The Effect of Different Types of Intra-Sentential Code-Switches on Cognitive Control Costs

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"To my inspiration and biggest supporter, M.M., this is for you".

ABSTRACT

The bilingual brain has the ability to control and switch between languages at any given moment. This alternation between two languages is known as code-switching (Bullock & Toribio, 2009), which requires cognitive control mechanisms to inhibit the first language once the second language is encountered (Green & Wei, 2014). During the process of switching from one language to the other, costs have been observed, which are assumed to mirror the effort required to access the target language schema. With this background in mind, this study examined the influence of intra-sentential code-switch types on cognitive control costs on (*N*= 70) L1 Greek L2 English bilinguals. We used an executive function task, where participants were presented with code-switched and non-code-switched sentences that were followed by either a comprehension question or a Flanker trial. Comprehension findings showed that higher scores in *Accuracy* lead to greater cognitive effort, and thus, costs on non-code-switch conditions, and in the presence of a code-switch, the costs and levels of *Accuracy* were decreased. Results from the Flanker task demonstrated a significant link between code-switching type, *Congruency* and direction: the performance on Alternational Conditions demanded greater levels of inhibition, and entailed larger costs compared to Insertional Conditions, that caused lower costs. However, the overall performance was better when on the direction of the switch occurred from the L2 to L1, in all levels. Lastly, it was observed that after a code-switch sentence, the performance on Flanker *Congruency* was faster and more accurate in incongruent than congruent trials. These results provide evidence of the processing demands that intra-sentential code-switch types generate in terms of domain-general cognitive control cost mechanisms.

Keywords: Bilingualism, Cognitive Control, Code-switching, Comprehension, Flanker Task, Processing Costs.

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List of Abbreviations

AdvP	Adverbial Phrase
BIA+	Bilingual Interactive Activation Plus
CS	Code-Switch
EC	Executive Control
EF	Executive Function
ENG	English
ERP	Event Related Potentials
fMRI	Functional Magnetic Resonance Imaging
GR	Greek
ICM	Inhibitory Control Model
L1	First Language
L2	Second Language
L3	Third Language
LEAP-Q	Language Experience and Proficiency Questionnaire
LTM	Long Term Memory
MEG	Magnetoencephalography
ms	Milliseconds
NCS	No-Code-Switch
NP	Noun Phrase
PP	Prepositional Phrase
RTs	Response Times/ Reaction Times
SD	Standard Deviation
SVO	Subject-Verb-Object
VP	Verb Phrase

CHAPTER 1: INTRODUCTION

1.1 Research Background

Populations all over the world have become increasingly interconnected, and as a result, bilingualism is becoming a global phenomenon (European Commission, 2017). While bilingualism is rising, the way the bilingual brain works in terms of comprehension and production of language is fundamental in psycholinguistic research. A noteworthy feature of the bilingual brain is the ability to control, and use of one or both of the languages at any given moment. Abutalebi and colleagues (2007) referred to this ability as "language control", which gives bilinguals the ability to selectively communicate in the target language, while suppressing interferences from the non-target language. Languages remain active, even when only one of them is used by the bilingual speaker (Kroll & Dijkstra, 2002). The effortless alternation between two languages (Bullock & Toribio, 2009), without violating grammatical constraints (Meisel, 1994) is defined as code-switching. Because code-switching involves a switching from one language to another, many psycholinguists have investigated whether this process incurs cognitive costs, which reflect the effort needed to access the target language (Jylkkä, Lehtonen, Kuusakoski, Lindholm, Hut, & Laine, 2017).

While many researchers have attempted to elucidate the cognitive processes involved when one is code-switching, and the possible models entailed in comprehension and production, there is still no consensus. There is a debate concerning the theoretical models associated with comprehension and production, and the switching costs associated with these processes. In production, code-switching costs have been attributed to the inhibitory control mechanism, which operates through a top-down process (Green, 1998; Green & Wei, 2014). In comprehension, code-switching occurs thought a bottom-up process, in which mental representations of words are activated according to the target language, while retrieving information of the non-target language (Bultena, Dijkstra, & van Hell, 2015). Distinctions have been observed in terms of the switching costs resulting from these models. Studies have indicated that switching costs in production are usually larger when bilinguals code-switch from their L2 to their L1 (e.g., Philipp, Gade, & Koch, 2007; Meuter & Allport, 1999). However, research on switching costs in comprehension have found mixed results. Some studies reported larger switching costs when the direction of the switch was from the L2 to L1 (Declerck & Grainger, 2017), whereas other studies reported the opposite; larger costs when the direction occurred form the L1 to the L2 (Bulterna et al., 2015). Also, symmetrical switching costs have also been reported in comprehension tasks (Macizo, Bajo, & Paolieri, 2012).

To further examine these contradictory findings, and explore the cognitive effect code-switches entail, this study will focus on the influence of intra-sentential code-switching. We will use both Alternational, the novel Insertional types of code-switch, on cognitive control costs, using the executive function Flanker Task, on native Greek L2 English bilinguals.

1.2 Thesis Overview

In the literature review in Chapter 2, research on bilingualism and the cognitive effects on bilingual brain will be described, and the different types of code-switching will be introduced. Furthermore, views and practises in code-switching will be explored, and the phenomenon of transliteration will be reviewed. In addition, the impact of code-switching on cognitive control costs will be discussed from the perspective of Conflict Adaptation Theory. Two theoretical models of code-switch will also be evaluated and compared in terms of production and comprehension processes. In Chapter 3, the methodology used for this research will be described in depth, with the materials, task design and experimental procedure. In Chapter 4, the statistical analyses used, and the results that were obtained will be demonstrated. In Chapter 5, the results of the study will be discussed and evaluated in line with previous findings. In Chapter 6, the implications of the experiment will be outlined, and improvements for future directions will be discussed. Finally, Chapter 7, will contain the overall conclusions drawn from this research.

CHAPTER 2: LITERATURE REVIEW

2.1 Bilingualism

The term "bilingual" has been given several definitions over the years, but for this study, Grosjean's (2010, p.4) definition will be used to describe bilinguals as "those who use two or more languages in their everyday lives". Broadly speaking, there are two types of bilinguals. An individual who learns two language from birth is known as simultaneous bilingual, as two languages are acquired at the same time. Alternatively, an individual who first acquires one language (henceforth L1), and at a later age learns a second language (henceforth L2), is referred to as sequential bilingual. For the purposes of this thesis, we will only focus on sequential bilinguals.

A bilingual speaker who communicates in more than one language has the ability to control voluntarily which language to use, in any context (Crinion et al., 2006). Halliday, McIntosh and Strevens (1970) described an "ambilingual" as a speaker who has complete control of two languages and uses both in all circumstances, to which s/he puts either of them to use. While there have been some documented cases of ambilinguals, such cases have been reported by Hoffman (1991) as rare, as an individual rarely manages to attain a symmetrical linguistic proficiency in both languages. Similarly, Grosjean (2010), argued that a bilingual's proficiency in speaking, listening, reading, and writing, is rarely equal across languages.

2.2 The Cognitive Effects of the Bilingual Brain

Studies throughout the years have presented evidence regarding the changes in the anatomical and functional brain organisation (Reiterer, Berger, Hemmelmann, & Rappelsberger, 2005), and the cognitive effects linked to bilingualism. Benefits on bilingual cognitive performance include higher levels of controlled attention and inhibition. Advantages in the performance of bilingual adults in verbal tasks have been related to metalinguistic awareness (Galambos & Goldin-Meadow, 1990; Ben-Zeev, 1977), and on non-verbal tasks, in which participants were required to disregard misleading context (Bialystok & Majumber, 1998). Such cognitive advantages become apparent with the successful performance of a bilingual to ignore irrelevant stimuli, the shorter reaction times, the smaller conflict effects, and reduced switching costs in executive function tasks (Bialystok, 2009; Bialystok, Craik, Klein, & Viswanathan, 2004).

2.2.1 Executive Functions and Inhibition

To preserve a balance between two languages, the brain relies on Executive Functions (henceforth EFs), which trigger the ability to control and coordinate cognitive processes (Miyake, Friedman, Emrson, Witzki, & Howerter, 2000). Executive functioning is vital in the process of overcoming involuntary behaviour, which then allows an individual to have the aptitude to attend selectively, concentrate on a specific task, inhibit attention and hold information in working memory (Daniels, Toth, & Jacoby, 2006). Inhibition is a fundamental aspect of EF, as it deals with the ability to supress an action or irrelevant stimuli, and keep thoughts and language separation under conscious control (Posner & Rothbart, 2000). The simultaneous activation of language systems requires selective attention and inhibition abilities in order to maintain fluency in one language, while preventing disruption from the other language (Declerck, Koch, & Philipp, 2015). Through these functions, bilinguals gain extensive practise with regulating executive control (henceforth EC), which improves the selective attention and inhibition functions. These are important mechanisms involved in the performance on both linguistic and non-linguistic tasks.

In order to address the effect of bilingualism on cognitive control, one has to consider the way bilinguals organise the knowledge of their linguistic system. Within a bilingual mind, lexical representations for each language are stored distinctively, while the conceptual representations are shared. Evidence illustrates that fluent bilinguals show a measure of activation and interaction between the two languages, even in contexts that are solely driven by one of the two languages. The activation of the two languages is primarily present, during production, as the speaker has control of the produced discourse, unlike reading and listening, where switches may occur unexpectedly (Kroll, Bobb, & Wodniecka, 2006).

2.2.2. Bilingual Mechanisms

A bilingual mechanism involved in EFs during linguistic processing is the joint activation, which creates an attention problem that only exists in bilinguals, as they must choose the appropriate language from two competing options. Though this mechanism poses a risk for language errors and language interferences, these occur rarely, signifying that the choice of the target language happens with great accuracy. However, the need to select the appropriate language requires more cognitive effort, which causes a processing cost. This notion is supported by linguistic processing studies, involving lexical decision tasks, where a subject has to decide whether a series of letters is an actual word, and if it belongs to one of the two languages. For non-linguistic processing, the requirement to direct attention and resolve competition is primarily the responsibility of cognitive systems (Hofweber, Marinis, & Treffers-Daller, 2020). Such studies manifest a joint activation mechanism in which the target language influences the non-target language in both comprehension and production. Further, they can help to understand the cognitive effects involved during linguistic and non-linguistic processing (Kroll, Bobb, Misrea, & Guo, 2008; Colomé, 2001; Hernandez, Bates, & Avilla, 1996).

2.3 Code-Switching

A bilingual experience that is known to regulate EF abilities is code-switching. Muysken (2007, p.315) suggested that code-switching is a phenomenon that demonstrates extensive amounts of lexical and morphosyntactic knowledge from at least two languages. Code-switching between two languages can appear amid whole stretches of speech, within a sentence, between sentences, or phrases (Miccio, Hammer & Rodríguez, 2009). As explained by Poplack (1980) fluent bilinguals who tend to code-switch within a sentence create Intra-sentential switches, which require a more complex syntactic structure of the between the native and the non-native languages. Less fluent bilinguals who tend to code-switch between sentences or discourse boundaries are referred to as Inter-sentential code-switching. Poplack suggested that instances of code-switch arise from a bilingual's grammar, where the structure and the knowledge of the matrix (native) and embedded (non-native) languages overlap, which then illustrates the level of proficiency. This thesis will focus on Intra-sentential types of code-switching.

2.3.1 Types of Code-Switching

Within psycholinguistic research, numerous types of code-switching have been identified, each of which engages inhibition to various degrees, and engages different control modes. Muysken (2000) defined three types of code-switching: Alternational, Insertional, and Congruent Lexicalisation (also known as Dense code-switching).

In Alternational code-switching, there are two long, structurally-independent stretches of language, which contain grammatical elements from both languages, and require high levels of inhibition to keep languages separate during code-switching.

I. Spanish-English Alternational Code-switch

Andale pues and *do come again*.

"That's alright then, and do come again".

(Peñalosa, 1980)

In Insertional code-switch, elements for the embedded language; such as the adverbial (AdvP) or noun phrases (NP), are incorporated into the morphosyntactic frame of the matrix language with a sentence. This type of code-switch requires medium levels of inhibition, as language switches occur more frequently within a sentence.

II. Spanish-English Insertional Code-switch

Yo anduve *in a state of shock* por dos dias.

"I walked in a state of shock for two days".

(Pfaff, 1979, p.296)

Lastly, Congruent Lexicalisation occurs when "the two-participating languages, share a grammatical structure, which can be filled lexically with elements from either language" (Muysken, 2000, p.306). Due to the limited levels of language separation, a small level of inhibition is necessary for this code-switch type.

III. Spanish-English Congruent Lexicalization Code-switch

Bueno, *in other words*, el *flight* que sale de Chicago *around three o'clock*.

"Good, in other words the flight that leaves from Chicago around three o'clock".

(Pfaff, 1979, p.310)

2.3.2 Reasons for and Views on Code-Switching

There are many reasons as to why bilingual adults tend to code-switch. First, code-switching can be used as a communicative or social strategy, to show involvement of the interlocutors, demonstrate expertise and mark group identity. Second, specific notions are better expressed in one language, as the translation of that notion may not have an equivalent to another language. Third, bilinguals tend to use code-switch while writing message and emails (Grosjean, 2010), as a quicker mean of communication, which even extends to transliteration between languages (Tseliga, 2007).

In the past, code-switching practises were discouraged, due to the misconception that it caused language delay and affected negatively the learning of the two languages (Aitchison, 1991). Furthermore, code-switch was perceived as a sign of limited language proficiency, and as a failure of the speakers to differentiate between the two languages (Hughes, Shaunessy, Brice, Ratliff, & McHatton, 2006). Code-switching was regarded as a negative social attribute from monolingual speakers, as bilinguals who code-switched within a group demonstrated exclusion to monolingual users (Hughes et al., 2006). However, more recent and systematic research contradicted these views, as evidence showed that the systematic use of code-switching is a sign of high competence in both languages (De Houwer, 2009), carried out in such a way that speakers still obey the grammatical constraints imposed by the syntactic structures of each language (Quin Yow, Tan, & Flynn, 2018).

2.4 Code-Switching Practises

Transliteration can be defined as the mapping of one language system into the phoneme-to-grapheme conversion of another language (Karakos, 2003). A well-known example of transliteration is the Katakana-Kanji transliteration of Japanese with null graphemic overlap and extensive phonemic overlap (Hino, Lupker, Ogawa, & Sears, 2003). Also, transliteration is found in the Cyrillic-Roman letters that are used in Serbian scripts; where a number of the Cyrillic and Roman graphemes depict the equivalent Serbian phonemes (Havelka & Rastle, 2005). This thesis will focus on Greeklish transliteration, which is discussed next.

2.4.1 Greeklish Transliteration

The term Greeklish refers to the combination of Modern Greek and English words, which are written in the Latin alphabet through phonetic and orthographic transliteration (Fragou, 2014; Karakos, Papaioannou, & Georgiadou, 2012). Greeklish representations are commonly used by speakers as a quick and easy mean of communication when writing texts (Koutsogiannis, 2015; Tsourakis & Digalakis, 2007). Studies have found that Greeklish activates a discourse strategy for the simplification of the grammatical writing rules of the Modern Greek language (Androutsopoulos, 2009; Tseliga, 2007).

Dimitropoulou, Duñabeitia and Carreriras (2011, p.730) suggested that "experienced users of Greeklish have formed a highly internalized process to comprehend Greeklish conversions". They hypothesised that Greeklish words are mapped into lexicosemantic representations, and that their processing should facilitate the activation and translation of the matrix language equivalents. An earlier finding revealed a significant dissociation on the impact between phonemic and graphemic overlap between Greek and Greeklish readings (Grainger & Holocomb, 2009). In Greeklish reading, overlapping graphemes between Greeklish and Greek, provide the reader a visual cue in order to match every transliteration item to the analogous Greek word. To that end, Dimitropoulou and colleagues (2011), indicated that Greeklish words tend to be unconsciously processed during reading, and effectively activate the lexicosemantic representations of Greek words. As such, it can be argued that the processing of Greeklish words should imitate the processing of the orthography of Greek words.

2.5 Cognitive Control and Conflict Adaptation

Cognitive Control is defined as the adjustment of mental activity to bias processing on task-relevant cues through a goal-directed behaviour, due to the ability to modulate conflict attentional demands with interference suppression. This process is crucial when a participant encounters conflict information, which can surface when the task requires the suppression of stimulus cues. In such cases, the participant has to focus the attention to the stimulus characteristics, which are based on the task demands. For example, during a Flanker Task (Eriksen & Eriksen, 1974), irrelevant stimuli have to be inhibited in order to respond to the target stimulus. In this task, five letters or arrows are presented, and the participant has to focus on the central letter or arrow, which is the task-relevant stimulus, while inhibiting the other four letters or arrows, which are the irrelevant stimuli. However, in the domain of sentence processing, in order to maintain comprehension under control, cognitive control must modulate parsing strategies based on the relative cues (Adler, Valdés Kroff, & Novick, 2019). Such conflicting situations involve the implementation of cognitive control, as relevant and irrelevant stimuli prompt different actions, and cost outcomes (Norman & Shallice, 1986).

This relationship between cognitive control and parsing strategies, can be explained according to the Conflict Adaptation effect, which occurs when conflict identification initiates behavioural adjustment that decreases the cost of a subsequent conflict (Botvinick, Braver, Barch, Carter, & Cohen, 2001). Botvinick and colleagues argued that cognitive control can contribute to the resolution of the conflicting cues between languages, such as orthography, to integrate code-switching representations. The Conflict Adaptation effect occurs on the interaction between the preceding and current consecutive trials (Botvinick, Nystrom, Fissell, Carter, & Cohen, 1999). For instance, on the Flanker task, trials are referred to as congruent; when the direction of all arrows is the same, and as incongruent when directions of the arrows are different. According to the Conflict Adaptation effect, responses on Flanker incongruent trials indicate a decreased conflict, which is presumed to illustrate the elevated activation for the resolution of novel incongruences, and therefore, attenuates costs, and facilitates the accuracy of incongruent trials (Egner, Etkin, Gale, & Hirsch, 2008). The Conflict Adaptation effect is domain specific, as it does not modulate across different stimulus response compatibility trials, which are performed consecutively (Egner et al., 2008). Contrarily to the Conflict Adaptation, a Classic Flanker effect emerges when responses are faster and more accurate in congruent than incongruent trials (Gratton, Coles, & Donchin, 1992).

To address the effect of Conflict Adaptation, Eben and Declereck (2019) assessed the conflict monitoring during comprehension, using a bilingual language Flanker task, and a non-linguistic numerical Flanker task on sequential French-English bilinguals. In each trial, French and English words, and non-words, were presented and subjects had to decide if the centrally-presented word was French or English. In addition, they conducted a numerical Flanker task, on which participants performed a numerical magnitude judgement by specifying if the numerical stimulus had a value smaller or larger than five, with digits 1 to 9, (excluding the number 5).

Their findings showed a significant congruency effect in the bilingual Flanker task, but no conflict adaptation in the RTs of error data. Moreover, there was no congruency from the preceding trials on the congruency of the next trial. Contrastively, in the numerical Flanker task, results demonstrated a congruency effect in the error data that was greater after congruent trials. Based on these outcomes, Eben and Declereck suggested that conflict monitoring might not arise in bilingual language comprehension.

Regardless of the type of effect that is achieved, it can be argued that such adjustments are formed through the cognitive control and EFs, which enhance overall performance in a non-linguistic task. However, the extent that code-switching comprehension regulates the performance on a successive Flanker trial, and thus, cognitive costs that are entailed during the task performance have to be further investigated.

2.6 Code-Switching Costs in Comprehension

Reading comprehension is a multifaceted cognitive ability, which entails decoding input, retrieving semantic and lexical representations from long-term memory (henceforth LTM), and integrating to the general representation of the text (Perfetti & Stafura, 2014). Empirical studies have established that code-switching from one language to the other incurs a cognitive cost. Despite the fact that languages remain active at the same time, the degree of activation may differ on each language (Bultena, Dijkstra, & van Hell, 2015). When a bilingual has to comprehend a code-switch, it is necessary to first access the mental representations of the switch language, immediately after retrieving the lexical information from the non-target language. For instance, the target language is the switched language, whereas the non-target language is the one that the bilingual has to inhibit. Throughout this process, a cognitive cost is incurred while comprehending the code-switch, as a consequence of the rising levels of activation between the target and the non-target language, which will be either L1 or L2 depending on the language direction in the sentence (Declerck & Grainger, 2017).

Language comprehension studies that examined the effect that switching directions have on code-switching costs have shown contradictory findings. For instance, a study by Macizo, Bajo and Paolieri (2012) examined the asymmetrical language switching costs in a word reading task and a categorisation task on Spanish-English bilinguals. Based on language proficiency questionnaire, participants were found to be highly fluent in English, but dominant in Spanish, which was confirmed also in the word-reading task, as participants were slower to switch from their weaker to the more dominant language. In the categorisation task, bilinguals showed asymmetrical costs when they switched between the two languages, respectively. Consequently, Macizo and colleagues, proposed that inhibitory process in bilingual processing demonstrate asymmetrical code-switching costs only when there is a competence between L1 and L2 lexical selection, and costs are not related to language proficiency per se. Similar observations were made by Philipp and Huestegge (2015), who investigated the effect of language switch on comprehension, and word level processing L1 German L2 English subjects using eye-tracking. Findings revealed a decrease in comprehension after language switches, with larger costs in L1 German than in L2 English, possibly due to "the endogenous inhibition processes influencing the higher-level text integration" (Philipp & Huestegge, 2015, p.623). However, results from the eye movements (initial fixation duration and gaze durations) showed larger costs when switching from L1 to L2. They explained these findings by posing that bottom-up lexical activation and top-down cognitive control are associated in language comprehension. Specifically, they suggest that bottom-up activation would influence short-term lexical processing, whereas top-down cognitive control would have a greater effect on the long-term global processing.

Further support for the account of domain-general control comes from the research by Adler and colleagues (2019), who examined the integration of code-switching in real-time comprehension, and how code-switch engages cognitive control mechanisms in Spanish-English bilinguals. Participants completed a self-paced reading task contained both monolingual English, and Spanish sentences, and Alternational Spanish-English code-switched sentences. Their results demonstrated that, as opposed to reading monolingual sentences, when subjects encountered a code-switch, performance on a subsequent incongruent Flanker trial was more accurate, and reaction times (hereafter RTs) were reduced. Adler et al. (2019) proposed that integrating a code-switch in real time comprehension, does recruit domain-general cognitive control, and such mechanisms facilitate the competing representation that develop between languages.

A study related to that of Adler and colleagues' (2019) was conducted by Bosma and Pablos (2020), who used a sentence reading comprehension Event Related Potential (henceforth ERP) paradigm combined with a Flanker task to examine the relationship between the domain general cognitive control and code-switching in sequential Dutch English bilinguals. Half of the subjects read code-switched sentences from Dutch to English, and monolingual sentences in Dutch followed by Flanker trials; the other half read code-switched sentences from English to Dutch, with monolingual English sentences also followed by Flanker trials. The behavioural findings showed a classic Flanker effect, where slower RTs and less accurate responses were obtained for incongruent rather than congruent trials, but there was no effect on code-switch. However, their ERP analysis demonstrated a code-switch effect shown by the elicitation of a P300 component: when the direction of the switch occurred from L1→L2 (Dutch to English), the Flanker effect was smaller in comparison to L1 Dutch non-switched sentences. In the L2→L1 (English to Dutch) context, the Flanker effect was smaller for non-switched L2 English sentences than for code-switched sentences. Bosma and Pablos (2020) argued that code-switching from L1 to L2 employs domain general cognitive control mechanisms outside of the bilingual lexicon, whereas code-switch from L2 to L1 releases domain general mechanisms.

2.7 Models of Code-Switching: Production versus Comprehension

In code-switching research, there is a debate concerning the locus of switch costs, and the theoretical models accounting for production and comprehension. The findings presented over the years are mixed with respect to the switch cost patterns, and the processes involved in each domain. This thesis will focus on the Inhibitory Control Model (1998) of production, and the Bilingual Interactive Activation Plus Model (2002) of comprehension, and will provide evidence regarding the switch costs from an experimental paradigm that examines language comprehension.

2.7.1 The Inhibitory Control Model (ICM)

It is generally accepted that bilingual speakers have to inhibit lexico-semantic and phonological competition from the non-target language when producing speech. Green (1998) proposed the Inhibitory Control Model (henceforth ICM) in which conflict between languages is resolved through lemma suppression. That is, representations from the non-target language are inhibited, while representations of the target language remain activated and are produced by the speaker. In the case of code-switching, if a bilingual speaker aims to switch from one language to another, s/he has to operate top-down control processes, to supress the active language, and then, activate the output of the other language. Furthermore, the ICM predicts that the amount of inhibition and the engagement of control processes when code-switching, incurs cognitive effort and therefore, switching costs, which may be related to language proficiency. Literature suggests that unbalanced language dominance causes greater switching costs, hence, causing asymmetries (Verhoef, Roelofs, & Chwilla, 2009). In particular, switching back to the dominant language may induce larger costs, as inhibition of the dominant language entails additional EF effort, and hence, requires longer time to overcome reactivation, than when switching to the non-dominant language.

In behavioural studies, evidence suggests that during code-switching, when bilingual produce utterances in their L2, activation from their L1 must be inhibited (Meuter & Allport, 1999). In language switching tasks, such as picture naming, findings showed that responses in the L1 are slower when followed by the L2, rather than when L2 follows the L1 (Misra, Guo, Bobb, & Kroll, 2012). In other words, an asymmetry is observed based on the magnitude of code-switching costs in production. Such asymmetries in production have been taken as evidence of the inhibitory processes involved, and the function of proficiency levels of the bilingual (Finkbeiner, Almeida, Janssen, & Carammazza, 2006). Contrastively, symmetrical code-switching costs in production have been found in balanced bilinguals, in a study by Costa, Sansteban and Ivanonva (2006), who explored the code-switching performance of bilinguals in picture-naming tasks, over four experiments. The highly proficient bilinguals demonstrated symmetrical switching costs, when switching between their dominant L1 and L2, and their weaker L3. These contradictory findings indicate that even if equal inhibition is applied to both languages, inhibition may not be sufficient to explain code-switching costs in production.

2.7.2 Bilingual Interactive Activation Plus Model (BIA+)

To account for comprehension-based language control, Dijkstra and van Heuven (2002) proposed the Bilingual Interactive Activation Plus (henceforth BIA+) model, which is driven by the visual input, which activates mental representations of words, through bottom-up processing. In accordance to BIA+ model, a language is identified at word level based on letter and feature recognition, which signifies that language nodes are activated reasonably late in the system. Language nodes in the BIA+ model serve as a crucial mechanism for the inhibition and selection of words between the two languages. During the word selection process, each language has independent access, where words from various languages are signified in “an integrated lexicon” and identified during word recognition (Li & Farkas, 2002, p.60). Even though it is widely assumed that word recognition in a sentence context is the outcome of an interactive process, where syntax and semantics are presumed to exert through top down control (van Hell & De Groot, 2008), the exact function of language nodes in this process remains unclear. Due to the fact that recognition and comprehension work in a bottom-up process, relying on word activation level, top-down control or the suppression mechanism that occurs in language production cannot be implemented in comprehension. BIA+ assumes that the language node will not disappear entirely prior to the processing of the following word. Consequently, during comprehension of code-switching input, costs will be clarified from the lingering activation of the language node. Specifically, the language node will be activated in bottom-up fashion by the preceding words, which can impact the ease of processing on subsequently incoming words (Declerck & Philipp, 2015). Therefore, the pre-activation of the corresponding language node facilitates processing and comprehension of a following word in the same language, whereas preceding words in the other language render activation of the new language more effortful.

Considering the effects on comprehension and the costs they entail, Bultena, Dijkstra and van Hell (2015), examined whether code-switching costs in sentence comprehension modulated by cross-linguistic lexical activation and proficiency. They found larger code-switching cost when switching to L2 than when switching to L1. Using a self-paced reading task with sentence switching between Dutch (L1) and English (L2), they found that there was an influence of the switch direction. This was shown in that a cost was observed when participants had to switch into their L2, but not when switching into their L1. With respect to bilingual proficiency, results demonstrated that switching costs in language comprehension depend on language dominance. Based on the BIA+ model (Dijkstra & van Heuven, 2002), Bultena and colleagues (2015) argued that in comprehension, switching costs are caused through bottom-up activation instead of top-down control. When an individual tends to use a language frequently, the mental and lexical representations of that language develop a higher resting level of activation, and essentially the most frequently used words in L2 are activated with greater ease (Bultena et al., 2015).

Code-switching costs have also been found in a study by Wang (2015) who used reading of code-switched sentences and language dominance on a maze task. Participants were English-Chinese bilinguals; half of whom were English dominant, while the other half were Chinese dominant. In the maze task, participants were presented with sentences, during which every trial would present two alternatives from which they had to choose the grammatically correct option.

Findings showed code-switching costs in both directions (i.e., L1→L2 and L2→L1) due to inhibitory control and lexical activation. In addition, Wang (2015) found that language dominance modulated the lexical effect, but did not influence the inhibitory effect. It was suggested that language control mechanisms are linked in bilingual reading, despite the fact that control process is not driven by selection.

2.8 The Present Study

The purpose of this thesis is to carry out an in-depth investigation on the influence that code-switches have on cognitive control during real-time comprehension, and contribute with additional evidence to the literature investigating the modulation of mental activity following a code-switch processing. Hence, this research aims to provide new insights into the effect that processing and comprehension of a code-switch have on cognitive control. This study will therefore focus on the influence of intra-sentential code-switch types, both Alternational and Insertional levels, on cognitive control costs. To explore this effect, this study will use an executive function test on native Greek, proficient L2 English speakers. Bilingual participants will read monolingual and code-switched sentences followed with either a non-linguistic task, i.e., a Flanker trial (Eriksen & Eriksen, 1974), or a linguistic task, i.e., a trial with a comprehension question about the preceding sentence.

The following questions were formulated to explore these effects:

1. To what extent do cognitive costs arise in the process of comprehending intra-sentential code-switches?
    i. If cognitive costs emerge during the comprehension of code-switches, will the Alternational and Insertional types impact differently the Flanker Effect?
2. Does the code-switching direction of a sentence have an influence on a consecutive Flanker trial?

2.8.1 Predictions

Based on the previous research presented so far, cognitive costs should arise according to the resting activation levels between L1 and L2 (Wang, 2015; Bultena et al., 2015). In terms of comprehension, it is expected that performance should be similar between the two languages, due to the language transliteration, which should activate easier the mental representations between the L1 and L2 (Dimitropoulou et al., 2011).

Furthermore, it was hypothesised that Insertional code-switch sentences would have a smaller Flanker effect on cognitive costs, as they incur medium levels of inhibition, as opposed to Alternational, which cause higher levels of inhibition (Muysken, 2000), and hence, entail more cognitive effort. Lastly, the hypothesis for the influence of a code-switched sentence on a consecutive Flanker trial, was based on the Conflict Adaptation effect. It was expected that while processing a code-switched sentence, cognitive control would be engaged, and as a result, it would facilitate the subsequent incongruent Flanker trial, with more accurate and faster responses (Adler et al., 2019).

CHAPTER 3: METHODOLOGY

3.1 Participants

Seventy native (L1) speakers of Greek with English as their L2 (27 males: *M* age = 26.04, *SD* = 4.1, 43 females: *M* age = 24.16, *SD* = 3.9) were recruited from two online platforms to participate in this experiment. All subjects were healthy, with no clinically diagnosed learning, motor, or visual impairments. This research has obtained ethical approval by the Board of Examiners at the Faculty of Humanities, at Leiden University. Participants provided their consent online, prior to the start of the experiment, and did not receive any compensation. They only participate for the sake of science.

3.2 Language Background and Proficiency

3.2.1 The LEAP-Q Questionnaire

Participants language background and English proficiency was obtained through a Qualtrics questionnaire (Qualtrics, Provo, UT), based on an adaptation of the Language Experience and Proficiency Questionnaire (LEAP-Q; Marian, Blumenfeld, & Kaushanskaya, 2007) (See Appendix 1). The language background questionnaire contained a series of questions concerning their knowledge, exposure and use of English in everyday life. Participants had to rate their proficiency of English for speaking, reading, auditory and visual understanding of language on a Likert scale form 0 (none) to 5 (excellent) (Table 1).

Furthermore, participants were asked to answer questions regarding their use and views on code-switching and Greeklish transliteration. In terms of code-switching, 72.9% of the participants reported positive attitudes, and 27.1% were reported as neutral. In terms of Greeklish use, 44.3% of participants reported to always use it, 30% answered most of the time, and 12.9% reported half of the time and sometimes, respectively.

Table 1. Proficiency Rates of the L1 Greek L2 English Bilinguals.

Measure	Mean
AoA English	6.92 (2.69)
SRP - Overall Proficiency (out of 5)	4.68 (0.52)
SRP – Speaking (out of 5)	4.74 (0.50)
SRP – Reading (out of 5)	4.75 (0.46)
SRP – Understanding (out of 5)	4.78 (0.41)

Note. AoA = Age of Acquisition of L2 English, SRP = Self Rating Proficiency. Mean assessment scores with standard deviations for the proficiency profiles of participants.

In addition, they had to state the percentage of which language they choose to use when speaking with an individual who is fluent in all the language they speak. As participants were residents in a Greek-speaking country, most of their daily exposure was in Greek. Findings are illustrated in table 2 below.

Table 2. Mean Percentages of the Daily Exposure and Use of Languages.

Languages	Average Exposure	Average Use
Greek	58.35 %	57.92 %
English	35.44 %	35.92 %
Other	6.21 %	6.28 %

3.2.2 The LexTale Proficiency Test

It has been reported that a wide range of vocabulary is indicative of a higher proficiency (Verhallen & Schoonen, 1996). To test the proficiency of the participants by means of their vocabulary score, the LexTale test, originally created by Lemhöfer and Broersma (2012), was modified for the present study. This test was used as a more reliable measure than self-rating proficiency rates, for vocabulary knowledge and general proficiency of L1 Greek L2 English learners (See Appendix 1).

In this test, 19 British English words, and 11 non-words were used, and participants had to decide whether the word presented was an English word, or a non-word. Each word was presented on the screen, and participants had to respond with a "Yes" or "No", without time restrictions. The results showed that participants were highly proficient learners of English (M = 88.06 %, SDs = 5.80), and that self-assessment reports on speaking, reading and understanding were accurate. The LEAP-Q questionnaire and LexTale tests took approximately 10 minutes to complete.

3.3 Materials and Task Design

3.3.1 Sentence Stimuli

Judgement tasks have been assumed to be representative of code-switch practises among bilingual users (Hofweber, Marinis, & Treffers-Daller, 2019), and attitudes have been argued to modulate their acceptability ratings (Badiola, Delgado, Sande, & Stefanich, 2018). Hence, to increase the ecological validity of the stimuli (Beatty-Martinez, Valdes Kroff, & Dussias, 2018), and to verify that such code-switches are frequently practised among L1 Greek L2 English speakers, an Acceptability Judgement Questionnaire (See Appendix 2), which was created in Qualtrics (Qualtrics, Provo, UT).

Sentences were formed according to the sentence structure of Subject-Verb-Object (henceforth SVO) and they were tailored to the three language presentation modes: Greeklish only, English only, and Greeklish-English code-switches. Stimuli varied based on the linguistic structures of Greek and English, and contained elements from seven grammatical categories: noun phrase (NP), verb phrase (VP), object (O), prepositional phrase (PP), articles (A), pronouns (P), and adverbial phrase (AdvP) (See Table 3). For the code-switched materials, all sentences that began with Greeklish followed the structure of NP-V-AdvP-NP-PP, whereas

English sentences were structured as NP-V-NP-AdvP-PP. Therefore, the location and type of code-switch was manipulated based on each language and the code-switch type: Non-Code-Switch (hereafter NCS), Alternational, and Insertional code-switches (See Table 3 on the next page).

Table 3. Illustrations of Grammatical Elements and Switching Points based on Code-Switching Conditions.

Code-Switching Type	Conditions	Language Switch	Examples				
			Region 1	Region 2	Region 3	Region 4	Region 5
NCS	L1	Greeklish	**NP** I Anna	**VP** irthe	**AdvP** noris	**PP** sto mathima	**NP** simera.
	L2	English	**NP** Anna	**VP** arrived	**PP** to the lesson	**AdvP** early	**NP** today.
Alternational	L1→L2	Greeklish to English	**NP** I Anna	**VP** irthe	**AdvP** noris	**PP** *to the lesson*	**NP** *today.*
	L2→L1	English to Greeklish	**NP** Anna	**VP** arrived	**PP** to the lesson	**AdvP** *noris*	**NP** *simera.*
Insertional	L1→L2→L1	Greeklish-English-Greeklish	**NP** I Anna	**VP** irthe	**PP** *to the lesson*	**AdvP** *early*	**NP** simera.
	L2→L1→L2	English-Greeklish-English	**NP** Anna	**VP** arrived	**AdvP** *noris*	**PP** *to the lesson*	**NP** today.

Notes. Translations for each word component: *ENG*: arrived – *GR*: irthe/ήρθε | *ENG*: early – *GR*: noris/ νωρίς | *ENG*: to the lesson – *GR*: sto mathima/στο μάθημα | *ENG*: today – GR: simera/σήμερα. Italicized words (i.e., *noris, sto mathima, simera, to the lesson, today, early*) represent the constituents where the language changes during the *Alternational* and *Insertional* conditions in the code-switched sentences.

For the Alternational code-switch, language switches occurred at the last two regions of each sentence. When a sentence began with Greeklish and changed to English, the switch occurred at [NP-PP] (i.e., Regions 4 and 5), whereas when the sentence began with English and switched to Greeklish, the switch was at the same regions, but due to the language structure, the switched components were [AdvP-PP]. For the Insertional code-switch, language switches occurred at the Regions 3, 4 and again at Region 5. As can be seen from Table 3, depending on the language that the sentence began, the structure differed. Hence, when starting with Greeklish, the English switch at Regions 3 and 4, was in a NP-AdvP form, and followed by a final switch back to Greeklish at Region 5. However, when the sentence began with English, and the Greeklish change was at Regions 3 and 4, that switch contained an AdvP-NP structure, followed by the change of the English language at Region 5. Further, all the sentences used in this study were presented randomly, and the patterns on switch types was unpredicted for the readers.

According to the acceptability judgement task of Greek L2 English learners, almost all presented formats of code-switch types were accepted to some extent. The most acceptable form in terms of Alternation, from Greeklish to English was NP-V-AdvP-NP-PP, with rating of 59.8% extremely likely, and 36.1% somewhat likely cases. For English to Greeklish options NP-VP-NP-AdvP-PP was the most accepted structure. For Insertional L1→L2→L1 sentences, NP-V-AdvP-NP-PP was the most highly rated, at 60.7%, and for the L2→L1→L2, while responses to NP-V-NP-AdvP-PP structure had different acceptability ratings, with 48.4% accepted as somewhat likely, and at 26.2% rated as extremely likely.

3.3.2 Flanker Task Design

Once the ecological validity of grammatical structure to be used in the main experiment was established, 66 different code-switch sentences of each type created: 22 monolingual sentences

(11 for L1 and 11 for L2), 22 Alternational code-switch sentences: (11 for L1→L2 and 11 for L2→L1), and 22 Insertional code-switch sentences (11 for L1→L2→L1 and 11 for L2→L1→L2) (See Appendix 3). Half of the sentences were followed by simple "Yes/No" comprehension questions that were introduced to make sure that participants were paying attention and understood the sentence. Questions were always presented in the same language in which the sentence ended, and they did not contain any code-switches. The other half of the sentences were followed by either congruent or incongruent Flanker trials.

On congruent (no conflict) trials, the centre arrow pointed in the same direction as the Flanker arrows. Conversely, on incongruent (conflict) trials, the central arrow pointed in the opposite direction of the flanking arrows (See Figure 1 below, Figure 2 on the next page). The experiment was conducted using Open Sesame Kafkaesque Koffka (Version 3.2.8, Mathôt, Schreij, & Theeuwes, 2012).

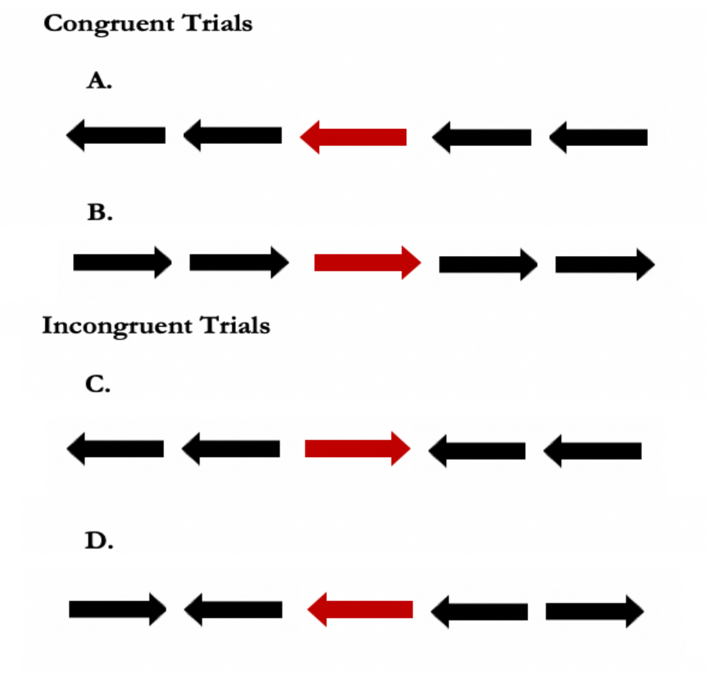

Figure 1. Examples of Trial Types in a Flanker Task: (**A**) Congruent trial with all the arrows pointing to the left, (**B**) Congruent trial with all the arrows pointing to the right, (**C**) Incongruent

trial with the centre arrow pointing to the right, (**D**) Incongruent trial with the centre arrow pointing to the left.

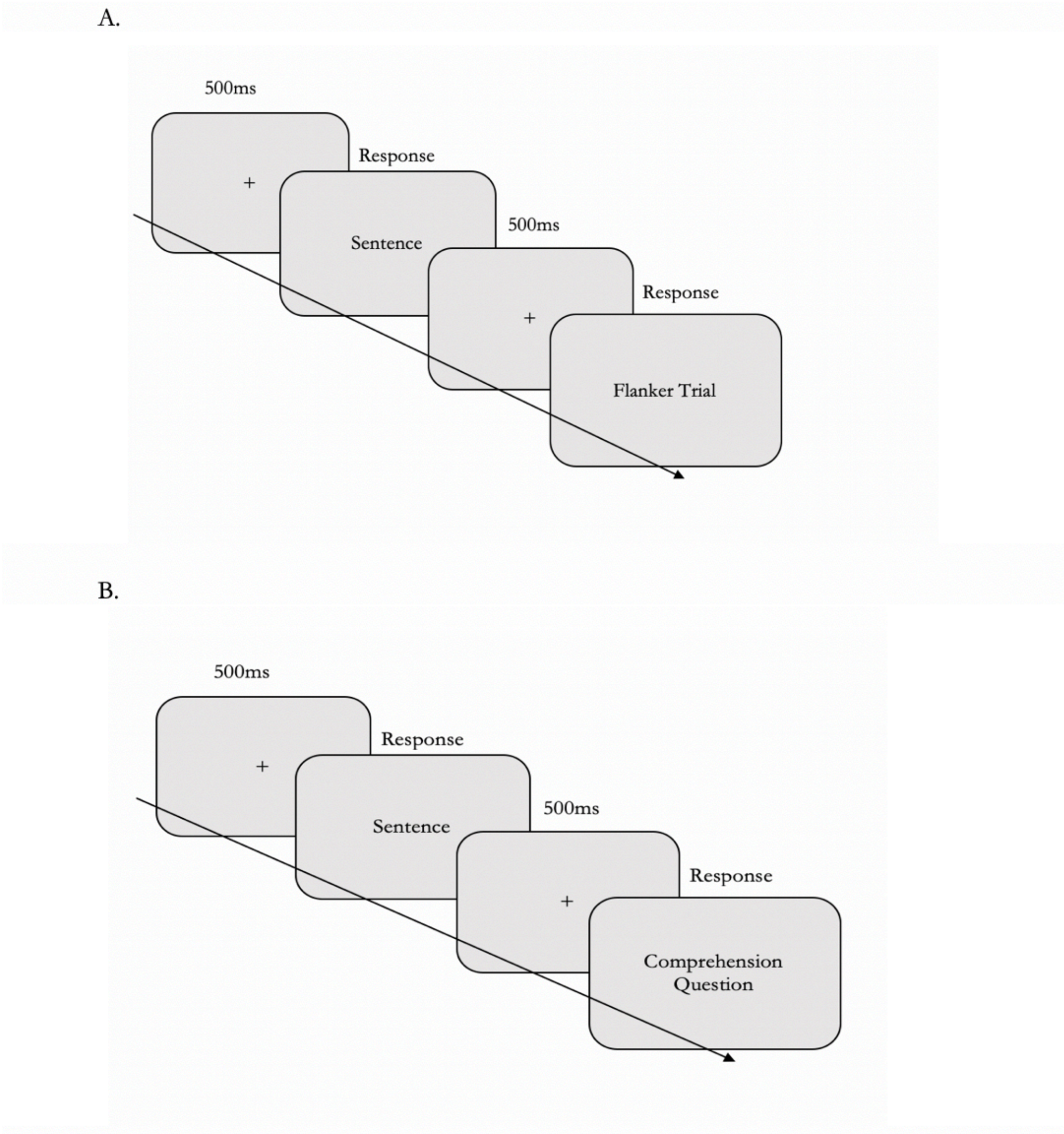

Figure 2. Experiment design show for the presentation of the trial sequences. A 500ms fixation cross preceded and followed the presentation of the sentence that participants had to read. In half of the trials, the second fixation cross was followed by a Flanker trial (**A**), and in the other half it was followed by a comprehension question (**B**).

3.4 Experimental Procedure

Participants first received electronically an information form that contained information about the study, instruction and contact information (See Appendix 4). On this electronic form, participants were advised to sit in a quiet room and use a computer when completing the task. Once they accepted the invitation to participate in the study, each participant received the first link, in which they gave their consent, and then, they began the LEAP-Q questionnaire and LexTale test in Qualtrics. When this first phase was completed, they received a secondary link through JATOS (Lange, Kühn, & Filevich, 2015), that contained the second phase of this study, which was the experimental portion.

The task consisted of a small practise with six trials, followed by two experimental blocks in which subjects read a sentence in one of the six different condition: **1**) Greeklish monolingual NCS sentences; **2**) English monolingual NCS sentences; Alternational code-switched sentences where the direction was **3**) L1 Greeklish→L2 English or **4**) L2 English→ L1 Greeklish; and Insertional code-switched sentences where the direction was **5**) L1 Greeklish→ L2 English → L1 Greeklish, or **6**) L2 English → L1 Greeklish → L2 English.

Each of these sentences remained on screen until the participant made a response to continue, and they were followed by either a comprehension question or a Flanker trial. When a comprehension question followed the sentence, participants had to answer whether the question matched the content of the sentence by pressing "A" when the answer was "No", and "L" when the answer was "Yes". On the other hand, when a Flanker trial followed the sentence, subjects had to indicate the direction of the centre arrow by pressing "A" for indicating the left direction of the arrow, and "L" for the right direction. On-screen instructions advised subject to be as quick, yet accurate as possible when completing each trial. The duration of the whole experiment was approximately 30 minutes.

CHAPTER 4: RESULTS

4.1 Statistical Analyses

Accuracy rates and response times (RTs) were collected for Flanker trials and comprehension questions from all participants. In addition, to ensure that participants read the sentences and completed the task as intended, reading times were also collected as a measure of sustained attention. Prior to the analysis, 888 trials were eliminated from the data set, including: Practise trials, Incorrect responses, Correct responses with RTs below 250 ms, and Correct responses with RTs above 2.5 *SDs* of participants individual means for each experimental condition.

4.2 Comprehension Questions Accuracy

The *Accuracy* on comprehension questions was analysed based on (the six different experimental) *Conditions* (Non-Code-Switch (NCS) × Alternational × Insertional). Overall, participants obtained an average mean score of 85.94% (SD = 7.42) of correct trials across all conditions, illustrating that they understood the sentences, and were paying attention while performing the task.

To analyse the comprehension data, we used a one-way repeated-measures ANOVA with factor *Condition*, with six experimental levels. Results showed a significant main effect on comprehension *Accuracy* by-subject factor, [F_1 (5, 345) = 23.045, $p < .001$, $\eta^2 = .250$]. Furthermore, *Post-hoc* tests using the Bonferroni correction revealed that *NCS* L1 and L2 mean *Accuracy* percentage were significantly different to the two *Insertional* code-switch levels ($p < .001$). Significant differences were also found between all the *Alternational (*L1→L2 and L2→L1) and *Insertional (*L1→L2→L1 and L2→L1→L2) code-switch levels ($p < .001$). Therefore, it can be concluded that there was a significant by-subject effect of *Conditions* on comprehension question *Accuracy*.

The by-item repeated-measures ANOVA showed a statistically significant main effect of comprehension *Accuracy*: F_2 (5, 325) = 16.191, $p < .001$, $\eta^2 = .199$. *Post hoc* test with Bonferroni corrections indicated significant mean differences between the *NCS* levels of L1 and L2 on the two *Insertional* levels: L1→L2→L1 and L2→L1→L2 ($p < .001$). Additionally, significant differences were noted between the two *Alternational* and two *Insertional Condition* levels ($p < .001$).

Table 4. Means and Standard Deviation for Comprehension Accuracy on *Conditions* (NCS; Alternational Code-switch; Insertional Code-Switch)

	Conditions	Mean %	Standard Deviation
NCS	L1	90.45	11.57
	L2	93.19	11.69
Alternational CS	L1 → L2	88.74	16.76
	L2 → L1	89.28	12.37
Insertional CS	L1 → L2 → L1	73.54	17.37
	L2 → L1 → L2	80.44	8.50

As can be seen from Table 4, participants had a higher percentage of accurate responses on the *NCS Conditions* (L1 and L2). In addition, results showed that *Accuracy* responses were significantly lower when *Insertional* code-switched sentences preceded the comprehension questions, rather than *Alternational* switches (See Figure 3 on the next page).

To examine the differences between *Accuracy* responses on comprehension, Chi-square tests of independence were administered for each condition pair. For the *NCS* variables no significant association was established between the L1 and L2 levels (χ^2 (2) = 11.771, $p = .067$). Similarly, for the *Alternational* code-switch pairs, there was no statistically significant difference between the L1→L2 and L2→L1 (χ^2 (2) = 6.245, p = .903). Contrastively, on *Insertional* code-switches, a significant difference was found between the L1→L2→L1 and L2→L1→L2 (χ^2 (2) = 22.229, p = .035).

4.3 Comprehension Questions Reaction Times

To further investigate the responses times on comprehension questions, a one-way repeated-measures ANOVA was conducted on *Condition,* with six levels, on subject (F_1) and item (F_2) factors. The ANOVA by subjects revealed a significant main effect of the experimental *Conditions* on comprehension RTs: F_1 (5, 345) = 3.521, p = .004, η^2 = .049. Results from the one-way repeated-measures by-item analysis on comprehension questions RTs with fixed factor *Condition* yielded a significant main effect: F_2 (5, 325) = 5.788, $p < .001$, η^2 = .082. These findings demonstrate that there was a cognitive cost on participants effort while responding to comprehension questions.

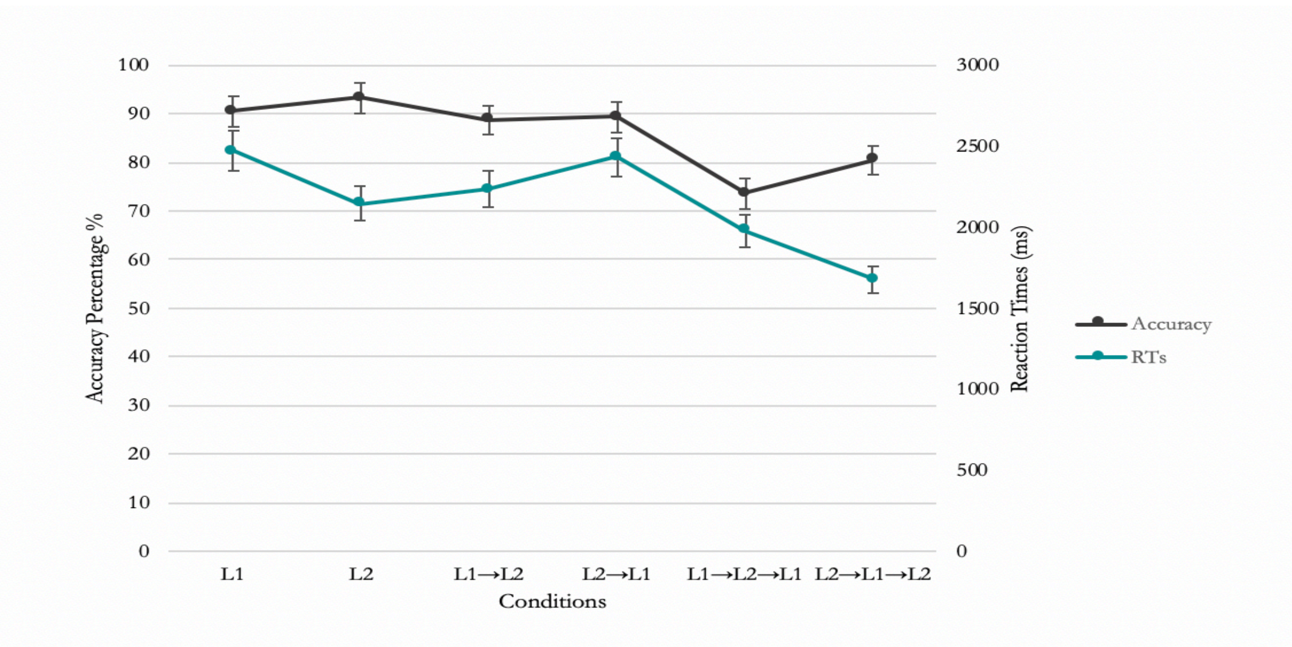

Figure 3. Mean *Accuracy* Responses and RTs for Comprehension Questions based on the Experimental *Conditions*.

As can be seen in Figure 3 above, results showed that participants tended to be faster when an *Insertional* code-switched sentence preceded the comprehension question, specifically when the sentence followed an L2→L1→L2 direction.

The slowest RTs were noted for the *NCS* L1 level (M = 2438.4 ms, SD = 946.7), and the *Alternational* L2→L1 level (M = 2431.7 ms, SD = 2590.0). *Post hoc* tests with Bonferroni adjustments showed on the F_1 significant difference between the Mean RTs for the *NCS* L1 and *Insertional* code-switches, both L1→L2→L1 and L2→L1→L2 (p < .001). The *NCS* L2 level had a significant mean difference with the *Insertional* L2→L1→L2 level (p = .002). For the *Alternational* code-switch there was a significant distinction between L1→L2 level and the *Insertional* L2→L1→L2 (p = .035).

Post hoc test for the F_2 analysis of comprehension RTs indicated significant main effect between the *NCS* L1 and the two *Insertional* levels: L1→L2→L1 and L2→L1→L2 (p <.05). Another significant mean difference was found between the *NCS* L2 and the *Insertional* L1→L2→L1 (p = .002).

4.4 Flanker Task Accuracy

The *Accuracy* data from the Flanker task were analysed using a two-way repeated-measures ANOVA with the fixed factor *Condition* (on NCS, Alternational, Insertional levels), and *Congruency* (Congruent and Incongruent Flanker), on subject (F_1) and item (F_2). The results from the analysis by-subject indicated a statistically significant main effect of *Condition* and *Congruency* (F_1 (11, 759) = 56.688, p = .000, η^2 = .460). *Post-hoc* tests on by-subject analyses with Bonferroni adjustments showed that *NCS* L1 congruent level significantly differed from the *NCS* L1 incongruent level (p < .001). The *NCS* L2 congruent level significantly differed from all five experimental *Conditions* (i.e., NCS, Alternational, Insertional) and the two *Congruency* levels (p <

.001). In addition, the *NCS* L2 incongruent level mean RTs differed from L2 congruent level ($p < .001$), and the *Insertional* L1→L2→L1 congruent ($p = .049$) level.

Furthermore, the ANOVA by-item analysis with *Condition* and *Congruency* items showed a statistically significant effect for the Flanker *Accuracy*: F_2 (11, 715) = 52.944, $p < .001$, $\eta^2 = .449$. The *Post hoc* comparisons with Bonferroni corrections demonstrated statistically significant differences between the *NCS* L1 congruent and *NCS* L2 congruent and incongruent levels ($p < .001$). The congruent *Alternational* L1→L2 direction differed from the *Insertional* L1→L2→L1 congruent and incongruent levels ($p <.001$). Also, the congruent L1→L2 mean differed from the *Insertional* congruent L2→L1→L2 congruent level.

In addition, chi-square tests on *Condition* pairs were conducted, and showed that for *Congruency* on the NCS levels indicated no significant mean difference in their responses, L1 congruent × incongruent: χ^2 (2) = 2.968, $p = .227$, and L2 congruent × incongruent: χ^2 (2) = 2.607, $p = .272$. Moreover, chi-square analyses on the two code-switch *Alternational* levels yielded non-significant differences between the L1→L2 (χ^2 (2) = 350, $p = .073$) and L2→L1 (χ^2 (2) = .190, $p = .663$) congruent and incongruent responses. Similarly, *Insertional* congruent and incongruent code-switch pairs had no significant distinctions between the mean accuracy responses: L1→L2→L1 and L2→L1→L2 (χ^2 (2) = .015, $p = .903$).

Table 5. Mean (SDs) Accuracy Percentages based on *Condition* (NCS, Alternational, Insertional) and *Congruency* (Congruent × Incongruent).

Type	**Condition**	**Congruency**	
		Congruent	**Incongruent**
NCS	L1	97.1 (10.9)	94.2 (23.3)
	L2	55.7 (16.0)	92.8 (16.9)
Alternational CS	L1-L2	90.7 (22.9)	96.4 (9.7)
	L2-L1	97.1 (11.6)	98.5 (6.8)
Insertional CS	L1-L2-L1	99.5 (3.99)	97.1 (13.6)
	L2-L1-L2	98.3 (12.6)	99.1 (8.44)

Based on Table 5 presented above, the overall the results from the mean percentage of *Accuracy* responses on the Flanker task showed that trials preceded by *Insertional* code-switched sentences facilitated the *Accuracy* performance on both congruent and incongruent levels, compared to the other *Conditions.*

4.5. Flanker Task Reaction Times

For the analysis of Flanker RTs, we used a two-way repeated-measures ANOVA with *Condition* and *Congruency* as within-subject fixed factors. By-subject analysis indicated a marginally significant main effect between *Condition* and *Congruency*, F_1 (11, 759) = 1.778, p = .051, η^2 = .025. *Post hoc* comparisons on the by subject analysis using the Bonferroni correction showed a statistically significant difference between the *NCS* L2 congruent level and the *Alternational* L2→L1 incongruent levels (p = .003). Another significant mean difference was noted between the two *Alternational* levels, in terms of congruency: L1→L2 congruent and L2→L1 incongruent levels (p = .024).

The results on the by-item ANOVA on *Congruency* and *Condition* showed a statistically significant main effect of the Flanker RTs on experimental items (F_2 (11, 715) = 2.975, $p < .001$, $\eta^2 = .044$. *Post-hoc* comparisons using the Bonferroni adjustment on the item analysis showed significant differences between the *NCS* L1 congruent and *NCS* L2 congruent variables ($p < .001$). Furthermore, a mean difference was found between the *Alternational* L1→L2 congruent and L1→L2 incongruent levels ($p < .001$). Results on the mean RTs on the experimental *Conditions* and *Congruency* variables are shown on Figure 4.

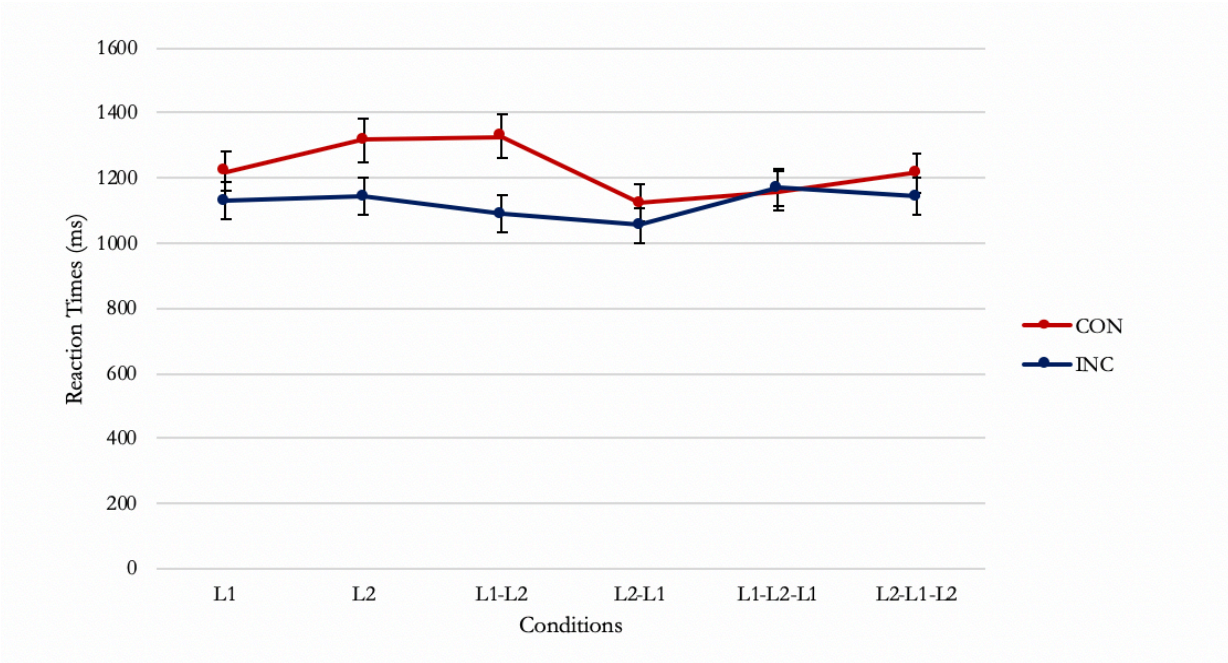

Figure 4. Mean RTs on *Congruency* (Congruent and Incongruent Flanker trials) for all Conditions.

As can be seen in Figure 4, participants were overall faster on *Alternational* incongruent trails. Specifically, the L2→L1 direction condition had the fastest RTs when followed by both incongruent trials and congruent trial compared to the rest of experimental conditions. Nonetheless, RTs on congruent trials were faster when preceded by an L1→L2→L1 *Insertional* sentences (M = 1160 ms, SD = 392.9).

4.6 The Flanker Effect

The Flanker Effect was calculated in order to represent the resolution of conflict adaptation across trials (Wu & Thierry, 2013). The mean RTs of all the valid congruent trials was subtracted from the mean RTs of all valid incongruent trial (i.e., RT congruent – RT incongruent) (Bosma & Pablos, 2020). Table 6 contains the calculated Flanker Effect based on the *Conditions* and the *Congruency*.

Table 6. Flanker Effect of Conflict Resolution on Experimental Conditions.

Condition	Flanker Effect
No-Code-Switch (NCS)	131.6
Alternational CS	152.6
Insertional CS	31.6

The higher the number of the Flanker Effect is an indication of the effort and difficulty of the participant's performance on the overall conditions. Based on the analysis, *Insertional* code-switched conditions had a limited effect on participants cognitive control performance. Contrastively, *Alternational* code-switches had the higher effect on cognitive control, when followed by a Flanker trial. Similarly, *NCS* conditions had a slightly less of an effect that *Alternational* condition, yet, still caused an elevated degree of cognitive costs than *Insertiona*l switches.

CHAPTER 5: DISCUSSION

5.1 Summary of Main Findings

The main focus of the present study was to investigate the extent to which cognitive costs arise while comprehending intra-sentential code-switches, and the effect that code-switching direction has on a consecutive Flanker trial during cognitive processing. To address these questions, native Greek L2 English learners completed an executive function (EF) paradigm, in which they were intermittently presented with sentences that contained a code-switch, or sentences that did not contain a switch (NCS), and were followed by either a comprehension question or a Flanker trial. The predictions of this study were based on existing evidence regarding the engagements of cognitive control on the processing and comprehension of code-switching during real time (Adler et al., 2019; Bultena et al., 2015; Wang, 2015; Dimitropoulou et al., 2011).

Our findings on comprehension revealed that higher *Accuracy* rates on "Yes/No" questions resulted in an increased cognitive processing cost. Specifically, during the presentation of NCS sentences, the *Accuracy* on comprehension questions was found to be the highest compared to the code-switched conditions. Yet the costs for the NCS conditions were found to be larger compared to the Alternational and Insertional conditions of comprehension questions. Contrastively, the presence of a code-switch in the sentences followed by a comprehension question had lower *Accuracy* rates, but significantly reduced the cognitive costs.

In terms of the effect of the code-switching direction and the degree of cognitive costs arising depending on the type of code-switch presented prior to the Flanker trial indicated that the type and direction of the switch have a significant Flanker effect on cognitive costs and the effort required. Findings demonstrated that *Accuracy* on Flanker trials was higher when the language direction of the sentence started from L2 English to L1 Greeklish. Furthermore, results from Flanker *Congruency* indicated that code-switched sentences facilitated the responses on incongruent trials. Lastly, the cognitive costs on Flanker trials appeared to be attenuated by Insertional code-switches, rather than Alternational code-switches and NCS sentences.

5.2 Code-switching and Comprehension

When reading intra-sentential code-switches, a bilingual reader encounters lexical items belonging to two languages, and must to respond to schemas of different languages, and to unexpected switches. In this study, bilinguals did not perform equally across conditions, which suggests that based on the language presentation the degree of cognitive effort requires different levels of inhibition. From the statistical analyses in section 4.2, it was shown that *Accuracy* performance was greater in NCS contexts, particularly when the sentence was in English (L2). This came in contrast to our predictions, as the performance was not as good as expected when the language began with the Greeklish Transliteration (L1). This hypothesis was based on the assumption that as the orthographic cues in Greeklish transliteration are similar to English, these cues should be easier during the recognition process, compared to the presentation of the Greek orthographic system and English system (Dijkstra & van Heuven, 2002). Support for this assumption comes from the study of Pasfield-Neofitou (2011), who examined the way native English L2 proficient Japanese learners used their L2 during code-switching transliteration in online writing contexts. All the participants used orthographic switches between English and Japanese, or used the Katakana-Kanji transliteration of Japanese. Reports from participants showed a preference for the transliteration types, and Pasfield-Neoifitou argued that it was easier to use when code-switching, rather than changing the input to the normal language grapheme (Pasfield-Neofitou, 2011). Yet, in our study, the reading of transliteration sentences before answering the comprehension questions was costlier, both in terms of *Accuracy* and response times.

The comprehension of the different types of intra-sentential code-switches paralleled the findings on monolingual processing in that these instances of code-switching had higher *Accuracy* and greater cognitive costs. Alternational code-switches *Accuracy* scores were relatively higher than Insertional code-switches. However, Alternational code-switches postulated a greater load on cognitive control upon their processing during the EF task, as opposed to Insertional code-switches, which require lower cognitive effort during reading comprehension of theses sentences. This finding supports our hypothesis, and converges with studies that account on the levels of inhibition required for each type of code-switching. Nonetheless, our study points to the fact that, comparted to Insertional code-switches, Alternational code-switches requires more inhibition upon their processing, and thus, cause high cognitive control costs (Hofweber et al., 2020, Green & Wei, 2014; Treffers-Daller, 2009). Also, as Guzzardo Tamargo and colleagues (2016) proposed, code-switching costs can be modulated in that some language switches seem to be easier to comprehend than others, rather than hypothesizing that all code-switch types derive into the same processing difficulties for the bilingual readers. For instance, Alternational code-switches may be more difficult to process than Insertional code-switches, or other types of intra-sentential switches.

A possible reason for these findings can be attributed to the writing system in which the L1 Greek was presented to participants for purposes of unifying writing systems and lowering the cost that reading in different writing systems intra-sentential might carry with it. Due to the fact that participants were proficient L2 English learners, such asymmetries cannot be accounted for solely on language dominance. Notably, high proficiency is found to cause increased effort on the processing of L1, due to the weakened links among word forms and concepts in L2 (Ivanova & Costa, 2008), or due to the increased probability of intrusion of the L2 knowledge during the L1 processing (Whitford & Titone, 2012).

Additionally, such asymmetries can be attributed rather to language identification based on the orthographic or writing system used during testing. For instance, when switching from the L1 to the L2, the bilingual reader must first identify the features that discriminate the two language systems. Second, the reader has to control the interference from Greeklish, while activating English, which is similar to the process found in conflicting monitoring. This process may be influenced by the ability of the reader to resolve the cross-language conflicts found in Greeklish and English that cause inhibition, which in comprehension must be resolved through bottom-up activation. Another possibility for these findings is the way that languages were processed. For instance, because of the high proficiency, the processing was involuntary, and as a result there was less demand for inhibitory control. In addition, high L2 proficiency is found to cause increased effort during the processing of L1, due to the weakened links among word forms and concepts in L2 (Ivanonva & Costa, 2008), or due to the increased probability of intrusion of the L2 knowledge to L1 processing (Whitford & Titone, 2012).

In reading comprehension, processing is driven by visual stimuli, which activates words through mental representations that involve bottom-up activation in the initial stages of processing. In conformity with the BIA+ model, language is recognised on word level, and language nodes are activated moderately late in the system (Dijkstra & van Heuven, 2002). However, the language activation of each word does not disappear entirely until the following word in the sentence is processed, and as a result code-switching costs arise due to the lingering activation (Bultena, Dijkstra, & van Hell, 2015). Further, preceding words activated with respect to bottom-up mechanisms, affect the ease of processing of the incoming words. At the same time pre-activation of the language node simplifies the processing of the next word in the L1, while a previous word in L2 language, renders' activation of the other language as more effortful.

5.3 Cognitive Control, Directionality and Congruency

A relationship between the processing of a code-switched sentence and the engagement of cognitive control while reading such sentence posits that performance can be adjusted according to the linguistic context and the modulation of cognitive processing. Since some studies showed that code-switching can be costly in terms of eliciting higher reading time (Bobb & Wodniecka, 2013; Jackson, Swainson, Mullin, Cunnington, & Jackson, 2004), one might have expected that the cost of responding to incongruent Flanker trials succeeding a code-switch would be inferior, compared to trials that did not contain a code-switch. However, other studies denote that the processing of a sentence that contains a code-switch and is followed by a Flanker trial has a higher conflict resolution and cognitive control monitoring in participants (Adler et al., 2019; Thothathiri, Asaro, Hsu & Novick, 2018; Hsu & Novick, 2016).

The observed findings of the present study can be interpreted as evidence to the studies supporting that the presentation of a sentence contain an Alternational code-switch facilitates the performance on a subsequent Flanker trial. Specifically, responses to the Flanker task on trials preceded by a sentence with a code-switch had an advantage on incongruent trials, both with respect to *Accuracy* and response times. This suggests that there is an overall facilitation effect of Alternational code-switches on incongruent Flanker task performance driven by conflict resolution. Yet, the findings in this study varied according to the type of code-switch presented (i.e., Alternational or Insertional), and the direction of the language switch (L1→L2; L2→L1; L1→L2→L1; L2→L1→L2). While the overall scores of Alternational code-switched were better on incongruent Flanker trials (both for the obtain *Accuracy* and RTs; In Sections 4.4 and 4.5), the direction of the switch had an impact on the Flanker Effect. In particular, when the direction of the Alternational switch in the sentence was from L2→L1, the response times were significantly faster than when the direction occurred from L1→L2, and the Flanker *Accuracy* rates were improved.

On Insertional code-switches followed by a Flanker trial, the findings showed that the overall performance on incongruent trials was better, but on conditional levels depending on direction (L1→L2→L1 and L2→L1→L2), different patterns were noted in the participants' performance. On the Insertional L1→L2→L1 direction the performance was more accurate and faster on congruent Flanker trials, whereas on the L2→L1→L2 direction, the performance was faster and more accurate on incongruent trials. This was a crucial outcome in our study due to the novelty of Insertional code-switches in relation to cognitive control, *Congruency* and directionality. It demonstrates that even though the direction of the code-switch influences the performance of a subsequent Flanker trial differently, it still causes an overall lower cognitive cost for the Flanker task in incongruent cases. The decrease in cognitive control costs and the advantage in performance, was also observed by Wu & Thierry (2013), who revealed that English-Welsh bilingual performed better on a conflict resolution task when presented within an experimental block with isolated words both in English and Welsh, compared to when they were presented with monolingual cases in different experimental blocks.

In the current experiment, the design of NCS and direction of the code-switch sentences (between Alternational and Insertional) was unpredictable to during the presentation. This unpredictability of the whole experimental procedure arguably required higher monitoring demands in our participants (Gollan & Ferreira, 2009; Costa, Hernández, Costa-Faidella, & Sebastián-Gallés, 2009). While reading the sentences, the code-switch directions are difficult to predict, since the reader can never be sure whether a switch may occur and whether the sentence might contain one type of switch, or more. Such uncertainty concerning the expectation of where the switch may occur, or whether the sentence might contain a switch may lead to slow-down in the trial response. As a consequence, switching costs may arise, which will also illustrate the reader's involvement of cognitive control processes.

When a sufficient sentence input is presented, the context stipulates information that either elongates or eliminates the processing costs (Gullifer, Kroll, & Dussias, 2013). Most studies have argued that the direction of the code-switch within a sentence from L1 to L2 elicit smaller costs in bilinguals, due to the fact that the weaker L2 necessitates less inhibition than the more dominant L1 (See Kang & Lust, 2019; van Hell, Litcofsky, & Ting, 2015; Meuter & Allport, 1999). Our study presents evidence that contradicts these research findings, as we demonstrate better performance on the task when the direction of the switch in the sentence occurred from the L2 to L1. This finding is coherent with the study by Wang (2015), who showed that code-switches from L2 to L1 were facilitated during the maze task. Similarly, Costa, Sansteban and Ivanova (2006) proposed that code-switching into the L1 tends to be harder than switching into the L2, because L1 is inhibited to a greater degree compared to the L2. Nonetheless, Bonfieni, Branigan, Pickering & Sorace (2019) claimed that when bilinguals are exposed and use the L2 on a regular basis, it is easier to code-switch between the two languages, and that the L2 appears to lessen the effort required to reactively inhibit the L1.

In order to further interpret the cause of our outcome, it can be reasoned that the presence of conflict information in the visual input prepares the system to employ cognitive control on attention. According to this reasoning, the conflict recognition found in incongruent trials enforces an adjustment in behaviour by regulating the system to concentrate on task-relevant instead of task-irrelevant information and hence, assists the resolution of other cases of conflict to be more successful (Kerns, Cohen, MacDonald, Cho, Stenger, & Carter, 2004). In this study, the detection of a code-switch increased the demands to focus on the task-relevant information (which in the Flanker task is the central arrow), while ignoring the task-irrelevant information (the surrounding arrows). These findings are supported by Adler and colleagues (2019) who found that Spanish-English bilinguals performed better when presented with Alternational code-switched sentences, whose processing assisted in the subsequent conflict resolution of succeeding incongruent Flanker trials. A key manifestation of that in the current findings is that, when bilingual adults read an Alternational or Insertional code-switched sentence, conflict resolution is involved which in turn engages cognitive control mechanisms in the participants when responding to a succeeding Flanker task.

CHAPTER 6: LIMITATIONS AND FUTURE DIRECTIONS

6.1 Methodological Limitations

The empirical findings reported herein should be considered in terms with some methodological limitations. First, and despite the clear instructions and guidelines provided to the participants, the situational contexts the study was operated were not controlled. Due to the global COVID-19 pandemic, the experiment had to be carried out online, and as a result, distractions, and noise that participants may have encountered while completing the task could not be controlled, which could have been avoided in a laboratory setting.

A second limitation of the study was the web-based response time measurements, and the fact that these measures always come with some constraints with regard to the amount of "noise" they contain. Despite the fact that many well-established RTs effect have been replicated with web-based studies (e.g., Simcox & Fiez, 2014; Crump, McDonnel, & Gureckis, 2013), scepticism still circulates the use of these on-line measurements and on-line data collection platforms.

Our main experiment was conducted using a JATOS internet link and the RTs obtained from participants who had different computer displays, web browser and operating systems. As a consequence, it is possible that the RTs were subjected to variation among technical and software technologies, as existing evidence suggests that different input devices such as mice and keyboards, and the number of other application processes running on the background affect RT measurements (Reimers & Stewart, 2015; Plant & Turner, 2009). Nevertheless, we tried to get this confined by filtering the RT data according to the standards that are common to previous studies that have collected this type of data in laboratory settings.

6.2 Future Implications

The limitations of this study point towards the issues that need to be addressed in future research. Interesting areas to be further investigated in terms of intra-sentential code-switching and cognitive control are neural correlates and age.

As this study assessed linguistic and non-linguistic performance through an executive function paradigm using solely behavioural methods, future research should investigate these effects using neural correlates of intra-sentential code-switching on Insertional switches and directions. By examining the neural mechanisms through Insertional code-switching reading paradigms, progress can be made towards understanding the fundamental neurocognitive processes involved in this type. Future research can use Functional Magnetic Resonance Imaging (fMRI) or Magnetoencephalography (MEG) to investigate the response-based or stimulus-based language conflicts during a sentence reading task in bilinguals, and explore the activations in the brain areas involved for the resolution of conflict for Insertional switches.

Additional insights into the comprehension of intra-sentential code-switches should investigate the effect of how participants perform and the extent to which would the Flanker Effect would change with the presentation of different orthographic systems in real time. For example, using the Greek language orthography, the Greeklish transliteration and English orthography on all intra-sentential levels including the Alternational, Insertional and the Congruent Lexicalisation. Focusing on this research area can bridge the gap in the literature with regards to Insertional code-switching and other intra-sentential types, and the influences that it has on bilingual processing.

CHAPTER 7: CONCLUDING REMARKS

Bilingualism is a complicated skill that entails brain mechanisms to select continuously between two languages, inhibit interference from one of them (the non-target language), and switch between them. Previous research has demonstrated that recognition of conflict information in a task recruits cognitive control mechanisms for a resolution of a successful comprehension and for the prevention of comprehension failure (Adler et al., 2019; Hsu & Novick, 2019; Thothathiri et al., 2018). To further examine these results, this study explored the domain of intra-sentential reading by investigating the differential impacts of two code-switch types on cognitive control costs with respect to conflict resolution inherent to Flanker task.

Analogous to some forms of linguistic conflict, such as language presentation, it was shown that the presence of an Insertional code-switch in sentence comprehension engages cognitive control, and impacts the performance on a subsequent Flanker trial. Importantly, it was demonstrated that the level of effort required based on the type of intra-sentential code-switch presented prior to the linguistic (Comprehension Questions) and non-linguistic (Flanker) task has its corresponding effects on cognitive costs. We argue that the processing demands during the course of reading a code-switch interacts with the domain-general cognitive control mechanisms, which are a fundamental aspect for understanding the way that the bilingual mind works. This study adds to the theoretical debate concerning the underlying mechanisms in the comprehension of a code-switch, and sheds more light into the psycholinguistic research on the processing of Insertional code-switches and the processing of code-switching using different orthographic systems.

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APPENDICES

Appendix 1: Language Proficiency & LexTale Questionnaire

LUCL Experimental Labs

Universiteit Leiden
Centre for Linguistics

Researcher: Nataly Aristodimou

Supervisors: Dr. Leticia Pablos Robles
Dr. Andreea Geambasu

The Effect of Different Types of Intra-Sentential Code-Switches on Cognitive Control Costs

Welcome!

This questionnaire is being conducted as a part of Leiden University Centre for Linguistics Experimental Labs, to explore the use of code-switch utterances of Greek and English languages. Code-switching can be defined as the alternation between languages within a bilingual speech or text.

In the first part of this questionnaire, you will have to answer a series of questions about your language background and abilities. In the second part, you will be asked to complete a small English language proficiency test.

Your participation in the questionnaire will take approximately 10 minutes.

Once you finish these parts of the study, you will then receive a new link to participate in the final part of the experiment.

Taking part in this study is **completely voluntary and discretional**. You **have the right to withdraw from the study at any time** without having to give any reason. All information collected with regards to this study will be treated **strictly confidentially**.

- I agree to participate in this study on an entirely voluntary basis
- I do not agree to participate in this study.

<u>Basic Information Block</u>

Question 1: What is your gender?
- Male
- Female
- Other

Question 2: How old are you?

Question 3: Have you ever been **clinically diagnosed** with any of the conditions mentioned below? Please check all applicable.
- Vision problems
- Hearing impairment
- Language disability
- Learning disability
- Motor impairment
- None of the above

<u>Code-switching Block</u>

Question 4:

Please list all the languages you know **in order of dominance**.

	Language Name	Age of Acquisition	Proficiency Level (1-5) (1; being the lowest, and 5; being the highest)
Language 1			
Language 2			
Language 3			
Language 4			

Question 5: Please list what percentage of time you are currently on average exposed to each language. Your percentage should add up to 100%
Greek
English
Other languages

Total

Question 6: When choosing a language to speak with a person who is equally fluent in all your languages, what percentage of time would you choose to speak each language? Please state the percentage of total time (percentage should add up to 100%)
Greek

English	
Other languages	
	Total

Question 7: *Code-switching can be defined as a system for transliterating Greek into the Latin alphabet either phonetically or orthographically*. What is your attitude towards code-switching?

- Positive
- Neutral
- Negative

Question 8: *Greeklish can be defined as a system for transliterating Greek into the Latin alphabet either phonetically or orthographically*. Do you use Greeklish transliteration?

- Yes
- No

Question 9: How often do you use Greeklish Transliteration?

- Always
- Most of the time
- Half of the time
- Sometimes
- Never

<u>English language knowledge block</u>

Question 10:

All questions below refer to your knowledge of English language.

State the age when you:

	Age
Began acquiring English:	
Became fluent in English:	
Began reading in English:	
Became fluent reading in English:	
Began writing in English	
Became fluent writer in English	

Question 11:

On a scale from 0 to 5, please select your level of proficiency in English in the following areas:

	0 - None	1 - Low	2 - Fair	3 - Adequate	4 - Good	5 - Excellent
Speaking	○	○	○	○	○	○
Reading	○	○	○	○	○	○
Understanding spoken language	○	○	○	○	○	○

Question 12: Please rate how frequently other have identify you as a non-native speaker based on your accent in English:

- Always
- Most of the time
- About half of the time
- Sometimes
- Never

<u>LexTale Proficiency Questionnaire Block</u>

The second part of the questionnaire is a proficiency test. This test consists of about **30 trials**, in each of which you will see a string of letters. Your task is to decide whether this is an existing English word or not. If you think it is an **existing English word** you should click on "**YES**", and if you think it is **not an existing English word**, you click on "**NO**".

If you are sure the word exists, even though you don't know its exact meaning, you may still respond "YES". But if you are not sure if it is an existing word, you should respond "NO".

In this experiment, we use **British English** rather than American English spelling. For example: "realise" instead of "realize"; "colour" instead of "color", and so on. Please don't let this confuse you. This experiment is not about detecting such subtle spelling differences. You are advised not to use a dictionary while answering this part of the questionnaire.

You have as much time as you like for each decision.

This part of the experiment will take about 2 minutes to complete.

If everything is clear, you can now start the experiment.

START

Trial 1: *Platery* | *Non-word*
- Yes
- No

Trial 2: *Denial* | *Word*
- Yes
- No

Trial 3: *Generic* | *Word*
- Yes
- No

Trial 4: *Kermshaw* | *Non-word*
- Yes
- No

Trial 5: *Moonlit* | *Word*
- Yes
- No

Trial 6: *Hurricane* | *Word*
- Yes
- No

Trial 7: *Flaw* | *Word*
- Yes
- No

Trial 8: *Alberation* | *Non-word*
- Yes
- No

Trial 9: *Plaudate* | *Non-word*
- Yes
- No

Trial 10: *Fluid* | *Word*
- Yes
- No

Trial 11: *Spaunch* | *Non-word*
- Yes
- No

Trial 12: *Eloquence* | *Word*
- Yes
- No

Trial 13: *Rebondicate* | *Non-word*
- Yes
- No

Trial 14: *Hasty* | *Word*
- Yes
- No

Trial 15: *Length* | *Word*
- Yes
- No

Trial 16: *Majestic* | *Word*
- Yes
- No

Trail 17: *Magrity* | *Non-word*
- Yes
- No

Trial 18: *Nourishment* | *Word*
- Yes
- No

Trial 19: *Mensible* | *Non-word*
- Yes
- No

Trail 20: *Fellick* | *Non-word*
- Yes
- No

Trial 21*: Censorship | Word*
- Yes
- No

Trial 22: *Muddy | Word*
- Yes
- No

Trial 23: *Listless | Word*
- Yes
- No

Trial 24: *Purrage | Non-word*
- Yes
- No
-

Trial 25: *Quirty | Non-word*
- Yes
- No

Trial 26: *Turmoil | Word*
- Yes
- No

Trial 27: *Kilp | Non-word*
- Yes
- No

Trial 28: *Plaintively | word*
- Yes
- No

Trial 29: *Interfate | Non-word*
- Yes
- No

Trial 30: *Upkeep | Word*
- Yes
- No

End Message

This is the end of the first part of the study. You will receive a link shortly for the final part of the experiment. If you have any questions or concerns regarding the study, please feel free to add them on the box below.

Appendix 2: Acceptability Judgement Questionnaire

LUCL Experimental Labs

Universiteit Leiden
Centre for Linguistics

Researcher: Nataly Aristodimou

Supervisors: Dr Leticia Pablos Robles
Dr Andreea Geambasu

The Effect of Different Types of Intra-Sentential Code-Switches on Cognitive Control Costs

Welcome!

This questionnaire is being conducted as a part of Leiden University Centre for Linguistics Experimental Labs, to explore the use of code-switch utterances of Greek and English. Code-switching can be defined as the practise of moving back and forth between two languages in a conversation.

By participating in this survey, you will have to answer a few questions about your language background.

Next, you will read a series of sentences written in Greeklish transliteration, with combinations of Greek and English languages. You have to rate the extent that these formats are likely to be used by speakers in terms of meaning, use and acceptable forms of the language in normal speech; from the most unlikely to the most likely case.

Please feel free to add comments or questions regarding the sentence options.

Any information you provide will remain completely anonymous and will exclusively be used for the purposes of this assignment.

This survey should take less than 10 minutes to complete.

START

<u>Information Block</u>

Question 1: What is your gender?

- Female
- Male
- Other

Question 2: How old are you?

- Under 18
- 18-24
- 25-34
- 35-44
- 45+

Question 3: What is your native language?

- Greek
- English

Question 4: What is your second language?

- Greek
- English

Question 5: How often do you usually code-switch between Greek and English?

(*Code-switching is the practise of moving back and forth between two languages.*)

- Always
- Most of the time
- About half of the time
- Sometimes
- Never

<u>Experimental Blocks</u>

Question 6: L1-L2 | Form: NP-V-Adv-[NP-PP]

Please rate the following sentence in terms of use and meaning in normal speech:

I Laoura etoimase prosektika the dinner for tonight.

- o Extremely likely
- o Somewhat likely
- o Neither likely or unlikely
- o Somewhat unlikely
- o Extremely unlikely

Question 7: L1-L2 | Form: NP-V-[Adv-NP-PP]

Please rate the following sentence in terms of use and meaning in normal speech:

I Victoria efage the soup slowly in the kitchen.

- o Extremely likely
- o Somewhat likely
- o Neither likely or unlikely
- o Somewhat unlikely
- o Extremely unlikely

Question 8: L1-L2 | Form: NP-V-NP-[Adv-PP]

Please rate the following sentence in terms of use and meaning in normal speech:

O Christoforos epekse tin kithara badly at the festival.

- o Extremely likely
- o Somewhat likely
- o Neither likely or unlikely
- o Somewhat unlikely
- o Extremely unlikely

Question 9: L2-L1 | Form: NP-VP-NP-[Adv-PP)

Please rate the following sentence in terms of use and meaning in normal speech:

Laoura prepared the dinner prosektika gia appose.

- o Extremely likely
- o Somewhat likely
- o Neither likely or unlikely

- Somewhat unlikely
- Extremely unlikely

Question 10: L2-L1 | Form: NP-V-[NP-Adv-PP]

Please rate the following sentence in terms of use and meaning in normal speech:

Christoforos played tin kithara asxima sto panigiri.

- Extremely likely
- Somewhat likely
- Neither likely or unlikely
- Somewhat unlikely
- Extremely unlikely

Question 11: L2-L1 | Form: NP-V-Adv-[NP-PP]

Please rate the following sentence in terms of use and meaning in normal speech:

Victoria ate slowly tin soupa stin kouzina.

- Extremely likely
- Somewhat likely
- Neither likely or unlikely
- Somewhat unlikely
- Extremely unlikely

Question 12: L1-L2-L1 | Form: NP-V-[Adv-NP]-PP

Please rate the following sentence in terms of use and meaning in normal speech:

I Laoura etoimase carefully the dinner gia apopse.

- Extremely likely
- Somewhat likely
- Neither likely or unlikely
- Somewhat unlikely
- Extremely unlikely

Question 13: L2-L1-L2 | Form: NP-V-[NP-Adv]-PP

Please rate the following sentence in terms of use and meaning in normal speech

Christoforos played tin kithara asxima at the festival.

- o Extremely likely
- o Somewhat likely
- o Neither likely or unlikely
- o Somewhat unlikely
- o Extremely unlikely

Question 14: L1-L2-L1 | Form: NP-V-[NP-Adv]-PP

Please rate the following sentence in terms of use and meaning in normal speech

I Laoura etoimase the dinner carefully gia apopse.

- o Extremely likely
- o Somewhat likely
- o Neither likely or unlikely
- o Somewhat unlikely
- o Extremely unlikely

Question 15: L2-L1-L2 | Form: NP-V-[Adv-NP]-PP

Please rate the following sentence in terms of use and meaning in normal speech

Christoforos played asxima tin kithara at the festival.

- o Extremely likely
- o Somewhat likely
- o Neither likely or unlikely
- o Somewhat unlikely
- o Extremely unlikely

This is the end of the survey thank you for participating!
Please feel free to add comments, questions or suggestions in the box below.

Appendix 3: Sentences for the Experimental Conditions

NCS L1 | Greeklish

1. I Evgenia eksafanistike mystiriodos apo to spiti prin ena mina.
2. I Marina epleke ysixa to plekto stin veranta.
3. O Nikos apantise sosta stin erotisi sto diagonisma.
4. O Philippos kolimpaei taktika stin thalassa konta sto spiti mou.
5. I Stefani tragoudise apsoga to tragoudi sto panigiri.
6. I Artemis koitakse me periergeia ton perastiko ston dromo.
7. O Spyros etrexe xaroumena me tin adelfi tou sto parko.
8. I Eleftheria efage grigora to mesimeriano simera.
9. I Chrystalla agkaliase apala to neogenito tis sto nosokomeio.
10. I Emily epekse omorfa to violi stin prova.
11. O Tolis dierevnise dieksodika tin ypothesi tis oikogeneias.

NCS L2 | English

1. Dionysis rang the phone immediately for an ambulance.
2. Ifigeneia donated the check charitably to the organization.
3. Elena examined the facts carefully today.
4. Stelios awaits for his flight anxiously at the gate.
5. Rania treated the wound cautiously at the clinic.
6. Katerina confronted the manager directly at the office.
7. Mattheos stopped the car abruptly in the street.
8. Michaella paid the fine promptly at the tax office.
9. Elina responded to the family sympathetically at the gathering.
10. Zacharias controlled the situation slowly at the green house.

11. Isavella admitted her crime remorsefully in court.

Alternational L1→L2 | Greeklish to English

1. O Savvas frourouse genea the gates at the castle.
2. I Anna odigise me prosoxi her motorbike on the freeway.
3. I Elisavet paratirouse ypopta the man at the counter.
4. O Giorgos irthe noris to the lesson today.
5. I Martha troei arga the cake with a fork.
6. O Andreas fonakse orgismena to the captain of the game.
7. O Loukas espase katalathos the chair in class.
8. O Thomas tragoudise xaroumena the song at the contest.
9. I Kassiani kalese me anisixia her father on the phone.
10. I Semeli pige konta to the doctor at the station.
11. Orestis akolouthise ypakoua the instructions that day.

Alternational L2→L1 | English to Greeklish

1. Iakovos shook his head koroideftika ston daskalo.
2. Miltiadis moved the boxes grigora sto diamerisma.
3. Diamando eyed the judge me amfivolia gia tin apofasi tou.
4. Sokratis trapped the bird eksipna stin avli.
5. Marios tugged his hand epigontos apo tin porta.
6. Valeria laughed with her friends dynata sto parko.
7. Demetris left the house aprosmena to prwi.
8. Elias glanced at Aglaia me periergeia sto treno.
9. The soldiers marched with their units arga stin parelasi.

10. Costas was watching the movie siopila ston kinimatografo.
11. Sandra spoke to the crowd deila simera.

Insertional L1→L2→L1 | Greeklish – English - Greeklish

1. O Timoleon perimene his results patiently stin kliniki.
2. O Yanis spoudase for a semester abroad stin Souidia.
3. I Anthia ipie the juice quickly sto dialima.
4. O Manos zitokravgaze for his team loudly xthes.
5. O Neophytos skarfalose the wall clumsily tin teleftea fora.
6. I Alexis tha stamatisei with Ioanna later stin agora.
7. I Emmanouela eskise the book violently stin vivliothiki.
8. I Eleonora filise her husband gently sto magoulo.
9. I Anastasia perpatise towards the thief boldly simera.
10. I Agapi kalipse the position temporary simera.
11. I Christina episkeptete her mother often sto xorio.

Insertional L2→L1→L2 | English – Greeklish - English

1. Amarryllis painted xromatista ton toixo yesterday.
2. Neophytos spoke tryfera stin Chrysi yesterday.
3. Nadia hugged me agapi to koutavi tis yesterday.
4. Michalis gazed epimonetika tin Manto on the train.
5. Michalis drove aperiskepta tin motosikleta tou on the highway.
6. Sergios went apo noris sto gymnastirio today.
7. Nafsika ironed prosektika to poukamiso tis today.
8. Elvira hugged glyka to arkoudaki tis on the couch.

9. Andrianos asked evgenika gia mia xari from the board.
10. Charis twisted odinira ton astragalo tou on the field.
11. Vanessa ate peinasmena tin pita on her break.

Appendix 4: Participant Information Sheet

LUCL Experimental Labs

Universiteit Leiden
Centre for Linguistics

Researcher: Nataly Aristodimou

Supervisors: Dr Leticia Pablos Robles
Dr Andreea Geambasu

The Effect of Different Types of Intra-Sentential Code-Switches on Cognitive Control Costs

Dear participant,

We would be grateful if you could assist us by participating in our study exploring the effect of different types of intra-sentential code-switching on cognitive control costs. Code-switching can be defined as the alternation between languages within a bilingual speech or text. This study is specifically interested in Greek L2 English speakers.

Your participation will take approximately 30 minutes, during which you advised to stay on a quiet place and use your computer to avoid screen problems. You will first receive a link to fill a language background questionnaire along with an English language proficiency test. Once you finish the first part of the study, you will receive a second link, where the experimental phase will start. The task will consist of a practise phase, and two experimental blocks, during which you will read a sentence in Greeklish transliteration or in English language. Each of these trials will be followed by either a comprehension question or an arrow trial. When the sentence is followed by a comprehension question, you will have to answer whether the question matches the content of the sentence that you just read; by pressing "**L**" when the answer is "**yes"**, or press "**A**" when the answer is "**no"**. When the sentence is followed by an arrow trial, you will see five arrows on the screen, and you have to indicate the direction of the centre arrow; by pressing "**A**" for the **left direction**, or "**L**" for the **right direction** of the arrow.

Each sentence will remain on screen until you press the space bar to continue. After you have read the sentence and continue with the space by press, this action will be followed by a fixation point, and consecutively by either a comprehension question or the arrow trial. The rate at which you will see every sentence, and move to the next sentence will be controlled by how fast you respond to each trial. You are advised to be as quick, yet accurate as possible when completing each trial.

Taking part in this study is completely voluntary and discretional. You have the right to withdraw from the study at any time, without having to give any reason. All information collected with regard to this study will be treated strictly confidentially. All data will be processed and securely stored anonymously. The data will not be accessible to unauthorised people and will not allow individual participants to be personally identified.

This study has been reviewed and approved by the Board of Examiners at Leiden University, but should you find that you have been incorrectly or insufficiently informed about
participation in this study, or if you have any complaints about the way this study was performed or the way you have been treated as a participant, it is recommended that you discuss this with the experimenter or the coordinator of the study. If you do not wish to do so, or in case that does not resolve the issue, you can also lodge a complaint with the Leiden University Centre for Linguistics (LUCL). Please find LUCL's contact information below.

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