subtracted from 2024 (the year the questionnaire was completed) to obtain the number of years spent in France. Alternatively, if the response was a number between 1 and 100, it was taken as the number of years lived in France.

Responses to determine language dominance and AoA were standardized to account for spelling, script, and language variability in answers (e.g., "anglais," "english," or "الانجليزية" for English). All entries were lower-cased, trimmed, and mapped to unified language categories (Arabic[2], French, English, etc.). Although participants could list up to five languages, only the first three were considered for analysis. Unclear or unmatched responses were excluded.

5.4.1.2 Bilingual Language Profile (BLP)

In the BLP dataset, several transformations were carried out to ensure standardized and analyzable responses. All "20+" entries in the BLP data, indicating 20 years or more of exposure, were transformed to a value of 20, ensuring consistency in the representation of proficiency and attitudes. For the self-rated proficiency and attitudes sections, where text responses were provided (e.g., "0 = non pas bien du tout" [not well at all] or "6 = oui très bien" [very well]), the text was removed and standardized into numeric

[2] In the following sections, "Arabic" refers specifically to Lebanese Arabic.

values. Specifically, “non pas bien du tout” was converted to a value of “0” and “oui très bien” to a value of “6” for proficiency; similarly, “pas d’accord” [disagree] was converted to “0” and “d’accord” [agree] to “6” for attitudes. These transformations allowed for a more uniform and analyzable dataset.

5.4.1.3 Bilingual Code-Switching Profile (BCSP)

To create a CSP for each participant, subcategory scores were calculated by summing the responses for each item within the subcategory. However, two exceptions were made for questions regarding the age at which participants began switching languages and when they felt comfortable doing so, as these items were reverse scored. Responses such as “depuis la naissance” [since birth] or “dès mes premiers souvenirs” [as early as I can remember] were assigned a score of 20 points, reflecting early or lifelong code-switching, while responses like “Je n’utilise jamais le ML (mélange de langues)” [I don’t ever switch] or “Je ne me sens pas à l’aise pour utiliser le ML” [I don’t feel comfortable switching] were given 0 points, indicating minimal or no code-switching. All other responses were scored according to the designated scale for each subcategory.

5.4.2 Descriptive Results

This section presents descriptive analyses of the questionnaire data, centered on the key variables of interest.

- **Language Age of Acquisition (AoA)**
  The analysis of reported AoA across first (L1), second (L2), and third (L3) languages revealed distinct patterns, as shown in Figure 5.1. Arabic was the most frequent L1, reported by 80.5% of participants, followed by French (18.1%) and English (1.3%). Pairwise comparisons confirmed that Arabic was significantly more frequent than French and English as L1 (both ps < 0.001). In contrast, French was the most common L2 (72.6%), with English (13.3%) and Arabic (12.8%) also reported, and it was significantly more frequent than both (ps < 0.001). The distribution shifted significantly for L3, where English was overwhelmingly common (88.7%) compared to French (8.82%), Arabic (1.5%), Portuguese (0.5%), and Spanish (0.5%) (all ps < 0.001). This trend highlights the fact that the participants predominantly acquired French as their second language, or even as a simultaneous L1, while English emerged as the third language. Additionally, many participants also reported other languages as L4 and L5, such as Italian, German, Turkish and Hungarian.

  Analysis of AoA revealed that the first language (L1) was typically acquired very early, with a minimum of 0 years (from birth), a maximum of 5 years, an average of 0.95 years ($SD = 1.35$), and a median of 0 years. The second language (L2) showed a broader range, with a minimum of 0 years (from birth), a maximum of 10 years, an average of 3.91 years ($SD = 2.35$), and a median of 3 years. For the third language (L3), acquisition started a little later, between 1 and 17 years, with a mean of 8.55 years ($SD = 3.71$) and a median of 8 years.

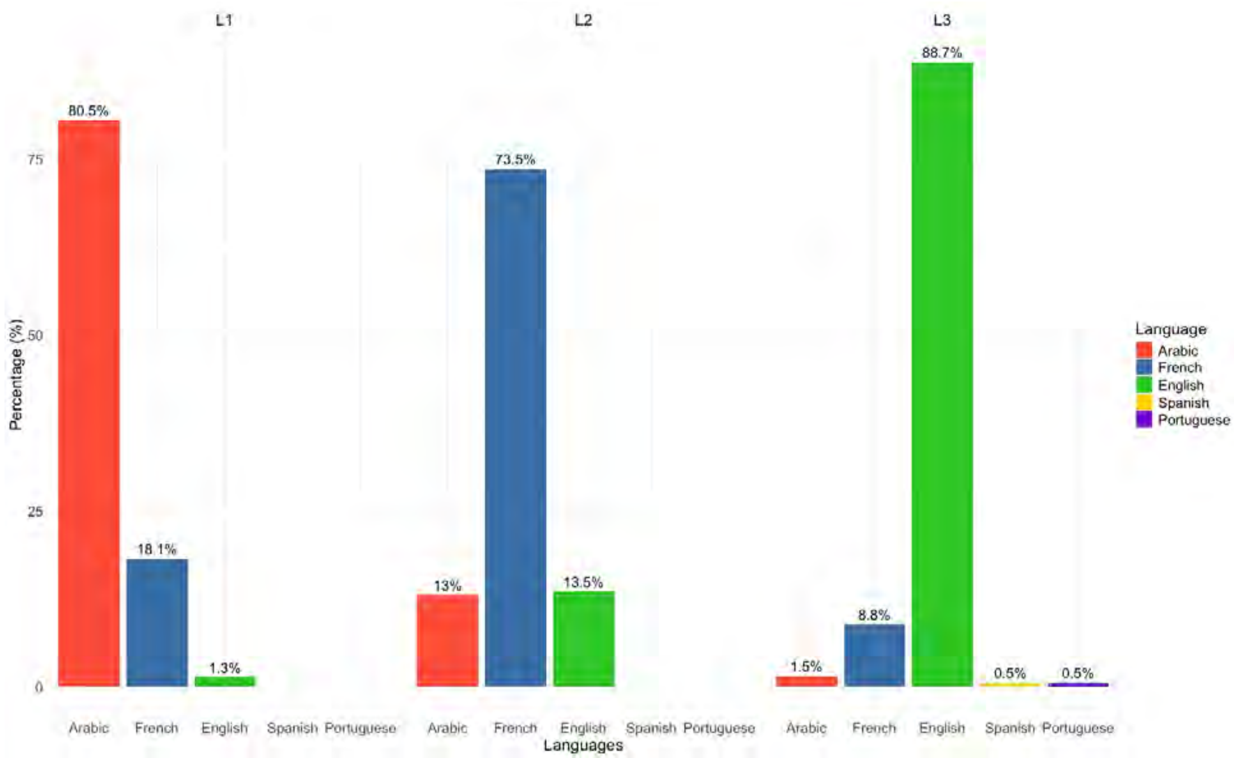

Figure 5.1: AoA Language Distribution Across L1, L2, and L3

- **Language Dominance Index (LDI)**
  Before computing the LDI, raw dominance scores were calculated by summing the four BLP modules (history, use, proficiency, and attitudes) for each language. As shown in Table 5.1, Arabic (L1) emerged as the most dominant language in terms of raw scores, with the highest mean (M = 393.83) and the least variability (SD = 97.13). This was followed by French (L2), which showed a lower mean score (M = 309.47) and the highest variability (SD = 115.89). English (L3) was the least dominant, with the lowest mean (M = 173.96) and the slightly lower variability (SD = 114.50). These values offer a general overview of participants' relative dominance before applying the weighted LDI formula.

Language	Range	Mean	SD	Median
L1 (Arabic)	118–638	393.83	97.13	382.00
L2 (French)	66–630	309.47	115.89	297.00
L3 (English)	13–616	173.96	114.50	146.50

Table 5.1: Descriptive Statistics for Raw Language Dominance Scores

Regarding the LDI comparison ranges, the dominance score for L1 vs.L2 (Arabic vs. French) ranged from -501.85 to 537.70, with a mean of 86.40 (SD = 168.0), indicating considerable variation in how participants perceived the relative dominance of their first and second languages. The scores for L1 vs. L3 (Arabic vs. English) ranged from -242.1 to 594.9, with a mean of 229.4 (SD = 144.0), reflecting a generally stronger dominance of L1 (Arabic) over L3 (English). Finally, for the L2 vs. L3 comparison (French vs. English), the range was from -320.19 to 540.42, with a mean of 143.01 (SD = 150.0), showing a moderate dominance of L2 (French) over L3 (English) in most participants. These ranges demonstrate the diversity in how language dominance is distributed among the participants, with some individuals showing substantial dominance for one language over another, while others exhibited more balanced or ambiguous dominance profiles.

The results of the LDI classification revealed that the majority of participants were classified as L1 dominant (Arabic), with 67.7% of participants falling into this category. This was followed by 28.7% classified as L2 dominant (French), and 3.7% as L3 dominant (English). Non-parametric analyses confirmed that these differences were statistically significant: a Friedman test showed a significant effect of language on total dominance scores ($\chi^2(2) = 169$, $p < 0.001$**), and post-hoc Wilcoxon signed-rank tests revealed significant pairwise differences between all languages (L1 > L2, $r = 0.51$; L1 > L3, $r = 0.84$; L2 > L3, $r = 0.73$), all with large effect sizes. This suggests that most participants had their native language (Arabic) as the most dominant in comparison to the other languages.

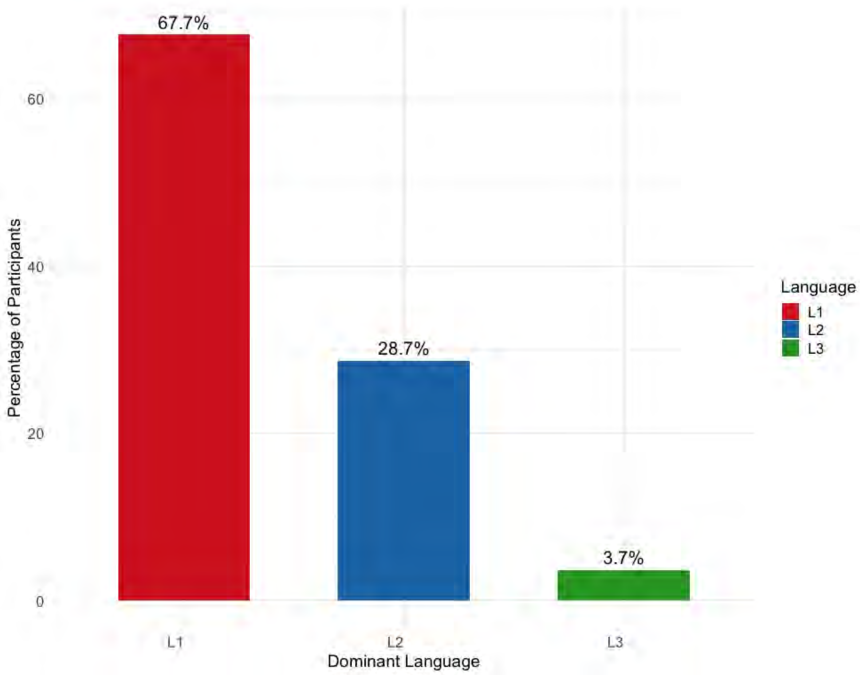

Figure 5.2: Dominant Language Distribution

- **Language Preference**
  Language preference was extracted from LEAP-Q questions regarding written and oral language use: ”What language do you prefer reading a text in?” and ”What language do you prefer engaging a conversation in?” (See Appendix A for exact wording). Participants had to assign a percentage for each language, with the sum adding up to 100%. On average, participants reported a preference for reading in French ($M = 42.1\%$, $SD = 29.7$), followed by Arabic ($M = 36.9\%$, $SD = 30.6$) and English ($M = 31.8\%$, $SD = 27.6$). In oral communication, Arabic was the most preferred language ($M = 61.2\%$, $SD = 26.8$), followed by French ($M = 32.4\%$, $SD = 27.1$) and English ($M = 18.7\%$, $SD = 21.2$).

  A repeated-measures ANOVA on written and oral preferences was conducted to examine significant differences between languages in each domain. For written language, results revealed a significant effect of *Language* ($F(2, 450) = 5.59$, $p = 0.004$*). Pairwise comparisons showed that participants preferred French significantly more than English ($p < 0.001$**), while Arabic did not differ significantly from either French ($p = 0.17$) or English ($p = 0.20$). For oral preferences, the ANOVA also indicated a strong *Language* effect ($F(2, 450) = 149.27$, $p < 0.001$**). Pairwise comparisons revealed that Arabic was preferred significantly more than both English and French ($p < 0.001^{**}$), and French was also preferred over English ($p < 0.001^{**}$).

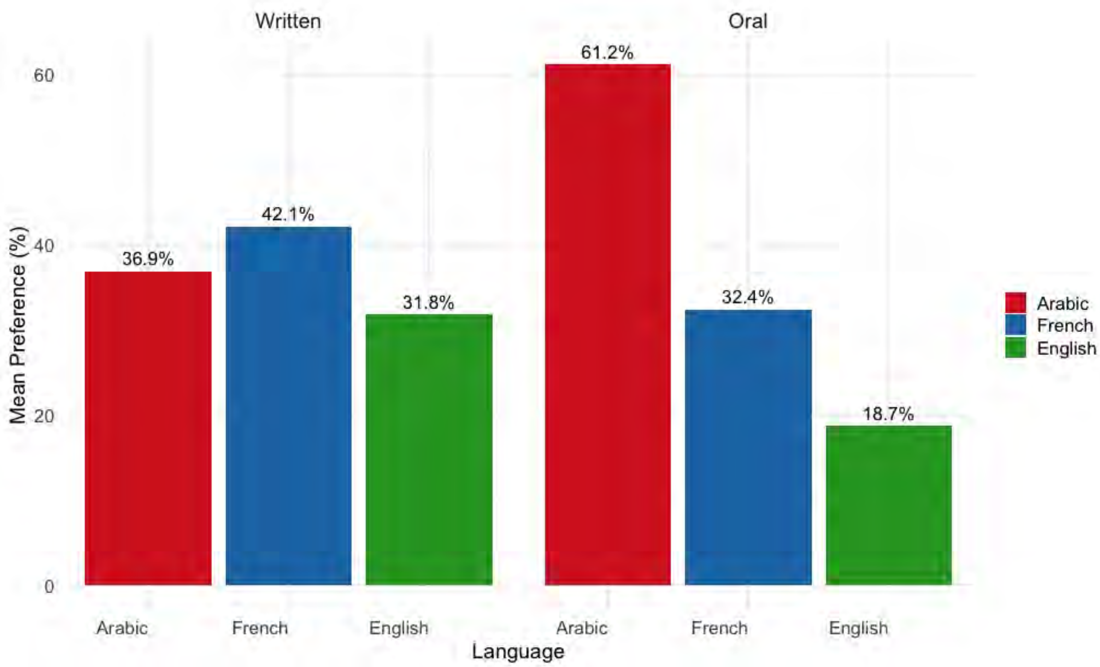

Figure 5.3: Language Preference Distribution

- **Self-Reported Language Proficiency**
  Language proficiency was self-evaluated by participants using the BLP, through questions assessing self-reported oral and written proficiency in comprehension and expression for each language, rated on a Likert scale from 0 to 6, where *0 = not well* at all and *6 = very well*.

  As expected, participants reported the highest proficiency in Arabic, their L1, across all domains, with mean scores above 5.5 for oral and written comprehension and production. French, their L2, was rated slightly lower but still highly proficient, particularly in oral production ($M = 5.61$, $SD = 0.65$) and written comprehension ($M = 5.58$, $SD = 0.93$). English, their L3, had the lowest proficiency ratings, with written production ($M = 4.82$, $SD = 1.30$) being the least proficient skill. Nevertheless, participants were still highly proficient overall: Arabic averaged 5.63/6, French 5.43/6, and English 4.98/6.

  A repeated-measures ANOVA confirmed significant differences across languages in the oral domain. Post-hoc Bonferroni tests revealed that, for both oral comprehension and oral production, participants rated themselves significantly higher in Arabic than in French, and higher in French than in English (all $p < 0.001^{**}$). In contrast, no significant differences across languages were found in the written domain. Additionally, a paired t-test revealed that participants reported significantly higher overall oral proficiency compared with written proficiency ($t(225) = 3.96$, $p < 0.001^{**}$).

  These self-reported ratings parallel participants' language acquisition patterns, with L1 Arabic acquired first, L2 French reported as highly proficient, and L3 English showing more variability, particularly in written contexts.

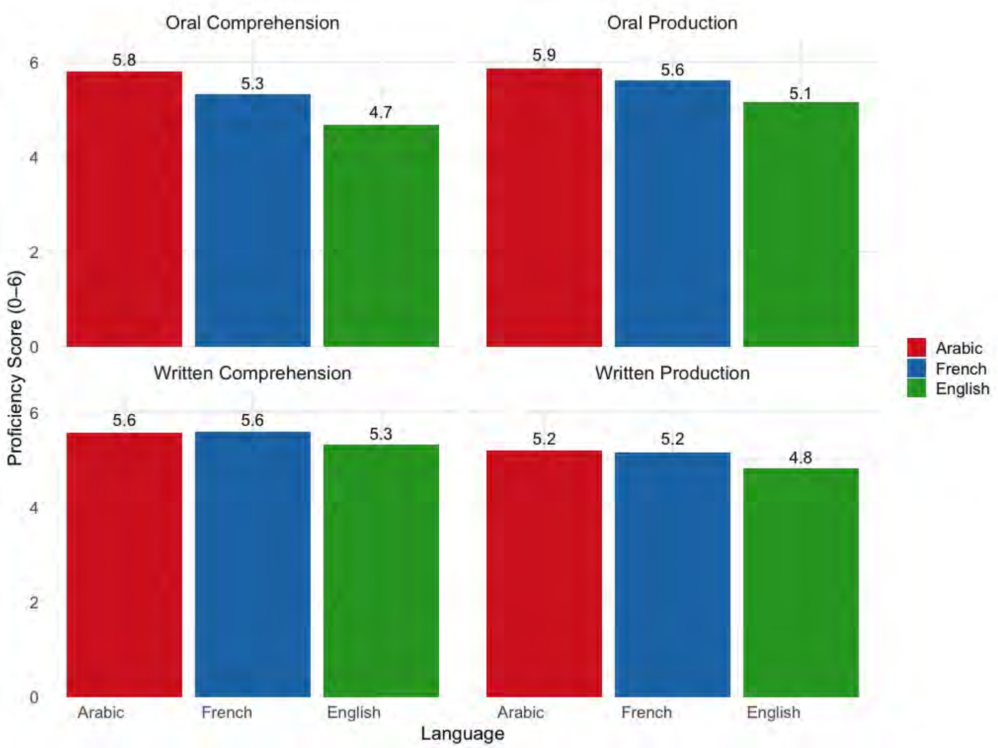

Figure 5.4: Self-Reported Language Proficiency

- **Language Entropy (LE)**
  LE quantifies the diversity of language use across the following communicative contexts: Family, Friends, Work, Self-talk, Counting, Reading Preference, Speaking Preference. Ranging from 0 to 1.585 in this study because it was computed over 3 languages, LE reflects the predictability of language choice, with higher values indicating more integrated language use (Gullifer & Titone, 2020).

Context	Range	Mean	SD	Median
Family	0.000–1.585	0.689	0.514	0.722
Friends	0.000–1.585	1.212	0.322	1.295
Work	0.000–1.585	0.759	0.461	0.881
Self-talk	0.000–1.585	1.056	0.429	1.000
Counting	0.000–1.585	1.018	0.491	1.000
Reading	0.000–1.585	1.070	0.441	1.157
Speaking	0.000–1.585	1.059	0.461	1.157
Overall	**0.412–1.580**	**0.981**	**0.262**	**0.962**

Table 5.2: Language Entropy across Communicative Contexts

In this study, participants had relatively high LE values across most contexts (see Table 5.2), with the highest mean observed in Friends (M = 1.212, Md = 1.295), indicating more integrated language use in this context. Reading (M = 1.070, Md = 1.157), Speaking (M = 1.059, Md = 1.157), and Self-talk (M = 1.056, Md = 1.000), also showed high levels of integration. Family (mean = 0.689, median = 0.722) and Work (mean = 0.759, median = 0.881) demonstrated relatively more compartmentalized language use. The overall LE was on average

0.981 (±0.262, median = 0.962), suggesting a tendency toward integrated language use across various communicative contexts. These patterns are further illustrated in Figure 5.5, where points represent mean entropy for each communicative context and the gradient indicates low (light blue) to high (dark blue) entropy.

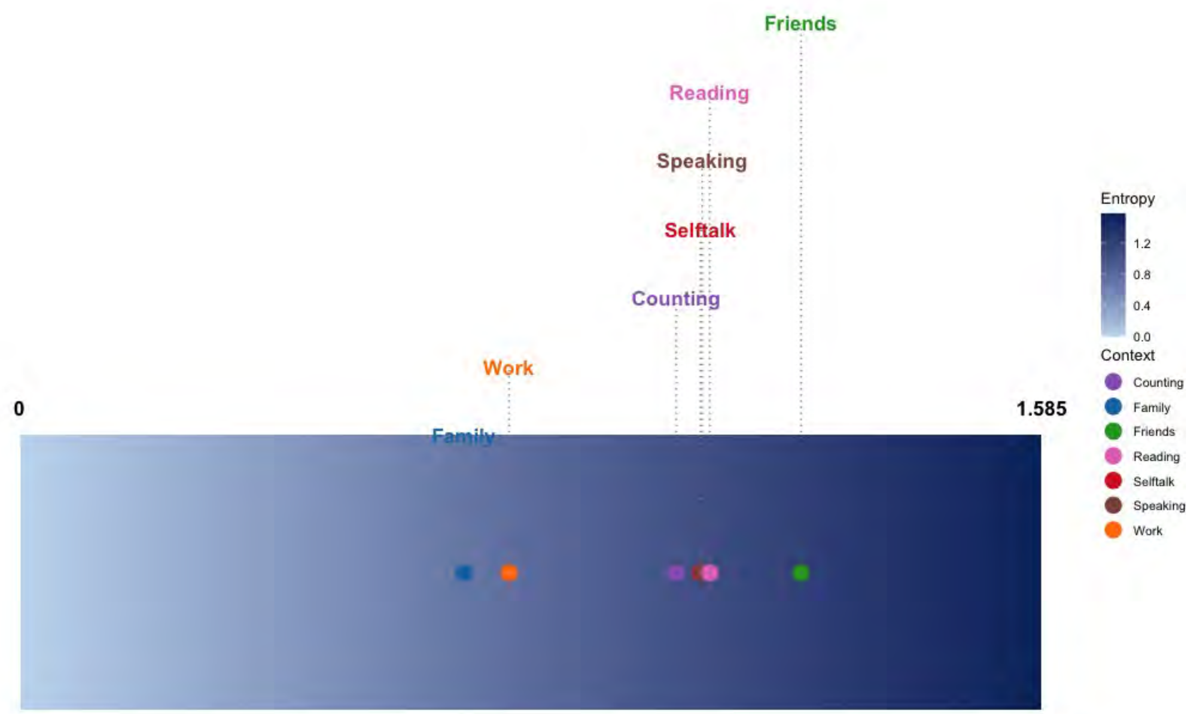

Figure 5.5: Mean Language Entropy Across Contexts

- **Code-Switching Profile (CSP)**
  The CSP reflects participants' overall engagement with and attitudes toward code-switching on a scale from 0 to 100, with higher scores indicating more frequent use and positive perceptions of switching between languages, across the following categories: code-switching History, Use, Ease of Use, and Attitudes.
  Code-Switching History captures participants' experience with code-switching across various contexts, such as school, region, family, and work, with an average score of 41.3 (±16.4). Code-Switching Use reflects the frequency of code-switching in daily interactions, with participants reporting an average of 38.0 (±28.2). Code-Switching Proficiency refers to participants' self-reported ease in using code-switching, yielding an average of 75.7 (±37.1). Code-Switching Attitudes assesses participants' overall stance toward code-switching, resulting in an average score of 52.4 (±37.0). The overall CSP, which aggregates these components, averaged 51.8 (±22.3), and ranged from 4.79 to 98.47, reflecting wide variability in self-reported code-switching habits.

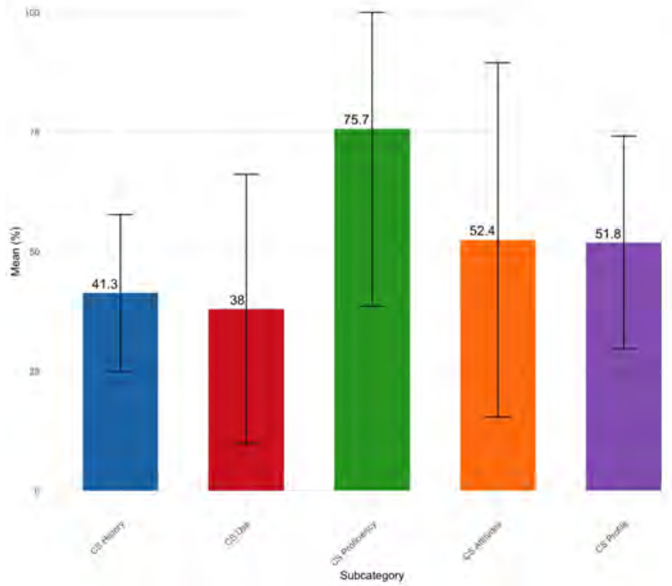

Figure 5.6: Code-Switching Profile Scores

One question was added to the online questionnaire concerning participants' opinion on code-switching: whether they judged it as a phenomenon that's good, bad or neutral, and why. The results (Figure 5.7) showed that almost half (48.7%) of the participants consider code-switching as positive. The main reasons provided for this view include mental flexibility, ability to enhance expression, and the enrichment of knowledge. Participants also mentioned the cultural richness it provides, its role in boosting self-confidence, in facilitating communication with a broader range of people, and its professional advantages. Additionally, code-switching was seen as an adaptable tool to fill gaps in vocabulary. On the other hand, 39.8% of participants saw code-switching as neutral, explaining it as a habitual behavior that characterizes the Lebanese population, as something easy to do, or simply unconscious. Only 11.5% of participants assessed code-switching as negative, citing concerns about poorer vocabulary in each language, the risk of confusing interlocutors who are not proficient in all the languages involved, and the perception that code-switching could be seen as an act of arrogance.

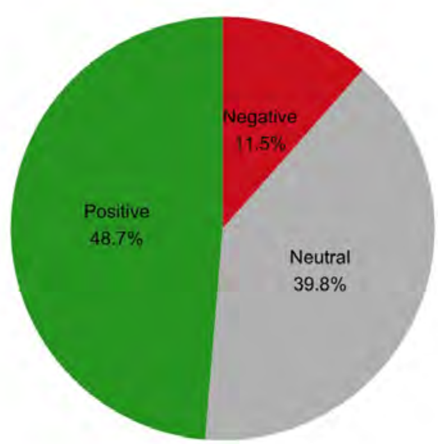

Figure 5.7: Participants' Opinion on Code-Switching

Summary of Sociolinguistic Study Findings

Participants:
The sample consisted of 226 bilingual and trilingual speakers of Arabic, French, and/or English. Participants had a mean age of 30.1 years ($SD = 10.1$, $Md = 27.0$), and 69.03% held higher education degrees (Master's or PhD).

Language AoA:
The majority of participants acquired Arabic as their first language (80.5%), significantly more than French (18.1%) and English (1.3%). French was the predominant second language (73.5%), reported significantly more often than English (13.5%) and Arabic (13%). English was the predominant third language (88.7%), significantly more than French (8.8%), Arabic (1.5%), Spanish (0.5%), and Portuguese (0.5%).

Language Dominance (based on BLP):
Most participants were dominant in Arabic (67.7%), followed by French (28.7%), and a small proportion were dominant in English (3.7%).

Language Preference Ranking (from most to least preferred):
Written (Reading): French > Arabic > English
Oral (Speaking): Arabic > French > English

Self-Reported Language Proficiency:
Participants reported the highest proficiency in Arabic (5.63/6), followed by French (5.43/6) and English (4.98/6), across oral and written comprehension and production, yet indicating relatively hihgh proficiency in all three languages.

Language Entropy (LE):
The mean LE was 0.981 (SD = 0.262), knowing that the theoretical maximum is of 1.585 for three languages.

Code-Switching Profile (CSP):
The mean CSP was 51.8 (SD = 22.3) on a scale from 0 to 100.

5.5 Discussion

Despite the growing body of research interested in bilingualism and its assessment, the sociolinguistic profiles of bilingual populations remain insufficiently described in most current studies. As De Bruin (2019) emphasizes, it is essential to carefully examine and describe not only a bilingual's proficiency and AoA, but also their patterns of language use and switching, as well as the different interactional contexts in which they use their languages, as suggested by Green and Abutalebi (2013)'s ACH. Yet, many studies still rely on single questionnaires or short surveys specifically designed for the purpose of the research, often based on limited self-reports or a narrow set of variables. This restricts the understanding of how bilinguals organize and control their linguistic repertoires in daily life.

To address these gaps, the present study deliberately combined three questionnaires, each targeting a distinct dimension of bilingual experience: the LEAP-Q assessed language history and acquisition, the BLP addressed language dominance, and the BCSP collected participants' code-switching habits. This multi-instrument approach provides a more complete and fine-grained description of the bilingual individual than is usually found in studies that rely on a single survey. It also enables the use of continuous measures such as entropy to capture how languages are integrated across contexts. Based on existing research, no previous study has examined the sociolinguistic profiles of Lebanese bilinguals using such a comprehensive approach. Therefore, the present study provides baseline data on AoA, language dominance, code-switching habits, and LE in this community.

5.5.1 Language Age of Acquisition (AoA)

The analysis of reported AoA across first (L1), second (L2), and third (L3) languages reveals clear tendencies in the Lebanese bilingual participants of this study. Arabic was the dominant L1, and was acquired first significantly more frequently than French and English. French was the most common L2, significantly more than English and Arabic. As the third acquired language, English was significantly dominant over French and Arabic, with other languages present only in minority (Portuguese, Spanish). These patterns confirm that participants predominantly acquire French as a second language, or in some cases simultaneously with Arabic as L1, while English generally emerges as the third language. Some participants also reported additional languages (L4 and L5), such as Italian, German, Turkish, and Hungarian.

The AoA data support the widely assumed notion that in Lebanon, Arabic is acquired from birth or early childhood, often in combination with French or followed by it, while English is introduced later. These findings converge with Chehimi et al. (2024), who found that Arabic overwhelmingly dominated early family language exposure in Lebanon, with English and French playing a comparatively smaller role, thereby confirming Arabic's central role in early family exposure in the Lebanese context (see Section 1.4.1.2).

Notably, in Chehimi and Hejase (2024) and Chehimi et al. (2024)'s study, English appeared to be used more than French in early childhood; however, for the present study's participants, residence in France likely explains the pattern of French as L2 and English as L3, as most Lebanese who move to France are francophone and pursue higher education in French universities (69.03% of respondents held a master's or PhD degree). This trend is consistent with sociolinguistic practices in Lebanon, where parents typically speak Arabic with their child from birth, sometimes alongside French (or English); French is reinforced in nursery and kindergarten, and English is formally introduced around the age of 8 at school. The present results align with this developmental trajectory.

Interestingly, a similar developmental pattern is observed in Catalan–Spanish bilinguals, known to be FCS like Lebanese (Bacha & Bahous, 2011; Rodriguez-Fornells et al., 2012). They are typically exposed to Catalan and Spanish from birth or early childhood, with English introduced later (Soto-Corominas, 2025), suggesting that Spanish–Catalan bilinguals are also exposed to two languages from birth or early childhood, with a third language introduced later. This parallels language acquisition patterns in the Lebanese community.

Overall, these patterns confirm a clear sequential acquisition of languages in Lebanese bilinguals, with Arabic as L1, French as L2, and English as L3.

5.5.2 Language Dominance Index (LDI)

Language dominance results, based on LDI and percentages, both showed that the majority of participants had Lebanese Arabic as their dominant language, followed by French, then English, paralleling language acquisition patterns. Non-parametric analyses confirmed significant differences between languages, indicating a hierarchical dominance difference between the three languages in this Lebanese bilingual sample.

Although both LDI and percentages yielded similar results, reporting the percentages of dominance for each language provides a more straightforward and interpretable overview of language hierarchy, especially when considering three languages simultaneously. This recommendation was given by David Birdsong (personal communication), the author of the BLP, who noted that the LDI was originally designed for assessing two languages, making it less representative and reliable when applied to three languages (Birdsong et al., 2012).

The current findings align with Kassir et al. (2024), who reported that most older Lebanese adults (mean age ≈68 years) exhibited balanced bilingualism, with fewer showing Arabic or French dominance (see Section 1.4.1.2 for details). It should be noted that, unlike Kassir et al. (2024), the present study did not offer participants the option to indicate that two languages were equally dominant. As a result, participants were required to choose which of their two most dominant languages was stronger, which may have reinforced the observed hierarchical pattern of dominance. Moreover, while the comparison study collected data in Lebanon on older adults, the current study was conducted in France on a younger Lebanese population (mean age ≈30.1 years), and the results suggest that neither context nor age substantially alters the overall pattern of language dominance. These findings support the notion that, across different Lebanese bilingual populations, age groups, and collection contexts, Lebanese Arabic tends to remain the most dominant language, French may be less dominant or balanced, and English potentially appears as a third language.

The observed presence of English as a third language in the current sample may be explained by historical and educational factors. Unlike the older adults in Kassir et al. (2024)'s study (mean age ≈68), who were school-educated in a period when French predominated and English exposure was minimal (Bacha & Bahous, 2011; Kanaan, 2011; Shaaban & Ghaith, 1999), the participants in the present study (mean age ≈30) attended schools during the rise of globalization, when English was increasingly introduced around third grade, even in francophone institutions (Bacha & Bahous, 2011; Shaaban, 2017). This shift in the educational system, together with the growing role of English as a *lingua franca*, likely accounts for its consistent emergence as a third language, while the hierarchical dominance of Arabic and French remains stable across generations. Additional exposure to English through television and social media (Baidoun, 2018; Bassam, 2022; Smairat, 2020), international travel and professional opportunities abroad (Diab, 2009; Shaaban & Ghaith, 2002), and interactions with foreign helpers in the household (Bacha & Bahous, 2011) may also contribute to its emergence as a third language in younger Lebanese adults. In sum, Arabic maintains its status as the dominant language, while French and English occupy complementary roles, with English emerging more prominently among younger generations due to educational and sociocultural shifts.

5.5.3 Language Preference

Participants reported their language preferences in both oral and written domains across Arabic, French, and English. In oral communication, Arabic was significantly preferred over both French and English. This is consistent with Shaaban and Ghaith (2002), who found that Lebanese university students generally perceive Arabic as a key marker of identity, whereas French is associated with high culture and formal education, and English is primarily used in business, science, and mass communication. Similarly, Diab (2009) reported that students who had acquired French as a first foreign language tended to prefer using it over English, whereas those who had learned English first preferred it over French, highlighting the influence of first foreign language acquisition on language preferences.

For reading, French was the most preferred language, followed by Arabic and then English; the difference between French and Arabic was not significant, while both French and Arabic were preferred significantly more than English. This pattern resonates with the sociolinguistic context in which French dominates educational and formal written domains (Shaaban & Ghaith, 2002). Additionally, research on written communication, including Bassam (2017), highlights the use of Arabizi, a romanized form of Arabic in SMS messaging, which shows how Arabic is adapted in writing, whereas French maintains a strong presence in formal literacy and reading (refer to Section 1.3.2.2).

Although English was the least preferred language across both oral and written domains, it should be noted that the participants in the current study are Lebanese adults residing in France, which may partly explain this preference. Furthermore, even when not preferred, attitudes toward English remain generally favorable, influenced by its widespread use on social media, with Lebanese speakers, including public figures, often using English and/or French even when their proficiency is limited (Esseili, 2017).

5.5.4 Self-Reported Language Proficiency

Participants in the current study reported high proficiency across all languages and domains. In Arabic, high proficiency was reported across all domains. French was also rated highly, particularly in oral production and written comprehension, whereas English showed lower proficiency, especially in written production. Significant differences between languages were observed in the oral domain (Arabic > French > English), but not in the written domain. Consistent with this, participants reported significantly higher overall oral proficiency compared with written.

These patterns are consistent with prior research on Lebanese university students. For instance, Chehimi et al. (2024) found that self-rated Arabic proficiency was highest, English intermediate, and French lowest, reflecting the dominant role of Arabic as L1 and the variability in second- and third-language acquisition. However, in their study, L2 and L3 self-reported scores were substantially lower than the ones in the current study, where participants reported high proficiency across all languages and domains, with no mean score below 4.7/6, whereas English (M = 3.29/5) and French (M = 1.67/5) were rated lower in Chehimi et al. (2024). Similarly, Bassam (2017) reported that Arabic was generally rated as "excellent" or "very good," while French and English proficiency showed more variability, with French often rated lower than English. The difference between the current findings and these studies regarding the second-most proficient language, French here vs. English in their samples, likely reflects the francophone background of this study's participants and their residence in France, highlighting the impact of the current language environment on proficiency.

Overall, participants' self-reported proficiency in the current study aligns with these previous findings, confirming that Arabic remains the dominant language for Lebanese speakers, French is highly proficient but secondary, and English is acquired later and shows more variability, particularly in written skills. These findings mirror participants' language acquisition patterns. They also suggest that differences in oral proficiency are more salient than written in everyday use and participants generally perceive their oral skills as stronger than their reading abilities. Furthermore, participants' self-ratings indicate high proficiency across languages, underscoring their perception of being highly multilingual and relatively balanced bilinguals.

5.5.5 Language Entropy (LE)

Participants exhibited generally high LE across all communicative contexts, with the most integrated language use reported with friends, then in speaking and reading, followed by self-talk and counting, and relatively more compartmentalized use in family and work contexts. In general, the mean LE (0.981 ± 0.262) suggests a trend toward integrated language use in most contexts, reflecting the flexible code-switching practices of participants. Additionally, the relatively low variability in LE scores suggests that language use patterns were consistent across participants, reflecting a representative sample and supporting the robustness of the findings.

As reported, participants in this study were FCS who used languages in an integrated manner across most of their daily contexts, including when talking to friends, speaking more generally, reading, as well as in counting and when talking to themselves. The lower LE scores observed in Family and Work contexts may reflect participants' habitual use of Arabic when talking to their family in Lebanon and French in their workplace in France[3].

Previous work by Gullifer and Titone (2020) tested bilinguals in Montreal, a city known for frequent language switching in daily life. Their results showed relatively high LE in the Social/Friends context, followed by moderate LE in the Work context and then in Speaking, and lower entropy at Home and in Reading. Their results were compared with those of this study in Table 5.3. Effect sizes (Cohen's d) calculated for each comparable context indicate that participants in the current study exhibited moderately lower integration in Family/Home and Friends/Social contexts, and substantially lower integration in Work contexts, while LE levels for Reading and Speaking were similar.

Context	**This Study (Mean ± SD)**	**Gullifer & Titone (Mean ± SD)**	**Cohen's d**
Family/Home	0.43 ± 0.32	0.61 ± 0.46	-0.45
Friends/Social	0.76 ± 0.20	0.94 ± 0.28	-0.74
Work	0.48 ± 0.29	0.76 ± 0.37	-0.84
Reading	0.68 ± 0.28	0.60 ± 0.41	0.23
Speaking	0.67 ± 0.29	0.70 ± 0.41	-0.08
Self-talk	0.67 ± 0.27	-	-
Counting	0.64 ± 0.31	-	-
Average	0.62 ± 0.28	0.72 ± 0.39	-

Table 5.3: Normalized Mean Language Entropy across Contexts for the Current Study Compared with Gullifer and Titone (2020)

Reading and Speaking LE levels were comparable between the participants of this study and the one by Gullifer and Titone (2020), reflecting integrated language use across both FCS populations. The lower integration observed in Family/Home contexts in the current study may be attributable to participants' living circumstances, as they were young adults residing in France while many had their families in Lebanon. This geographical separation likely reduced opportunities for varied language use in the home domain, resulting in lower LE values. In the Friends/Social context, Lebanese participants living in France may have displayed more compartmentalized patterns of use, as they interacted primarily in French with monolingual French-speaking peers. A similar explanation applies to the workplace, where participants in Montreal interacted in a bilingual environment, whereas Lebanese adults in France were generally required to use only French with colleagues.

To compare to non-FCS, Wagner et al. (2023) reported substantially lower LE values across most communicative contexts, with means ranging from 0.09 to 0.62, characterizing the group of 523 bilinguals from a wide range of linguistic backgrounds as non-FCS, showing more compartmentalized language use. In contrast, the present study reported normalized LE means ranging from 0.43 to 0.76, and Gullifer and Titone (2020) reported means ranging from 0.60 to 0.94, reflecting more integrated language use consistent with frequent code-switching. Another ongoing study on non-FCS by Baulande and Köpke (in preparation) assessed LE in French-English bilinguals, alongside their L2 proficiency. Their results indicate that more balanced bilinguals exhibited higher LE. This pattern also reflects the results of the current study: based on self-reported proficiency, participants generally had high proficiency scores, indicating relatively balanced bilingualism, and exhibited relatively high and homogeneous LE, with an average of 0.619, comparable to the balanced bilinguals group in Baulande and Köpke (in preparation)

[3]For comparison with previous studies involving two languages (maximum entropy = 1), the LE values in this study (maximum entropy = 1.585 for three languages) were normalized by dividing by 1.585. For example, the Family context mean was normalized as $0.689/1.585 \approx 0.43$. Similarly, all other context means and standard deviations were divided by 1.585 to obtain normalized values comparable with prior studies, as reported in the first column of Table 5.3.

(0.627) (see Section 2.5.2 for details).

Altogether, LE results indicate that the participants in the current study display language use patterns characteristic of FCS, with relatively high and homogeneous LE across most communicative contexts. Contextual factors, such as living in France away from family or interacting with primarily monolingual peers, contribute to lower integration in Family/Home and Work contexts. Comparisons with non-FCS further underscore that balanced bilingualism and higher proficiency are associated with more integrated language use. Together, these findings suggest that both individual linguistic experience and social context shape the degree of language integration.

5.5.6 Code-Switching Profile (CSP)

The CSP, derived from the adapted Lebanese version of the BCSP (Olson, 2022) (see Appendix A for the adapted version used), indicated a moderate overall engagement with code-switching in the sample. Participants tended to report high confidence in their code-switching abilities and generally positive attitudes toward the practice, while their frequency of use and history of code-switching appeared comparatively more moderate.

The CSP in the present study aligns with previous findings. While Olson (2022) and Kheder et al. (2025) did not report sub-component scores (refer to Section 1.4.1.2 for sample details), overall CSP values across studies are broadly similar, indicating comparable engagement with code-switching, as reported in Table 5.4.

CSP	**This Study**	**Olson (2022)**	**Kheder et al. (2025)**
Mean	51.8	58.7	Exp 2: 58.4 Exp 3: 66.1 Exp 4: 64.7
SD	22.3	19.2	Not reported
Range	4.8–98.5	8.3–96.9	Exp 2: 10.4–92.7 Exp 3: 19.2–97.2 Exp 4: 42.7–84.9

Table 5.4: Comparison of Code-Switching Profiles Across Studies

Although the overall CSP in the present study was broadly comparable to previous studies (Kheder et al., 2025; Olson, 2022), whose participants were, respectively, diverse bilinguals from around the world and early Spanish-English bilinguals, it was lower than might be expected for a population of FCS. This can potentially be explained by the wide range of scores, reflecting heterogeneous language practices among participants. All Lebanese participants resided in France, which may have promoted more compartmentalized language use in certain contexts, particularly at work and in family/home domains, consistent with the LE results reported above. This pattern is further reflected in the sub-component scores: Code-Switching Use was relatively low (38.0 ±28.2) and highly variable, suggesting that participants did not use code-switching as frequently as predicted. In contrast, Code-Switching Proficiency was the highest score (75.7 ±37.1), indicating strong confidence in participants' ability to engage in code-switching when the context allowed, consistent with a robust code-switching habitus and competence.

Similarly, this pattern is also reflected in the Code-Switching Attitudes sub-component, which averaged 52.4 (±37.0), indicating neutral attitudes toward code-switching overall. The follow-up question in the survey further clarified these attitudes: nearly half of the participants (48.7%) explicitly considered code-switching to be positive. They highlighted benefits such as mental flexibility, enhanced expressive capacity, enrichment of knowledge, cultural richness, increased self-confidence, facilitation of communication with diverse interlocutors, and professional advantages. Code-switching was also perceived as a flexible strategy to fill gaps in vocabulary. In contrast, 39.8% viewed code-switching as neutral, describing it as a habitual or unconscious behavior characteristic of Lebanese bilinguals, while only 11.5% judged it negatively, citing potential vocabulary reduction in each language alone, risks of confusing languages, or being perceived as arrogant. These findings align with the moderate CS Attitudes score, suggesting that participants generally hold favorable or neutral views toward code-switching, consistent with their confidence and engagement in the practice as reflected in the CS Proficiency scores.

Attitudes toward code-switching in Lebanon have evolved over the past 25 years, likely influenced by globalization and the rise of social media. Historical portrayals of language attitudes can be seen in TV series, which reflect the language practices of the time they are released. For example, in the TV series *Familia* (Tayeh, 2003) (Episode 8, min 31:35 - 32:02), the main character, a prominent journalist and editor-in-chief, frequently emphasizes her preference for others to purely speak Arabic rather than French or English. She instructs her staff to replace greetings like “Bonjour” and “Good morning” with ”صباح الخير“ and expresses a preference for using Arabic with family and friends to promote the national language. Similarly, the Lebanese TV comedy show *La Youmal* (Fakih, 2003-2010) and its sequel *Mafi Metlo* (Fakih, 2011-2017), running from 2003 until 2017 featured the nationally famous character, “Mister Loughat” (Mister Languages), played by the actor Abbas Chahine, who consistently code-switches while humorously twisting English and French words. Other public figures have been criticized for using foreign words incorrectly, such as the singer Elissa saying “tanks” instead of “thanks,” and TV hosts and journalists have publicly shamed those who do not use standard English or French (Esseili, 2017, p.700). This practice, while preserving a purist image of foreign languages and preventing the emergence of local variants, has also contributed to maintaining high standards of linguistic performance through publicly mocking or sanctioning linguistic deviations or modifications.

In more recent years, multiple Lebanese social media influencers and public figures have faced criticism for not exclusively using Arabic in their content. Professionals such as psychologists, journalists, speech therapists, dieticians, etc. have been accused of pretentiousness, mainly by users from other Arabic countries, for using English and French in their content. Ghena Sandid (2025) (known as *LighterStyle*), for instance, produced a series of videos on Instagram explaining that code-switching is often not voluntary and primarily serves to convey technical terms. Yet, this practice, which has been characteristic of Lebanese multilingualism for a long time, is increasingly widespread across the world population, particularly given the current omnipresence of English in professional, social and media domains, and may come to be viewed more positively in the coming years.

This diachronic review of sociocultural views on code-switching reveals a shift in attitudes from predominantly negative toward more positive perceptions, mirroring the results obtained in the current study. Interestingly, qualitative examination of participants’ responses revealed that negative views of code-switching were predominantly expressed by older adults, whereas younger participants more often adopted positive or neutral stances.

5.6 Limitations and Perspectives

Although this questionnaire provides valuable information on language history and practice in Lebanese adults residing in France, several limitations should be considered. First, the study relies entirely on self-reports, which can be influenced by subjective factors such as attitudes toward languages and code-switching, stigmas, awareness of switching, identity, and the framing of questions. As shown by Tomoschuk et al. (2019), self-ratings can differ significantly across dominance groups. In the present questionnaire, some concerns about item framing were partially addressed by including multiple items measuring overlapping constructs to assess robustness, but time constraints prevented systematic investigation of their convergence. For instance, correlations between the LEAP-Q and the BLP could verify self-reported language dominance, as the LEAP-Q contains a direct dominance question while the BLP derives dominance from oral and written proficiency measures. Examination of such correlations would strengthen confidence in the reliability of the indices derived from the questionnaire. Second, the questionnaire included numerous variables that were not analyzed, such as self-reported and perceived foreign accent, detailed ages of language acquisition across different contexts, years of formal education, measures of cultural identification, etc. Analysis of these variables could provide additional insight into participants' linguistic profiles. Third, the use of the BCSP is limited by its novelty, as it has only been applied to a few populations since its creation in 2022. Likewise, LE (Gullifer & Titone, 2018, 2020) is a recently developed measure, and comparative data across populations remain limited. Future studies on different populations can be beneficial for comparing current FCS with other populations who have a different use of languages and code-switching. Lastly, the sample consisted of Lebanese bilinguals residing in France. Comparison with bilinguals residing in Lebanon could clarify the influence of linguistic and sociocultural context on language use, code-switching habits, and dominance patterns, providing further understanding of environmental effects on language profiles.

In sum, Study 1 provides a comprehensive overview of language experience and switching behavior in the Lebanese FCS population. It represents one of the first investigations to describe this population in detail, considering not only proficiency and AoA, but also patterns of language use, switching habits, and the various interactional contexts in which languages are employed, in line with De Bruin (2019)'s recommendation that bilingual research should examine these multiple dimensions. Participants exhibited early acquisition of both Arabic and French, relatively balanced language dominance, and high self-reported proficiency, reflecting well-established bilingual competence. LE analyses indicated high integration in most social domains, although some compartmentalization emerged in home and work contexts, likely shaped by participants' residence in France. The CSP further revealed moderate overall engagement in language switching, with particularly high proficiency and generally positive or neutral attitudes toward code-switching. Taken together, the findings show that Lebanese FCS combine strong language abilities with flexible switching patterns and generally favorable attitudes toward code-switching, highlighting its role in daily language practice and providing potential predictors for performance in experimental tasks of language control.

Chapter 6

Experimental Language Switching Study

The second study focused on bilingual language switching, examining participants' performance in picture naming and semantic fluency tasks, while also assessing executive functions to explore the cognitive mechanisms underlying language control.

6.1 Participants

Participants in Phase 2 were 61 participants from Phase 1 who consented to take part in the laboratory experiments.

6.1.1 Recruitment Criteria

For practical reasons, only participants located in the cities of Toulouse and Montpellier were included. A total of 62 participants initially met this criterion. However, one participant was excluded from the final sample due to incomplete responses on the questionnaire, resulting in a final sample of 61 participants. Data collection took place between February and April 2024. Sessions were all conducted in person, either at the laboratory or in participants'/experimenter's homes, depending on their mobility and availability.

6.1.2 Final Sample Description

For the second phase, all 61 participants (30 females) were early bilinguals of Lebanese Arabic and French. Although English was not a requirement for participation, all participants happened to have English as their third language. They had acquired Arabic from birth (M = 0.95 years, SD= 1.35, Md = 0), French at around 3.8 years (SD = 2.29, Md = 3), and English at around 8.4 years (SD

= 3.60, Md = 8). Their ages ranged from 18 to 35 years, with an average age of 26.48 years (±4.7) and a median of 28.0 years. The majority held higher education degrees, with 70.5% having obtained a Master's or PhD degree. On average, participants had lived in France for 5.4 years (±5.6), with a median LOR of 4 years. Participants showed an average LE of 0.838 (±0.255), with a median of 0.891. Their average CSP was 74.1 (±13.1), with a median of 76.6.

Comparison with the original Phase 1 sample indicated no significant differences in AoA or LOR (Wilcoxon ps > 0.005), suggesting that the Phase 2 participants are representative of the larger sample in these aspects. However, LE was significantly higher in Phase 1 than in Phase 2 (t-test, $p < 0.005$**), and CSP scores were significantly higher in Phase 2 compared to Phase 1 (Wilcoxon, $p < 0.005$**), reflecting less integrated language use but more frequent daily code-switching among the participants in the current phase, further supporting their FCS status.

For the Stroop and WCST tasks specifically, the final sample size was 60 instead of 61, as one participant could not complete the Stroop tasks in both Arabic and French, as well as the WCST, due to colorblindness.

6.2 Procedure

Participants completed a series of language and executive tasks in Phase 2 in a single laboratory session at Toulouse Jean Jaurès University's experimental platform, *Cognition, Comportement et Usages*. Alternatively, when participants faced constraints, the sessions were conducted in their homes or the experimenter's home. The session lasted between 75 and 90 minutes, depending on the participant's pace. Prior to the session, all participants provided written informed consent. They received a gift card as a token of appreciation for their participation. All sessions were administered by the doctoral researcher. A detailed description of the tasks follows in the next section.

Participants completed most tasks using a computerized experimental setup, except for the semantic fluency and the working memory tasks. These tasks, were presented via PsychoPy v.2023.2.3 software (PsychoPy Contributors, 2023), running on a Dell 15-inch (1920 x 1080 pixels resolution) portable computer with Windows 10 and an Intel Core i7 processor. The visual background for all computerized tasks was set to a neutral grey, in order to reduce visual fatigue and maintain a comfortable viewing experience throughout the session. Participant responses were recorded using a Poly Blackwire 5220 headset with microphone noise cancellation, ensuring high-quality audio capture for naming tasks.

Verbal responses for the fluency task were intended to be recorded using a portable Roland R-26 audio recorder, but due to technical difficulties, a smartphone was used instead. The smartphone was unused for any other purpose, with no SIM card, apps, or data other than the recordings. The phone was not connected to the internet and only contained the recordings, which were transferred directly to the computer after each session and then deleted from the phone to ensure data security.

The data collected were primarily behavioral, encompassing RT and accuracy scores for most tasks, unless otherwise stated. All responses were directly recorded through the headset, and RT and accuracy scores were later extracted using the Checkfiles tool from Checkvocal® software (Protopapas, 2007).

Participants were divided into two groups (A and B), each assigned a different task administration order, as shown in Table 6.1:

Order	Group A	Group B
1	French Language Proficiency	French Language Proficiency
2	Bilingual Picture Naming (starting with monolingual conditions)	Bilingual Picture Naming (starting with bilingual conditions)
3	Working Memory	Working Memory
4	French Stroop Test	Arabic Stroop Test
5	Flanker Task	Flanker Task
6	Wisconsin Card Sorting Test	Wisconsin Card Sorting Test
7	Arabic Stroop Test	French Stroop Test
8	Semantic Fluency (starting with monolingual conditions)	Semantic Fluency (starting with bilingual conditions)

Table 6.1: Order of task administration for Groups A and B

All experimental materials, scripts, and data are available in Appendix N in the folder *Phase 2*.

6.3 Materials

In this phase of the study, participants completed tasks to assess their French L2 proficiency and bilingual language production (including picture-naming and semantic fluency), which is the primary focus of this phase. In addition, they performed a series of executive control tasks, including measures of inhibition, mental flexibility/ set shifting, and working memory.

6.3.1 French Language Proficiency

French language proficiency was assessed using the *Oscar* tool (Centre d'Étude de Langues, 2025), which provides both an overall proficiency score ranging from 0 to 100, as well as a CEFR level. The test consists of 30 questions targeting written comprehension and expression, administered under timed conditions. The difficulty level adapts dynamically to the participant's performance, ensuring a tailored assessment experience. The test, which typically lasts between 10 and 15 minutes depending on individual pace, yields sub-scores in vocabulary, grammar, comprehension, and expression, in addition to the global proficiency score.

In addition to the objective assessment, participants had also reported their French proficiency via the BLP questionnaire. Self-reported scores in four domains — expression, comprehension, reading, and writing — were averaged and rescaled to a 0–100 scale to allow direct comparison with the Oscar test scores. To assess the relationship between objective and self-reported proficiency, a Pearson correlation was computed between the subjective BLP score and the objective Oscar score.

Experimental language tasks were Bilingual Picture Naming, based on the LSP (Declerck and Philipp, 2015), and Bilingual Semantic Fluency. These two tasks were selected because they best reflect the existing literature on bilingual word production and allow for a complementary evaluation of bilingual language control by assessing both lexical retrieval (naming) and elicitation (verbal fluency) processes. While both tasks assess bilingual language control, Bilingual Picture Naming primarily relies on responses to external cues, whereas Bilingual Semantic Fluency involves internally driven lexical retrieval within the target language(s). Both tasks involved the same four conditions, designed to reflect distinct language control contexts from the ACH (Green & Abutalebi, 2013):

1. **Monolingual Arabic** — single-language context (L1 only)
2. **Monolingual French** — single-language context (L2 only)
3. **Bilingual Alternate/Cued** — dual-language context with externally imposed switching
4. **Bilingual Free/Voluntary** — dense Code-Switching (CS) context, enabling free choice of language on each trial

6.3.2 Bilingual Picture-Naming

In line with widely used bilingual research methods, the Bilingual Picture Naming (BPN) task reflects participants' lexical access and language control mechanisms in speech production. The LSP for this experiment examines how bilinguals manage cross-linguistic interference and co-activation in both monolingual and bilingual contexts.

6.3.2.1 Stimuli

Twenty-five black-and-white line drawings were used as stimuli, representing non-cognate words in Lebanese Arabic and French. These items were selected from the standardized picture database by Cycowicz et al., 1997, which was originally developed for English-speaking children and adapted for adult speakers of French (Alario and Ferrand, 1999) and Lebanese Arabic (Chedid et al., 2022). The selection process aimed to ensure a high degree of comparability across the two languages. Only items that appeared in both the French and Arabic adaptations and that exhibited high name agreement (90–100%) in both languages were retained.

In addition to name agreement, several psycholinguistic variables that are known to influence picture naming performance were controlled for. These included subjective frequency, familiarity, and number of syllables (ranging from 1 to 4), using the normative values reported in the respective databases. Items with the highest subjective frequency in both adaptations were prioritized to ensure balanced lexical accessibility across languages. The final selection was designed to represent a range of semantic fields. Final stimuli were evenly distributed across five semantic categories, reported in Table 6.2 showing the English concepts, alongside their target French (FR) and LA correspondents, as well as a phonetic transcription of the LA words.

Category	English Concept	FR Correspondent	LA Correspondent	LA Phonetic Pronunciation
Food	Apple	Pomme	تفّاحة/تفّاح	[teffe:ħ/teffe:ħa]
	Carrot	Carotte	جزرة/جزر	[ʒazra/ʒazar]
	Banana	Banane	موزة/موز	[mawze/mo:z]
	Tomato	Tomate	بندورة	[banadu:ra]
	Pear	Poire	نجاصة/نجاص	[nʒa:sa/nʒa:s]
Animals	Fish	Poisson	سمكة/سمك	[samke/samak]
	Dog	Chien	كلب	[kalb]
	Butterfly	Papillon	فراشة	[fara:ʃe]
	Rabbit	Lapin	أرنب	[ʔarnab]
	Mouse	Souris	فار/فارة	[fa:r/fa:ra]
Furniture	Door	Porte	باب	[be:b]
	Chair	Chaise	كرسي	[kirse]
	Table	Table	طاولة	[ta:wle]
	Ladder	Échelle	سلّم	[sellom]
	House	Maison	بيت	[be:t]
Objects	Key	Clé	مفتاح	[mefte:ħ]
	Fork	Fourchette	شوكة	[ʃawke]
	Book	Livre	كتاب	[kte:b]
	Bottle	Bouteille	قنّينة	[ʔanni:ne]
	Ball	Balle	طابة	[tˤa:be]
Other	Tree	Arbre	شجرة	[ʃaʒra]
	Sun	Soleil	شمس	[ʃams]
	Car	Voiture	سيّارة	[siyya:ra]
	Heart	Cœur	قلب	[ʔalb]
	Star	Étoile	نجمة	[neʒme]

Table 6.2: BPN Stimuli in English, with their French and Lebanese Arabic (Arabic and Phonetic) Correspondents

In LA, some words have two correspondents, reflecting singular/plural (Apple, Carrot, Banana, Pear, Fish) or masculine/feminine forms (Mouse). The IPA conventions for Arabic were followed, with some modifications to reflect LA pronunciation (e.g., [e] is used instead of [a] in certain words).

To confirm the equivalence of the stimuli across languages, Kruskal–Wallis tests were conducted for name agreement, familiarity, and number of syllables between the LA and FR items. No statistically significant differences were found (all ps > 0.05), indicating that the stimuli were well balanced across languages on these key characteristics.

6.3.2.2 Experimental Design

- **Language Switching Paradigm**
  The experiment involved a cued and a voluntary LSP, and included four conditions (one block each), in which images were randomized:

  1. **Arabic monolingual condition** (50 trials):
     Images had to be named exclusively in LA; each image was presented twice within the condition. This condition only comprised *blocked* trials.

2. **French monolingual condition** (50 trials):
   Images had to be named exclusively in FR; each image was presented twice throughout the condition. This condition only comprised *blocked* trials.

3. **Cued bilingual condition** (100 trials):
   Images had to be named either in LA or in FR, depending on a color cue; a red frame was assigned to LA and blue to FR. Each image was presented four times throughout the condition, twice with a red frame and twice with a blue frame. This condition included 49 *switch* trials and 50 *stay* trials, and it began with a *neutral* trial.

4. **Voluntary bilingual condition** (100 trials):
   Images had to be named either in LA or in FR; the participant was free to use the language they wanted; each image was presented four times throughout the condition (alone with no frame). It began with a *neutral* trial and the number of *switch* and *stay* trials depended on each participant's language switching.

Remark. ”Monolingual conditions” correspond to single-language blocks, and ”Bilingual conditions” to mixed-language blocks.

- **Trial number**
  A total of 300 trials were used in this task and distributed across four experimental conditions, yielding 18,600 observations overall. This included 3,100 observations per monolingual condition and 6,200 observations per bilingual condition. In the cued bilingual condition, trials were distributed across languages and trial types (stay vs. switch) in a balanced manner at the task level, resulting in comparable numbers of observations for LA and FR.
  Following Brysbaert and Stevens (2018), the design exceeds the recommended minimum of 1,600 observations per experimental condition. In this context, language was treated as a within-condition factor rather than as a separate experimental condition.

- **Parameters**
  To determine the parameters of the experiment, a preliminary literature review was conducted on 36 articles that had run similar experiments, focusing on the extraction of SOA, defined as the amount of time between the start of one stimulus and the next, and the ITI, which is the interval between the display of the stimulus and the start of the new trial. The average SOA (2050 ms) and ITI (1101 ms) across these 36 articles were calculated to guide the design of our experiment. Based on these averages, the following setup was used (see Figure 6.1): Each image remained on the screen for 2000 ms (SOA), while the microphone was active for recording. An ITI of 1000 ms preceded each stimulus, consisting of 500 ms of a blank screen followed by 500 ms of a fixation cross.

  For each trial, responses were recorded through a Poly Blackwire 5220 USB-A Wired Headset with microphone noise cancellation. The audio for each stimulus was saved individually in a corresponding folder for later analysis.

  After the experiment, the CheckVocal® tool (Protopapas, 2007) was used to determine manually RT in milliseconds and accuracy scores. Switch and stay trials for the voluntary condition were also annotated manually during the data cleaning phase post-test.

- **Familiarization**
  Prior to running the experiment, participants were familiarized with the 25 target images and their corresponding names in both LA and FR. This procedure aimed to ensure that all target words were activated in the participants' mental lexicon and to minimize errors due to item unfamiliarity. Each experimental condition was preceded by a practice block to confirm that participants understood the task instructions (6 trials). For the practice segment only, participants received corrective feedback to ensure task comprehension.

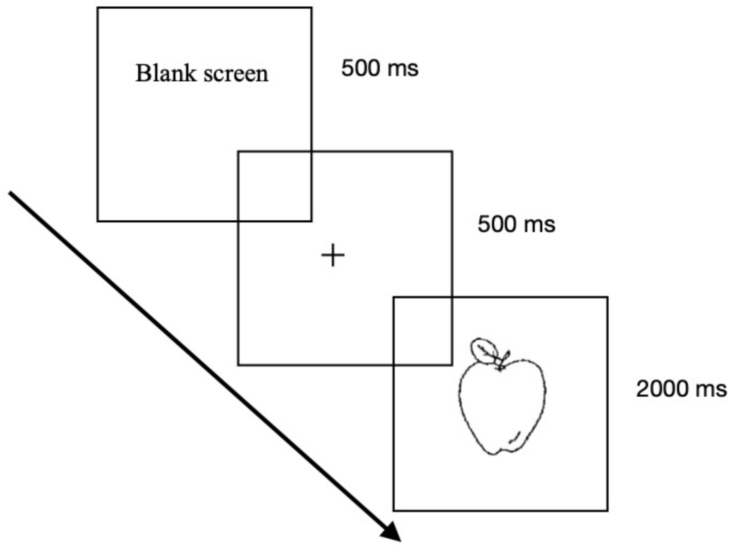

Figure 6.1: BPN Experimental Design

- **Order of administration**
  To control for potential order effects, the sequence of conditions was counterbalanced across participants: half began with the monolingual blocks, and the other half began with the bilingual ones. Instructions for each condition were presented on-screen before the block began (see Appendix B for full instruction scripts). Monolingual and bilingual blocks were counterbalanced across participants, resulting in two experimental groups:
  - Group A followed the order: Arabic monolingual, French monolingual, cued bilingual then voluntary bilingual.
  - Group B followed the order: cued bilingual, voluntary bilingual, Arabic monolingual, French monolingual.

  For image presentation, a single randomized sequence was generated prior to implementing the experiment in *PsychoPy* (PsychoPy Contributors, 2023) and was used uniformly for all participants.
  In the voluntary condition, participants were explicitly instructed to name the images as quickly and accurately as possible in the language of their choice, without following any specific switching pattern.

6.3.2.3 Annotation Procedure

All annotations were completed independently by two annotators: the main doctoral researcher and a research intern. Discrepancies were discussed and resolved to ensure consistency and accuracy across the dataset.

For each trial, the response was recorded individually. All recordings were reviewed manually after the experiment and transcribed in an Excel file. The annotation included the following:

- **For all conditions:**
  - **Response Time (RT)** :
    RT were provided by PsychoPy's (Peirce et al., 2019) internal voice key and manually checked using Checkvocal (Protopapas, 2007). Responses preceded by hesitations ("euh…banane") were manually marked as correct and response onset was set using Checkvocal® at the beginning of the word (/b/ for the given example).
  - **Accuracy**:
    Accuracy was coded as + for correct and – for incorrect. An answer was coded as incorrect if:
    a) It was absent or given after the microphone was no longer active (after 2000 ms),
    b) It did not correspond to the target item,
    c) It was not given in the required language (for all conditions except Voluntary).
  - **Trial type**: *blocked*, *switch*, *stay*, or *neutral*
    In the monolingual conditions (Arabic and French), all trials were blocked. In the Cued condition, trial types were predetermined by the task design, either switch or stay. In contrast, in the Voluntary condition, trial types were derived based on participants' responses, also either switch or stay but depending on the participant's switching.
    Neutral trials were defined as the first trial in each bilingual block and any trial that followed an incorrect response.
- **For bilingual conditions only:**
  - **Language**: *Arabic*, *French*, or *English*
    In the Cued condition, the language variable referred to the expected language based on the color cue, not the actual language used by the participant. If the participant responded in the wrong language, the response was coded as incorrect.
    In the Voluntary condition, language choice depended on the participant's spontaneous response on each trial.
    English was included as a third category, as some participants used it in the Voluntary condition. To ensure that this condition reflected free language choice, English responses were not coded as errors, given that the task instructions (see Appendix B) did not restrict participants to naming the images in either Arabic or French only.

6.3.2.4 Measures of Interest

The measures taken from BPN were RT and accuracy score for all conditions, as well as switching frequency in the Voluntary condition:

- **Response Time (RT)**: Measured in milliseconds (ms), this referred to the time participants took to name each stimulus. It was calculated as the time between the appearance of the stimulus on screen and the onset of speech. It reflected the speed of lexical retrieval and language production in both languages (LA and FR). RT served as the basis for calculating switch costs (i.e., the additional time required to switch languages relative to staying in the same language) and mixing costs (i.e., the added processing cost of maintaining two languages active compared to a monolingual context), which were the main measures of interest in this study.
- **Accuracy Score**: Expressed as a percentage, this indicated the proportion of correct responses. A response was considered correct when the participant named the image accurately in the target language. This measure assessed the participant's ability to retrieve the correct item.

- **Switching Rate**: Indicated in percentage, this represented the proportion of trials in which participants switched languages between consecutive trials. In the Cued condition, switching rate was fixed at 49%. In the Voluntary condition, switching rate depended on each participant's individual switching behavior. This was the primary condition of interest for this measure.

6.3.2.5 Research Hypotheses

Drawing on established predictions in the literature, the following hypotheses were formulated concerning switch and mixing costs in BPN:

- **Hypothesis A**: Switching languages incurs a switch cost, calculated as the difference in the average RT between switch and stay trials, and reflecting the cognitive cost associated with switching between languages (Declerck & Philipp, 2015).
- **Hypothesis B**: Switch costs are higher in the Cued condition compared to the Voluntary, as the restriction on language choice in the Cued condition requires more cognitive control. In contrast, the Voluntary condition offers more flexibility, as participants can freely choose the language that is more accessible at the moment of naming, thus reducing cognitive load and minimizing switch costs (Jevtović et al., 2020; Kennis et al., 2025).
- **Hypothesis C**: Frequent code-switchers exhibit reduced mixing costs, or even a mixing benefit, when switching languages voluntarily: Mixing costs are lower in the Voluntary condition compared to the Cued. A mixing benefit in the Voluntary condition may even be observed; allowing participants to choose the most accessible language during naming in the Voluntary condition reduces the cognitive load arising from language inhibition, as proposed by De Bruin et al. (2018).

6.3.3 Bilingual Semantic Fluency

The Bilingual Semantic Fluency (BSF) task is widely used to assess lexical retrieval and executive control (Troyer, 2000; Troyer et al., 1997). By requiring participants to generate words within a given category during a restricted period of time (generally 1 minute), this task provides insight into how bilinguals organize and access their mental lexicon. Secondarily, it also serves as a measure of executive functions, engaging processes such as mental flexibility, response inhibition, and working memory (Giovannoli et al., 2023). While it is less frequently used with the LSP, the current study integrates the paradigm into semantic fluency to create a more holistic approach to understanding language production control mechanisms in bilinguals.

6.3.3.1 Experimental Design

1. **Language Switching Paradigm**
   This task followed an experimental design similar to the one used for the picture naming task, based on alternating and voluntary LSPs. Within 60 seconds, each participant was required to name as many items as possible from a given category in the required language(s). The four conditions were:

a) **Arabic Monolingual**: items in the category of foods had to be named in Lebanese Arabic only.

b) **French Monolingual**: items in the category of animals had to be named in French only.

c) **Alternate Bilingual**: items in the category of clothes had to be named by alternating between French and Lebanese Arabic (FR-LA-FR-LA...), beginning with the language of their choice.

d) **Voluntary Bilingual**: items in the category of fruits had to be named by freely choosing either French or Lebanese Arabic for each word.

Categories were chosen to be as frequent and easy as possible, based on their familiarity to Lebanese Arabic-French bilinguals and their suitability for generating a wide range of responses in both languages (Jebahi et al., 2022; Kassir et al., 2025; Villalobos et al., 2023).

2. **Parameters**
   Each trial lasted exactly 60 seconds, during which participants were instructed to generate as many words as possible within the specified category. Instructions clearly stated that repetitions and out-of-category responses were not allowed. An example was provided before the start of each condition to ensure participants understood the task requirements (see Appendix C for the full instructions). All responses were audio-recorded for transcription and scoring. The experimenter was present throughout the task but did not intervene in case of errors, allowing for natural performance and minimizing external influence on switching behavior.

3. **Order of administration**
   As for the BPN task, half the participants started with the monolingual conditions and the other half with the bilingual conditions, following the same groups:
   - Participants from Group A followed the order: French monolingual, Arabic monolingual, alternate bilingual then voluntary bilingual.
   - Participants from Group B followed the order: alternate bilingual, voluntary bilingual, French monolingual, Arabic monolingual.

6.3.3.2 Annotation Procedure

All fluency responses were transcribed and annotated manually by the doctoral researcher in Microsoft Excel, with a separate sheet dedicated to each task condition. This annotation process, which spanned approximately four months, was carried out by the same researcher to ensure consistency and accuracy. The full set of annotated files is provided in Appendix N (folder: *Phase 2*; files: *Fluency Phase 2.xlsx* and *Fluency Phase 3.xlsx*).

For each item produced by a participant, five lines were created under the same column, allowing for detailed coding across several dimensions (see Figure 6.2). These included:

1. **Given response**: the raw word or utterance provided by the participant.
2. **Nature**: whether the entry was a word or a modalizer (e.g., self-reflective comments such as "I already said that" or "Oh, I forgot") (Nespoulous, 2010).
3. **Language**: the language used for the word (French, Arabic or cognate). *Cognate* refers to a word that is identical in both Arabic and French, such as *kiwi*.
4. **Switching**: the language pattern relative to the previous word, coded as *stay, switch, repetition*, or *cognate*.
5. **Concept**: the underlying semantic concept conveyed by the word, indicated in English to ensure consistency across both languages and to enable accurate detection of repetitions and errors.

battix	avocat	pastèque	melon
word	word	word	word
arabic	cognate	french	french
stay	cognate	repetition	stay
watermelon	*avocado*	*watermelon*	*melon*

Figure 6.2: Phase 2 Fluency Annotation Sample in the Voluntary condition in BSF

6.3.3.3 Measures of Interest

The measures taken from the BSF task, within each condition, were the following:

- **Fluency score**: The final count of correct words generated within the 60-second time limit for each category, consistent with previous verbal fluency studies (Troyer, 2000; Troyer et al., 1997).
- **Accuracy percentage**: The percentage of correctly named items out of the total items generated. Items were excluded from the correct count if they fell into any of the following error categories:
  - Repetitions: Repeating previously produced words.
  - Intrusions: Producing words that do not belong to the target semantic category.
  - Translations: Providing the same word in different languages in the bilingual conditions (e.g., saying both "dog" and "chien" for the same concept), which was counted as a repetition rather than a switch, thus an error.
  - Modalizers (Nespoulous, 2010): Comments or reflections on one's own speech (e.g., "I already said this", "Oh I forgot"...). These were excluded from the final count of words.
  - Switches to another language: Only in the monolingual conditions, switching to another language was considered as an error.
  - Stay trials in the alternate bilingual condition: since the instruction involves participants to switch language for every response, stay trials were counted as errors.
- **Switching rate**: The number of switches between languages was extracted, in line with previous fluency work (Jevtović et al., 2020; Taler et al., 2013). In bilingual conditions, switching rate was calculated as the ratio of switches to the total number of words produced (including all errors, except modalizers), multiplied by 100:

$$\text{Switching Rate} = \left(\frac{\text{Number of Switches}}{\text{Total Number of Words}}\right) \times 100$$

  In the Alternate Bilingual condition, this value is expected to be 100% because the task requires participants to alternate languages on each word. In the Voluntary Bilingual condition, the switching rate varied based on the participant's choice to switch or remain in the same language.

6.3.3.4 Research Hypotheses

This task aimed to investigate how language control mechanisms manifest in a semantic fluency task adapted to a LSP. The following hypotheses were formulated based on broader predictions regarding switch and mixing costs in bilingual language use, adapted to the nature of the fluency task:

- **Hypothesis A (not applicable)**: The general hypothesis that switching languages incurs a switch cost could not be evaluated in this task, as RT data were not collected.
- **Hypothesis B**: Lexical retrieval is less efficient in the Alternate (forced-switching) condition compared to the Voluntary (free-switching) condition. Given the absence of stay trials in the Alternate condition and the lack of RT data, switch costs were approximated by subtracting the average fluency score in the Alternate condition from that in the Voluntary condition. A negative difference would reflect a switch cost, indicating that forced language switching reduces lexical access, while a positive difference would indicate better lexical access during voluntary switching compared to forced switching.
- **Hypothesis C**: FCS exhibit reduced mixing costs, or even a mixing benefit, when switching languages voluntarily, compared to the alternate condition. Mixing costs were defined as the difference between average fluency scores in the bilingual conditions and those in the monolingual conditions. Lower mixing costs in the Voluntary condition, compared to the Alternate condition, would support this hypothesis.

This task was repeated with the 24 participants who took part in the third phase of the study, in order to counterbalance the assignment of semantic categories across different conditions, ensuring that any observed differences in fluency performance were not due to the particular categories used. This approach aimed to ensure that fluency scores reflected participants' language production abilities rather than differences in category productivity or familiarity, as some semantic categories naturally allow for more word elicitation than others.

6.3.4 Executive Tasks

To assess executive control, the inhibition component was of central importance. According to Miyake et al., 2000, executive control consists of three related functions: inhibition, set shifting (or mental flexibility), and updating (or working memory). These components are considered control variables in this study, as they are essential for understanding the cognitive processes underlying language switching but are not the primary focus of the analysis.

Inhibition refers to the ability to "deliberately inhibit dominant, automatic, or prepotent responses" (Miyake et al., 2000; p 177). It was assessed in its nonverbal and verbal components: nonverbal through the Flanker task and verbal through the Stroop test in two adapted versions to French and Arabic.

All executive tasks, except for digit span, were computerized using PsychoPy v.2023.2.3 software (PsychoPy Contributors, 2023), following the same parameters as for BPN. The computerized version was prioritized because it allowed collection of both RT and accuracy measures, providing more sensitive results, particularly relevant for healthy adults, where accuracy can reach ceiling levels and may not fully reflect underlying mechanisms. Additionally, the RT data enabled the establishment of correlations with the RT measures from the language BPN task. Verbal responses for Stroop tasks were recorded using the same Blackwire 5220 headset with microphone noise cancellation.

6.3.4.1 Flanker task

The Flanker task (Eriksen & Eriksen, 1974) assesses inhibition through nonverbal material: five arrows pointing either to the left or to the right, or squares for the neutral condition. The participant has to give the direction of the middle arrow while ignoring the other arrows around it.
The task was computerized and presented on a screen with a grey background throughout all conditions

to minimize distractions and maintain visual uniformity. The arrows and squares were displayed in black to ensure clear visibility and contrast against the grey background (see Figure 6.3).

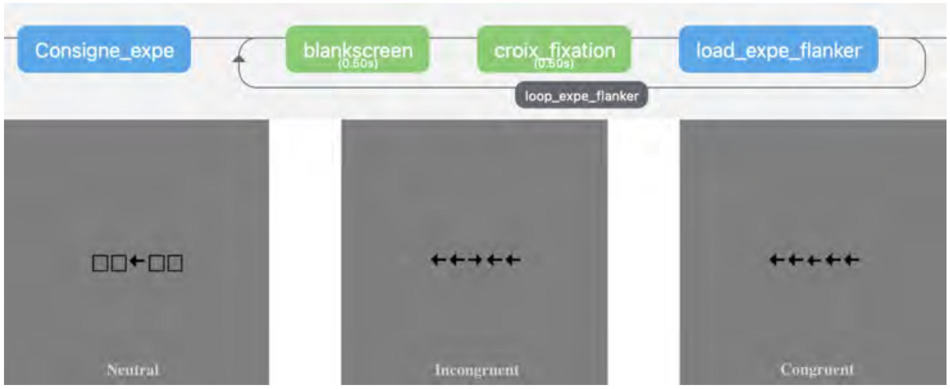

Figure 6.3: Flanker Task Experimental Design

The task contained 90 trials, with three types of trials: congruent (the middle arrow pointing in the same direction as the others around), incongruent (the middle arrow pointing in the opposite direction from the ones around it), and neutral (the middle arrow surrounded by empty squares). There were 30 trials per trial type, and all trials were randomized across types and participants. The total number of trials and distribution across trial types were comparable to the design used in a recent study by Van der Lubbe et al. (2025), who employed 44 congruent, 44 incongruent, and 22 neutral trials per block. Each trial was preceded by a 500 ms blank screen and a 500 ms fixation cross, and was presented until a response was given (self-paced task). Participants were required to use only their index finger to press the keyboard button indicating the left or right direction. A practice segment of 6 trials (2 trials per type) was completed before the task. The task was self-paced, resulting in variable administration times across participants, with an average duration of approximately 5 minutes.

The main measures taken from this task were RT (in ms) and accuracy score (in percentage), overall and by type of trial.

6.3.4.2 Stroop test

The Stroop test (Stroop, 1935) is among the most frequently used tests to assess inhibition. Multiple versions have been developed based on the original task created by Stroop (1935), which involves an evaluation of inhibition through 3 consecutive conditions (see Appendix F for full instructions):

(1) **Naming colored rectangles**

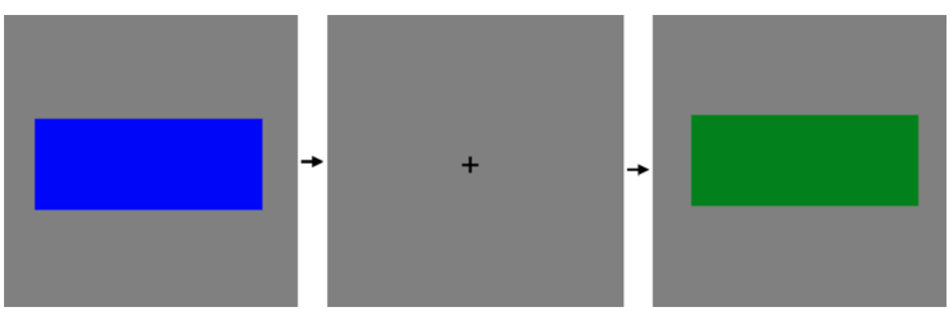

Figure 6.4: Color Naming Condition in the French Stroop

(2) **Reading color names, written in black ink**

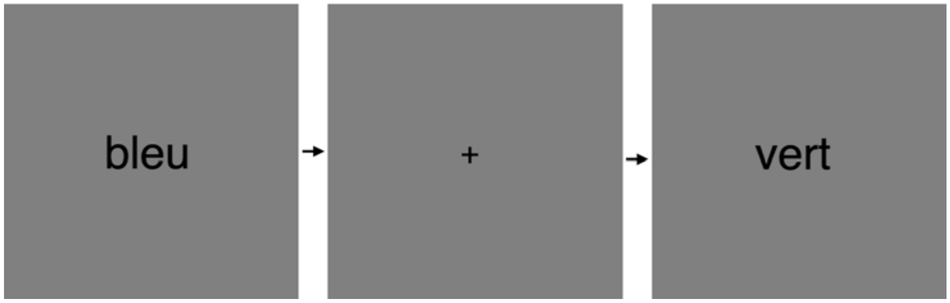

Figure 6.5: Reading Condition in the French Stroop
Note: Color labels used in the task were bleu = blue, vert = green.

(3) **Giving the color of words indicating names of colors, and written in the same color (congruent) or a different color (incongruent).** For instance, the word "blue" may be written in blue ink on the congruent trial or in red ink for the incongruent trial.

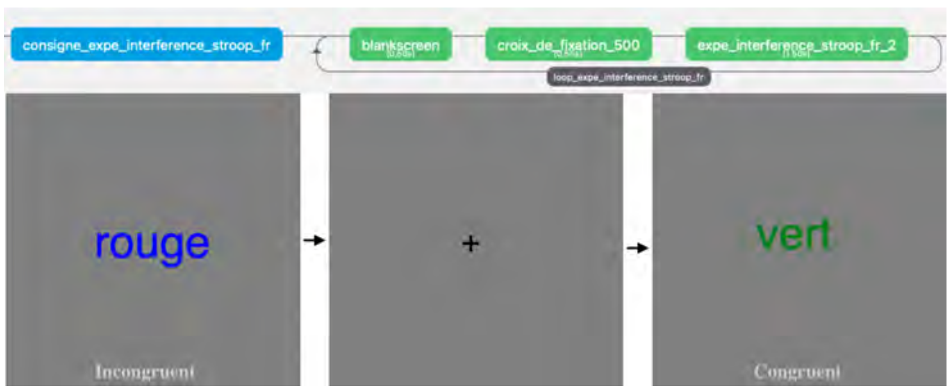

Figure 6.6: Interference Condition in the French Stroop
Note: Color labels used in the task were rouge = red, vert = green.

A computerized single-item Stroop paradigm was chosen over the traditional paper-and-pencil version, as it allows for precise measurement of RT and error rates for each stimulus, and enables the exclusion of error trials from the RT analyses (Davidson et al., 2003; Parsons & Barnett, 2018). Computerized Stroop versions were found to be reliable for research purposes, although their altered interference effects suggest caution when using them for clinical assessment (Penner et al., 2012). The task design was based on well-established findings showing that congruent trials speed responses compared to incongruent trials, and that interference increases with the similarity of distractors (MacLeod, 1991). These insights support measuring both reaction times and accuracy and justify the need for a higher proportion of incongruent trials than congruent, to better assess inhibitory control.

The computerized version designed for this study included 120 trials in total, distributed among the three conditions: 30 trials for color naming, 30 trials for word reading and 60 trials for interference (with 20 congruent and 40 incongruent). This trial structure resembles the distribution used by Loy and Demberg (2023), who had implemented 100 trials (60 congruent and 40 incongruent). For the interference trials, twice as many incongruent trials as congruent trials were included, as incongruent trials were the primary trial type of interest for assessing interference, requiring stronger inhibition to override the automatic reading response. All trials were randomized.

Each trial was preceded by a 500 ms blank screen followed by a 500 ms fixation cross, and was presented for 1000 ms regardless of the time of response.

Before each condition (color naming, word reading and interference), a practice segment of 9 trials was completed, 3 trials per condition.

The Stroop task in each language took about 8 minutes to complete.

All responses were given orally by the participants, to allow accurate measurement of language inhibition (following Davidson et al., 2003). Each vocal response was subsequently annotated manually in a Excel file to assess accuracy, and voice onset times were extracted using the CheckVocal software (Protopapas, 2007).
The main measures taken from this task were RT (in ms) and accuracy score (in percentage) by condition.

The Stroop test was conducted in a French version and an Arabic version, using equivalent stimuli and the same experimental design. Participants in Group A completed the French version first, while those in Group B started with the Arabic version. The two versions were administered at separate moments of the experiment and never consecutively.

6.3.4.3 Wisconsin Card Sorting Test (WCST)

Set shifting, also known as mental flexibility, refers to the capacity to "shift back and forth between multiple tasks or mental sets" (Miyake et al., 2000; p 176).

The WCST (Grant & Berg, 1993) is a widely used tool to measure mental flexibility, often employed in populations with executive function or language difficulties. The task involves a set of cards containing three variables: shape, number, and color. Participants are required to sort the cards based on an unknown rule, which changes after a set number of trials (the timing of change remains unknown to the participant).

Importantly, previous research with 475 Taiwanese participants aged 20–89 years has found no evidence of a significant difference in performance between manual and computerized versions of the WCST (Shan et al., 2008). In the computerized version used, there were 42 trials, with a rule change occurring every 6 trials. Participants were presented with a set of 4 cards at the top of the screen and one target card at the bottom. The goal was to associate the target card with one of the 4 cards above according to the current rule (see Figure 6.7).
Each trial was preceded by a 500 ms fixation cross, and followed by feedback indicating whether the participant's response was "correct" or "incorrect," allowing them to adjust their card selection in subsequent trials (see Appendix H). The task was self-paced, with an average duration of approximately 4 minutes.

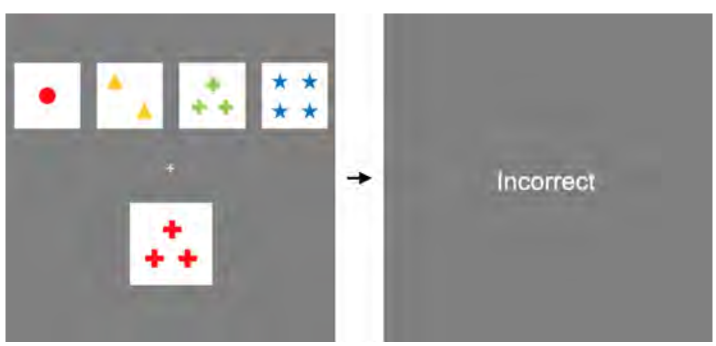

Figure 6.7: Experimental Design of the Wisconsin Card Sorting Test

The main measures taken from this task were RT (in ms) and accuracy (percentage of correct responses), both for the entire task and for each of the congruent (same rule as the preceding card) and incongruent (different rule from the preceding card) trials.

Following Rammal et al. (2019), who set norms of the WCST on Lebanese adults, three additional performance metrics were calculated:

1. **Number of Categories Correct:** the number of sequences of six consecutive correct responses completed by a participant during the task. Scores may range from 0 to 6, reflecting how many rules the participant successfully identified.
2. **Number of Perseverative Errors:** the number of incorrect responses in which the participant continued to sort according to the previous rule, despite the rule having changed. In the current study, these correspond to errors on congruent trials.
3. **Total Errors:** the total number of incorrect responses, including both perseverative and non-perseverative errors, representing overall task performance.

These metrics, alongside accuracy and RT, allow to capture both overall performance and more fine-grained aspects of set shifting abilities.

6.3.4.4 Digit Span (DS)

Working memory, or updating, is the capacity to ”monitor incoming information for relevance to the task at hand and then appropriately updating the informational content by replacing old, no longer relevant information with newer, more relevant information” (Miyake et al., 2000, p.176-177). Working memory was assessed through the Working Memory Index from the Wechsler Adult Intelligence Scale IV (Wechsler, 1955). This task was a Digit Span (DS) test divided into 3 sub-tasks:

1. **DS Forward**: the participant was required to repeat digits forward, in the same order they hear them.
2. **DS Backward**: the participant was required to repeat digits backward, in the opposite order they hear them.
3. **DS Sequencing**: the participant was required to repeat digits in ascending order.

Each sub-task was preceded by a practice segment to ensure participants understood the task and could perform it with lower difficulty before progressing to more challenging trials. The number of digits progressively increased from 2 to 9.

Participants were given a set number of trials per sequence length and continued until they failed to correctly recall the digits for two consecutive trials at a particular length.
A sample of the instructions for the administration of this task are provided in Appendix I.

6.4 Data Analysis and Results

All statistical analyses were conducted using `R` (version 4.4.1). For parametric and non-parametric tests, the packages `stats` and `car`. Linear mixed-effects models were fitted using `lme4` and `nlme`,

with model selection and diagnostics performed using `MuMIn`, `emmeans`, and `performance`. Data visualization was carried out using `ggplot2`, `sjPlot`, and `patchwork`. Additional packages including `tidyverse`, `parallel`, and `languageEntropy` (Gullifer & Titone, 2018) supported data handling, computational efficiency, and LE calculations.
The full R script for all conducted analyses is available in Appendix N, in the folder *Phase 2*, within the file *PhD Analysis Phase 2.R*.

Remark.

1. In the following analyses, the term *response time* refers to latency measures from tasks requiring verbal or language-based responses (e.g., bilingual picture naming, Stroop), while *reaction time* refers to latency measures from tasks requiring a motor response, such as a keypress or mouse click (e.g., WCST, Flanker task).
2. Consistently with recent recommendations, (Benjamin et al., 2018; De Ruiter, 2019), a stricter significance threshold of $p < 0.005$ was applied rather than the classic $p < 0.05$, in order to reduce false positives and present more robust results.

6.4.1 French Language Proficiency

Participants' French proficiency was assessed using the *Oscar* test (Centre d'Étude de Langues, 2025), which provides an overall score (0–100) and a CEFR level. Overall scores ranged from 23 to 100, with a mean of 71.9, a standard deviation of 22.8, and a median of 70, indicating generally high yet variable proficiency across the sample. The distribution of participants across CEFR levels was as follows: A1 = 0, A2 = 5, B1 = 11, B2 = 14, C1 = 9, and C2 = 22, showing that most participants were at upper-intermediate to advanced levels in their second language. L1 proficiency was not directly assessed objectively, as all participants were native speakers who acquired and used their first language from early childhood, and it represented the dominant language for most. Moreover, no standardized instrument exists to assess Lebanese Arabic proficiency. Given their native-level competence in L1 and high proficiency in L2, participants can be considered relatively balanced bilinguals.

Participants' self-reported French proficiency, computed from the BLP rescaled to 0–100, was high, with an average of 89.3 (SD = 13.6, Md = 95.8). However, the correlation with objective French proficiency measured via the Oscar test was very low (r = 0.06), suggesting limited agreement between subjective and objective assessments, with participants' self-ratings generally exceeding their objectively measured proficiency.

6.4.2 Bilingual Picture Naming

Participants completed a BPN task in monolingual (Arabic, French) and bilingual (Cued, Voluntary) conditions. Data cleaning and retained variables (accuracy, switching rate, switch and mixing costs) are reported first. Descriptive statistics for accuracy and RT follow, including switch and mixing costs and the voluntary switching rate. Individual variability factors and their effects on RT are then described, followed by mixed-effects models testing the formulated hypotheses on switch and mixing costs.

6.4.2.1 Final Dataset

The final dataset comprised a total of 16,182 observations following data cleaning. Cleaning procedures involved the exclusion of trials with RT falling outside ± 2 standard deviations from the mean for each participant and condition, incorrect responses (0.06% of total trials), and neutral trials (first trial of each task and first trial after an error). These steps resulted in the exclusion of 13% of the data.

6.4.2.2 Computed Variables

The main measures of interest extracted from the BPN task were:

- **Accuracy Score**: Calculated as the rate of correct responses in each condition, this score, in percentage, assesses the precision of responses across different task conditions.
- **Switching Rate**: This measure was used to assess how frequently participants switched between languages during the Voluntary condition. It was calculated as the ratio of *switch* occurrences to the total number of words produced in the condition. In the Cued condition, the switching rate was identical for all participants and fixed at 49%.
- **Switch Costs (SC)**: The average Switch Cost (SC) per bilingual condition was calculated as the difference in RT between switch and stay trials (Meuter and Allport, 1999).

$$\mathrm{SC} = \text{Mean } \mathrm{RT}_{\text{switch}} - \text{Mean } \mathrm{RT}_{\text{stay}}$$

- **Mixing Costs (MC)**: The average Mixing Cost (MC) per bilingual condition was calculated as the difference in RT between stay trials in each bilingual condition and blocked trials in monolingual conditions (Los, 1996, Gollan and Ferreira, 2009).

$$\mathrm{MC} = \mathrm{RT}_{\text{stay}} - \mathrm{RT}_{\text{blocked}}$$

6.4.2.3 Statistical Analysis

All data were analyzed using the `lme4` package in `R` (Bates et al., 2015) to compute Mixed-Effects Model (MEM). Two separate models were constructed: one for testing Hypotheses A and B on switch costs, and another for Hypothesis C on mixing costs. RT were log-transformed to reduce skewness. The three-level categorical variables: *Trial Type* (blocked, stay, switch) and *Language* (Arabic, French, English), were contrast-coded using effect coding. Participants and items were included as random effects.

All models were initially specified with a maximal random-effects structure (Barr et al., 2013), which included random intercepts for participants and items, and random slopes for the relevant predictors. In cases of non-convergence, correlations among random slopes were removed to allow model convergence. All MEMs converged following this approach.

In both MEMs, log RT was used as the dependent variable. Fixed effects included *condition* × *trial type* × *language*, along with L2 proficiency, LE, CSP, and LOR. The switch cost model included only *stay* and *switch* trials from the bilingual conditions (Cued and Voluntary), whereas the mixing cost model included *blocked* trials from the monolingual conditions and *stay* trials from the bilingual conditions. The maximal random structure included random intercepts for participants and items, as well as random slopes for *condition*, *trial type*, and *language* in the switch costs model, and random slopes for *condition* and *trial type* for the mixing costs model.

Post hoc comparisons were performed using the `emmeans` package (Lenth et al., 2020) to extract estimated marginal means and pairwise contrasts. Statistical significance was set at $p < 0.005$. One asterisk (*) indicates $0.001 < p < 0.005$; two asterisks (**) indicate $p \leq 0.001$.

6.4.2.4 Descriptive and Inferential Results

Accuracy

Condition	**Trial Type**	**Mean (%)**	**Median (%)**	**SD (%)**
Arabic monolingual	Blocked	100.0	100.0	0.0
French monolingual	Blocked	99.8	100.0	4.2
Cued bilingual	Stay	100.0	100.0	1.9
Cued bilingual	Switch	100.0	100.0	0.0
Voluntary bilingual	Stay	99.9	100.0	3.5
Voluntary bilingual	Switch	100.0	100.0	0.0

Table 6.3: Accuracy by Condition and Trial Type in BPN

The average accuracy was near ceiling across all conditions, as shown in Table 6.3. In the monolingual blocked conditions, accuracy was perfect for Arabic (M = 100%, SD = 0.0, Md = 100%) and French (M = 99.8%, SD = 4.2, Md = 100%). In the bilingual conditions, accuracy remained high, with participants achieving nearly perfect accuracy in the Voluntary condition (M = 99.9%, SD = 3.5, Md = 100% for stay trials; M = 100%, SD = 0.0, Md = 100% for switch trials). Similarly, in the Cued condition, accuracy was perfect in both switch (M = 100%, SD = 0.0, Md = 100%) and stay trials (M = 100%, SD = 1.9, Md = 100%). Due to the accuracy values being very close to each other and near ceiling, normality tests could not be performed, and this variable was not further analyzed.

RT

Condition	Mean RT (ms)	Median	SD
Arabic monolingual	890.3	839.0	231.9
French monolingual	840.8	797.9	191.1
Cued bilingual	1055.1	1004.5	255.4
Voluntary bilingual	890.0	844.6	218.6

Table 6.4: Descriptive Statistics of RT by Condition in BPN

RT data showed notable variation across conditions. As shown in Table 6.4 and Figure 6.8, the French monolingual condition was the fastest, with an average RT of 840.8 ms (Md = 797.9 ms, SD = 191.1), followed by Arabic monolingual (M = 890.3 ms, Md = 839.0 ms, SD = 231.9), then the Voluntary condition (M = 890.0 ms, Md = 844.6 ms, SD = 218.6), while the Cued condition was the slowest (M = 1055.1 ms, Md = 1004.5 ms, SD = 255.4) (see Figure 6.8). Moreover, the Anderson-Darling test revealed that the RT data did not follow a normal distribution for any condition ($p < 0.001$ for all conditions).

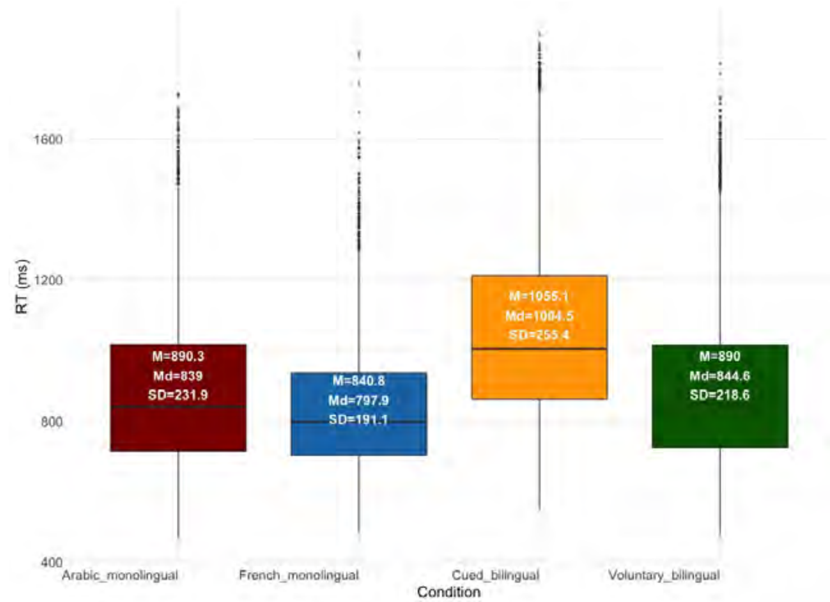

Figure 6.8: RT Distribution by Condition in BPN

Figure 6.9 further illustrates the distribution of RT, broken down by trial type. Notably, the Cued bilingual condition showed a wider spread and higher RT, as compared to the other conditions. Within the monolingual conditions, participants exhibited longer RT in the L1 Arabic condition relative to the L2 French condition.

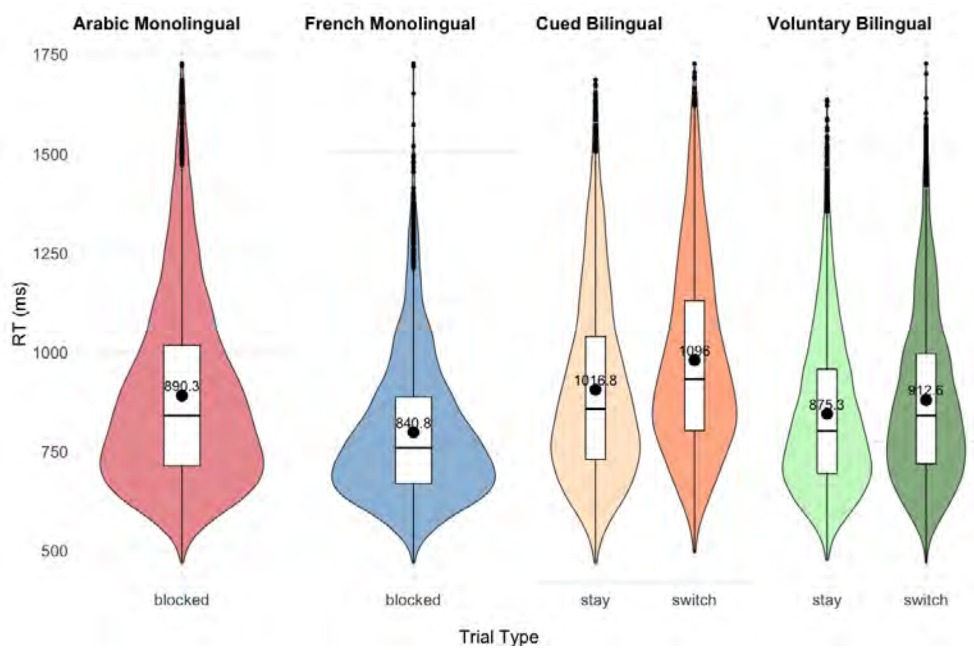

Figure 6.9: RT Distribution Across Conditions and Trial Types in BPN

As shown in Figure 6.9, the distribution of RT across the four experimental conditions revealed generally longer RT in both trial types within the Cued condition compared to the Voluntary and Monolingual conditions. Within both bilingual conditions, switch trials were longer than stay trials.

Reversed Language Dominance Effect

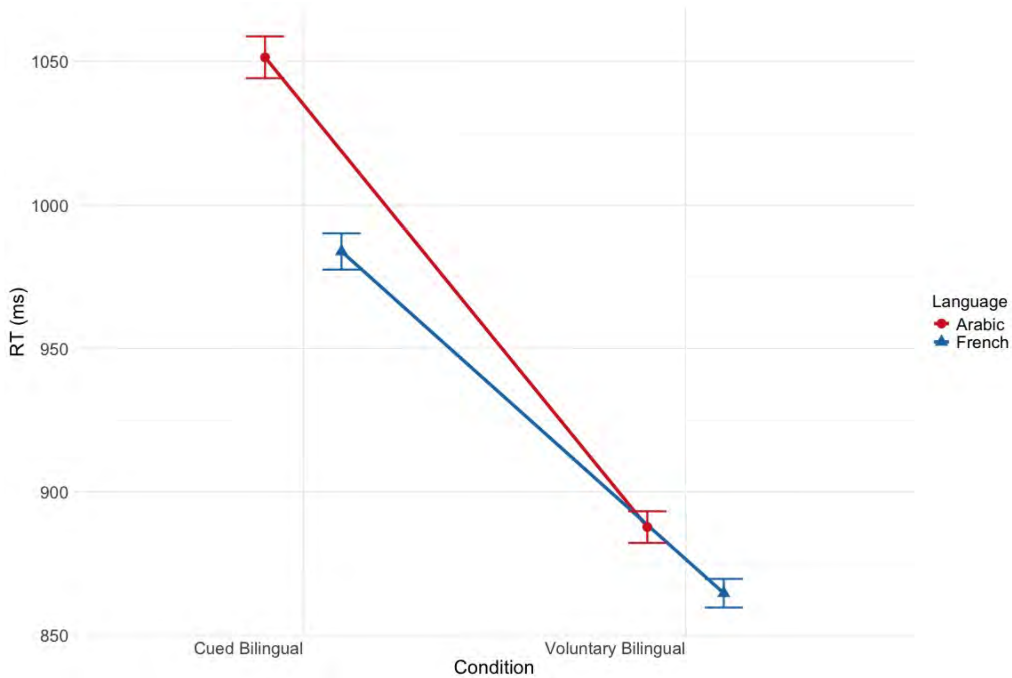

Figure 6.10: Mean RT by Condition and Language in Bilingual Conditions in BPN

Reversed language dominance effects were examined by comparing RT between trials in Arabic and in French, within each bilingual condition. As shown in Figure 6.10, mean RT were longer in the Cued compared to the Voluntary condition across both languages. Additionally, responses in Arabic L1 were consistently slower than those in French L2, regardless of condition.

Switching Rate (Voluntary Condition)

Statistic	Mean	Median	SD
Switching Rate	39.6%	40.4%	12.4%

Table 6.5: Summary of Switching Rates in the Voluntary Condition in BPN

The summary of switching rates for the Voluntary condition is provided in Table 6.5. The mean switching rate across participants was 39.6%, with a median rate of 40.4%. The standard deviation of switching rates was 12.4%, indicating some variability in the frequency of language switches among participants. Switching rates ranged from 1.1% to 61.9%.

Further exploration showed that 67.21% of the participants switched on 25% to 50% of the trials. One participant named all images in French, and was excluded from further analyses. 48.2% of trials were named in Arabic (SD = 16.7, range 3.6 – 90.4%), 52.5% in French (SD = 17.6, range 9.57 – 100%) and English was also used for 2.0% of the trials (SD = 0.9, range 1.28 – 2.63%).

The Anderson-Darling test revealed that the switching rate data were normally distributed ($p = 0.035$, greater than the significance threshold of 0.005). This is further illustrated in Figure 6.11, which shows the distribution of switching rates for the Voluntary condition.

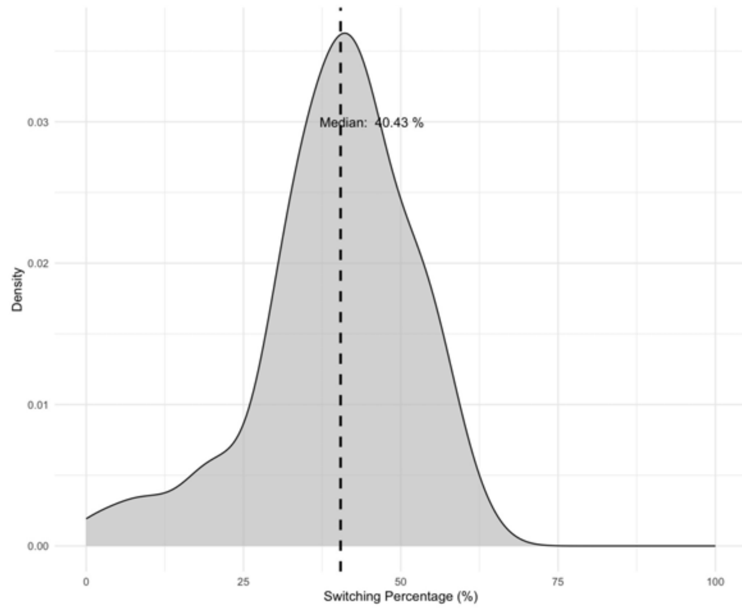

Figure 6.11: Distribution of Switching Rates in the BPN Voluntary Condition

Key Factors Influencing RT

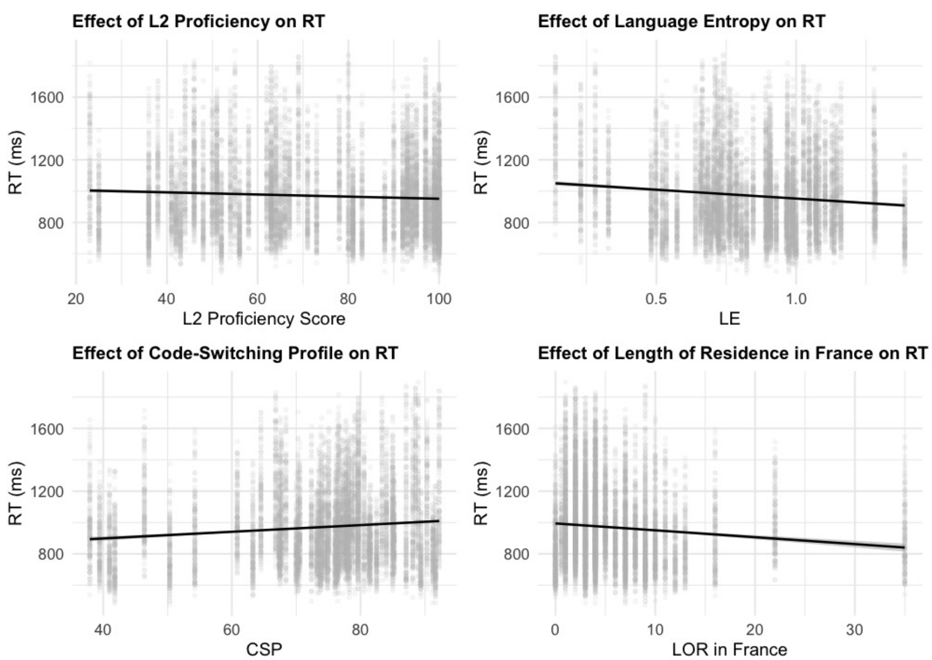

Figure 6.12: Effects of L2 Proficiency, Language Entropy, Code-Switching Profile and Length of Residence in France on RT in BPN

Trends depicted in Figure 6.12 indicate that higher L2 proficiency, greater LE, and longer LOR in France were associated with faster RT across all conditions, while more frequent daily code-switching, as indicated by the CSP, was linked to longer RT in BPN.

Switch costs

Condition	Stay Trials			Switch Trials			Switch Costs		
	M	SD	Md	M	SD	Md	M	SD	Md
Cued	1017.0	250.0	965.0	1096.0	255.0	1046.0	79.2	5.0	81.0
Voluntary	875.0	213.0	829.0	913.0	225.0	870.0	37.3	12.0	41.0

Table 6.6: Descriptive Statistics for Stay Trials, Switch Trials, and Switch Costs in BPN

Table 6.6 presents the average RT for stay and switch trials, along with the calculated switch costs, for both the Cued and Voluntary conditions. The Cued condition exhibited an average switch cost of 79.2 ms (stay: 1017 ms, switch: 1096 ms), while the Voluntary Bilingual condition had a lower average switch cost of 37.3 ms (stay: 875 ms, switch: 913 ms).

Mixing costs

Condition	Stay Trials			Blocked Trials			Mixing Costs		
	M	SD	Md	M	SD	Md	M	SD	Md
Monolingual (LA & FR)	-	-	-	865.4	213.8	816.8	-	-	-
Cued Bilingual	1027.0	51.0	1027.0	-	-	-	157.2	81.5	152.0
Voluntary Bilingual	883.0	48.5	883.0	-	-	-	13.6	85.8	3.4

Table 6.7: Descriptive Statistics for Stay Trials, Blocked Trials, and Mixing Costs in BPN

As shown in Table 6.7, participants exhibited higher mixing costs in the Cued condition (157.2 ms) compared to the Voluntary condition (13.6 ms).

6.4.2.5 Results by Hypothesis

Hypotheses A and B: Switching languages incurs a switch cost, and this switch cost was expected to be higher in the Cued condition compared to the Voluntary.

A MEM was fitted to log-transformed RTs to test Hypotheses A and B. Fixed effects included condition (Cued vs. Voluntary), trial type (stay vs. switch), language (Arabic, French, English), and their interactions. French proficiency, CSP, LE, and LOR in France were included as fixed effects. Importantly, CSP, LE, and LOR values were computed from the subset of 61 participants who completed the experimental study, rather than from the full sociolinguistic sample from Phase 1. Random intercepts and by-participant and by-item random slopes for condition, trial type, and language were included.

The mixed-effects model for switch costs was specified as follows:

$$\begin{aligned}\log(\text{RT}) \sim\ & \text{Condition} \times \text{TrialType} \times \text{Language} \\ & + \text{L2 Proficiency} + \text{CSP} + \text{LE} + \text{LOR} \\ & + (1 + \text{Condition} + \text{TrialType} + \text{Language} \mid \text{Participant}) \\ & + (1 + \text{Condition} + \text{TrialType} + \text{Language} \mid \text{Item})\end{aligned}$$

The model included:

- A full factorial interaction between *Condition*, *Trial Type*, and *Language*.
- Fixed effects of *L2 Proficiency Score*, *CSP*, *LE*, and *LOR*.
- Maximal random slopes for *Condition*, *Trial Type*, and *Language* by *Participant* and *Item*.

The random effects structure included participant-specific and image-specific random intercepts and slopes; the corresponding variance and standard deviations are reported in Table 6.8. Participant-level intercepts and slopes exhibit substantially greater variance than those at the item level, indicating that individual differences contribute more prominently to observed switch costs than the characteristics of the specific stimuli. The residual variance captures the portion of variability in RT not accounted for by the model's random effects.

Group	Name	Variance	Std. Dev.
participant_ID	(Intercept)	0.0111725	0.105700
	conditionVoluntary	0.0104775	0.102360
	trial_typeSwitch	0.0006558	0.025610
	languageArabic	0.0114918	0.107200
	languageFrench	0.0110249	0.105000
item	(Intercept)	0.0002635	0.016230
	conditionVoluntary	0.0004437	0.021060
	trial_typeSwitch	0.0003287	0.018130
	languageArabic	0.0019310	0.043940
	languageFrench	0.0018881	0.043450
Residual		0.0334802	0.182980

Table 6.8: Switch Costs Model Random Effects in BPN

The fixed effects results for the switch costs model are presented in Table 6.9.

Term	Estimate	Std. Error	df	t value	p-value
(Intercept)	6.918e+00	1.107e-01	4.177e+01	62.483	$< 2e-16$**
conditionVoluntary	-1.263e-01	1.554e-02	9.430e+01	-8.131	1.66e-12**
trial_typeSwitch	1.006e-01	9.886e-03	1.611e+02	10.179	$< 2e-16$**
languageArabic	9.243e-03	4.670e-02	5.621e+00	0.198	0.850066
languageFrench	-5.963e-02	4.598e-02	5.499e+00	-1.297	0.246401
L2 proficiency	-5.190e-04	6.579e-04	4.645e+01	-0.789	0.434156
CSP	2.525e-03	1.175e-03	5.266e+01	2.149	0.036255
overall.entropy	-1.499e-01	5.597e-02	1.087e+01	-2.678	0.021677
LOR_France	-2.673e-03	2.770e-03	5.584e+01	-0.965	0.338669
conditionVoluntary x trial_typeSwitch	-6.321e-02	1.158e-02	3.307e+03	-5.457	5.20e-08**
conditionVoluntary x languageArabic	-4.286e-02	1.073e-02	5.453e+03	-3.993	6.60e-05**
trial_typeSwitch x languageArabic	-4.558e-02	1.202e-02	3.316e+03	-3.793	0.000151**
conditionVoluntary x trial_typeSwitch x languageArabic	3.697e-02	1.636e-02	5.588e+03	2.259	0.023907

Significance Codes: * p-value < 0.005, ** p-value < 0.001

Table 6.9: Switch Costs Model Fixed Effects in BPN

A significant main effect of trial type was observed, indicating that **RTs were significantly longer on switch trials relative to stay trials** (beta = 0.10, $p < 0.001$**). This result shows that there is indeed a switch cost in the bilingual naming task, consistent with Hypothesis A.

Furthermore, significant main effects were observed for condition, with shorter RT in the Voluntary condition (beta = –0.13, $p < 0.001$**), and for trial type, with longer RT on switch trials (beta = 0.10, $p < 0.001$**). **A significant interaction between condition and trial type (beta = –0.06, *p***

< **0.001**) indicated reduced switch costs in the Voluntary condition compared to the Cued**, in line with Hypothesis B.

A significant interaction was found between condition and language (beta = –0.04, $p < 0.001$**), driven by the Voluntary–Arabic contrast, indicating that the RT advantage in the Voluntary condition was especially pronounced when naming in Arabic. A significant interaction was also found between trial type and language (beta = –0.05, $p < 0.001$**), further revealing that switch costs were lower when naming in Arabic compared to French across both bilingual conditions.

The three-way interaction between condition, trial type, and language was not significant (beta = 0.037, $p = 0.024$).

Among the fixed effects, higher CSP scores were associated with slightly longer RT (beta = 0.0025, $p = 0.036$), whereas higher LE (beta = –0.15, $p = 0.022$), longer LOR in France (beta = –0.0027, $p = 0.339$), and greater L2 proficiency (beta = –0.0005, $p = 0.434$) were associated with slightly shorter RT; however, none of these effects reached statistical significance under the corrected threshold.

Switch costs were further examined for symmetry by comparing trials involving switches from Arabic to French vs. French to Arabic. A paired t-test on mean switch costs per participant showed no significant difference between the two directions (mean difference = –14.27 ms, t(60) = –1.89, $p = 0.064$), indicating that **switch costs were largely symmetric across languages**.

Hypothesis C: Mixing costs are lower in the Voluntary compared to the Cued condition. A mixing benefit in the Voluntary condition may even be observed.

A MEM was fitted to log-transformed RT to test Hypothesis C, which compares stay trials in the Cued and Voluntary bilingual conditions with blocked trials in the monolingual conditions. Fixed effects included condition (Arabic monolingual, French monolingual, Cued, Voluntary), trial type (blocked, stay), their interaction, and language (Arabic, French, English). A three-way interaction between condition, trial type, and French proficiency was included to assess whether mixing costs differed by bilingual condition as a function of participants' proficiency in French. CSP, LE, and LOR in France were included as fixed effects. Random intercepts and by-participant and by-item random slopes were included for condition and trial type.

The mixed-effects model for mixing costs was specified as follows:

$$\begin{aligned}\log(\text{RT}) \sim\ & \text{Condition} \times \text{TrialType} \times \text{L2 Proficiency}\\ & + \text{Language} + \text{CSP}\\ & + \text{LE} + \text{LOR}\\ & + (1 + \text{Condition} + \text{TrialType} \mid \text{Participant})\\ & + (1 + \text{Condition} + \text{TrialType} \mid \text{Item})\end{aligned}$$

The model included:

- A three-way interaction between *Condition*, *Trial Type*, and *French Proficiency.*
- Fixed effects of *Language*, *CSP*, *LE*, and *LOR in France.*
- Maximal random slopes for *Condition* and *Trial Type* by *Participant* and *Item.*

The random effects structure included participant-specific and image-specific random intercepts and slopes. Participant-level random effects show greater variance than item-level effects, indicating that individual differences contribute more to observed mixing costs than the specific images used. Residual variance reflects the portion of variability in RT not captured by the model's random effects.

Group	Name	Variance	Std. Dev.
participant_ID	(Intercept)	0.017736	0.13318
	conditionCued__bilingual	0.005187	0.07202
	conditionFrench__monolingual	0.007556	0.08693
	conditionVoluntary__bilingual	0.005608	0.07489
	trial__typeBlocked	0.004232	0.06506
	trial__type2Stay	0.001247	0.03531
image_name	(Intercept)	0.001155	0.03398
	conditionCued__bilingual	0.002896	0.05381
	conditionFrench__monolingual	0.005970	0.07727
	conditionVoluntary__bilingual	0.003194	0.05652
	trial__typeBlocked	0.004123	0.06421
	trial__typeStay	0.001159	0.03404
Residual		0.034187	0.18490

Table 6.10: Mixing Costs Model Random Effects in BPN

The fixed effects results for the mixing costs model are presented in Table 6.11.

Term	Estimate	Std. Error	df	t value	p-value
(Intercept)	6.745e+00	1.145e-01	8.912e+01	58.919	$< 2 \times 10^{-16**}$
conditionCued	1.030e-01	4.421e-02	7.184e+01	2.329	0.022658
conditionFrench__monolingual	-4.660e-02	4.337e-02	7.374e+01	-1.075	0.286101
conditionVoluntary	-3.280e-02	5.337e-02	8.409e+01	-0.615	0.540473
trial__typeBlocked	-7.579e-02	2.074e-02	1.497e+02	-3.654	0.000357^{**}
L2 proficiency	-7.183e-04	8.285e-04	6.141e+01	-0.867	0.389360
languageArabic	5.856e-02	3.626e-02	1.511e+04	1.615	0.106355
languageFrench	2.372e-02	3.625e-02	1.512e+04	0.654	0.512947
CSP	2.160e-03	1.104e-03	5.592e+01	1.956	0.055475
overall.entropy	-1.154e-01	5.570e-02	5.608e+01	-2.072	0.042866
LOR France	-3.249e-03	2.588e-03	5.598e+01	-1.255	0.214598
conditionCued x trial__typeBlocked	1.915e-02	2.465e-02	1.559e+04	0.777	0.437235
conditionCued x L2 proficiency	2.121e-04	5.565e-04	6.147e+01	0.381	0.704418
conditionFrench__monolingual x L2 proficiency	3.363e-04	5.350e-04	5.909e+01	0.629	0.532025
conditionVoluntary x L2 proficiency	2.125e-05	6.785e-04	7.409e+01	0.031	0.975095
trial__typeBlocked x L2 proficiency	6.116e-04	2.718e-04	1.453e+02	2.251	0.025918
conditionCued x trial__typeBlocked x L2 proficiency	-9.442e-04	3.241e-04	1.582e+04	-2.913	0.003584^{*}

Significance Codes: * $p < 0.005$, ** $p < 0.001$

Table 6.11: Mixing Costs Model Fixed Effects in BPN

A significant main effect of trial type was observed, indicating that **RT were significantly higher on stay trials relative to blocked trials** (beta = -0.075, p <0.001**). This result supports the presence of a mixing cost in bilingual language production, consistent with Hypothesis C.

Additionally, a significant interaction between condition, trial type, and L2 proficiency score (beta = -0.00094, p = 0.003584*) indicated that **mixing costs were reduced for participants with higher L2 proficiency**, particularly in the Cued condition.

Pairwise comparisons (Table 6.12) revealed significant differences across most trial types and conditions. In contrast, no significant differences were observed between blocked trials in the Arabic and French monolingual conditions, nor between Voluntary stay trials and either of the monolingual blocked conditions.

Contrast	Estimate	Std. Error	df	z-ratio	p-value
Arabic_mono blocked – French_mono blocked	0.0223	0.0199	Inf	1.121	0.8729
Arabic_mono blocked – Cued stay	-0.1499	0.0161	Inf	-9.333	< 0.0001**
Arabic_mono blocked – Voluntary stay	-0.0004	0.0180	Inf	-0.021	1.0000
Arabic_mono blocked – Cued switch	-0.2306	0.0154	Inf	-14.975	< 0.0001**
Arabic_mono blocked – Voluntary switch	-0.0320	0.0167	Inf	-1.914	0.3932
French_mono blocked – Cued stay	-0.1723	0.0141	Inf	-12.247	< 0.0001**
French_mono blocked – Voluntary stay	-0.0227	0.0146	Inf	-1.557	0.6271
French_mono blocked – Cued switch	-0.2529	0.0148	Inf	-17.057	< 0.0001**
French_mono blocked – Voluntary switch	-0.0543	0.0145	Inf	-3.740	0.0025*
Cued stay – Voluntary stay	0.1496	0.0146	Inf	10.277	< 0.0001**
Cued stay – Cued switch	-0.0807	0.0073	Inf	-11.110	< 0.0001**
Cued stay – Voluntary switch	0.1179	0.0145	Inf	8.146	< 0.0001**
Voluntary stay – Cued switch	-0.2302	0.0162	Inf	-14.214	< 0.0001**
Voluntary stay – Voluntary switch	-0.0316	0.0069	Inf	-4.559	0.0001**
Cued switch – Voluntary switch	0.1986	0.0148	Inf	13.383	< 0.0001**

Table 6.12: Pairwise Comparisons across Trial Types in BPN

Among the fixed effects, similarly to the switch costs model, higher CSP was associated with slightly longer RT (beta = 0.0022, p = 0.055), whereas higher LE (beta = –0.115, p = 0.043), longer LOR in France (beta = –0.0032, p = 0.215), and greater L2 proficiency (main effect: beta = –0.0007, p = 0.389) were associated with slightly shorter RT; however, none of these effects reached significance under the selected threshold ($p < 0.005$), except for the aforementioned reduced mixing costs for participants with higher L2 proficiency, particularly in the cued condition.

Finally, to examine the direction of the mixing effect (cost or benefit), participant-level mixing costs were computed as the difference in mean RT between stay trials in the voluntary bilingual condition and blocked trials in the combined monolingual baseline. The distribution of mixing costs in the voluntary condition, illustrated in Figure 6.13 was approximately centered around a median of 3.3 ms, indicating that, on average, RT did not differ between voluntary switching and monolingual blocks. A one-sample t-test confirmed that the mean mixing cost was not significantly different from zero ($t(60) = 1.237$, p = 0.221).

However, when taking into account individual data, mixing costs were computed as the difference between each participant's mean RT in stay trials of the voluntary bilingual condition and their mean RT in blocked trials of the combined monolingual (Arabic and French) baseline. Participants with negative mixing costs were classified as exhibiting a mixing benefit (faster RT in the voluntary condition), whereas participants with positive mixing costs were classified as exhibiting a mixing cost. Based on this classification, 47.5% of participants exhibited a mixing benefit (faster RT in the voluntary than in the monolingual conditions), while 52.5% showed a mixing cost. This distribution is illustrated in Figure 6.13, with benefits highlighted in dark green and costs in red. These results indicate that voluntary language switching produced a heterogeneous mixing effect, with almost half of the participants exhibiting a mixing cost and the other half a mixing benefit.

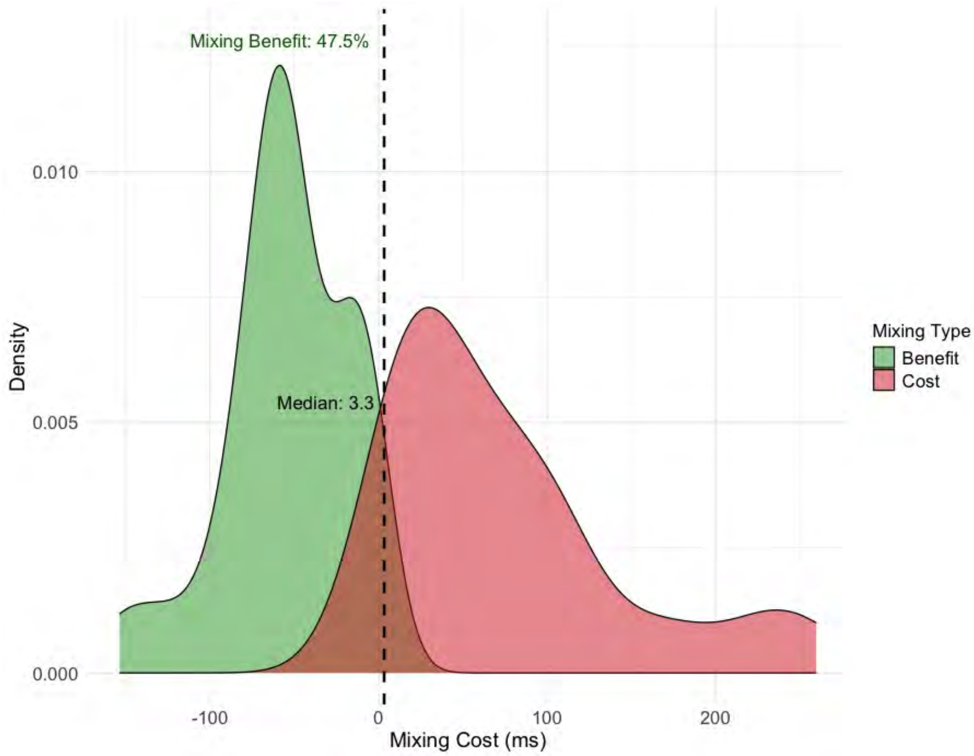

Figure 6.13: Distribution of Mixing Costs in the Voluntary Condition of the BPN

6.4.3 Bilingual Semantic Fluency from Phase 2

In the BSF task, participants from Phase 2 (61 participants) had to name a maximum of items from a given category in 60 seconds, under each of the monolingual (Arabic or French) and bilingual (Alternate and Voluntary) conditions. Data cleaning, annotation, and retained variables (fluency score, switching rate, switch and mixing costs) are reported first. Descriptive statistics for accuracy, including mean fluency score by condition and voluntary switching rate, are then presented, followed by Welch two-sample t-tests and Wilcoxon signed-rank tests evaluating the hypotheses on switch and mixing costs.

6.4.3.1 Final Dataset

Orthographic transcriptions of participants' verbal responses were systematically documented in an Excel file by the researcher. The final dataset used for analysis included participants' responses, following key variables related to fluency and switching behavior across conditions :

- Fluency_condition: The four experimental conditions (Arabic and French monolingual, Voluntary bilingual, Alternate bilingual).
- Fluency_score: The participant's fluency score for each condition, based on correct responses only.

- Accuracy_percentage: The percentage of correct answers provided by the participant.
- Nb_switch_trials: The number of language switch trials during the task.
- Nb_stay_trials: The number of stay trials during the task.
- Nb_cognate_trials: The number of trials preceded by a cognate, a word that's identical in both Arabic and French, such as *kiwi* or *ananas*. This measure was only used for the Voluntary condition. In the Cued condition, any cognate word was assumed to be a switch.

These variables were used to calculate switch costs, mixing costs, and fluency performance across conditions.

6.4.3.2 Error Categorization

Condition-specific errors, as outlined in the Method section (Section 6.3.3.3), included repetitions, intrusions, translations, modalizers, switches to another language in the monolingual conditions, and stay trials in the Alternate condition.
For the Voluntary condition, cognates were treated as an additional category.
Category-specific errors were:

- Animals:
  - Gendered or offspring-related forms: Words with the same derivative morphology (e.g., "lion," "lionne," "lionceau") were treated as a single response. The first word was retained (e.g., "lion") and subsequent words (e.g., "lionne," "lionceau") were coded as repetitions. However, gender-related words that were morphologically different (e.g., "bouc," "chèvre") were treated as separate words because they were assumed to require different morphological and phonological activation.
  - Items within the same subcategory (e.g., "bird" followed by "hummingbird," "pigeon") were considered distinct responses rather than repetitions, to reflect lexical diversity.
  - Insects were accepted as animals.
- Food:
  Given the broad nature of this category in both languages, few restrictions were applied. However, different subtypes of the same dish (e.g., "chicken pasta," "pasta Bolognese") were counted as a single response.
- Clothes:
  Accessories, such as "jewelry", "handbag" or "belt", were ruled out from clothes and counted as errors.
- Fruits:
  The main errors in this category were responses that involved vegetables, which were counted as errors (mainly "carrot" was mentioned by many participants and ruled out, while "tomato" was accepted as a fruit).

6.4.3.3 Computed Variables

Several measures were extracted from the BSF task to assess both lexical retrieval and language control:

- **Fluency Score**: Calculated by determining the number of final correct words produced. This was done by subtracting the number of errors from the total number of items generated.

$$\text{Fluency Score} = \text{Total number of items} - \text{Number of errors}$$

- **Switching Rate**: This measure was used to assess how frequently participants switched between languages during the task. It was calculated as the ratio of switch occurrences to the total number of words produced (not limited to the fluency score, which includes only correct words). *Cognates* and *stay* trials were excluded from this calculation.
- **Switch Costs**: Switch costs were calculated by comparing the fluency scores between the Voluntary and Alternate conditions. It was hypothesized that switch costs would be higher in the Alternate condition compared to the Voluntary condition.

  Since the Alternate condition did not include *stay* trials and no RTs were measured here, switch costs could not be computed using the typical approach employed in classic LSPs (Declerck and Philipp, 2015). Instead, switch costs were calculated by determining the mean fluency score for both bilingual conditions, using the formula:

$$\text{Switch Cost} = \text{Mean Fluency Score}_{\text{Voluntary}} - \text{Mean Fluency Score}_{\text{Alternate}}$$

- **Mixing Costs**: To calculate mixing costs, the data were separated into three experimental conditions: monolingual (Arabic and French), voluntary bilingual, and alternate bilingual. Mixing costs were calculated using the following formula:

$$\text{Mixing Cost} = \text{Mean Fluency Score}_{\text{Bilingual}} - \text{Mean Fluency Score}_{\text{Monolingual}}$$

Additional measures, such as the list of words and concepts across participants, were calculated to assess word frequency in the Lebanese population for each category. However, these will not be further discussed in the present analysis, as they are not the primary focus of the current study.

6.4.3.4 Statistical Analysis

The distribution of fluency scores was assessed using the Shapiro-Wilk test, which indicated a significant deviation from normality. As a result, differences across the four conditions were tested using a non-parametric Kruskal-Wallis test. Post-hoc pairwise comparisons were conducted with Dunn's test, applying Bonferroni correction to control for multiple comparisons.

To investigate the effects of language switching on lexical retrieval during the semantic fluency task, two main comparisons were conducted in line with the hypotheses.

In Hypothesis B, switch costs were expected to be higher in the Alternate condition compared to the Voluntary. For this hypothesis, the fluency scores were compared between the Alternate condition and the Voluntary condition to determine if they were significantly lower in the Alternate condition, reflecting higher switch costs under externally imposed language alternation. Since the Alternate condition involved forced switching without stay trials, switch cost was operationalized as the difference in mean fluency scores between the Voluntary and Alternate conditions. A two-sample t-test was conducted after verifying the normality assumption using Shapiro-Wilk tests for each group.

In Hypothesis C, mixing costs were expected to be lower in the Voluntary condition compared to the Alternate condition. Mixing costs are typically computed as the difference between stay trials from bilingual conditions and blocked trials from the monolingual conditions. However, since the Alternate condition did not involve stay trials (due to forced switching on every trial as per the task design), a slightly different approach was adopted. Mixing costs were defined as the difference between fluency scores from the bilingual conditions and those from the monolingual conditions. Specifically, the mean fluency scores in the monolingual conditions (Arabic and French) were subtracted from the scores in the Voluntary and Alternate bilingual conditions. A Wilcoxon rank-sum test was employed to compare mixing costs across the two bilingual conditions, given the non-normal distribution of the data.

6.4.3.5 Descriptive and Inferential Results

Descriptive statistics for fluency scores across the four conditions are shown in Table 6.13.

Condition	Mean Fluency	SD Fluency	Median Fluency
Arabic Monolingual (Food)	21.1	5.6	20.5
French Monolingual (Animals)	19.0	5.5	19.0
Alternate Bilingual (Clothes)	8.2	2.5	8.0
Voluntary Bilingual (Fruits)	13.1	3.3	14.0

Table 6.13: Descriptive Statistics for BSF Scores across Conditions in Phase 2

Figure 6.14 illustrates the distribution of fluency scores across the same four conditions. The results indicate that fluency scores were generally higher in the monolingual conditions compared to the bilingual ones. Notably, the Alternate bilingual condition yielded the lowest scores, followed by the Voluntary bilingual condition.

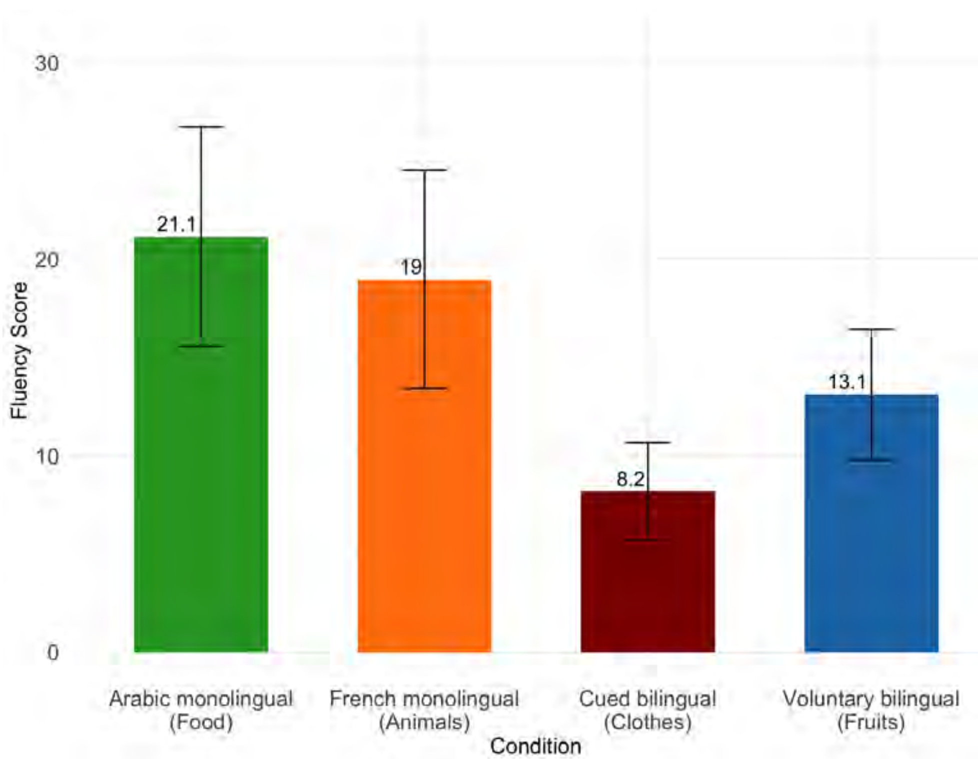

Figure 6.14: Phase 2 BSF Scores across Conditions

The Kruskal-Wallis test revealed a significant effect of condition on fluency scores ($X^2(3) = 155.15$, $p < 0.001$**). Post-hoc analyses using Dunn's test (Bonferroni-adjusted) indicated that scores in the Alternate condition were significantly lower than those in the Arabic monolingual, French monolingual, and Voluntary conditions (all $ps < 0.001$**). Additionally, the Arabic monolingual condition yielded significantly higher scores than both the Voluntary bilingual and French monolingual conditions (both $p < 0.001$**), while the difference between the Arabic and French monolingual conditions was not statistically significant ($p = 0.3623$).

Accuracy rate across all conditions ranged from 18.8% to 100%, with a mean accuracy of 78.1% (SD = 19.3%) and a median of 83.3%.

Fluency Condition	**Range**	**Mean Accuracy**	**Median**	**SD**
Arabic Monolingual (Food)	50.0–100.0%	84.0%	85.1%	11.3%
French Monolingual (Animals)	29.4–100.0%	87.0%	92.2%	14.5%
Alternate Bilingual (Clothes)	18.8–90.9%	56.3%	58.6%	18.2%
Voluntary Bilingual (Fruits)	26.7–100.0%	84.9%	88.6%	13.9%

Table 6.14: Descriptive Statistics for Accuracy Percentage by BSF Condition in Phase 2

Mean accuracy scores varied across fluency conditions: it was highest for the French monolingual condition (M = 87.0%, SD = 14.5%), followed by the Voluntary bilingual (M = 84.9%, SD = 13.9%) and Arabic monolingual (M = 84.0%, SD = 11.3%) conditions, while the lowest accuracy was observed in the Alternate condition (M = 56.3%, SD = 18.2%).

Moreover, switching rate, as shown in Figure 6.15, was calculated in the Voluntary condition. The average switching rate in the Voluntary condition was 30% (SD = 16%, Md = 30%), reflecting participants' relative engagement in language switching when given the choice.

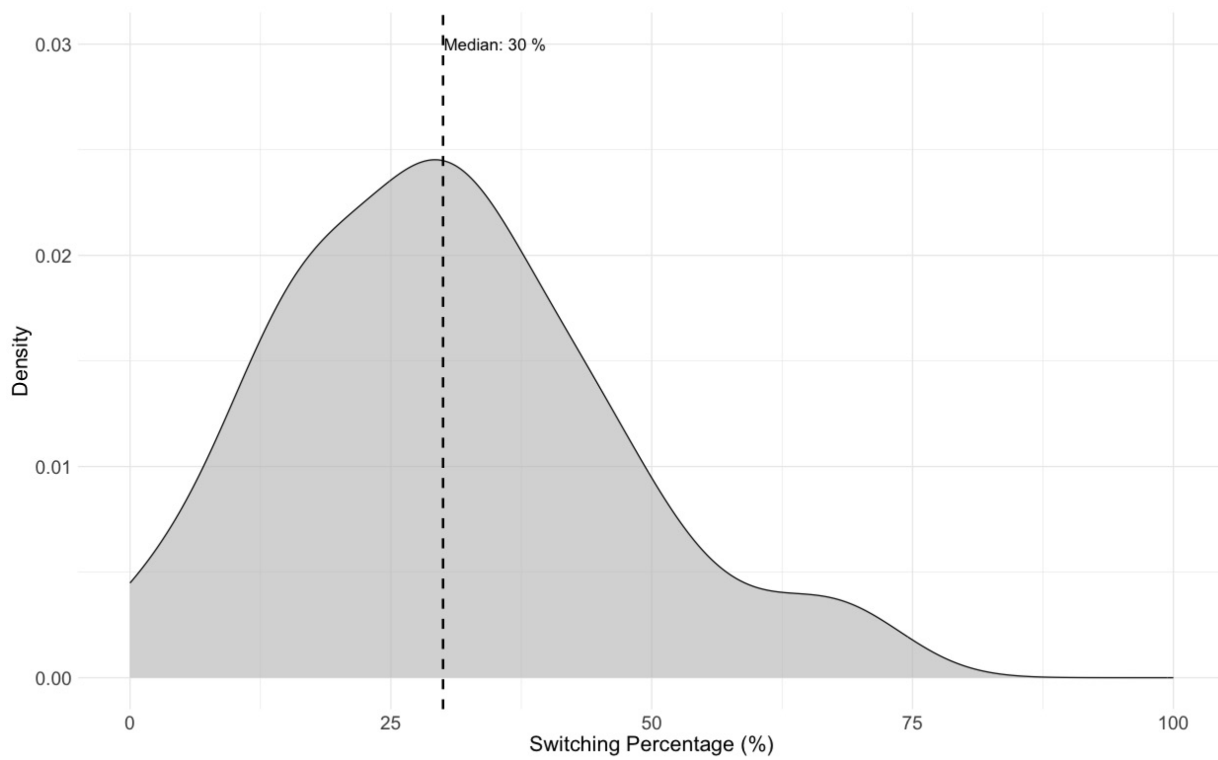

Figure 6.15: Phase 2 BSF Distribution of Switching Rate in the Voluntary Condition

6.4.3.6 Results by Hypothesis

Hypothesis B: Switch Costs Are Higher in the Alternate Condition Compared to the Voluntary Condition.

The switch cost, calculated as the difference in mean fluency between the Voluntary and Alternate conditions, was found to be 4.94, indicating a higher fluency score in the Voluntary condition compared to the Alternate condition.

A Welch two-sample t-test comparing fluency scores between conditions revealed a significant difference ($t(112.91) = -9.38$, $p < 0.001$**), with higher fluency in the Voluntary condition (M = 13.1, SD = 3.3, Md = 14.0) compared to the Alternate condition (M = 8.2, SD = 2.5, Md = 8.0).

These results support the hypothesis that **switch costs were significantly higher in the Alternate condition compared to the Voluntary.** Furthermore, corresponding boxplot of fluency scores (Figure 6.16) visually reinforces this finding, illustrating significant higher fluency in the Voluntary condition.

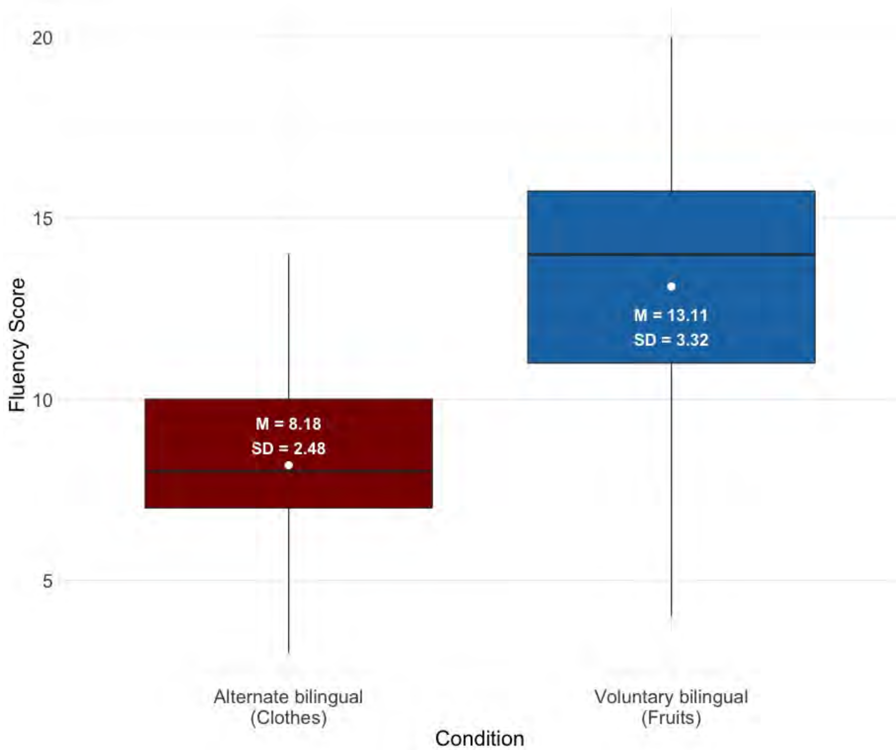

Figure 6.16: Phase 2 BSF Scores in Bilingual Conditions

Hypothesis C: Mixing Costs Are Lower in the Voluntary Condition Compared to the Alternate Condition.

In Phase 2, fluency scores in the bilingual conditions were compared to the monolingual baseline to assess mixing costs. To establish this baseline, scores from the Arabic and French monolingual conditions were combined by averaging across the two language-specific conditions. In line with Hypothesis C, the calculated average mixing costs were lower in the Voluntary condition (M = -6.94, SD = 5.33, Md = -6.50) than in the Alternate condition (M = -11.90, SD = 5.51, Md = -12.00), indicating a reduction in performance costs when language switching was self-initiated rather than externally imposed. A Wilcoxon signed-rank test confirmed that this difference was statistically significant (V = 6499, $p < 2.2e-16$**).

These results support the hypothesis that **mixing costs were significantly lower in the Voluntary condition compared to the Alternate condition**. As shown in Figure 6.17, mixing costs were consistently more negative in the Alternate condition. The figure illustrates the voluntary switching advantage, with higher (less negative) values in the Voluntary condition reflecting a smaller performance drop relative to the monolingual baseline.

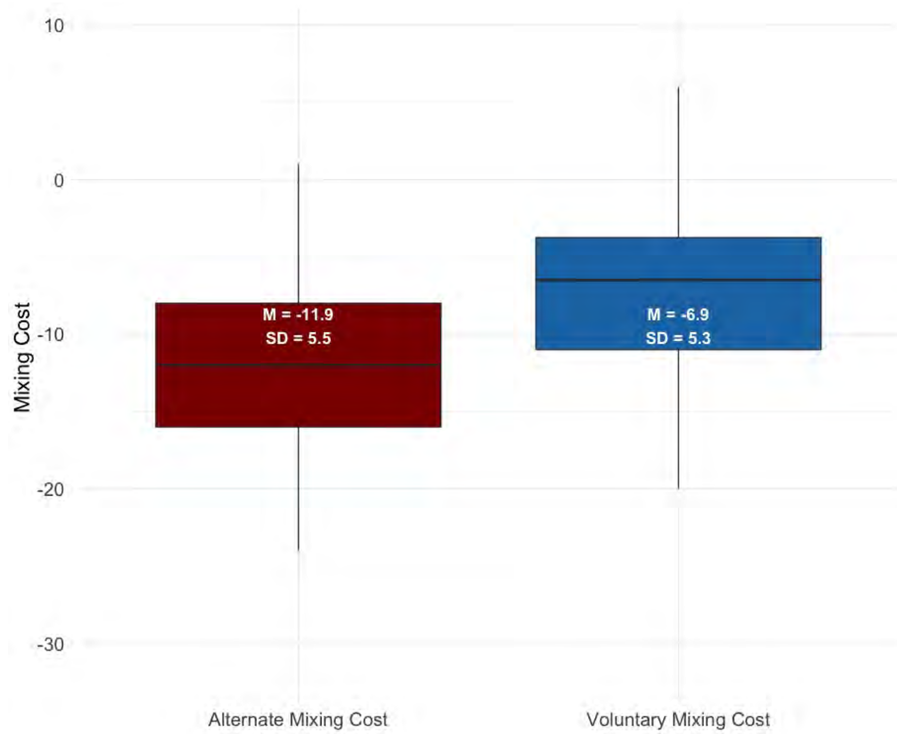

Figure 6.17: Phase 2 BSF Mixing Costs Comparison between Voluntary and Alternate Conditions

This task was repeated with the 24 participants who took part again in the last phase (involving the discourse task) a few months later. To control for potential category effects, the categories were inverted within the monolingual conditions (foods for French, animals for Arabic) and within the bilingual conditions (*Fruits* for Alternate, *Clothes* for Voluntary) (see Appendix D for full instructions). Exceptionally for this task, data from the third phase are described in this section.

6.4.4 Bilingual Semantic Fluency from Phase 3

The data analysis procedure for BSF in Phase 3 was identical to that in Phase 2, with the same hypotheses, dataset structure, error categorization, and computed variables applied.

6.4.4.1 Descriptive and Inferential Results

Descriptive statistics for fluency scores across the four conditions in Phase 3 are shown in Table 6.15: the French monolingual condition showed the highest average fluency (M = 25.3, SD = 6.2), followed by Arabic monolingual (M = 20.0, SD = 5.8) then Voluntary (M = 16.5, SD = 3.9), while the Alternate bilingual condition had the lowest average fluency (M = 11.2, SD = 2.5) (illustrated in Figure 6.18).

Condition	Mean Fluency	SD Fluency	Median Fluency
Arabic Monolingual (Animals)	20.0	5.8	20.5
French Monolingual (Food)	25.3	6.2	25.0
Alternate Bilingual (Fruits)	11.2	2.5	11.0
Voluntary Bilingual (Clothes)	16.5	3.9	16.0

Table 6.15: Descriptive Statistics for BSF Scores Across Conditions in Phase 3

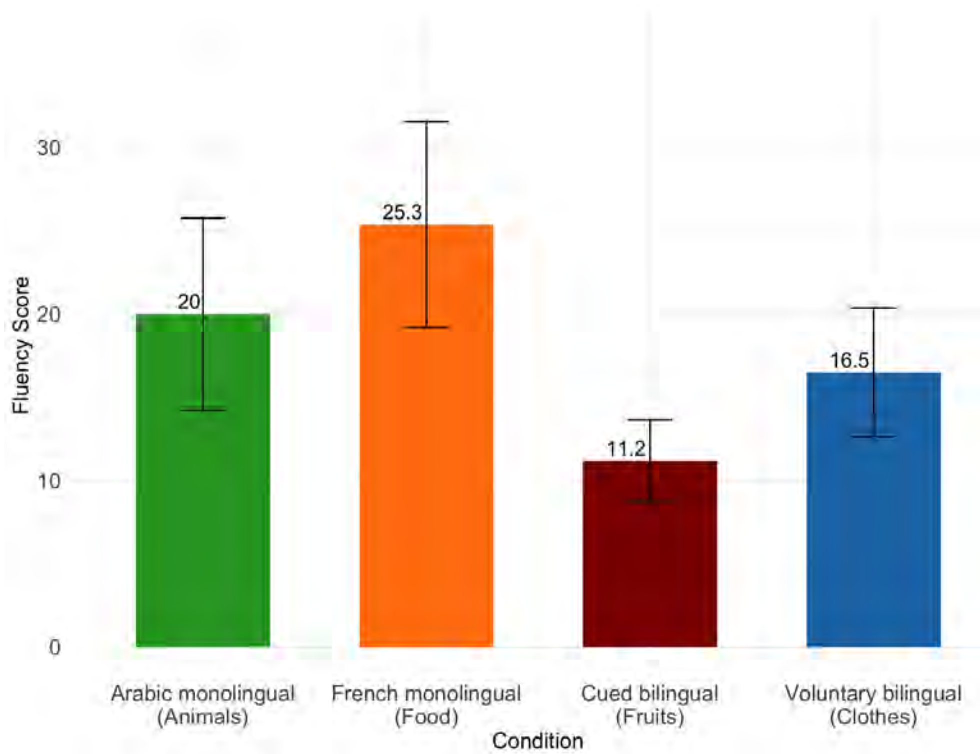

Figure 6.18: Phase 3 BSF Scores across Conditions

Since the data deviated from normality (W = 0.966, p = 0.014), the non-parametric Kruskal-Wallis test was used and yielded a significant effect of condition on fluency scores, ($X^2(3) = 54.03$, $p < 0.001$**). Post-hoc Dunn's test with Bonferroni correction revealed significant differences between the Alternate condition and both the Monolingual and Voluntary conditions, with the French monolingual condition also scoring significantly higher than the Voluntary condition. The French monolingual (*Food*) condition yielded the highest mean fluency, followed by the Arabic monolingual (*Animals*) condition. Among the bilingual conditions, the Voluntary bilingual (*Clothes*) condition outperformed the Alternate bilingual (*Fruits*) condition.

Accuracy rate across all conditions ranged from 45.5% to 100%, with a mean accuracy of 90.0% (SD = 10.6%) and a median of 92.9%.

Fluency Condition	Mean Accuracy	Median	SD	Min	Max
Arabic Monolingual (Animals)	89.4%	91.5%	8.96%	58.3%	100.0%
French Monolingual (Food)	95.1%	100.0%	7.81%	68.8%	100.0%
Alternate Bilingual (Fruits)	84.4%	88.3%	14.3%	45.5%	100.0%
Voluntary Bilingual (Clothes)	91.0%	93.0%	7.68%	72.2%	100.0%

Table 6.16: Descriptive Statistics for Accuracy Percentage by BSF Condition in Phase 3

Mean accuracy scores varied across fluency conditions, and resembled Phase 2 results despite inverting categories: it was highest for the French monolingual condition (M = 95.1%, SD = 7.81%), followed by the Voluntary bilingual (M = 91.0%, SD = 7.68%) and Arabic monolingual (M = 89.4%, SD = 8.96%) conditions, while the lowest accuracy was observed in the Alternate bilingual condition (M = 84.4%, SD = 14.3%).

In addition, the switching rate was calculated in the Voluntary condition, and was 56.8% (SD = 15.7%, Md = 60.0%), reflecting participants' relatively frequent engagement in language switching when given the choice. This is notably higher than the average switching rates observed in Phase 2, which was 30% (SD = 16%).

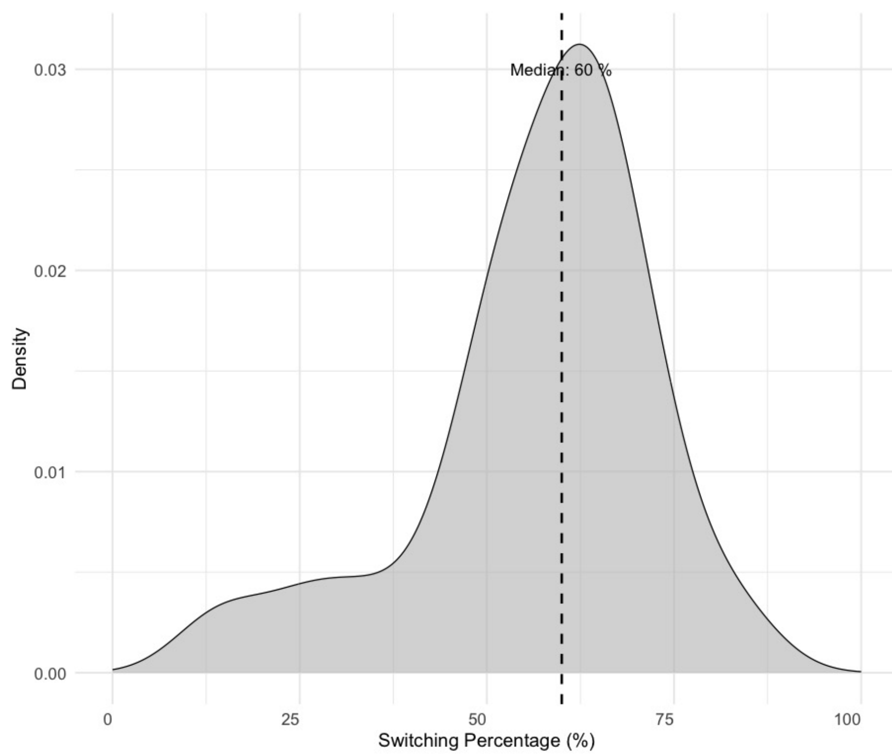

Figure 6.19: Phase 3 BSF Distribution of Switching Rate in the Voluntary Condition

6.4.4.2 Results by Hypothesis

Hypothesis B: It was hypothesized that switch costs would be higher in the Alternate condition compared to the Voluntary condition.

The mean fluency score for the Alternate condition was 11.2 (SD = 2.5, Md = 11.0), while the mean fluency score for the Voluntary condition was 16.5 (SD = 3.9, Md = 16.0). The switch cost, determined as the difference in mean fluency between the Voluntary and Alternate conditions, was 5.3, indicating a higher fluency score in the Voluntary compared to the Alternate condition.

A Welch two-sample t-test comparing fluency scores between bilingual conditions revealed a significant difference, with higher fluency in the Voluntary condition ($M = 16.5$, $SD = 3.9$) compared to the Alternate condition ($M = 11.2$, $SD = 2.5$), ($t(39.1) = -5.7$, $p < 0.001 **$). These results support the hypothesis that **switch costs were significantly higher in the Alternate condition compared to the Voluntary.**

Additionally, a corresponding boxplot of fluency scores (Figure 6.20) visually reinforces this finding, illustrating higher fluency in the Voluntary condition.

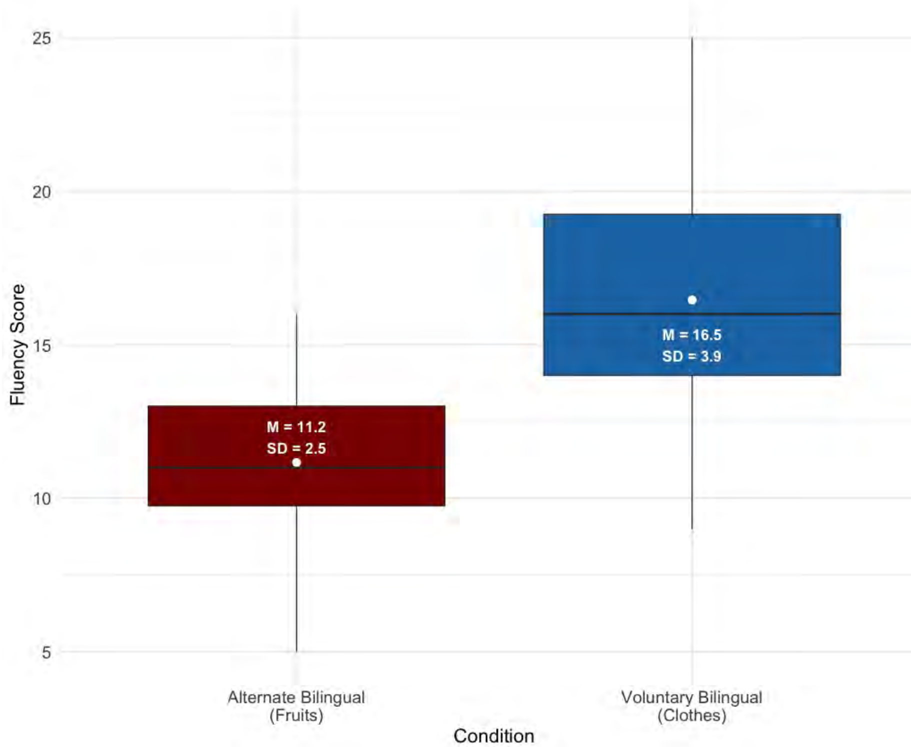

Figure 6.20: Phase 3 BSF Scores in Bilingual Conditions

Hypothesis C: Mixing Costs Are Lower in the Voluntary Condition Compared to the Alternate Condition.

In Phase 3, fluency scores in the bilingual conditions were compared to the corresponding monolingual baseline to assess mixing costs. In line with Hypothesis C, the calculated average mixing costs were slightly lower in the Voluntary condition (M = -8.9, SD = 6.9, Md = -10.0) than in the Alternate condition (M = -8.8, SD = 5.9, Md = -9.0), indicating a trend toward reduced costs when switching was self-initiated rather than externally imposed. A Wilcoxon signed-rank test showed that

this difference was not statistically significant (V = 109.5, p = 0.5915). These results are consistent with the expectation that mixing costs tend to be lower in the Voluntary condition compared to the Alternate condition, although the observed difference did not reach significance.
As illustrated in Figure 6.21, mixing costs were slightly higher (i.e., more negative) in the Alternate condition. The figure highlights the voluntary switching advantage, with less negative/more positive values in the Voluntary condition reflecting a smaller performance drop, or even a small benefit, relative to the monolingual baseline.

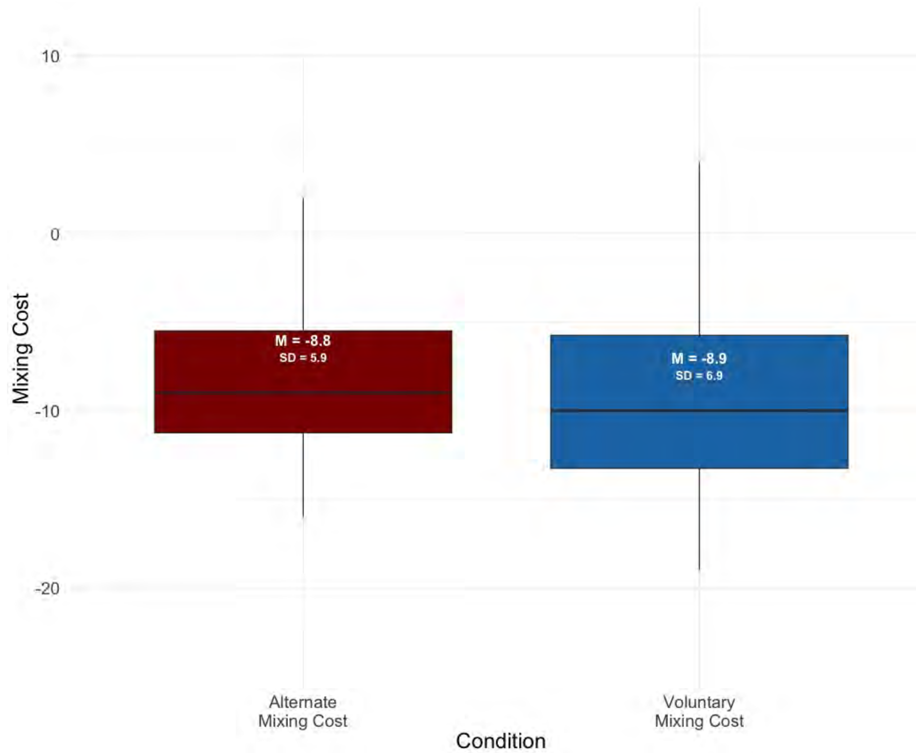

Figure 6.21: Phase 3 BSF Mixing Costs Comparison between Voluntary and Alternate Conditions

These results are consistent with those from Phase 2, although the mixing costs were not statistically significant in Phase 3.

6.4.5 Comparison of Bilingual Semantic Fluency Across Phases 2 and 3

To compare fluency results from Phase 2 and Phase 3 and account for potential effects of condition type and semantic category, paired comparisons were conducted for participants who completed both phases. Fluency was analyzed separately by *condition type* (Arabic Monolingual, French Monolingual, Alternate Bilingual, Voluntary Bilingual) and by *semantic category* (Food, Animals, Clothes, Fruits). Descriptive statistics for each condition and phase are presented in Table 6.17, showing mean fluency scores and standard deviations for the corresponding condition-specific categories.

Condition	Phase 2 (n=61)	Phase 3 (n=24)
Arabic Monolingual	Food: 21.1 ± 5.6	Animals: 20.0 ± 5.8
French Monolingual	Animals: 19.0 ± 5.5	Food: 25.3 ± 6.2
Alternate Bilingual	Clothes: 8.2 ± 2.5	Fruits: 11.2 ± 2.5
Voluntary Bilingual	Fruits: 13.1 ± 3.3	Clothes: 16.5 ± 3.9

Table 6.17: Descriptive Statistics for BSF Scores across Conditions in Phases 2 and 3

Comparison **by condition type**, as illustrated in Figure 6.22, showed that fluency scores were significantly higher in Phase 3 than in Phase 2 for Alternate Bilingual ($t = -5.00$, $df = 23$, $p < 0.001$**; Wilcoxon $p = 0.000375$**), French Monolingual ($t = -3.51$, $df = 23$, $p = 0.00188$*; Wilcoxon $p = 0.00442$*), and Voluntary Bilingual ($t = -3.65$, $df = 23$, $p = 0.00134$*; Wilcoxon $p = 0.00216$*). Only the Arabic Monolingual condition did not show a significant difference between phases ($t = 1.74$, $df = 23$, $p = 0.095$; Wilcoxon $p = 0.112$).

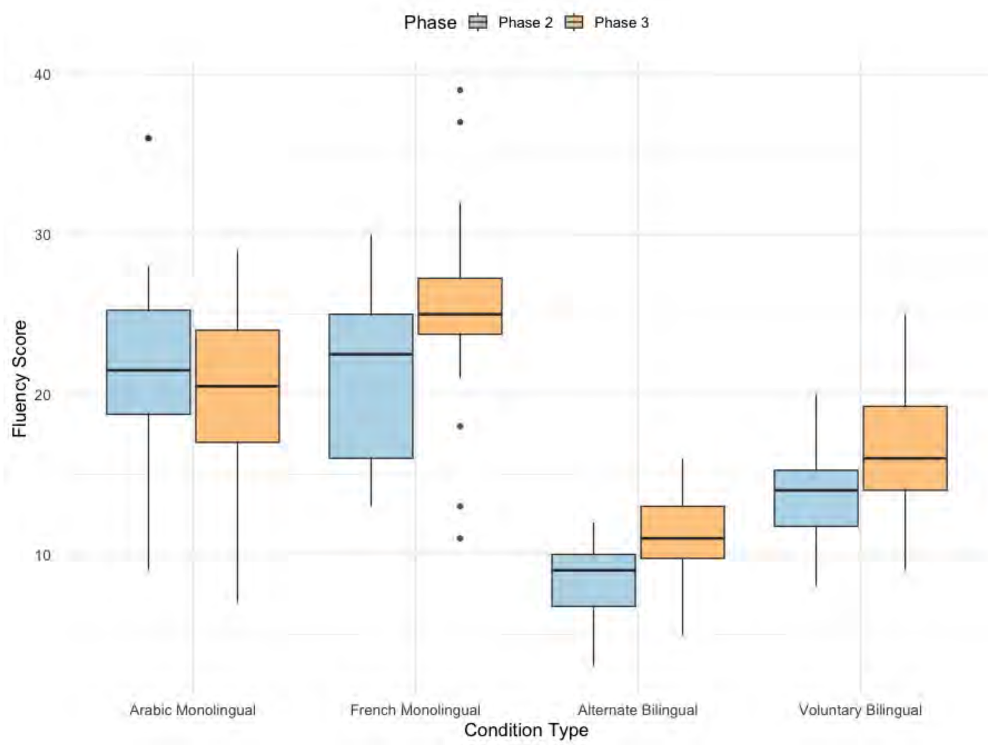

Figure 6.22: Phase 2 and Phase 3 BSF Comparison by Condition Type

Comparison **by semantic category**, as illustrated in Figure 6.23, showed significantly higher fluency scores in Phase 3 for *Clothes* ($t = -8.82$, $df = 23$, $p < 0.001$**; Wilcoxon $p = 0.0000216$**). Fluency for *Fruits* was higher in Phase 2, but did not reach significance under the $p < 0.005$ threshold ($t = 2.98$, $df = 23$, $p = 0.00675$; Wilcoxon $p = 0.00991$). *Food* showed a non-significant trend toward higher scores in Phase 3 ($t = -2.25$, $df = 23$, $p = 0.034$; Wilcoxon $p = 0.0547$), while *Animals* did not show any significant difference between phases ($t = 0.969$, $df = 23$, $p = 0.343$; Wilcoxon $p = 0.256$).

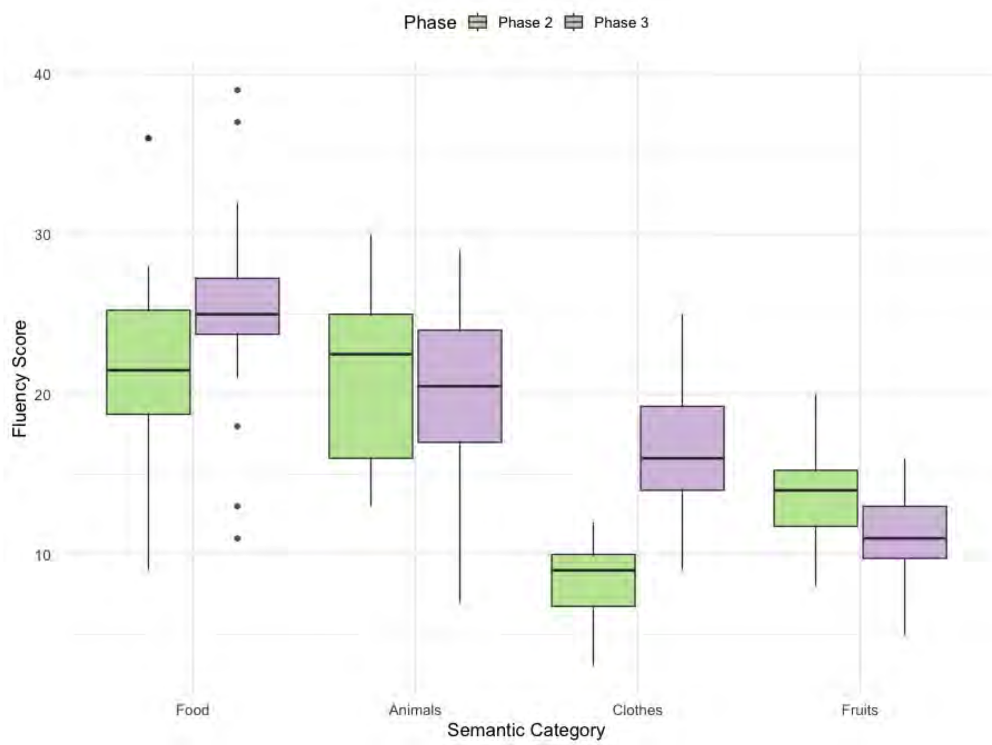

Figure 6.23: Phase 2 and Phase 3 BSF Comparison by Semantic Category

Overall, these results indicate that fluency scores were generally higher in Phase 3 than in Phase 2, particularly for bilingual conditions and for certain semantic categories (*Clothes*). In contrast, the Arabic Monolingual condition and the *Animals* and *Food* categories did not show significant differences between phases. Additionally, switch costs were significant in both phases, whereas mixing costs were significant in Phase 2 only.

6.4.6 Executive Tasks

Executive Tasks data analysis involved descriptive statistics, as well as t-tests, repeated measures ANOVAs and emmeans to assess inter-trial differences. These analyses were used to evaluate the variability in performance across different trial types and identify any significant effects.

6.4.6.1 Flanker task

The analysis of the Flanker task data revealed that accuracy was highest for the congruent trials, followed by neutral and incongruent trials. Similarly, RT were fastest for the neutral trials, followed by congruent trials, with the slowest RT observed in the incongruent trials, as shown in Table 6.18.

Measure	Accuracy (in %)			RT (in ms)		
	Mean	SD	Median	Mean	SD	Median
Overall	99.52	0.89	100.00	584.83	109.85	563.96
Neutral trials	99.72	0.92	100.00	561.88	107.23	534.16
Congruent trials	99.79	0.82	100.00	571.62	116.16	549.44
Incongruent trials	99.03	2.29	100.00	621.11	120.90	598.34

Table 6.18: Flanker Task Descriptive Statistics for Accuracy and RT across Trial Types

Accuracy across the three trial types was analyzed using repeated measures ANOVA. The analysis revealed no significant differences in accuracy between trial types ($p > 0.005$). Post-hoc pairwise comparisons using emmeans further supported the absence of significant differences across trial types, with all comparisons yielding p-values greater than the set significance level of 0.005.

RT was analyzed using repeated measures ANOVA, and significant differences were found across trial types ($p < 0.005$*). Post-hoc comparisons showed that participants responded significantly slower on Incongruent trials compared to both Neutral trials ($p < 0.001$**) and Congruent trials ($p < 0.001$**). The mean RT for Incongruent trials was the highest (621.11 ms), while Neutral trials had the fastest mean RT (561.88 ms). The difference in RT between Congruent and Neutral trials was not significant ($p = 0.3906$) (Figure 6.24).

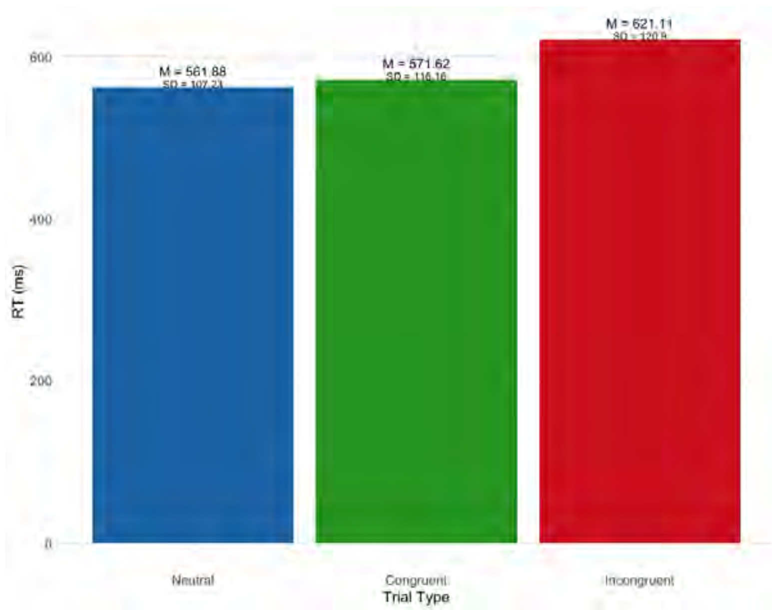

Figure 6.24: Flanker Task RT Distribution across Trial Types

6.4.6.2 Stroop task

Descriptive statistics for accuracy and RT across different conditions in both French and Arabic included Naming, Reading, overall Interference, as well as Congruent and Incongruent trials from the Interference condition, which were analyzed for their accuracy and RT performance (Table 6.19).

Trial Type	Accuracy (%)			RT (ms)		
	Mean	Median	SD	Mean	Median	SD
French						
Naming	98.44	100.00	2.97	661.92	632.51	99.40
Reading	99.83	100.00	0.73	566.57	552.71	83.87
Interference	95.45	98.33	5.25	800.01	815.17	182.92
Interference Congruent	98.04	100.00	3.12	781.77	749.86	128.18
Interference Incongruent	94.29	97.50	7.18	856.55	850.32	119.79
Arabic						
Naming	98.79	100.00	2.04	654.83	632.50	128.89
Reading	99.83	100.00	0.74	558.65	559.00	101.43
Interference	94.57	96.67	7.01	804.38	780.45	116.77
Interference Congruent	98.02	100.00	4.58	745.88	734.08	155.68
Interference Incongruent	93.03	97.50	8.96	829.06	806.41	121.06

Table 6.19: Stroop Task Descriptive Statistics for Accuracy and RT for French and Arabic across Trial Types

For French, the condition with the highest accuracy was Reading (99.83%), followed closely by Naming (98.44%). Congruent trials from the Interference condition had a slightly lower accuracy (98.04%), followed by overall Interference (95.45%) and Incongruent trials (94.29%). In terms of RT, Reading was the fastest (566.57 ms), followed by Naming (661.92 ms). Congruent trials were slightly slower (781.77 ms), with overall Interference (800.01 ms) and Incongruent trials (856.55 ms) being the slowest.

For Arabic, Reading had the highest accuracy at 99.83%, followed by Naming with 98.79%. Congruent trials followed closely at 98.02%, with Interference (94.57%) and Incongruent trials (93.03%) having the lowest accuracy. In terms of RT, Reading was again the fastest (558.65 ms), followed by Naming (654.83 ms). The Congruent trials were the next fastest (745.88 ms), with overall Interference (804.38 ms) and Incongruent trials being the slowest.

Accuracy and RT in both Arabic and French Stroop tasks were analyzed through repeated measures ANOVA.

For accuracy, a significant main effect of trial type was observed in both French ($F(4, 248) = 8.45$, $p < 0.005$*) and Arabic ($F(4, 228) = 6.12$, $p < 0.005$*). Post-hoc comparisons for French showed that Congruent trials (from the Interference condition) had significantly higher accuracy than Incongruent trials ($p < 0.001$**) and overall Interference ($p = 0.0002$**). Similarly, Incongruent trials had lower accuracy than Reading and Naming conditions ($p < 0.001$** for both comparisons).

For Arabic, the contrast results showed that Congruent trials were significantly more accurate than Incongruent trials ($p < 0.001$**) and overall Interference ($p = 0.0002$**). The Incongruent condition had the lowest accuracy compared to Reading and Naming (ps < 0.001** for both comparisons).

For RT, significant main effects were found in both languages (see Figure 6.25). In French, Reading trials were significantly faster than Incongruent trials ($p < 0.001$**) and overall Interference ($p = 0.0008$**). Similarly, in Arabic, Reading trials were the fastest, with Congruent trials being faster than Incongruent trials ($p < 0.001$**) and overall Interference ($p = 0.0008$**).

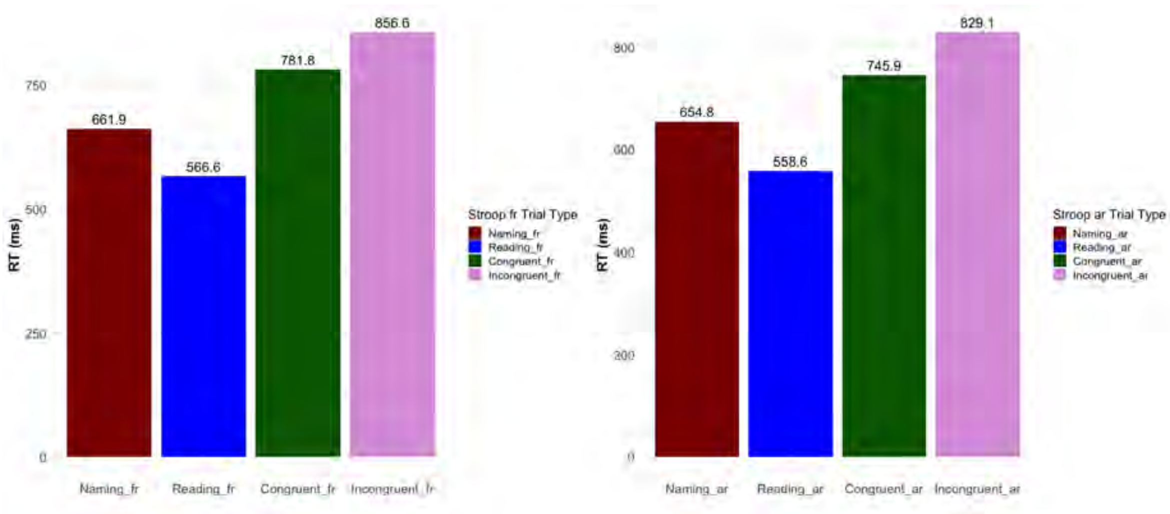

Figure 6.25: French and Arabic Stroop Task RT Distribution across Trial Types.

Comparison between French and Arabic Stroop
A paired-sample t-test showed no significant difference between the French and Arabic Stroop tasks. Accuracy was slightly higher in Arabic ($p = 0.2975$), and RT were marginally faster ($p = 0.1142$), but neither difference was statistically significant.

6.4.6.3 Wisconsin Card Sorting Test (WCST)

Descriptive statistics for the WCST included calculating the mean, standard deviation and median of accuracy and RT for the overall performance in the task, as well as performance on congruent and incongruent trials separately (Table 6.20).

Trial Type	Accuracy (%)			RT (ms)		
	Mean	Median	SD	Mean	Median	SD
Overall	70.54	70.73	9.99	2691.35	2678.38	416.73
Congruent	74.85	75.00	11.73	2610.84	2610.49	532.20
Incongruent	28.67	20.00	19.61	2522.80	2378.50	653.57

Table 6.20: WCST Descriptive Statistics for Accuracy and RT

The overall performance corresponded to an average of 12.4 errors per participant (SD = 4.20, Md = 12.3) across the 42 trials. Perseverative errors, corresponding to incorrect responses on congruent trials, averaged 8.72 per participant (SD = 4.04). Participants completed on average 0.72 categories correctly (SD = 0.84, Md = 1), reflecting the number of sequences of six consecutive correct responses achieved during the task.

The highest accuracy rate was observed in congruent trials (74.85%), followed by overall accuracy (70.54%). Accuracy was lowest in Incongruent trials (28.67%), reflecting increased task demands when sorting rules changed unpredictably.
In terms of RT, Congruent trials had slightly faster RT (2610.84 ms) compared to overall RT (2691.35 ms), while Incongruent trials were unexpectedly the fastest (2522.80 ms).

Accuracy and RT were analyzed using repeated measures ANOVA to compare performance between congruent and incongruent trials.

For accuracy, a significant main effect of trial type was observed ($p < 0.001$**). Post-hoc comparisons showed higher accuracy for Congruent trials compared to Incongruent ($p < 0.001$**) and Overall performance ($p = 0.1961$). Incongruent trials were also less accurate than Overall ($p < 0.001$**).

For RT, the main effect of trial type was not significant ($p = 0.124$). Pairwise comparisons revealed no significant differences between trial types (all ps > 0.001) (see Figure 6.26).

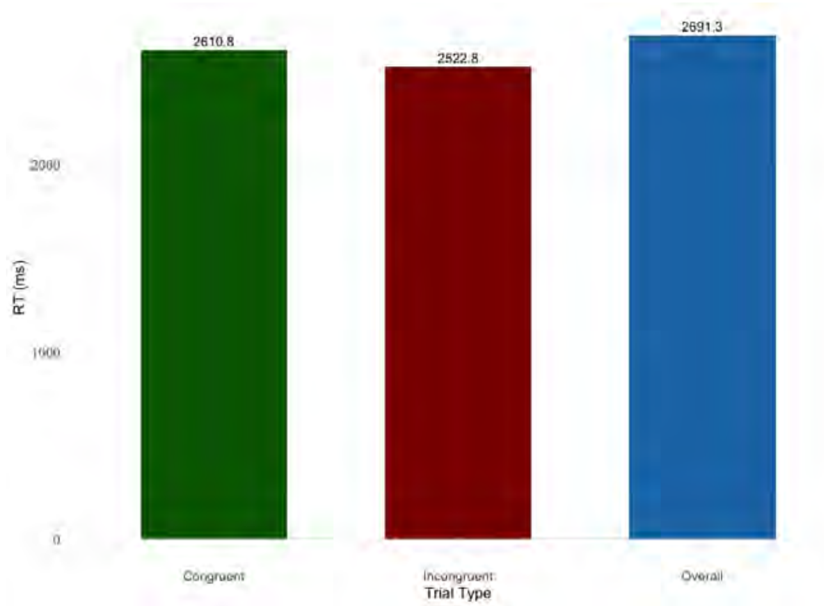

Figure 6.26: WCST RT Distribution across Trial Types

6.4.6.4 Digit Span (DS)

Participants' performance on the Working Memory task is summarized in Table 6.21. On average, the highest score was observed in the Forward span (M = 6.25, SD = 1.35; Md = 6), followed by the Sequencing span (M = 5.25, SD = 1.07; Md = 5), and finally the Backward span (M = 4.54, SD = 0.96; Md = 4).

Span Type	Mean	Median	SD
Forward	6.25	6	1.35
Backward	4.54	4	0.96
Sequencing	5.25	5	1.07

Table 6.21: Descriptive Statistics for Working Memory Task

A repeated measures ANOVA was conducted to examine the effect of span type on working memory performance. The main effect of span type was significant ($p < 0.001$**). Post-hoc pairwise comparisons with Bonferroni correction revealed significant differences between all conditions. Specifically, the Forward span was significantly higher than the Backward span ($p = 3.3\text{e-}14$**) and the Sequencing span (p = 4.0e-05**). The Backward span was also significantly lower than the Sequencing span (p = 1.3e-06**) (see Figure 6.27).

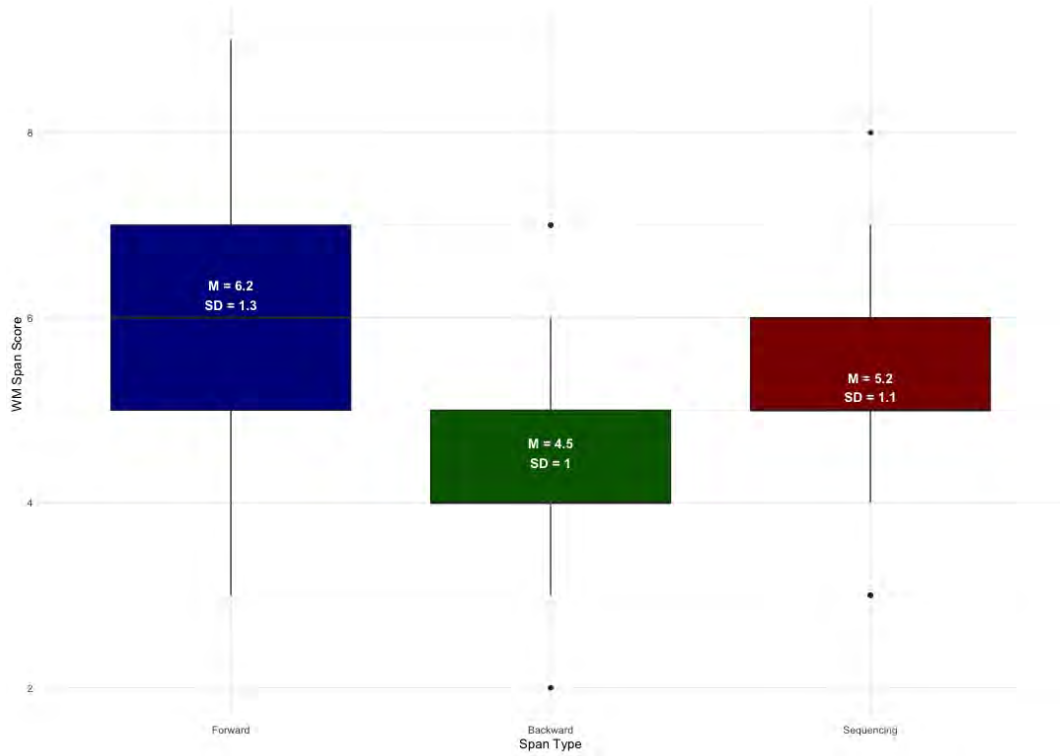

Figure 6.27: Working Memory Digit Spans Comparison

6.4.7 Cross-Task Analyses: Language and Executive Tasks

In this section, the analyses conducted to explore the relationships between language tasks and executive functions are presented. Initially, MEM were tested but did not converge due to multicollinearity among several correlated variables. Therefore, Pearson correlation analyses were conducted to assess these relationships across the different language and executive measures. Analyses implying BSF (from Phase 2 only, because they included all participants) focused on accuracy scores, while those with BPN included accuracy and RT scores. A summary of the results is reported in Appendix J.

6.4.7.1 Overall Correlational Matrix Across Language and Executive Function Tasks

A comprehensive correlation matrix was constructed to provide an overview of the relationships among language and executive function measures across tasks. These correlations, while extensive, were intended as a general, exploratory examination of domain-generality versus language-specificity of control, with no formal hypotheses formulated.

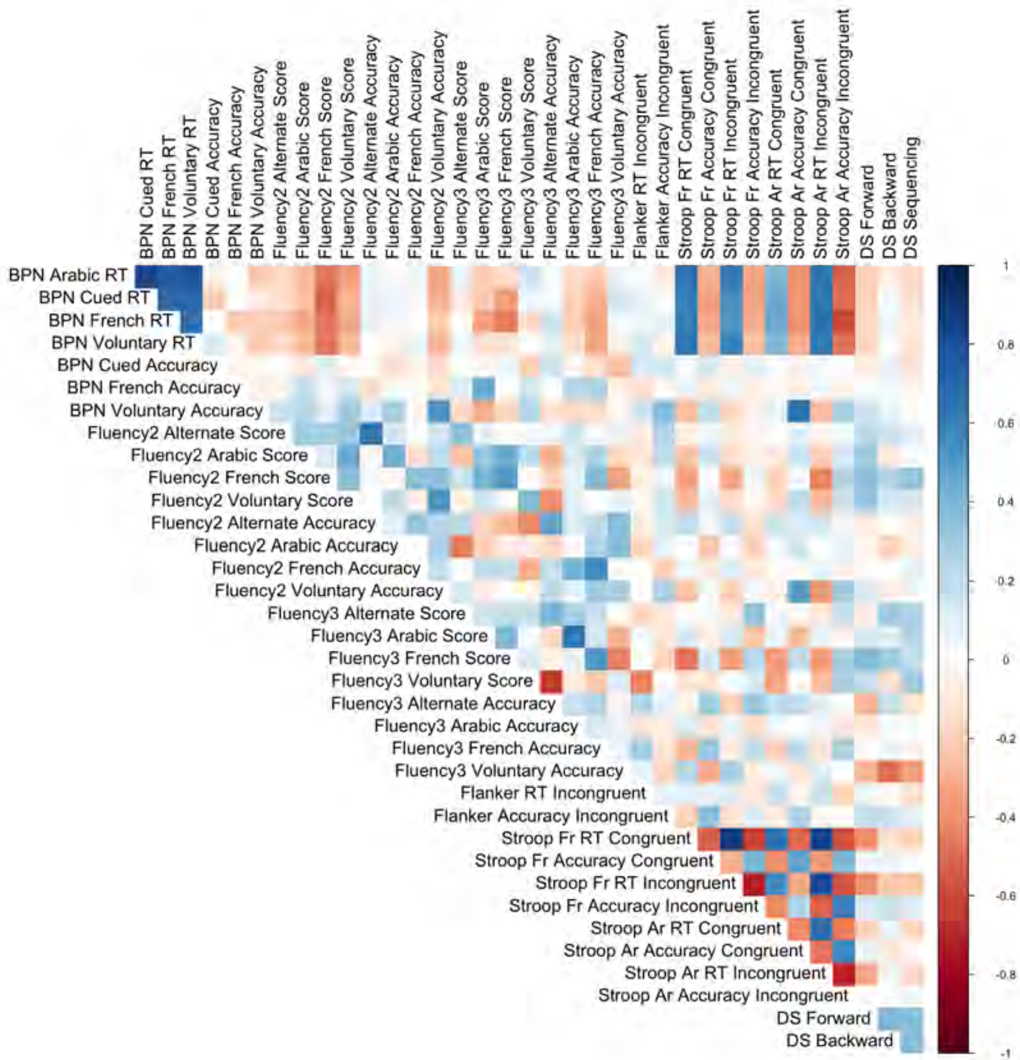

Figure 6.28: Full correlation matrix across Language and Executive Function Tasks

The color scale ranges from dark red (−1, strong negative correlation) to dark blue (+1, strong positive correlation), reflecting both the strength and direction of the relationships.

Within-task correlations were generally high: RT in both Stroop and BPN tasks were highly correlated across conditions (Stroop RT: $r = 0.66$–0.87; BPN RT: $r = 0.67$–0.84), and within-task accuracy and RT showed the expected inverse relationships (Stroop incongruent accuracy RT: $r = -0.69$ to -0.70). Accuracy and total word production in the BSF tasks were positively correlated within conditions ($r \approx 0.44$–0.63).

Cross-task correlations were also present: Stroop RT correlated positively with BPN RT ($r \approx 0.60$–0.64), higher fluency scores were associated with faster BPN responses ($r \approx -0.46$ to -0.53), and Flanker accuracy showed a moderate positive correlation with voluntary bilingual BPN accuracy ($r = 0.37$). Working memory DS showed moderate associations with Stroop RT ($r \approx -0.39$), indicating links between memory capacity and interference control.

The following section presents detailed two-by-two analyses examining the associations between language measures and executive function tasks, based on accuracy and/or RT, and broken down by condition within each task.

6.4.7.2 Bilingual Semantic Fluency & Inhibition (Flanker and Stroop Tasks)

Inhibition was assessed through both nonverbal (Flanker) and verbal (Arabic and French Stroop) tasks.

Bilingual Semantic Fluency & Nonverbal Inhibition (Flanker Task)

First, Pearson's correlations were examined between the overall accuracy percentage in the Flanker task (nonverbal inhibition) and the overall BSF score (representing global fluency). Additionally, correlations between overall Flanker accuracy percentage and each BSF condition score (Arabic monolingual, French monolingual, Alternate bilingual, and Voluntary bilingual) were analyzed. This analysis aimed to explore the relationship between different fluency conditions and inhibitory control in bilinguals.

As shown in Figure 6.29, the results revealed no significant correlation between overall BSF and overall Flanker performance (r= -0.004; p = 0.267). However, significant small negative correlations were found between overall Flanker accuracy and both the Arabic monolingual fluency condition (r = -0.032; p = 1.232e-05**) and the French monolingual fluency condition (r = -0.079; $p <$ 2.2e-16**). These findings suggest that higher fluency scores in the monolingual conditions were associated with poorer nonverbal inhibition performance. In contrast, a significant positive small to medium effect size correlation was observed between overall Flanker accuracy and the Alternate bilingual fluency condition (r = 0.220; $p <$ 2.2e-16**), indicating that better fluency in the Alternate condition was linked to improved inhibition. No significant correlation was found between overall Flanker accuracy and the Voluntary fluency condition (r= -0.008; p = 0.2982).

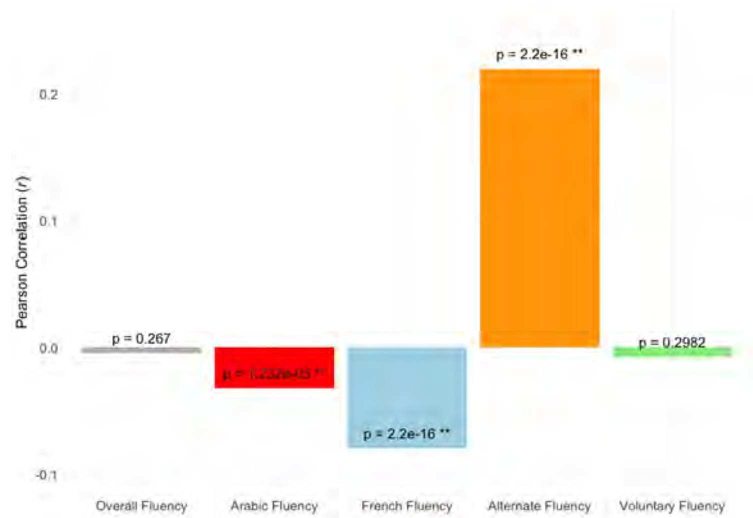

Figure 6.29: Correlations between BSF and Flanker Accuracy

Bilingual Semantic Fluency & Verbal Inhibition (Stroop Test)

Pearson's correlations were computed between the overall BSF score (representing global fluency) and the accuracy percentage from the interference condition of both the Arabic Stroop and French Stroop tasks. Additionally, correlations between overall Stroop interference accuracy and each BSF condition score were analyzed. This analysis aimed to explore the relationship between fluency in different conditions and verbal inhibitory control in bilinguals.

As shown in Figure 6.30, the results revealed a significant small positive correlation between overall fluency and Arabic Stroop interference accuracy (r = 0.120; p < 2.2e-16**). However, no significant correlation was found between overall fluency and French Stroop interference accuracy (r = 0.001; p = 0.7067). Significant moderate positive correlations were found between Arabic fluency and Arabic Stroop interference accuracy (r = 0.174; p < 2.2e-16**), as well as between French fluency and French Stroop interference accuracy (r = 0.027; p = 0.00035**). These findings suggest that higher fluency in Arabic and French was associated with improved verbal inhibition capacities in both languages.

Furthermore, a significant small positive correlation was observed between Alternate bilingual fluency and Arabic Stroop interference accuracy (r = 0.063; p < 2.2e-16**). Conversely, a significant small negative correlation was found between Alternate bilingual fluency and French Stroop interference accuracy (r = -0.023; p = 0.0016*), indicating that higher fluency in the Alternate condition was linked to slightly poorer inhibition in French. Lastly, a small but significant positive correlation was found between Voluntary bilingual fluency and Arabic Stroop interference accuracy (r = 0.200; p < 2.2e-16**), suggesting that higher voluntary switching fluency was associated with better verbal inhibition in Arabic. No significant correlation was observed with French Stroop interference accuracy (r = 0.005; p = 0.4681).

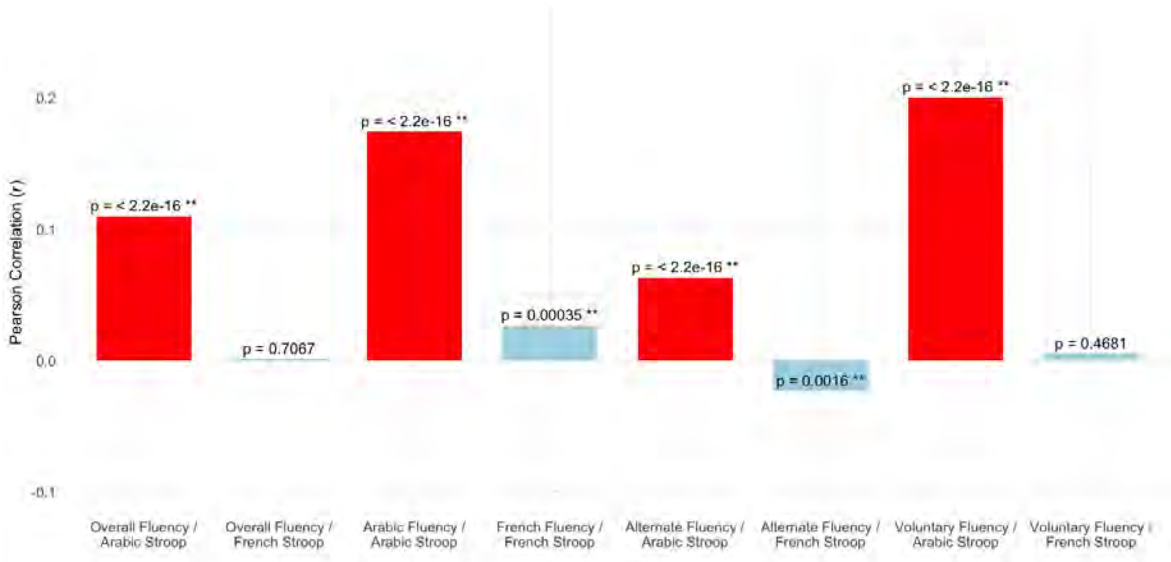

Figure 6.30: Correlations between BSF and Stroop Interference Accuracy

6.4.7.3 Bilingual Semantic Fluency & Mental Flexibility (WCST)

Pearson's correlations were computed between the overall BSF score and the accuracy percentage on the WCST, that measures mental flexibility. In addition, correlations between WCST accuracy and each BSF condition (Arabic monolingual, French monolingual, Alternate bilingual, and Voluntary bilingual) were examined. This analysis aimed to investigate the relationship between fluency in different conditions and mental flexibility in bilinguals.

As shown in Figure 6.31, the results revealed a significant small positive correlation between overall fluency and WCST accuracy (r = 0.066; p < 2.2e-16**), suggesting a positive correlation between bilingual semantic fluency and mental flexibility. A significant moderate positive correlation was observed between Arabic monolingual fluency and WCST accuracy (r = 0.286; p <2.2e-16**), indicating that better performance in Arabic fluency was associated with improved mental flexibility. In contrast, French monolingual fluency was negatively correlated with WCST accuracy (r = -0.058; p = 4.247e-15**). Further, a significant small positive correlation was found between Alternate bilingual fluency and WCST accuracy (r = 0.046; p = 4.562e-10**), and a slightly stronger positive correlation emerged in the Voluntary bilingual condition (r = 0.120; p < 2.2e-16**).

These findings show that higher fluency was mostly associated with enhanced mental flexibility (except for the French condition).

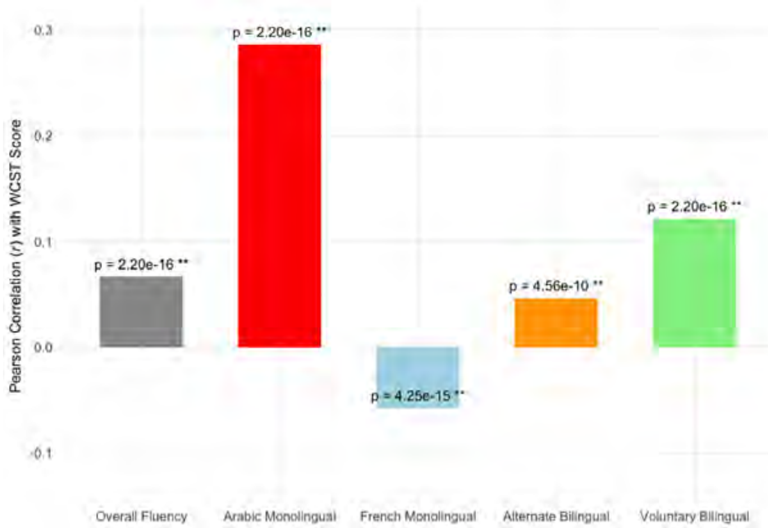

Figure 6.31: Correlations between BSF and WCST Accuracy

6.4.7.4 Bilingual Semantic Fluency and Working Memory (Digit Span)

Measure	Pearson's r	95% Confidence Interval	p-value
Fluency vs. Forward DS	0.187	(0.179, 0.194)	$< 2.2 \times 10^{-16}$**
Fluency vs. Backward DS	0.063	(0.055, 0.071)	$< 2.2 \times 10^{-16}$**
Fluency vs. Sequencing DS	0.100	(0.093, 0.108)	$< 2.2 \times 10^{-16}$**

Table 6.22: Correlations between BSF and Working Memory

The correlations between BSF scores and the three different measures of working memory (forward, sequencing, and backward DS) were examined.

Pearson's correlation analyses revealed small but statistically significant positive correlations between fluency scores and each of the working memory measures (see Table 6.22). Specifically, fluency scores were most positively correlated with forward DS (r = 0.187, (p < 0.001**), followed by sequencing DS (r = 0.100, p < 0.001**), and finally, the weakest but still significant correlation was with backward DS (r = 0.063, p < 0.001**), as shown in Figure 6.32.

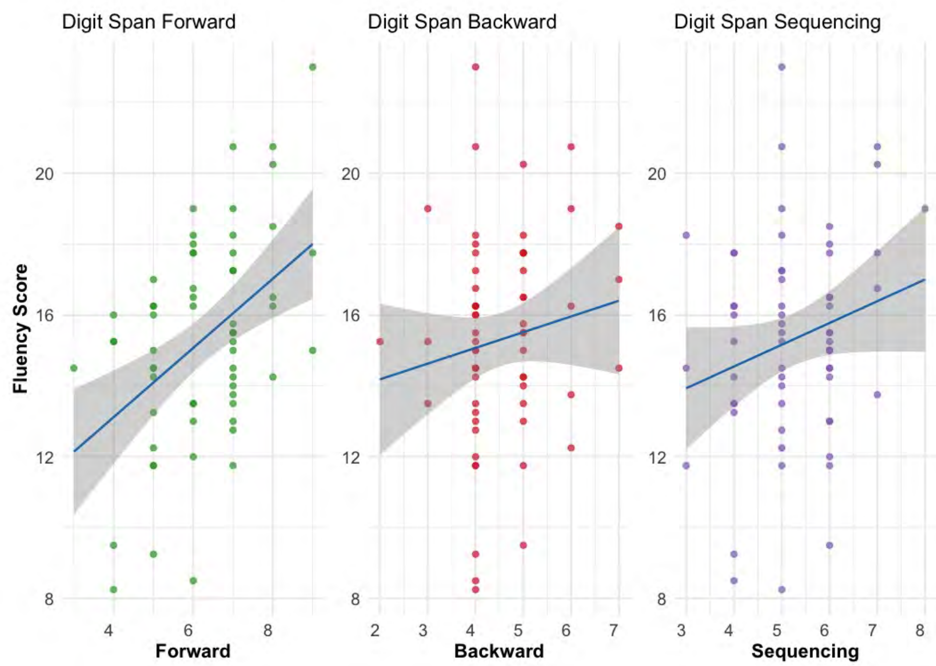

Figure 6.32: Scatter Plots of Correlations between BSF and Working Memory

Overall, these results reveal consistent associations between BSF performance and executive function measures within the domain of inhibition.

6.4.7.5 Bilingual Picture Naming & Inhibition (Flanker and Stroop Tasks)

Bilingual Picture Naming & Nonverbal Inhibition (Flanker Task)

Accuracy

Correlations between accuracy in the BPN task and Flanker accuracy across conditions showed a small but significant positive correlation at the global level, (r = 0.036, p < 0.001**), indicating a general link between performance on bilingual language production and nonverbal inhibitory control. This relationship varied across conditions. In the Arabic monolingual condition, the correlation was slightly stronger (r = 0.109, p <.001**). In contrast, the French monolingual condition did not yield a significant correlation (r = 0.015, p = 0.090). Among the bilingual conditions, a significant small positive correlation was observed in the Cued condition (r = 0.062, p < 0.001**), while a significant small negative correlation emerged in the Voluntary condition (r = -0.055, p < 0.001**). This may indicate that in the Cued condition, more nonverbal inhibition may help with language switching, while in the Voluntary condition, lower nonverbal inhibition might be linked to better performance (see Figure 6.33).

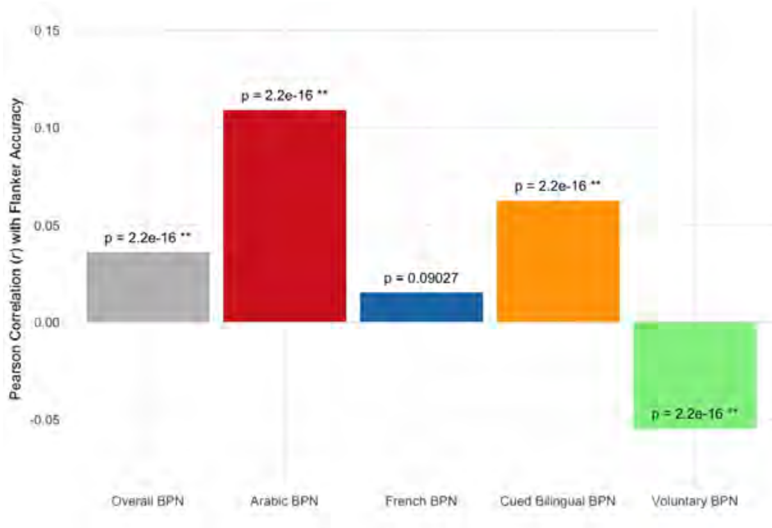

Figure 6.33: Correlations between BPN Accuracy and Flanker Accuracy

RT

Correlations between RT in the BPN and Flanker tasks revealed a small but significant positive correlation at the global level (r = 0.046, $p < 0.001$**), suggesting the presence of a link between RT in bilingual language production and nonverbal inhibitory control. This relationship varied across BPN conditions. In the Arabic monolingual condition, the positive correlation was slightly stronger (r = 0.049, $p < 0.001$**), whereas in the French monolingual condition, the correlation was still positive but weaker (r = 0.047, $p < 0.001$**). Among the bilingual conditions, a significant small positive correlation was observed in the Cued (r = 0.051, $p < 0.001$**) and Voluntary (r = 0.054, $p < 0.001$**) conditions (see Figure 6.34).

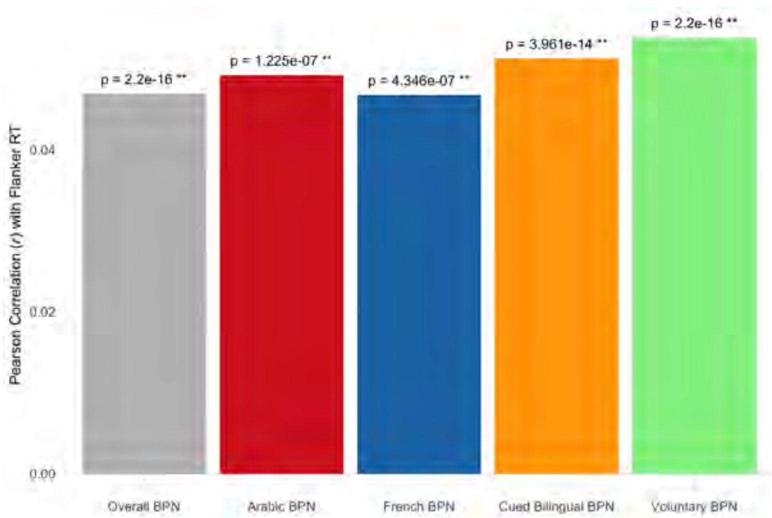

Figure 6.34: Correlations between BPN RT and Flanker RT

Bilingual Picture Naming & Verbal Inhibition (Stroop Test)

Accuracy

Pearson's correlations were computed between the BPN accuracy percentage and the accuracy percentage from the interference condition of both the Arabic Stroop and French Stroop tasks. Additionally, correlations between Stroop interference accuracy and each BPN condition (Arabic monolingual, French monolingual, Cued bilingual, and Voluntary bilingual) were analyzed. This analysis aimed to explore the relationship between BPN in different conditions and verbal inhibitory control in bilinguals.

As shown in Figure 6.35, all correlations between BPN accuracy and Stroop interference accuracy were significant. The strongest correlation was found between Arabic monolingual BPN and Arabic Stroop (r = 0.19; $p <$ 2.2e-16**), followed by a moderate correlation between Cued bilingual and Arabic Stroop (r = 0.18; $p <$ 2.2e-16**). A significant but smaller positive correlation was observed between overall BPN and Arabic Stroop (r = 0.16; $p <$ 2.2e-16**). Additionally, a moderate correlation was found between French monolingual BPN and French Stroop (r = 0.11; $p <$ 2.2e-16**), which was equal to the correlation between overall BPN and French Stroop (r = 0.11; $p <$ 2.2e-16**). The smallest correlations were observed for Voluntary bilingual and French Stroop (r = 0.08; $p <$ 2.2e-16**). These findings indicate that better BPN performance was consistently associated with better verbal inhibition performance.

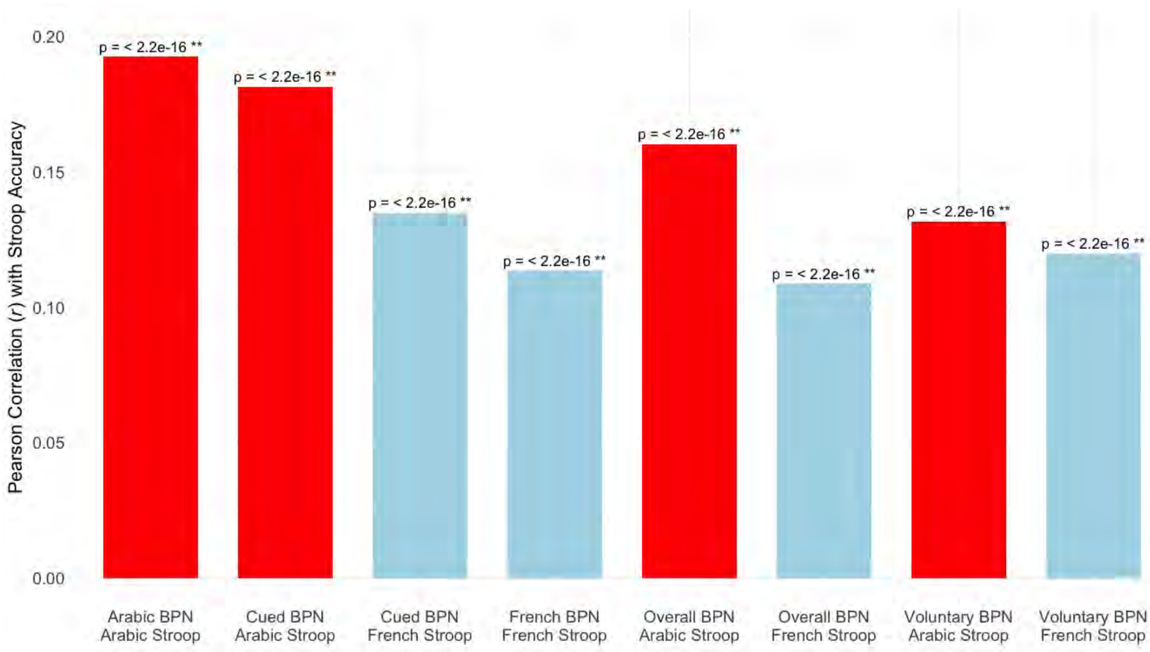

Figure 6.35: Correlation between BPN Accuracy and Stroop Interference Accuracy

RT

As shown in 6.36, all correlations between BPN RT and Stroop interference RT were significant and positive. The strongest correlation was observed between Voluntary bilingual BPN and Arabic Stroop (r = 0.32; $p <$ 2.2e-16**), followed by Voluntary bilingual BPN and French Stroop (r = 0.30; $p <$ 2.2e-16**), Arabic monolingual BPN and Arabic Stroop (r = 0.29; $p <$ 2.2e-16**), and Cued bilingual BPN and Arabic Stroop (r = 0.28; $p <$ 2.2e-16**). This was followed by overall BPN and Arabic Stroop (r = 0.28; $p <$ 2.2e-16**), French monolingual BPN and French Stroop (r = 0.25; $p <$ 2.2e-16**), Cued bilingual BPN and French Stroop (r = 0.25; $p <$ 2.2e-16**), and lastly, overall BPN and French Stroop (r = 0.25; $p <$ 2.2e-16**). These findings indicate that faster BPN performance was consistently associated with faster verbal inhibition performance.

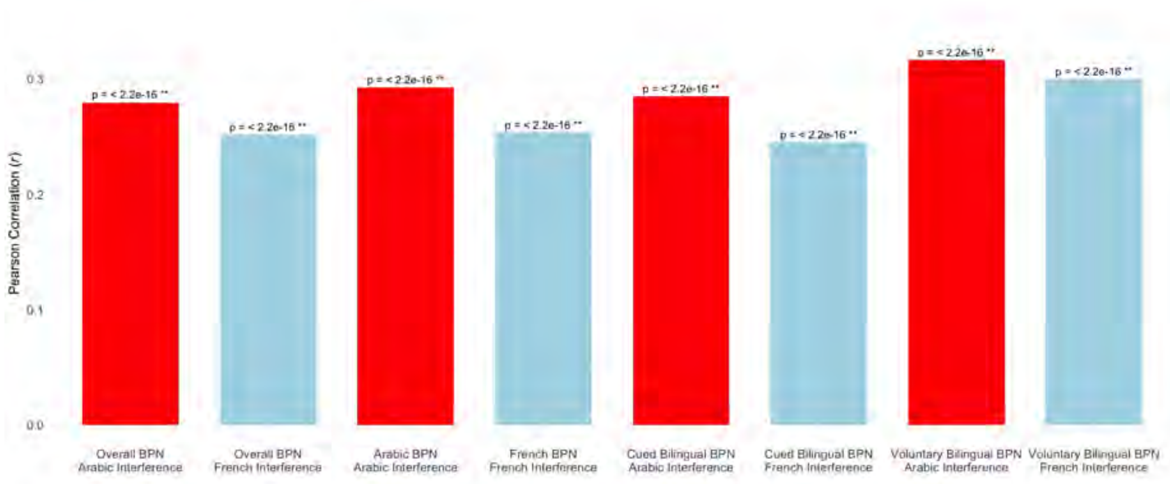

Figure 6.36: Correlation between BPN RT and Stroop RT

6.4.7.6 Bilingual Picture Naming & Mental Flexibility (WCST)

Accuracy
Pearson's correlations were computed between the overall BPN accuracy and the accuracy percentage on the WCST, which measures mental flexibility. Additionally, correlations between WCST accuracy and each BPN condition were examined. This analysis aimed to investigate the relationship between accuracy in different BPN conditions and mental flexibility in bilinguals.

As shown in Figure 6.37, the results revealed a significant moderate positive correlation between Arabic monolingual BPN accuracy and WCST accuracy (r = 0.105; $p <$ 2.2e-16**). Similarly, French monolingual condition showed a significant positive correlation with WCST accuracy (r = 0.104; p < 2.2e-16**). A smaller positive correlation was found between Voluntary bilingual BPN accuracy and WCST accuracy (r = 0.090; $p <$ 2.2e-16**), followed by a small positive correlation between Cued bilingual BPN accuracy and WCST accuracy (r = 0.072; $p <$ 2.2e-16**). Finally, a the smallest positive correlation was observed between overall BPN accuracy and WCST accuracy (r = 0.069; $p <$ 2.2e-16**). These findings suggest that higher BPN accuracy across different conditions was associated with enhanced mental flexibility.

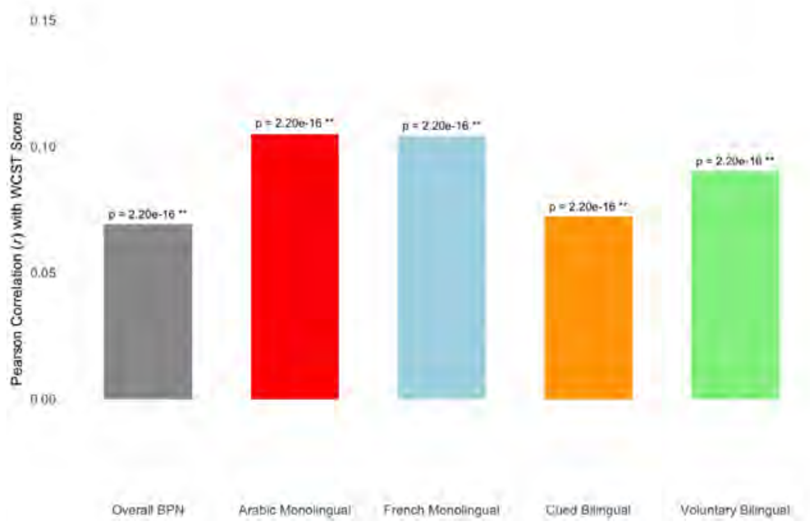

Figure 6.37: Correlations Between BPN and WCST Accuracy

RT

The correlation between BPN RT and WCST RT was significant across all conditions, with varying effect sizes. The strongest positive correlation was found with the French Monolingual condition (r = 0.140, p < 2.2e-16**), followed by the Voluntary Bilingual condition (r = 0.134, p < 2.2e-16**). The overall correlation across all conditions was r = 0.113 (p < 2.2e-16**). The Cued Bilingual condition showed a slightly lower but still significant correlation (r = 0.108, p < 2.2e-16**), and the weakest correlation was observed in the Arabic Monolingual condition (r = 0.090, p < 2.2e-16**). These patterns mainly suggest that voluntary switching engages faster mental flexibility than the externally cued condition.

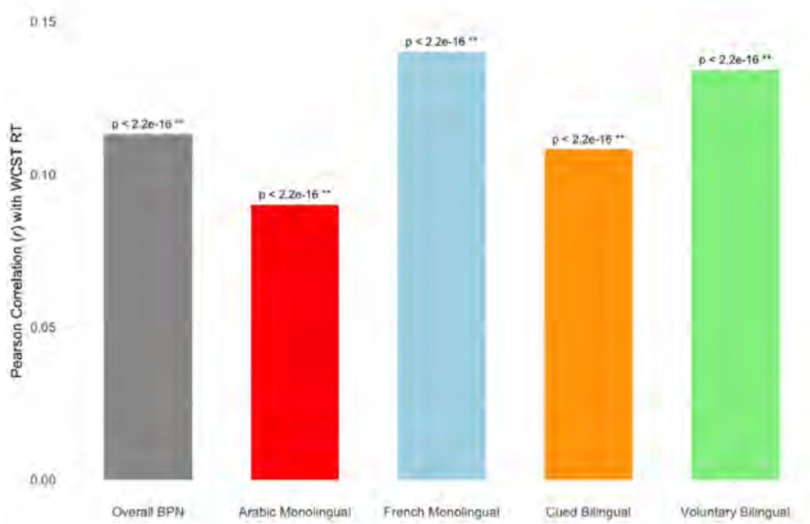

Figure 6.38: Correlation between BPN RT and WCST RT

6.4.7.7 Bilingual Picture Naming & Working Memory (Digit Span

Working Memory Measure	*r*	95% CI	*p*-value
BPN vs. Forward DS	0.160	[0.153, 0.167]	< 2.2e-16**
BPN vs. Backward DS	0.025	[0.018, 0.032]	9.006e-12**
BPN vs. Sequencing DS	-0.015	[-0.022, -0.007]	7.506e-05**

Table 6.23: Correlation between BPN Accuracy and Working Memory

Pearson's correlation analyses were conducted to explore the relationship between BPN performance and working memory. As working memory was assessed only through accuracy-based DS tasks (no RT data available), only BPN accuracy scores were included in these analyses.

Results (Table 6.23) showed a small but statistically significant positive correlation between BPN accuracy and forward DS (r = 0.160, $p < 0.001$**), indicating an association between short-term verbal memory and performance on the BPN task. A weak but still significant positive correlation was found with backward DS (r = 0.025, $p < 0.001$**). In contrast, sequencing DS showed a small but significant negative correlation with BPN accuracy (r = -0.015, $p < 0.001$**), indicating a slightly inverse relationship (see Figure 6.39).

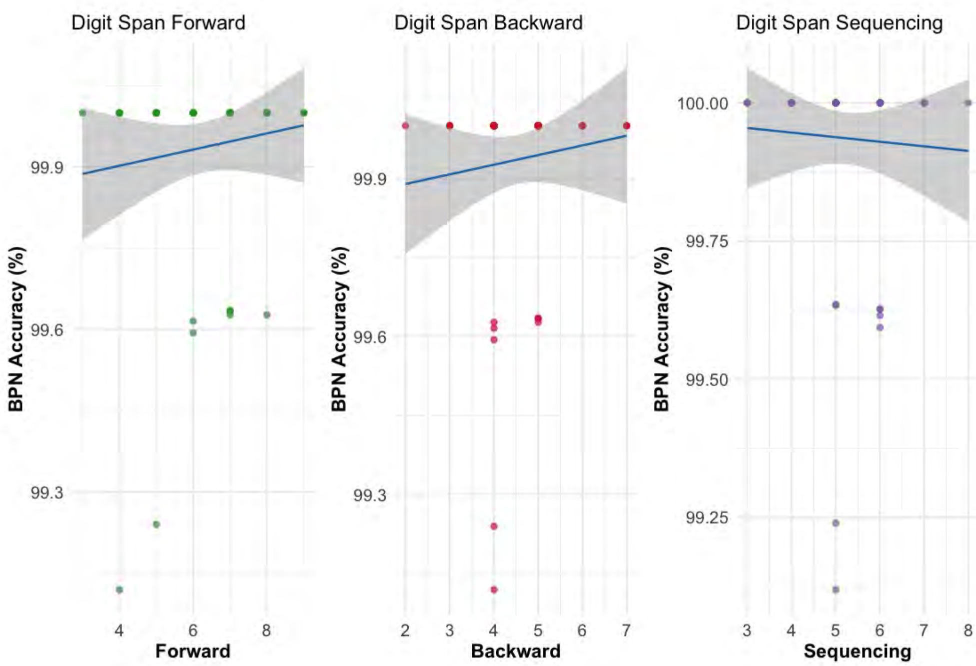

Figure 6.39: Scatter Plots of Correlations between BPN Accuracy and Working Memory

Overall, the pattern of significant correlations observed between executive function tasks and language switching performance highlights consistent associations between the two domains.

Summary of Language Switching Findings

French Language Proficiency:
The mean French language proficiency of participants was 71.9 (SD = 22.8), ranging from 23 to 100, indicating that most participants were at an upper-intermediate to advanced level (CEFR B2–C2).

Bilingual Picture Naming:
- *Accuracy:* Performance was near ceiling across all conditions.
- *RT:* Monolingual responses were significantly faster than cued bilingual responses, whereas voluntary responses were comparable to Arabic monolingual trials; within bilingual trials, French responses were faster than Arabic.
- *Switching:* Participants switched voluntarily on average on 40% of the trials.
- *Switch costs:* Switch costs were significantly reduced in the voluntary condition compared to the cued condition.
- *Mixing costs:* Mixing costs were significantly lower in the voluntary condition than in the cued condition.
- *Individual Differences:* Faster RT were associated with higher L2 proficiency, greater LE, and longer LOR in France, while CSP was linked to slower RT.

Bilingual Semantic Fluency:
Phase 2 (N = 61):
- *Fluency:* Participants produced the most words in the Arabic monolingual condition, followed by French monolingual, then voluntary, and finally in the alternate bilingual condition.
- *Accuracy:* Accuracy was highest in the Arabic monolingual condition and lowest in the alternate bilingual condition.
- *Switching:* In the voluntary condition, participants switched on average on 30% (± 16%) of the trials.
- *Switch costs:* Voluntary fluency was significantly higher than alternate, indicating a switch cost in the alternate condition.
- *Mixing costs:* Mixing costs were significantly lower in the voluntary compared to the alternate condition.

Phase 3 (N = 24):
- *Fluency:* Participants produced the most words in the French monolingual condition, followed by Arabic monolingual, then voluntary, and finally in the alternate bilingual condition.
- *Accuracy:* Accuracy was highest in the French monolingual condition and lowest in the alternate bilingual condition.
- *Switching:* In the voluntary condition, participants switched on average on 56.8% (± 15.7%) of the trials.
- *Switch costs:* Voluntary fluency was significantly higher than alternate, indicating a switch cost in the alternate condition.
- *Mixing costs:* There was no significant difference in mixing costs between voluntary and alternate conditions.

Summary of Executive Tasks Findings

Nonverbal Inhibition (Flanker):
- *Accuracy:* Performance was near ceiling across all trial types (congruent, neutral, and incongruent), with no significant differences.
- *RT:* RT were slowest on incongruent trials, intermediate on congruent trials, and fastest on neutral trials. There were significant differences across trial types ($p < 0.005$*). Post-hoc analyses revealed that RT were significantly slower in the incongruent condition compared to both the neutral and congruent conditions ($p < 0.001$**), while the difference between congruent and neutral trials was not significant ($p = 0.391$).

Verbal Inhibition (Stroop):
- *Accuracy:*
In French, accuracy was highest in the Reading condition, followed by Naming, and lower in Congruent Interference, Overall Interference, and Incongruent trials.
In Arabic, accuracy was also highest in Reading, followed by Naming, then lower in Congruent Interference, Overall Interference, and lowest in Incongruent trials.
There was a significant main effect of trial type in both languages (ps < 0.005*). Post-hoc comparisons showed that Congruent trials yielded higher accuracy than Incongruent and Overall Interference trials, while Incongruent trials were less accurate than Reading and Naming conditions (all ps < 0.001**).
- *RT:*
In both French and Arabic, RT were fastest in the Reading condition, followed by Naming, then Congruent, then Overall Interference, and slowest in Incongruent trials. Significant main effects were found in both languages, with Reading trials being faster than Incongruent and Overall Interference trials ($p < 0.001$**).
- *Comparison between languages:* No significant differences were observed in accuracy (p=0.298) or RT (p=0.114) between French and Arabic Stroop tasks.

Mental Flexibility (WCST):
- *Accuracy:* Accuracy was highest in Congruent trials, followed by Overall, and lowest in Incongruent trials. A significant main effect of trial type was found ($p < 0.001$**). Post-hoc analyses indicated that Congruent trials were more accurate than Incongruent trials ($p < 0.001$**), Congruent did not differ significantly from Overall ($p = 0.1961$), and Incongruent trials were less accurate than Overall ($p < 0.001$**).
- *RT:* RT followed the pattern Congruent < Overall < Incongruent. The main effect of trial type was not significant ($p = 0.124$), and no significant pairwise differences were observed (all ps > 0.001).

Working Memory (DS):
- *Scores:* Participants achieved the highest mean span in the Forward condition ($M = 6.25$, $SD = 1.35$), followed by Sequencing ($M = 5.25$, $SD = 1.07$), and the lowest in the Backward condition ($M = 4.54$, $SD = 0.96$).
- *Analysis:* There was a significant effect of span type ($p < 0.001$**). Post-hoc analyses showed that the Forward span was significantly higher than both the Backward and Sequencing spans, and the Backward span was significantly lower than the Sequencing.

Summary of Cross-Task Correlational Findings

Nonverbal Inhibition: Significant positive correlations between Flanker accuracy and fluency/BPN accuracy were observed, suggesting better language control is linked to improved nonverbal inhibition. However, negative correlations with Arabic and French monolingual fluency, as well as Voluntary bilingual BPN, suggest higher fluency in these conditions was associated with poorer inhibition. Significant positive correlations were also found between Flanker and BPN RT.

Verbal Inhibition:

- Stroop Arabic accuracy was positively correlated with fluency in Arabic monolingual, alternate bilingual, and voluntary bilingual conditions, indicating that better L1 inhibition was linked to stronger language control.
- Stroop French accuracy showed positive correlations with overall fluency and French monolingual fluency, while a negative correlation with alternate bilingual fluency suggested weaker L2 inhibition in more constrained tasks.
- Stroop RT in both Arabic and French were positively correlated with fluency and BPN, reflecting that better language control was associated with faster verbal inhibition.

Mental Flexibility:

- WCST accuracy was positively correlated with fluency in Arabic monolingual, alternate bilingual, and voluntary bilingual conditions, indicating that better mental flexibility was associated with stronger language control in these contexts. However, it was negatively related to French monolingual fluency.
- WCST accuracy and RT were positively correlated with BPN accuracy and RT across all conditions, suggesting better flexibility was linked to stronger language control.

Working Memory:

Positive significant correlations were found between most working memory components (forward, backward, and sequencing DS) and both fluency and BPN accuracy, except for BPN and Sequencing DS, which showed a negative correlation.

6.5 Discussion

Assessing language switch and mixing costs in bilinguals in the laboratory environment requires using various LSPs. These paradigms, increasingly used in recent years (Bonfieni et al., 2019; Christoffels et al., 2007; Declerck & Philipp, 2015), measure the cost of switching and mixing languages through precise accuracy and RT measures. Although widely used, particularly for bilingual picture-naming tasks, they remain underexplored in FCS.

The present study therefore examined a specific population of FCS not previously addressed in the literature: Lebanese bilinguals of Arabic and French. Lebanese bilinguals regularly use two to three languages in daily life, typically Lebanese Arabic, French, and/or English, granting them the reputation of FCS. In this study, a baseline of sociolinguistic data was collected using the same questionnaires as in Phase 1, reporting participants' age, education, AoA, LOR in France, and computing LE and CSP to characterize language use and switching. Objective and subjective French language proficiency were also assessed. The laboratory assessment included bilingual picture-naming and semantic fluency LSPs. To address the second objective of testing the domain-generality versus language-specificity hypothesis, executive functions were assessed: inhibition through Flanker and Stroop tasks, set shifting through the WCST, and working memory through a digit span task. To the best of current knowledge, no previous study has examined experimental language switching and the associated switch and mixing costs and benefits in Lebanese bilinguals using such a comprehensive approach. Therefore, the present study provides a detailed investigation of these processes, combining laboratory tasks, sociolinguistic measures, and executive function assessments to offer a holistic understanding of language control in this population.

6.5.1 French Language Proficiency

Participants' L2 French proficiency was generally high, with an average of 71.9 ($\pm$22.8) and most participants (73.8%) reaching upper-intermediate to advanced levels (B2–C2), indicating a relatively balanced Lebanese Arabic–French bilingual profile. These findings align with the broader linguistic reality of Lebanon, where French maintains a prominent role in education, administration, and daily life. For instance, El Samaty (2002), based on a large corpus analysis of Lebanese television shows, reported that Lebanese speakers often exhibit high French proficiency, as reflected in their frequent use of French lexical items and the quality of their pronunciation. This observation is consistent with the historical and sociolinguistic context of Lebanon, where French has long been a key language of instruction and social status (Bizri, 2013; Shaaban & Ghaith, 1999, 2002). The importance of French proficiency in Lebanon has also been highlighted by Diab (2000), who noted that success in academic and professional domains often depends on strong skills in both French and English, with French historically playing a central role in education and professional trajectories (Shaaban, 2017). This aligns with Bacha and Bahous (2011), who describe Lebanese curricula as aiming to produce citizens proficient in at least one foreign language, encouraging openness to other cultures and enabling interactions in multilingual settings. Consequently, participants' high French proficiency likely reflects both the structural demands of the educational system and the sociolinguistic opportunities for practicing French in daily life, including through media exposure, social networks, and interactions with French-speaking communities. French proficiency also constitutes a salient marker of identity in Lebanon, as emphasized by Joseph (2004). Arabic–French bilingualism is often linked to social prestige and a cosmopolitan identity, which further encourages maintaining high proficiency.

Moreover, prolonged exposure to French through living and/or studying in a francophone context, reflected by the participants' reported LOR in France, further strengthens their bilingual profiles. In addition, the high educational level of the sample, with 70.5% holding a Master's or PhD degree, likely contributed to their balanced bilingualism, as higher education in France may have provided extended opportunities for academic language use and immersion.

Taken together, the educational system, professional and academic demands, daily language practice, and identity provide a comprehensive explanation for the relatively high and balanced French proficiency observed in the sample, positioning the empirical findings within the broader sociolinguistic and historical context of Lebanese bilingualism.

However, self-reported proficiency was poorly correlated with objective scores, suggesting that subjective and objective measures capture different aspects of language ability. This difference highlights a possible limitation in much of the existing research on bilingual language switching, which often relies solely on self-reported measures, potentially overlooking important aspects of actual language competence, such as over- or underestimating skills and differences between modalities (speaking, writing, etc.). Consequently, a growing body of research emphasizes the importance of combining both objective and subjective assessments to obtain a more comprehensive understanding of language proficiency (Aydogan & Akbarov, 2018; Gehebe et al., 2023; Luque et al., 2025; Olson, 2024; Steiber, 2023).

In this study, participants generally overestimated their skills in self-reports, consistent with previous findings in the Lebanese context. For instance, Kanaan (2011) found that 7 out of 8 participants rated their oral French proficiency as "good" or "very good," and all 8 rated their written French proficiency as "good" or "very good." Similarly, both Bassam (2017) and Chehimi et al. (2024) found that Lebanese university students rated their Arabic proficiency highest, English at an intermediate level, and French lowest. These patterns reflect a general tendency for overestimation in self-assessment and highlight differences across languages in the Lebanese multilingual context. They also indicate a shift toward English replacing French as a second language, possibly due to the widespread use of English and its role in academic and professional opportunities outside Lebanon (Shaaban, 2017), as noted by Kelly et al. (2020, p. 2), who observed that "especially in Beirut, many people are highly proficient in English." In the context of the current study, this overestimation can be interpreted as participants' confidence in their own language proficiency and a subjective sense of competence. This shift toward English is also mirrored in the current study, where all 61 participants reported English as their third language. English, introduced more recently through globalization, has gained prominence as a *lingua franca*, particularly in science, business, and social media (Smairat, 2020). Given its role as a shared L3, the rise of English may have also influenced participants' language switching patterns, as it forms an integral part of their daily linguistic repertoire.

6.5.2 Bilingual Picture-Naming

The primary objective of this task was to compare voluntary and cued language switching and mixing within a BPN task among Lebanese FCS. It is the first study to examine these costs within this population, using the same material across both conditions. Generally, the voluntary condition appeared to be less cognitively demanding than the cued condition, as shown by faster overall RT, reduced switch costs, and smaller mixing costs. Previous research comparing voluntary and cued tasks separately had also reported faster RT in voluntary conditions (Blanco-Elorrieta & Pylkkänen, 2017; De Bruin et al., 2018; Kennis et al., 2025). However, interpreting overall RT differences between voluntary and cued switching is more complex when they are presented in separate tasks. Additionally, some previous studies have used different stimuli in each condition, potentially increasing overall task demands.

6.5.2.1 Overview of Findings

Accuracy and RT

Accuracy rates were near ceiling across the four picture-naming conditions. In BPN, more precisely among balanced bilinguals with higher L2 proficiency, such high accuracy is expected and reflects participants' strong proficiency in both Arabic and French.

By contrast, RT differed across conditions. Overall, responses were slower in the cued condition, for both switch and stay trials, compared to the voluntary and monolingual conditions, consistent with prior work showing that externally guided language switching imposes additional control demands (De Bruin et al., 2018; Jevtović et al., 2020). Within monolingual blocks, RT were longer in L1 Arabic than in L2 French.

Reversed Language Dominance Effect

Slower responses in Arabic (L1) than in French (L2) were observed across both monolingual and bilingual conditions, indicating the presence of a reversed language dominance effect. This phenomenon has been documented in prior work, where bilinguals sometimes perform worse in their dominant language than in their less dominant one in bilingual conditions (= mixed-language blocks) (Christoffels et al., 2007; Declerck & Philipp, 2015). One explanation is that proactive inhibition of the dominant language (Arabic in this case) is applied throughout mixed-language blocks, which reduces the activation gap between L1 and L2 and can even make the latter (French in this study) more accessible. In the Lebanese context, the strong educational and institutional reinforcement of French may further enhance its accessibility, contributing to the observed effect. Moreover, since all participants currently reside in France, where exposure to and use of French is intensified, this likely further contributes to the emergence of this reversed dominance. Importantly, the bilinguals in the current study were mostly balanced, similar to the participants in Declerck, Kleinman, and Gollan (2020), who found that reversed language dominance effects were especially pronounced in more balanced bilinguals in mixed-language blocks.

Switching Rate (Voluntary Condition)

In the Voluntary condition, participants switched languages on average on 39.6% of trials, with most participants switching between 25% and 50% of the time. This pattern indicates that Lebanese bilinguals flexibly alternated between Arabic and French. These results are highly consistent with previous work on balanced bilinguals: De Bruin et al. (2018) reported an average switching rate of 40.8%, with most participants switching between 30% and 50% of trials, while Jevtović et al. (2020) found an average of 43.5%. This consistency across studies, with voluntary switching rates around 40%, suggests that balanced bilinguals tend to distribute their language use relatively evenly.

Across trials, participants named 48.2% in Arabic, 52.5% in French, showing a rather balanced use of languages across participants, and 2.0% of the trials were also named in English, indicating that both dominant languages were used fairly evenly, with English minimally. This pattern of language choice is comparable to De Bruin et al. (2018)'s participants, who chose 43% in Spanish of the voluntary trials and Basque for 57%, and to Jevtović et al. (2020), whose participants named 44.4% of trials in Spanish and 55.6% in Basque.

Notably, although English was not included in the instructions, English answers were coded as correct when they corresponded to the target picture. The presence of English trials, even minimally, suggests that the L3 may be active in the background, indicating constant trilingual language activation that could create interference and require ongoing L3 inhibition, given that all 61 participants possessed English as their L3.

Key Factors Influencing RT

Across all conditions, several individual factors appeared to influence RT in the BPN. Participants with higher L2 proficiency, greater LE, and longer LOR in France tended to respond faster, suggesting that more integrated and balanced bilinguals can access lexical items more efficiently. In contrast, participants with higher CSP exhibited slower responses, indicating that frequent daily switching may impose additional language control demands, even among highly proficient bilinguals. These findings highlight that both long-term language experience (proficiency, exposure, residence) and habitual switching behavior shape naming performance, emphasizing the importance of capturing detailed individual backgrounds and usage patterns through comprehensive sociolinguistic questionnaires, ideally using continuous measures as recommended by De Bruin (2019). Considering individual differences alongside experimental manipulations is crucial for accurately understanding bilingual language control and switching behavior.

6.5.2.2 Discussion by Hypothesis

Switch Costs in Lebanese FCS

Hypothesis A predicted that switching languages would incur a cost, with slower responses on switch trials relative to stay trials. Consistent with this prediction, a significant main effect of trial type was observed in the switch costs MEM: participants responded more slowly on switch trials than on stay trials, confirming the presence of a switch cost in BPN. This finding aligns with a large body of research demonstrating that bilingual language production requires additional control when alternating between languages (Costa & Santesteban, 2004; Gollan & Ferreira, 2009; Heikoop et al., 2016; Hirsch et al., 2015).

Hypothesis B posited that switch costs would be higher in the cued condition than in the voluntary condition, reflecting the greater control demands imposed by externally dictated language selection. Supporting this hypothesis, the interaction between condition and trial type was significant: switch costs were smaller in the voluntary condition, indicating that allowing participants to select the language reduced the cost of switching. This pattern is consistent with previous evidence showing that voluntary language choice lowers switch costs by enabling more flexible language use (De Bruin et al., 2018; Jevtović et al., 2020).

Further analyses revealed that the advantage of the voluntary condition was especially pronounced for Arabic trials, as indicated by the significant condition × language interaction. Additionally, the trial type × language interaction suggested that switch costs were generally lower when naming in Arabic compared to French, possibly reflecting language-specific dominance effects of the L1 in the sample. The three-way interaction between condition, trial type, and language was not significant, indicating that the modulation of switch costs by condition was broadly consistent across languages.

Results therefore showed primarily that there is a switch cost in bilingual conditions, with responses being significantly slower on switch trials compared to stay trials in both the cued and voluntary conditions, confirming hypothesis A. Switch costs differed between conditions, with responses in the cued condition being significantly slower than in the voluntary condition, confirming hypothesis B. This patterns aligns with previous research on other types of bilingualism and different languages (Blanco-Elorrieta & Pylkkänen, 2017; De Bruin et al., 2018; Jevtović et al., 2020) and extends those findings to Lebanese FCS. The behavioral effects found in the current study were also confirmed by Magnetoencephalography (MEG) (Blanco-Elorrieta & Pylkkänen, 2017).

In fact, language switching in a cued paradigm implies simultaneous activation of the target language and inhibition of the non-target language (Green, 1998). Additional control mechanisms are also involved in this process, such as goal maintenance, conflict monitoring, interference suppression, and salient cue detection (Green & Abutalebi, 2013). On the other hand, voluntary switching is supposed to rely more on opportunistic planning, where the first accessible language is the one used

(Green & Abutalebi, 2013), consequently involving lower demands and more open control (Green & Wei, 2014). For Lebanese FCS, current results suggest that it is behaviorally easier to switch languages at will than to switch in response to external cues.

Moreover, while previous studies had mainly found such effects in unbalanced or late bilinguals (Christoffels et al., 2007; Costa & Santesteban, 2004), the current study extends them to balanced bilinguals who frequently use two to three languages in their daily lives. Similar results have also been reported in balanced bilinguals of Spanish-Basque, where reduced but persistent switch costs were observed (De Bruin et al., 2018; Jevtović et al., 2020). Even for these bilinguals, who are highly proficient and comfortable using multiple languages, a switch cost still exists. In addition, although switch costs were very low in the voluntary condition compared to the cued condition, the present findings challenge research that reports no switch cost (Declerck et al., 2019; Kleinman & Gollan, 2016).

LSP studies often use experimental designs where stimuli (e.g., words or images) are repeated multiple times, controlling or fixing which language each stimulus is presented in, thereby reducing the usual effort involved in switching. In the absence of such a design (in the voluntary condition), speakers are more likely to select the language based on which word comes to mind most easily or quickly. This reflects opportunistic planning (Kleinman & Gollan, 2016), where language choice is guided by immediate lexical accessibility rather than a predefined switching pattern: the first word uttered is the one that enter the speech plan and matches the concept conveyed by the image, regardless of the language. However, other factors might also influence language choice: participants may default to a preferred language (Grosjean, 1998), use the L2 for prestige (Smairat, 2020), or not prioritize switching efficiency (Kleinman & Gollan, 2016). Moreover, switching could depend on previously named items (Kennis et al., 2025) or, in more ecological settings, on the interlocutor or context (Green & Abutalebi, 2013).

Furthermore, individual differences showed trends consistent with theoretical predictions, although none reached the corrected significance threshold ($p < 0.005$). Higher code-switching frequency (CSP) was associated with slightly longer RT, whereas greater language entropy (LE) and L2 proficiency tended to be associated with slightly faster responses. LOR in France did not significantly influence RT. These patterns are in line with prior work suggesting that habitual language use and language integration may subtly shape the efficiency of lexical access during bilingual production (De Bruin, 2019).

Switch costs (a)symmetry

In the literature, asymmetrical language switch costs are typically observed, with larger costs when switching to the dominant L1 than to the less dominant L2, reflecting reactive language control (Declerck & Koch, 2023; Festman & Schwieter, 2015; Meuter & Allport, 1999). However, in balanced bilinguals, more symmetrical switch costs have been reported between L1 and L2 (Costa & Santesteban, 2004; Zhu & Sowman, 2020), consistent with the findings of the present study. Analyses of switch cost symmetry revealed no significant difference between switches from Arabic (L1) to French (L2) versus French (L2) to Arabic (L1), indicating that switch costs were largely symmetric across languages. This pattern aligns with evidence that, in balanced bilinguals, both languages are similarly accessible and controlled during production.

Mixing Costs in Lebanese FCS

Hypothesis C predicted that mixing costs would be lower in the voluntary compared to the cued condition, and that a mixing benefit might even be observed in the population of FCS. Results showed a significant main effect of trial type in the mixing costs MEM, confirming that stay trials were slower than blocked trials, consistent with the presence of a mixing cost. A significant interaction between condition, trial type, and L2 proficiency indicated that higher L2 proficiency reduced mixing costs, particularly in the cued condition. Pairwise comparisons confirmed that cued stay trials were slower than monolingual blocked trials, whereas voluntary stay trials did not differ significantly from monolingual blocked trials, consistent with a potential mixing benefit.

As for switch costs, individual differences revealed trends consistent with theoretical predictions: higher CSP was associated with slightly longer RT, whereas higher LE, longer LOR, and greater L2 proficiency tended to reduce RTs, though none reached significance under the corrected threshold ($p < 0.005$) except the reduced mixing costs for higher L2 proficiency participants in the cued condition.

In the voluntary language switching condition, the mean mixing cost was not significantly different from zero, and the distribution of individual mixing costs was heterogeneous, with almost half participants exhibiting a mixing benefit and the other half showing a cost (refer to Figure 6.13). This pattern is partially consistent with the findings of De Bruin et al. (2018) and Jevtović et al. (2020) on balanced bilinguals, who reported that voluntary switching can reduce mixing costs, potentially due to participants' ability to select the language in which lexical retrieval is more efficient. In contrast, these results go in the opposite direction of Gollan and Ferreira (2009), who observed reduced mixing costs for balanced bilinguals and a clear mixing benefit for unbalanced bilinguals (in the non-dominant language). In the present study, higher L2 proficiency was associated with lower mixing costs, suggesting that more balanced bilinguals tended to exhibit greater mixing benefits.

In addition to balanced bilingualism, the status of being a FCS may contribute to the observed mixing benefits, as this population regularly alternates between languages in daily conversations, which may facilitate voluntary switching and reflect greater flexibility. The voluntary condition reflects FCS's ecological use of languages more than both cued and monolingual conditions, as they are free to switch languages at their will. As noted by De Bruin et al. (2018, p. 40), freely using both languages in a voluntary switching context may be less effortful than being required to remain in a single language, since the non-target language does not need to be suppressed, reducing overall language control demands. This pattern aligns with models of bilingual language control, in which both languages remain active and accessible in an *open control mode* typical of dense code-switching contexts (Green & Abutalebi, 2013; Green & Wei, 2014; Grosjean, 2008). In contrast, monolingual (blocked) conditions require suppression of the non-target language, leading to higher inhibitory demands and longer RT. Consequently, balanced bilinguals, and FCS more specifically, may show a mixing benefit in voluntary contexts, as lexical retrieval is more efficient when both languages are freely available.

Taken together, these findings provide robust support for the three hypotheses formulated within the BPN task: switching between languages incurs a cost, and this cost is reduced when language choice is voluntary. The results suggest that voluntary language switching in Lebanese FCS can reduce or even reverse mixing costs, particularly in more balanced bilinguals, highlighting the facilitatory influence of voluntary language selection. Additionally, the findings support previous accounts of symmetrical switch costs in balanced bilinguals and reversed language dominance effects, extending these observations to a population of FCS not previously explored.

6.5.3 Bilingual Semantic Fluency from Phases 2 and 3

To complete the BPN, a bilingual semantic fluency LSP was implemented to investigate whether the patterns observed in the preceding BPN task also extend to a production task requiring lexical retrieval. Specifically, this task examined whether the effects of cued/alternate and voluntary switching observed in the BPN paradigm were similarly present in FCS. Switch and mixing costs were calculated based on accuracy scores.

In Phase 2, all 61 participants completed the BSF task across four conditions: Arabic (Food) and

French (Animals) monolingual, Alternate Bilingual (Clothes), and Voluntary Bilingual (Fruits). In Phase 3, a subset of 24 participants completed the same task with categories inverted between the monolingual conditions and between the bilingual conditions, to control for potential category effects.

6.5.3.1 Overview of Findings

Comparison with Previous Literature

Table 6.23 presents a comparison of fluency scores from Phase 2 and Phase 3 with published norms from previous studies (Mean ± SD), focusing on the semantic categories Animals, Fruits, and Clothes (as ”Food” was not found in the literature). The language of testing is indicated between parentheses for each category (LA = Arabic, FR = French), knowing that for clothes and fruits, bilingual (alternate and voluntary) conditions were involved.

Condition / Study	Language	Sample (n)	Age	Animals	Fruits	Clothes
Phase 2	French/Lebanese Arabic	61	18-35	21.1 ± 5.6 (FR)	13.1 ± 3.3 (FR & LA)	8.2 ± 2.5 (FR & LA)
Phase 3	French/Lebanese Arabic	24	19-34	20.0 ± 5.8 (LA)	11.2 ± 2.5 (FR & LA)	16.5 ± 3.9 (FR & LA)
Troyer (2000)	English	411	18-91	19.5 ± 5.3	–	–
Khalil (2010)	Saudi Arabic	98	17-29	16.58 ± 3.30	–	–
Khalil (2010)	Saudi Arabic	70	30-39	17.82 ± 2.54	–	–
Abdel Aziz et al. (2017)	Egyptian Arabic	55	20-40	17.84 ± 5.82	–	–
Jebahi et al. (2022)	Lebanese Arabic	25	19-39	17.96 ± 4.68	15.16 ± 2.46	11.68 ± 3.24
El-Hayeck et al. (2023)	Lebanese Arabic	277	55-64	13.0 ± 4.3	11.1 ± 3.2	–

Table 6.23: Comparison of Phase 2 and Phase 3 BSF Scores with Literature Norms for Semantic Categories (Animals, Fruits, Clothes)

Compared to previous literature in similar age groups, Lebanese participants in both phases showed higher fluency scores for the monolingual category *Animals* than other Arabic-speaking populations (Abdel Aziz et al., 2017; Khalil, 2010), and even higher than previously tested Lebanese populations (Jebahi et al., 2022), with values also comparable to English-speaking norms (Troyer, 2000). For the category *Fruits*, average fluency was lower than previously reported in Lebanese Arabic (Jebahi et al., 2022); however, this category was assessed in bilingual conditions (alternate and voluntary) across Arabic and French, limiting direct comparison. Similarly, for *Clothes*, the alternate bilingual condition showed lower average fluency than in prior studies (Jebahi et al., 2022), whereas the voluntary bilingual condition showed higher mean scores, potentially reflecting an advantage for voluntary language switching.

It should be noted that part of the observed differences may be related to cultural and linguistic variability across populations (Ardila, 2020; Villalobos et al., 2023), as well as methodological differences, such as the way errors were counted in the tasks (repetitions, clusters, intrusions, etc.). The *Food* category yielded higher fluency scores than other categories in both Arabic and French. Being a broad and inclusive category, it may have inflated overall performance. This category has not been reported in previous semantic fluency studies, limiting direct comparisons with the literature.

Voluntary Switching Rate

Switching rate was calculated in the voluntary condition to examine how frequently participants alternated languages when given the choice. In Phase 2, the average switching rate was 30% (SD = 16%, Md = 30%), indicating moderate engagement in language switching. In contrast, in Phase 3, participants switched languages more frequently, with an average switching rate of 56.8% (SD = 15.7%, Md = 60.0%). This difference suggests that while participants consistently engaged in language alternation under voluntary conditions, the extent of switching was notably higher in Phase 3 compared to Phase 2. One possible explanation for this increase could be the smaller sample size in Phase 3, which may have accentuated individual variability in switching behavior. Moreover, in their BSF experiment with 40 balanced Spanish–Basque bilinguals, Jevtović et al. (2020) reported an average switching rate of 43.5% (SD = 7.24%) in the voluntary condition. This rate falls between that observed in Phase 2 (30%) and Phase 3 (56.8%), also aligning with the fact that their sample size was intermediate between the two phases, thus yielding broadly comparable findings.

6.5.3.2 Discussion by Hypothesis

To examine whether the patterns of voluntary and cued/alternate language switching observed in the BPN task extend to lexical retrieval in semantic fluency, two hypotheses were tested. Hypothesis B predicted higher switch costs (defined as the difference between fluency scores in the voluntary and the alternate condition) in the alternate condition compared to the voluntary, while Hypothesis C predicted lower mixing costs (defined as the difference between the target bilingual condition and the monolingual average) in the voluntary condition compared to the alternate. Results from both Phase 2 (n=61) and Phase 3 (n=24) were considered together to provide a comprehensive view.

Hypothesis B: Switch Costs

Across both phases, fluency scores were consistently higher in the voluntary condition relative to the alternate condition, indicating larger switch costs when language selection was externally imposed. In Phase 2, the switch cost was significant, with higher mean fluency in the voluntary condition than in the alternate condition. Similarly, Phase 3 also yielded a significant switch cost, again with higher fluency in the voluntary condition relative to the alternate condition. These findings provide robust support for Hypothesis B, suggesting that externally constrained switching imposes greater costs on lexical retrieval than free switching, regardless of the category.

Comparable patterns have been reported in previous literature. For example, Taler et al. (2013) examined English–French bilinguals under monolingual, forced-switch, and free-switch conditions, finding that free switching produced fluency scores comparable to monolingual performance but notably higher than forced switching, a pattern corresponding to the "switch cost" observed in the current study. Likewise, Jevtović et al. (2020) reported that voluntary switching yielded higher fluency than forced switching in a comparable BSF task. Together, these findings support the conclusion that voluntary switching is less demanding than externally constrained switching.

Hypothesis C: Mixing Costs

Mixing costs were evaluated by comparing fluency scores in each bilingual condition to the monolingual baseline (average monolingual fluency score). In Phase 2, mixing costs were significantly lower in the voluntary condition than in the alternate condition, indicating that free switching reduced performance costs compared to externally cued switching. In Phase 3, mixing costs were lower in the voluntary condition, but this difference did not reach statistical significance. The voluntary switching advantage was thus present in both phases, though it was statistically reliable only in Phase 2. The smaller sample size in Phase 3 may account for the reduced significance.

Although mixing costs as such were not directly reported in Jevtović et al. (2020), their results are consistent with the current findings: participants in the voluntary condition performed similarly to the dominant-language (Spanish) monolingual condition, while the forced condition yielded the lowest performance. This pattern mirrors the present observation that voluntary switching reduced language mixing costs relative to externally imposed switching conditions.

In the present study, average mixing costs had negative values in all conditions (i.e., average voluntary fluency was lower than monolingual), indicating that monolingual fluency remained easier than free switching. This suggests the absence of a mixing benefit in voluntary semantic fluency tasks. While voluntary switching may confer advantages for balanced bilinguals in BPN, and even more so for FCS, this advantage does not extend to semantic fluency, as FCS still perform better in monolingual than in free-switching conditions. A possible explanation for the absence of a mixing benefit is the involvement of other executive control processes fluency tasks. In fact, experimental and clinical research often describes fluency tasks as generally demanding in terms of executive resources and they are commonly used in neuropsychological evaluations to assess cognitive flexibility (Aita et al., 2019; Amunts et al., 2021; Giovannoli et al., 2023; Kousaie et al., 2014).

6.5.4 Executive Tasks

Given that executive tasks in the present study were included primarily as control measures rather than as within a specific hypothesis, the following section provides an integrated discussion of their outcomes. After summarizing the results for each task, their implications are discussed jointly to provide a broader perspective on executive control processes in relation to bilingual language control.

Flanker task

The analysis of the Flanker task data revealed that accuracy was highest for the congruent trials, followed by neutral and incongruent trials. RT were fastest for the neutral trials, followed by congruent trials, with the slowest RT observed in the incongruent trials.

These results are consistent with previous studies reporting a *congruency effect* (also called *Flanker effect*), characterized by faster responses on congruent than incongruent trials (Van der Lubbe et al., 2025), observed in both letter- and arrow-based computerized Flanker tasks. Some studies included neutral trials (Davelaar, 2008; Davelaar & Stevens, 2009; Van der Lubbe et al., 2025), while others did not (Bugg & Gonthier, 2020; Erb et al., 2020, 2021; Hübner & Töbel, 2019; Umebayashi & Okita, 2010). When neutral trials were present, they typically yielded RT intermediate between congruent and incongruent trials, as in the current study. This pattern aligns with fMRI evidence (Davelaar, 2008), showing that ACC activation is highest in incongruent trials, followed by neutral, and lowest in congruent ones. Experimental findings suggest that this pattern reflects differences in how efficiently information is accumulated during response selection. In congruent trials, both the target and flankers provide consistent cues toward the same response, allowing evidence to build up quickly. In contrast, in neutral trials, only the target provides information, leading to slower evidence accumulation and a longer period of low-level conflict. This extended processing time results in higher ACC activation in neutral compared to congruent trials, even though observable response conflict remains minimal.

In addition to congruency effects, the Flanker task is sensitive to multiple levels of executive control. List-level (proactive) control biases attention across trials (Bugg & Gonthier, 2020), while activation suppression adapts responses to task demands (Hübner & Töbel, 2019). Sequential effects, like the *Gratton effect*, show reduced interference after incongruent trials (Davelaar & Stevens, 2009). Performance is also influenced by stimulus distance (Lee & Pitt, 2024) and error correction (Kopp et al., 1996). Finally, contextual variables such as time pressure (Van der Lubbe et al., 2025) and age (Erb et al., 2020, 2021) can further modulate the Flanker effect.

Stroop task

The pattern of performance in the Stroop task in the current sample aligns with previous normative findings in Lebanese Arabic participants (Ktaiche et al., 2022). Accuracy was highest in the Reading condition, followed by Color Naming, and lowest in the Interference condition. Similarly, RT were fastest for Reading, then Color Naming, and slowest for Interference trials. These trends mirror those observed in Lebanese Arabic speaking adults in Ktaiche et al. (2022)'s normative study, which included 321 healthy participants aged 18 and above from different Lebanese regions, and showed the highest accuracy in Reading, followed by Color Naming and Interference. This indicates that the task elicited the expected interference effects in the current bilingual sample. Comparable patterns were also observed for the French version of the Stroop, with no significant differences from the Arabic version, highlighting, as noted by MacLeod (1991), the robustness of the Stroop effect across languages and testing modalities.

Additionally, the *congruency* effect refers to the difference in RT and/or accuracy between incongruent and congruent trials in the interference condition (Paap et al., 2020). Although this effect was not directly assessed in Ktaiche et al. (2022), multiple other studies have repeatedly demonstrated its robustness across languages, age groups, and gender (Afsaneh et al., 2012; Houx et al., 1993; MacLeod, 1991; Verhaeghen & De Meersman, 1998). This effect was also observed in the current study, with congruent trials yielding significantly higher accuracy and faster responses than incongruent trials in the interference condition, in both the Arabic and French Stroop tasks.

Wisconsin Card Sorting Test (WCST)

Set shifting (or mental flexibility) as measured by the WCST showed the highest accuracy on congruent trials, followed by overall accuracy, with incongruent trials yielding the lowest accuracy. Accuracy was significantly higher for congruent trials compared to incongruent trials, while there was no significant difference between congruent and overall performance. Incongruent trials were also less accurate than overall performance.

RT followed a similar pattern, with the fastest responses observed for congruent trials, followed by overall performance, and the slowest responses for incongruent trials. However, no significant differences in RT were found between trial types.

Compared to Lebanese normative data for individuals with more than 12 years of education (Rammal et al., 2019), the current sample performed around the 50th percentile in terms of total errors and below the 50th percentile for the number of categories completed correctly, while perseverative errors were moderately frequent. This pattern suggests that overall WCST performance was slightly lower than expected based on normative data. Although the population is similar, these differences are likely due to task design: Rammal et al. (2019) employed a modified paper version of the WCST, whereas the current study used a computerized version that included RT measurements and modified card stimuli.

Digit Span (DS)

In the current sample, participants showed the highest performance on Forward span, followed by Sequencing, and the lowest on Backward span. Forward span scores (M = 6.25) are consistent with norms reported for young adults in Spanish (Tamayo et al., 2012), Brazilian (Zimmermann et al., 2015), and U.S.A. samples (Taub, 1972), as well as the 20–30 age group in Iranian norms (Sisakhti et al., 2024), all indicating typical spans around 6–7 items. Backward span scores (M = 4.54) fall within normal limits according to Lezak et al. (2012), who suggest that scores of 4–5 are average for adults. No comparable normative data were found for the Sequencing span, which remains less frequently reported in the literature. Overall, this pattern reflects the typical hierarchy of digit span tasks, confirming that the task effectively captured working memory differences in this sample.

6.5.5 Cross-Task Analyses: Language and Executive Tasks

Cross-task analyses were conducted to examine whether performance patterns reflect domain-general executive mechanisms or language-specific control processes, testing the domain-generality versus language-specificity hypothesis.

6.5.5.1 Overall Correlational Matrix Across Language and Executive Function Tasks

Cross-task correlations between executive functions and language tasks can reveal the nature of control mechanisms: strong correlations generally indicate domain-general control, reflecting shared resources across linguistic and non-linguistic tasks, whereas weaker or selective correlations suggest language-specific control.

The high within-task correlations in both the Stroop and BPN tasks suggest strong internal consistency, indicating that participants' performance was stable across conditions. The expected inverse relationship between Stroop incongruent accuracy and RT further confirms that faster responses were associated with more efficient interference resolution.

Within the BSF tasks, positive correlations between accuracy and total word production indicate that participants who retrieved more words also tended to respond more accurately.

Cross-task correlations generally highlight potential shared mechanisms across language control and executive functions. Positive correlations between Stroop and BPN RT suggest overlapping processes, including verbal inhibitory control and processing speed, underlying performance in both tasks.

The negative associations between fluency scores and BPN RT potentially indicate that stronger lexical retrieval abilities was linked to faster picture naming.

Moderate negative correlations between working memory DS and Stroop RT and accuracy indicate that participants with better memory capacity responded faster but less accurately on the Stroop task. This suggests that memory resources support faster interference resolution.

To better examine the relationships within each task, conditions within tasks were also correlated with one another. The detailed correlations are discussed to provide a clearer understanding of these patterns.

6.5.5.2 Links Between Language Control and Executive Functions

To better understand how bilingual language control mechanisms manifest across the different executive tasks, Table 6.24 summarizes the significant associations observed between language performance measures (BSF and BPN) and executive control measures (Flanker, Stroop, WCST, and DS span). While effect sizes vary and are often weak, the table highlights how language-specific and domain-general control processes may differentially support performance across monolingual, cued, and voluntary conditions.

Executive Function	Main Associations	Dominant Control Type	Interpretation
Nonverbal Inhibition (Flanker)	BSF: Negligible overall (r = -0.004). BSF: Negligible negative in Arabic monolingual (r = -0.032) and French monolingual (r = -0.079). BSF: Weak positive in Alternate bilingual (r = 0.220). BSF: Negligible in Voluntary bilingual (r = -0.008). BPN Accuracy: Negligible global positive (r = 0.036), slightly stronger in Arabic monolingual (r = 0.109), negligible in French monolingual (r = 0.015). BPN Accuracy: Negligible positive in Cued bilingual (r = 0.062); negligible negative in Voluntary bilingual (r = -0.055). BPN RT: Negligible global positive (r = 0.046), slightly stronger in Arabic monolingual (r = 0.049) then French monolingual (r = 0.047), and comparable across Cued (r = 0.051) and Voluntary (r = 0.054) conditions.	Domain-general nonverbal inhibition (weak effect)	Nonverbal inhibition weakly supports both BSF and BPN, especially in externally cued contexts. Its minimal role in voluntary switching suggests that self-initiated control relies less on inhibitory mechanisms.
Verbal Inhibition (Stroop)	BSF: Weak positive with Arabic Stroop (r = 0.174), negligible with French Stroop (r = 0.027). BSF: Alternate bilingual shows weak positive with Arabic (r = 0.063) and negligible negative with French (r = -0.023) Stroop. BSF: Voluntary bilingual shows weak positive with Arabic (r = 0.200) and negligible with French (r = 0.005). BPN Accuracy: Weak positive overall with Arabic Stroop (r = 0.160), strongest in Arabic monolingual (r = 0.190) and Cued bilingual (r = 0.18). BPN Accuracy: Weak positive with French Stroop overall (r = 0.110), slightly lower in Voluntary bilingual (r = 0.08). BPN RT: Moderate positive across conditions, strongest in Voluntary bilingual with Arabic (r = 0.320) and French (r = 0.300) Stroop, followed by Arabic monolingual (r = 0.290), Cued bilingual (r = 0.280), and overall (r = 0.250–0.280).	Language-specific verbal inhibition (weak-moderate effect)	Verbal inhibition shows consistent positive associations with both BSF and BPN, strongest when the task and inhibition measure share the same language. This indicates a language-specific control process that is self-regulated under voluntary conditions.
Set-Shifting / Mental Flexibility (WCST)	BSF: Negligible overall (r = 0.066). BSF: Weak positive in Arabic monolingual (r = 0.286). BSF: Negligible negative in French monolingual (r = -0.058). BSF: Negligible positive in Alternate bilingual (r = 0.046) and weak in Voluntary bilingual (r = 0.120). BPN Accuracy: Negligible positive across conditions (overall r = 0.069), with slightly stronger correlations in Arabic (r = 0.105) and French (r = 0.104) monolingual contexts. BPN RT: Weak positive across all conditions (overall r = 0.113), strongest in French monolingual (r = 0.140) and Voluntary bilingual (r = 0.134), followed by Cued bilingual (r = 0.108) and Arabic monolingual (r = 0.090).	Domain-general mental flexibility (weak effects)	Mental flexibility supports both BSF and BPN, with stronger associations in self-initiated switching. This pattern reflects a shared, domain-general control mechanism engaged during voluntary language switching.

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Table 6.24 – continued from previous page

Executive Function	Main Associations	Dominant Control Type	Interpretation
Working Memory (DS)	BSF: Weak positive with forward span (r = 0.187), weak with sequencing (r = 0.100), and negligible with backward (r = 0.063). BPN Accuracy: Weak positive with forward span (r = 0.160), negligible with backward (r = 0.025), and negligible negative with sequencing (r = -0.015).	Mixed (language-specific and domain-general; weak effect)	The pattern indicates mixed involvement of working memory components: verbal short-term storage (forward span) supports lexical retrieval in BPN, pointing to language-specific processes, whereas weaker links with manipulation-based spans suggest a modest domain-general contribution.

Table 6.24: Summary of correlations between BSF, BPN, and Executive Control Tasks

Note. Strength categories follow standard cutoffs: weak (r = 0.10–0.29), moderate (r = 0.30–0.49), strong (r $\geq$0.50). Positive correlations indicate that higher scores on one variable were associated with higher scores on the other, whereas negative correlations indicate an inverse relationship. Approximate correlations are indicated with $\approx$.

The results indicate that bilingual language performance, as measured by BSF and BPN, appears to be supported by both domain-general and language-specific executive mechanisms. Following Miyake et al. (2000), the inhibition component can be divided into three sub-components: inhibition, set-shifting, and working memory, with inhibition further specified as verbal or nonverbal. Specifically, nonverbal inhibition modestly facilitated picture naming, particularly in L1 and under externally cued switching, but seems less critical in voluntary switching, where lower reliance on inhibition may even support freer language alternation. These findings potentially indicate domain-general nonverbal inhibition, consistent with the literature supporting domain-general control via Flanker tasks (Nair et al., 2021; Tao et al., 2021; T. Wu et al., 2020; W. Xie & Ng, 2024; Z. Xie & Zhong, 2024). In contrast, verbal inhibition within the same language appears to consistently support fluency and naming, highlighting language-specific control, with voluntary switching showing efficient self-regulation in L1, suggesting language-specific verbal inhibition, in line with prior studies using Stroop tasks (Kałamała et al., 2020; Paap et al., 2019). Set-shifting seems to broadly enhance performance across tasks, with particularly strong contributions during voluntary switching that require self-initiated control, potentially reflecting domain-general mental flexibility, consistent with findings using WCST in bilinguals (Nair et al., 2021; T. Wu et al., 2020; W. Xie & Ng, 2024; Z. Xie & Zhong, 2024). Finally, working memory contributes across tasks, with forward span showing the strongest positive associations, backward span moderate support, and sequencing span weaker or slightly negative effects, especially on picture naming, indicating mixed domain-general and language-specific working memory, in line with multiple studies testing working memory in bilinguals (Degirmenci et al., 2022; Jiao et al., 2022; Mooijman et al., 2022; Semenova et al., 2025; Van den Noort et al., 2019).

Together, these patterns suggest that bilingual language control likely involves both domain-general and language-specific mechanisms, aligning with a substantial body of research showing mixed evidence regarding the extent to which language control overlaps with general executive control and contributes to the so-called bilingual advantage (Degirmenci et al., 2022; Jiao et al., 2022; Kang et al., 2020; Luque & Morgan-Short, 2021; Mooijman et al., 2022; Semenova et al., 2025; Van den Noort et al., 2019; Vïnerte & Sabourin, 2019).

Although several correlations reached statistical significance, they were mostly weak or moderate, indicating limited evidence for strong conclusions. However, given that correlational approaches may not fully capture the complexity of these interactions, and that the MEM did not converge, requiring pairwise analyses, further research using more comprehensive modeling and experimental designs is needed to clarify the relative contributions of domain-general and language-specific mechanisms.

As for constrained and voluntary language switching and their relation to executive functioning, nonverbal inhibition appears to support performance in cued and monolingual conditions, as participants rely on general inhibition to suppress the non-target language, but its contribution is reduced in voluntary switching, where self-initiated choices allow participants to regulate interference efficiently. Verbal inhibition contributes most within the same language, particularly in L1, facilitating accurate fluency and naming; in voluntary switching, participants show efficient self-regulated verbal control, relying less on general inhibition. Set-shifting supports both cued and voluntary switching, with particularly strong effects in voluntary conditions that imply self-initiated switching and rapid adaptation. Working memory supports fluency and naming across both cued and voluntary conditions, reflecting the role of verbal memory in managing lexical retrieval, with no clear difference in reliance between switching types. Overall, voluntary switching shows a reduced reliance on both nonverbal and verbal inhibition, reflecting efficient self-regulated control, while still engaging set-shifting for rapid adaptation and, to a moderate extent, working memory.

6.6 Limitations and Perspectives

French Language Proficiency

Only L2 proficiency was assessed objectively in the present study, given that participants' L1 was considered their dominant language and that no validated measure is currently available for Lebanese Arabic proficiency. While this approach provided a continuous measure of L2 proficiency, it limits the ability to fully characterize bilingual competence. Assessing both L1 and L2 proficiency would provide a more complete and balanced measure, particularly for Lebanese individuals residing in France, whose language use may be influenced by the sociolinguistic context and may not reflect strict L1 dominance. Also assessing L3 (English, which was common to all participants), would complete the proficiency profile of participants.

On the other hand, comparative analysis revealed discrepancies between objective and subjective measures of L2 proficiency. Objective assessments capture standardized performance, whereas self-reports reflect participants' perceived abilities. The lack of convergence indicates that these measures may reflect partially distinct dimensions of proficiency. Future research could investigate the sources of these discrepancies and explore composite measures that integrate both objective and subjective indicators, yielding a more robust estimate of bilingual proficiency.

Bilingual Picture Naming

Several design considerations may have influenced the observed results. First, tasks were not fully counterbalanced across participants, and the same image sets were used in all conditions. Creating four counterbalanced groups was not implemented due to concerns that subgroup sizes (approximately 15 participants each) would be too small to detect effects reliably. The absence of counterbalancing may have contributed to practice effects, particularly in the voluntary condition, which was consistently administered after the cued condition. Such ordering could account partly for the lower switch costs observed in the voluntary task, as performance and switch costs typically improve with repeated exposure. However, a preliminary familiarization phase with all images was included precisely to minimize potential practice effects. During this phase, participants were exposed to the entire image set and asked to name each item in both Lebanese Arabic and French, receiving corrections when necessary. Moreover, the number of images used per condition is consistent with previous studies employing similar LSPs (e.g., Blanco-Elorrieta & Pylkkänen, 2017; Costa & Santesteban, 2004; Declerck, Meade, et al., 2021a), where relatively small sets of repeated stimuli are commonly used. Future research could nonetheless address these limitations by counterbalancing task order across participants and using distinct image sets for each condition, which would reduce practice effects and allow for a more precise assessment of language switch and mixing costs.

The voluntary condition, which allows free language switching, has been described as the closest approximation to real-life switching, particularly for FCS, as it mirrors participants' actual language use. However, in the present study, one language, English L3, common to all participants, was effectively inhibited. This indicates that switching was not fully free, as this language did not enter the speech plan as opportunistic planning would allow. Future studies should consider including L3 in voluntary switching paradigms to capture more ecologically valid patterns of language use among Lebanese bilinguals.

Bilingual Semantic Fluency

Several methodological considerations may have influenced the observed results. First, trials containing modalizers or errors were removed from the analysis. Although this was necessary for data cleaning, such trials likely reflect language activation, which could have influenced the order and number of switches, ultimately affecting the alternate condition and voluntary switching rate. Future analyses could consider retaining or systematically coding these trials to better capture natural patterns of language activation and switching.

Second, error categorization and annotation may differ across studies, which can directly influence fluency scores. In the present study, the scoring criteria were relatively broad; for instance, the offspring of animals were considered distinct items, and animals belonging to the same subcategory were also treated as separate entries (e.g., bird, parrot, pigeon). Although the same method was applied consistently across all conditions, other studies may apply stricter criteria, which can directly influence fluency scores and limit cross-study comparisons. Future research could aim to establish standardized scoring guidelines and refine item classification to minimize ambiguity and enhance comparability across studies.

Third, the food category was chosen for its familiarity but may have been too broad. Selecting narrower categories to obtain more precise measures of lexical access and switching would be more relevant.

Fourth, counterbalancing categories between conditions was implemented, but a more rigorous design, such as a Latin square, could have minimized potential language-specific effects on fluency scores. This approach was not feasible in the present study due to the small sample size in Study 3. Future research with larger samples could implement Latin square designs to control for order and category effects more effectively.

Fifth, switch and mixing costs were calculated using a novel method based on fluency scores, which has not been widely applied in prior research. To assess the robustness and generalizability of this measure, additional studies should apply the same approach in diverse populations and contexts.

Sixth, similar to the suggestion of including English in the voluntary switching condition in the BPN, the same could be applied to this task, to account for entirely free language switching and capture opportunistic planning.

Executive Tasks

Executive tasks were included in this study as control measures, hence their results were not examined in detail. A more in-depth analysis of these data in relation to existing literature could provide valuable insights into the functioning of executive processes in bilinguals. The computerized versions of the Flanker, Stroop (in both Arabic and French), and WCST already offer a solid basis for comparing RTs and performance with different populations. Furthermore, the digit span tasks collected as part of the study yield particularly informative findings regarding working memory capacity in Lebanese adults, as few studies have previously examined these abilities within this linguistic and cultural context.

Cross-Task Analyses: Language and Executive Tasks

Cross-task analyses between executive and language tasks, which aimed to explore the hypothesis of domain-generality versus language-specificity, were conducted using correlational methods. Although most effects reached statistical significance, the observed correlations remained weak, indicating that these relationships require more detailed and comprehensive examination. As this part of the analysis was primarily exploratory, future research should employ more robust statistical modeling approaches to better capture the underlying mechanisms linking executive and language control.

In sum, Study 2 provides valuable and innovative experimental evidence on BPN, BSF, and executive functions in a population of Lebanese FCS. Overall, the findings indicate an advantage for voluntary language switching compared to more constrained situations, reflected in higher accuracy, faster RT, and reduced switching and mixing costs, with a moderate influence of individual variability factors such as L2 proficiency and LOR in France. Moreover, the results reveal complex and partly mixed correlations between language control and executive control. While certain executive components, such as set-shifting and nonverbal inhibition, appear to support domain-general control, others, like working memory and verbal inhibition, show language-specificity. These patterns suggest that the coordination of multiple control mechanisms underlies bilingual performance, with both domain-general and language-specific processes contributing depending on task demands, switching context, and individual differences.

Chapter 7

Exploratory Ecological Study

Phase 3 was an exploratory study that included discourse-based tasks designed to provide more ecologically valid data on bilingual language switching. These tasks involved both video-based and personal event narratives. The structure of the discourse tasks was based on the Adaptive Control Hypothesis (Green and Abutalebi, 2013), which emphasizes the role of interactional contexts in shaping language control processes in bilinguals.

The session comprised the ecological discourse tasks and the second evaluation of semantic fluency (previously reported in Section 6.3.3), and lasted for around 35 minutes for each participant.

7.1 Participants

Participants in Phase 3 were 24 individuals from Phase 2 who consented to pursue the study.

7.1.1 Recruitment Criteria

Participants in the final phase were primarily residents of Toulouse, with the exception of two participants from Montpellier, resulting in a total of 24 participants. Data collection took place between June and September 2024. Sessions were conducted either in the laboratory or in participants' homes, depending on their availability.

7.1.2 Final Sample

In the final phase of the experiment, all 24 participants (11 females) were, as in Phase 2, early bilinguals of Lebanese Arabic and French, with English as their third language. Their ages ranged from 19 to 34 years, with an average of 28.62 years (± 3.2) and a median of 30 years. The vast majority (95.8%) held a Master's or PhD degree. On average, they had been living in France for 5.9 years (± 4.2), with a median LOR of 5.5 years.

These participants completed the ecological discourse tasks, which included video descriptions and elaborate responses to general questions.

7.2 Material

The material consisted of two main components:

(1) Video Stimuli
Participants viewed 4 short video clips, each lasting approximately 90 seconds. All videos were excerpts from the animated cartoon Tom & Jerry (Joseph Barbera, 1940), and depicted scenes set in a kitchen environment to ensure consistency in vocabulary. The kitchen setting was selected to limit variability in lexical content across clips and to elicit a similar range of familiar lexicon across participants, facilitating controlled comparisons of language production.

(2) Discourse Prompts
Each video was paired with a specific question presented by a prerecorded interlocutor, designed to elicit a narrative response. A second series of questions focused on personal life events, such as a memorable birthday, family celebrations, or daily routines.

7.3 Procedure

At the beginning of the task, three interlocutors presented themselves to the participant on a computer screen asynchronously (available in the videos in the folder *Phase 3*, sub-folder *Phase 3 Video Material* in Appendix N). They briefly stated their age, where they lived and most importantly the languages they spoke:

- **Interlocutor 1 (I1)** was a monolingual Arabic native speaker who spoke Syrian, a dialect close to Lebanese Arabic. A Syrian speaker was deliberately chosen, as this population is generally known for exclusively using Arabic, unlike Lebanese speakers who are typically more accustomed to switching between languages. This choice was intended to create an Arabic Single-Language context by intuitively encouraging participants to stick to Arabic during the interaction.
- **Interlocutor 2 (I2)** was a monolingual French native speaker. A French speaker was selected to ensure that participants could engage in a purely French interaction, allowing to assess responses in a French Single-Language context.
- **Interlocutor 3 (I3)** was a bilingual Lebanese Arabic-French native speaker. A Lebanese speaker was chosen because, as a bilingual, they intuitively encourage more language switching, reflecting the common practice of bilingual Lebanese individuals who often alternate between languages in everyday conversation, and offering a dense CS context.

These interlocutors asked several questions to each participant in the following contexts, that corresponded to the ACH:

- **Single-language**:
  - Frame 1: one question was asked only in Arabic by I1
    (Video Arabic Single-Language and Narration Arabic Single-Language; overall setting: Arabic Single-Language)
  - Frame 2: one question was asked only in French by I2
    (Video French Single-Language; Narration French Single-Language; overall setting: French Single-Language)
- **Dual-language**:
  - For the video description task: In the same frame, the two monolingual speakers I1 and I2 alternatively asked the participant to describe what each character in the video in one language.
  - For the narration task: In the same frame, the two monolingual speakers I1 and I2 alternatively asked 4 questions to the participant (2 questions each).
    (Video Dual-Language; Narration Dual-Language Arabic; Narration Dual-Language French; overall setting: Dual-Language)
  - **Dense CS**: Interlocutor I3 asked a question to the participant, inducing code-switching by using it himself within the question.
    (Video Dense CS; Narration Dense CS; overall setting: Dense CS)

The asynchronous modality was chosen for several reasons. First, it ensured that all participants received identical versions of the questions, maintaining consistency across groups. Second, it minimized interaction between the interviewer and the participant by eliminating spontaneous feedback or comments, thereby allowing for a greater amount of uninterrupted discourse from the participant. Third, the fictional nature of the interaction, since the interviewer does not actually hear the response, offered participants more freedom to speak openly about personal events, potentially reducing feelings of self-consciousness.

As stated above, the discourse task was divided into two consecutive parts:

1. Part 1 consisted of questions related to the videos the participant watched. There were 4 different videos, one for each language context as stated above.
   The participant was asked to describe the scene either in Arabic, in French or in both languages (see Appendix K for detailed instructions).
2. Part 2 consisted of 7 questions about personal events related to the participant, they were asked to narrate in details (a memorable birthday, a family celebration, their daily routine...) (see Appendix K for detailed instructions).

Remark. In the context of this study, the term *setting* refers to the broader interactional setting: Single-language, Dual-language, and Dense CS. In contrast, *condition* refers to the specific discourse task context (e.g., Arabic Single-Language video, Arabic Single-Language narration, dense CS video, dense CS narration, etc.).

7.3.1 Order of Administration

To avoid any order effect, participants were divided into 4 groups : groups 1 and 2 started with the single-language conditions, while groups 3 and 4 started with the dense code-switching conditions.

For the single and Dual-language conditions, groups 1 and 4 started with Arabic, and groups 2 and 3 started with French. As for the videos, they were also randomized among the groups (see Appendix K for detailed instructions and order of administration).

7.3.2 Corpus Processing

7.3.2.1 Data Collection and Transcription

Material was built in a way to collect a minimum of a 700 words discourse per condition and per participant, in order to obtain statistically relevant data in each corpus (Ossewaarde et al., 2020).

Verbal responses were intended to be recorded using a Roland R-26 audio recorder, but due to technical issues, a smartphone was used instead. The smartphone was unused for any other purpose, with no SIM card, apps, or data other than the recordings. The phone was not connected to the internet and only contained the recordings, which were transferred directly to the computer after each session and then deleted from the phone to ensure data security.

Transcriptions were done using CLAN tool, following Semtalk transcription norms for Arabic and orthographic transcription for French (MacWhinney, 2017). To ensure accuracy, a double transcription procedure was employed. Both an intern and the doctoral researcher transcribed the recordings independently. Afterward, the transcriptions were compared, and any discrepancies were resolved through discussion. The majority of the transcriptions were identical, ensuring consistency and reliability in the data.

One clause was reported per line. Hesitations were coded as ”&-euh” (without reporting their duration), and repetitions were coded as the repeated word(s) preceded by ”&-” (see example in 7.1).

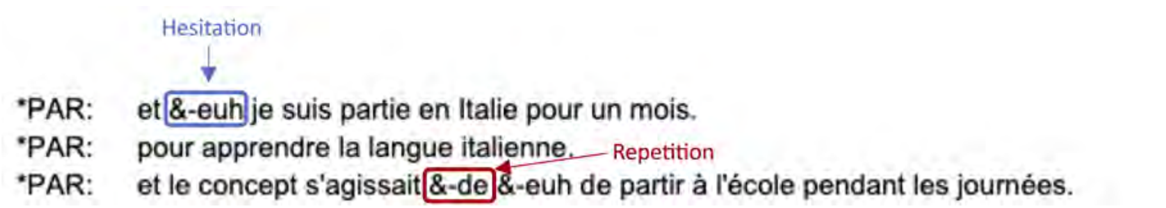

Figure 7.1: Example of CLAN Transcription for Repetition and Hesitation

Every code-switch was marked at the word level using the format word@s:language (”ara”, ”fra”, ”eng”), and lines containing a code-switch were annotated with ”[+cs]” at the end of the line (see example in 7.2).

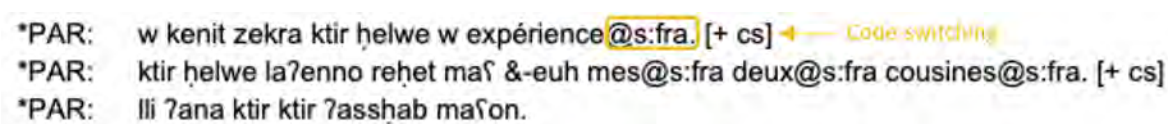

Figure 7.2: Example of CLAN Transcription for Code-Switching

The complete set of corpora is available in Appendix N, in the folder *Phase 3/CLAN_Transcriptions*.

7.3.2.2 Code-Switching and Loanword Classification

As code-switching was a central component of both transcription and analysis, the annotation of code-switching and loanwords was conducted manually following transcription. In the conditions where Lebanese Arabic was the target language to be used (Arabic Single-Language and Dual-Language Arabic), loanwords were defined as lexical items considered part of the host language (integrated into Lebanese Arabic), while other insertions from another language (French or English) were coded as code-switching.

Several lexical items were ambiguous and difficult to classify as either code-switching or loanwords, given that many words commonly used in Lebanese Arabic are derived from French or English. To address this, a questionnaire was distributed to a group of native Lebanese Arabic–French bilinguals (N = 286) to gather intuitive judgments regarding the linguistic status of these items. The questionnaire was administered online in Lebanese Arabic via the internal LimeSurvey platform of Toulouse Jean Jaurès University, in January 2025 (see Appendix M).

Participants were presented with a list of 40 target words and asked to indicate whether a monolingual Lebanese Arabic speaker (i.e., someone who only speaks Arabic) would use each word, on a scale from 0% to 100%, with increments of 20%. A threshold of 60% was applied: any word reported to be used at a rate of 60% or more was classified as a loanword, while those used less frequently were considered instances of code-switching. In cases where fewer than half of participants categorized a word as a loanword (i.e., used it 60% or more of the time), it was classified as a code-switch; otherwise, it was treated as a loanword. When participants indicated usage below the 60% threshold (i.e., when the word was considered a switch), they were also asked to provide an alternative lexical item they consider would be used by a monolingual Arabic speaker instead.

The questionnaire was filled by 286 participants. The results of the questionnaire were used to guide the final classification decisions. Out of the 40 target lexical items, 35 (87.5%) were classified as loanwords, while 5 (12.5%) were considered code-switches. Most loanwords were words that do not have equivalents in Arabic and were therefore borrowed from French or English (*cake*, *hôtel*, *computer*, *shopping*). Participants also reported difficulty finding Arabic counterparts for these words. Some loanwords were brand names, such as *Nescafé* and *Jell-O* (see Appendix M for final results, and Appendix N, folder *Phase 3/Loanwords_CS_Survey_Results.xlsx* for detailed Excel results and analysis).

This step ensured that the annotation was informed by community linguistic intuitions and increased the ecological validity of the code-switching measures. Subsequent annotations were made according to the measures outlined below.

7.3.3 Measures of Interest

The following qualitative and quantitative measures were extracted from the discourse data. Each measure was calculated in each condition.

- **Qualitative measures**:
  - **Type of code-switching**: Each instance of code-switching was categorized as either insertion or alternation, following the typology proposed by Muysken (1997). Alternation refers to a full switch from one language to another at the clause level, whereas insertion involves embedding a lexeme or morpheme from one language into a sentence that is

in another language. Instances of congruent lexicalization were not included in the present analysis, as this type of switching involves complex patterns of shared grammatical structures that are often difficult to identify and annotate with consistency.

  - **Grammatical category of code-switching**: The grammatical nature of each switch was identified, with categories including Noun/Nominal phrase, Verb/Verbal phrase, Preposition/Prepositional phrase, Adverb/Adverbial phrase, Interjection, Determiner, Conjunction, Adjective, Numeral, and Pronoun.

- **Quantitative measures**:

  - **Code-Switching Score (CSS)**: This measure reflects the frequency of language switching. It was calculated by dividing the number of code-switches produced by each participant in each sub-task by their total speaking time in seconds, and multiplying the result by 60. This measure estimates the average number of switches per minute (Yim and Bialystok, 2012; p 878).

$$\text{CSS} = \left(\frac{\text{Number of code-switches}}{\text{Total speaking time (in seconds)}}\right) \times 60$$

  - **Hesitation Score (HS)**: The number of both filled pauses and repetitions were quantified to assess speech disfluency. It was calculated as the rate of pauses over the total number of words.

$$\text{HS} = \left(\frac{\text{Number of hesitations}}{\text{Total number of words}}\right)$$

  - **Speech rate (SR)**: Speech Rate (SR) was used as an indicator of speech fluency. It was calculated by dividing the total number of words produced by the total duration of speech (initially in seconds), and multiplying the result by 60. This measure reflects the average number of words spoken per minute.

$$\text{SR} = \left(\frac{\text{Total number of words}}{\text{Total speaking time (in seconds)}}\right) \times 60$$

7.4 Data Analysis and Results

This exploratory phase of the study aimed to assess language control mechanisms in a more ecological environment for FCS. The experimental design was grounded in communicative contexts derived from the ACH framework (Green and Abutalebi, 2013).

7.4.1 Final Dataset

The final dataset consisted of transcribed and annotated speech samples from the 24 participants who completed 11 discourse tasks each: 4 video descriptions and 7 personal event narrations. This resulted in a total of 264 discourse samples (24 participants × 11 samples). Across all discourse samples, participants produced a total of 42,381 words, with an average of 161.14 (SD = 113.31) words per sample. The total speech duration was approximately 6.24 hours (374.12 minutes or 22,447 seconds), with an average duration of 85.35 seconds (1.42 minutes) ($SD = 49.32$ seconds) per sample. The Excel file reporting all data statistics is available in Appendix N, in the folder *Phase 3/CLAN_Transcriptions_Analysis.xlsx*. All transcriptions are available in the same appendix, in the folder *CLAN Transcriptions*.

7.4.2 Computed Variables

To provide a comprehensive index of language control in the discourse task, a **Language Control Index (LCI)** was computed by integrating the three quantitative measures: SR, HS, and CSS. Generally, higher SR reflects more efficient language production (Baker-Smemoe et al., 2014; Kormos & Dénes, 2004; Olkkonen et al., 2024), although it remains subject to individual variability (Dewaele, 2001; Dewaele & Furnham, 1999). On the contrary, whereas HS and CSS indicate increased processing difficulty, the contributions of HS and CSS were assigned negative weights in the LCI formula. Moreover, each measure was standardized using z-scores, calculated as:

$$z = \frac{x - \mu}{\sigma}$$

where x is the raw score, μ is the sample mean, and σ is the sample standard deviation.

The LCI was then computed as a weighted and averaged linear combination of the standardized scores:

$$\text{LCI} = \frac{1}{n} \left(\alpha \cdot Z_{\text{CSS}} + \beta \cdot Z_{\text{HS}} + \gamma \cdot Z_{\text{SR}}\right)$$

where n is the number of contributing components (3 for Single-Language and Dual-Language settings; 2 for Dense CS, as CSS was not included in this setting since code-switching was primed, thus expected, and did not reflect a lack of control), and $Z_{\text{CSS}}, Z_{\text{HS}}, Z_{\text{SR}}$ are the z-scored values of CSS, HS, and SR, respectively.

The weights α, β, and γ varied by interactional setting:

$$\begin{cases} \alpha = -1, \quad \beta = -1, \quad \gamma = 1, \quad n = 3 & \text{for Single-language and Dual-Language} \\ \alpha = 0, \quad \beta = -1, \quad \gamma = 1, \quad n = 2 & \text{for Dense CS} \end{cases}$$

The weight α was set to -1 in Single-Language and Dual-Language settings to reflect the role of code-switching as a marker of increased language control demands in these contexts, and to 0 in the dense CS setting, where frequent switching is expected and not considered indicative of reduced control. The weight β was consistently set to -1, as HS is treated as an indicator of increased processing effort across all settings.
The weight γ was consistently set to 1 because SR is positively related to language control: higher SR is interpreted as reflecting more efficient and controlled language production.

This composite score provides a continuous, integrative measure of language control demands by combining speed, fluency, and switching behavior in discourse.

Subsequently, switch and mixing costs were computed using differences in LCI values across relevant settings, to quantify language control capacities related to switching and mixing languages, following an approach analogous to that used in bilingual LSPs. Since the task was based on the ACH (Green and Abutalebi, 2013) and did not involve explicitly defined stay or switch trials, comparisons were made based on setting types. The *Dense CS* setting was interpreted as reflecting switching behavior in a voluntary bilingual condition, while the *Dual-Language* setting was treated as an approximation of bilingual stay trials. For mixing costs, the *Dual-Language setting* was compared to the Arabic and French *Single-Language* settings, which were considered equivalent to monolingual blocked trials.

Because the LCI served as a measure of control efficiency, with higher values indicating better language control, difference scores were inverted to align with the conventional interpretation of switch and mixing costs, where higher values denote greater cost (i.e., reduced performance). This inversion ensured consistency in the directionality of cost metrics.

Switch cost was assessed by comparing LCI values between the Dense CS and Dual-Language conditions:

$$\text{Switch Cost (SC)} = \text{LCI}_{\text{Dual-Language}} - \text{LCI}_{\text{Dense CS}}$$

Switch costs and benefits are defined relative to the voluntary switching condition (here assimilated to the Dense CS setting). A positive SC value indicates better control in the Dual-Language relative to the Dense CS setting, consistent with a switch cost when going from voluntary switching to a constrained cued switching. Conversely, a negative SC value indicates better control in the Dense CS relative to the Dual-Language setting, reflecting a switching benefit in the voluntary switching condition.

Mixing cost was examined by comparing LCI values in the Dual-Language setting to those in Single-Language settings (Arabic and French). The average LCI from the two Single-Language settings was subtracted from the LCI in the Dual-Language setting to compute the mixing cost:

$$\text{Mixing Cost (MC)} = \left(\frac{\text{LCI}_{\text{Arabic Single-Language}} + \text{LCI}_{\text{French Single-Language}}}{2} \right) - \text{LCI}_{\text{Dual-Language}}$$

Mixing costs and benefits are defined relative to the cued switching condition (here assimilated to the Dual-Language setting). A positive MC value indicates better control in the Single-Language (monolingual condition) compared to the Dual-Language (cued) setting, consistent with a mixing cost. Conversely, a negative MC value indicates better control in the Dual-Language (cued) relative to the Single-Language (monolingual condition) setting, reflecting a mixing benefit.

7.4.3 Research Hypotheses

The following predictions were developed in continuity with the laboratory-based hypotheses, aiming to extend experimental findings on language control to a more ecological environment, based on an exploratory sample:

- **Hypothesis A:** A switch cost is expected when alternating between languages. This is predicted to manifest as increased control demands in the constrained switching (Dual-Language) relative to the free switching setting (Dense CS), practically reflected as lower LCI in the dual compared to the dense CS setting.
- **Hypothesis B:** Mixing costs are expected when comparing the Dual-Language setting to monolingual ones (Arabic and French Single-Language). This is predicted to manifest as increased control demands in the Dual-Language setting compared to the Single-Language settings (Arabic and French), practically reflected as lower LCI in the dual compared to the single-language setting.

7.4.4 Statistical Analysis

Statistical analyses were conducted in `R` (version 4.4.1). Descriptive statistics (means, medians and standard deviations) were computed for all key measures across settings and conditions to provide an overview of task performance. Assumptions of normality were checked using the Shapiro–Wilk test. Depending on the distribution and nature of the data, either parametric tests (e.g., paired and independent-samples t-tests, one-way and two-way ANOVAs) or non-parametric alternatives (e.g., Wilcoxon signed-rank tests, Kruskal–Wallis tests) were used. When the Kruskal–Wallis test revealed significant effects, follow-up pairwise comparisons were conducted using Dunn's post hoc tests with Bonferroni correction. For categorical data, chi-square tests of independence were used to assess associations between qualitative variables.

To assess the effects of individual differences on language control performance, MEMs were fitted using the `lme4` package. Two separate models were computed for switch costs and mixing costs, respectively. Each model included four fixed-effect predictors: L2 French proficiency, CSP, LE, and LOR in France. Random intercepts for participants were included to account for individual variability. The full R script is available in Appendix N in the folder *Phase 3*, within the file *PhD Analysis Phase 3 Ecological.R.*

7.4.5 Descriptive and Inferential Results

7.4.5.1 Qualitative Analysis

The qualitative analysis involved types and grammatical categories of code-switching.

Type of Code-Switching

The distribution of CS types (*alternation* and *insertion*) was examined across the different settings.

Setting	CS Type	Mean	Median	SD
Arabic Single-Language	Alternation	7.38	0	42.5
	Insertion	4.33	3	4.98
French Single-Language	Alternation	0.77	0	3.57
	Insertion	0.77	0	2.11
Dual-Language	Alternation	0.98	0	2.60
	Insertion	2.74	1	4.44
Dense CS	Alternation	1.20	0	2.88
	Insertion	6.43	5.5	5.78

Table 7.1: Descriptive Statistics of Code-Switching types by Setting

As shown in Table 7.1, alternation occurred most frequently in the Arabic Single-Language setting (M = 7.38, SD = 42.5), though with a median of zero, indicating many participants produced no alternations. Insertion counts were also higher in Arabic Single-Language (M = 4.33, SD = 4.98) compared to French Single-Language (M = 0.77, SD = 2.11) and Dual-Language (M = 2.74, SD = 4.44) settings. The Dense CS setting showed relatively low alternation counts (M = 1.20, SD = 2.88) but the highest average insertion counts (M = 6.43, SD = 5.78), with a median insertion count of 5.5, reflecting more consistent insertion use across participants in the dense CS setting (see relative percentage of CS types use in Figure 7.3).

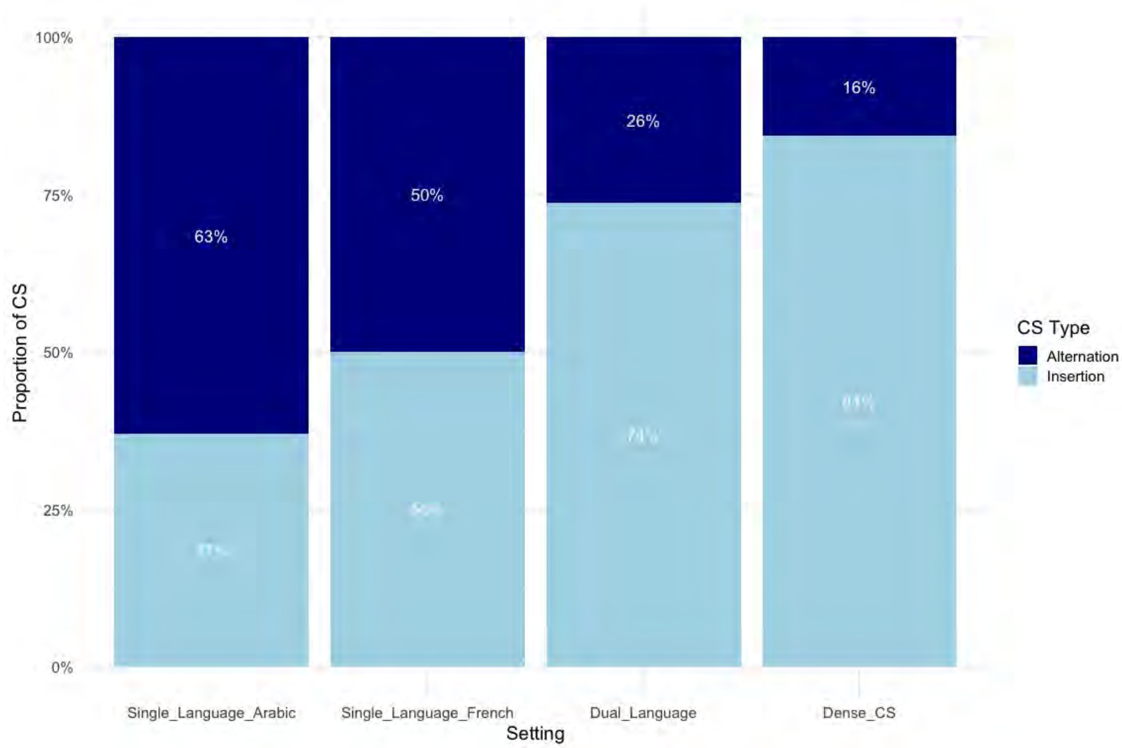

Figure 7.3: Distribution of Code-Switching types by Setting

A chi-square test of independence was performed to examine the association between Setting and CS Type. The results showed a significant association, ($X^2(3) = 249.81$, $p < 0.001^{**}$). Post-hoc analysis of standardized residuals indicated that the setting was significantly associated with the CS type. Specifically, the Arabic Single-Language setting exhibited a significantly higher occurrence of total alternations (residual = 14.77) and fewer insertions (residual = –14.77) than expected. In contrast, the Dual-Language setting showed fewer alternations (residual = –6.80) and more insertions (residual = 6.80), while the Dense CS setting also had fewer alternations (residual = –10.42) and more insertions (residual = 10.42). The French Single-Language setting did not show standardized residuals exceeding |2|, suggesting no significant deviations from expected values and a more balanced use of CS types.

Grammatical Category of Code-Switching

The overall distribution of grammatical categories of CS was examined across all settings and languages. As illustrated in Figure 7.4, nouns and nominal phrases were the most frequently used, followed by verbs, prepositions, interjections, and other categories in decreasing order of frequency.

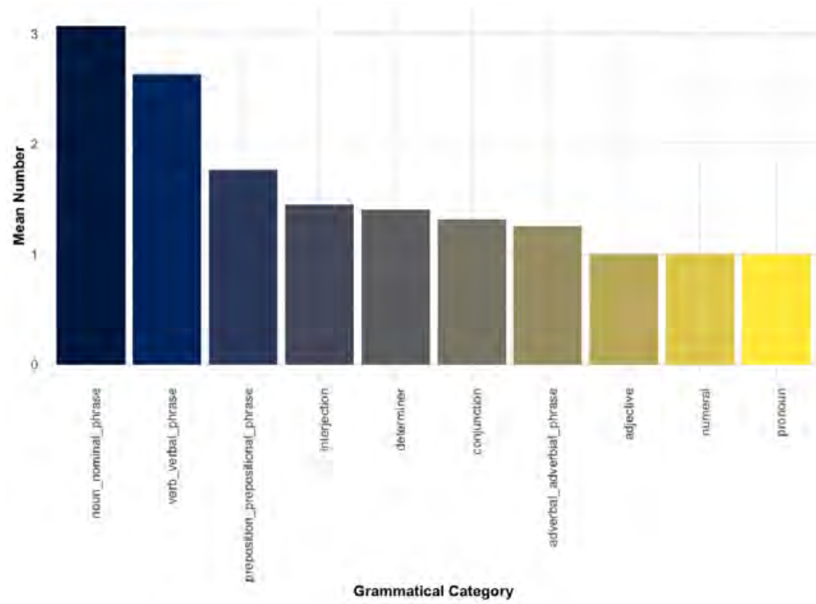

Figure 7.4: General Grammatical Categories Distribution of Code-Switching

A more detailed analysis of CS grammatical category patterns across settings and languages, revealed consistent trends across settings, with nouns remaining the most frequently code-switched grammatical category overall, as shown in Figure 7.5.

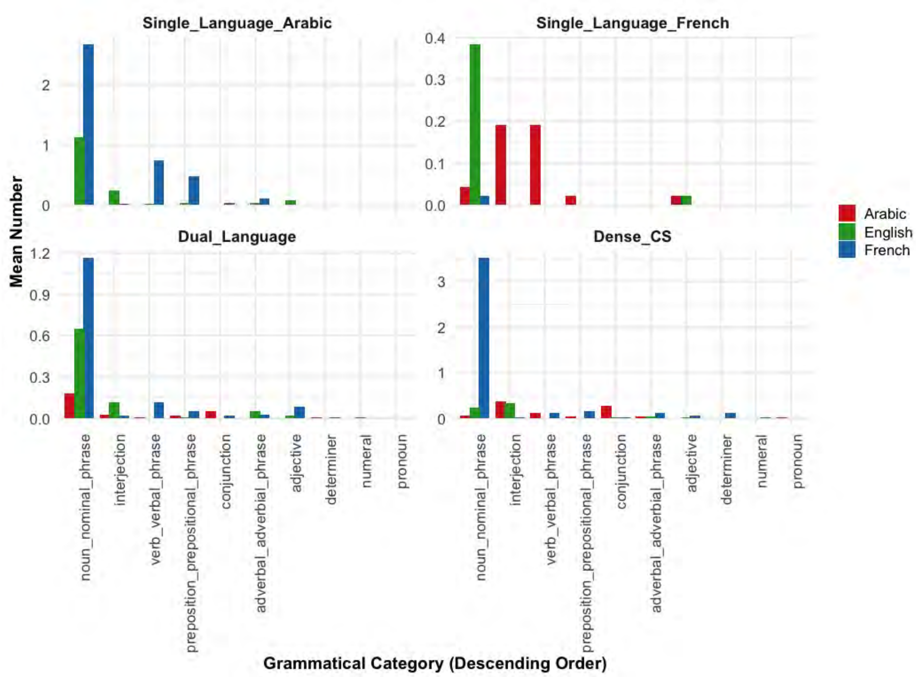

Figure 7.5: Grammatical Category Distribution of Code-Switching across Settings and Languages

Arabic Single-Language setting

In the Arabic Single-Language setting, most CS into French were noun/nominal phrases (e.g., *crème*, *activité*, *détail*), followed by verbs and verbal phrases (e.g., *regarder*, *travailler*, *je veux dire*). Next were prepositional phrases (*dans*, *en gros*), adverbial phrases (*voilà*, *enfin*, *plutôt*), and conjunctions (*donc*). For switches into English, the majority were also noun/nominal phrases (*coffee*, *drink*, *break*), followed by interjections (*so*, *ok*), with fewer occurrences of adjectives (*cool*, *ready*), adverbs (*recently*, *almost*), and prepositions (*on*).

French Single-Language setting

In the French Single-Language setting, switches into Arabic were most often interjections (*fa* (so), *ya'ne* (meaning), *'anjad* (really), *hek* (like this)) and verb/verbal phrases (*bedde* (I want), *nsit* (I forgot), *ken* (was)), followed by noun/nominal phrases (*ḥemmem* (toilet), *sha're* (my hair)), then prepositional phrases (*bas* (only), *mesh* (not), *ma fina* (we can't), *ma ba'rif* (I don't know)) and adjectives (*ktir* (a lot)). Additionally, some French words featured Arabic suffixes, which may explain the few occurrences of French nouns represented in the graph (*el-anglais* (the English), *émotionet* (emotions), *el-souvenirat* (the souvenirs)). Switches into English were primarily noun/nominal phrases (*lunch*, *stickers*), with a minority of adjectives (*addicted*).

Dual-Language setting

In the Dual-Language setting, switches into all three languages were predominantly noun/nominal phrases. For French, most switches were noun/nominal phrases (*château* (castle), *collègue* (colleague), *musique* (music)), followed by verb/verbal phrases (*j'ai passé l'examen* (I took the exam), *je sais pas comment on dit* (I don't know how to say it)), then adjectives (*intéressante* (interesting), *simple* (simple)), with a minority of prepositions (*après* (after), *en même temps* (at the same time)), adverbs (*apparemment* (apparently), *voilà* (there you go)), and interjections (*non* (no)). Switches into Arabic were mainly noun/nominal phrases (*subya* (chimney), *lirit dahab* (gold coin)), followed by a small number of conjunctions (*w* (and), *'aw* (or)), interjections (*la'* (no), *ya'ne* (meaning)), and prepositions (*bi* (in)). For English, switches were principally noun/nominal phrases (*seafood*, *date*, *interview*), with a minority of interjections (*so*, *ok*) and adverbs (*actually*).

Dense code-switching setting

In the Dense CS setting, switches into French were largely noun/nominal phrases (*la bouteille de lait* (the milk bottle), *dessert* (dessert), *vacances* (vacation)), with a minority of verbs (*il galérait* (he was struggling)), prepositions (*à ce moment-là* (at that moment)), adverbs (*facilement* (easily)), and determiners (*un, une* (a, an)). Switches into Arabic were relatively minimal, consisting mainly of interjections (*ya'ne* (meaning), *heke* (like this)) and conjunctions (*w* (and)), with very few verbs (*yerja'* (he returns)) and nouns (*djej* (chicken)). Switches into English were primarily interjections (*so*), with a few occurrences of nouns (*process*, *movies*).

Furthermore, a one-way ANOVA was conducted to determine whether the use of grammatical categories in CS differed overall, irrespective of language or setting. The analysis revealed a significant main effect of grammatical category ($F(9, 364) = 3.707$, $p = 0.000182$**), indicating that some categories were used more frequently than others. However, post-hoc pairwise comparisons using Tukey's HSD did not reveal any significant differences between specific categories at the significance level of $p < 0.005$.

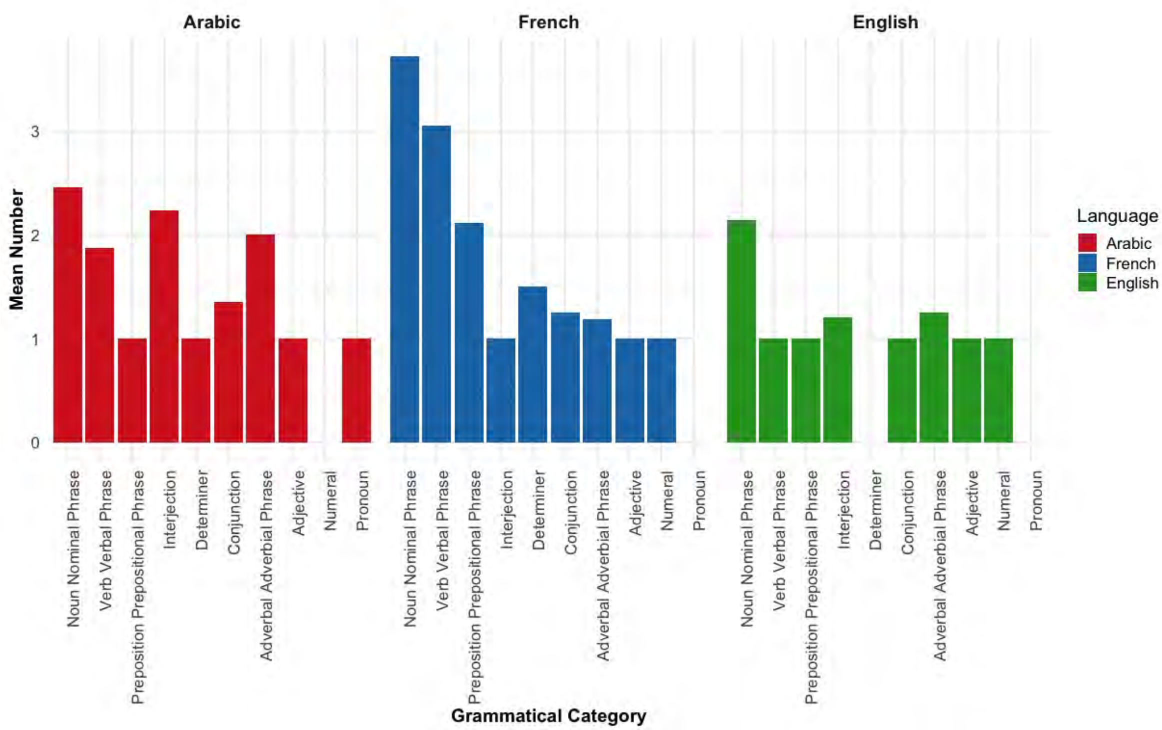

Figure 7.6: Grammatical Category Distribution of Code-Switching across Languages

Additionally, a two-way ANOVA examined whether the use of grammatical categories varied across languages (Figure 7.6). The analysis revealed significant main effects of grammatical category ($F(9, 348) = 3.744$, $p = 0.000164$**), and language ($F(2, 348) = 7.111$, $p = 0.000940$**), but no significant interaction effect ($F(14, 348) = 0.388$, $p = 0.978$). This indicates that while some grammatical categories and languages differed in overall usage, the pattern of category usage did not significantly vary by language. Post-hoc Tukey tests showed that French differed significantly from English in overall usage ($p = 0.0015$*), with French exhibiting higher mean values. No other pairwise comparisons between languages were significant, and none of the pairwise comparisons between grammatical categories reached significance at the $p < 0.005$ threshold. These results suggest that although language and grammatical category independently influence usage, their combined effect was not statistically significant.

A two-way ANOVA tested whether the use of grammatical categories varied across settings (Figure 7.7). There was a significant main effect of grammatical category (F(9, 343) = 3.78, p = 0.000149*), but the main effect of Setting was not significant (F(3, 343) = 2.99, p = 0.031). The interaction was also not significant (p = 0.41). Post-hoc Tukey pairwise comparisons revealed no significant differences between levels of grammatical category or setting. This suggests that while grammatical categories differ overall, no individual pairwise contrasts reached significance.

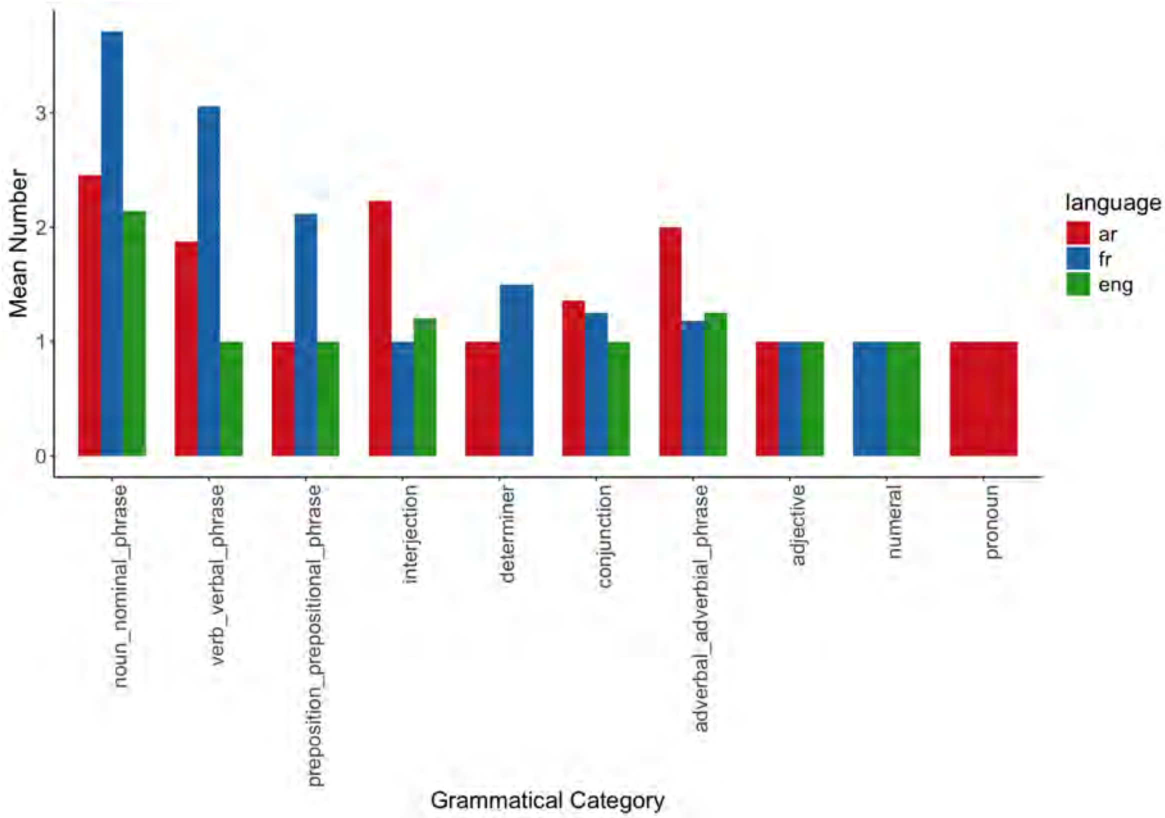

Figure 7.7: Interaction of Code-Switching Grammatical Category with Language

7.4.5.2 Quantitative Analysis

The quantitative analysis includes both descriptive and inferential statistics examining code-switching scores, hesitation scores, and speech rate across different experimental settings.

Code-Switching Score (CSS)

To examine variation in the frequency of code-switching across communicative settings, a CSS was calculated for each participant by dividing the total number of code-switches by the interview duration in seconds and multiplying by 60, yielding a normalized rate of switches per minute. Descriptive statistics for CSS across settings are presented in Table 7.2.

Setting	Mean CSS	Median CSS	SD CSS
Arabic Single-language	6.10	2.60	14.8
French Single-language	0.55	0	1.50
Dual-Language	2.89	1.08	4.24
Dense CS	6.21	5.71	4.76

Table 7.2: Descriptive Statistics of Code-Switching Score by Setting

As shown in Figure 7.8, participants exhibited the highest switching frequency in the Dense CS setting (M = 6.21, SD = 4.76), followed by the Arabic Single-Language (M = 6.10, SD = 14.8). Lower CSS values were observed in the Dual-Language (M = 2.89, SD = 4.24) and French Single-Language

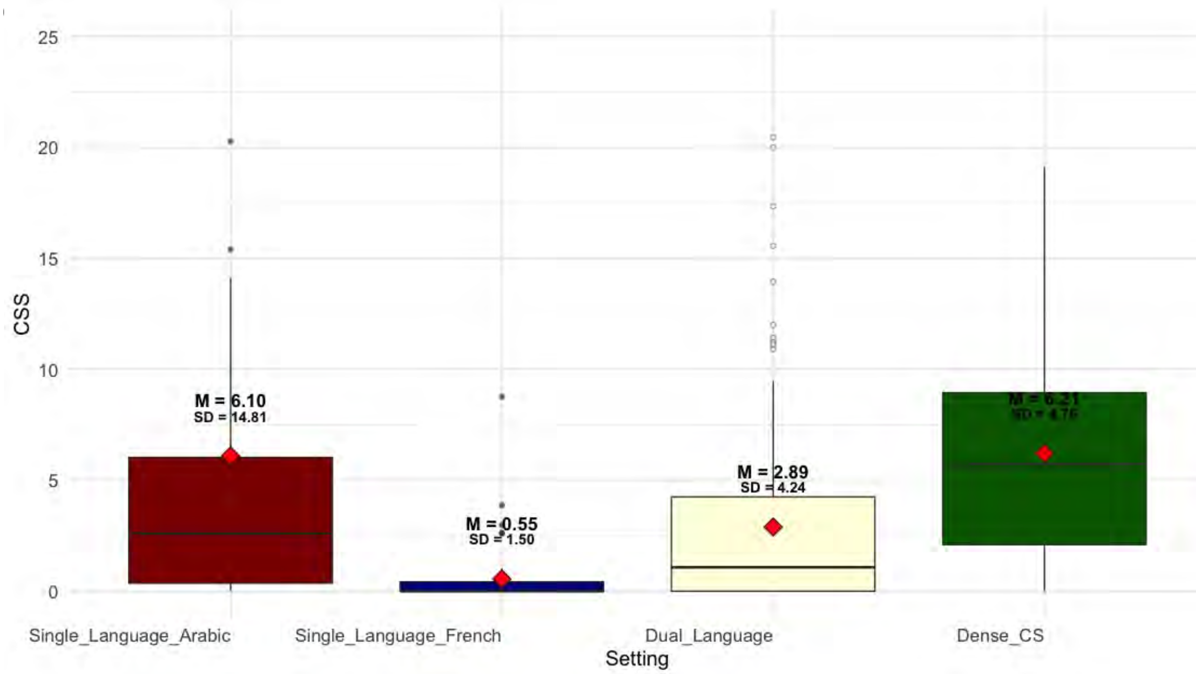

Figure 7.8: Code-Switching Score Distribution by Setting

Due to non-normal distributions (Shapiro-Wilk tests, all ps < 0.005*), a non-parametric Kruskal-Wallis test was conducted, revealing a significant difference in CSS across conditions ($X^2(3) = 60.39$, $p < 0.001$**).

Follow-up Dunn's post hoc tests (Bonferroni corrected) revealed that CSS was significantly higher in:

- Dense CS compared to Dual-Language ($p < 0.001$**),
- Dense CS compared to French Single-Language ($p < 0.001$**),
- Dual-Language compared to French Single-Language ($p < 0.001$**),
- Arabic Single-Language compared to French Single-Language ($p < 0.001$**).

No significant difference emerged between Arabic Single-Language and Dense CS (p = 0.011), or between Arabic Single-Language and Dual-Language (p = 0.025).

To determine whether the influence of condition on CSS varied as a function of task modality, a more fine-grained analysis was subsequently conducted separately within the narration and video modalities.

Condition	**Mean CSS**	**Median CSS**	**SD**
Video Arabic Single-Language	1.96	1.04	2.24
Video French Single-Language	0.78	0.00	1.94
Video Dual-Language	1.92	1.20	2.23
Video Dense CS	6.35	6.19	5.06
Narration Arabic Single-Language	10.20	5.48	20.20
Narration French Single-Language	0.32	0.00	0.81
Narration Dual-Language Arabic	5.49	4.32	5.40
Narration Dual-Language French	0.77	0.00	1.41
Narration Dense CS	6.06	5.49	4.51

Table 7.3: Descriptive Statistics for Code-Switching Score by Condition

As shown in Figure 7.9, the highest mean CSS was observed in the Narration Arabic Single-Language condition (M = 10.20), followed by the Narration Dense CS condition (M = 6.06) and the Video Dense CS condition (M = 6.35). The Narration Dual-Language Arabic condition also showed a relatively high mean CSS (M = 5.49), while all remaining conditions yielded considerably lower CSS scores. These included the Video Dual-Language (M = 1.92), Video Arabic Single-Language (M = 1.96), and Narration Dual-Language French (M = 0.767). The lowest CSS scores were found in the Video French Single-Language (M = 0.776) and Narration French Single-Language (M = 0.316) conditions, indicating the least amount of CS and potentially stronger language control in these contexts.

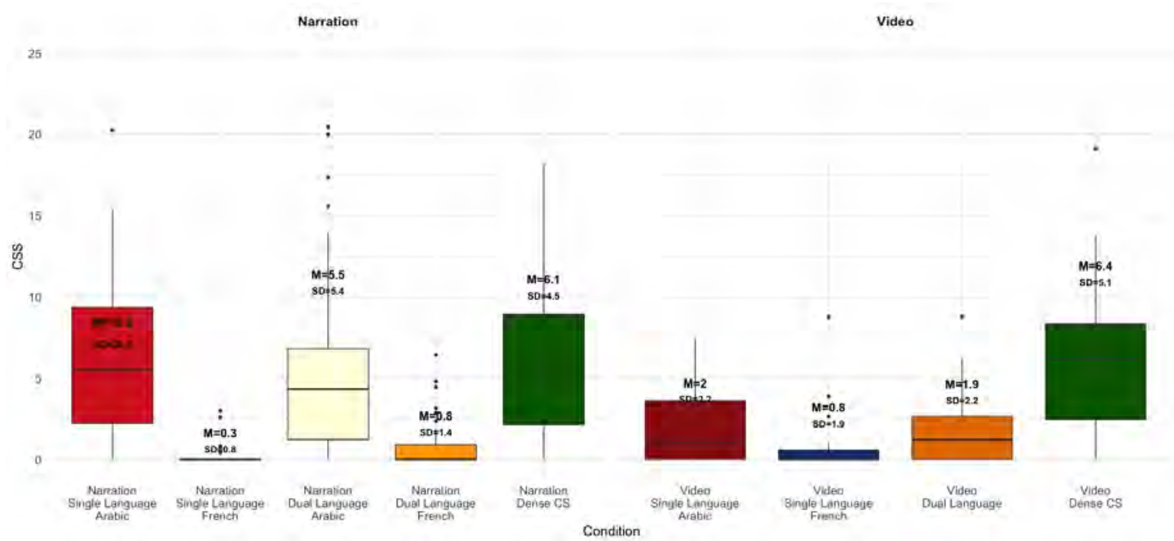

Figure 7.9: Code-Switching Score Distribution by Condition

A Shapiro-Wilk test revealed that CSS scores were not normally distributed across most conditions ($ps < 0.005$ in most cases), justifying the use of non-parametric tests. A Kruskal-Wallis rank sum test indicated a significant main effect of Condition on CSS scores ($X^2(8) = 104.47$, $p < 0.001$**).

As detailed in Figure 7.10, follow-up Dunn's post hoc tests (Bonferroni corrected) showed that CSS was significantly higher in:

- Narration Dual-Language Arabic than Narration Dual-Language French, $p < 0.001$**
- Narration Dense CS than Narration Dual-Language French, $p < 0.001$**

- Narration Dual-Language Arabic than Narration French Single-Language, $p < 0.001$**
- Narration Dense CS than Narration French Single-Language, $p < 0.001$**
- Narration Arabic Single-Language than Narration French Single-Language, $p < 0.001$**
- Narration Dual-Language French than Narration Arabic Single-Language, $p < 0.001$**
- Narration Dual-Language French than Video Dense CS, $p < 0.001$**
- Narration French Single-Language than Video Dense CS, $p < 0.001$**
- Narration Dense CS than Video French Single-Language, $p < 0.001$**
- Narration Dual-Language Arabic than Video French Single-Language, $p < 0.001$**
- Narration Arabic Single-Language than Video French Single-Language, $p < 0.001$**
- Video Dense CS than Video French Single-Language, $p < 0.001$**
- Narration Dense CS than Video Arabic Single-Language, $p < 0.001$**
- Narration Dense CS than Video Dual-Language, $p < 0.001$**
- Narration Arabic Single-Language than Video Arabic Single-Language, $p = 0.00108$*
- Video Dense CS than Video Arabic Single-Language, $p = 0.00124$*
- Narration Dual-Language Arabic than Video Dual-Language, $p = 0.00349$*
- Video Dense CS than Video Dual-Language, $p = 0.00204$*
- Narration Arabic Single-Language than Video Dual-Language, $p = 0.00177$*
- Narration French Single-Language than Video Dual-Language, $p = 0.00408$*
- Narration Dual-Language Arabic than Video Arabic Single-Language, $p = 0.00203$*

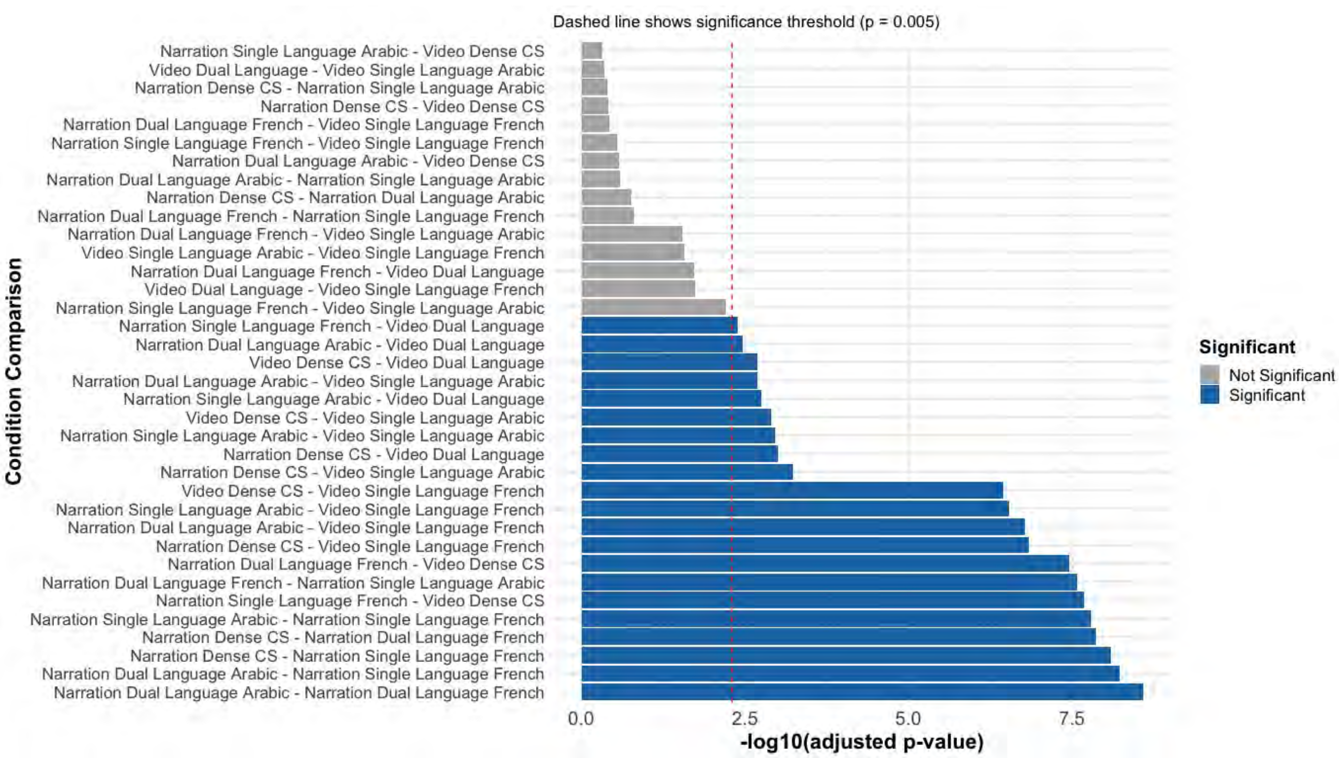

Figure 7.10: Code Switching Score Pairwise Comparisons of Ecological Conditions

On the other hand, several comparisons did not reach statistical significance, indicating no reliable difference in CSS between those conditions. Specifically, CSS did not differ significantly between

Narration Dense CS and Narration Dual-Language Arabic ($p = 0.177$), Narration Dense CS and Narration Arabic Single-Language ($p = 0.405$), Narration Dual-Language Arabic and Narration Arabic Single-Language ($p = 0.252$), Narration Dual-Language French and Narration French Single-Language ($p = 0.158$), Narration Dense CS and Video Dense CS ($p = 0.388$), Narration Dual-Language Arabic and Video Dense CS ($p = 0.268$), Narration Arabic Single-Language and Video Dense CS ($p = 0.483$), Narration Dual-Language French and Video Dual-Language ($p = 0.019$), Video Dual-Language and Video Arabic Single-Language ($p = 0.439$), Narration Dual-Language French and Video Arabic Single-Language ($p = 0.029$), Narration French Single-Language and Video Arabic Single-Language ($p = 0.006$), Narration Dual-Language French and Video French Single-Language ($p = 0.369$), Narration French Single-Language and Video French Single-Language ($p = 0.280$), and Video Dual-Language and Video French Single-Language ($p = 0.018$).

Overall, regarding differences in CSS between conditions for the same context (e.g., French Single-Language in Video vs. Narration), no significant differences were found for French Single-Language and Dense CS. In contrast, significant differences were observed for Arabic Single-Language (Video vs. Narration) as well as for most sub-components of the Dual-Language conditions (Video vs. Narration).

Hesitation Score (HS)

To quantify hesitation during the ecological tasks, a HS, defined as the number of filled pauses and repetition per minute of speech, was computed for each participant.

Setting	Mean HS	Median HS	SD
Arabic Single-language	14.3	14.1	6.6
French Single-language	18.6	16.7	9.1
Dual-Language	17.2	16.7	6.9
Dense CS	15.2	15.4	6.3

Table 7.4: Descriptive Statistics for Hesitation Score by Setting

Across the four settings, the highest mean HS was observed in the French Single-Language setting ($M = 18.6$, $SD = 9.08$), followed by the Dual-Language setting ($M = 17.2$, $SD = 6.92$). The Dense CS setting showed a lower mean HS ($M = 15.2$, $SD = 6.34$), while the lowest mean HS was found in the Arabic Single-Language setting ($M = 14.3$, $SD = 6.64$), as shown in Figure 7.11.

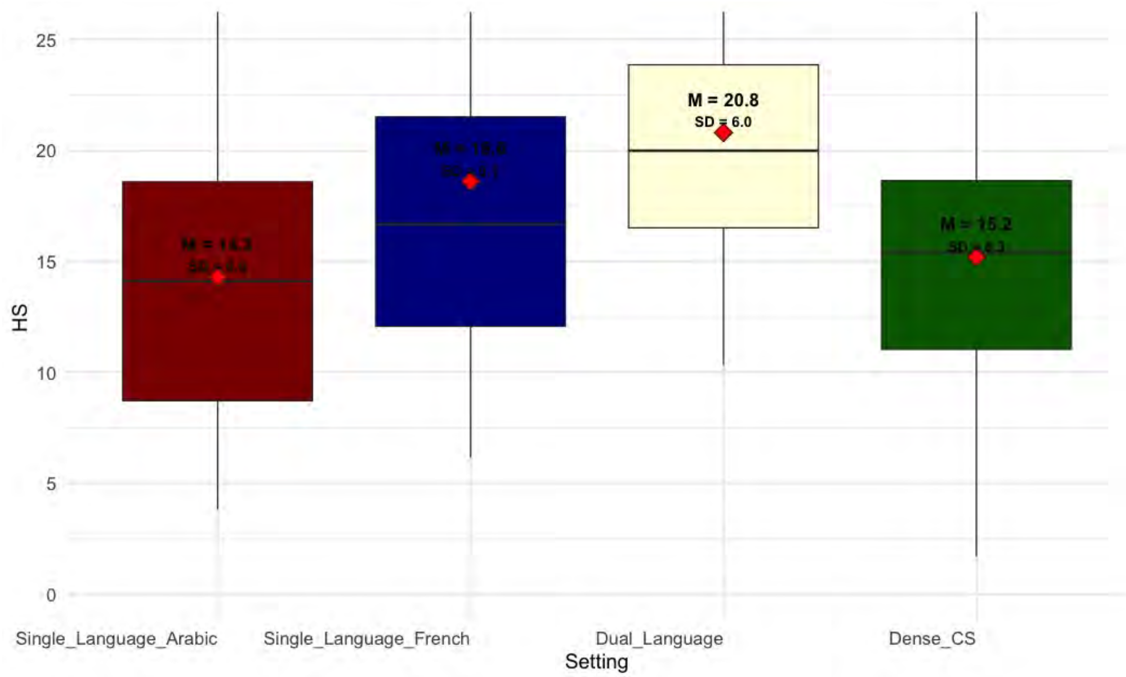

Figure 7.11: Hesitation Scores by Setting

A Shapiro-Wilk test revealed that the data were not normally distributed for the French Single-Language and Dual-Language settings ($p < 0.001$), whereas the Arabic Single-Language and Dense CS settings showed no significant deviations from normality. Given the violations of normality, a non-parametric Kruskal-Wallis test was conducted to compare HS across the four settings. The Kruskal-Wallis test revealed a non-significant effect of setting on HS ($X^2(3) = 7.01, \quad p = 0.072$). Although the overall test did not reach significance, a Dunn's post hoc test was conducted to explore pairwise comparisons. None of the pairwise comparisons remained significant after correction.

To determine whether the influence of condition on HS varied as a function of task modality, a more fine-grained analysis was subsequently conducted separately within the narration and video modalities.

A Shapiro-Wilk test revealed that HS scores were not normally distributed across several conditions (ps < 0.005 in some cases), justifying the use of non-parametric tests. A Kruskal-Wallis rank sum test indicated a significant main effect of Condition on HS scores ($\chi^2(8) = 25.50$, $p = 0.00128$).

As detailed in Figure 7.12, follow-up Dunn's post hoc tests (Bonferroni corrected) showed that HS was significantly in:

- Narration Dense CS than Video Dual-Language, $p < 0.001$**
- Narration Dual-Language Arabic than Video Dual-Language, $p < 0.001$**
- Narration Arabic Single-Language than Video Dual-Language, $p < 0.001$**
- Video Dual-Language than Video Arabic Single-Language, $p < 0.001$**
- Narration Dense CS than Video French Single-Language, $p < 0.001$**

All other comparisons did not reach significance.

Overall, regarding differences in HS between conditions for the same context (e.g., French Single-Language in Video vs. Narration), no significant differences were found for all contexts.

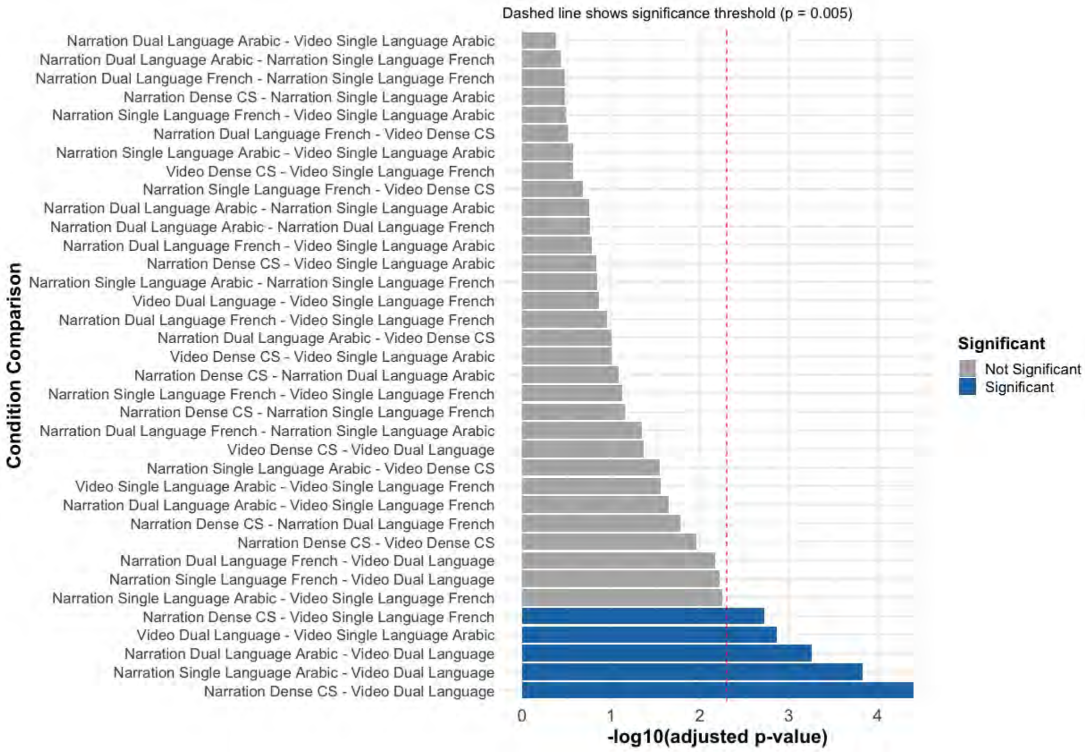

Figure 7.12: Hesitation Score Pairwise Comparisons of Ecological Conditions

Speech Rate (SR)

SR was defined as the number of words per minute.

Setting	Mean SR	Median SR	SD
Arabic Single-language	101.0	99.6	21.7
French Single-language	119.0	123.0	31.2
Dual-Language	111.0	104.0	27.3
Dense CS	104.0	99.3	27.1

Table 7.5: Descriptive Statistics of Speech Rate by Setting

As shown in Figure 7.13, the French Single-Language setting showed the highest average SR (M = 119.0, Md = 0.0), followed by the Dual-Language setting (M = 111.0, Md = 104.0), the Dense CS setting (M = 104.0, Md = 99.3), while the Arabic Single-Language setting exhibited the lowest SR (M = 101.0, Md = 99.6).

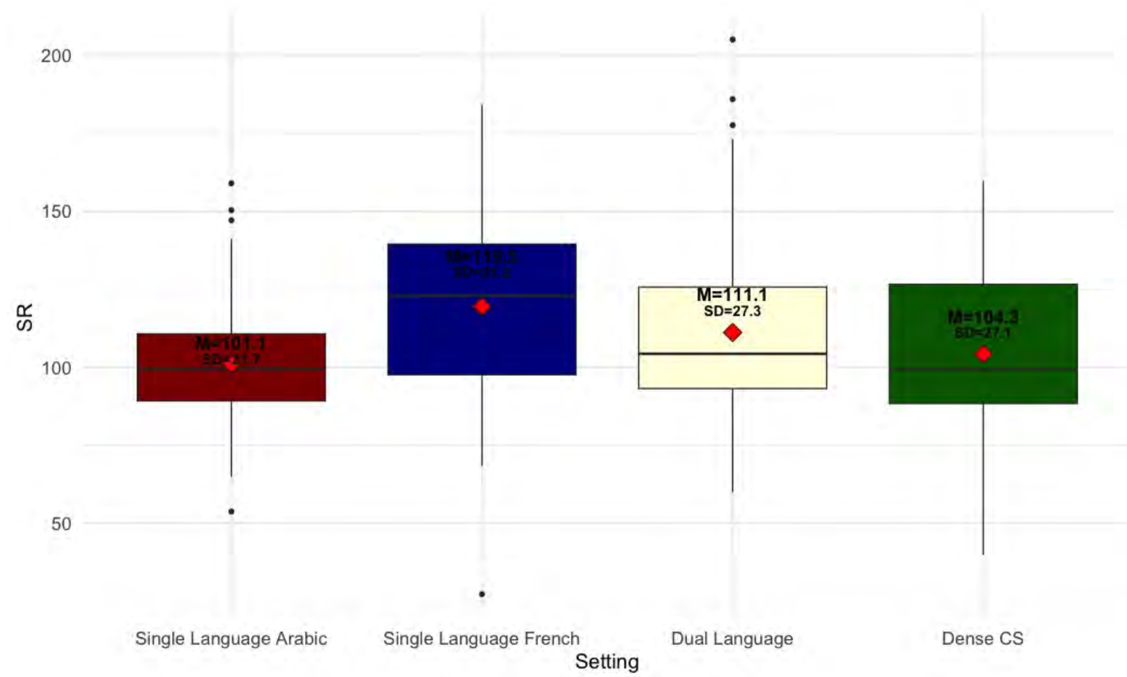

Figure 7.13: Speech Rate by Setting

A one-way ANOVA revealed a borderline significant effect of setting on SR, (F(3, 257) = 4.36, p = 0.00515*). However, Tukey's post-hoc comparisons showed that none of the pairwise differences between settings reached the significance level of $p < 0.005$. For example, the difference between French Single-Language and Arabic Single-Language approached significance ($p = 0.006$) but did not meet the threshold. Therefore, no pairwise comparisons were considered statistically significant.

To determine whether the influence of condition on SR varied as a function of task modality, a more fine-grained analysis was subsequently conducted separately within the narration and video modalities.

A Shapiro-Wilk test revealed that SR scores were not normally distributed across several conditions (ps < 0.005 in some cases), justifying the use of non-parametric tests. A Kruskal-Wallis rank sum test indicated a significant main effect of Condition on SR scores ($\chi^2(8) = 40.05$, $p < 0.001$).

As detailed in Figure 7.14, follow-up Dunn's post hoc tests (Bonferroni corrected) showed that SR was significantly higher in:

- Narration Dual-Language Arabic than Narration Dual-Language French, $p = 0.0015268$*
- Narration Dual-Language Arabic than Narration French Single-Language, $p < 0.001$**
- Narration Dual-Language French than Narration Arabic Single-Language, $p < 0.001$**
- Narration Dual-Language French than Video Dense CS, $p < 0.001$**
- Narration Dual-Language French than Video Dual-Language, $p < 0.001$**
- Narration Dual-Language French than Video Arabic Single-Language, $p = 0.0014358$
- Narration Arabic Single-Language than Narration French Single-Language, $p < 0.001$**
- Narration French Single-Language than Video Dense CS, $p < 0.001$**
- Narration French Single-Language than Video Dual-Language, $p < 0.001$**

- Narration French Single-Language than Video Arabic Single-Language, $p < 0.001$**
- Narration French Single-Language than Video French Single-Language, $p = 0.0020218$*

All other comparisons did not reach significance.

Overall, regarding differences in SR between conditions within the same context (e.g., French Single-Language in Video versus Narration), the difference was significant for French Single-Language (Video vs. Narration) and for most sub-components of the Dual-Language condition, but not significant for Arabic Single-Language nor for Dense CS.

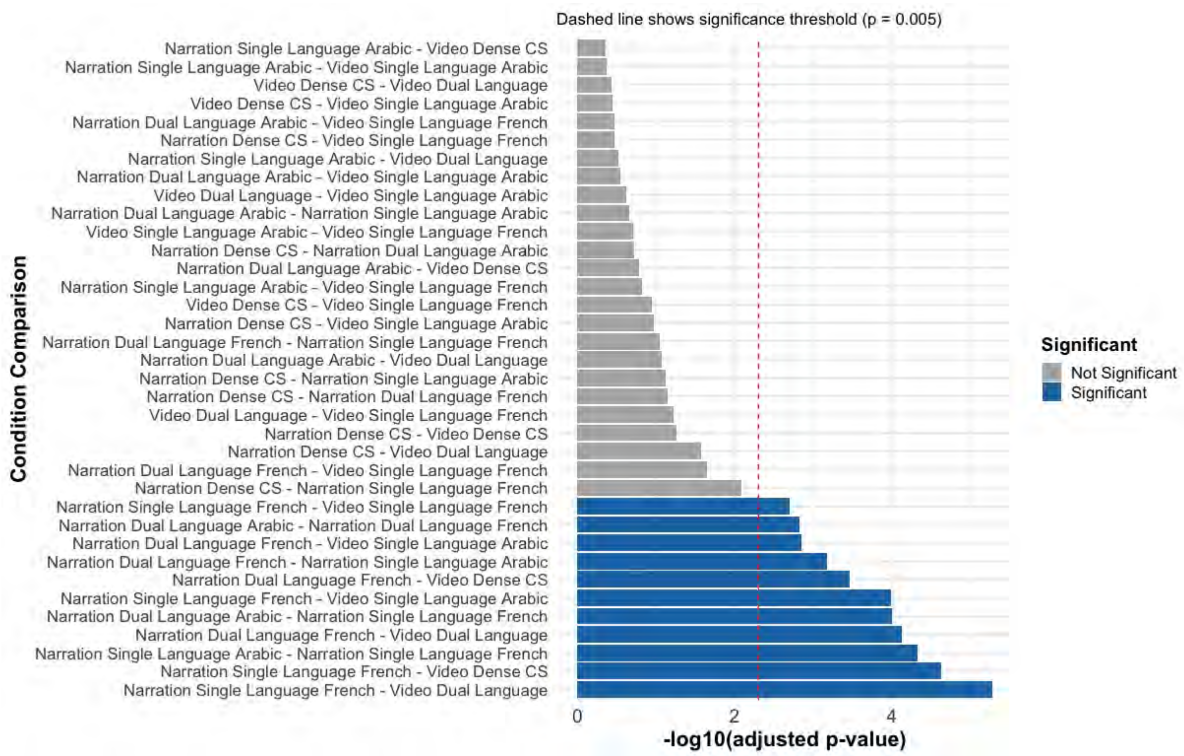

Figure 7.14: Speech Rate Pairwise Comparisons of Ecological Conditions

Language Control Index (LCI)

The LCI was computed by standardizing and combining the z-scored HS, CSS, and SR measures, with HS and CSS reversed, to represent language control costs.

Analysis by Setting

As shown in Figure 7.15, the French Single-Language setting showed the highest mean LCI ($M = 0.16$, $SD = 0.60$), indicating the greatest language control capacity. This was followed by the Dual-Language setting ($M = 0.02$, $SD = 0.52$), the Dense Code-Switching setting ($M = -0.01$, $SD = 0.70$), and the Arabic Single-Language setting, which exhibited the lowest mean LCI ($M = -0.11$, $SD = 0.64$), reflecting the lowest language control capacity.

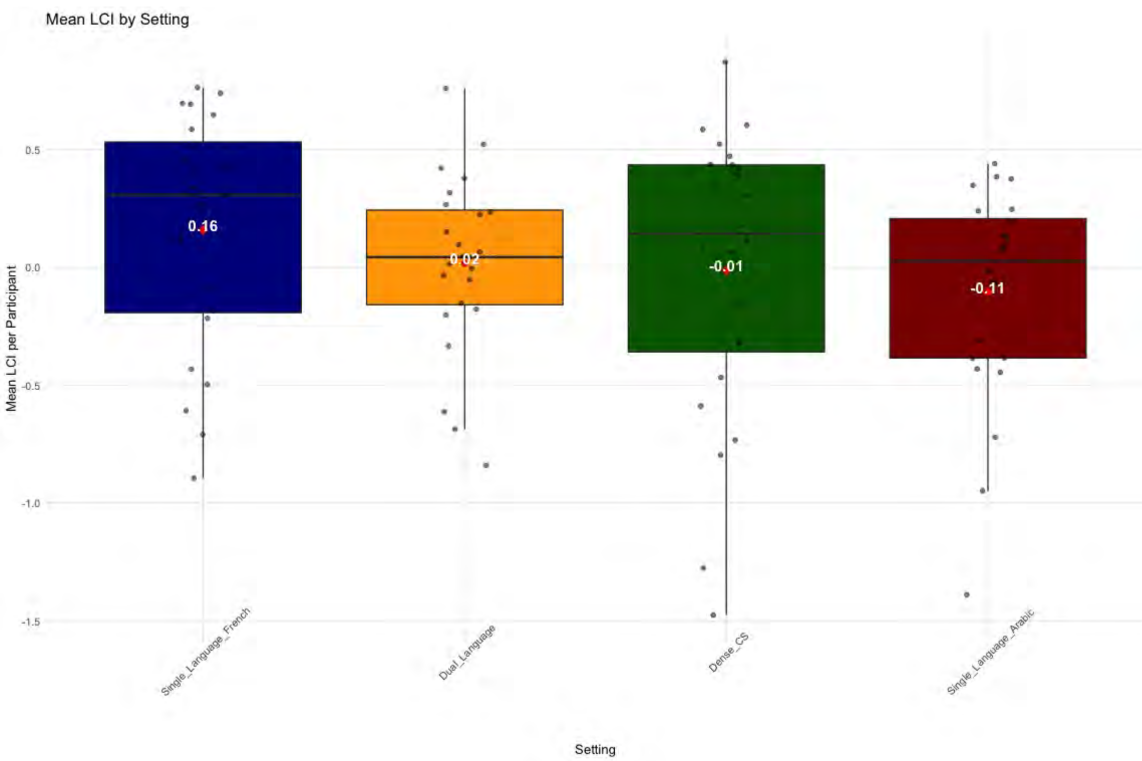

Figure 7.15: Language Control Index by Setting

Since the data did not follow a normal distribution (Shapiro-Wilk test, $W = 0.961$, $p < 0.001^{**}$), a non-parametric Kruskal-Wallis test was employed to evaluate differences in LCI across Settings, and revealed no statistically significant differences between Settings ($H(3) = 6.26$, $p = 0.099$). Post-hoc pairwise comparisons were conducted using Wilcoxon tests with Bonferroni correction, which did not reveal any significant contrasts (all ps > 0.005).

Analysis by Condition

A more detailed analysis by condition was performed. As shown in Figure 7.16, the French Narration Single-language condition showed the highest mean LCI ($M = 0.39$, $SD = 0.45$), indicating the strongest language control among all conditions. It was followed by Narration Dense CS ($M = 0.32$, $SD = 0.65$) and French Narration Dual-Language ($M = 0.26$, $SD = 0.58$), both reflecting relatively strong control. Intermediate values were observed in the Arabic Video Single-language condition ($M = 0.05$, $SD = 0.46$), while French Video Single-language ($M = -0.05$, $SD = 0.65$) and Arabic Narration Dual-Language ($M = -0.06$, $SD = 0.44$) showed slight reductions in control. The lowest LCI values, indicating the least language control, were found in the Arabic Narration Single-language condition ($M = -0.26$, $SD = 0.76$), the Video Dual-Language condition ($M = -0.27$, $SD = 0.35$), and the Video Dense CS condition ($M = -0.28$, $SD = 0.64$).

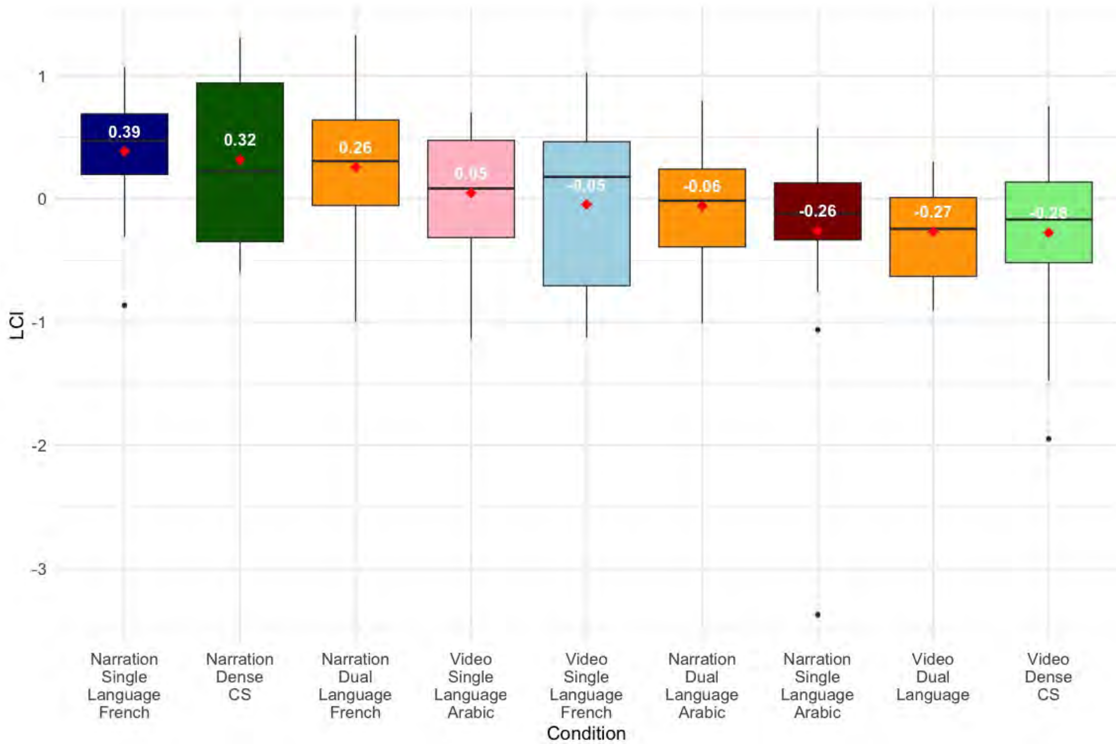

Figure 7.16: Language Control Index by Condition

Residuals violated the assumption of normality (Shapiro-Wilk test, $W = 0.950$, $p < 0.001$**). Consequently, a Kruskal-Wallis test was conducted and revealed a significant effect of Condition on LCI ($H(8) = 42.33$, $p < 0.001$**).

Subsequent Wilcoxon pairwise comparisons with Bonferroni adjustment identified significant differences between Narration French Single-Language and Video Dual-Language ($p = 9.1 \times 10^{-5}$**), Narration French Single-Language and Video Dense CS ($p = 0.0019$*), as well as Narration Dual-Language French and Video Dual-Language ($p = 0.0012$*). No other pairwise comparisons reached statistical significance under the $p < 0.005$ threshold.

Overall, regarding differences in LCI between conditions for the same context (e.g., French Single-Language in Video versus Narration), no significant differences were found for all contexts.

These results demonstrate that the LCI varies as a function of condition but not general setting, with significant differences observed between specific narrative and video conditions.

7.4.5.3 Results by Hypothesis

Hypothesis A : Switch Costs

Discourse switch cost was assessed by comparing LCI values in the Dense CS setting, which represents switch trials in a voluntary bilingual context, to the Dual-Language setting, which represents stay trials in a bilingual context.

On average, the switch cost was small ($M = 0.031$, $SD = 0.474$, $Md = 0.013$). A Wilcoxon signed-rank test indicated that the difference in LCI between Dense CS and Dual-Language settings was not statistically significant ($V = 144$, $p = 0.572$). These results indicate a small and non-significant switch cost, providing insufficient evidence to support Hypothesis A.

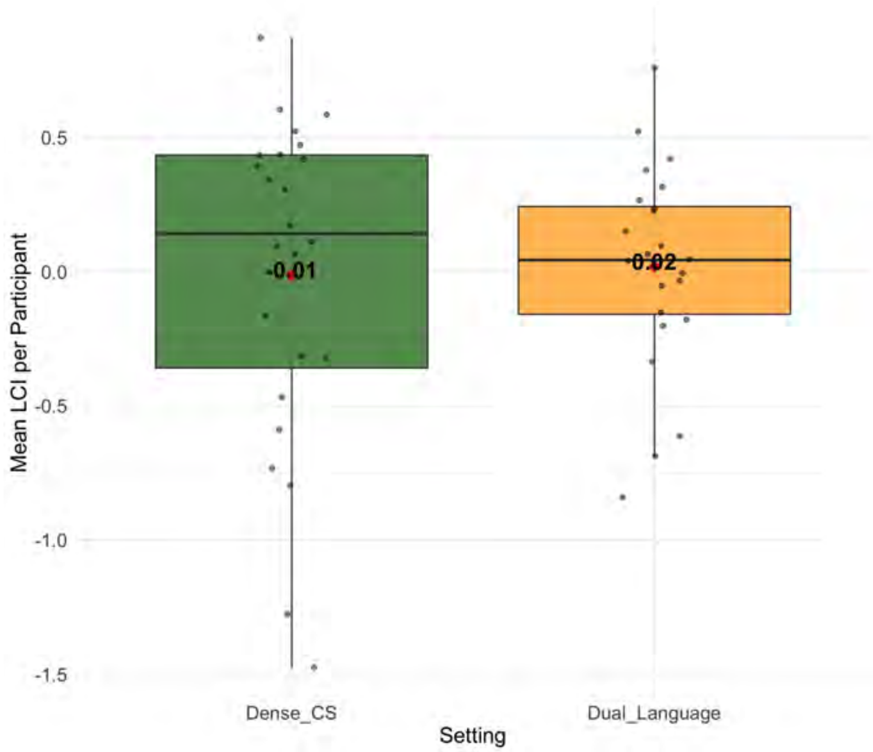

Figure 7.17: Discourse Switch Costs: Language Control Index by Setting: Dense CS vs. Dual-Language

Hypothesis B : Mixing Costs

Discourse mixing cost was examined by comparing LCI values in the Dual-Language setting, representing stay trials in a bilingual setting, to those in single-language settings (Arabic and French), representing blocked trials in monolingual contexts.

The mean mixing cost was small ($M = 0.008$, $SD = 0.289$, $Md = 0.049$). A Wilcoxon signed-rank test showed no significant LCI difference between Dual-Language and Single-Language settings ($V = 134$, $p = 0.678$). These findings indicate insufficient evidence to confirm Hypothesis B.

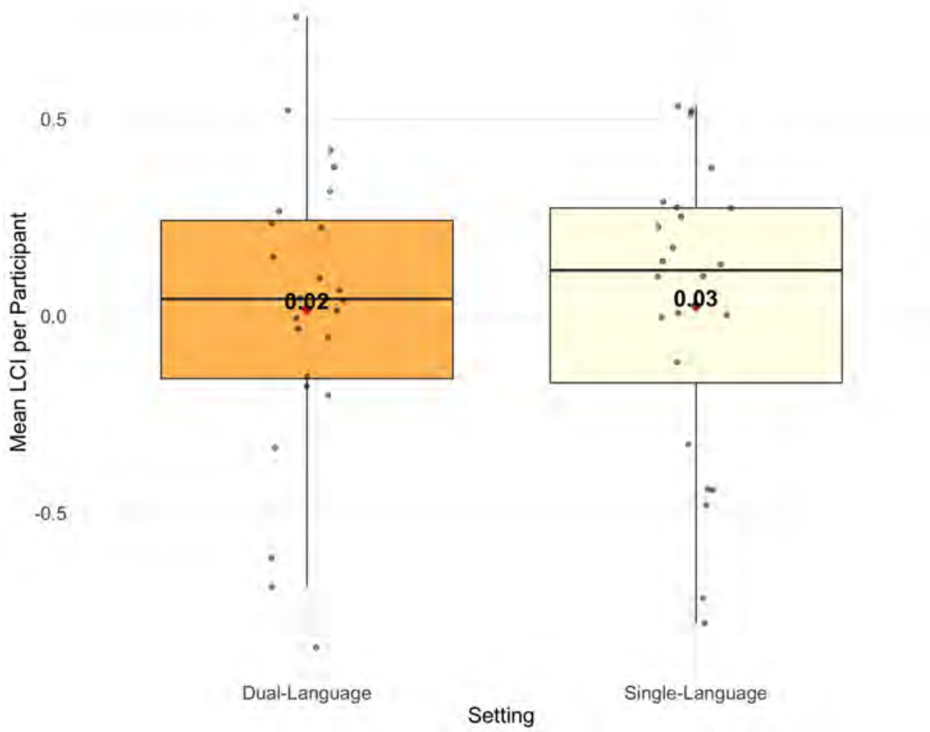

Figure 7.18: Discourse Mixing Costs: Language Control Index by Setting: Dense CS vs. Single-Language

7.4.5.4 Modeling Individual Variability in Discourse Language Control Costs

To further explore the effects of individual predictors (L2 French proficiency, CSP, LE, and LOR in France) on switch and mixing costs, two MEMs were computed. One model predicted switch costs, and the other predicted mixing costs, following the same approach applied in the laboratory-based study from Phase 2.

A MEM was computed to predict switch costs using the following predictors: L2 French proficiency, CSP, LE, and LOR in France. All predictors were scaled prior to model fitting. The model included a random intercept for participants to account for individual differences. To ensure convergence, the optimizer was set to `bobyqa` with an increased maximum number of function evaluations (`maxfun = 1e5`).

Switch Cost $\sim$ L2 French proficiency score + CSP + LE + LOR France + (1 | participant ID)

As shown in Figure 7.19, the model revealed a significant negative effect of L2 French proficiency on switch costs ($\beta = -0.2081$, $p = 0.00105$**), indicating that a higher L2 proficiency was associated with reduced switch costs. In contrast, CSP had a significant positive effect ($\beta = 0.3472$, $p = 4.35 \times 10^{-7}$ **), suggesting that participants who code-switched more frequently in their daily lives exhibited larger switch costs. Similarly, LOR in France showed a significant positive effect on switch costs ($\beta = 0.3443$, $p = 6.62 \times 10^{-7}$ **). LE did not significantly predict switch costs ($\beta = -0.0852$, $p = 0.11291$).

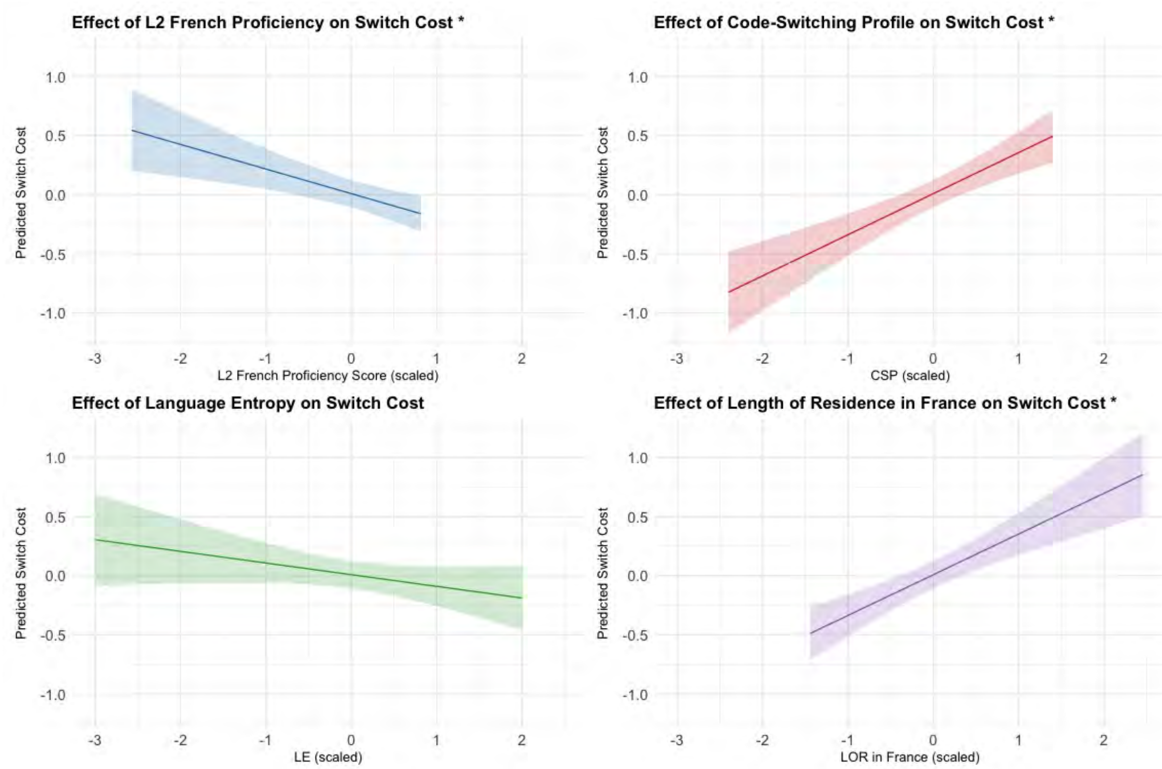

Figure 7.19: Effects of Individual Predictors on Discourse Switch Costs

A MEM was computed to predict mixing costs, using the same set of predictors as in the switch cost model. All predictors were scaled prior to analysis. The model included L2 French proficiency score, CSP, LE, and LOR in France as fixed effects. Unlike the switch costs model, no random effects were included due to convergence issues with mixed-effects modeling.

$$\text{Mixing Cost} \sim \text{L2 French proficiency score} + \text{CSP} + \text{LE} + \text{LOR France}$$

The model showed a marginally significant positive effect of L2 French proficiency on mixing costs ($\beta = 0.048$, $p = 0.012$), indicating that participants with higher French proficiency tended to have larger mixing costs. CSP also had a marginally significant negative effect ($\beta = -0.051$, $p = 0.012$), suggesting that participants who code-switched more frequently in daily life exhibited smaller mixing costs. LOR in France showed a significant negative effect on mixing costs ($\beta = -0.059$, $p = 0.00467^{*}$), implying that longer residence in France was associated with reduced mixing costs. LE did not significantly predict mixing costs ($\beta = 0.025$, $p = 0.18$). Note that effects with p-values between 0.005 and 0.05 are described as marginally significant here because the significance threshold was set at 0.005 for all results to reduce the risk of false positives.

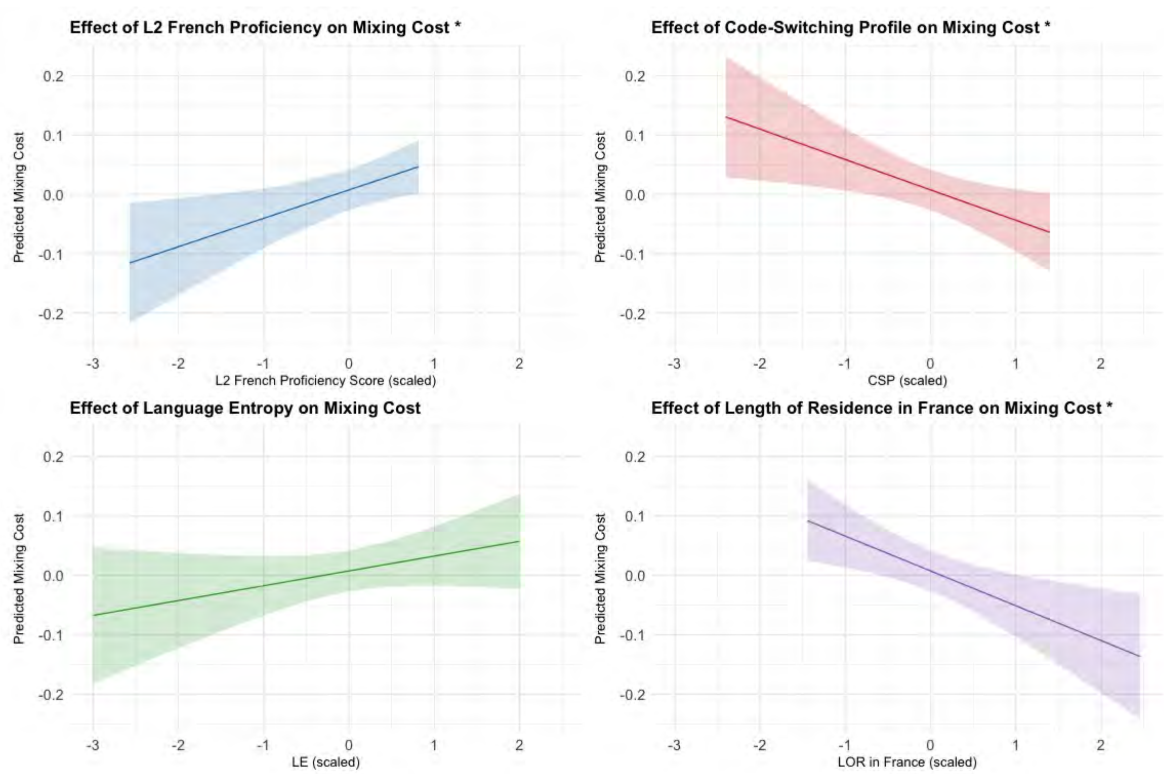

Figure 7.20: Effects of Individual Predictors on Discourse Mixing Costs

Summary of Exploratory Study Findings

Qualitative analysis:

- Types of code-switching

- In the Arabic Single-Language setting, participants produced more alternations than insertions.
- In the Dual-Language setting, insertions occurred more frequently than alternations.
- In the Dense CS setting, insertions were also more common than alternations.
- In the French Single-Language setting, there was no significant difference between insertions and alternations.

- Grammatical category of code-switching

Across all settings, nouns were the most frequently switched grammatical category, followed by verbs, then prepositions. Interjections, determiners, conjunctions, and adverbs occurred less frequently, while adjectives, numerals, and pronouns were the least frequent.

Quantitative analysis:

- CSS (Switches/minute)

- In the Arabic Single-Language condition, the mean CSS was M = 6.10 (SD = 14.8).
- In the French Single-Language condition, the mean was M = 0.55 (SD = 1.50).
- In the Dual-Language condition, participants produced an average of M = 2.89 (SD = 4.24).
- In the Dense CS condition, the mean number of switches per minute was M = 6.21 (SD = 4.76).

*Significant differences were found: Dense CS and Dual-Language settings yielded higher switch rates than the French Single-Language condition. The Arabic Single-Language setting also showed higher switch rates than the French Single-Language condition. No significant differences were observed between the Arabic Single-Language, Dense CS, or Dual-Language settings.

- HS (Hesitations/minute)

- In the Arabic Single-Language setting, mean HS was M = 14.3 (SD = 6.6).
- In the French Single-Language setting, mean HS was M = 18.6 (SD = 9.1).
- In the Dual-Language setting, mean HS was M = 17.2 (SD = 6.9).
- In the Dense CS setting, mean HS was M = 15.2 (SD = 6.3).

*Significant effects were observed: Dense CS elicited more hesitations than Dual-Language; Dual-Language Arabic and Arabic Single-Language both differed significantly from the Dual-Language setting; and Dense CS yielded more hesitations than French Single-Language. All other comparisons were not significant.

- SR (Words/minute)

- In the Arabic Single-Language condition, the mean speech rate was M = 101.0 (SD = 21.7).
- In the French Single-Language condition, participants produced M = 119.0 (SD = 31.2).
- In the Dual-Language condition, the mean was M = 111.0 (SD = 27.3).
- In the Dense CS condition, participants produced M = 104.0 (SD = 27.1).

There were no significant differences in speech rate between settings.

- Hypotheses

- Overall, only limited differences in LCI were observed across settings, providing insufficient evidence for clear switch or mixing costs.
- In the MEM models, L2 French proficiency, CSP, and LOR in France significantly influenced switch and mixing costs, whereas LE did not have a significant effect.

7.5 Discussion

This study was based on an innovative approach, assessing language switching and mixing in FCS through discourse-based tasks grounded in the ACH's interactional contexts (Green & Abutalebi, 2013). It explored an LSP in a more naturalistic manner than traditional single-word BPN paradigms, by collecting a large corpus dataset based on video descriptions and personal event narrations, produced in multiple languages depending on the interlocutor and communicative situation. Multiple measures were annotated and analyzed to capture switching and mixing costs in discourse, notably CSS, SR, and HS. These measures jointly contributed to the creation of a novel composite index of language control: the Language Control Index (LCI).

Although the experiment was conducted in a laboratory setting, careful attention was given to ensure that it reflected naturalistic interactional contexts as closely as possible. The discourse tasks were designed to encourage spontaneous speech in realistic communication situations, aiming to keep the tasks as natural as possible while still allowing experimental control of variables of interest, mainly material, interlocutor speech and language knowledge. This approach allowed participants to produce speech that resembled real-life exchanges, while still enabling systematic analysis of language control and switching behavior.

Qualitative and quantitative analyses were conducted to describe the corpus and address the hypotheses, which focused on the presence of switching and mixing costs across the interactional contexts proposed by the ACH.

7.5.1 Qualitative Analysis

Qualitative analysis focused on describing the distribution of code-switching types and the grammatical categories involved across the four settings. The following section briefly summarizes these results prior to their discussion.

Type of Code-Switching

The qualitative analysis is based on the code-switching typology suggested by Muysken (1997), distinguishing alternation from insertion. Alternation was found to be most frequent in the Arabic Single-Language setting, although the median of zero indicates high variability, while insertion was also higher in this setting compared to French Single-Language and Dual-Language settings. In contrast, the Dense CS setting showed the highest and most consistent insertion counts, with alternation remaining low. A significant association between setting and code-switching type indicated that Arabic Single-Language favored alternations over insertions, while Dual-Language and Dense CS settings showed more insertions than other settings, and French Single-Language exhibited a balanced distribution.

These results suggest that the type of code-switching is influenced by interactional context, with single-language contexts, particularly Arabic, encouraging alternation, and dense code-switching rather promoting frequent insertions. The predominance of insertions observed in the dense CS setting is consistent with Poplack (1980), who noted that fluent bilinguals tend to switch within sentences at various syntactic boundaries (alternations and insertions), whereas less fluent speakers prefer switching between sentences to avoid grammatical errors (only alternations). Given that FCS are typically fluent bilinguals, this pattern aligns well with Poplack's observation.

Moreover, the pattern of code-switching types in the present study potentially indicates that participants found it more challenging to remain in Arabic in the single-language context, leading them to produce full clauses in French that may reflect a possible reduction in language control. This difficulty of staying in Arabic may be partly explained by their current residence in France, where French is regularly used in daily life. Moreover, Lebanese FCS are rarely placed in situations requiring exclusive use of Arabic, as conversations with Lebanese peers typically occur in dense CS contexts, where French and even English words are freely inserted. This is reflected in the high rate of insertions observed in the Dense CS setting.

In a previous pilot study (Awada, 2022), ten Lebanese Arabic–French bilinguals produced a corpus of French speech centered on their experience of the 2020 Beirut port explosion. The results showed that, among the switches to Lebanese Arabic, 63% were alternations and 36% insertions (and 1% other). In contrast, the French Single-Language condition in the present study showed a more balanced distribution between alternations and insertions. This difference may be explained by the experimental characteristics of the pilot study, including a bilingual interviewer who, despite not speaking Arabic during the interview, may have encouraged the use of dense CS. Switching behavior may also have been influenced by the highly emotional nature of the subject. In addition, inter-individual variability in code-switching use was also related to the duration and contexts of exposure to French, as well as language proficiency and preference. Similar variability patterns were also observed by Zantout (2019), who assessed Lebanese teenagers enrolled in French- and English-medium schools in Lebanon, and reported that some participants switched infrequently and used long stretches in one language, typically through alternation, while others switched very frequently, combining alternations and insertions.

Grammatical Category of Code-Switching

The qualitative analysis of grammatical categories of code-switching revealed that nouns and nominal phrases were the most frequently switched across all settings, followed by verbs, interjections, prepositions, and other categories. This overall pattern was consistent across both languages and settings, highlighting the central role of nouns in code-switching. Statistical analyses confirmed these observations, showing a significant main effect of grammatical category, which indicates that some categories were generally more frequent than others. However, no significant differences were found across languages or settings, and no interaction effects reached significance. These results suggest that while certain grammatical categories were more commonly code-switched, the distribution of categories was stable across interactional contexts and languages, with no consistent variation linked to setting or language. Notably, the predominance of nouns aligns with Haspelmath and Tadmor (2009), who reported that, across more than 40 languages, loanwords are more frequently nouns than verbs, supporting the idea that nouns are particularly prone to cross-linguistic phenomena.

In the Arabic Single-Language setting, switches to French were predominantly nouns and nominal phrases, followed by verbs and verbal phrases, with few occurrences of prepositions, adverbs, and conjunctions. A few switches to English occurred, and were mainly nouns, with occasional interjections and adjectives. These switches were mostly alternations, consistent with the predominance of full-clause switches in this context. In contrast, in the French Single-Language setting, switches into Arabic were primarily interjections and verbs/verbal phrases, followed by nouns and prepositional phrases, whereas switches into English mostly involved nouns. Here, switches were more evenly distributed between alternations and insertions, reflecting a balanced pattern of code-switching types. These findings are consistent with those observed by Awada (2022) in a comparable French Single-Language setting, where switches to Lebanese Arabic were predominantly interjections (51%), followed by expressions (corresponding to phrases) (37%), and to a lesser extent adverbs, nouns, and conjunctions. The Dual-Language setting showed a similar trend, with nouns dominating across all languages, followed by verbs and a smaller number of adjectives, prepositions, adverbs, and interjections. Switches in this context involved relatively more insertions, in line with the mixed-language nature of this setting. Finally, in the Dense CS setting, French switches were largely nouns, with verbs, prepositions, and adverbs occurring less frequently, while Arabic switches were minimal and mainly consisted of interjections and conjunctions. English switches were rare and predominantly interjections. These switches were mainly insertions. These patterns suggest that the type and grammatical category of code-switching depended on the setting, and across all settings, nouns dominated as the switched category.

7.5.2 Quantitative Analysis

Quantitative analysis comprised the calculation of CSS, HS, SR, as well as their combination into the LCI, across the four interactional settings (refer to Section 7.3.3 for more details).

Code-Switching Score (CSS)

The analysis of CSS revealed clear differences in code-switching frequency across communicative settings. As expected, participants exhibited the highest switching rates in the Dense CS setting, followed by the Arabic Single-Language setting, then the Dual-Language setting, whereas the French Single-Language setting yielded the lowest CSS scores. In the Dense CS setting, code-switching was both expected and encouraged by the situation and the interlocutor, illustrating the Interactive Alignment model proposed by Kootstra et al. (2020), which posits that language choices are shaped by alignment with the interlocutor's linguistic behavior. In line with this model, participants were found to code-switch more often when the interviewer had just code-switched. In contrast, monolingual French settings elicited stronger language control, potentially reflecting participants' habitual management of French in their daily life in France. Notably, the lack of a significant difference between Dense CS and Arabic Single-Language conditions indicates that participants produced frequent switches even when instructed to speak in Arabic, suggesting reduced control in the Arabic Single-Language setting. Overall, the present study's CSS score in the Dense CS setting (M = 6.21, SD = 4.76) are comparable to Yim and Bialystok (2012)'s, who had introduced the CSS, and found a mean CSS in mixed-language Cantonese–English conversations of 5.0 (SD = 4.0).

Notably, distinguishing code-switches from borrowings can be challenging in a population of FCS, which motivated the administration of a large-scale questionnaire (see Section 7.3.2.2 for a detailed description). Following Treffers-Daller (2025), it may also be useful to consider formulaicity for such distinction: borrowings tend to be stored as fixed units, whereas code-switches are generated online (see Section 2.3.2).

Hesitation Score (HS)

The highest HS was observed in the Dual-Language setting, followed by the French Single-Language condition, then Dense CS, and finally Arabic Single-Language. No significant differences in HS were found across settings. The high HS in the French and Dual-Language contexts may reflect increased lexical retrieval demands when using the L2 or managing two languages separately. In contrast, the lower hesitation rates in Arabic and Dense CS suggest greater automaticity and ease of lexical access in the dominant language and in the free switching setting. Overall, the relatively comparable hesitation levels across settings indicate that participants maintained relatively fluent speech. In line with the present findings, Grosjean (1997a) showed that the number of hesitations decreased as French–English bilinguals moved from a monolingual to a bilingual mode, indicating that switching freely between languages can be associated with more fluent speech, as observed in the dense CS setting in the present study.

Speech Rate (SR)

Speech rate, reflecting speech fluency, was lowest in the Arabic Single-Language setting and gradually increased across the Dense CS and Dual-Language settings, with the French Single-Language setting exhibiting the highest SR. Overall, SR was comparable across settings, with no significant pairwise differences. The slower rate in Arabic may reflect the increased difficulty of producing speech exclusively in Arabic, consistent with findings from the CSS and HS. The lower rate in Dense CS was somewhat surprising, as this setting was expected to be the easiest for FCS. Conversely, the faster rate in French likely reflects participants' familiarity and comfort producing narratives in their second language, influenced by their residence in France and habitual exclusive use of French with daily interlocutors in work or community contexts.

Although previous studies typically report SR in syllables per minute rather than words per minute, the overall trends are broadly consistent: L1 speech is generally faster than L2 speech (Olkkonen et al., 2024). Similarly, in Baker-Smemoe et al. (2014), advanced L2 learners produced French at 125.4 words per minute and Arabic at 105 words per minute. The slower rate in Arabic compared to French in the same L2 position may reflect language-specific characteristics. In a study comparing Arabic to English, Guba et al. (2023) found that Arabic is generally less stress-timed than English, meaning that the number of syllables rather than stresses largely determines rhythm. Moreover, Modern Standard Arabic and dialectal Jordanian Arabic feature simpler syllable structures than English, which can influence speech production demands. Interestingly, R. J. Morris et al. (2024) reported that while utterance durations and word-based utterance rates were similar across Arabic and English, syllable-based utterance rates were faster in Arabic. As noted by Aldholmi et al. (2021), defining a baseline SR for Arabic is also necessary yet challenging. Together, these studies suggest that Arabic SR depends on the measurement method rather than on language control alone, and highlight the importance of accounting for language-specific properties when interpreting speech fluency differences across settings and languages, contextualizing the slower SR found in the Arabic Single-Language setting relative to French and bilingual settings in the present study.

Language Control Index (LCI)

The LCI, combining the standardized three previous measures (namely HS, CSS, and SR), provides a composite index of language control, with higher scores supposed to reflect greater capacity to manage linguistic demands. Across settings, the French Single-Language setting showed the highest mean LCI, followed by Dual-Language, Dense CS, and Arabic Single-Language settings, which exhibited the lowest mean LCI. This ordering is consistent with the individual measures: French speech was produced with relatively high fluency, low hesitation, and minimal code-switching, whereas Arabic speech showed slower rates, more hesitation, and greater difficulty controlling code-switching.

Despite these descriptive trends, statistical analyses revealed no significant differences in LCI across settings. This suggests that, while setting influences specific aspects of speech production (HS, SR, CSS), the overall capacity for language control remains relatively comparable across settings for this population of FCS. These findings align with observations from the CSS, HS, and SR analyses: participants maintained fluent and controlled speech across settings. However, LCI did differ significantly across some conditions, which may reflect that paired experimental situations (video vs. narration) were not always fully comparable. Differences could arise from participants' distance to the situation: describing a video is more neutral, whereas narrating a personal event engages memory, affect, and individual experience, potentially influencing language control. In line with Green (2019), retrieving a specific autobiographical memory demands a narrow, internally directed attentional focus, whereas describing external stimuli, such as a video, relies on a broader, externally directed attentional focus.

Altogether, the LCI thus provides a useful integrative metric, confirming that habitual switchers can effectively balance multiple linguistic demands in everyday communicative situations.

7.5.3 Results by Hypothesis

Reminder

- **Switch Costs**: Defined relative to the voluntary switching condition (Dense CS). A positive SC value indicates better control in the Dual-Language condition relative to Dense CS (switch cost), while a negative value indicates better control in Dense CS (switching benefit).

- **Mixing Costs**: Defined relative to the cued switching condition (Dual-Language). A positive MC value indicates better control in the Single-Language (monolingual) condition (mixing cost), while a negative value indicates better control in the Dual-Language condition (mixing benefit) [1].

Hypothesis A : Switch Costs

Hypothesis A predicted a switch cost, operationalized as lower LCI in the constrained Dual-Language setting compared to the voluntary Dense CS setting, indicating a higher language control requirement in the dual setting. Although Dense CS exhibited slightly higher LCI values, indicating somewhat better language control in the free-switching context, the difference was small and non-significant. This suggests that switch costs were minimal for this population of FCS.

This is in line with the results observed by Sanchez et al. (2022) assessed switch costs in bilingual sentence production using filled pauses, comparable to HS in the present study. They found that switch costs were primarily evident in L2 sentences compared to L1, a result consistent with the current findings, where HS in the L2 French Single-Language setting was higher than in the L1 Arabic Single-Language setting.

Hypotheses B: Mixing Costs

Hypothesis B predicted a mixing cost, operationalized as lower LCI in the Dual-Language setting compared to monolingual Single-Language settings. While LCI values in Dual-Language were marginally lower than in the monolingual settings, reflecting slightly lower control demands, these differences were not statistically significant. The results indicate that mixing costs were negligible.

These results contrast with findings from sentence-production paradigms, such as those reported by Declerck, Grainger, and Hartsuiker (2021), who examined mixing costs in bilingual language production using language intrusions (corresponding to actual CSS) and filled pauses (corresponding to HS). In their study, mixing costs were reflected in a higher proportion of language intrusions and filled pauses during language-repetition sentences within mixed-language blocks. Moreover, filled pauses were significantly more frequent in the L2 than in the L1, consistent with the present findings showing higher hesitation rates in the L2 French Single-Language setting compared to the L1 Arabic setting. The absence of comparable effects in the current discourse-level task suggests that, in more natural communicative contexts, bilinguals may rely on proactive control strategies that minimize interference and maintain fluency even when managing multiple languages. It is also worth noting that the participant population differed across studies: Declerck, Grainger, and Hartsuiker (2021) tested balanced Dutch–French bilinguals with relatively high L2 proficiency, whereas the present study focused on Lebanese FCS, who engage in more frequent language switching.

Taken together, these findings suggest that FCS can maintain effective language control across both voluntary and constrained bilingual contexts, exhibiting minimal costs when alternating or managing multiple languages simultaneously. This aligns with previous observations from the individual measures (HS, SR, CSS), confirming that participants sustained fluent and controlled speech regardless of switching demands.

Although the LCI provides an integrative measure of language control, it failed to reveal clear switch or mixing costs that were otherwise apparent in the BPN paradigms. This suggests that, while useful for capturing overall control across discourse-level narratives, the LCI may be less sensitive to specific trial-level effects. Alternatively, it may indicate that language control operates more efficiently at the discourse level than in more artificial laboratory paradigms. In line with this interpretation, Sanchez et al. (2022) observed that more ecologically valid communicative contexts may require little to no language control.

[1] Since switch and stay trials cannot be differentiated at the discourse level, the Dual-Language setting was assimilated to stay trials from the bilingual condition, and the Dense CS setting was assimilated to switch trials, when compared to BPN.

7.5.4 Modeling Individual Variability in Discourse Language Control Costs

The analysis of switch and mixing costs using the LCI revealed that, across settings, FCS maintained relatively stable language control, with only small and non-significant switch and mixing costs.

When examining individual predictors through MEM, nuanced effects emerged. Higher L2 French proficiency was associated with reduced switch costs, suggesting that more balanced bilinguals had better language control capacities. In contrast, participants with higher daily code-switching use (reflected by CSP) exhibited larger switch costs, indicating that habitual switching may not always reduce the immediate control demands during constrained bilingual situations. Similarly, longer residence in France was linked to larger switch costs, potentially reflecting adaptation to L2-dominant contexts, which might increase control demands in constrained situations. LE did not significantly predict switch costs, suggesting that variability in overall language use across contexts may play a less direct role in ecological language switching.

Regarding mixing costs, the pattern differed. Marginally significant effects suggested that higher L2 proficiency was linked to slightly larger mixing costs, whereas higher CSP and longer residence in France were associated with smaller mixing costs. These results point to a dissociation between switch and mixing costs: while L2 proficiency supports efficient switching, more FCS and participants with extensive L2 immersion may experience reduced demands when managing multiple languages alternatively rather than when staying in one single language.

Together, these findings underscore the value of integrating the LCI with individual variability measures. The LCI captures the composite impact of hesitation, code-switching, and speech rate, while the MEM reveal how personal language experience shapes specific control demands. This dual approach demonstrates that FCS can effectively balance multiple language control demands in ecological contexts, yet subtle individual differences modulate the cost of switching versus mixing multiple languages.

7.5.5 Implications for the Adaptive Control Hypothesis

Returning to the ACH (Green & Abutalebi, 2013), the present discourse-based study examines how its principles apply to naturalistic language switching. The ACH posits that language control mechanisms adjust in response to the recurring demands of the interactional context. Within this framework, the authors identified eight key control processes and examined how these processes operate under three distinct interactional settings: single-language, Dual-Language, and dense CS (refer to Section 2.2.3 for a detailed description). These same settings formed the basis of the current experiment, which investigated language control in Lebanese Arabic and French. In line with the authors' recommendations, the present study also adhered to the principle that testing the ACH requires assessing multiple behavioral components within the same individuals, first examining language switching through laboratory paradigms (BPN and BSF in Study 2) and then in more ecological discourse. The individual differences proposed by Green and Abutalebi (2013) as potential modulators of adaptive control were daily switching habits, proficiency in the languages used, sensitivity to interactional cost, and capacity for cognitive control. In the present research, these factors were assessed at different stages of the experiment: daily switching habits were measured through CSP in Study 1, L2 French proficiency in Study 2, sensitivity to interaction cost through the discourse Study 3, and capacity for cognitive control via executive function tasks (Flanker, Stroop, WCST, and DS) in Study 2. As stated by the authors, "Examining the role of individual differences in adaptive response is a discovery procedure" (Green & Abutalebi, 2013, p. 526), which guided the systematic assessment of these factors in the current research.

Control processes, as illustrated in Figure 2.4 from Section 2.2, varied across interactional contexts. For example, dense CS contexts involve more opportunistic planning, whereas Dual-Language contexts require greater engagement of salient cue detection and selective response inhibition. According to Green and Abutalebi (2013), the Dual-Language context is the most demanding, as it engages the largest number of control processes and necessitates rapid adaptation, such as adjusting language use when a new communication partner enters the conversation, which involves quick task disengagement followed by successive task engagement. This was partially visible in the current study, as the Dual-Language setting exhibited reduced LCI values. Furthermore, the types of control processes differ across contexts: competitive control predominates in single and dual-language contexts, while cooperative and open control are engaged in dense code-switching contexts (see Figure 2.8; Green & Wei, 2014) In this study, the dense CS context in fact had relatively low LCI, further supporting its reliance on opportunistic planning and an open control mode.

7.6 Limitations and Perspectives

Several limitations and perspectives for future research emerge from Study 3. First, a more detailed analysis of the loanword questionnaire could provide a finer-grained distinction between borrowing and code-switching. Future work might develop a continuum or scale ranging from loanwords to full code-switches in the Lebanese context. Furthermore, the existence of a "perfect" Lebanese Arabic monolingual, strongly related to the classification of loanwords vs. code-switching, remains an open question. One interesting study by Kelly et al. (2020) reports comparisons in voice onset time between Lebanese bilinguals and monolinguals, but the methods used to identify and assess monolingual participants require further clarification.

Second, data annotation of code-switching types was limited to insertions and alternations. Future research could expand this approach by examining congruent lexicalization through detailed syntactic analyses. Additionally, further investigation of the grammatical categories involved in code-switching would provide a more comprehensive understanding of bilingual language patterns. Also looking at the functions of code-switched words would be interesting to find the motivation behind language switching.

Third, differences observed between video description and personal event narratives suggest that task heterogeneity may influence language performance. Designing more homogeneous tasks in future studies could help reduce variability and improve comparability across conditions.

Lastly, the novel measure of LCI developed in the present study, could be applied in larger and more diverse populations to further assess its robustness and generalizability. As a new index, its potential to capture switch and mixing costs across different sociolinguistic contexts remains to be fully explored. In populations where languages are used in a more compartmentalized manner, different patterns of switch and mixing costs may emerge, offering additional insight into bilingual language control in discourse and the ecological validity of the LCI. In sum, Study 3 provides an ecological, discourse-based assessment of language control in Lebanese FCS, complementing the laboratory-based findings from Study 2 and incorporating individual variability factors (LE, L2 proficiency, LOR, and CSP) from Study 1. The study extends the investigation of language control to more naturalistic speech and introduces a novel metric, the LCI, based on measures of CSS, HS, and SR. The findings indicate minimal switch and mixing costs, suggesting that language control in discourse is generally efficient, potentially more so than in controlled experimental settings. Additionally, individual differences, such as L2 proficiency and LOR in France, were found to significantly influence language control in discourse.

Chapter 8

General Discussion

The present study aimed to provide a comprehensive exploration of bilingual language control in FCS by adopting a multimethod approach that combined sociolinguistic, experimental, and discourse-based measures within the same population of Lebanese FCS. This is the first study to investigate Lebanese FCS and to combine these three assessment approaches in the same participants, while viewing bilingualism as a continuum, by adopting continuous rather than categorical measures (De Bruin, 2019), such as CSP (Olson, 2022) and LE (Gullifer & Titone, 2018, 2020). In contrast to most research relying solely on participants' self-rated proficiency, the current study included both subjective and objective measures of language proficiency to ensure a more robust assessment of individual linguistic profiles. Furthermore, it is among the first studies to examine more ecological contexts predicted by the Adaptive Control Hypothesis (Green & Abutalebi, 2013) using naturalistic discourse data, and to introduce a novel Language Control Index in order to assess language switch and mixing costs in discourse corpora, based on code-switching frequency (CSS), filled pauses (HS), and speech rate (SR). Progressing from self-reported language history and practices (Study 1), to controlled experimental language assessments of language switching and executive functions (Study 2), and finally to ecological discourse reflecting naturalistic language use (Study 3), the present research captured multiple facets of bilingual language control.

The study was guided by three primary objectives. First, it sought to characterize individual differences in this population, including AoA, proficiency, language dominance, code-switching habits, and LE, and to explore how these factors shape language control in everyday bilingual communication. Second, it aimed to compare constrained to voluntary language switching across experimental and discourse LSPs, testing the hypotheses that switch costs would be higher under constrained conditions and that voluntary switching could reduce these costs. Third, the study examined the relationship between language control and executive functions, investigating whether the observed mechanisms are domain-general or language-specific.

Building on these objectives, the current discussion is organized around four main axes. The first axis considers the impact of switching constraint (cued vs. voluntary) on switch and mixing costs. The second examines how cued and voluntary language control manifests across experimental and more ecological discourse. The third focuses on the role of individual differences in shaping language switch and mixing costs, and the fourth explores the contribution of executive functions to bilingual language control. Together, these sections synthesize the findings across the three phases of the study and offer insights into both the mechanisms and variability of bilingual language control in FCS.

8.1 Cued vs. Voluntary Switching: Costs and Benefits in Bilingual Language Control

Switching between languages incurs two types of processing costs. *Switch costs* refer to the transient effort of changing languages, manifested as longer RT on switch trials compared to stay trials within mixed-language (bilingual) blocks in BPN. They reflect the temporary adjustments required to select the appropriate language on each trial, corresponding to reactive control, and are typically smaller when participants can choose the language themselves rather than when it's externally cued (Arrington & Logan, 2005; Declerck et al., 2013; Festman & Mosca, 2016; Mosca & Clahsen, 2016). In contrast, *mixing costs* capture the sustained demands of managing two languages, manifested as longer RT on stay trials in mixed-language (bilingual) blocks compared to single-language (monolingual) blocks. These costs reflect the ongoing need to maintain both languages active, corresponding to proactive control (Festman & Schwieter, 2015).

In the present study, switch and mixing costs were assessed across three paradigms: BPN, BSF, and a more ecological discourse-based task. In the BPN task, these costs were computed from RT differences, between switch and stay trials for switch costs, and between stay and blocked trials for mixing costs. In the BSF, where RT data were unavailable, costs were calculated from mean fluency scores across conditions. Switch costs represented performance differences between the voluntary and alternate bilingual conditions, while mixing costs were derived by comparing bilingual to monolingual fluency performance. Finally, in the discourse study, based on the ACH (Green & Abutalebi, 2013), a novel measure, the LCI, was developed to quantify control demands in naturalistic discourse. Switch and mixing costs were then computed from LCI differences across interactional contexts, with switch cost defined as the difference between the Dual-Language and Dense CS contexts, and mixing cost as the difference between the Single-Language and Dual-Language contexts.

8.1.1 Hypotheses and General Results

Across all three tasks, the study tested the same two hypotheses regarding switch and mixing costs. First, it was predicted that switch costs would be higher in externally cued conditions compared to voluntary conditions, reflecting the greater control demands when language choice is constrained. Conversely, voluntary switching was expected to reduce switch costs by allowing participants to select the most accessible language at each moment of production. Second, mixing costs were hypothesized to be lower in voluntary switching, with FCS potentially exhibiting a mixing benefit due to the reduced control demands when maintaining two languages active. Although language switching measures were operationalized differently across the three tasks, the underlying logic remained consistent, enabling a transversal examination of the effects of switching constraint on bilingual language control.

Switch costs were generally higher in externally cued or forced-switching conditions than in voluntary conditions, consistent with the formulated switch costs hypothesis and with previous literature using BPN (Costa & Santesteban, 2004; De Bruin et al., 2018; Jevtović et al., 2020). In the BPN task, switch costs were significantly reduced in the voluntary condition relative to the cued condition. In the BSF task, Phase 2 also showed significantly higher switch costs in the alternate condition compared to the voluntary condition, a pattern that persisted in Phase 3. In the ecological discourse task, however, the difference in switch costs between the Dense CS and Dual-Language settings was present, but remained small and non-significant, providing insufficient evidence to support the hypothesis in more naturalistic language use. These findings indicate that voluntary switching effectively reduces switch costs in controlled experimental contexts, whereas its impact in ecological discourse appears more limited.

Mixing costs were generally lower in voluntary switching conditions compared to externally cued or forced-switching conditions, consistent with the formulated hypothesis and with previous literature using BPN (Jevtović et al., 2020). In the BPN task, not only was the mixing cost reduced in the voluntary condition, but also approximately half of participants exhibited a mixing benefit, a finding similar to De Bruin et al. (2018)'s and Jevtović et al. (2020)'s. Additionally, participants with higher L2 proficiency tended to experience smaller mixing costs in the cued condition, contrary to Gollan and Ferreira (2009)'s findings, who found a voluntary mixing benefit in unbalanced bilinguals in the non-dominant language. In the BSF task, Phase 2 showed significantly lower mixing costs in the voluntary condition compared to the alternate condition, supporting the hypothesis. In Phase 3, however, the difference in mixing costs between conditions was present, but remained small and non-significant, potentially because of the smaller sample of participants. In the ecological discourse task, the difference in mixing costs between Dual-Language and Single-Language contexts was minimal and non-significant, providing insufficient evidence to confirm the hypothesis in naturalistic language use. Similar to what has been observed for switch costs, these results indicate that voluntary switching can reduce mixing costs in controlled experimental settings, particularly among more proficient bilinguals, whereas its impact in discourse contexts appears limited.

8.1.2 Variability in Language Switch and Mixing Costs

Several factors may account for the observed differences in switch and mixing costs across tasks, matching previous literature on individual differences in bilingual language control (see Section 2.5).

1. Metrics:
The measures used to compute switch and mixing costs varied across tasks. In the BPN task, costs were based on RT; in the BSF task, they were derived from fluency scores, a novel approach not previously applied in the literature; and in the discourse task, they relied on the LCI, which is based on discursive variables, including code-switching frequency (CSS), filled pauses (HS), and speech rate (SR). Although CSS and HS have been used separately in prior studies (Yim & Bialystok, 2012 and Declerck, Grainger, & Hartsuiker, 2021 for CSS; Declerck, Grainger, & Hartsuiker, 2021 and Sanchez et al., 2022 for HS), no unified metric had previously combined all three measures. These differences in operationalization may have contributed to variability in observed effects.

2. Sample and Task Characteristics:
In BSF Phase 3, the smaller sample and significantly higher fluency scores compared to Phase 2 may have reduced detectable differences. The semantic categories used in Phase 3 could also have influenced results, as broader categories, such as "food," allow for greater word productivity and are less comparable to those used in prior studies.

3. Cognitive Demands:
The BSF task imposes additional executive demands, such as inhibition, mental flexibility, and working memory, which may have affected participants' language switching performance compared to the BPN.

4. Contextual and Technical Factors:
In discourse, multiple interacting factors, including topic, interlocutor, and social norms, affect language control and production. The use of asynchronous video interviews may have produced opposing effects across participants: some may have felt more at ease and opened up in personal event narratives, given

that the interviewer was not actively listening in real time, whereas others may have been inhibited by the lack of immediate feedback. In addition, human errors during annotation, transcription, and error categorization, particularly in BSF and ecological tasks, may have further contributed to variability. The PsychoPy voicekey system and the computer's internal processing speed, along with experimental features in the BPN task including the SOA, CSI, ITI, and RCI (Festman & Mosca, 2016; Mosca, 2017), as well as the timing of the CheckVocal speech identification, may have introduced additional variability.

5. Individual Differences:
Participant characteristics also modulated switch and mixing costs. For example, in the BPN task, higher L2 proficiency was associated with reduced mixing costs, suggesting that more balanced bilinguals are better able to manage Dual-Language demands. L2 proficiency also influenced switch cost (a)symmetry, with more balanced bilinguals exhibiting more symmetrical switch costs, consistent with previous findings (Bonfieni et al., 2019; Costa & Santesteban, 2004; Declerck & Koch, 2023). Other individual factors, such as code-switching habits, language dominance, and entropy, may similarly influence bilingual language control, contributing to variability across participants (these factors are further detailed in section 8.3).

Taken together, these methodological, cognitive, contextual, and individual factors likely explain the differences in switch and mixing costs observed across the three paradigms.

8.1.3 Control Processes in Language Switch and Mixing Costs

Switch costs reflect the transient, trial-to-trial control required to alternate between languages. In externally cued or forced-switching conditions, these costs are higher because participants must activate the target language while inhibiting the non-target language on each trial (Costa & Santesteban, 2004; Green, 1998; Meuter & Allport, 1999). This pattern was observed in the present study: in the BPN task and BSF Phase 2 and 3, switch costs were higher in the cued/alternate conditions than in voluntary conditions, indicating that allowing participants to freely select the language reduces inhibitory demands (De Bruin et al., 2018; Jevtović et al., 2020).

Mixing costs represent sustained control, reflecting the constant activation and monitoring of multiple languages in the background. Voluntary switching typically reduces these costs because bilinguals can flexibly choose the most accessible language, minimizing the sustained effort required to manage two languages simultaneously (Festman & Schwieter, 2015). In the present study, the BPN task showed smaller mixing costs in the voluntary condition, with almost half of participants exhibiting a mixing benefit. Higher L2 proficiency further reduced mixing costs, consistent with prior findings that balanced bilinguals are better able to maintain Dual-Language activation (Bonfieni et al., 2019; Declerck & Koch, 2023).

Beyond the controlled manipulations of switch and mixing costs, certain linguistic and individual factors may have influenced language control processes across tasks. In the BSF, some trials were excluded, principally modalizers (i.e., comments on one's own speech, such as "Oh, I forgot") (Nespoulous, 2010), which occasionally appeared in the other language. These utterances may have functioned as unreported switches, facilitating activation of the non-target language in the following trial. Similarly, in the voluntary condition of the BPN, a few trials were unexpectedly produced in English. Since all participants had English as their L3, this language was likely active in the background, despite not being part of the experimental design. This unintended activation represents a factor beyond experimental control and reflects the natural multilingualism of the participants. Such co-activation could have increased the overall inhibitory demands required to suppress non-target languages, potentially influencing both the transient control reflected in switch costs and the sustained monitoring processes reflected by mixing costs.

According to the ACH (Green & Abutalebi, 2013) and the CPM (Green & Wei, 2014), the different experimental conditions in the present study likely engaged distinct control modes. In the single-language or monolingual conditions, participants operated under a competitive control mode, in which one language is strongly selected while the other is actively inhibited. The dual-language, cued, or alternate conditions also correspond to a competitive control mode, requiring alternation between the languages at syntactic boundaries. Finally, in the Dense CS and voluntary switching conditions, participants likely relied on a cooperative/coupled and open control mode, which allow coordination and parallel activation of languages, flexible selection, and engages opportunistic planning.

Green and Abutalebi (2013) argue that the dual-language mode is the most demanding, as it requires the active management of two languages. This interpretation is consistent with findings from previous research showing increased switch and mixing costs in cued or externally constrained conditions (Costa & Santesteban, 2004; Jevtović et al., 2020), as well as with the present results, where the cued condition also yielded higher costs than other conditions. In contrast, De Bruin et al. (2018) suggest that freely using both languages in a voluntary or Dense CS context may, in fact, be less effortful than maintaining a single language, as the non-target language(s) does/do not need to be inhibited. This reduced control demand aligns with the CPM (Green & Wei, 2014), which proposes that Dense CS engages an open control mode in which both languages remain simultaneously active and accessible, corresponding to the bilingual language mode described by Grosjean (2008). Single-language/monolingual conditions, on the other hand, impose stronger inhibitory demands and tend to elicit longer RT or lower performance. Consequently, balanced bilinguals, and FCS in particular, may exhibit a mixing benefit in voluntary contexts, as lexical retrieval becomes more efficient when both languages can be accessed freely.

Taken together, these results indicate that voluntary switching reduces both transient and sustained control demands, by lowering inhibitory demands on a trial-by-trial basis and decreasing the ongoing monitoring effort needed to maintain multiple languages simultaneously.

8.2 The Effect of Context: Experimental vs. Discourse Bilingual Language Control

As discussed in the previous section (8.1), switch and mixing costs were computed differently across tasks: in the BPN, they were derived from classic RT measures; in the BSF, from adjusted fluency scores; and in the discourse task, from a discourse-based index incorporating code-switching frequency (CSS), filled pauses (HS), and speech rate (SR). These methodological differences in cost computation may partly explain why switch and mixing costs emerged clearly in the experimental tasks but not in the more ecological discourse task.

In fact, the observed differences may also stem from the nature of the task itself: calculating switch and mixing costs at the level of isolated words fundamentally differs from calculating them within continuous discourse, where language alternation occurs more fluidly. Although ACH contexts were controlled for in Study 3 by carefully determining each interlocutor's language knowledge and limiting their speech to reduce interactive alignment effects (Kootstra et al., 2020; Pickering & Garrod, 2004), certain pragmatic and situational factors likely remained beyond experimental control. The asynchronous video format was deliberately used to limit the influence of interlocutor behavior, as it is known that interlocutor actions strongly influence language switching (Kootstra et al., 2020). Nevertheless, the combination of asynchronous modality and unfamiliar interviewers may have created a certain interpersonal distance, leading participants to reduce their monitoring of language use. Furthermore, as observed by Fricke and Kootstra (2016), several factors of variability naturally emerge in discourse-based analyses of language switching, including the presence or absence of code-switching in the interlocutor's speech, the default language of the conversation, the language of the preceding utterance or the preceding ten utterances, speaker change, and lexical overlap with prior utterances in the other language. In the present study, most of these parameters were controlled: the presence of interlocutor switches and speaker change were minimized, and the interviewer's language knowledge determined the default language of the conversation. Yet, some factors, such as the language of the participant's preceding utterances and lexical overlap with prior utterances, depended on participants' own spontaneous speech and could not be controlled, and might have affected their language control.

On another note, the LCI, which was computed using discursive indicators, is a novel approach, although its components have been previously used in the literature to estimate switch and mixing costs (Declerck, Grainger, & Hartsuiker, 2021; Sanchez et al., 2022; Yim & Bialystok, 2012). However, these indicators may be imprecise because they do not exclusively reflect switch or mixing costs. For example, filled pauses, as measured by HS, can indicate lexical retrieval difficulties or longer processing time to recall a word or event, rather than a cost specifically related to language switching. Similarly, SR varies substantially between individuals; slower speech may reflect affective factors, such as introversion, rather than technical or cognitive constraints (Dewaele & Furnham, 1999). While more balanced bilinguals generally show an "increase in speech rate and a decrease in the frequency of pausing" (Huang & Gráf, 2020, p. 57), SR differences between L1 and L2 persist (Derwing et al., 2004; R. J. Morris et al., 2024), and establishing a baseline for SR in Arabic is also necessary (Aldholmi et al., 2021). Regarding CSS, it was likely the most robust indicator of language control costs, as it directly reflects changes in language use. Nevertheless, even code-switching can also occur for reasons other than control, such as to compensate for lexical retrieval difficulties (Awada, 2022; Ezzedine, 2023). Despite these limitations and their potential impurity, discursive indicators remain among the best known measures for assessing language control in bilingual discourse, making the LCI a valuable tool for investigating these processes.

Finally, although the BPN and BSF tasks provide precise, word-level measures of language control and are often assumed to reflect the same processes as naturalistic discourse (see Section 8.1.3), this may not entirely be the case. Experimental tasks focus on lexical retrieval and switching on a trial-by-trial basis, highlighting transient and sustained control under highly structured conditions. In contrast, ecological, discourse-based language use involves continuous, context-dependent speech, where a greater volume of language must be managed, with additional influences from social and affective factors; for instance, how freely a participant chooses to share personal experiences with an unfamiliar interviewer when describing the way they spend their weekend. Consequently, the control processes engaged in naturalistic discourse may be more variable, relying less on discrete inhibitory mechanisms and more on flexible, adaptive management of co-activated languages. As illustrated by the LMH (Grosjean, 2008), co-activation and inhibition can be clearly separated in lab-based, word-by-word LSPs (e.g., monolingual vs. bilingual mode), whereas in spontaneous discourse these processes are better conceptualized as a continuum rather than distinct categories.

8.3 The Influence of Individual Variability on Bilingual Language Control

Beyond task and contextual influences, bilingual language control is also shaped by individual variability, affecting language switch and mixing costs across participants. These factors were examined in Study 1 using three sociolinguistic questionnaires, providing a systematic characterization of Lebanese FCS residing in France, a population that has rarely been studied experimentally. This assessment also yielded continuous measures of bilingual experience, such as LE and CSP, in line with De Bruin (2019)'s recommendation to rely on continuous rather than categorical measures when assessing bilingualism.

Predictor	Outcome	BPN Direction / Significance	Ecological Direction / Significance	Consistent / Opposing
L2 Proficiency	Switch costs	Slightly lower RT / NS	Lower / Sig	Consistent
	Mixing costs	Slightly lower RT / Sig in Cued	Higher / Marginal	Opposing
LOR in France	Switch costs	Slightly lower RT / NS	Higher / Sig	Opposing
	Mixing costs	Slightly lower RT / NS	Lower / Sig	Consistent
CSP	Switch costs	Slightly higher RT / NS	Higher / Sig	Consistent
	Mixing costs	Slightly higher RT / NS	Lower / Marginal	Opposing
LE	Switch costs	Slightly lower RT / NS	Slightly lower / NS	Consistent
	Mixing costs	Slightly lower RT / NS	Slightly higher / NS	Opposing

Table 8.1: Effects of Individual Variability on Switch and Mixing Costs across BPN and Discourse Tasks

NS = Not significant; Sig = Significant ($p < 0.005$); effects with $0.005 < p < 0.05$ are reported as marginal.

The effect of four individual variability factors was assessed in both the BPN and the discourse task using MEMs: L2 proficiency, LOR in France, CSP, and LE. Together, they capture complementary aspects of bilingual experience. Their influence was examined on both switch costs and mixing costs, to determine whether similar individual patterns emerged across the experimental and the more ecological discourse tasks, as reported in Table 8.1.

L2 Proficiency:
Switch costs were consistently reduced across both tasks, indicating that higher L2 proficiency facilitated language switching, reflecting better trial-level reactive control. In contrast, mixing costs showed opposing patterns: participants with higher L2 proficiency exhibited reduced mixing costs in the cued BPN condition, indicating better sustained proactive control in the constrained condition. On the contrary, in the discourse task, mixing costs were slightly larger for more balanced bilinguals, which may reflect increased competition between languages in spontaneous speech, making sustained control more demanding. These patterns suggest that higher L2 proficiency is consistently associated with more efficient reactive control. In contrast, its relationship with proactive control appears context-dependent: L2 proficiency was linked to enhanced proactive control in the experimental task but showed a slight disadvantage in discourse.

LOR in France:
Longer residence in France had minimal effect in the BPN task, but in the discourse task, it increased switch costs while reducing mixing costs, producing opposing patterns across tasks for switch costs

and consistent effects for mixing costs. This pattern potentially indicates that, in spontaneous speech, individuals with longer residence in the L2 country engage less in trial-by-trial reactive control but display more efficient sustained proactive control over the activation of both languages. Prolonged immersion may therefore allow bilinguals to anticipate language demands in discourse through more efficient proactive control, while reactive, trial-by-trial adjustments remain less efficient.

CSP:
Participants who reported more frequent code-switching use in daily life tended to show slightly higher RT in BPN and higher switch costs in the discourse task, indicating consistent effects for switch costs. For mixing costs, the effect was contrary: higher CSP was associated with slightly higher mixing costs in BPN but lower mixing costs in the discourse task. Since switch costs in the discourse task were partly derived from CSS (as well as SR and HS), this pattern likely reflects the fact that individuals with higher CSP do effectively engage in more frequent switching in their discourse, indicating the robustness of the CSP (Olson, 2022) as a subjective measure of daily code-switching. These results also suggest that more frequent code-switchers may experience greater trial-level control demands when switching spontaneously but exhibit more efficient sustained control when maintaining both languages active in natural discourse.

LE:
Entropy showed minimal influence overall, with consistent effects for switch costs (lower in both tasks) and opposing effects for mixing costs (slightly lower RT in BPN, slightly higher in discourse). This minimal effect may be attributed to the relative homogeneity of the participant sample, as all were FCS who exhibited highly integrated language use, reflected by high mean LE and limited variability across individuals. A comparison with a group of more compartmentalized bilinguals who use their languages in more context-dependent ways, could help clarify the role of constraint and interactional context in shaping language control mechanisms.

Overall, these results indicate that some individual variability factors, particularly L2 proficiency and CSP, exerted consistent effects across tasks for switch costs, whereas mixing costs appeared more sensitive to task context, showing both consistent and opposing patterns depending on the predictor.

It should be noted that the significance threshold was set at a strict $p < 0.005$ instead of the conventional 0.05, in order to focus on more robust effects. Consequently, some effects that might be considered significant under the conventional threshold are reported as marginal in Table 8.1, yet they still reflect informative patterns worth considering.

Additionally, it should be emphasized that the calculation of switch and mixing costs was not based on identical measures in the BPN and discourse tasks. While the BPN traditionally relies on RT measures, switch and mixing costs in the discourse task were computed from CSS, SR, and HS. Although some studies have used these measures separately to estimate switch and mixing costs in sentence or discourse bilingual language control (Declerck, Grainger, & Hartsuiker, 2021; Sanchez et al., 2022; Yim & Bialystok, 2012), they remain relatively novel in the literature, and the LCI developed in the present study, which combined the three measures together (CSS, SR, and HS), should therefore be regarded as exploratory.

Lastly, in the BPN task, switch and mixing costs were significant, but the influence of individual differences (L2 proficiency, CSP, LOR, and LE) on these costs was non-significant. In contrast, in the discourse task, switch and mixing costs themselves were not significant, yet individual variability significantly affected these costs. This possibly indicates that, despite their relative artificial nature, experimental tasks yield more robust language switching effects that are less influenced by individual variability, whereas in the discourse task, language control appears to be more sensitive to individual differences, possibly due in part to the smaller sample size in the ecological phase.

8.4 Executive Functions in Bilingual Language Control

The fourth and final axis of this discussion concerns the contribution of executive functions to bilingual language control, with an exploratory examination of the extent to which control mechanisms are domain-general or language-specific. Across the BPN and BSF tasks, both types of control appeared to be at play, as shown by the coexistence of domain-general and language-specific associations between language control measures and executive tasks. This pattern supports the view that bilingual language control is dynamic rather than strictly modular. It aligns with evidence from previous behavioral and neuro-imaging research suggesting partial overlap between language control and general executive control (Lehtonen et al., 2023; Luque & Morgan-Short, 2021; Semenova et al., 2025; Van den Noort et al., 2019).

When interpreted through the framework of Miyake et al. (2000), bilingual language control appears to engage all three core executive components: inhibition, set shifting, and updating, but in task- and context-dependent ways. Nonverbal inhibition may have contributed to general suppression processes shared with non-linguistic control, whereas verbal inhibition seems more specifically tied to lexical control within a given language. Set shifting supported adaptive transitions between languages, reflecting domain-general flexibility that was particularly relevant in voluntary contexts. Verbal short-term memory supported lexical retrieval, reflecting mainly language-specific processes, whereas backward and sequencing digit span (working memory in more complex manipulation tasks) contributed modestly to domain-general control.

Green and Abutalebi (2013) highlighted the need to refine Miyake's model by more clearly specifying these three executive functions, directly testing their contributions in language (speech comprehension and production), and contrasting proactive and reactive control in line with Braver (2012)'s DMC framework. The authors specified eight control processes that govern language control and adapt to the demands of the interactional context: goal maintenance, conflict monitoring, interference suppression, salient cue detection, selective response inhibition, task disengagement and engagement, and opportunistic planning. They illustrated the ACH using a theoretical LSP and the Stroop task, referencing interference effects, but did not provide concrete tools to assess each of the eight control processes in ways that capture both language-specific regulation and the demands of interactional contexts. Consequently, many studies operationalizing the framework rely on standard executive tasks, picture-naming paradigms, and/or self-report measures of language use, which often fail to reflect how control processes are dynamically recruited across contexts and leave the risk of task impurity unresolved (Blanco-Elorrieta & Pylkkänen, 2017; Hartanto & Yang, 2020; Rafeekh & Mishra, 2021; Spinelli & Sulpizio, 2025; Struys et al., 2019). Critiques of the ACH (Paap et al., 2021) further emphasize that generalizing predictions to non-linguistic tasks has produced inconsistent results, underscoring the need for clearer definitions and methods sensitive to both language-specific and context-dependent aspects of control. Accordingly, citing the ACH requires specifying whether reference is made to the eight proposed control processes, the interactional contexts, or ideally both, given that the model was developed to account for their interplay.

In order to address this gap in the literature, it may be useful to shift the focus away from the question of overlap, and instead observe the evidence emerging from bilingual speech, including switch costs, mixing costs, and most importantly discourse-level code-switching, alongside the models of language control currently available. For instance, parallels between the ACH (Green & Abutalebi, 2013), CPM (Green & Wei, 2014), LMH (Grosjean, 2008) provide insights into how language control operates. In single-language contexts, control mechanisms function to inhibit the non-target language while activating the target language, engaging the processes of selective response inhibition, interference suppression, and goal maintenance (ACH), which correspond to a more monolingual-oriented position along the language mode continuum (LMH). According to the CPM, languages in single-language contexts operate in a competitive control mode. As evidenced by the LCI, language control in the Arabic Single-Language setting was the lowest, indicating minimal engagement of these processes in the L1, more specifically goal maintenance, conflict monitoring and interference suppression. On the contrary, control was highest in the French Single-Language setting, suggesting that the stated control processes are more strongly recruited for the L2. This points to a language-dependent modulation of control engagement.

In Dual-Language contexts, bilingual speakers must disengage from one language to engage in another depending on the interlocutors' language knowledge. In these cases, both languages remain partially active, cooperating to allow alternation between speakers (CPM). Dual-Language context operates as long sequences of alternation. Inhibition continues to play a role alternatively, and mental flexibility becomes increasingly important. The LCI was relatively medium in Dual-Language settings, suggesting moderate control: language alternation was managed efficiently between interlocutors, without strong facilitation or interference effects.

In Dense CS contexts, control demands are minimized, corresponding to an open control mode (CPM), while the speaker operates in bilingual language mode (LMH), and opportunistic planning guides the choice of the next word based on lexical availability and memory, resulting in code-switching as insertions or congruent lexicalizations. Salient cue detection is implied in all three contexts, reflecting sensitivity to situation and interlocutor rather than to specific languages. The LCI was around 0 in Dense CS settings, reflecting efficient language use guided by opportunistic planning.

Generally, language control is typically proactive (Braver, 2012), regulating language use by pre-activating or inhibiting the relevant languages. When proactive control is more effortful, it can manifest as hesitations (HS) or slower speech (SR). In the present study, these indices varied across settings. In the Arabic Single-Language setting, language control was relatively high, with fewer hesitations and faster speech, suggesting efficient proactive control. In the French Single-Language setting, control was lower, evidenced by more hesitations and slower speech, reflecting the increased demands of operating in the L2. In the Dual-Language context, control was intermediate, indicating efficient management of language alternation. Finally, in the Dense CS setting, control demands were minimized, with opportunistic planning guiding speech, and HS and SR indicating smooth, low-effort language production.

Conversely, reactive control may intervene after errors or unexpected language use, such as producing a language unknown to the interlocutor. These instances were captured by CSS, which indicated when corrections or compensatory strategies were necessary, in all settings except Dense CS. In the present study, CSS was relatively high in the Arabic Single-Language and Dense CS settings, moderate in the Dual-Language setting, and lowest in French Single-Language. This pattern suggests that reactive control, as inferred from potential post-switch adjustments (which were not reported here), was most engaged when managing L1-dominant speech and least when operating in L2. An actual annotation of post-CSS adjustments would be necessary to more accurately account for effective reactive control.

In sum, although language control may partially overlap with domain-general executive functions, language-specific mechanisms remain that are sensitive to the communicative context and cannot be fully captured by executive tasks, as reflected in both the mixed results in the literature and the present correlational analyses. There is clearly an interplay between language control and domain-general executive functions, but reducing language control to simple executive tasks overlooks its nuances and the language-specific processes that shape communication.

8.5 General Perspectives

Beyond the specific limitations discussed for each study, a few broader considerations should be noted. First, although the three studies together provide a comprehensive picture of bilingual language control among Lebanese FCS, the focus on a relatively homogeneous sample, as reflected by similar LE scores, may limit the generalizability of the findings to other bilingual groups. Second, although using different methods across tasks made the thesis more comprehensive, it also made it harder to directly compare the results. For example, in the experimental language-switching paradigm, switch and mixing costs were significant but not modulated by individual variability, whereas in the discourse task the reverse was observed: costs were non-significant, yet individual variability played a central role. Third, the decision to apply a stricter significance threshold of $p < 0.005$, although consistent with recent recommendations (Benjamin et al., 2018; De Ruiter, 2019) to reduce false positives, may have been overly conservative, potentially obscuring subtle effects and increasing the risk of false negatives. Additionally, future studies could include English as a third active language, as it was the L3 for all participants and may have been activated even when not used, therefore influencing performance in bilingual tasks. Finally, future research could extend this line of work to more diverse bilingual populations and employ this multimethod approach to better capture how control mechanisms evolve across interactional settings.

Chapter 9

Conclusion

The present thesis offered an original contribution to the study of bilingual language control by adopting a multimethod approach that combined sociolinguistic, experimental, and discourse evaluation. This integrative perspective made it possible to capture how control processes operate across contexts ranging from experimental laboratory paradigms to more ecological communication, and to identify the individual factors that shape these mechanisms among Lebanese French–Arabic bilinguals, a population of FCS that remains underexplored in the literature.

The sociolinguistic investigation (Study 1) provided a detailed profile of participants' language experience and use. In line with recent recommendations to consider continuous rather than categorical measures of bilingualism (De Bruin, 2019), continuous indices were used to capture individual variability, including relatively recent measures such as LE and CSP. Participants typically reported Arabic as their L1, French as their L2, and English as their L3, and this pattern was mirrored in both AoA and dominance. They exhibited high self-rated proficiency across all three languages, relatively homogeneous and high LE values, and average CSP. This linguistic configuration reflects the sociolinguistic reality of the Lebanese context, where multiple languages coexist and are used in a highly integrated manner through frequent code-switching, despite data collection being conducted among Lebanese speakers residing abroad. These individual differences, as later observed, modulated switch and mixing costs differently across the experimental and discourse phases, having a more pronounced impact on discourse.

The experimental results from Study 2, drawn from the BPN and BSF tasks, revealed lower switch and mixing costs in voluntary compared to constrained conditions, providing empirical support for the view that free language switching is less effortful for Lebanese FCS than more constrained switching. This aligns with evidence that voluntary switching may reflect a more natural mode of control for FCS, shaped by frequent switching in daily life (De Bruin et al., 2018; Jevtović et al., 2020). Regarding the nature of control, results did not provide conclusive evidence for a purely domain-general or language-specific account. Instead, they pointed to a partial overlap and an interactive relationship between both levels of control. This underscores the need to operationalize Green's (2013) eight control processes and to develop more precise tools that can assess their contribution to both executive and language-specific control across different interactional contexts.

The discourse tasks (Study 3) extended this investigation into a more ecological context. Although no statistically significant switch or mixing costs were observed, a novel Language Control Index (LCI) was developed to approximate such costs at the discourse level, incorporating the indices of code-switching frequency (CSS), hesitation markers (HS), and speech rate (SR). This innovative metric offers a valuable starting point for capturing bilingual control mechanisms in discourse, and can be applied to other populations and contexts.

Importantly, individual differences played a much stronger role in discourse than in experimental performance. L2 proficiency, LE, CSP, and LOR in France had minimal influence on experimental costs but significantly affected discourse-based measures, highlighting the context-dependent nature of bilingual control.

Altogether, these findings suggest that bilingual language control is dynamic, task-sensitive, and shaped by both situational and individual variability. While experimental paradigms capture momentary control processes operating under structured conditions, naturalistic discourse reflects a more adaptive form of regulation that adjusts to the interactional and situational context. This thesis therefore contributes to bridging the gap between laboratory-based and discourse-based perspectives on bilingualism, showing that a comprehensive understanding of language control requires adopting a multimethod approach. The present findings further indicate that understanding how bilinguals manage their languages goes beyond general executive control, as language regulation also depends on other factors. Control processes emerge from the interplay between internal mechanisms and the communicative contexts in which languages are used. By combining sociolinguistic profiles, experimental paradigms, and discourse-based analyses, this work provides an integrative framework for future research seeking to capture the complex and multifaceted nature of bilingual language control.

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French Summary of the Thesis
Résumé français de la thèse

Adoptant une approche multiméthode, ce travail avait trois objectifs principaux, réalisés à travers trois études consécutives et complémentaires : premièrement, dresser un profil sociolinguistique détaillé des bilingues libanais résidant en France et pratiquant fréquemment le code-switching, en prenant en compte des facteurs individuels tels que la dominance linguistique, l'âge d'acquisition et les habitudes de code-switching. Deuxièmement, étudier comment ces individus alternent les langues dans des conditions à la fois contraintes et libres, en comparant leurs performances en contexte expérimental et écologique via les coûts de changement et de mélange (*switch* et *mixing costs*). Troisièmement, explorer le lien entre le contrôle des langues et le contrôle exécutif, en testant si les mécanismes soutenant le contrôle de langues sont généraux ou spécifiques à la langue.

Comme l'expérience bilingue est très hétérogène, une description approfondie de la population cible s'est avérée essentielle dès le départ. Conformément aux recherches antérieures, des mesures continues telles que la dominance, l'âge d'acquisition, ainsi que l'entropie et les habitudes de code-switching, permettent de rendre compte de la manière la plus précise possible de l'expérience bilingue (De Bruin, 2019; Gullifer & Titone, 2020; Olson, 2022). Au Liban, cependant, les travaux dans ce domaine restent rares : si certains auteurs ont documenté les bases historiques, éducatives et sociales du bilinguisme (Kanaan, 2011; Shaaban, 2017), aucune description complète du profil sociolinguistique détaillé de la population n'a été réalisée. Pour combler cette lacune, nous avons élaboré un questionnaire à grande échelle visant à recueillir ces caractéristiques sociolinguistiques auprès d'individus libanais résidant en France. Étant donné la situation politique et économique au Liban, il était plus faisable de recruter des participants vivant en France.

Dans un deuxième temps, comme le suggèrent de nombreuses recherches sur le contrôle des langues au cours de la dernière décennie, les paradigmes expérimentaux autour du code-switching sont devenus l'un des outils comportementaux les plus utilisés pour évaluer les coûts associés au changement de langues (Declerck & Philipp, 2015; Festman & Schwieter, 2015). S'appuyant sur cette approche, la deuxième partie de la recherche a consisté à collecter des données expérimentales en laboratoire auprès de participants libanais afin d'examiner les *switch* et *mixing costs*, en s'intéressant particulièrement à la question de savoir si changer de langue librement serait moins coûteux cognitivement pour cette population de code-switchers fréquents par rapport à un changement plus contraint (De Bruin et al., 2018; Jevtović et al., 2020; Kennis et al., 2025). Ces tâches expérimentales ont été complétées par des mesures des fonctions exécutives, afin de tester si les performances en switchant de langue sont liées aux performances exécutives des participants. Il s'agit d'une question encore débattue dans la littérature, notamment en lien avec l'hypothèse de l'avantage bilingue, qui postule que les bilingues auraient de meilleurs performances exécutives grâce à leur pratique régulière de changement de langue (Donnelly, 2016; Mattschey, 2023).

Dans un troisième temps, plusieurs auteurs (Blanco-Elorrieta & Pylkkänen, 2017; Kootstra et al., 2020; Yim & Bialystok, 2012) ont constaté que les expériences en laboratoire ne rendent pas pleinement compte de la réalité du changement de langue dans la vie quotidienne, car elles sont artificielles et reposent généralement sur la production de mots isolés plutôt que sur des données de discours. Pour pallier cette limite, nous avons mené une expérience plus écologique de discours inspirée de l'hypothèse du contrôle adaptatif (Green & Abutalebi, 2013), au cours de laquelle les participants ont réalisé des tâches simulant différentes situations communicatives nécessitant des types variés d'usage et de contrôle des langues. Pour analyser ces données, nous avons introduit un nouvel Indice de Contrôle des Langues (LCI) afin de quantifier les coûts de changement de langue (*switch* et *mixing costs*) au cours du discours.

La thèse est divisée en deux parties principales: la première concerne la revue de la littérature, et la seconde présente les trois études expérimentales. Dans la première partie, la section 9.1.1 décrit les aspects généraux du bilinguisme, incluant définitions, typologies et contexte libanais, en évoquant les pratiques historiques, éducatives et sociales. La section 9.1.2 traite du contrôle des langues en lien avec le code-switching, incluant les modèles théoriques principaux, l'évaluation expérimentale et les sources de variabilité individuelle. La section 9.1.3 est une revue des recherches sur la généralité versus la spécificité du contrôle. Dans la seconde partie, la section 9.2.1 présente les objectifs de recherche. La partie expérimentale détaille les trois études consécutives, chacune faisant l'objet d'un chapitre dédié détaillant la méthode, l'analyse des données, les résultats, la discussion et les limites et perspectives. Enfin, la section 9.2.5 propose une discussion trans-études pour synthétiser l'ensemble des résultats et leurs implications.

9.1 Revue des mécanismes de contrôle des langues : perspectives issues du code-switching chez les bilingues

9.1.1 Comprendre le bilinguisme : fondements théoriques et réalités libanaises

9.1.1.1 Bilinguisme : définitions et classifications

Le bilinguisme est abordé à travers différentes typologies, reflétant les diverses manières dont les individus acquièrent et utilisent plusieurs langues.

Certaines distinctions s'appuient sur la temporalité de l'acquisition des langues, à travers notamment l'âge d'acquisition de la L2. Le bilinguisme peut ainsi être précoce ou tardif, selon que les langues sont acquises avant ou après la petite enfance. Il peut également être simultané ou séquentiel, selon que les langues sont acquises en même temps ou l'une après l'autre.

Les définitions basées sur la dominance se rapportent à la langue la mieux maitrisée par un individu, la maitrise étant basée sur la compétence linguistique et la rapidité de traitement (Kohnert et al., 2020), ainsi qu'à l'usage des langues (Treffers-Daller, 2016). En fonction de la compétence, on distingue ainsi des bilinguismes plutôt équilibrés ou dominants dans une langue.
On évoque ensuite la distinction entre bilinguisme composé et coordonné de Ervins and Osgood (1954). Plus récemment, le concept de l'entropie linguistique (LE) développé par Gullifer and Titone (2018, 2020) mesure la diversité de l'usage des langues dans différents contextes. Ce dernier, particulièrement intéressant par rapport au contrôle des langues, distingue des usages plus compartementalisés lorsque chaque langue est limitée à un usage spécifique dans des contextes précis, et des usages plus intégrés impliquant un usage flexible et mixte des langues avec code-switching fréquent.

Les approches récentes du bilinguisme tendent à remplacer les classifications catégoriques par une perspective plus continue. De Bruin (2019) souligne l'importance de prendre en compte les facteurs de variation individuelle, tels que l'âge d'acquisition, la compétence, l'usage et les habitudes de code-switching, et met en avant l'intérêt de l'entropie linguistique pour mieux prendre en compte les différences subtiles entre bilingues. Divers outils et méthodes, allant des questionnaires aux analyses conversationnelles, permettent d'établir une classification plus continue et nuancée de l'expérience bilingue.

9.1.1.2 Le bilinguisme au Liban

La situation historique, géographique et politique du Liban a favorisé un environnement multilingue riche, où l'arabe libanais, le français et l'anglais coexistent et se mélangent dans les conversations quotidiennes, tandis que d'autres langues minoritaires comme l'arménien, le turc et le kurde contribuent également à la diversité linguistique du pays.

La position stratégique du Liban à la croisée de l'Orient et de l'Occident, combinée à un contexte historique et sociopolitique favorable, a façonné son caractère multiculturel et multilingue. Après vingt-trois ans sous le mandat français (1920–1943), le français a été établi comme langue co-officielle aux côtés de l'arabe, et, bien que ce statut ait été supprimé, il conserve jusqu'aujourd'hui une forte présence dans l'enseignement, notamment dans les écoles privées et les missions religieuses. L'anglais, introduit dès le XIX siècle par des missionnaires américains, a progressivement gagné en importance avec la mondialisation et est devenu une langue de plus en plus dominante dans l'éducation, notamment dans les écoles anglophones et les universités, rivalisant aujourd'hui avec le français dans l'enseignement supérieur et plus généralement dans l'usage des langues au Liban (Abou, 1962; Bacha & Bahous, 2011; Kanaan, 2011; Shaaban, 2017).

La situation diglossique de l'arabe au Liban se caractérise par la dominance de l'arabe libanais dans la communication quotidienne et les médias, tandis que l'arabe standard moderne reste la variété institutionnelle et scolaire, avec le français et l'anglais souvent utilisés dans l'enseignement, l'administration et les discours publics (Bassam, 2022; Bizri, 2013; Shaaban & Ghaith, 1999).

Au Liban, l'arabe libanais est généralement la première langue acquise dès la petite enfance, tandis que le français et/ou l'anglais sont introduits à l'école dès la maternelle ou dans certains foyers dès la naissance, dans un contexte éducatif trilingue où l'enseignement des langues étrangères commence dès le CP avec une deuxième langue ajoutée vers la CM1 ou CM2 selon les établissements, et où l'usage des langues varie entre matières scientifiques et littéraires, et entre écoles publiques ou privées (Esseili, 2014; Hreich et al., 2022; Thonhauser, 2001). Dans le contexte libanais, l'usage des langues va bien au-delà de l'éducation, l'arabe, le français et l'anglais étant omniprésents dans la vie publique, les panneaux publicitaires, les documents officiels et les médias, favorisant ainsi un environnement où le multilinguisme est une réalité quotidienne (Baidoun, 2018; Grosjean, 1982; Smairat, 2020). De plus, les idéologies linguistiques sont fortement influencées par des facteurs historiques, culturels et socio-économiques : l'arabe incarne l'identité nationale et domine les contextes culturels et religieux, le français est associé au prestige social et à la culture, tandis que l'anglais est perçu comme une langue mondiale offrant des opportunités professionnelles, particulièrement pour les jeunes générations et la mobilité internationale (Bahous et al., 2014; Shaaban & Ghaith, 2002).

9.1.1.3 Contact des langues et pratiques de code-switching au Liban

Le code-switching désigne l'alternance entre deux langues ou plus, ou entre différentes variétés ou dialectes, au sein d'un même événement communicatif, d'une phrase ou d'un tour de parole, sans enfreindre les règles grammaticales de chacune des langues impliquées ; il peut se produire entre phrases (interphrastique), à l'intérieur d'une phrase ou même d'un constituant (intraphrastique). Le terme *code-mixing* est parfois utilisé comme synonyme, mais certains auteurs le définissent plus précisément comme une forme d'alternance intraphrastique combinant des unités linguistiques provenant de systèmes grammaticaux distincts (Gumperz, 1982; Poplack, 1980; Wei, 2000).

Le *code-switching* est une pratique courante et naturelle au Liban, reflétant l'identité multilingue du pays, où l'alternance entre l'arabe libanais, le français et l'anglais se produit dans divers contextes sociaux, y compris la vie académique et la communication quotidienne, motivée par des facteurs structurels, pragmatiques et interactionnels, et se manifeste aussi bien dans les médias, l'éducation et les échanges numériques, souvent de manière inconsciente et habituelle (Baidoun, 2018; Bassam, 2017; Bassam, 2022; Smairat, 2020).

Les attitudes envers le *code-switching* au Liban sont globalement positives, en particulier chez les jeunes étudiants universitaires, même si des inquiétudes persistent quant à la possible perte de l'usage exclusif de l'arabe, notamment avec l'essor de l'*Arabizi*. Cette pratique est néanmoins valorisée pour ses fonctions expressives et communicatives, et reflète un bilinguisme intégré où les langues sont utilisées de manière flexible dans différents contextes, plutôt qu'un bilinguisme compartementalisé (Bahous et al., 2014; Bassam, 2022; Diab, 2009; Esseili, 2017; Gullifer & Titone, 2020; Shaaban & Ghaith, 2002).

9.1.1.4 Evaluation du bilinguisme et du code-switching

L'évaluation du bilinguisme et des habitudes de *code-switching* nécessite une approche multidimensionnelle combinant des outils objectifs et subjectifs ainsi qu'une analyse de corpus.

L'évaluation subjective du bilinguisme repose sur des auto-évaluations portant sur l'histoire linguistique (âge d'acquisition, contextes d'apprentissage, fréquence d'usage), la dominance et les attitudes envers l'utilisation des langues, permettant de construire des profils sociolinguistiques détaillés. Des questionnaires tels que le LEAP-Q, le LHQ, le LSBQ, le BLP ou le BCSP sont utilisés pour mesurer la compétence, l'usage et les habitudes de *code-switching*. Chez les «*Frequent Code-Switchers*» (FCS), ceux-ci révèlent une exposition précoce, une maîtrise élevée des langues et une utilisation flexible selon les contextes (Anderson et al., 2018; Birdsong et al., 2012; P. Li et al., 2006; Marian et al., 2007; Olson, 2022).

L'évaluation objective du bilinguisme repose sur des tests standardisés, tels que le TOEFL, l'IELTS ou le DELF, qui attribuent un niveau CECR pour mesurer globalement la compétence linguistique, tandis que des instruments comme LexTALE ou DIALANG ou OSCAR permettent une évaluation rapide du vocabulaire. Le test OSCAR permet une évaluation multidimensionnelle et adaptable, incluant vocabulaire, grammaire et compréhension, et fournit un niveau CECR ainsi qu'un score continu reflétant plus fidèlement le spectre des compétences linguistiques (Centre d'Étude de Langues, 2025; Lemhöfer & Broersma, 2012; Olson, 2024).

L'évaluation basée sur les corpus complète les approches subjectives et objectives en analysant l'usage effectif des langues dans le discours, incluant la richesse lexicale, l'accent, et l'usage du *code-switching*, à partir de conversations spontanées ou semi-spontanées, offrant ainsi une mesure écologique et détaillée des interactions bilingues, comme le montrent les corpus arabes incluant le *code-switching* entre l'arabe et le français et/ou l'anglais (Baidoun, 2018; Bassam, 2017; El Samaty, 2002; Hamed et al., 2024; Mubarak et al., 2021; Xi, 2017).

9.1.2 Le code-switching comme fenêtre sur le contrôle des langues

9.1.2.1 Contrôle des langues: définition et portée

Chez les bilingues, le contrôle des langues désigne la capacité à gérer les systèmes linguistiques concurrents lors de la production et de la compréhension du langage, en sélectionnant la langue cible et en inhibant la langue non cible, grâce à des mécanismes dynamiques d'activation, d'inhibition, de sélection et de suppression des interférences (Branzi et al., 2016; Declerck & Philipp, 2015; Green, 1986, 1998; Mishra, 2018).

Les études neurocognitives montrent que le contrôle des langues bilingue fonctionne en temps réel, mobilisant des réseaux cérébraux frontaux et centraux pour sélectionner la langue cible et minimiser les interférences de la langue non cible. Les études en IRM fonctionnelle indiquent que le cortex cingulaire antérieur (ACC) contrôle les conflits linguistiques, le cortex préfrontal dorsolatéral (DLPFC) soutient le contrôle proactif, et la zone pré-supplémentaire motrice (pre-SMA) facilite le changement de tâche. Les potentiels évoqués (EEG) révèlent l'engagement de processus inhibiteurs, modulés par l'expérience et les habitudes de *code-switching*, soulignant un système flexible adaptatif impliqué dans la production et la compréhension langagières (M. Chen et al., 2021; Gosselin & Sabourin, 2021; Jiao et al., 2022; S. Liu et al., 2023).

9.1.2.2 Les modèles théoriques du contrôle des langues

Au cours des trente dernières années, l'essor grandissant du bilinguisme a fait du contrôle des langues un thème central de recherche, donnant lieu à des modélisations visant à expliquer les mécanismes cognitifs et neuronaux qui le sous-tendent. La présente revue se concentre plus particulièrement sur les modèles du contrôle dans la production bilingue.

L'Hypothèse du Mode Langagier (LMH) (Grosjean, 1997b, 2008, 2024) propose que les bilingues évoluent sur un continuum allant d'un mode monolingue à un mode bilingue, selon le contexte, l'interlocuteur et l'intention de communication. Les études empiriques (Dewaele, 2001) montrent que les situations informelles favorisent davantage le *code-switching* (mode bilingue), tandis que les contextes formels renforcent l'usage d'une seule langue (mode monolingue). Ces observations soutiennent l'idée que l'activation des langues dépend à la fois de facteurs contextuels et de mécanismes de contrôle interne.

Le Modèle du Contrôle Inhibiteur (ICM) (Green, 1998) propose que le contrôle des langues chez les bilingues repose sur l'interaction entre le conceptualiseur, le Système Attentionnel Superviseur (SAS) et les schémas de tâches linguistiques. Le SAS sélectionne le schéma approprié (« parler en L1 », « traduire en L2 »), qui active la langue cible tout en inhibant la langue non cible. Ce mécanisme d'inhibition explique notamment pourquoi le retour à la langue dominante est souvent plus difficile, en raison de l'inhibition résiduelle.

L'Hypothèse du Contrôle Adaptatif (ACH) (Green & Abutalebi, 2013) propose que les processus de contrôle des langues s'ajustent dynamiquement en fonction du contexte interactionnel, c'est-à-dire de la manière dont les bilingues utilisent leurs langues dans la vie quotidienne. Green et Abutalebi (2013) distinguent trois types de contextes principaux :

- **Contexte monolingue** : une seule langue est utilisée dans un environnement spécifique, tandis que l'autre est réservée à un autre domaine (par exemple L1 à la maison, L2 au travail). Les exigences de contrôle sont faibles, car une seule langue est activée et le besoin d'inhibition ou de détection des conflits est limité.
- **Contexte bilingue duel (Dual-Language)** : les deux langues sont actives dans le même environnement, mais utilisées avec des interlocuteurs différents (par exemple anglais avec un collègue de travail, français avec le partenaire, présents dans un même contexte de communication). Ce contexte impose les plus fortes exigences de contrôle, car il faut maintenir les deux langues actives, détecter les signes contextuels pertinents, et ajuster l'usage de la langue en fonction de l'interlocuteur.
- **Contexte de code-switching dense** : les deux langues sont employées au sein d'une même phrase ou énoncé, souvent avec des fusions lexicales ou morphologiques (par exemple *Bonjour-ein* en arabe libanais-français). Ici, le contrôle favorise une planification opportuniste, permettant une intégration fluide des deux systèmes linguistiques et une flexibilité accrue dans la production.

Dans ces contextes, huit processus de contrôle interconnectés régulent l'usage des langues :

1. **Maintien du but (*Goal Maintenance*)** : conserver l'objectif communicatif en mémoire malgré la compétition des langues.
2. **Surveillance du conflit (*Conflict Monitoring*)** : détecter la compétition entre réponses potentielles dans les deux langues.
3. **Suppression des interférences (*Interference Suppression*)** : inhiber les représentations non pertinentes au niveau lexical, syntaxique ou sémantique.
4. **Détection d'indices saillants (*Salient Cue Detection*)** : repérer des signaux contextuels indiquant un changement de langue (par exemple arrivée d'un nouvel interlocuteur).
5. **Inhibition sélective des réponses (*Selective Response Inhibition*)** : bloquer une réponse dominante lorsqu'une autre est plus appropriée.
6. **Désengagement de la tâche (*Task Disengagement*)** : désactiver la langue précédemment utilisée pour éviter les interférences.
7. **Engagement de la tâche (*Task Engagement*)** : activer la langue cible pour la poursuite de la communication.
8. **Planification opportuniste (*Opportunistic Planning*)** : utiliser de manière flexible les ressources disponibles pour atteindre les buts communicatifs.

Ainsi, l'ACH montre que le contrôle des langues est un système adaptatif : il s'ajuste selon les exigences contextuelles et le degré d'intégration entre les langues du locuteur.

Le modèle des processus de contrôle du *code-switching* (CPM) (Green & Wei, 2014) explique la manière dont les bilingues régulent la sélection des langues lors de la planification du discours grâce aux schémas de tâche linguistique (*language task schemas*). Trois modes de contrôle sont distingués :

- Contrôle compétitif (*Competitive Control*) : une seule langue est activée, les autres sont inhibées. C'est le contrôle typique des contextes monolingues ou alternances interphrastiques (*intersentential switching*).
- Contrôle coopératif couplé (*Coupled/Cooperative Control*) : la langue dominante permet un accès contrôlé à la langue secondaire (*subordinate/embedded language*) pour des insertions planifiées (*planned insertions*).

- Contrôle coopératif ouvert (*Open Control*) : les deux langues sont actives, les éléments lexicaux les plus activés entrent librement dans le plan du discours, favorisant un code-switching dense (*dense code-switching*).

L'ICM, le LMH et l'ACH reposent sur le concept de contrôle proactif, focalisé sur l'inhibition et la régulation contextuelle, tandis que le CPM combine contrôle proactif, anticipant les objectifs de la tâche (*task goals*) à l'avance, et contrôle réactif, supprimant dynamiquement les candidats lexicaux interférents. Ces deux modes proactif et réactif ont été développés dans le modèle des mécanismes duels de contrôle (DMC) (Braver, 2012; Chiew & Braver, 2017), qui distingue leur temporalité cérébrale, le contrôle proactif étant soutenu et anticipatoire, et le contrôle réactif étant déclenché à la demande après détection de conflit.

9.1.2.3 Code-switching et exigences de contrôle

Le *code-switching* chez les bilingues se manifeste sous différentes formes/types et implique des demandes de contrôle variées. Il peut être inter- ou intraphrastique (Poplack, 1980), ou selon Muysken (1997), impliquer alternance, insertion ou lexicalisation congruente, chaque type modulant différemment les mécanismes de contrôle des langues.

Le *code-switching* consiste en l'insertion en temps réel de mots, expressions ou phrases d'une langue dans une autre au sein d'un même énoncé, souvent pour des fonctions pragmatiques ou identitaires, tandis que le *code-mixing* correspond à l'intégration de différentes unités linguistiques, comme des morphèmes ou des affixes, dans la structure lexicale d'une langue. Les emprunts, en revanche, se caractérisent par une utilisation stable et intégrée de mots ou de structures d'une langue dans une autre, allant de simples mots (*loanwords*) à des changements morphosyntaxiques ou phonologiques profonds (*loanblend* et *loanshift*), et sont souvent employés même par des locuteurs monolingues (Bokamba, 1989; Gumperz, 1982; Thomason & Kaufman, 1988; Treffers-Daller, 2010; Treffers-Daller, 2025).

Le *code-switching* mobilise la gestion simultanée de deux systèmes linguistiques, mobilisant activation, inhibition et sélection. Dans la situation monolingue (LMH/ACH), seule une langue est activée et le contrôle compétitif (CPM) est nécessaire, sans *code-switching*. Dans la situation bilingue avec code-switching dense, le contrôle ouvert (CPM) permet des insertions/*code-switching* intraphrastique et des lexicalisations congruentes, tandis que les modes intermédiaires mobilisent un contrôle coopératif/couplé (CPM) pour l'alternance/*code-switching* interphrastique entre langues. Ces différences sont expérimentalement réflétées dans les paradigmes de switching, dans la condition contrainte qui nécessite de rapidement contrôler la langue active en réponse à un indice externe, ainsi que dans la condition libre qui repose sur une alternance libre entre les langues (Declerck & Philipp, 2015).

Les paradigmes expérimentaux d'alternance des langues (*Language switching paradigms*; LSP), dérivés du Task Switching Paradigm (Rogers & Monsell, 1995), évaluent le traitement bilingue via des tâches de dénomination de couleurs, d'images, de nombres. Ils comportent des blocs monolingues, servant de niveau de référence, et des blocs bilingues où les participants alternent entre langues selon une séquence prédéterminée ou aléatoire, engageant davantage les mécanismes de contrôle lors des essais de *switch*. On distingue deux types d'essais : les essais de répétition (*stay*) où deux items consécutifs sont nommés dans la même langue, et les essais de *switch* où deux items consécutifs doivent être nommés dans des langues différentes (Declerck & Philipp, 2015; Festman & Schwieter, 2015).

On identifie deux coûts principaux dans les LSP : le *switch cost*, qui correspond au temps additionnel lors du passage d'une langue à l'autre au sein des blocs bilingues, et le *mixing cost*, qui reflète le temps additionnel de maintenir deux langues actives au sein des essais de répétition (*stay trials*), par rapport à des blocs monolingues. Ces coûts traduisent l'engagement des mécanismes de contrôle proactif et réactif, observés notamment via des effets comme le "*reversed language dominance effect*", "*blocked language order effect*", "*asymmetrical switch costs*", "*n−2 language repetition costs*". Mais ces coûts ne se manifestent pas uniquement au sein de paradigmes expérimentaux contrôlés, mais aussi dans des contextes plus écologiques de discours. Des études récentes (Faroqi-Shah & Wereley, 2021; Fricke & Kootstra, 2016; Kootstra et al., 2020; Yim & Bialystok, 2012) montrent l'importance d'évaluer le *code-switching* dans des contextes écologiques, allant de la production de phrases courtes à des conversations semi-structurées ou à des corpus de grande taille. Ces approches révèlent que les *switch* et *mixing costs* persistent en situation écologique et que des facteurs tels que l'usage précédent de la langue, les indices lexicaux et le comportement de l'interlocuteur influencent fortement la fréquence et la fluidité du *code-switching*.

9.1.2.4 Sources de variabilité dans le contrôle des langues

Le contrôle des langues chez les bilingues varie selon des facteurs liés aux paramètres expérimentaux, comme le temps de préparation ou l'intervalle entre l'indice et le stimulus (Festman & Mosca, 2016; Mosca, 2017) et des caractéristiques individuelles, telles que la maîtrise et la dominance des langues, l'âge d'acquisition, l'usage quotidien et les habitudes de *code-switching* (Birdsong et al., 2012; Bonfieni et al., 2019; Declerck & Koch, 2023; Kheder & Kaan, 2021). Des mesures comme l'entropie (Gullifer & Titone, 2020) quantifient la diversité d'utilisation des langues dans différents contextes, tandis que des variables sociales et biographiques (âge, sexe, niveau d'éducation, motivation et acceptation du *code-switching*) (Dewaele & Wei, 2014; Smairat, 2020; Yim & Clément, 2021) influencent également la manière dont les bilingues contrôlent leurs langues.

9.1.3 La généralité vs. spécificité du contrôle des langues

Un débat persistant dans la littérature porte sur la relation entre le contrôle des langues et le contrôle exécutif : les mécanismes de contrôle mobilisés par les bilingues sont-ils spécifiques au langage ou dépendent-ils de fonctions exécutives générales? Les modèles tels que l'ICM et l'ACH suggèrent que plusieurs processus de contrôle interviennent dans l'usage de deux langues, mais la façon dont ces processus sont mis en place, soit dans des tâches exécutives générales, soit dans des contextes linguistiques spécifiques, varie selon les études. Cette ambiguïté conceptuelle, appelée par Green et Abutalebi (2013) «*dynamics of control*», contribue à la controverse persistante sur le caractère linguistique ou général de ces mécanismes.

Selon Miyake et al. (2000), le contrôle exécutif général se compose de trois fonctions interdépendantes: l'inhibition, la flexibilité mentale et la mémoire de travail, qui permettent de supprimer des réponses dominantes, d'alterner entre différentes tâches et de manipuler activement l'information pertinente en mémoire.

Au contraire, selon l'hypothèse de la généralité du contrôle (*domain-generality hypothesis*), l'avantage bilingue suppose que la gestion continue de deux langues renforcerait les fonctions exécutives des bilingues par rapport aux monolingues. Toutefois, malgré de nombreuses études portant sur le sujet (Bialystok et al., 2012; De Bruin et al., 2021), les résultats demeurent contradictoires : plusieurs travaux suggèrent un effet positif du bilinguisme, mais d'autres, prenant en compte les biais de publication et les variables confondantes, concluent à une absence d'avantage significatif (Lehtonen et al., 2018; Paap et al., 2015).

Selon l'hypothèse de la spécificité du contrôle (*language specificity hypothesis*), la gestion des langues chez les bilingues reposerait sur des mécanismes propres au langage, distincts des fonctions exécutives générales. Les huit processus proposés par Green and Abutalebi (2013) (maintien du but, détection d'indices saillants, planification opportuniste, etc.) illustrent cette spécificité selon le contexte interactionnel. Des études récentes soutiennent cette perspective en montrant une dissociation entre les performances linguistiques et non linguistiques (Lehtonen et al., 2023) ainsi que des activations cérébrales distinctes lors du *code-switching* (Jiao et al., 2022).

Les résultats empiriques sur le lien entre contrôle des langues et contrôle exécutif général demeurent hétérogènes, variant selon la méthodologie, les tâches et le profil des participants. Certaines études suggèrent un chevauchement partiel entre les deux domaines (Jiao et al., 2022; Timmer et al., 2019), tandis que d'autres mettent en évidence des réseaux et des processus distincts (Wolna et al., 2024), modulés par le contexte, l'âge et la compétence linguistique. Dans l'ensemble, les données récentes indiquent que le contrôle bilingue repose à la fois sur des mécanismes de contrôle exécutif général et des mécanismes spécifiques au langage, dont l'implication varie selon les exigences de la tâche.

9.2 Étudier le contrôle des langues chez les bilingues : perspectives sociolinguistiques, expérimentales et discursives

9.2.1 Objectifs de la recherche

La présente étude a été structurée en trois phases consécutives, visant à examiner en profondeur le *code-switching* chez les bilingues switchant fréquemment (FCS). Le protocole expérimental a progressé de mesures subjectives vers des évaluations objectives en laboratoire, incluant les LSPs et les fonctions exécutives, pour aboutir à des récits plus écologiques fondés sur le modèle du contrôle adaptatif (ACH) (Green & Abutalebi, 2013). Cette approche multiméthode vise à pallier le manque de compréhension de la manière dont les différences individuelles (âge d'acquisition, compétence, dominance, habitudes de *code-switching*, entropie linguistique, etc.) influencent le contrôle des langues chez les FCS, en combinant des mesures expérimentales et discursives recueillies auprès des mêmes participants.

Trois objectifs principaux ont guidé cette recherche :

1. **Explorer l'influence des facteurs individuels sur le comportement de code-switching**, en offrant une description détaillée d'une population de FCS jusqu'ici peu étudiée, particulièrement pertinente compte tenu de son contexte socioculturel et de ses alternances quotidiennes entre l'arabe libanais, le français et/ou l'anglais (Phase 1).
2. **Comparer le code-switching contraint et libre**, à la fois dans des contextes de laboratoire contrôlés et dans des contextes de discours plus écologiques (Phases 2 et 3), afin de tester deux hypothèses générales :
    - Le *code-switching* entraîne un *switch cost*, se traduisant par une baisse de performance lorsqu'un participant change de langue par rapport à une situation où il reste dans la même langue. Il est estimé que ce coût est plus élevé dans les conditions contraintes que

dans les conditions libres, où les participants disposent d'une plus grande liberté pour sélectionner la langue la plus accessible, réduisant ainsi les demandes de contrôle.

- Le mélange de plusieurs langues dans un même contexte entraîne un *mixing cost*, se traduisant par une baisse de performance dans les essais *stay* d'une condition bilingue comparée au essais d'une condition monolingue. Cet effet est généralement observé dans les situations contraintes et réduit dans les situations libres. Les FCS peuvent même présenter un *mixing benefit*, comme prédit par De Bruin et al. (2018), où la performance s'améliore grâce à la liberté du choix de la langue, permettant la sélection de la langue la plus accessible au moment de la dénomination.

3. **Examiner le lien entre le contrôle des langues et le contrôle exécutif**, en évaluant si les mécanismes sous-jacents sont d'ordre général ou spécifiques au langage, à travers des corrélations entre les performances aux LSPs et aux mesures de fonctions exécutives (Phase 2).

Une illustration détaillée des tâches utilisées dans les trois phases de cette recherche est présentée dans la Figure 9.1.

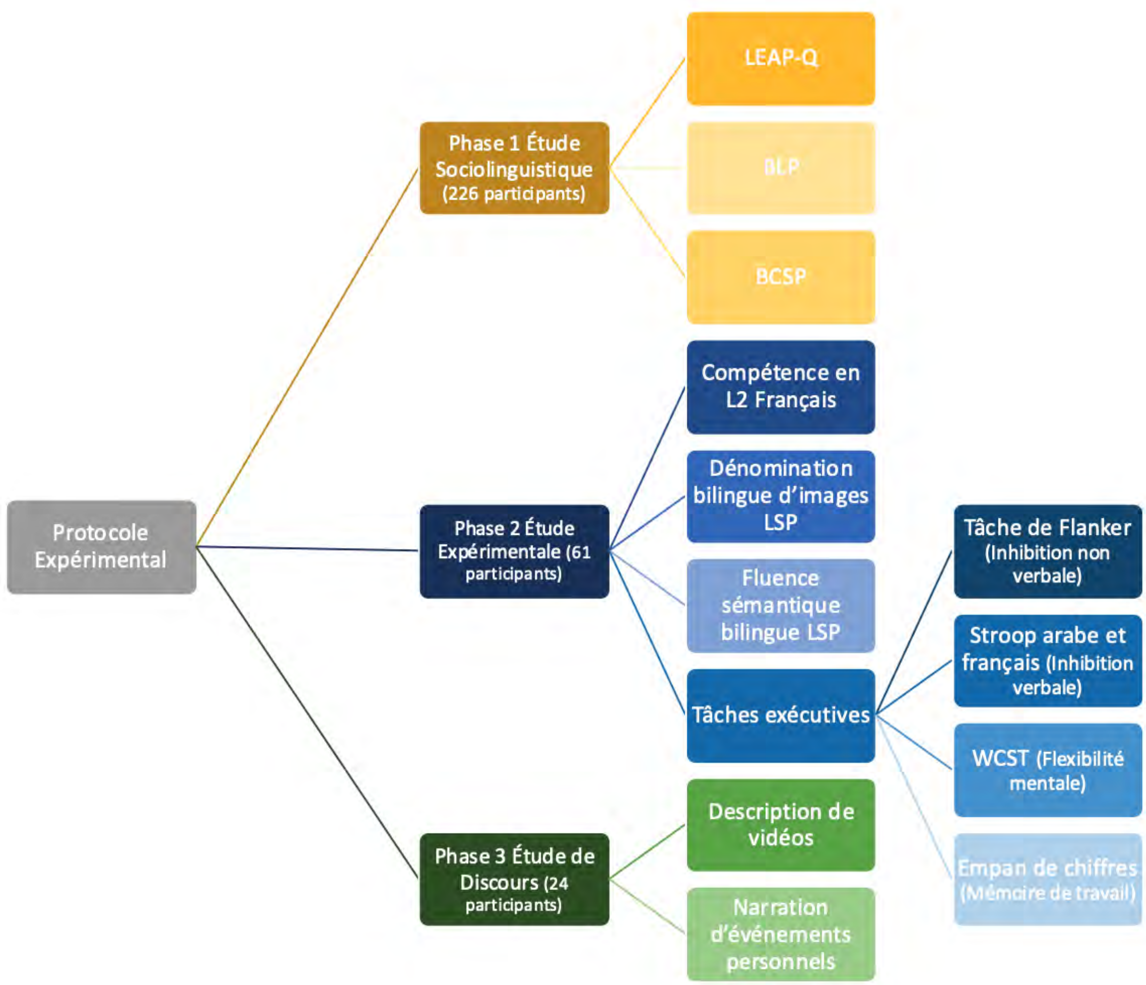

Figure 9.1: Vue d'ensemble des tâches dans les trois études

9.2.2 Étude sociolinguistique

Dans le but de décrire les caractéristiques sociolinguistiques de la population libanaise résidant en France, la Phase 1 de l'étude a recueilli les réponses de 226 participants dans le cadre d'une enquête à grande échelle utilisant une adaptation de trois questionnaires : le LEAP-Q (Marian et al., 2007), le BLP (Birdsong et al., 2012) et le BCSP (Olson, 2022).

Tous les participants étaient des adultes libanais résidant en France et bilingues précoces en arabe libanais et en français. Leur âge variait de 18 à 68 ans (M = 30,1 ans, ET = 10,1, Md = 27,0), la majorité possédant un diplôme supérieur (69,03 % avaient un master ou un doctorat). Leur durée de résidence (LOR) en France allait de 4 mois à 51 ans, avec une moyenne de 7,98 ans (± 9,4) et une médiane de 4,0 ans.

Les mesures d'intérêt tirées de ces questionnaires étaient l'âge d'acquisition des langues (AoA), l'indice de dominance linguistique (LDI), la préférence et la compétence subjective dans chacune des langues, l'entropie et le *code-switching profile* (CSP).

Concernant l'AoA, l'arabe (L1) était la première langue prédominante pour 80,5% des participants, bien plus que le français (18,1%) et l'anglais (1,3%). Le français (L2) était la langue seconde prédominante pour 73,5% des participants, comparé à l'anglais (13,5%) et l'arabe (13%), tandis que l'anglais (L3) était la langue troisième prédominante pour 88,7% des participants, bien plus que le français (8,8%), l'arabe (1,5%), l'espagnol (0,5%) et le portugais (0,5%).
L'analyse de l'AoA chez les participants libanais montre des tendances claires : l'arabe est la première langue dominante (L1) et est acquise significativement plus tôt que le français et l'anglais. Le français est la langue seconde (L2) la plus fréquente, tandis que l'anglais apparaît majoritairement comme troisième langue (L3), d'autres langues étant également reportées en L3 mais plus rarement (italien, allemand, turc, hongrois). Ces résultats confirment que les participants acquièrent principalement le français comme L2, parfois simultanément avec l'arabe, tandis que l'anglais apparaît plus tard, conformément aux pratiques éducatives et sociolinguistiques au Liban, où l'arabe est utilisé dès la naissance, le français est renforcé à l'école maternelle, et l'anglais est introduit vers l'âge de 8 ans. Ce schéma séquentiel d'acquisition rappelle celui observé chez les bilingues précoces catalan–espagnol (FCS) acquérant l'anglais plus tard, soulignant la cohérence des trajectoires de développement linguistique dans des contextes de bilinguisme précoce (Soto-Corominas, 2025).

En termes de LDI (Birdsong et al., 2012), 67,7% des participants étaient dominants en arabe, 28,7% en français et 3,7% en anglais. Ces résultats reflètent les schémas d'AoA. Les analyses non paramétriques confirment des différences significatives entre les langues, indiquant une hiérarchie claire dans cette population bilingue libanaise. Contrairement aux adultes plus âgés étudiés par Kassir et al. (2024), les participants plus jeunes de la présente étude ont été scolarisés dans un contexte de mondialisation, où l'anglais était introduit dès le début du cycle primaire, ce qui explique sa présence comme troisième langue. Malgré ces différences générationnelles et contextuelles, l'arabe libanais reste la langue dominante, le français conserve une position secondaire, et l'anglais émerge comme troisième langue, surtout chez les jeunes adultes.

Pour la préférence, la langue française était majoritairement préférée pour la lecture, suivie de l'arabe puis de l'anglais, tandis que l'expression orale se faisait préférentiellement en arabe libanais, puis en français et moins en anglais. L'ordre de préférence des langues en lecture reflète le rôle du français dans les contextes éducatifs et écrits formels au Liban (Bassam, 2017; Shaaban & Ghaith, 2002). Malgré une moindre préférence pour l'anglais dans les deux modalités orale et écrite, cette langue reste généralement perçue positivement, notamment en raison de son usage dans les médias et sur les réseaux sociaux (Esseili, 2017). À l'oral, l'arabe libanais était significativement préféré, en concordance avec l'étude de Shaaban and Ghaith (2002), qui soulignent son rôle identitaire, tandis que le français est associé à la culture et à l'éducation formelle, et l'anglais aux domaines professionnel et scientifique. Une influence de l'acquisition de la première langue étrangère a également été observée : les étudiants ayant appris le français en premier le préfèrent à l'anglais, et inversement (Diab, 2009).

L'auto-évaluation de la compétence a montré une compétence subjective élevée dans toutes les langues et domaines. Les scores les plus élevés ont été reportés pour l'arabe (5,63/6), suivi du français (5,43/6) et de l'anglais (4,98/6), pour la compréhension et la production orales et écrites. Les différences entre langues étaient significatives à l'oral (arabe > français > anglais) mais pas à l'écrit, et la compétence orale globale était perçue comme supérieure à la compétence écrite. Ces résultats reproduisent les tendances observées par Bassam (2017) et Chehimi et al. (2024), confirmant que l'arabe reste la langue dominante, le français est secondaire mais bien maîtrisé, et l'anglais est acquis plus tard avec une variabilité plus importante, surtout à l'écrit. Les différences observées entre cette étude et d'autres concernent la langue dans laquelle les participants se sentent le plus compétents après l'arabe: dans la présente étude, c'est la langue française, et cette compétence reflète l'influence du contexte francophone et la résidence en France, soulignant l'impact de l'environnement actuel sur la maitrise de la langue.

L'entropie moyenne était de 0,981 (ET = 0,262), avec un maximum théorique de 1,585 pour trois langues. Les participants ont ainsi présenté une entropie globalement élevée dans la majorité des contextes de communication, reflétant une utilisation intégrée des langues, notamment avec les amis, en lecture et en parole, et plus compartementalisée en famille et au travail. L'entropie moyenne indique une forte flexibilité dans l'usage du *code-switching*, avec une faible variabilité entre participants. Ces résultats confirment le profil FCS des participants libanais de la présente étude. Ils rejoignent également les observations de Gullifer and Titone (2020) sur des bilingues de Montréal, où l'entropie était également élevée dans les contextes sociaux et modérée ou faible à domicile. Les niveaux plus faibles en famille et au travail dans l'échantillon actuel peuvent s'expliquer par la résidence en France, loin de la famille, et des interactions professionnelles et communautaires principalement en français. Comparativement aux non-FCS, dont l'entropie est beaucoup plus basse (Baulande & Köpke, in preparation; Wagner et al., 2023), les participants montrent une utilisation plus intégrée des langues, reflétant un bilinguisme relativement équilibré et une compétence élevée.

Enfin, le CSP, basé sur la version adaptée libanaise du BCSP (Olson, 2022), présentait un score moyen de 51,8 (ET = 22,3) sur une échelle de 0 à 100. Les participants ont rapporté une forte confiance dans leurs compétences de *code-switching* et des attitudes globalement positives, tandis que la fréquence d'usage et l'histoire du *code-switching* (âge de début d'utilisation et contextes d'usage) étaient plus modérés. Le CSP moyen est comparable à celui observé par Olson (2022) et Kheder et al. (2025), bien qu'inférieur à ce que l'on pourrait attendre pour une population de FCS. Cette variation reflète l'hétérogénéité des pratiques linguistiques, notamment en France où l'usage des langues peut être plus compartementalisé au travail et en famille, en concordance avec les résultats d'entropie. Néanmoins, les attitudes envers l'usage du *code-switching* étaient globalement neutres à positives (52,4 $\pm$ 37,0), avec 48,7% de participants considérant le *code-switching* comme bénéfique pour la flexibilité mentale, l'expression, l'ouverture culturelle et la communication, 39,8% le jugeant comme neutre et seulement 11,5% comme négatif.

9.2.3 Étude expérimentale du code-switching

La deuxième étude a porté sur le *code-switching* dans le cadre d'un LSP expérimental chez les bilingues. Elle a examiné les performances des participants dans des tâches de dénomination d'images et de fluence sémantique, ainsi que les fonctions exécutives afin d'explorer les mécanismes cognitifs sous-jacents au contrôle des langues. Les participants de la Phase 2 étaient 61 participants de la Phase

1 qui ont consenti à prendre part aux expériences en laboratoire, recrutés dans les villes de Toulouse et de Montpellier. Pour la deuxième phase, les 61 participants (30 femmes) étaient des bilingues précoces en arabe libanais et en français. Ils maîtrisaient également tous l'anglais comme troisième langue. Les participants avaient acquis l'arabe dès la naissance (M = 0,95 an, ET = 1,35, Md = 0), le français vers 3,8 ans (ET = 2,29, Md = 3) et l'anglais vers 8,4 ans (ET = 3,60, Md = 8). Leur âge variait de 18 et 35 ans, avec une moyenne de 26,48 ans (±4,7) et une médiane de 28 ans. La majorité possédait un diplôme d'enseignement supérieur, 70,5% ayant obtenu un master ou un doctorat. En moyenne, les participants vivaient en France depuis 5,4 ans (±5,6), avec une durée médiane de séjour de 4 ans.

Les participants présentaient une entropie moyenne de 0,838 (±0,255), avec une médiane de 0,891. Leur CSP moyen était de 74,1 (±13,1), avec une médiane de 76,6. La comparaison avec l'échantillon initial de la Phase 1 n'a révélé aucune différence significative concernant l'AoA ou la durée de séjour (LOR) (tests de Wilcoxon, ps > 0,005), suggérant que les participants de la Phase 2 étaient représentatifs de l'échantillon global sur ces aspects. En revanche, l'entropie était significativement plus élevée en Phase 1 qu'en Phase 2 (t-test, $p < 0{,}005$**), tandis que les scores de CSP étaient significativement plus élevés en Phase 2 qu'en Phase 1 (test de Wilcoxon, $p < 0{,}005$**). Cela reflète un usage linguistique moins intégré mais un *code-switching* plus fréquent dans la vie quotidienne chez les participants de la présente phase, confirmant ainsi leur statut de FCS.
Pour les tâches de Stroop et de WCST spécifiquement, la taille finale de l'échantillon était de 60 au lieu de 61, un participant n'ayant pas pu compléter les tâches de Stroop en arabe et en français, ni la tâche de WCST, en raison d'un daltonisme.

Les résultats de cette étude sont résumés ci-dessous:

1. **Compétence en français**:
   La compétence moyenne des participants en français s'élevait à 71,9 (ET = 22,8), avec une étendue allant de 23 à 100. La majorité d'entre eux présentaient un niveau intermédiaire supérieur à avancé, correspondant aux niveaux B2 à C2 du Cadre européen commun de référence pour les langues (CECR).

2. **Dénomination bilingue d'images**:

   a) Score de précision: Les scores étaient presque à 100% (effet plafond) dans toutes les conditions.

   b) Temps de réponse (RT): Les réponses en condition monolingue étaient significativement plus rapides que les réponses bilingues contraintes. Le RT en condition libre était comparable à celui de la condition monolingue en arabe. Dans les essais bilingues, les réponses en français étaient plus rapides qu'en arabe.

   c) Switching: Les participants ont "switché" de langue dans la condition libre en moyenne pour 40% (ET = 12.4%) des essais.

   d) *Switch costs*: significativement réduits dans la condition libre par rapport à la condition contrainte.

   e) *Mixing costs*: significativement réduits dans la condition libre par rapport à la condition contrainte, particulièrement chez les participants ayant une compétence élevée en L2.

   f) Différences individuelles: Des RT plus rapides étaient associés à une compétence plus élevée en L2, à une entropie plus forte et à une durée de séjour plus longue en France, tandis qu'un CSP plus élevé était lié à des RT plus lents.

3. **Fluence sémantique bilingue**:
   Phase 2 (N=61)

   a) Fluence: Arabe monolingue (21.1 ± 5.6) > Français monolingue (19.0 ± 5.5) > Libre (13.1 ± 3.3) > Alternée (8.2 ± 2.5).

b) Score de précision: Le plus élevé en condition arabe monolingue et le plus faible en condition alternée.

c) *Switching*: En condition libre, les participants ont switché de langue en moyenne pour 30% (±16%) des essais.

d) *Switch costs*: La fluence était significativement plus élevée en condition libre qu'en condition alternée, indiquant un *switch cost* dans la condition alternée.

e) *Mixing costs*: significativement plus faibles en condition libre qu'en condition alternée.

Phase 3 (N=24)

a) Fluence: Français monolingue (25.3 ± 6.2) > Arabe monolingue (20.0 ± 5.8) > Libre (16.5 ± 3.9) > Alternée (11.2 ± 2.5).

b) Score de précision: Le plus élevé en condition français monolingue et la plus faible en condition bilingue alternée.

c) *Switching*: En condition libre, les participants ont switché de langue en moyenne pour 56,8% (±15,7%) des essais.

d) *Switch costs*: La fluence était significativement plus élevée en condition libre qu'en condition alternée, indiquant un *switch cost* dans la condition alternée.

e) *Mixing costs*: Aucune différence significative de *mixing cost* entre les conditions libre et alternée.

4. **Fonctions exécutives**:

a) Inhibition non verbale (Flanker): Effet plafond des scores de précision, RT plus lents pour les essais incongruents, moyens pour les essais congruents, les plus rapides pour les essais neutres.

b) Inhibition verbale (Stroop): Il n'y avait pas de différence significative en termes de scores de précision ni de RT entre le Stroop arabe et le Stroop français.

c) Flexibilité mentale (WCST): Les scores de précision étaient significativement plus élevés pour les essais congruents que pour les essais incongruents. Les RT ne différaient pas significativement entre les types d'essais.

d) Mémoire de travail (Empan de chiffres): Les résultats sont conformes à ceux généralement observés dans les tâches de mémoire de travail et ne révèlent aucune différence significative entre les conditions (endroit, envers et croissant).

5. **Analyse transversale inter-tâches**:

a) Inhibition non verbale:
Un meilleur score de précision en fluence et en dénomination d'images est généralement lié à une meilleure inhibition non verbale. Cependant, des corrélations négatives avec les conditions de fluence monolingues arabe et française, ainsi que la condition bilingue libre en dénomination bilingue, suggère qu'une meilleure performance dans ces conditions était liée à une inhibition plus faible. De plus, des corrélations positives significatives étaient présentes entre les RT de Flanker et de dénomination d'images.

b) Inhibition verbale:
- Le score de précision au Stroop arabe était positivement corrélée avec la fluence en condition arabe monolingue, ainsi qu'avec la dénomination d'images bilingue contrainte et libre, indiquant qu'une meilleure inhibition de la L1 était liée à un meilleur contrôle des langues.
- Le score de précision au Stroop français a montré des corrélations positives avec la fluence globale et la fluence en français monolingue, tandis qu'une corrélation négative

avec la fluence bilingue alternative suggérait une inhibition plus faible de la L2 dans des tâches plus contraintes.
- Les RT au Stroop arabe et français étaient positivement corrélés avec la fluence et la dénomination d'images bilingue, reflétant qu'un meilleur contrôle des langues était associé à une inhibition verbale plus rapide.

c) Flexibilité mentale:
- Le score de précision au WCST était positivement corrélé à la fluence en condition arabe monolingue, alternée et libre, indiquant qu'une meilleure flexibilité mentale était associée avec un meilleur contrôle des langues dans ces conditions-là. Toutefois, le score de précision au WCST était négativement corrélé à la fluence en condition monolingue française.
- Le score de précision et les RT au WCST étaient positivement corrélés aux scores de précision et RT à la tâche de dénomination d'imafes, indiquant qu'une meilleure flexibilité mentale était liée à un meilleur contrôle des langues.

d) Mémoire de travail:
Des corrélations positives significatives étaient observées entre les composantes de la mémoire de travail et les scores de précision en tâches de fluence et de dénomination d'images, sauf pour la dénomination d'image et l'empan croissant qui étaient corrélés négativement.

9.2.4 Étude de discours

La troisième étude a porté sur le *code-switching* en contexte plus écologique, sur des données de discours, construites autour du cadre théorique de l'hypothèse du contrôle adaptatif (Green & Abutalebi, 2013). Les tâches impliquaient des récits basés à la fois sur la description de vidéos et sur la narration d'événements personnels. Les participants de la Phase 3 étaient 24 individus de la Phase 2 ayant accepté de poursuivre l'étude. Tous les 24 participants (11 femmes) étaient, comme pour l'étude 2, des bilingues précoces en arabe libanais et en français, ayant tous l'anglais comme troisième langue. Leur âge variait de 19 à 34 ans, avec une moyenne de 28,62 ans (± 3,2) et une médiane de 30 ans. La grande majorité (95,8%) possédait un diplôme de master ou de doctorat. En moyenne, ils résidaient en France depuis 5,9 ans (± 4,2), avec une LOR médiane de 5,5 ans.

Le corpus final était constitué d'échantillons de discours de 24 participants ayant produit chacun 11 tâches discursives : 4 descriptions vidéo et 7 récits d'événements personnels. Au total, 264 échantillons discursifs ont été collectés (24 participants × 11 échantillons). Sur l'ensemble des échantillons, les participants ont produit un total de 42 381 mots, avec une moyenne de 161,14 mots par échantillon (ET = 113,31). La durée totale de parole était d'environ 6,24 heures (374,12 minutes ou 22 447 secondes), avec une durée moyenne de 85,35 secondes soit 1,42 minutes par échantillon (ET = 49,32 secondes).

Afin de décrire notre corpus, nous donnerons d'abord quelques éléments qualitatifs, puis des données quantitatives en lien avec nos hypothèses.

Analyse qualitative :
- Types de code-switching
Dans la condition monolingue arabe, les participants ont produit davantage d'alternances (63%) que d'insertions (37%), indiquant une prédominance du *code-switching* portant sur des segments ou des phrases entières plutôt que sur l'intégration de mots isolés. À l'inverse, dans la condition bilingue duelle,

les insertions (74%) se sont révélées significativement plus fréquentes que les alternances (26%), reflétant une utilisation plus intégrée et flexible des deux langues au sein d'un même discours. Une différence encore plus marquée apparaît dans la condition de code-switching dense, où les insertions (84%) ont largement surpassé les alternances (16%), traduisant une forte intégration linguistique caractéristique de ce contexte. Enfin, dans la condition française monolingue, aucune différence significative n'a été observée entre les insertions (50%) et les alternances (50%), suggérant un équilibre relatif entre les deux types de *code-switching*.

- Catégorie grammaticale du code-switching
L'analyse des catégories grammaticales des mots switchés met en évidence une hiérarchie dans la fréquence d'utilisation des différentes classes de mots. Les noms constituent la catégorie la plus fréquemment impliquée dans le *code-switching*, suivis des verbes, puis des prépositions. Les interjections, déterminants, conjonctions et adverbes apparaissent de manière plus marginale. Enfin, les adjectifs, numéraux et pronoms sont les catégories les moins concernées par le *code-switching*. Ceci suggère que les unités grammaticalement plus centrales au discours, notamment les noms et les verbes, sont celles qui font le plus souvent l'objet d'un changement de langue, contrairement aux éléments fonctionnels ou morphosyntaxiques périphériques.

Analyse quantitative :
- Score de code-switching (Switches/minute)
Les scores de *code-switching* (switches/minute) ont révélé une faible fréquence de switch dans la condition monolingue française ($M = 0.55$, $ET = 1.50$), contrastant avec la condition monolingue arabe, où les participants ont présenté un taux plus élevé ($M = 6.10$, $ET = 14.80$). Les deux conditions bilingues se situent entre ces extrêmes : la condition bilingue duelle a montré un score moyen de $M = 2.89$ ($ET = 4.24$), tandis que la condition de *code-switching* dense a atteint une moyenne comparable à celle en monolingue arabe ($M = 6.21$, $ET = 4.76$). Ces résultats suggèrent que le *code-switching* est resté marginal dans un contexte strictement monolingue en français, indiquant un contrôle relativement adapté. Cependant, il était plus fréquent en contexte bilingue duel, en contexte monolingue arabe, indiquant un manque de contrôle, ainsi que naturellement dans le contexte de *code-switching* dense, où son usage est attendu et ne constitue pas un indice de contrôle des langues.

- Score d'hésitation (Pauses remplies/minute)
Le score d'hésitation, mesuré en pauses remplies par minute, a révélé des différences selon les conditions. La condition monolingue arabe a présenté le nombre le plus faible de pauses ($M = 14,3$, $ET = 6,6$), suivie de la condition de code-switching dense ($M = 15,2$, $ET = 6,3$), de la condition bilingue duelle ($M = 17,2$, $ET = 6,9$) et enfin de la condition monolingue française, qui a montré le score le plus élevé ($M = 18,6$, $ET = 9,1$). Ces résultats suggèrent que la fréquence des pauses remplies varie selon la condition, étant plus faible dans la condition arabe monolingue et de code-switching dense, et plus élevée dans la condition bilingue duelle et monolingue française, reflétant un moindre contrôle par rapport aux conditions arabe et libre.

- Débit de parole (Mots/minute)
Le débit de parole, mesuré en mots par minute, a présenté des variations selon les conditions. La condition monolingue arabe a montré le débit le plus lent ($M = 101,0$, $ET = 21,7$), suivie de la condition de code-switching dense ($M = 104,0$, $ET = 27,1$), puis de la condition bilingue duelle ($M = 111,0$, $ET = 27,3$), et enfin de la condition monolingue française, qui a montré le débit le plus rapide ($M = 119,0$, $ET = 31,2$).

- Validation des hypothèses
Les hypothèses ont été testées en comparant l'indice de contrôle des langues (Language Control Index ; LCI) entre les différents contextes. Les analyses ont montré des différences limitées dans le LCI entre les différents contextes, fournissant ainsi des preuves insuffisantes pour établir la présence de *switch* et de *mixing costs*. En revanche, les modèles à effets mixtes ont montré que la compétence en français, le

CSP et la durée de séjour en France (LOR) ont significativement influencé les *switch* et *mixing costs*, tandis que l'entropie linguistique n'a pas eu d'effet notable.

9.2.5 Discussion générale

Les trois études dans cette thèse visaient à offrir une exploration complète du contrôle des langues chez les FCS bilingues en adoptant une approche multiméthode combinant des mesures sociolinguistiques, expérimentales et discursives au sein de la même population de FCS libanais. Il s'agit de la première étude à examiner les FCS libanais et à combiner ces trois approches d'évaluation chez les mêmes participants, tout en considérant le bilinguisme comme un continuum, en utilisant des mesures continues plutôt que catégoriques (De Bruin, 2019), telles que le CSP (Olson, 2022) et l'entropie (Gullifer & Titone, 2018, 2020). La présente étude a intégré des mesures subjectives et objectives de la compétence linguistique afin d'assurer une évaluation plus robuste des profils linguistiques individuels. De plus, il s'agit de l'une des premières études à examiner des contextes plutôt écologiques tels que prédits par l'hypothèse du contrôle adaptatif (Green & Abutalebi, 2013), en utilisant des données de discours, et à introduire un indice de contrôle des langues novateur pour évaluer les *switch* et *mixing costs* dans des corpus de discours.

Rappelons aussi que l'étude s'est articulée autour de trois objectifs principaux. Le premier visait à caractériser les différences individuelles au sein de cette population, incluant l'AoA, la compétence linguistique, la dominance linguistique, les habitudes de *code-switching* et l'entropie, et à explorer comment ces facteurs influencent le contrôle des langues dans la communication bilingue quotidienne. Le second objectif consistait à comparer le *code-switching* contraint et libre dans les évaluations expérimentales et discursives, en testant l'hypothèse selon laquelle les *switch* et *mixing costs* seraient plus élevés dans des conditions contraintes et que le switching libre pourrait les réduire. Le troisième objectif a examiné la relation entre contrôle des langues et fonctions exécutives, en étudiant si les mécanismes observés sont généraux ou spécifiques au langage.

À partir de ces objectifs, la discussion actuelle s'organise autour de quatre axes principaux. Le premier axe considère l'impact de la contrainte (cued vs. libre) sur les *switch* et *mixing costs*. Le second examine comment le contrôle des langues, contraint ou libre, se manifeste à la fois dans les évaluations expérimentales et dans le discours plus écologique. Le troisième axe porte sur le rôle des différences individuelles dans la modulation des coûts de changement de langue (*switch* et *mixing costs*), et le quatrième explore la contribution des fonctions exécutives au contrôle des langues. Ensemble, ces sections synthétisent les résultats des trois phases de l'étude et offrent un aperçu à la fois des mécanismes et de la variabilité du contrôle des langues chez les FCS.

Code-Switching Contraint vs. Libre: Coûts et Bénéfices dans le Contrôle des Langues

Dans les trois tâches (BPN, BSF et discours), l'étude a testé les deux mêmes hypothèses concernant les *switch* et *mixing costs*. Premièrement, il était attendu que les *switch costs* soient plus élevés dans les conditions contraintes que dans les conditions libres, reflétant les exigences accrues de contrôle lorsque le choix de la langue est externe. Inversement, le changement de langue libre était supposé réduire les *switch costs* en permettant aux participants de sélectionner la langue la plus accessible au moment de la production. Deuxièmement, il était attendu que les *mixing costs* soient plus faibles lors du *switching* libre, les FCS pouvant même présenter un *mixing benefit* en raison de la réduction des exigences de contrôle pour maintenir les deux langues actives. Bien que les mesures de *code-switching* aient été opérationnalisées différemment selon les trois tâches, la logique sous-jacente restait identique, permettant une évaluation transversale des effets de la contrainte du switch sur le contrôle des langues.

Les *switch costs* étaient généralement plus élevés dans les conditions où le switch était contraint que dans les conditions libres, conformément à l'hypothèse formulée et à la littérature précédente utilisant le BPN (Costa & Santesteban, 2004; De Bruin et al., 2018; Jevtović et al., 2020). Dans la tâche de dénomination bilingue (BPN), les *switch costs* étaient significativement réduits dans la condition libre par rapport à la condition contrainte. Dans la tâche de fluence bilingue (BSF), les Phases 2 et 3 ont également montré des *switch costs* significativement plus élevés dans la condition alternée par rapport à la condition libre. Dans la tâche de discours, toutefois, la différence des *switch costs* entre les contextes de code-switching dense et duel était présente mais restait faible et non significative, fournissant des preuves insuffisantes pour soutenir l'hypothèse en situation de discours. Ces résultats indiquent que le switching libre réduit efficacement les *switch costs* dans les contextes expérimentaux contrôlés, tandis que son impact dans le discours écologique semble plus limité.

Les *mixing costs* étaient généralement plus faibles dans les conditions de *switching* libre par rapport aux conditions contraintes, conformément à l'hypothèse formulée et à la littérature précédente utilisant le BPN (Jevtović et al., 2020). Dans la tâche BPN, non seulement le *mixing cost* était réduit dans la condition libre, mais environ la moitié des participants a présenté un *mixing benefit*, résultats similaires à ceux de De Bruin et al. (2018) et Jevtović et al. (2020). De plus, les participants avec une compétence plus élevée en L2 ont montré une réduction dans les *mixing costs* en condition contrainte, contrairement aux résultats de Gollan and Ferreira (2009), qui ont observé un *mixing benefit* libre en situation de bilinguisme non équilibré dans la langue non dominante.

Dans la tâche BSF, la Phase 2 a montré des *mixing costs* significativement plus faibles dans la condition libre par rapport à la condition alternée, soutenant l'hypothèse. En Phase 3, la différence des *mixing costs* entre conditions était présente mais restait faible et non significative, possiblement en raison de l'échantillon plus réduit de participants. Dans la tâche de discours, la différence des *mixing costs* entre les contextes duel et monolingues était minimale et non significative, fournissant des preuves insuffisantes pour confirmer l'hypothèse dans l'usage écologique. Ces résultats suggèrent que le switching libre peut réduire les *mixing costs* dans les contextes expérimentaux, en particulier chez les bilingues les plus équilibrés, tandis que son impact dans le discours écologique semble limité.

La variabilité dans les coûts de *switching* (*switch* et *mixing costs*) était liée à plusieurs facteurs, principalement les mesures utilisées pour calculer les coûts, les caractéristiques de la tâche et de l'échantillon, les exigences cognitives, les facteurs contextuels et techniques, ainsi que les différences individuelles entre participants.

L'effet du Contexte : Contrôle des Langues en Situation Expérimentale vs. Discursive

Comme discuté précédemment, les *switch* et *mixing costs* ont été calculés différemment selon les tâches: dans le BPN, à partir des RT classiques ; dans le BSF, à partir de scores de fluence; et dans la tâche de discours, via un nouvel indice basé sur la fréquence de *code-switching* (CSS), les pauses remplies (HS) et le débit de parole (SR). Ces différences méthodologiques peuvent expliquer pourquoi les coûts apparaissent clairement dans les tâches expérimentales mais pas dans le discours écologique.

De plus, la nature même de la tâche joue un rôle : mesurer les coûts sur des mots isolés diffère fondamentalement de leur mesure dans un discours continu, où le *code-switching* est plus fluide. Malgré un contrôle partiel des contextes d'interaction et des connaissances linguistiques de l'interlocuteur, certains facteurs situationnels restaient non contrôlable, et l'asynchronicité des vidéos avec les interlocuteurs a pu réduire le naturel de la tâche. Par ailleurs, certains paramètres du discours spontané, comme la langue des énoncés précédents, échappaient au contrôle expérimental et ont pu influencer le contrôle des langues.

L'indice de contrôle linguistique (LCI), combinant CSS, HS et SR, constitue une approche innovante pour estimer les coûts de *switch* et de *mixing* dans le discours. Bien que ces indicateurs puissent refléter d'autres phénomènes que le contrôle des langues strict (accès lexical, caractère affectif, débit de parole individuel), ils restent parmi les meilleures mesures connues à ce jour pour évaluer le contrôle des langues en contexte discursif.

Enfin, les tâches expérimentales (BPN et BSF) fournissent des mesures précises et mettent en évidence le contrôle transitoire et soutenu, mais ne reflètent pas entièrement les processus en discours naturel. Le discours écologique implique une gestion continue et contextuelle des langues, modulée par des facteurs sociaux et affectifs, et nécessite un contrôle plus flexible et adaptatif des langues co-activées, conformément au modèle du continuum de co-activation et d'inhibition (Grosjean, 2008).

Influence de la Variabilité Individuelle sur le Contrôle des Langues

Quatre facteurs principaux ont été évalués: la compétence en français (L2), la durée de résidence en France (LOR), les habitudes de *code-switching* (CSP) et l'entropie (LE)

- Compétence en français (L2) : les participants plus compétents en L2 ont montré des *switch costs* réduits dans les deux types de tâches, mais les *mixing costs* ont présenté des tendances contraires : plus faibles dans la tâche BPN mais légèrement plus élevés dans le discours spontané.
- Durée de résidence en France (LOR): un effet minimal dans le BPN, mais dans le discours, une résidence plus longue a augmenté les *switch costs* tout en réduisant les *mixing costs*.
- Habitudes de *code-switching* (CSP): les participants pratiquant plus fréquemment le *code-switching* dans leur vie quotidienne présentaient des *switch costs* plus élevés dans le discours et légèrement plus élevés dans le BPN, tandis que les *mixing costs* étaient inversés, indiquant un contrôle soutenu plus efficace dans le discours spontané.
- Entropie (LE): effet global minimal, reflétant l'homogénéité relative de l'échantillon, avec des *switch costs* légèrement réduits et des *mixing costs* variables selon la tâche.

Dans l'ensemble, la compétence en français et le *code-switching* quotidien ont exercé une influence relativement consistante sur les *switch costs*, tandis que les *mixing costs* étaient plus sensibles à la tâche, présentant des motifs parfois concordants, parfois divergents selon le prédicteur. Enfin, les résultats indiquent que les tâches expérimentales produisent des effets de *switch* et de *mixing* plus robustes, moins sensibles aux différences individuelles, alors que le contrôle des langues dans le discours semble fortement influencé par la variabilité individuelle.

Fonctions Exécutives et Contrôle des Langues chez les Bilingues

Le quatrième et dernier axe de cette discussion porte sur la contribution des fonctions exécutives au contrôle des langues, explorant dans quelle mesure ces mécanismes sont cognitifs généraux ou spécifiques au langage. Les analyses de corrélation entre les tâches exécutives et les tâches de dénomination d'images (BPN) et de fluence sémantique bilingue (BSF) suggèrent que les deux types de contrôle interviennent, soutenant l'idée d'un contrôle bilingue dynamique plutôt que strictement modulaire. Le contrôle bilingue mobilise l'inhibition, la flexibilité mentale et la mémoire de travail, mais dépendamment de la tâche et du contexte : l'inhibition verbale est surtout liée au contrôle langagier, tandis que l'inhibition non verbale relève du contrôle cognitif général. La mémoire de travail verbale soutient la récupération lexicale, alors que les tâches de manipulation en mémoire mobilisent davantage le contrôle général.

Cependant, Green and Abutalebi (2013) ont souligné la nécessité de spécifier plus clairement ces trois fonctions exécutives, en testant directement leur contribution au langage (compréhension et production de la parole), et en contrastant le contrôle proactif et réactif conformément au cadre DMC de Braver (2012). Les auteurs ont identifié huit processus de contrôle qui régissent le contrôle des langues et s'adaptent aux exigences du contexte interactionnel. Ils ont illustré l'hypothèse du contrôle adaptatif en utilisant un LSP théorique et la tâche de Stroop faisant référence aux effets d'interférence, mais n'ont pas fourni d'outils concrets pour évaluer chacun des huit processus de contrôle de manière à capturer à la fois le contrôle spécifique au langage et les exigences des contextes interactionnels. Par conséquent, de nombreuses études ultérieures opérationnalisant ce cadre reposent sur des tâches exécutives standard, des paradigmes de dénomination d'images et/ou des mesures d'auto-évaluation de l'usage des langues, qui ne reflètent souvent pas la façon dont les processus de contrôle sont recrutés de manière dynamique selon le contexte et conservent un risque d'impureté de la tâche (Blanco-Elorrieta & Pylkkänen, 2017; Hartanto & Yang, 2020; Rafeekh & Mishra, 2021; Spinelli & Sulpizio, 2025; Struys et al., 2019). Les critiques de l'ACH (Paap et al., 2021) soulignent en outre que la généralisation des prédictions à des tâches non linguistiques a produit des résultats inconsistants, mettant en évidence le besoin de définitions plus claires et de méthodes sensibles à la fois aux aspects spécifiques au langage et dépendant au contexte. En conséquence, citer l'ACH nécessite de préciser si la référence porte sur les huit processus de contrôle proposés, sur les contextes interactionnels, ou idéalement sur les deux, étant donné que le modèle a été développé pour rendre compte de leur interaction.

Afin de combler cette lacune dans la littérature, il peut être utile de déplacer l'attention de la question du chevauchement vers l'observation des preuves issues de la parole bilingue, incluant les *switch* et *mixing costs*, et surtout le *code-switching* au niveau discursif, en parallèle avec les modèles de contrôle des langues. Par exemple, les parallèles entre l'ACH (Green & Abutalebi, 2013), le CPM (Green & Wei, 2014), et le LMH (Grosjean, 2008) présente des indications sur le fonctionnement du contrôle des langues. Dans les contextes monolingues, les mécanismes de contrôle inhibent la langue non ciblée tout en activant la langue cible, mobilisant les processus d'inhibition sélective des réponses, de suppression des interférences et de maintien des objectifs (ACH), correspondant à une position plus orientée du côté monolingue le long du continuum du mode langagier (LMH). Selon le CPM, les langues dans les contextes monolingues fonctionnent dans un mode de contrôle compétitif. Dans cette étude, comme le montre le LCI, le contrôle des langues dans le contexte monolingue arabe était le plus faible, indiquant un engagement minimal de ces processus de contrôle dans la L1, tandis qu'il était le plus élevé dans le contexte monolingue français, suggérant que les processus de contrôle sont davantage mobilisés pour la L2. Cela suggère que l'implication du contrôle des langues dépend de la langue.
Dans le contexte bilingue duel, les locuteurs doivent se désengager d'une langue pour en engager une autre selon la connaissance linguistique de l'interlocuteur. Dans ces cas, les deux langues restent partiellement actives, coopérant pour permettre l'alternance entre les locuteurs (CPM). Le contexte bilingue duel opère comme de longues séquences d'alternance. L'inhibition continue de jouer un rôle de manière alternative, et la flexibilité mentale est importante dans ce contexte. Dans notre étude, le LCI était relativement moyen dans le contexte duel, suggérant un contrôle modéré : l'alternance des langues était gérée efficacement entre les interlocuteurs, sans effets notables de facilitation ou d'interférence.
Dans le contexte de code-switching dense, les exigences de contrôle sont minimisées, correspondant à un mode de contrôle ouvert (CPM), tandis que le locuteur opère en mode langagier bilingue (LMH), et la planification opportuniste guide le choix du mot suivant en fonction de la disponibilité lexicale et de la mémoire, engageant un *code-switching* sous forme d'insertions ou de lexicalisations congruentes.
La détection d'indices saillants est impliquée dans les trois contextes, reflétant une sensibilité à la situation et à l'interlocuteur plutôt qu'aux langues spécifiques. Le LCI était proche de zéro dans ce contexte, reflétant un usage des langues relativement efficace, base sur la planification opportuniste.

En général, le contrôle des langues est typiquement proactif (Braver, 2012), régulant l'usage des langues en pré-activant ou en inhibant les langues pertinentes. Lorsque le contrôle proactif est plus coûteux, il peut se manifester par des hésitations (HS) ou un débit de parole plus lent (SR). Dans la présente étude, ces indices ont varié dans les différents contextes. Dans le contexte monolingue arabe, le contrôle des langues était relativement élevé, avec moins d'hésitations et un débit plus rapide, suggérant un contrôle proactif efficace. Dans le contexte monolingue français, le contrôle était plus faible, comme en témoignent plus d'hésitations et un débit plus lent, reflétant les demandes accrues de

contrôle en L2. Dans le contexte bilingue duel, le contrôle était intermédiaire, indiquant une gestion efficace de l'alternance des langues. Enfin, dans le contexte de code-switching dense, les exigences de contrôle étaient réduites, la planification opportuniste guidant la production bilingue, et les indices de HS et SR on reflété une production fluide et peu coûteuse cognitivement.
À l'inverse, le contrôle réactif peut intervenir en cas d'erreurs, comme la production d'une langue inconnue de l'interlocuteur, ce qui se reflète par le CSS dans les contextes monolingue et bilingue, suivi éventuellement de stratégies telles que l'usage d'équivalents de traduction pour corriger ou clarifier l'énoncé. Dans la présente étude, le CSS était relativement élevé dans les contextes monolingue arabe et de code-switching dense, modéré dans le contexte bilingue duel, et le plus faible dans le contexte monolingue français. Ces résultats suggèrent que le contrôle réactif était le plus mobilisé pour contrôler le discours en L1 et le moins lorsque les participants parlaient exclusivement en L2, tel que sous-entendu par de potentiels ajustements post hoc suivant les CSS. Une annotation réelle des ajustements post-CSS serait nécessaire pour rendre compte plus précisément du contrôle réactif effectif.

En somme, bien qu'il existe un recouvrement entre le contrôle des langues et les fonctions exécutives générales, des mécanismes spécifiques au langage subsistent, sensibles au contexte communicatif et qui ne peuvent être entièrement saisis par les tâches exécutives, comme le reflètent à la fois les résultats mixtes de la littérature et les analyses corrélationnelles présentes. Il existe clairement une interaction entre contrôle des langues et fonctions exécutives générales, mais réduire le contrôle des langues à de simples tâches exécutives néglige les processus spécifiques au langage qui façonnent la communication.

9.2.6 Perspectives générales

Plusieurs limites et perspectives restent à prendre en compte pour cette étude. Premièrement, bien que les trois études fournissent ensemble un panorama quasi-complet du contrôle des langues chez les FCS libanais, l'échantillon relativement homogène, reflété par des scores d'entropie similaires, pourrait limiter la généralisation des résultats à d'autres groupes bilingues. Deuxièmement, l'utilisation de méthodes différentes selon les tâches a rendu la thèse plus complète, mais a également compliqué la comparaison directe des résultats. Par exemple, dans le paradigme expérimental (BPN), les *switch* et *mixing costs* étaient significatifs mais non modulés par les différences individuelles, tandis que dans la tâche de discours, l'inverse a été observé : les coûts n'étaient pas significatifs, mais la variabilité individuelle jouait un rôle central. Troisièmement, le choix d'appliquer un seuil de signification plus strict ($p < 0.005$), bien qu'aligné avec les recommandations récentes (Benjamin et al., 2018; De Ruiter, 2019) pour réduire les faux positifs, peut avoir été trop conservateur, masquant potentiellement des effets subtils et augmentant le risque de faux négatifs. De plus, de futures études pourraient inclure l'anglais comme troisième langue active, puisque c'était la L3 de tous les participants et qu'elle pouvait être activée même lorsqu'elle n'était pas utilisée, influençant ainsi les performances dans les tâches bilingues. Enfin, les recherches futures pourraient étendre ce travail à des populations bilingues plus diverses et employer cette approche multiméthode afin de mieux saisir les mécanismes de contrôle dans les différents contextes.

9.2.7 Conclusion

Cette thèse apporte une contribution originale à l'étude du contrôle des langues chez les bilingues en adoptant une approche multiméthode combinant profils sociolinguistiques, paradigmes expérimentaux et analyses discursives. Chez les bilingues libanais arabe–français, l'évaluation sociolinguistique a permis d'appréhender de manière continue l'expérience linguistique, notamment via l'entropie et le CSP, révélant une haute compétence dans les trois langues parlées (arabe, français, mais aussi anglais), une utilisation des langues intégrée plutôt que compartementalisée et des habitudes d'usage du *code-switching* modérées. Les résultats expérimentaux ont montré que le passage libre d'une langue à l'autre entraînait des *switch* et *1* plus faibles qu'en situation contrainte, confirmant que le changement libre est moins coûteux pour les locuteurs pratiquant fréquemment le *code-switching*. Dans l'ensemble, ces résultats indiquent que le contrôle des langues bilingue est dynamique, sensible au contexte et modulé à la fois par la régulation interne et le contexte de communication, soulignant l'intérêt d'une approche multiméthode pour saisir sa nature complexe.

Appendix

A Sociolinguistic Questionnaire : Contrôle des langues et code-switching chez les Libanais en France (Language Control and Code-Switching among Lebanese in France)

Contrôle des langues et code-switching chez les libanais en France

Nous vous remercions pour votre participation à notre recherche. Cette étude vise à mieux comprendre les profils langagiers des populations bilingues, plus particulièrement chez les libanais, et la façon dont s'effectue le contrôle des langues chez ces populations.

Vous êtes amenés à répondre à des questions concernant votre histoire langagière, votre pratique des langues, vos attitudes envers ces langues, votre compétence linguistique et vos habitudes de code-switching. Il n'y a pas de bonnes ou de mauvaises réponses : il faut seulement essayer de répondre le plus honnêtement possible aux questions. Certaines questions peuvent vous paraitre répétitives ; nous vous remercions d'y répondre quand même.

Prévoyez environ une demi-heure pour ce questionnaire. En cas d'imprévu, vous pouvez enregistrer vos réponses et reprendre le questionnaire plus tard. Votre participation est très appréciée ; elle permettra de faire avancer la recherche dans la compréhension du bilinguisme de manière générale, et plus particulièrement chez les libanais.

Il y a 86 questions dans ce questionnaire.

Renseignements biographiques

Date *

Veuillez entrer une date :

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Age

*

Seuls des nombres peuvent être entrés dans ce champ.
Veuillez écrire votre réponse ici :

Sexe

Veuillez sélectionner une seule des propositions suivantes :

- Féminin
- Masculin

Ville/Région de résidence actuelle: *

❗ Veuillez sélectionner une réponse ci-dessous
Veuillez sélectionner une seule des propositions suivantes :

- ◯ Toulouse
- ◯ Paris
- ◯ Marseille
- ◯ Lyon
- ◯ Nice
- ◯ Nantes
- ◯ Montpellier
- ◯ Strasbourg
- ◯ Bordeaux
- ◯ Lille
- ◯ Rennes
- ◯ Reims
- ◯ Saint-Étienne
- ◯ Toulon
- ◯ Grenoble
- ◯ Dijon
- ◯ Angers
- ◯ Nîmes
- ◯ Aix-en-Provence
- ◯ Clermont-Ferrand
- ◯ Brest
- ◯ Tours
- ◯ Amiens
- ◯ Limoges
- ◯ Autre ________

Plus haut niveau d'études complété *

❗ Veuillez sélectionner une réponse ci-dessous
Veuillez sélectionner une seule des propositions suivantes :

- ◯ Sans diplôme
- ◯ Bac/Lycée
- ◯ Un peu d'université
- ◯ Licence/B.A., B.S.
- ◯ Master
- ◯ Doctorat

Veuillez indiquer ici le plus haut diplôme déjà en votre possession. Par exemple, si vous êtes actuellement doctorant, votre plus haut niveau d'éducation complété est "Master".

Année d'immigration en France *

❗ Seuls des nombres peuvent être entrés dans ce champ.
Veuillez écrire votre réponse ici :

____

Avez-vous déjà eu: *

Choisissez la réponse appropriée pour chaque élément :

	Oui	Non
Des problèmes d'audition?	◯	◯
Des problèmes de vision?	◯	◯
Des troubles du langage?	◯	◯
Des troubles d'apprentissage (dyslexie, dyscalculie)	◯	◯

Evaluation individuelle des langues

Dans cette section, vous répondrez à des questions autour de chacune des langues que vous maitrisez par ordre de dominance.

Veuillez énumérer toutes les langues que vous connaissez par ordre de dominance:

Veuillez écrire votre(vos) réponse(s) ici :

1. (langue dominante)
2.
3.
4.
5.

La langue dominante est la langue dans laquelle vous êtes le plus à l'aise, et inversement.

Veuillez ajouter autant de lignes que vous connaissez de langues.

Veuillez énumérer toutes les langues que vous connaissez par ordre d'acquisition:

Veuillez écrire votre(vos) réponse(s) ici :

1. (première langue apprise)
2.
3.
4.
5.

L'ordre d'acquisition réfère à l'ordre dans lequel vous avez appris les langues.

Veuillez ajouter autant de lignes que vous connaissez de langues.

Langue 1 (première langue apprise) : *

Veuillez écrire votre réponse ici :

[ ]

Attention: mémorisez bien l'ordre des langues tel que vous l'avez déterminé ici, il vous sera demandé plus tard (quelle est la langue 1, la langue 2, la langue 3…).

Ceci est ma langue: *

Veuillez sélectionner une réponse ci-dessous

Veuillez sélectionner une seule des propositions suivantes :

- ○ Maternelle
- ○ Deuxième
- ○ Troisième
- ○ Quatrième
- ○ Cinquième

Age auquel... *

Vous avez commencé à acquérir la langue 1	[ ]
Vous avez commencé à parler couramment en langue 1	[ ]
Vous avez commencé à lire en langue 1	[ ]
Lisiez couramment en langue 1	[ ]

Veuillez énumérer le nombre d'années passées dans chaque environnement: *

Seuls les nombres sont acceptés.

	Nombre d'années
Dans un pays où est parlée la langue 1	[ ]
Dans une famille où est parlée la langue 1	[ ]
Dans une école, université et/ou lieu de travail où est parlée la langue 1	[ ]

Choisissez votre niveau de compétence à l'oral, en compréhension et lecture en langue 1 : *

Choisissez la réponse appropriée pour chaque élément :

	0	1	2	3	4	5	6	7	8	9	10
Expression orale	○	○	○	○	○	○	○	○	○	○	○
Compréhension de la langue orale	○	○	○	○	○	○	○	○	○	○	○
Lecture	○	○	○	○	○	○	○	○	○	○	○

Echelle:

- 0 – Aucun
- 1 – Très faible
- 2 – Faible
- 3 – Correct
- 4 – Un peu moins qu'adéquat
- 5 – Adéquat
- 6 – Un peu plus qu'adéquat
- 7 – Bon
- 8 – Très bon
- 9 – Excellent
- 10 – Parfait

Combien est-ce que chacun des facteurs suivants a contribué à votre apprentissage de cette langue?: *

Choisissez la réponse appropriée pour chaque élément :

	0	1	2	3	4	5	6	7	8	9	10
Interagir avec des amis	○	○	○	○	○	○	○	○	○	○	○
Interagir avec la famille	○	○	○	○	○	○	○	○	○	○	○
Regarder la télévision	○	○	○	○	○	○	○	○	○	○	○
Ecouter de la musique	○	○	○	○	○	○	○	○	○	○	○
Lire	○	○	○	○	○	○	○	○	○	○	○
Auto-apprentissage	○	○	○	○	○	○	○	○	○	○	○

Echelle:

- 0 - Pas contribué
- 1 - Contribué minimalement
- 2
- 3
- 4
- 5 - Contribué moyennement
- 6
- 7
- 8
- 9
- 10 - Le facteur le plus important

Evaluez dans quelle mesure vous êtes actuellement exposé à cette langue dans les contextes suivants:

*

Choisissez la réponse appropriée pour chaque élément :

	0 – Jamais	1 - Presque jamais	2	3	4	5 - La moitié du temps	6	7	8	9	10 – Toujour
Interagir avec les amis	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Interagir avec la famille	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Regarder la télévision	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Ecouter de la musique	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Lire	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Auto-apprentissage	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

Selon votre perception, à quel point avez-vous un accent étranger en cette langue? *

❗ Veuillez sélectionner une réponse ci-dessous

Veuillez sélectionner une seule des propositions suivantes :

- ◯ 0 - Aucun
- ◯ 1 - Presque aucun
- ◯ 2 - Très léger
- ◯ 3 - Léger
- ◯ 4 - Quelque peu
- ◯ 5 - Modéré
- ◯ 6 - Considérable
- ◯ 7 - Fort
- ◯ 8 - Très fort
- ◯ 9 - Extrêmement fort
- ◯ 10 - Envahissant

Vous arrive-t-il que des gens pensent que vous êtes un locuteur étranger de cette langue à partir de votre accent? *

❗ Veuillez sélectionner une réponse ci-dessous
Veuillez sélectionner une seule des propositions suivantes :

- ◯ 0 – Jamais
- ◯ 1 - Presque jamais
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5 - La moitié du temps
- ◯ 6
- ◯ 7
- ◯ 8
- ◯ 9
- ◯ 10 – Toujours

Langue 2 (deuxième langue apprise) : *

Veuillez écrire votre réponse ici :

[ ]

Attention! Notez bien l'ordre des langues tel que vous l'avez déterminé ici, il vous sera demandé plus tard (quelle est la langue 1, la langue 2...).

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Ceci est ma langue: *

❗ Veuillez sélectionner une réponse ci-dessous
Veuillez sélectionner une seule des propositions suivantes :

- ◯ Maternelle
- ◯ Deuxième
- ◯ Troisième
- ◯ Quatrième
- ◯ Cinquième

Age auquel... *

Vous avez commencé à acquérir la langue 2	[ ]
Vous avez commencé à parler couramment en langue 2	[ ]
Vous avez commencé à lire en langue 2	[ ]
Lisiez couramment en langue 2	[ ]

Veuillez énumérer le nombre d'années passées dans chaque environnement: *

Seuls les nombres sont acceptés.

	Nombre d'années
Dans un pays où est parlée la langue 2	
Dans une famille où est parlée la langue 2	
Dans une école, université et/ou lieu de travail où est parlée la langue 2	

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Choisissez votre niveau de compétence à l'oral, en compréhension et lecture en langue 2 : *

Choisissez la réponse appropriée pour chaque élément :

	0	1	2	3	4	5	6	7	8	9	10
Expression orale	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Compréhension de la langue orale	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Lecture	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

Echelle:

- 0 – Aucun
- 1 – Très faible
- 2 – Faible
- 3 – Correct
- 4 – Un peu moins qu'adéquat
- 5 – Adéquat
- 6 – Un peu plus qu'adéquat
- 7 – Bon
- 8 – Très bon
- 9 – Excellent
- 10 – Parfait

Combien est-ce que chacun des facteurs suivants a contribué à votre apprentissage de cette langue?: *

Choisissez la réponse appropriée pour chaque élément :

	0	1	2	3	4	5	6	7	8	9	10
Interagir avec des amis	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Interagir avec la famille	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Regarder la télévision	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Ecouter de la musique	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Lire	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Auto-apprentissage	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

Echelle:

- 0 - Pas contribué
- 1 - Contribué minimalement
- 2
- 3
- 4
- 5 - Contribué moyennement
- 6
- 7
- 8
- 9
- 10 - Le facteur le plus important

Evaluez dans quelle mesure vous êtes actuellement exposé à cette langue dans les contextes suivants: *

Choisissez la réponse appropriée pour chaque élément :

	0 – Jamais	1 - Presque jamais	2	3	4	5 - La moitié du temps	6	7	8	9	10 – Toujour
Interagir avec les amis	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Interagir avec la famille	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Regarder la télévision	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Ecouter de la musique	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Lire	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Auto-apprentissage	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

Selon votre perception, à quel point avez-vous un accent étranger en cette langue? *

❶ Veuillez sélectionner une réponse ci-dessous
Veuillez sélectionner une seule des propositions suivantes :

- ◯ 0 – Aucun
- ◯ 1 - Presque aucun
- ◯ 2 - Très léger
- ◯ 3 – Léger
- ◯ 4 - Quelque peu
- ◯ 5 – Modéré
- ◯ 6 – Considérable
- ◯ 7 – Fort
- ◯ 8 - Très fort
- ◯ 9 - Extrêmement fort
- ◯ 10 – Envahissant

Vous arrive-t-il que des gens pensent que vous êtes un locuteur étranger de cette langue à partir de votre accent? *

❶ Veuillez sélectionner une réponse ci-dessous
Veuillez sélectionner une seule des propositions suivantes :

- ◯ 0 – Jamais
- ◯ 1 - Presque jamais
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5 - La moitié du temps
- ◯ 6
- ◯ 7
- ◯ 8
- ◯ 9
- ◯ 10 – Toujours

Maitrisez-vous une troisième langue?

*

Veuillez sélectionner une seule des propositions suivantes :

- ◯ Oui
- ◯ Non

Quelle est cette langue (Langue 3) (troisième langue apprise)?

Répondre à cette question seulement si les conditions suivantes sont réunies :
La réponse était 'Oui' à la question ' [LEAPQ27a]' (Maitrisez-vous une troisième langue?)

Veuillez écrire votre réponse ici :

Attention! Notez bien l'ordre des langues tel que vous l'avez déterminé ici, il vous sera demandé plus tard (quelle est la langue 1, la langue 2...).

Ceci est ma langue

Répondre à cette question seulement si les conditions suivantes sont réunies :
La réponse était 'Oui' à la question ' [LEAPQ27a]' (Maitrisez-vous une troisième langue?)

Veuillez sélectionner une réponse ci-dessous
Veuillez sélectionner une seule des propositions suivantes :

- ◯ Maternelle
- ◯ Deuxième
- ◯ Troisième
- ◯ Quatrième
- ◯ Cinquième

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Age auquel...

Répondre à cette question seulement si les conditions suivantes sont réunies :
La réponse était 'Oui' à la question ' [LEAPQ27a]' (Maitrisez-vous une troisième langue?)

Vous avez commencé à acquérir la langue 3	
Vous avez commencé à parler couramment en langue 3	
Vous avez commencé à lire en langue 3	
Lisiez couramment en langue 3	

Veuillez énumérer le nombre d'années passées dans chaque environnement:

Répondre à cette question seulement si les conditions suivantes sont réunies :
La réponse était 'Oui' à la question ' [LEAPQ27a]' (Maitrisez-vous une troisième langue?)

Seuls les nombres sont acceptés.

	Nombre d'années
Un pays où est parlée la langue 3	
Une famille où est parlée la langue 3	
Une école, université et/ou lieu de travail où est parlée la langue 3	

Choisissez votre niveau de compétence à l'oral, en compréhension et lecture en langue 3 : *

Répondre à cette question seulement si les conditions suivantes sont réunies :
La réponse était 'Oui' à la question ' [LEAPQ27a]' (Maitrisez-vous une troisième langue?)

Choisissez la réponse appropriée pour chaque élément :

	0	1	2	3	4	5	6	7	8	9	10
Expression orale	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Compréhension de la langue orale	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Lecture	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

Echelle:

- 0 – Aucun
- 1 – Très faible
- 2 – Faible
- 3 – Correct
- 4 – Un peu moins qu'adéquat
- 5 – Adéquat
- 6 – Un peu plus qu'adéquat
- 7 – Bon
- 8 – Très bon
- 9 – Excellent
- 10 – Parfait

Combien est-ce que chacun des facteurs suivants a contribué à votre apprentissage de cette langue?: *

Répondre à cette question seulement si les conditions suivantes sont réunies :
La réponse était 'Oui' à la question ' [LEAPQ27a]' (Maitrisez-vous une troisième langue?)

Choisissez la réponse appropriée pour chaque élément :

	0	1	2	3	4	5	6	7	8	9	10
Interagir avec les amis	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Interagir avec la famille	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Regarder la télévision	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Ecouter de la musique	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Lire	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Auto-apprentissage	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

Echelle:

- 0 - Pas contribué
- 1 - Contribué minimalement
- 2
- 3
- 4
- 5 - Contribué moyennement
- 6
- 7
- 8
- 9
- 10 - Le facteur le plus important

Evaluez dans quelle mesure vous êtes actuellement exposé à cette langue dans les contextes suivants: *

Répondre à cette question seulement si les conditions suivantes sont réunies :
La réponse était 'Oui' à la question ' [LEAPQ27a]' (Maitrisez-vous une troisième langue?)

Choisissez la réponse appropriée pour chaque élément :

	0 – Jamais	1 - Presque jamais	2	3	4	5 - La moitié du temps	6	7	8	9	10 – Toujour
Interagir avec les amis	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Interagir avec la famille	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Regarder la télévision	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Ecouter de la musique	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Lire	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Auto-apprentissage	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

Selon votre perception, à quel point avez-vous un accent étranger en cette langue? *

Répondre à cette question seulement si les conditions suivantes sont réunies :
La réponse était 'Oui' à la question ' [LEAPQ27a]' (Maitrisez-vous une troisième langue?)

❗ Veuillez sélectionner une réponse ci-dessous
Veuillez sélectionner une seule des propositions suivantes :

◯ 0 – Aucun
◯ 1 - Presque aucun
◯ 2 - Très léger
◯ 3 – Léger
◯ 4 - Quelque peu
◯ 5 – Modéré
◯ 6 – Considérable
◯ 7 – Fort
◯ 8 - Très fort
◯ 9 - Extrêmement fort
◯ 10 – Envahissant

Vous arrive-t-il que des gens pensent que vous êtes un locuteur étranger de cette langue à partir de votre accent?

*

Répondre à cette question seulement si les conditions suivantes sont réunies :
La réponse était 'Oui' à la question ' [LEAPQ27a]' (Maitrisez-vous une troisième langue?)

❗ Veuillez sélectionner une réponse ci-dessous
Veuillez sélectionner une seule des propositions suivantes :

○ 0 – Jamais
○ 1 - Presque jamais
○ 2
○ 3
○ 4
○ 5 - La moitié du temps
○ 6
○ 7
○ 8
○ 9
○ 10 – Toujours

Histoire langagière

Dans cette section, vous répondrez aux questions qui traitent de votre histoire langagière.

Les langues (1, 2 et éventuellement 3) sont celles que vous avez vous-même reportées dans la partie "Evaluation individuelle des langues". Par exemple, si vous aviez indiqué que votre langue 1 était l'arabe, ici, "langue 1" correspond à "arabe".

A quel âge avez-vous commencé à apprendre les langues suivantes ? *

❗ Veuillez sélectionner 3 réponses
Choisissez la réponse appropriée pour chaque élément :

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+	N.A.
Langue 1	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Langue 2	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Langue 3	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○

N.A. = non applicable (en cas d'absence de langue 3)

A quel âge avez-vous commencé à vous sentir à l'aise d'utiliser les langues suivantes ? *

❗ Veuillez sélectionner 3 réponses
Choisissez la réponse appropriée pour chaque élément :

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+	N.A.
Langue 1	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Langue 2	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Langue 3	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○

N.A. = Non applicable (en cas d'absence de langue 3)

Combien d'années de cours (grammaire, histoire, maths, etc.) avez-vous suivi dans les langues suivantes (depuis l'école primaire jusqu'à l'université)? *

❶ Veuillez sélectionner 3 réponses
Choisissez la réponse appropriée pour chaque élément :

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+	N.A.
Langue 1	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Langue 2	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Langue 3	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○

N.A. = Non applicable (en cas d'absence de langue 3)

Combien d'années avez-vous passé dans un pays/une région où les langues suivantes sont parlées?

*

❶ Veuillez sélectionner 3 réponses
Choisissez la réponse appropriée pour chaque élément :

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+	N.A.
Langue 1	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Langue 2	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Langue 3	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○

N.A. = non applicable (en cas d'absence de langue 3)

Combien d'années avez-vous passé dans une famille qui parle les langues suivantes?

*

❶ Veuillez sélectionner 3 réponses
Choisissez la réponse appropriée pour chaque élément :

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+	N.A.
Langue 1	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Langue 2	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Langue 3	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○

N.A. = non applicable (en cas d'absence de langue 3)

Combien d'années avez-vous passé dans un lieu de travail où les langues suivantes sont parlées?

*

❶ Veuillez sélectionner 3 réponses
Choisissez la réponse appropriée pour chaque élément :

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+	N.A.
Langue 1	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Langue 2	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Langue 3	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○

N.A. = non applicable (en cas d'absence de langue 3)

Pratique des langues

Dans cette section, vous répondrez aux questions qui traitent de votre pratique des langues.

Les langues (1, 2 et éventuellement 3) sont celles que vous avez vous-même reportées dans la partie "Evaluation individuelle des langues". Par exemple, si vous aviez indiqué que votre langue 1 était l'arabe, ici, "langue 1" correspond à "arabe".

En cas d'absence de langue 3, indiquer 0%.

Pendant une semaine habituelle, quel pourcentage de temps utilisez-vous les langues suivantes avec vos amis?

L'usage total pour toutes les langues doit égaler 100%.

*

❶ Veuillez sélectionner 3 réponses
Choisissez la réponse appropriée pour chaque élément :

	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Langue 1	○	○	○	○	○	○	○	○	○	○	○
Langue 2	○	○	○	○	○	○	○	○	○	○	○
Langue 3	○	○	○	○	○	○	○	○	○	○	○

Pendant une semaine habituelle, quel pourcentage de temps utilisez-vous les langues suivantes avec votre famille?

L'usage total pour toutes les langues doit égaler 100%.

*

❶ Veuillez sélectionner 3 réponses
Choisissez la réponse appropriée pour chaque élément :

	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Langue 1	○	○	○	○	○	○	○	○	○	○	○
Langue 2	○	○	○	○	○	○	○	○	○	○	○
Langue 3	○	○	○	○	○	○	○	○	○	○	○

Pendant une semaine habituelle, quel pourcentage de temps utilisez-vous les langues suivantes à l'université/ au travail?

L'usage total pour toutes les langues doit égaler 100%.

*

❶ Veuillez sélectionner 3 réponses
Choisissez la réponse appropriée pour chaque élément :

	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Langue 1	○	○	○	○	○	○	○	○	○	○	○
Langue 2	○	○	○	○	○	○	○	○	○	○	○
Langue 3	○	○	○	○	○	○	○	○	○	○	○

Avec quelle fréquence vous parlez-vous à vous-même dans les langues suivantes?

L'usage total pour toutes les langues doit égaler 100%.

*

❶ Veuillez sélectionner 3 réponses

Choisissez la réponse appropriée pour chaque élément :

	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Langue 1	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Langue 2	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Langue 3	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

A quelle fréquence comptez-vous dans les langues suivantes?

L'usage total pour toutes les langues doit égaler 100%.

*

❶ Veuillez sélectionner 3 réponses

Choisissez la réponse appropriée pour chaque élément :

	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Langue 1	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Langue 2	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Langue 3	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

Veuillez inscrire, en pourcentage (%), la quantité de temps d'exposition *actuellement* à chacune de vos langues en moyenne.

*

❶ Seuls les nombres sont acceptés.
❶ Vos pourcentages devraient s'additionner à 100%.

	Pourcentage (%)
Langue 1	
Langue 2	
Langue 3	

Lorsque vous avez la possibilité de lire un texte disponible dans toutes les langues qui vous sont familières, dans quelle mesure (en pourcentage) choisiriez-vous de le lire dans chacune de vos langues (en imaginant que l'original a été écrit dans une langue qui vous est inconnue)?

*

❶ Seuls les nombres sont acceptés.
❶ Vos pourcentages devraient s'additionner à 100%.

	Pourcentage (%)
Langue 1	
Langue 2	
Langue 3	

Lorsque vous choisissez une langue pour engager une conversation avec un individu qui peut s'exprimer dans chacune de vos langues, dans quelle mesure (en pourcentage) choisiriez-vous d'employer chacune de vos langues? Inscrivez le pourcentage total.

*

❗ Seuls les nombres sont acceptés.
❗ Vos pourcentages devraient s'additionner à 100%.

	Pourcentage (%)
Langue 1	
Langue 2	
Langue 3	

Veuillez énumérer les cultures auxquelles vous vous identifiez. (Des exemples de cultures possibles incluent: Français, Arabe, Chinois, Allemand, Russe, etc.):

Veuillez écrire votre(vos) réponse(s) ici :

Culture 1

Culture 2

Culture 3

Veuillez ajouter autant de lignes que de cultures auxquelles vous vous identifiez.

Sur une échelle de zéro à dix, évaluez à quel point vous vous identifiez à chacune des cultures auxquelles vous vous identifiez selon vos réponses à la question précédente (suivez le même ordre de numérotation des cultures) : *

Choisissez la réponse appropriée pour chaque élément :

	0 - Pas d'identification	1 - Identification très faible	2	3	4	5 - Identification modérée	6	7	8	9	10 - Identific totale
Culture 1	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Culture 2	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
Culture 3	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

Les cultures sont celles que vous avez indiquées en réponse à la question précédente.

Compétence linguistique

Dans cette section, vous jugerez votre compétence linguistique sur une échelle de 0 à 6.

Les langues (1, 2 et éventuellement 3) sont celles que vous avez vous-même reportées dans la partie "Evaluation individuelle des langues". Par exemple, si vous aviez indiqué que votre langue 1 était l'arabe, ici, "langue 1" correspond à "arabe".

Expression *

Choisissez la réponse appropriée pour chaque élément :

	0 = non pas bien du tout	1	2	3	4	5	6 = oui très bien	Non applicabl
Parlez-vous bien votre langue 1 ?	◯	◯	◯	◯	◯	◯	◯	◯
Parlez-vous bien votre langue 2 ?	◯	◯	◯	◯	◯	◯	◯	◯
Parlez-vous bien votre langue 3 (si disponible) ?	◯	◯	◯	◯	◯	◯	◯	◯

Rappel: Les langues (1, 2 et éventuellement 3) sont celles que vous avez vous-même reportées dans la partie précédente. Par exemple, si vous aviez indiqué que votre langue 1 était l'arabe, ici, "langue 1" correspond à "arabe".

Si vous n'avez pas de L3, cochez "Non applicable".

Compréhension *

Choisissez la réponse appropriée pour chaque élément :

	0 = non pas bien du tout	1	2	3	4	5	6 = oui très bien	Non applicabl
Comprenez-vous bien votre langue 1 ?	◯	◯	◯	◯	◯	◯	◯	◯
Comprenez-vous bien votre langue 2 ?	◯	◯	◯	◯	◯	◯	◯	◯
Comprenez-vous bien votre langue 3 (si disponible) ?	◯	◯	◯	◯	◯	◯	◯	◯

Lecture *

Choisissez la réponse appropriée pour chaque élément :

	0 = non pas du tout	1	2	3	4	5	6 = oui très bien	Non applicabl
Lisez-vous bien votre langue 1 ?	◯	◯	◯	◯	◯	◯	◯	◯
Lisez-vous bien votre langue 2 ?	◯	◯	◯	◯	◯	◯	◯	◯
Lisez-vous bien votre langue 3 (si disponible) ?	◯	◯	◯	◯	◯	◯	◯	◯

Ecriture *

Choisissez la réponse appropriée pour chaque élément :

	0 = non pas bien du tout	1	2	3	4	5	6 = oui très bien	Non applicable
Écrivez-vous bien votre langue 1 ?	○	○	○	○	○	○	○	○
Écrivez-vous votre langue 2 ?	○	○	○	○	○	○	○	○
Écrivez-vous votre langue 3 (si disponible) ?	○	○	○	○	○	○	○	○

Attitudes linguistiques

Dans cette section, vous répondrez aux questions qui traitent de vos attitudes linguistiques vis-à-vis des langues que vous maitrisez. Les langues (1, 2 et éventuellement 3) sont celles que vous avez vous-même reportées dans la partie "Evaluation individuelle des langues". Par exemple, si vous aviez indiqué que votre langue 1 était l'arabe, ici, "langue 1" correspond à "arabe". Cochez la réponse qui vous convient sur une échelle de 0 à 6.

Sentiment *

Choisissez la réponse appropriée pour chaque élément :

	0 = pas d'accord	1	2	3	4	5	6 = d'accord	Non applicable
Je me sens moi-même quand je parle ma langue 1	○	○	○	○	○	○	○	○
Je me sens moi-même quand je parle ma langue 2	○	○	○	○	○	○	○	○
Je me sens moi-même quand je parle ma langue 3 (Si disponible)	○	○	○	○	○	○	○	○

Identification *

Choisissez la réponse appropriée pour chaque élément :

	0 = pas d'accord	1	2	3	4	5	6 = d'accord	Non applicable
Je m'identifie à la culture de ma langue 1	○	○	○	○	○	○	○	○
Je m'identifie à la culture de ma langue 2	○	○	○	○	○	○	○	○
Je m'identifie à la culture de ma langue 3 (Si disponible)	○	○	○	○	○	○	○	○

Utilisation *

Choisissez la réponse appropriée pour chaque élément :

	0 = pas d'accord	1	2	3	4	5	6 = d'accord	Non applicable
Il est important pour moi d'utiliser (ou d'utiliser un jour) ma langue 1 comme une personne dont c'est la langue maternelle	○	○	○	○	○	○	○	○
Il est important pour moi d'utiliser (ou d'utiliser un jour) ma langue 2 comme une personne dont c'est la langue maternelle	○	○	○	○	○	○	○	○
Il est important pour moi d'utiliser (ou d'utiliser un jour) ma langue 3 (si disponible) comme une personne dont c'est la langue maternelle	○	○	○	○	○	○	○	○

Perception des autres *

Choisissez la réponse appropriée pour chaque élément :

	0 = pas d'accord	1	2	3	4	5	6 = d'accord	Non applicable
Je veux qu'on croit que ma langue 1 est ma langue maternelle.	○	○	○	○	○	○	○	○
Je veux qu'on croit que ma langue 2 est ma langue maternelle.	○	○	○	○	○	○	○	○
Je veux qu'on croit que ma langue 3 (si disponible) est ma langue maternelle.	○	○	○	○	○	○	○	○

The Bilingual Code-Switching Profile

Partout dans le monde, là où les gens et les communautés utilisent deux langues différentes, il existe une possibilité de recourir au code-switching (CS). Dans ce questionnaire, le CS est défini comme le passage d'une langue à une autre au sein d'une même interaction ou conversation.

Nous nous intéressons particulièrement au CS impliquant le français et l'arabe libanais. Le CS est un phénomène courant, même s'il n'est pas pratiqué partout dans le monde ni dans toutes les communautés.

Exemples :

« *nezle 3a ssou2*. Je veux m'acheter des chaussures. »

« Elle est allée au *dafen* avec sa mère. »

« On avait un examen en cours de maths. *beftekir 3melet mni7.* »

« *L* chat *ken 3am yekol mnel* poubelle *w ba3den natt 3al* balcon. »

« *yi Maya, tu vas trop loin.* »

Pour vérifier que vous avez bien compris ce que nous voulons dire par « CS », veuillez cocher toutes les options incluant du CS.

*

❶ Cochez la ou les réponses
❶ Vous n'avez pas coché toutes les bonnes réponses
Veuillez choisir toutes les réponses qui conviennent :

- ☐ rayi7 chouf 3aylte samedi prochain
- ☐ teta ktir mabsouta liom
- ☐ kenit ktir gentille ma3e
- ☐ kermel hek lezim yeshtro lma7al halla2. Ils perdront beaucoup d’argent s'ils ne l’achètent pas tout de suite
- ☐ Il fait très froid dehors. Je gèle
- ☐ Merci, mesh ra7 tendam
- ☐ oul la cousinetak teje la 3ende. J’ai besoin de son aide kermel na22e robe jdide

Section 1. Histoire du CS

Dans cette section, nous aimerions que vous répondiez à quelques questions factuelles sur votre histoire avec le CS.

A quel âge avez-vous commencé à utiliser le CS ?

*

❶ Veuillez sélectionner une réponse ci-dessous
Veuillez sélectionner une seule des propositions suivantes :

- ◯ Depuis ma naissance
- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5
- ◯ 6
- ◯ 7
- ◯ 8
- ◯ 9
- ◯ 10
- ◯ 11
- ◯ 12
- ◯ 13
- ◯ 14
- ◯ 15
- ◯ 16
- ◯ 17
- ◯ 18
- ◯ 19
- ◯ 20+
- ◯ Je n’utilise jamais le CS

Rappel: CS = Code-Switching

A quel âge avez-vous commencé à vous sentir à l'aise en utilisant le CS ?

*

Veuillez sélectionner une réponse ci-dessous
Veuillez sélectionner une seule des propositions suivantes :

- ◯ Dès mes premiers souvenirs
- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5
- ◯ 6
- ◯ 7
- ◯ 8
- ◯ 9
- ◯ 10
- ◯ 11
- ◯ 12
- ◯ 13
- ◯ 14
- ◯ 15
- ◯ 16
- ◯ 17
- ◯ 18
- ◯ 19
- ◯ 20+
- ◯ Je ne me sens pas à l'aise pour utiliser le CS

Rappel: CS = Code-Switching

Section 2. Utilisation du CS

Dans cette section, nous aimerions que vous répondiez à quelques questions portant sur votre usage du CS.

Dans quelle mesure utilisez-vous le CS avec vos amis ?

*

Veuillez sélectionner une réponse ci-dessous
Veuillez sélectionner une seule des propositions suivantes :

- ◯ 0 - Jamais de CS
- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5
- ◯ 6 - CS très fréquent

Rappel: CS = Code-Switching

Dans quelle mesure utilisez-vous le CS avec votre famille ?

*

Veuillez sélectionner une réponse ci-dessous
Veuillez sélectionner une seule des propositions suivantes :

- ◯ 0 - Jamais de CS
- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5
- ◯ 6 - CS très fréquent

Rappel: CS = Code-Switching

Dans quelle mesure utilisez-vous le CS à l'université ou au travail ?

*

❶ Veuillez sélectionner une réponse ci-dessous
Veuillez sélectionner une seule des propositions suivantes :

- ◯ 0 - Jamais de CS
- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5
- ◯ 6 - CS très fréquent

Rappel: CS = Code-Switching

Dans quelle mesure utilisez-vous le CS dans votre communauté (par exemple : au supermarché, centre commercial, café, lieu de prière, association) ?

*

❶ Veuillez sélectionner une réponse ci-dessous
Veuillez sélectionner une seule des propositions suivantes :

- ◯ 0 - Jamais de CS
- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5
- ◯ 6 - CS très fréquent

Rappel: CS = Code-Switching

Dans quelle mesure utilisez-vous le CS lorsque vous vous parlez à vous-même ?

*

❶ Veuillez sélectionner une réponse ci-dessous
Veuillez sélectionner une seule des propositions suivantes :

- ◯ 0 - Jamais de CS
- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5
- ◯ 6 - CS très fréquent

Rappel: CS = Code-Switching

Dans quelle mesure utilisez-vous le CS lorsque vous comptez ?

*

❶ Veuillez sélectionner une réponse ci-dessous
Veuillez sélectionner une seule des propositions suivantes :

- ◯ 0 - Jamais de CS
- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5
- ◯ 6 - CS très fréquent

Rappel: CS = Code-Switching

Section 3. Facilité d'utilisation du CS

Dans cette section, nous vous demandons d'évaluer à quel point il est facile pour vous d'utiliser le CS dans les situations suivantes.

Est-il facile pour vous d'utiliser plusieurs langues à la fois lorsque vous parlez ?

*

Veuillez sélectionner une réponse ci-dessous
Veuillez sélectionner une seule des propositions suivantes :

- 0 - Pas du tout
- 1
- 2
- 3
- 4
- 5
- 6 - Très facile

Rappel: CS = Code-Switching

Est-il facile pour vous de comprendre lorsque les autres utilisent plusieurs langues à la fois dans leur conversation ?

*

Veuillez sélectionner une réponse ci-dessous
Veuillez sélectionner une seule des propositions suivantes :

- 0 - Pas du tout
- 1
- 2
- 3
- 4
- 5
- 6 - Très facile

Rappel: CS = Code-Switching

Est-il facile pour vous d'utiliser plusieurs langues à la fois lorsque vous écrivez (par exemple : littérature, SMS, réseaux sociaux) ?

*

Veuillez sélectionner une réponse ci-dessous
Veuillez sélectionner une seule des propositions suivantes :

- 0 - Pas du tout
- 1
- 2
- 3
- 4
- 5
- 6 - Très facile

Rappel: CS = Code-Switching

Est-il facile pour vous de comprendre le CS dans un texte écrit (par exemple : littérature, SMS, réseaux sociaux) ?

*

Veuillez sélectionner une réponse ci-dessous
Veuillez sélectionner une seule des propositions suivantes :

- 0 - Pas du tout
- 1
- 2
- 3
- 4
- 5
- 6 - Très facile

Rappel: CS = Code-Switching

Section 4. Attitudes envers le CS

Dans cette section, nous vous demandons de répondre à certaines affirmations concernant vos attitudes envers le CS.

Je me sens moi-même lorsque j’utilise plusieurs langues.

*

❗ Veuillez sélectionner une réponse ci-dessous
Veuillez sélectionner une seule des propositions suivantes :

- ◯ 0 - Pas d'accord
- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5
- ◯ 6 - D'accord

Rappel: CS = Code-Switching

Je m’identifie à une communauté/culture où on utilise plusieurs langues.

*

❗ Veuillez sélectionner une réponse ci-dessous
Veuillez sélectionner une seule des propositions suivantes :

- ◯ 0 - Pas d'accord
- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5
- ◯ 6 - D'accord

Rappel: CS = Code-Switching

Il est important pour moi de passer facilement d’une langue à une autre.

*

❗ Veuillez sélectionner une réponse ci-dessous
Veuillez sélectionner une seule des propositions suivantes :

- ◯ 0 - Pas d'accord
- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5
- ◯ 6 - D'accord

Rappel: CS = Code-Switching

Je veux que les autres pensent que j’utilise facilement plusieurs langues à la fois.

*

❗ Veuillez sélectionner une réponse ci-dessous
Veuillez sélectionner une seule des propositions suivantes :

- ◯ 0 - Pas d'accord
- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5
- ◯ 6 - D'accord

Rappel: CS = Code-Switching

Je pense que l'utilisation de plusieurs langues à la fois est quelque chose de:

Et pourquoi? (veuillez utiliser la zone de texte pour expliquer brièvement votre réponse)

*

Veuillez sélectionner une réponse ci-dessous
Veuillez sélectionner une seule des propositions suivantes :

- ◯ Bon
- ◯ Neutre
- ◯ Mauvais

Faites le commentaire de votre choix ici :

Fin du questionnaire

Le questionnaire est maintenant terminé. Merci beaucoup d'avoir pris le temps de le remplir; ces données sont précieuses pour mieux comprendre le bilinguisme chez les libanais.

Veuillez indiquer dans cette case toute remarque ou question que vous souhaiteriez partager avec l'équipe de recherche :

Veuillez écrire votre réponse ici :

Suite de l'étude

Une suite de l'étude est prévue. Elle comporte des tâches simples où il faut discuter, nommer des images, mémoriser des éléments simples... La participation à la suite de l'étude, optionnelle, nécessite que vous nous accordiez environ deux heures de votre temps. Si vous êtes intéressés, commencez par vérifier votre éligibilité à participer, puis veuillez indiquer votre adresse mail et nous vous recontacterons pour convenir d'un rendez-vous.

Je suis d'accord pour participer à la suite :

*

Veuillez sélectionner une seule des propositions suivantes :

- ◯ Oui
- ◯ Non

Pour pouvoir participer à la suite, vérifions d'abord que vous répondez aux critères de l'étude:

Critère 1:

Vous avez l'arabe libanais comme langue maternelle

*

Répondre à cette question seulement si les conditions suivantes sont réunies :
La réponse était 'Oui' à la question ' [END2]' (Je suis d'accord pour participer à la suite :)

Veuillez sélectionner une seule des propositions suivantes :

- ◯ Oui
- ◯ Non

Critère 2:

Vous parlez la langue française

*

Répondre à cette question seulement si les conditions suivantes sont réunies :
((END2.NAOK
(/index.php/questionAdministration/view/surveyid/358615/gid/47780/qid/1083554) ==
"Y"))

Veuillez sélectionner une seule des propositions suivantes :

- ◯ Oui
- ◯ Non

Critère 3:

Vous vivez en France

*

Répondre à cette question seulement si les conditions suivantes sont réunies :
((END2.NAOK
(/index.php/questionAdministration/view/surveyid/358615/gid/47780/qid/1083554) ==
"Y"))

Veuillez sélectionner une seule des propositions suivantes :

- ◯ Oui
- ◯ Non

Vous remplissez tous les critères, félicitations !
Vous pouvez participer à l'étude.
Merci de bien vouloir remplir les champs suivants :

Vos données de contact (prénom et adresse électronique) ne seront accessibles qu'à la doctorante Layana Awada et sa directrice Barbara Köpke. L'ensemble des données recueillies sera traité avec la plus entière confidentialité.

*

Répondre à cette question seulement si les conditions suivantes sont réunies :
(END2.NAOK (/index.php/questionAdministration/view/surveyid/358615/gid/47780/qid/1083554) == "Y") and ((END3a.NAOK (/index.php/questionAdministration/view/surveyid/358615/gid/47780/qid/1083552) == "Y") and (END3b.NAOK (/index.php/questionAdministration/view/surveyid/358615/gid/47780/qid/1099484) == "Y") and (END3c.NAOK (/index.php/questionAdministration/view/surveyid/358615/gid/47780/qid/1099485) == "Y"))

Veuillez écrire votre(vos) réponse(s) ici :

Prénom

Adresse mail

Étude de l'Université Toulouse - Jean Jaurès - Contrôle des langues et code-switching chez les libanais en France 19/5/25, 13:29

Malheureusement, vous ne remplissez pas tous les critères pour participer à la suite de l'étude :(

Merci pour votre intérêt!

*

Répondre à cette question seulement si les conditions suivantes sont réunies :
((END2.NAOK (/index.php/questionAdministration/view/surveyid/358615/gid/47780/qid/1083554) == "Y")) and ((END3a.NAOK (/index.php/questionAdministration/view/surveyid/358615/gid/47780/qid/1083552) == "N")) or (END3b.NAOK (/index.php/questionAdministration/view/surveyid/358615/gid/47780/qid/1099484) == "N") or (END3c.NAOK (/index.php/questionAdministration/view/surveyid/358615/gid/47780/qid/1099485) == "N")

❶ Veuillez sélectionner une réponse ci-dessous
Veuillez sélectionner une seule des propositions suivantes :

◯ Terminer le questionnaire

Merci pour votre participation et votre temps.

Nous restons disponibles par mail pour toute question ou information complémentaire: layana.awada@univ-tlse2.fr (mailto:layana.awada@univ-tlse2.fr), barbara.kopke@univ-tlse2.fr (mailto:barbara.kopke@univ-tlse2.fr)

Layana Awada, doctorante en Sciences du langage, Université Toulouse Jean Jaurès

Barbara Köpke, enseignante-chercheur en Sciences du langage, Université Toulouse Jean Jaurès

B Bilingual Picture Naming Instructions

Phase 2 Bilingual Picture Naming			
Order (group A)	**Condition**	**Instruction**	**English translation**
1	**Arabic monolingual**	هلأ رح تشوف صور عالشاشة . لازم تسميهن بالعربي الدارج، يعني باللبناني بأسرع وقت ممكن . استعمل كلمة وحدة لكل صورة. رح نعمل تجربة بالأول. قبل كل صورة رح تشوف علامة + : اطلع فيها منيح. اكبس على space لتبلش.	You will now see images on the screen. You should name them in Lebanese Arabic, the fastest possible. Use one word for each image. We will first make a practice trial. Before each image, you will see a cross: fix it well. Press on the space bar to start.
2	**French monolingual**	Vous allez voir des images à l'écran. Il faudra les dénommer en français, le plus rapidement possible. Utilisez uniquement un seul mot pour chaque image. Nous allons d'abord faire un essai. Avant chaque image, vous verrez le symbole + : regardez-le bien. Appuyez sur la barre d'espace quand vous êtes prêts à commencer.	You will now see images on the screen. You should name them in French, the fastest possible. Use one word for each image. We will first make a practice trial. Before each image, you will see a cross: fix it well. Press the space bar to start.
3	**Cued bilingual**	Vous allez voir des images à l'écran. Ces images seront encadrées soit en rouge, soit en bleu. Quand l'image est encadrée en rouge, il faudra la dénommer en arabe; quand elle est encadrée en bleu, il faudra la dénommer en français. Nous allons d'abord faire un essai. Avant chaque image, vous verrez le symbole + : regardez-le bien. Appuyez sur la barre d'espace pour commencer.	You will now see images on the screen. These images will be framed either in red or in blue. When the image is framed in red, you should name it in Arabic; when it is framed in blue, you should name it in French. We will first make a practice trial. Before each image, you will see a cross: fix it well. Press the space bar to start.
4	**Voluntary bilingual**	Vous allez voir des images à l'écran. Il faudra les dénommer soit en arabe libanais, soit en français, le plus rapidement possible. Vous êtes libre de choisir la langue à utiliser pour chaque image. Cependant, veuillez ne pas utiliser la même langue tout au long de la tâche. Nous allons d'abord faire un essai. Avant chaque image, vous verrez le symbole + : regardez-le bien. Appuyez sur la barre d'espace pour commencer.	You will see images on the screen. You should name them either in Lebanese Arabic or in French, as quickly as possible. You are free to choose which language to use for each image. However, please avoid using the same language throughout the entire task. We will first do a practice trial. Before each image, you will see a cross: fix it well. Press the space bar to start.

For group B, participants followed the order: 3, 4, 1,2.

C Phase 2 Bilingual Semantic Fluency Instructions

Phase 2 Bilingual Semantic Fluency			
Order (group A)	**Condition**	**Instruction**	**English translation of the instruction**
1	**French monolingual**	Donnez-moi le plus de noms d'animaux possible en français. Vous avez une minute.	Give me as many animal names as possible in French. You have one minute.
2	**Arabic monolingual**	بدي تعطيني أكبر عدد من المأكولات بالعربي الدارج، يعني باللبناني. معك دقيقة.	Give me as many types of food as possible in Lebanese Arabic. You have one minute.
3	**Alternate bilingual**	Donnez-moi le plus de noms de vêtements possible. Il faudra alterner entre les deux langues, en donnant un mot dans chaque langue. Par exemple, pour des noms de légumes, vous devriez dire : pomme de terre, [khyar], champignon, [basal]. Attention, il ne faut pas dire le même mot dans chacune des deux langues. Vous avez une minute.	Give me as many clothing item names as possible. You should alternate between French and Lebanese Arabic, giving one word in each language. For example, for vegetable names, you would say: pomme de terre$_{FR}$, [khyaar]$_{LA}$, champignon$_{FR}$, [basal]$_{LA}$. Be careful not to say the same word in both languages. You have one minute.
4	**Voluntary bilingual**	Donnez-moi le plus de noms de fruits possible. Vous pouvez les dire dans la langue qui vous convient, à condition d'utiliser les 2 langues (français et arabe libanais) au cours de la tâche. Vous avez une minute.	Give me as many fruit names as possible. You may say them in the language you prefer, as long as you use both languages (French and Lebanese Arabic) during the task. You have one minute.

For group B, participants followed the order: 3, 4, 1,2.

D Phase 3 Bilingual Semantic Fluency Instructions

Phase 3 Bilingual Semantic Fluency			
Order (group A)	**Condition**	**Instruction**	**English translation of the instruction**
1	**French monolingual**	Donnez-moi le plus de noms d'aliments possible en français. Vous avez une minute	Give me as many types of food as possible in French. You have one minute.
2	**Arabic monolingual**	بدي تقلّي أكبر عدد من الحيوانات بالعربي الدارج، يعني باللبناني. معك دقيقة.	Give me as many animal names as possible in Lebanese Arabic. You have one minute.
3	**Alternate bilingual**	Donnez-moi le plus de noms de fruits possible. Il faudra alterner entre le français et l'arabe, en donnant un mot dans chaque langue. Par exemple, pour des noms de légumes, vous devriez dire : pomme de terre, [khyaar], champignon, [basal]. Attention, il ne faut pas dire le même mot dans chacune des deux langues. Vous avez une minute	Give me as many fruit names as possible. You should alternate between French and Lebanese Arabic, giving one word in each language. For example, for vegetable names, you would say: pomme de terre$_{FR}$, [khyaar]$_{LA}$, champignon$_{FR}$, [basal]$_{LA}$. Be careful not to say the same word in both languages. You have one minute.
4	**Voluntary bilingual**	Donnez-moi le plus de noms de vêtements possible. Vous pouvez les dire dans la langue qui vous convient, à condition d'utiliser les 2 langues (français et arabe libanais) au cours de la tâche. Vous avez une minute	Give me as many clothing item names as possible. You may say them in the language you prefer, as long as you use both languages (French and Lebanese Arabic) during the task. You have one minute.

For group B, participants followed the order: 3, 4, 1,2.

E Flanker Task Instructions

Vous allez voir apparaître des flèches à l'écran. Sur le clavier de l'ordinateur, appuyez à gauche $\leftarrow$ quand la flèche du centre pointe vers la gauche et appuyez à droite $\rightarrow$ quand la flèche du centre pointe vers la droite, le plus rapidement possible. Essayez d'ignorer les flèches qui entourent celle du centre. Vous verrez d'abord le symbole + au centre de l'écran : regardez-le bien. Nous allons commencer par un essai. Appuyez sur la barre d'espace pour commencer.

English translation: You will see arrows appear on the screen. On the keyboard, press left $\leftarrow$ when the center arrow points to the left, and press right $\rightarrow$ when the center arrow points to the right, as quickly as possible. Try to ignore the arrows surrounding the center one. You will first see the symbol + at the center of the screen – watch it closely. We will start with a practice trial. Press the space bar to begin.

F French Stroop Task Instructions

Naming Condition

Vous allez voir des rectangles de trois couleurs différentes : rouge, bleu et vert. Il faudra dire la couleur de chaque rectangle le plus rapidement possible. Commençons par un essai. Avant chaque couleur, vous verrez le symbole + : regardez-le bien. Appuyez sur la barre d'espace quand vous êtes prêts à commencer.
English translation: You will see rectangles in three different colors: red, blue, and green. You should name the color of each rectangle as quickly as possible. We will start with a trial. Before each color, you will see the symbol +: focus on it. Press the space bar when you are ready to begin.

Reading Condition

Vous allez maintenant voir les noms de trois couleurs différentes : rouge, bleu et vert. Il faudra lire ces noms à voix haute, le plus rapidement possible. Commençons par un essai. Appuyez sur la barre d'espace quand vous êtes prêt.
English translation: You will now see the names of three different colors: red, blue, and green. You should read these names aloud as quickly as possible. We will start with a trial. Press the space bar when you are ready.

Interference Condition

Vous allez maintenant voir les noms de couleurs écrits dans une autre couleur (rouge, vert, bleu). Il faudra à chaque fois ne pas lire le mot mais donner la couleur de l'encre dans laquelle le mot est écrit, le plus rapidement possible. Commençons par un essai. Appuyez sur la barre d'espace quand vous êtes prêt.

English translation: You will now see color names written in a different color (red, green, blue). For each item, you should not read the word but name the color of the ink in which the word is written, as quickly as possible. We will start with a trial. Press the space bar when you are ready.

G Arabic Stroop Task Instructions

Naming Condition

هلأ رح تشوف مستطيلات بثلاث ألوان مختلفة: أحمر وأزرق وأخضر. لازم تقول لون كل مستطيل بأسرع وقت ممكن. رح نبلش بتجربة. اكبس على المسافة لتبلش. قبل كل صورة رح تشوف علامة +: اطلع فيها منيح.

English translation: You will now see rectangles in three different colors: red, blue, and green. You should name the color of each rectangle as quickly as possible. We will start with a trial. Press the space bar to begin. Before each rectangle, you will see a + symbol: look at it carefully.

Reading Condition

هلأ رح تشوف أسماء ثلاث ألوان مختلفة: أحمر وأزرق وأخضر. لازم تقرا هالأسماء ع صوت عالي بأسرع وقت ممكن. رح نبلش بتجربة. اكبس على المسافة لتبلش.

English translation: You will now see the names of three different colors: red, blue, and green. You should read these names out loud as quickly as possible. We will start with a trial. Press the space bar to begin.

Interference Condition

هلأ رح تشوف أسماء الألوان مكتوبة بغير لون (أحمر، أخضر، أزرق). مش لازم تقرا الكلمة، بس لازم تعطي لون الحبر اللي مكتوبة فيه الكلمة. اكبس على المسافة لتبلش.

English translation: You will now see color names written in a different color (red, green, blue). You should not read the word, but instead say the color of the ink it's written in, as quickly as possible. Press the space bar to begin.

H Wisconsin Card Sorting Task Instructions

Dans cette tâche, vous devrez trier les cartes présentées en fonction d'une règle, c'est-à-dire que les cartes devront être triées en fonction de leur couleur, de leur forme ou de leur nombre. La règle ne sera pas présentée, mais vous recevrez un retour d'information à chaque essai. Après un certain nombre d'essais, la règle changera. Pour sélectionner votre réponse, cliquez sur l'une des quatre cartes présentées en haut de l'écran. Appuyez sur la barre d'espace pour continuer.
Par exemple, vous verrez l'écran suivant : la carte présentée (en bas au centre) peut être classée en fonction de sa forme (cercles), de sa couleur (jaune) ou de son nombre (trois). Cliquez sur la première carte si vous souhaitez la classer en fonction de sa forme, sur la deuxième si vous souhaitez la classer en fonction de sa couleur, et sur la troisième si vous souhaitez la classer en fonction de son nombre. Après avoir sélectionné votre réponse, vous recevrez un feedback. Cliquez sur l'image pour commencer l'expérience.

English Translation: In this task, you will be asked to sort the displayed cards according to a rule — that is, by color, shape, or number. The rule will not be shown, but you will receive feedback after each trial. After a certain number of trials, the rule will change. To select your response, click on one of the four cards displayed at the top of the screen. Press the space bar to continue.
For example, you will see the following screen: the card displayed (at the bottom center) can be sorted according to its shape (circles), its color (yellow), or its number (three). Click on the first card if you want to sort it by shape, on the second card if you want to sort it by color, and on the third card if you want to sort it by number. After selecting your response, you will receive feedback. Click on the image to start the experiment.

I Working Memory (Digit Span) Task Instructions

Mémoire de travail/ Working Memory

a) Ordre direct/ Digit Span Forward

Dire : Maintenant, je vais vous dire quelques chiffres. Écoutez attentivement, je ne peux les dire qu'une seule fois. Quand j'aurai terminé, je veux que vous les répétiez exactement dans le même ordre. Dites-les comme je les ai dits.

English translation:
Say: Now I'm going to say some numbers. Listen carefully, I can only say them once. When I finish, I want you to repeat them in exactly the same order. Say them just as I said them.

Example:

- *Trial 1*: 9 – 7
- *Trial 8*: 7 – 1 – 3 – 9 – 4 – 2 – 5 – 6 – 8

b) Ordre inverse/ Digit Span Backward

Dire : Maintenant, je vais encore vous dire des chiffres mais cette fois-ci quand j'aurai terminé, je veux que vous me les répétiez en ordre inverse.

English translation:
Say: Now, I'm going to say some numbers again, but this time, when I'm done, I want you to repeat them in reverse order.

Example:

- *Trial 1*: 3 - 1
- *Trial 8*: 9 – 4 – 3 – 7 – 6 – 2 – 1 – 8

c) Ordre croissant/ Digit Span Sequencing

Dire : Maintenant, je vais encore vous dire des chiffres mais cette fois-ci quand j'aurai terminé, je veux que vous me les disiez dans l'ordre, en commençant par le plus petit.

English translation:
Say: Now, I'm going to say some numbers again, but this time, when I'm done, I want you to say them in order, starting with the smallest.

Example:

- *Trial 1*: 4 – 2
- *Trial 8*: 5 – 0 – 1 – 1 – 3 – 2 – 1 – 0 – 5

J Correlations Between Executive Measures and Language Tasks

Executive Measure	Task Pair	Correlation
Working Memory (Digit Span)		
	Fluency & Forward DS accuracy	+*
	Fluency & Backward DS accuracy	+*
	Fluency & Sequencing DS accuracy	+*
	BPN & Forward DS accuracy	+*
	BPN & Backward DS accuracy	+*
	BPN & Sequencing DS accuracy	-*
Inhibition (Flanker and Stroop)		
Nonverbal Inhibition (Flanker)		
	Flanker accuracy & Overall fluency	– (ns)
	Flanker accuracy & Arabic monolingual fluency	–*
	Flanker accuracy & French monolingual fluency	–*
	Flanker accuracy & Alternate bilingual fluency	+*
	Flanker accuracy & Voluntary bilingual fluency	– (ns)
	Flanker accuracy & Overall BPN accuracy	+*
	Flanker RT & Overall BPN RT	+*
	Flanker accuracy & Arabic monolingual BPN accuracy	+*
	Flanker RT & Arabic monolingual BPN RT	+*
	Flanker accuracy & French monolingual BPN accuracy	+ (ns)
	Flanker RT & French monolingual BPN RT	+*
	Flanker accuracy & Cued bilingual BPN accuracy	+*
	Flanker RT & Cued bilingual BPN RT	+*
	Flanker accuracy & Voluntary bilingual BPN accuracy	–*
	Flanker RT & Voluntary bilingual BPN RT	+*
Verbal Inhibition (Stroop)		
	Stroop Ar accuracy & Overall fluency	+*
	Stroop Ar accuracy & Arabic monolingual fluency	+*
	Stroop Ar accuracy & Alternate bilingual fluency	+*
	Stroop Ar accuracy & Voluntary bilingual fluency	+*
	Stroop Fr accuracy & Overall fluency	+ (ns)
	Stroop Fr accuracy & French monolingual fluency	+*
	Stroop Fr accuracy & Alternate bilingual fluency	–*
	Stroop Fr accuracy & Voluntary bilingual fluency	+ (ns)
	Stroop Ar accuracy & Overall BPN accuracy	+*
	Stroop Ar RT & Overall BPN RT	+*
	Stroop Ar accuracy & Arabic monolingual BPN accuracy	+*
	Stroop Ar RT & Arabic monolingual BPN RT	+*
	Stroop Ar accuracy & Cued bilingual BPN accuracy	+*
	Stroop Ar RT & Cued bilingual BPN RT	+*
	Stroop Ar accuracy & Voluntary bilingual BPN accuracy	+*
	Stroop Ar RT & Voluntary bilingual BPN RT	+*
	Stroop Fr accuracy & Overall BPN accuracy	+*
	Stroop Fr RT & Overall BPN RT	+*
	Stroop Fr accuracy & French monolingual BPN accuracy	+*
	Stroop Fr RT & French monolingual BPN RT	+*
	Stroop Fr accuracy & Cued bilingual BPN accuracy	+*
	Stroop Fr RT & Cued bilingual BPN RT	+*
	Stroop Fr accuracy & Voluntary bilingual BPN accuracy	+*
	Stroop Fr RT & Voluntary bilingual BPN RT	+*
Mental Flexibility (WCST)		
	WCST accuracy & Overall Fluency	+*
	WCST accuracy & Arabic Monolingual Fluency	+*
	WCST accuracy & French Monolingual Fluency	–*
	WCST accuracy & Alternate Bilingual Fluency	+*
	WCST accuracy & Voluntary Bilingual Fluency	+*
	WCST accuracy & Overall BPN accuracy	+*
	WCST RT & Overall BPN RT	+*
	WCST accuracy & Arabic Monolingual BPN accuracy	+*
	WCST RT & Arabic Monolingual BPN RT	+*
	WCST accuracy & French Monolingual BPN accuracy	+*
	WCST RT & French Monolingual BPN RT	+*
	WCST accuracy & Cued Bilingual BPN accuracy	+*
	WCST RT & Cued Bilingual BPN RT	+*
	WCST accuracy & Voluntary Bilingual BPN accuracy	+*
	WCST RT & Voluntary Bilingual BPN RT	+*

K Phase 3 Discourse Tasks Instructions

1. Discours semi-dirigé/Semi-structured discourse

Groupe 1 (1A)	Groupe 2 (1B)	Groupe 3 (2A)	Groupe 4 (2B)
Single-language: Q1 ar: بدي تخبّرني كيف بتقضّي نهارك (مراحل النهار والروتين اليومية، شو بتعمل من الصبح لعشية)، بأكثر تفاصيل ممكنة. *I would like you to tell me how you spend your day (the parts of the day and your daily routine, what you do from morning to evening), with as many details as possible.* Q2 fr: Je voudrais que tu me racontes comment se déroule un weekend typique pour toi (les activités, les étapes de ta routine, ce que tu fais du matin au soir pendant ces 2 jours), avec le plus de détails possibles. *I would like you to tell me what a typical weekend is like for you (the activities, the steps in your routine, what you do from morning to evening over those two days), with as many details as possible.*	Single-language: Q1 fr: Je voudrais que tu me racontes comment se déroule une journée typique pour toi (les étapes de ta routine journalière, ce que tu fais du matin au soir), avec le plus de détails possibles. *I would like you to tell me how you spend your day (the parts of the day and your daily routine, what you do from morning to evening), with as many details as possible.* Q2 ar: بدي تخبّرني كيف بتقضّي عطلة السبت والاحد (النشاطات اللي بتعملها، مراحل الروتين تبعك، شو بتعمل من الصبح لعشية خلال هاليومين)، بأكثر تفاصيل ممكنة. *I would like you to tell me what a typical weekend is like for you (the activities, the steps in your routine, what you do from morning to evening over those two days), with as many details as possible.*	Dense CS: Q7 bilingue: [Bedde tkhabberne 3an]$_{LA}$ [souvenir]$_{FR}$ [men toufoultak]$_{LA}$ [qui te tient à cœur]$_{FR}$, [enta w 3am ta3tine add ma fik]$_{LA}$ [détails]$_{FR}$. *I would like you to tell me about a cherished childhood memory, with as many details as possible.*	
Dual-language: Q3 ar: بدّي تحكيلي عن حفلة عائلية من خيارك (زواج أو عيد الميلاد أو الأضحى)، بأكثر تفاصيل ممكنة. *I would like you to tell me about a family celebration of your choice (such as a wedding, a Christmas Eve, or Eid al-Adha), with as many details as possible.* Q4 fr: Je voudrais que tu me racontes ce que tu as fait pendant les vacances d'été passées, avec le plus de détails possibles. *I would like you to tell me what you did during the past summer holidays, with as many details as possible.* Q5 ar: بدي تخبّرني شو عملت عراس السنة، بأكثر تفاصيل ممكنة. *I would like you to tell me what you did on last New Year's Eve, with as many details as possible.* Q6 fr: Je voudrais que tu me parles d'une de tes fêtes d'anniversaire dont tu te souviens bien ou que tu	Dual-language: Q3 fr: Je voudrais que tu me parles d'une fête de famille de ton choix (comme un mariage, un soir de Noël ou de Aïd Adha), avec le plus de détails possibles. *I would like you to tell me about a family celebration of your choice (such as a wedding, a Christmas Eve, or Eid al-Adha), with as many details as possible.* Q4 ar: بدي تخبّرني شو عملت بالصيفية الماضية، بأكثر تفاصيل ممكنة. *I would like you to tell me what you did during the past summer holidays, with as many details as possible.* Q5 fr: Je voudrais que tu me racontes ce que tu as fait à la soirée du nouvel an passé, avec le plus de détails possibles.	Dual-language: Q6 fr: Je voudrais que tu me parles d'une de tes fêtes d'anniversaire dont tu te souviens bien ou que tu apprécies particulièrement, avec le plus de détails possibles. *I would like you to tell me about one of your birthday parties that you remember well or particularly enjoy, with as many details as possible.* Q5 ar: بدي تخبّرني شو عملت عراس السنة، بأكثر تفاصيل ممكنة. *I would like you to tell me what you did on last New Year's Eve, with as many details as possible.* Q4 fr: Je voudrais que tu me racontes ce que tu as fait pendant les vacances d'été passées, avec le plus de détails possibles. *I would like you to tell me what you did during the past summer holidays, with as many details as possible.* Q3 ar:	Dual-language: Q6 ar: بدّي تحكيني عن حفلة عيد ميلاد إلك بتتذكرها منيح أو غالية عقلبك، بأكثر تفاصيل ممكنة. *I would like you to tell me about one of your birthday parties that you remember well or particularly enjoy, with as many details as possible.* Q5 fr: Je voudrais que tu me racontes ce que tu as fait à la soirée du nouvel an passé, avec le plus de détails possibles. *I would like you to tell me what you did on last New Year's Eve, with as many details as possible.* Q4 ar: بدي تخبّرني شو عملت بالصيفية الماضية، بأكثر تفاصيل ممكنة. *I would like you to tell me what you did during the past summer holidays, with as many details as possible.*

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Dense CS: Q7 bilingue: [Bedde tkhabberne 3an]$_{LA}$ [souvenir]$_{FR}$ [men toufoultak]$_{LA}$ [qui te tient à cœur]$_{FR}$, [enta w 3am ta3tine add ma fik]$_{LA}$ [détails]$_{FR}$. *I would like you to tell me about a cherished childhood memory, with as many details as possible.*		Single-language: Q2 fr: Je voudrais que tu me racontes comment se déroule un weekend typique pour toi (les activités, les étapes de ta routine, ce que tu fais du matin au soir pendant ces 2 jours), avec le plus de détails possibles. *I would like you to tell me what a typical weekend is like for you (the activities, the steps in your routine, what you do from morning to evening over those two days), with as many details as possible.* Q1 ar: بدي تخبّرني كيف بتقضّي نهارك (مراحل النهار والروتين اليومية، شو بتعمل من الصبح لعشية)، بأكثر تفاصيل ممكنة. *I would like you to tell me how you spend your day (the parts of the day and your daily routine, what you do from morning to evening), with as many details as possible.*	Single-language: Q2 ar: بدي تخبّرني كيف بتقضّي عطلة السبت والاحد (النشاطات اللي بتعملها، مراحل الروتين تبعك، شو بتعمل من الصبح لعشية خلال هاليومين)، بأكثر تفاصيل ممكنة. *I would like you to tell me what a typical weekend is like for you (the activities, the steps in your routine, what you do from morning to evening over those two days), with as many details as possible.* Q1 fr: Je voudrais que tu me racontes comment se déroule une journée typique pour toi (les étapes de ta routine journalière, ce que tu fais du matin au soir), avec le plus de détails possibles. *I would like you to tell me how you spend your day (the parts of the day and your daily routine, what you do from morning to evening), with as many details as possible.*

2. Description de vidéos/Video description

Condition	Instruction
Single-language Arabic	خبّرني شو عم بصير بالفيديو، بالعربي، بأكثر تفاصيل ممكنة. *I1: Tell me what is going on in this video, in Arabic, with as many details as possible.*
Single-language French	Raconte-moi ce qui se passe dans cette vidéo, en français, avec le plus de détails possibles. *I2: Tell me what is going on in this video, in French, with as many details as possible.*
Dual-language	I1 : خبّرني شو عم تعمل القطّة بالعربي. I2 :Et à moi, raconte-moi ce que la souris fait, en français. *I1: Tell me what the cat is doing, in Arabic.* *I2: And tell me what the mouse is doing, in French.*
Dense CS	I3 : [Raconte-moi ce qui se passe dans cette vidéo]$_{FR}$ [2enta w 3am te7kine bel leghten 3arabe lebnene w]$_{LA}$ [français]$_{FR}$. *I3 : Tell me what is going on in this video using both Lebanese Arabic and French.*

L Loanword vs. Code-Switching Classification Questionnaire

لبناني أو أجنبي؟ Lebanese Arabic or not?

هدف هالبحث هو فهم استعمال اللغات عند اللبنانيين. رح نطرح عليك كام سؤال بخصوص عدد من الكلمات وكيف اللبنانيين بيستعملوهن.

The purpose of this study is to understand how languages are used in Lebanese people. We will ask you a few questions regarding some words and how they are used by the Lebanese population.

يوجد 44 سؤال في هذا الإستبيان.

There are 44 questions in this survey.

لبناني أو أجنبي؟

رح تشوف عدد من الكلمات. لكلّ كلمة، مطلوب منّك تحدّد إذا شخص لبناني بيحكي بس عربي، بيستعملهن. فكّر بأي شخص بيحكي بس عربي دارج (يعني لبناني، مش فصحى) وما بيعرف أي لغة تانية.

You will now see some words. For each word, we ask you to determine if a Lebanese person who only speaks Arabic, uses it. Think of any person who only speaks Lebanese Arabic and doesn't know any other language.

من ٠ ل ١٠٠٪، قدّيش معقول يقول هالكلمات؟

On scale of 0 to 100%, how much is it possible for this person to use each of the following words?

أوتيل Hôtel

*

أختر احدى الاجابات التالية: Choose one of the following answers:

من فضلك اختر **واحدا فقط** مما يلي: Please choose only one answer from the following:

- 0% أبدًا ما بيستعملها — 0% They never use it
- 20%
- 40%
- 60%
- 80%
- 100% أكيد بيستعملها — 100% Of course they use it

كمبيوتر Computer

*

أختر احدى الاجابات التالية:

من فضلك اختر **واحدا فقط** مما يلي:

- 0% أبدًا ما بيستعملها
- 20%
- 40%
- 60%
- 80%
- 100% أكيد بيستعملها

جيلو Jello

*

أختر احدى الاجابات التالية:

من فضلك اختر **واحدا فقط** مما يلي:

- 0% أبدًا ما بيستعملها
- 20%
- 40%
- 60%
- 80%
- 100% أكيد بيستعملها

كرواسان Croissant

*

أختر احدى الاجابات التالية:
من فضلك اختر **واحدا فقط** مما يلي:

- ◯ 0% أبدًا ما بيستعملها
- ◯ 20%
- ◯ 40%
- ◯ 60%
- ◯ 80%
- ◯ 100% أكيد بيستعملها

سبور Sport

*

أختر احدى الاجابات التالية:
من فضلك اختر **واحدا فقط** مما يلي:

- ◯ 0% أبدًا ما بيستعملها
- ◯ 20%
- ◯ 40%
- ◯ 60%
- ◯ 80%
- ◯ 100% أكيد بيستعملها

بيسيكلة Bicyclette

*

أختر احدى الاجابات التالية:
من فضلك اختر **واحدا فقط** مما يلي:

- ◯ 0% أبدًا ما بيستعملها
- ◯ 20%
- ◯ 40%
- ◯ 60%
- ◯ 80%
- ◯ 100% أكيد بيستعملها

تواليت Toilettes

*

أختر احدى الاجابات التالية:
من فضلك اختر **واحدا فقط** مما يلي:

- ◯ 0% أبدًا ما بيستعملها
- ◯ 20%
- ◯ 40%
- ◯ 60%
- ◯ 80%
- ◯ 100% أكيد بيستعملها

أكتيفيتي Activité

*

أختر احدى الاجابات التالية:
من فضلك اختر **واحدا فقط** مما يلي:

- ◯ 0% أبدًا ما بيستعملها
- ◯ 20%
- ◯ 40%
- ◯ 60%
- ◯ 80%
- ◯ 100% أكيد بيستعملها

فورماسيون Formation

*

أختر احدى الاجابات التالية:
من فضلك اختر **واحدا فقط** مما يلي:

- ◯ 0% أبدًا ما بيستعملها
- ◯ 20%
- ◯ 40%
- ◯ 60%
- ◯ 80%
- ◯ 100% أكيد بيستعملها

ميساج Message

*

أختر احدى الاجابات التالية:
من فضلك اختر **واحدا فقط** مما يلي:

- ◯ 0% أبدًا ما بيستعملها
- ◯ 20%
- ◯ 40%
- ◯ 60%
- ◯ 80%
- ◯ 100% أكيد بيستعملها

لابتوب Laptop

*

أختر احدى الاجابات التالية:
من فضلك اختر **واحدا فقط** مما يلي:

- ◯ 0% أبدًا ما بيستعملها
- ◯ 20%
- ◯ 40%
- ◯ 60%
- ◯ 80%
- ◯ 100% أكيد بيستعملها

Mom / Pap موم / باب *

أختر احدى الاجابات التالية:
من فضلك اختر **واحدا فقط** مما يلي:

- 0% أبدًا ما بيستعملها
- 20%
- 40%
- 60%
- 80%
- 100% أكيد بيستعملها

Mail مايل *

أختر احدى الاجابات التالية:
من فضلك اختر **واحدا فقط** مما يلي:

- 0% أبدًا ما بيستعملها
- 20%
- 40%
- 60%
- 80%
- 100% أكيد بيستعملها

Scooter سكوتر *

أختر احدى الاجابات التالية:
من فضلك اختر **واحدا فقط** مما يلي:

- 0% أبدًا ما بيستعملها
- 20%
- 40%
- 60%
- 80%
- 100% أكيد بيستعملها

Bravo برافو *

أختر احدى الاجابات التالية:
من فضلك اختر **واحدا فقط** مما يلي:

- 0% أبدًا ما بيستعملها
- 20%
- 40%
- 60%
- 80%
- 100% أكيد بيستعملها

* جيلاتين Gélatine

أختر احدى الاجابات التالية:
من فضلك اختر **واحدا فقط** مما يلي:

- ◯ 0% أبدًا ما بيستعملها
- ◯ 20%
- ◯ 40%
- ◯ 60%
- ◯ 80%
- ◯ 100% أكيد بيستعملها

* لامبادير Lampadaire

أختر احدى الاجابات التالية:
من فضلك اختر **واحدا فقط** مما يلي:

- ◯ 0% أبدًا ما بيستعملها
- ◯ 20%
- ◯ 40%
- ◯ 60%
- ◯ 80%
- ◯ 100% أكيد بيستعملها

* توست Toast

أختر احدى الاجابات التالية:
من فضلك اختر **واحدا فقط** مما يلي:

- ◯ 0% أبدًا ما بيستعملها
- ◯ 20%
- ◯ 40%
- ◯ 60%
- ◯ 80%
- ◯ 100% أكيد بيستعملها

* سوص Sauce

أختر احدى الاجابات التالية:
من فضلك اختر **واحدا فقط** مما يلي:

- ◯ 0% أبدًا ما بيستعملها
- ◯ 20%
- ◯ 40%
- ◯ 60%
- ◯ 80%
- ◯ 100% أكيد بيستعملها

* دوش Douche

أختر احدى الاجابات التالية:

من فضلك اختر **واحدا فقط** مما يلي:

- 0% أبدًا ما بيستعملها
- 20%
- 40%
- 60%
- 80%
- 100% أكيد بيستعملها

* تشيبس Chips

أختر احدى الاجابات التالية:

من فضلك اختر **واحدا فقط** مما يلي:

- 0% أبدًا ما بيستعملها
- 20%
- 40%
- 60%
- 80%
- 100% أكيد بيستعملها

* ماكسيموم Maximum

أختر احدى الاجابات التالية:

من فضلك اختر **واحدا فقط** مما يلي:

- 0% أبدًا ما بيستعملها
- 20%
- 40%
- 60%
- 80%
- 100% أكيد بيستعملها

* سوبرماركت Supermarket

أختر احدى الاجابات التالية:

من فضلك اختر **واحدا فقط** مما يلي:

- 0% أبدًا ما بيستعملها
- 20%
- 40%
- 60%
- 80%
- 100% أكيد بيستعملها

Shopping شوبينغ *

أختر احدى الاجابات التالية:
من فضلك اختر **واحدا فقط** مما يلي:

- ◯ 0% أبدًا ما بيستعملها
- ◯ 20%
- ◯ 40%
- ◯ 60%
- ◯ 80%
- ◯ 100% أكيد بيستعملها

Gym دجيم *

أختر احدى الاجابات التالية:
من فضلك اختر **واحدا فقط** مما يلي:

- ◯ 0% أبدًا ما بيستعملها
- ◯ 20%
- ◯ 40%
- ◯ 60%
- ◯ 80%
- ◯ 100% أكيد بيستعملها

Noël نويل *

أختر احدى الاجابات التالية:
من فضلك اختر **واحدا فقط** مما يلي:

- ◯ 0% أبدًا ما بيستعملها
- ◯ 20%
- ◯ 40%
- ◯ 60%
- ◯ 80%
- ◯ 100% أكيد بيستعملها

Routine روتين *

أختر احدى الاجابات التالية:
من فضلك اختر **واحدا فقط** مما يلي:

- ◯ 0% أبدًا ما بيستعملها
- ◯ 20%
- ◯ 40%
- ◯ 60%
- ◯ 80%
- ◯ 100% أكيد بيستعملها

Gâteau كاتو *

أختر احدى الاجابات التالية:
من فضلك اختر **واحدا فقط** مما يلي:

- 0% أبدًا ما بيستعملها
- 20%
- 40%
- 60%
- 80%
- 100% أكيد بيستعملها

Cake كايك *

أختر احدى الاجابات التالية:
من فضلك اختر **واحدا فقط** مما يلي:

- 0% أبدًا ما بيستعملها
- 20%
- 40%
- 60%
- 80%
- 100% أكيد بيستعملها

Contrat كونترا *

أختر احدى الاجابات التالية:
من فضلك اختر **واحدا فقط** مما يلي:

- 0% أبدًا ما بيستعملها
- 20%
- 40%
- 60%
- 80%
- 100% أكيد بيستعملها

Vernis فارني *

أختر احدى الاجابات التالية:
من فضلك اختر **واحدا فقط** مما يلي:

- 0% أبدًا ما بيستعملها
- 20%
- 40%
- 60%
- 80%
- 100% أكيد بيستعملها

(صفّ المدرسة) بروميار Première (Classe d'école)

*

أختر احدى الاجابات التالية:
من فضلك اختر **واحدا فقط** مما يلي:

- 0% أبدًا ما بيستعملها
- 20%
- 40%
- 60%
- 80%
- 100% أكيد بيستعملها

(صفّ المدرسة) تارمينال Terminale (Classe d'école)

*

أختر احدى الاجابات التالية:
من فضلك اختر **واحدا فقط** مما يلي:

- 0% أبدًا ما بيستعملها
- 20%
- 40%
- 60%
- 80%
- 100% أكيد بيستعملها

تيفي TV

*

أختر احدى الاجابات التالية:
من فضلك اختر **واحدا فقط** مما يلي:

- 0% أبدًا ما بيستعملها
- 20%
- 40%
- 60%
- 80%
- 100% أكيد بيستعملها

آلارم Alarme *

أختر احدى الاجابات التالية:
من فضلك اختر **واحدا فقط** مما يلي:

- 0% أبدًا ما بيستعملها
- 20%
- 40%
- 60%
- 80%
- 100% أكيد بيستعملها

* نيسكافي Nescafé

أختر احدى الاجابات التالية:
من فضلك اختر **واحدا فقط** مما يلي:

- ◯ 0% أبدًا ما بيستعملها
- ◯ 20%
- ◯ 40%
- ◯ 60%
- ◯ 80%
- ◯ 100% أكيد بيستعملها

* كورن فلاكس Corn flakes

أختر احدى الاجابات التالية:
من فضلك اختر **واحدا فقط** مما يلي:

- ◯ 0% أبدًا ما بيستعملها
- ◯ 20%
- ◯ 40%
- ◯ 60%
- ◯ 80%
- ◯ 100% أكيد بيستعملها

* ويك آند Weekend

أختر احدى الاجابات التالية:
من فضلك اختر **واحدا فقط** مما يلي:

- ◯ 0% أبدًا ما بيستعملها
- ◯ 20%
- ◯ 40%
- ◯ 60%
- ◯ 80%
- ◯ 100% أكيد بيستعملها

* كوزينتي / كوزاني Cousinté / Cousané

أختر احدى الاجابات التالية:
من فضلك اختر **واحدا فقط** مما يلي:

- ◯ 0% أبدًا ما بيستعملها
- ◯ 20%
- ◯ 40%
- ◯ 60%
- ◯ 80%
- ◯ 100% أكيد بيستعملها

* Album ألبوم

أختر احدى الاجابات التالية:
من فضلك اختر **واحدا فقط** مما يلي:

- 0% أبدًا ما بيستعملها
- 20%
- 40%
- 60%
- 80%
- 100% أكيد بيستعملها

للكلمات يلّي حدّدت إنّو شخص لبناني بيحكي بس عربي ما بقولها, شو معقول يقول بدالها؟ For the words you mentioned that a Lebanese Arabic only speaker doesn't use, what do they say instead?

(حطّ نقطة بالخانة إذا ما في بديل). (Put a dot in the box if there is no alternative.)

من فضلك اكتب إجاباتك هنا: Please write your answer here:

Hotel	
Computer	
Jello	
Croissant	
Sport	
Bicyclette	
Toilette	
Activité	
Formation	
Message	

Laptop	
Mail	
Bravo	
Mom/ Pap	
Scooter	
Gélatine	
Lampadaire	
Toast	
Sauce	
Douche	
Maximum	
Chips	
Supermarket	
Shopping	
Gym	
Noël	
Routine	
Gâteau	
Contrat	
Cake	
Vernis	
Première (classe)	

Terminale (classe)

Tv

Alarme

Cornflakes

Cousinté, cousané

Nescafé

Weekend

Album

معلومات عنّك Information about you

بهالجزء رح نسألك كام سؤال عنّك
In this section we ask you a few questions about you.
اكبس ع "أرسل" بعد آخر سؤال.
Click on "Send" after the last question.

شو اللّغات اللي انت بتحكيها؟ What are the languages you speak?

*

أختر احدى الاجابات التالية: Choose one of the following answers:
من فضلك اختر **واحدا فقط** مما يلي: Please choose only one answer from the following:

- عربي لبناني بس Lebanese Arabic only
- عربي لبناني + فرنسي Lebanese Arabic + French
- عربي لبناني + إنجليزي Lebanese Arabic + English
- عربي لبناني + فرنسي + إنجليزي Lebanese Arabic + French + English

بأي منطقة من لبنان انت عايش؟ أو كنت عايش إذا انت حاليًّا بالاغتراب؟

* In which region of Lebanon do you live? or were you living if you're now abroad?

من فضلك اكتب إجابتك هنا: Please write your answer here:

خلصت الأسئلة، شكرًا لمُساهمتك! The survey has ended, thank you for participating.

إذا عندك أي إقتراح، ملاحظة أو تعليق، فيك تكتبه هون: If you have any suggestions or comment, you can write it here:

من فضلك اكتب إجابتك هنا: Please write your answer here:

! شكرًا لمشاركتك بهالبحث
Thank you for taking part in this study!

10:43 – 20-01-2025
قدّم استبيانك. Submit survey.
شكرا لك على إكمال هذا الاستبيان. Thank you for completing this survey.

M Loanword vs. Code-Switching Classification Results

The table below presents the 40 lexical items assessed for their status as either loanwords (borrowings) or code-switches, based on responses from 286 Lebanese Arabic–French bilinguals. Each word was rated for its likelihood of being used by a monolingual Lebanese Arabic speaker, on a scale from 0% to 100%. Items rated at or above the 60% threshold were classified as borrowings.

Classification	Word	Usage (%)
Borrowings	Hôtel	96%
	Computer	97%
	Jell-O	92%
	Croissant	93%
	Sport	74%
	Bicyclette	89%
	Toilettes	67%
	Message	66%
	Laptop	75%
	Mail	62%
	Bravo	97%
	Scooter	67%
	Gélatine	70%
	Lampadaire	69%
	Toast	73%
	Sauce	83%
	Douche	86%
	Maximum	91%
	Chips	90%
	Supermarket	94%
	Shopping	66%
	Gym	69%
	Noël	66%
	Routine	74%
	Gâteau	96%
	Contrat	75%
	Cake	75%
	Vernis	53%
	Terminale (school class)	84%
	TV	72%
	Alarme	76%
	Corn flakes	88%
	Nescafé	98%
	Weekend	74%
	Album	91%
Switches	Activité	35%
	Formation	25%
	Mom / Pap	40%
	Première (school class)	41%
	Cousinté / Cousané	47%

Table M.1: Final Classification of Loanwords vs. Code-Switching

N Complementary Material

All additional materials, including the questionnaire, task data, R scripts, and Phase 3 CLAN transcriptions for all participants, are available upon request by contacting the author by email: layana.awada@univ-tlse2.fr.

Titre : Contrôle des langues et code-switching dans une population switchant fréquemment: Une approche multiméthode des bilingues français-libanais

Mots clés : Bilinguisme, Contrôle des langues, Alternance codique, Arabe Libanais, Français, Approche multiméthode

Résumé : Cette thèse s'intéresse au contrôle des langues chez les personnes recourant fréquemment au code-switching (FCS) dans le contexte du bilinguisme arabe libanais–français, en analysant la manière dont l'alternance des langues (switching) varie entre contextes contraints et volontaires, et en explorant si le passage volontaire d'une langue à l'autre réduit les coûts généralement associés au switching en situation contrainte. Afin de compléter les paradigmes expérimentaux de switching habituels qui restent artificiels et ne rendent pas compte du switching en situation naturelle, cette recherche a aussi essayé de répondre au besoin d'évaluations plus écologiques du contrôle des langues au niveau discursif. Comprendre les dynamiques des coûts cognitifs en fonction du degré de contrainte est ainsi le premier objectif. Par ailleurs, bien que des facteurs individuels tels que l'âge d'acquisition, la compétence linguistique, la dominance, les habitudes de code-switching et l'entropie (Gullifer & Titone, 2020) aient potentiellement un effet sur la capacité à contrôler plusieurs langues (De Bruin, 2019), les mécanismes par lesquels ils influencent la performance bilingue, en particulier chez les FCS, restent peu explorés.
La thèse implique trois études consécutives :
La première porte sur 226 participants ayant rempli un questionnaire sociolinguistique en ligne, adapté du LEAP-Q (Marian et al., 2007), du BLP (Birdsong, 2012) et du BCSP (Olson, 2022), afin de caractériser leur expérience linguistique, la dominance, les habitudes de code-switching et l'entropie. Les résultats de cette étude montrent que les FCS libanais utilisent les langues de manière intégrée plutôt que compartementalisée, avec une entropie et des pratiques de code-switching plutôt élevées.
La deuxième, avec 61 participants, teste le contrôle des langues dans des paradigmes expérimentaux en situation contrainte (ciblés/alternée) et volontaire/libre, à l'aide de tâches de dénomination d'images et de fluence sémantique bilingues, et mesure la compétence en français et les fonctions exécutives (Flanker, Stroop arabe et français, Wisconsin Card Sorting, et mémoire de travail). Cette étude met en évidence des switch costs significativement réduits dans les conditions volontaires vs. contraintes pour les tâches de dénomination d'images et de fluence sémantique bilingues. De même, les mixing costs étaient également réduits lorsque les participants pouvaient alterner librement entre les langues par rapport aux conditions contraintes.
La troisième étude explore le code-switching en contexte écologique, dans des situations de communication inspirées de l'hypothèse du contrôle adaptatif (Green & Abutalebi, 2013), incluant la description de vidéos et la narration d'événements personnels en contexte monolingue, bilingue et de code-switching dense. Un Indice de Contrôle des Langues (LCI) a été développé pour mesurer le contrôle au niveau du discours, basé sur la fréquence du code-switching, les marqueurs d'hésitation et le débit de parole. Les résultats obtenus auprès de 24 participants ne montrent aucune différence significative du LCI entre les différentes conditions, et n'indiquent ni switch ni mixing costs au niveau discursif. Cependant, la compétence en français, les habitudes de code-switching et la durée du séjour en France modulent de manière significative les switch et mixing costs, contrairement à l'entropie.
En combinant approches sociolinguistiques, expérimentales et écologiques, cette thèse offre un panorama complet du contrôle des langues chez les FCS, soulignant les variations dans l'utilisation des langues entre contextes expérimentaux et écologiques. Elle soutient l'hypothèse que le fait de choisir librement quand changer de langue représente un avantage pour les FCS plutôt qu'un coût et elle introduit de nouvelles méthodes pour analyser le contrôle des langues dans des contextes naturels.

Title: Language Control and Code-Switching in Frequent Switchers: A Multimethod Approach of French–Lebanese Bilinguals

Key words: Bilingualism, Language control, Code-switching, Lebanese Arabic, French, Multimethod approach

Abstract: This dissertation examines language control in frequent code-switchers (FCS) in the context of Lebanese Arabic–French bilingualism, analyzing how language switching varies between constrained and voluntary contexts, and exploring whether switching voluntarily from one language to another reduces the costs typically associated with constrained switching. To complement traditional experimental switching paradigms, which remain artificial and fail to account for switching in natural contexts, this research also sought to address the need for more ecological evaluations of language control at the discourse level. Understanding the dynamics of language switching costs relatively to the degree of constraint (constrained vs. voluntary) is thus the first objective. Moreover, although individual factors such as age of acquisition, language proficiency, dominance, code-switching habits, and entropy (Gullifer & Titone, 2020) may potentially affect the ability to control multiple languages (De Bruin, 2019), the mechanisms through which they influence bilingual performance, particularly in FCS, remain underexplored.
The dissertation comprises three consecutive studies:
The first involved 226 participants who completed an online sociolinguistic questionnaire adapted from the LEAP-Q (Marian et al., 2007), the BLP (Birdsong, 2012), and the BCSP (Olson, 2022), to characterize their language experience, dominance, code-switching habits, and entropy. The results of this study show that Lebanese FCS use their languages in an integrated rather than compartmentalized manner, with relatively high entropy and frequent code-switching practices.
The second study, with 61 participants, tested language control in experimental paradigms under constrained (cued/alternate) and voluntary/free conditions, using bilingual picture-naming and semantic fluency tasks, as well as measures of French proficiency and executive functions (Flanker, Arabic and French Stroop, Wisconsin Card Sorting, and working memory). This study revealed significantly reduced switch costs in voluntary compared to constrained conditions for both picture-naming and semantic fluency tasks. Similarly, mixing costs were also reduced when participants could freely alternate between languages relative to constrained conditions.
The third study explored code-switching in ecological contexts, in communicative situations inspired by the Adaptive Control Hypothesis (Green & Abutalebi, 2013), including video descriptions and personal event narration in monolingual, bilingual, and dense code-switching contexts. A novel Language Control Index (LCI) was developed to capture discourse-level control, based on code-switching frequency, hesitation markers, and speech rate. Results from 24 participants revealed no significant differences in the LCI across conditions, indicating no evidence of switch or mixing costs at the discourse level. However, French proficiency, code-switching habits, and length of residence in France significantly modulated switch and mixing costs, whereas entropy had no notable effect.
By combining sociolinguistic, experimental, and ecological approaches, this dissertation offers a comprehensive account of language control in FCS, highlighting variations in language use across experimental and ecological contexts. It supports the hypothesis that freely choosing when to switch languages provides an advantage for FCS rather than a cost and introduces new methods for analyzing language control in naturalistic contexts.